GOVERNMENT OF TAMIL NADU

HIGHER SECONDARY FIRST YEAR

VOCATIONAL EDUCATION

Basic Electronics Engineering

THEORY & PRACTICAL

A publication under Free Textbook Programme of Government of Tamil Nadu

Department of School Education

Untouchability is Inhuman and a Crime

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PREFACE

This book is written in accordance with the new guidelines formulated by Tamilnadu Government School Education Vocational revamping Committee to strengthen the higher secondary vocational education on par with the Global Standards by providing different kinds of learning opportunities to promote holistic and vocational employabilty Skill. So that on completion of 12th standard the students can get a specialised certificate in this electronic currriculum and get job oppurtunites in the relevant industries. The objectives of this book is not only for knowledge upgradation but also for providing basic skills viz., hands-on-experience with electronic circuits, trouble shooting of minor problems in electronic equipment, handling of test and measuring equipment particularly computer hardware and software installations.

This book covers the up-to-date curriculum in the area of Electronics and related fields to encourage the multidisciplinary approach and discourage rote learning of Electronics with different subject areas. Each Chapter has been designed and written in such a way to inculcate the basic knowledge of Electronics and computer to the students and also to give opportunity to the stakeholders to provide a platform for exhibiting their creativity.

Each Chapter starts with the introduction of the concerned topic and covers the contribution from different domains such as brief history of scientists and their related inventions, learning objectives, learning outcomes and detailed description of the concepts with the related figures, equations for the easy and deep understanding of the subject matter. Further, several solved problems and self-evaluation exercises are given in each Chapter to motivate the students for self-learning and to develop self-confidence in the subject matter.

We are especially grateful to the members of the Tamilnadu State Council for Education Research and Training (SCERT) for their valuable support. For the systemic reform and continuous improvement in the standard of this book, we welcome critical comments and valuable suggestions, which will enable us to undertake further revision and refinement of the subject matters covered in this book.

We hope this book will bring an appreciable change in the teaching-learning process. We wish all the stakeholders to make use of this book effectively, to get the intended outcomes and benefits.

Basic Electronics Engineering has been revamped by SCERT in collaboration with Tamil Nadu Skill Development Corporation in order to get immediate employment opportunities for the vocational students in the Industrial Sectors in future. The skill certificate for practical assessment is given to every student by concerned Sector Skill Councils (SSCs) which are accredited by National Skill Development Corporation (NSDC) and TNSDC.

With Wishes

Dr. Damodaran Nedumaran

Chair Person

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BASIC ELECTRICAL PRINCIPLES

CHAPTER 1

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LEARNING OBJECTIVES

A student can understand the following in this Chapter

1. **Basics of electricity**
2. **Electrical parameters and its definitions**
3. **Ohm's law and its verification**
4. **Kirchhoff's law**
5. **Working of Resistors**
6. **Working of Capacitors**

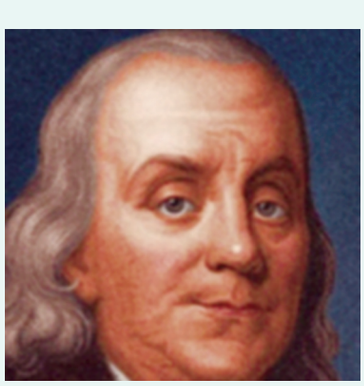
1.1 INTRODUCTION TO ELECTRICITY

Electricity is the integral part of human lives like water, space, land, fire and air. The human life is dominated by electrical and electronic gadgets, hence, the learning and understanding of their working principle is well advised for proper handling, maintenance and troubleshooting of those devices. Hence, we will discuss the history and basic principles of electricity in this Chapter.

1.1.1 History of Electricity

In June 1752, American Scientist Benjamin Franklin, tried to prove that lightning is a phenomenon of electricity by flying a kite with conductive rods to attract lightning to a Leyden jar, which was an early form of a capacitor. When a kite was flying at a certain height, he observed an electric spark and felt electric shock slightly, which proved that lightning is electric in nature.

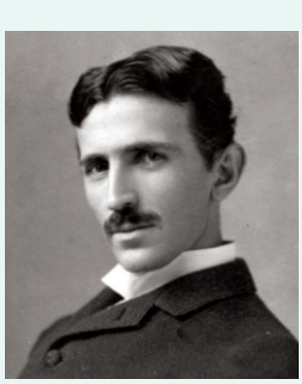
In 1800, in Paris (France), Italian scientist Alessandro Volta proved that his invention, "Voltaic Pile" produced electricity.



Benjamin Franklin



Benjamin Franklin Trying to Draw Electricity from Lightning



Nikola Tesla

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1.1.2 Electricity

It is a kind of energy that one cannot see as like air. It's existence can only be known through the working of electrical appliances. Also its existence can be found using line tester and multimeter.

1.1.3 Generation of Electricity

In 1831-32, a British scientist Michael Faraday invented electromagnetic generator using Faraday's laws of electro magnetism which produced Alternating current. Nikola Tesla, Serbian-American inventor contributed the design of modern A.C supply system.

1.1.4 Types of Power Generation

Important types of power generation are

1. Hydroelectric power station
2. Thermal power station
3. Atomic power station
4. Wind Power station
5. Natural Gas power station
6. Solar power station (D.C)

1.2 TYPES OF ELECTRICITY

Generally there are two types of Electricity. They are:

1. Alternating Current (AC)
2. Direct Current (DC)

1.2.1 Alternating Current

The direction of current varies with time is called as alternating current. It has two terminals viz., phase and Neutral. If the phase terminal acts as 'Positive', then neutral terminal acts as 'Negative' terminal. If phase terminal acts as 'Negative', then neutral terminal acts as 'Positive' terminal.

If you test the phase terminal with a line tester, you may see the light indication in the tester. Neutral shows no indication. Neutral is a common terminal used as a return path current flowing from phase to neutral through the connected device. It is neither 'Positive' nor 'Negative'.

Voltage and Frequency of Household AC Supply

In our country, the voltage and frequency of single phase AC supply is maintained as 220V/50Hz. In Foreign Countries, particularly in U.S.A, it is maintained as 110V/60Hz AC. Figure 1.1 shows the waveform of the alternating current.

Amplitude

Amplitude is the distance from the X-axis to the vertex or peak of the any one half cycle of the AC waveform. Its unit is volt.

Polarities

The top half cycle is positive half cycle and the bottom half cycle is negative half cycle. Both half cycles combined together to form the one complete full cycle.

Waveform

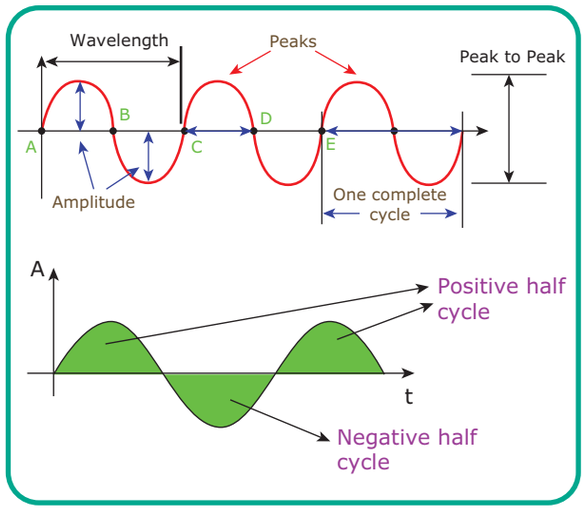

Figure 1.1 AC sine waveform

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Wavelength

The length from starting point of the wave to the finishing point, which includes one positive half cycle and one negative half cycle, is called wavelength. Its unit is meter.

Peak to Peak Value

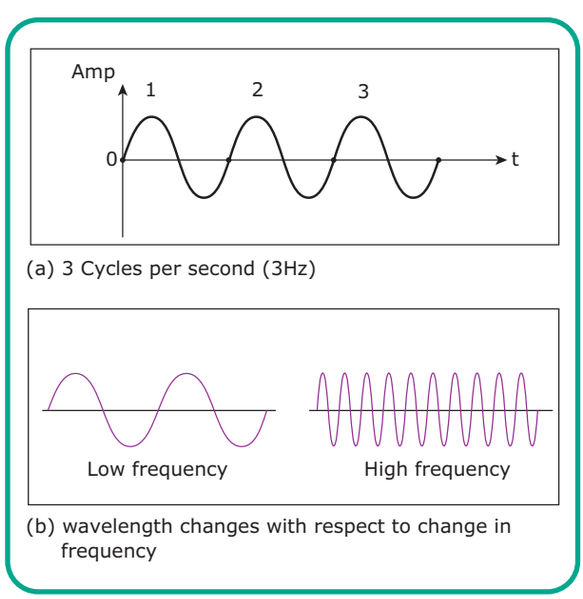
The distance between positive peak and negative peak is referred as peak to peak value. Its unit is volt.

Frequency

The number of complete cycles per second is called Frequency. Its unit is Hertz (Hz). Higher value units are Kilo-Hertz (KHz), Mega-Hertz (MHz), Giga Hertz (GHz) and so on.

If there are three full cycles occur in one second, then its frequency is 3 Hertz. It is shown in Fig 1.2 (a)

Low frequency has long wavelength and high frequency has short wavelength. It is shown in Fig 1.2 (b)



(a) 3 Cycles per second (3Hz)

(b) wavelength changes with respect to change in frequency

Figure 1.2 Frequency of the AC waveform

$$\text{Wavelength } (\lambda) = \frac{\text{Velocity of light or Electromagnetic waves (C)}}{\text{Frequency (F)}}$$

$\lambda = C / F$

(Unit of wavelength in meter, velocity of light - constant - 3×10^8 meter/sec and unit of frequency in Hertz)

1.2.2 Direct Current

The direction of current does not vary with time. Therefore, it is called as Direct Current. We can get DC from battery or by converting AC into DC using rectifier circuits. Figure 1.3 represents the direct current.

DC has two terminals namely Positive and Negative and hence battery symbol is used to denote DC.

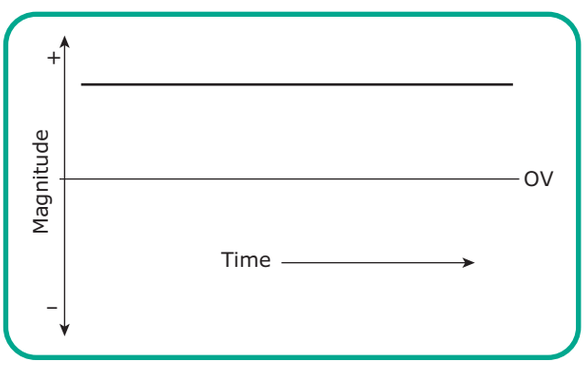


Figure 1.3 Representation of direct current

1.3 ELECTRICAL PROPERTIES

Basic Electrical properties are Voltage, Current and Resistance.

1.3.1 Voltage

Let us see an example to understand about voltage. In our home, water is filled in the overhead tank using electrical motor pump. Due to atmospheric air pressure and gravitational force, tank water is at

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the higher pressure. The pressure of the water in the tank is assumed as the supply voltage as shown in Figure 1.4.

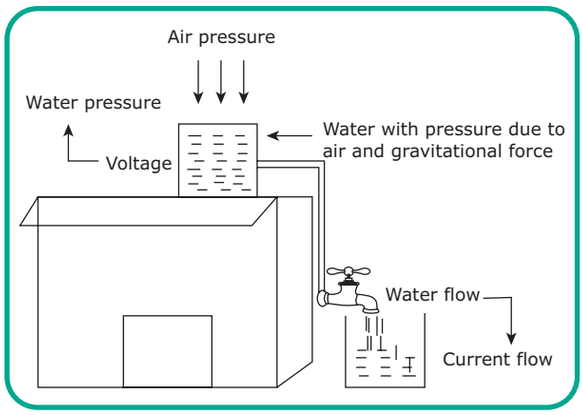

Figure 1.4 Comparison of voltage with pressure of water

The amount of electrical pressure required to pass the current in a conductor is known as voltage. It is represented by the letter V or E and measured by the unit Volt. Highest unit value is Kilo-Volt (KV). Lower value units are milli-Volt (mV) and micro-Volt (μV).

The quantity of one volt is defined as the voltage needed to send one ampere of current through one ohm resistance in a circuit.

As we designed weighing stone to measure rice, wheat etc., we defined one volt in the above paragraph.

1.3.2 Current

Let us try to understand current through an example. If we open a tap in our home, water flows quickly because it gets a path to flow from tank where water is under pressure.

Likewise, if we connect an electrical load through proper conducting wires, Electrons will flow from higher density point to lower density point as shown in Figure 1.5. This is called Electric Current.

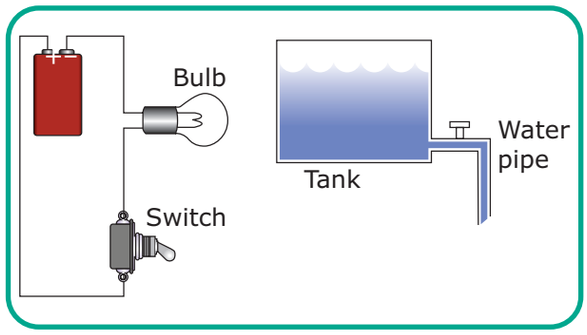

Figure 1.5 Comparison of electric current with flow of water

The flow of current can be measured as 'the number of electrons crossing the particular cross section of a conductor in a second". It is represented by the letter 'I'. Its unit is Ampere. It is the highest value. Lower values are milli-Ampere (mA) and micro-Ampere (μA).

1.3.3 Resistance

The property of a material which opposes the flow of current is known as resistance. An electrical component which has the resistance property is said to be resistor. It is denoted by the letter R and measured by the unit ohm. The units used to measure higher value resistance are Kilo ohm (KΩ) and mega ohm (MΩ).

To understand "what is resistance", an analogy between the water-tap and the resistance is the simplest way. For example, if the tap is fully opened, maximum water flows through the tap, otherwise if the tap is partially opened, then the amount of water flow through the tap is less.

Similarly, if the resistance offered to an electrical circuit is less, the amount of current flows in the circuit is maximum and vice versa.

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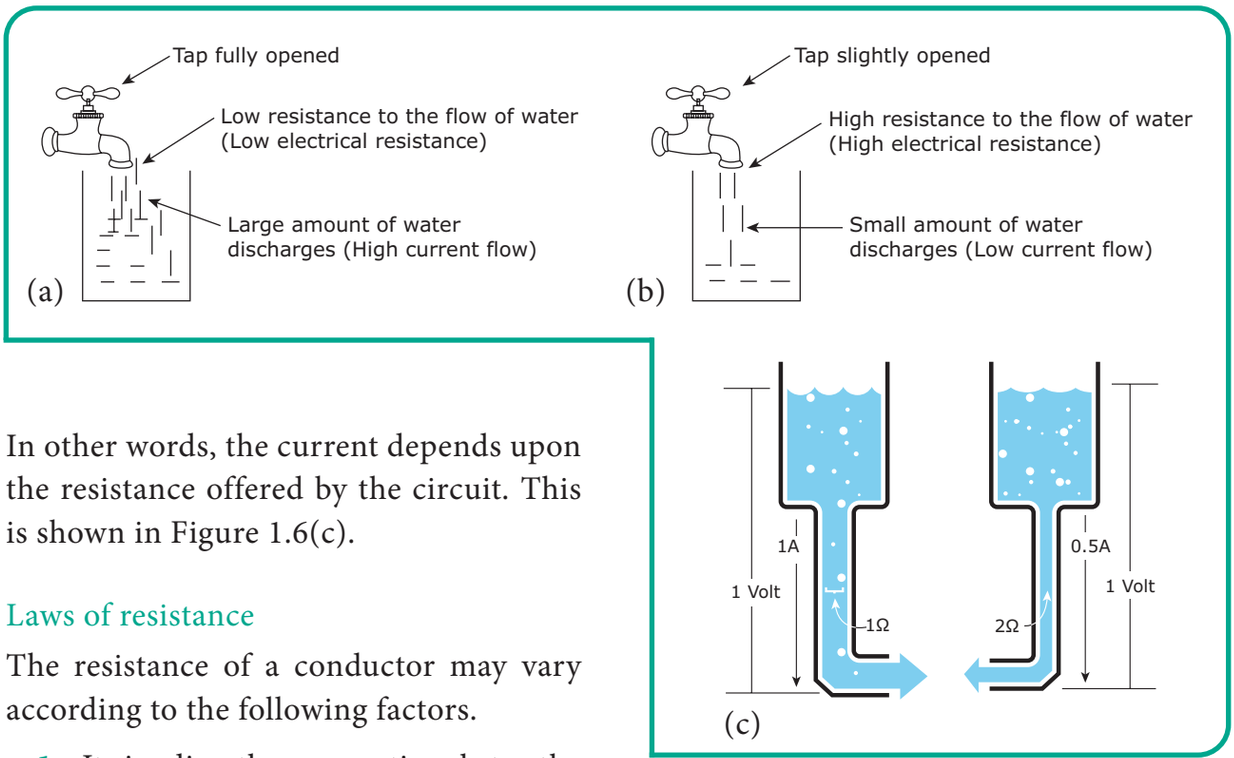

Figure 1.6 Comparison of resistance with flow of water

In other words, the current depends upon the resistance offered by the circuit. This is shown in Figure 1.6(c).

Laws of resistance

The resistance of a conductor may vary according to the following factors.

1. It is directly proportional to the length of the conductor.
2. Inversely proportional to the cross sectional area of the conductor.
3. Directly proportional to the specific resistance or resistivity of the conductor.

$$R = \rho \frac{l}{A}$$

Where R is the resistance, l is the length, A is the area of cross-section, and ρ is the specific resistivity of the conductor as shown in Figure 1.7.

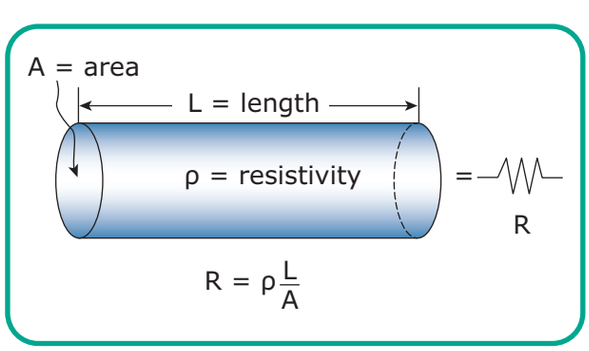

Figure 1.7 Factors affecting the resistance of a conductor

1.4 OHM'S LAW

German physicist George Simon Ohm found that "voltage, current and resistance" are related to each other and derived a law. This is called Ohm's law. Let us try to understand ohm's law through the example shown in Figure 1.8.

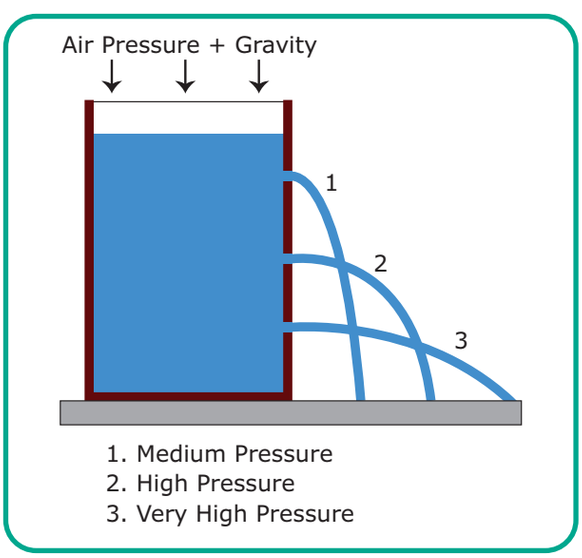

Figure 1.8 Demonstration of Ohm's law

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Take a plastic bottle and make three equal sizes of holes viz. (i) Top (ii) centre and (iii) bottom and fill up the bottle with water.

What will happen?

There are air pressure and gravitational force always around us. Due to this, water in that bottle is under pressure.

1. From top hole, water flows with a low speed. Because, only air pressure and gravity act on it.
2. Water from the *middle hole* flows with increasing speed than in the top hole, because pressure increases due to water in the top portion of the bottle along with air and gravity.
3. Water from the *bottom hole* flows with high speed than in the first and middle, because pressure increases due to water in the top and middle parts along with air and gravity.

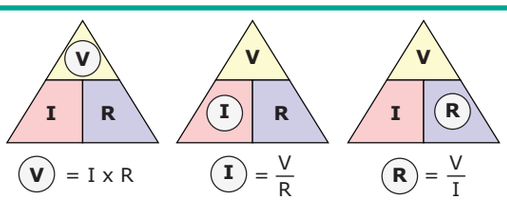
Likewise, in a circuit, if the supply voltage increases, the electric current increases. If the supply voltage decreases, current also decreases (Resistance value should be constant in both condition)

$$I \propto V$$

Therefore, the current in a circuit can be represented as,

$$I \alpha \frac{V}{R}$$

The other forms of Ohm's law are given below:



Theoretical Verification of Ohm's Law

Example 1: Let V=100 V, R=10Ω,Find the value of I. Assume that the resistance value is kept constant.

$$I = \frac{V}{R} = \frac{100}{10} = 10\,A$$

1.4.1 Power

The Electrical work done during a specific time interval is known as power.

$$Power\,(P) = \frac{Work\ done}{Time} = \frac{W}{T}$$

$$P = \frac{V \times I \times t}{t}$$

$$P = V \times I \quad or\ Power = Voltage \times Current$$

Power (P) is measured using the unit called watt. To represent high power values, kilo-watt or mega-watt is used.

1 kilowatt = 1000 watt
i.e. 1 kw = 1000 watt
1 Mw = 10,00,000 watt

To find and measure the power, the following formula is used

$$P = V \times I \quad \ldots\ldots\ldots\ldots\ldots\ 1$$

According to ohm's law, $(V = I\,R)$. Substitute this in the equation..1

$$P = I \times R \times I = I^2 R \quad \ldots\ldots\ldots\ldots\ldots 2$$

And also substitute $I = \frac{V}{R}$ in equation 1,

we get $P = V \times \frac{V}{R} = \frac{V^2}{R}$

Therefore, power can be calculated by following three formulae.

1. $P = V \times I$
2. $P = I^2R$
3. $P = \frac{V^2}{R}$

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Example 1: Let V = 10 V,
I=2 A, find the value of P.

$$P = V \times I = 10 \times 2 = 20 \ watt$$

1.4.2 Electromotive Force (E.M.F)

The force exerted by the density of the electrons in a point is referred as Electromotive Force (E.M.F). Also, it is the voltage developed by any source of electrical energy such as battery or dynamo. Its unit is Volt.

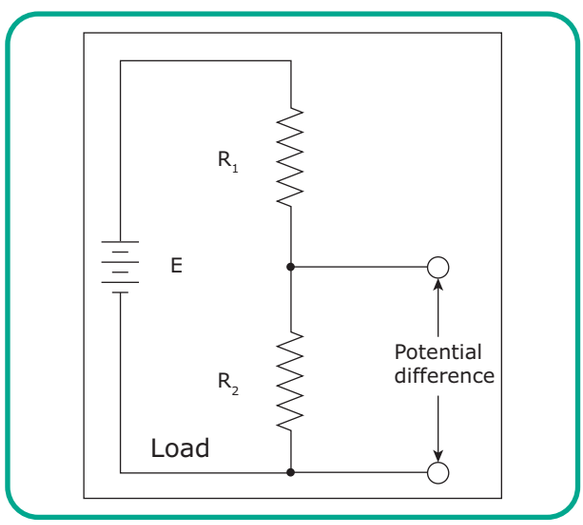

Figure 1.9 Potential difference across the load

1.4.3 Potential Difference

It is the voltage across any two terminals of a load in a circuit as shown in Figure 1.9. It is measured in Volt.

1.4.4 Electrical Load

If electrical energy is supplied to an electrical appliance, it starts operating using that energy. For example, an electrical fan supplied with electrical energy starts rotating and gives air circulation. In this phenomenon, fan is a load, consuming the electrical energy. Similarly, electric lamp offers light using electrical energy. Here, lamp acts as a load by consuming the electrical energy. From this we come to know that

An object that consumes electrical energy is called electrical load. e.g., electrical lamp, fan, mixie, radio, television, etc.

1.4.5 Electrical Circuit

If two terminals of an electrical supply is connected to a load, which enable to pass current through the electrical devices is called electrical circuit as shown in Figure 1.10.

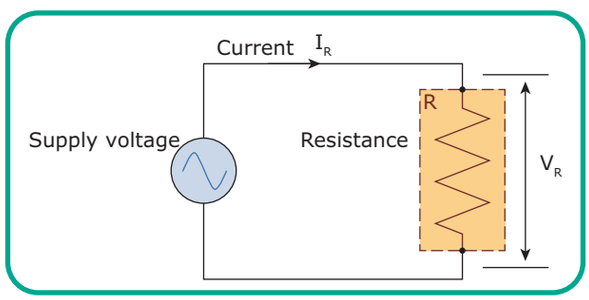

Figure 1.10 Electrical circuit

1.4.6 Symbols

One cannot draw the actual appearance of electrical connections and loads. Hence, simplified symbols are allotted to electrical connections, loads, appliances and devices. For example, few symbols are given in Figure 1.11.

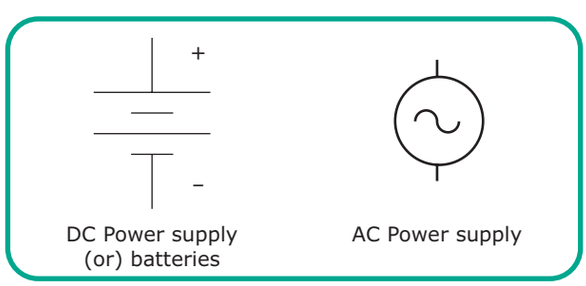

Figure 1.11 Electrical symbols

1.4.7 Circuit Diagram -Closed Circuit

A method of drawing electrical connections with simplified symbols is called circuit diagram. Figure 1.12 shows a sample electrical circuit and Closed Circuit.

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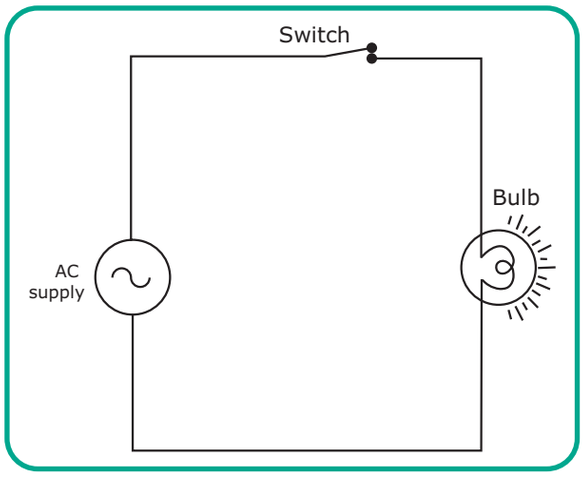

Figure 1.12 Example of a circuit diagram

A circuit connected in such a way to allow current flow through one or more loads with respect to the electrical supply. In a closed circuit, current will flow in the circuit.

1.4.8 Open Circuit

In a circuit, if there is no current flow due to disconnection of wire or switched-off condition, then the circuit is said to be open circuit. In an open circuit, no current flow in the circuit. Figure 1.13 shows a sample open circuit.

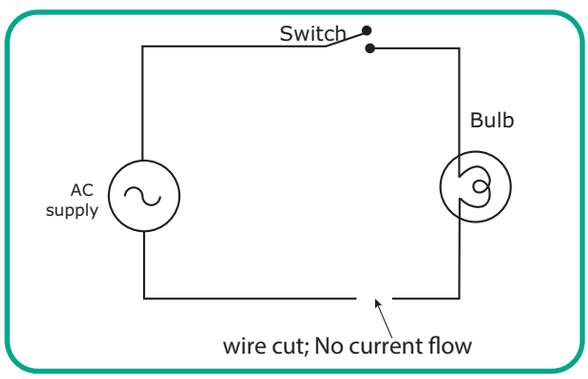

Figure 1.13 Open circuit

1.4.9 Short Circuit

In a circuit, if the two terminals of a supply are connected directly without load, then the circuit is said to be short circuit. Figure 1.14 shows a circuit in a short circuit condition.

In this circuit, the flow of current is infinite $I = \frac{V}{0} = \infty A$. When short-circuit occurs, enormous amount of heat will be produced and heavy spark will occur. This will cause electrical fire accidents. Hence, it is very dangerous. To avoid this, fuse wire, main circuit breakers (MCB) and Earth leakage circuit breakers (ELCB) are used in electrical circuits.

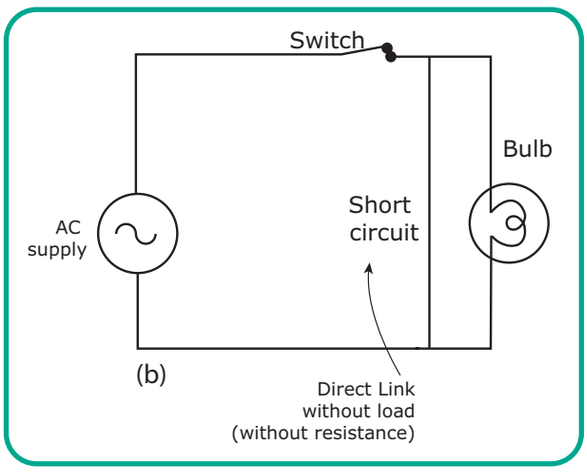

Figure 1.14 Short circuit

1.4.10 Fuse Wire

To avoid fire accidents due to short circuit, thin tin coated copper wires with low melting point is used in series with the circuit. If short-circuit or overload occurs, heat increases in the wires and fuse wire is blown within a second. So, the short-circuit becomes open-circuit, no further current flow and thus avoids fire accident. Figure 1.15 shows the fuse wire connected in an electrical circuit.

Fuse wires are available in amperes such as 1A, 2A, 5A and 10A in the market. Presently, fuse wires are substituted with mains circuit breaker and Earth leakage circuit breaker (ELCB).

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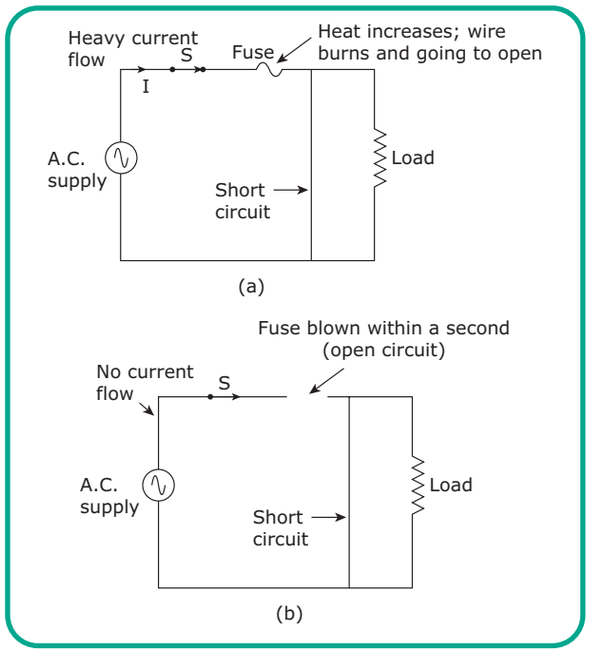

Figure 1.15 Circuit using fuse wire

1.4.11 Series Circuit

A circuit which has current flow in only one path through more than one load connected in serial manner (one after another load) with a power supply is said to be series circuit. Figure 1.16 shows a series circuit.

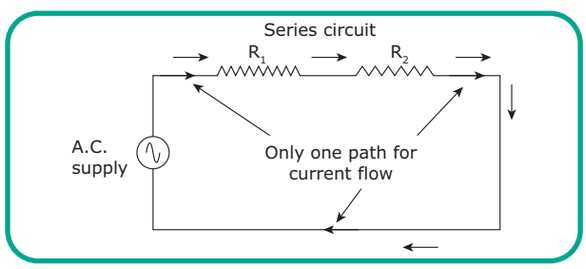

Figure 1.16 Series circuit

1.4.12 Parallel Circuit

A circuit, in which all the loads connected, have individual path for current flow, then it is said to be parallel circuit. Figure 1.17 shows the parallel circuit.

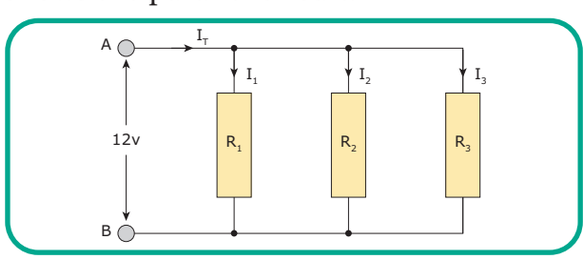

Figure 1.17 Parallel circuit

1.5 RESISTORS IN SERIES CIRCUIT

Figure 1.18 shows three resistors R_1, R_2 and R_3 connected in series. When the voltage (V) is applied to the circuit, the current flow through the circuit and the following important points are to be noted.

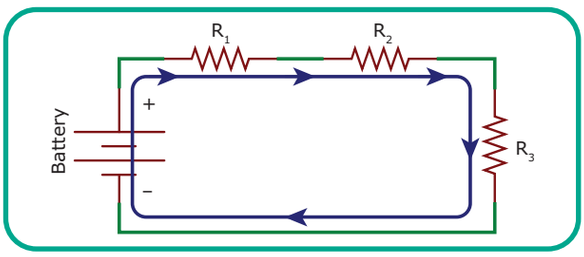

Figure 1.18 Resistors in series

1. The current I is equal in all the resistors.
2. The voltage drop across each resistor depends upon their resistance value i.e.,

$$V_1 = I.\ R_1$$
$$V_2 = I.\ R_2$$
$$V_3 = I.\ R_3$$

3. The EMF applied to the circuit is equal to the sum of the voltage drops across all resistors (Kirchhoff's voltage law).
Hence $V = V_1 + V_2 + V_3$
We can derive formula for Total resistance of a series circuit from the above equation.

As per ohm's law $V = IR_1 + IR_2 + IR_3$

$V = I(R_1 + R_2 + R_3)$

$$\frac{V}{I} = R_1 + R_2 + R_3$$

$$R = R_1 + R_2 + R_3$$

$$R = \frac{V}{I}$$

Where R is the total resistance of the series circuit

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That is total resistance R is the sum of individual resistors present in the series circuit.

4. The current flows in the individual resistors will be $I = \frac{V}{R}$
5. The current cannot flow through the circuit, if there is any disconnection in any one point of the circuit.

Uses of Series Connection

1. Series connection is used in serial sets as decorative lamps which are used in festivals and functions.
2. It is used to find out the defect in electrical appliances such as tube light, mixie, electric stove and fans.

1.6 RESISTORS IN PARALLEL CIRCUIT

When two resistors are connected one after the other as shown in the Figure 1.19 (the first ends and last ends are connected separately), the number of current flowing paths (two) is equal to the number of resistors present in the circuit.

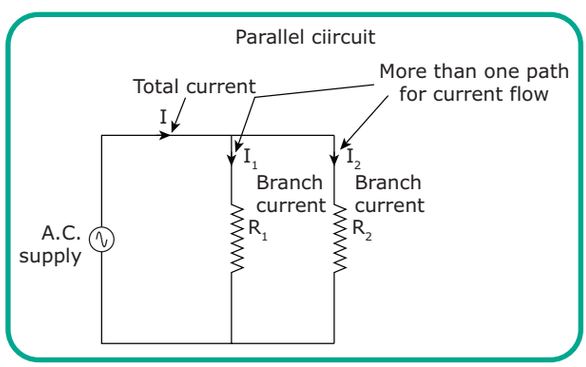

Figure 1.19 Resistor in Parallel

Figure 1.21 shows R_1 and R_2 are connected in parallel. When the voltage 'V' is applied in between the ends of the circuit, the following points are to be noted.

1. The potential difference across all the resistors is equal to the EMF applied.
2. The current flows through resistors will differ according to the value of the resistor.

   The current flows through resistor R_1 is referred as I_1, whereas the current flows through resistorR_2, is referred as I_2.

$$I_1 = \frac{V}{R_1} \qquad I_2 = \frac{V}{R_2}$$

3. Hence, the sum of the currents flows through the individual resistor is equal to the flow of total current in the circuit. Using this, we can derive the formula for the total resistance *(R)*.

$$I = I_1 + I_2$$

As per ohm's law, $\frac{V}{R} = \frac{V}{R_1} + \frac{V}{R_2}$

$$\frac{V}{R} = V\left(\frac{1}{R_1} + \frac{1}{R_2}\right)$$

Cancelling 'V' on both sides,

$$\frac{1}{R} = \left(\frac{1}{R_1} + \frac{1}{R_2}\right)$$

Again simplifying the above formula by taking LCM,

$$\frac{1}{R} = \left(\frac{R_2 + R_1}{R_1 R_2}\right)$$

Cross multiplying: $R(R_1 + R_2) = R_1 \cdot R_2$

$$R_T = \frac{R_1 R_2}{R_1 + R_2}$$

4. There will be current flow in other paths, even if any of the paths is disconnected. It is shown in Figure 1.20

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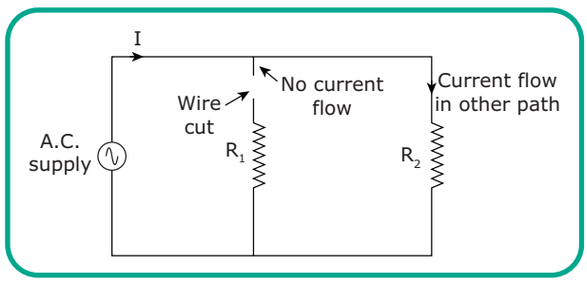

Figure 1.20 Resistor in Parallel - Open circuit

5. The current in this circuit takes two or more branch paths from main path. The current takes branch path (i.e. flows through each resistor) is called branch current.

Uses of Parallel Connection

At homes and industries, this type of connection is used.

1.7 CLASSIFICATIONS OF RESISTOR

Resistors are broadly classified into two categories.

1. Fixed Resistor
2. Variable Resistor

1.7.1 Fixed Resistor

The value of fixed type resistors cannot be changed. Hence, these resistors are called as fixed resistors as shown in Figure 1.21. Its symbol is also shown in Figure 1.21.

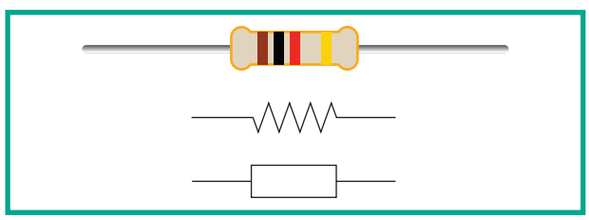

Figure 1.21 Symbols of fixed resistor

The classification of resistors depends upon their materials and fabrication methods used.

1. Carbon resistors
2. Wire wound resistors
3. Metal oxide resistors
4. Metal film resistors
5. Printed resistors
6. SMD (Surface Mount Device) resistor.

In modern circuits, Printed resistors and SMD type resistors are used.

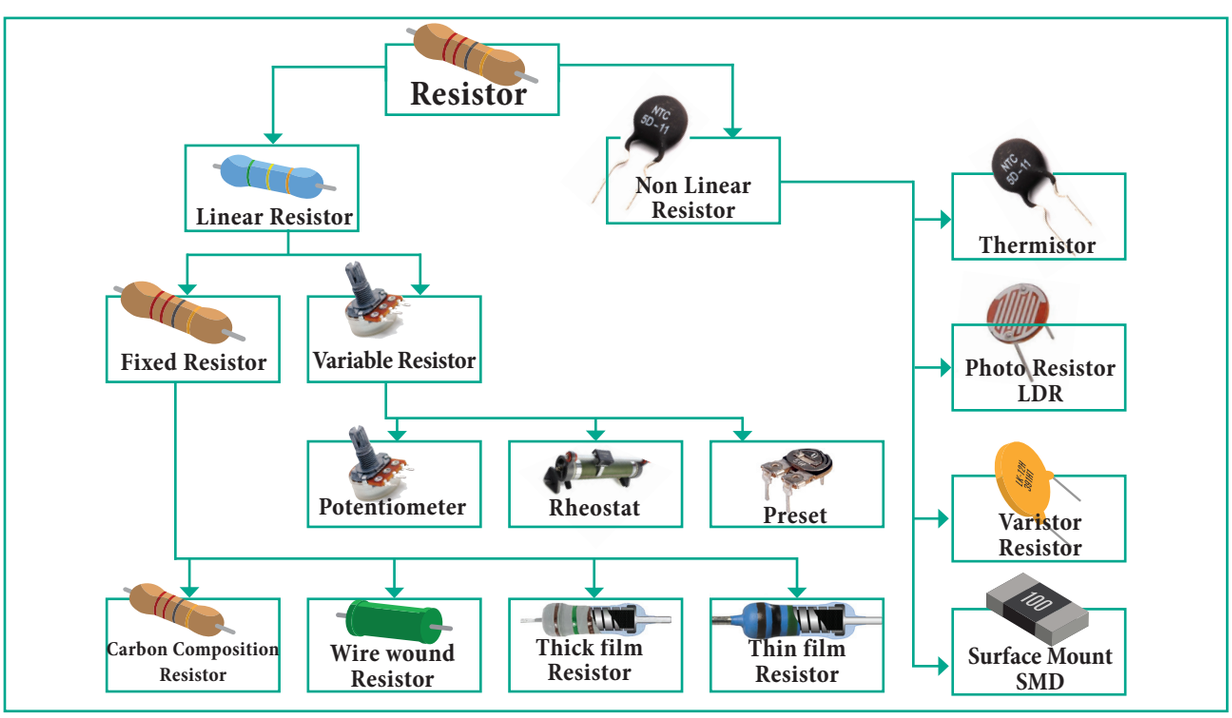

Figure 1.22 Fixed Resistor - Various types

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Special Type of Resistors

7. Positive Temperature Coefficient Resistor (PTC)
8. Negative Temperature Coefficient Resistor (NTC)

1.7.2 Carbon Resistor

It is made up of carbon paste and burnt clay with connecting leads, which is heated and kept under high pressure. The resistor is formed as small sticks. It can handle small amount of current through it. If high current flows through this type of resistor, it will burn. Figure 1.23 shows the internal construction of a carbon resistor.

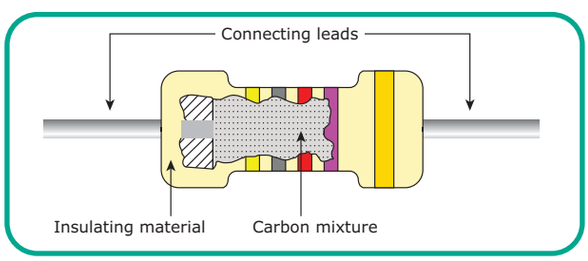

Figure 1.23 Carbon resistor

Uses

1. It is widely used in low current flowing circuits like Radio, DVD players and Television etc.

1.7.3 Wire Wound Resistors

Figure 1.24 shows the cut away view of a wire wound resistor. Particular length of Nichrome is wound on a small Porcelain cylinder. The two terminals of the nichrome are connected to the copper legs. The surface is given a protective coating with glass and enamel. These types of resistors are manufactured with high precision.

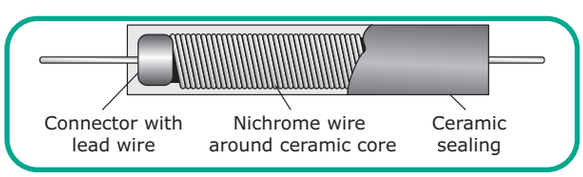

Figure 1.24 Wire wound resistor

Uses

1. Regulated power supplies in television, inverters etc.
2. Also used in Public Address system amplifiers.

1.7.4 SMD Resistors

SMD stands for Surface Mounted Device. This type of resistor is directly soldered on copper solder points in the surface of the board and therefore they are called SMD resistors. They are smaller in size than their traditional carbon resistors. They are square, rectangular or oval in shape. The SMD resistor is shown in Figure 1.25 (a) and (b).

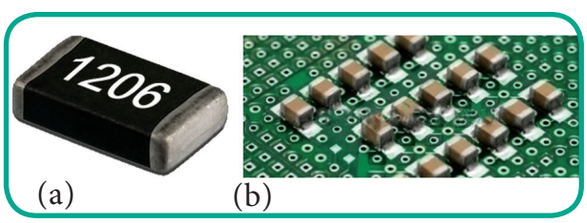

Figure 1.25 SMD resistors

Advantages

1. This type of resistor has small leads or points that are soldered on copper solder points in the surface of the board. This eliminates the need for holes in the PCB and we can utilize both sides of the PCB.
2. Once the PCB is manufactured, SMDs can be placed on it using a special machine called a pick and place machine.

Disadvantages

1. Replacement of faulty resistors is complicated.

1.7.5 Variable Resistor

The resistor which value can be changed is called as variable resistor.

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Its symbol is shown in Figure 1.26

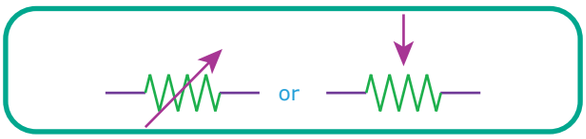

Figure 1.26 Symbol of variable resistor

Variable resistors are also called as potentiometers. In this, base is like a washer type with carbon coating. There is a rotary setup having slip-ring to the resistor and have three electrical contacts as shown in Figure 1.27. Between the first terminal T_1 and last terminal T_3, the value of resistance is fixed, i.e., cannot be altered. But centre terminal T_2 is a variable terminal with respect to T_1 and T_3.You can check this using a multimeter. A plastic or metal shaft attached to T_2 is used to change the value of the resistance.

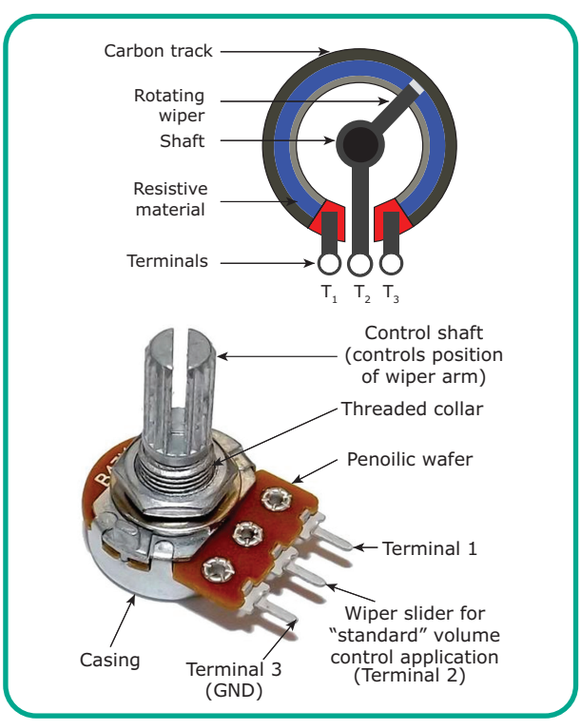

Figure 1.27 Variable resistor

Uses

1. Used as volume control in television and radio sets.
2. Used as a variable control in amplifiers as bass and treble controls.

1.7.6 Special Type Resistors

Now, we are going to study about special type resistors. They have special characteristics.

They are:

1. Positive Resistors (PTC)
2. Negative Resistors (NTC)

1.7.7 Positive Temperature Coefficient Resistor (PTC)

If the temperature of this resistor increases, its resistance value increases. Hence, the resistor is known as Positive Temperature Coefficient (PTC) resistor. It is also called as Posistor and is shown in Figure 1.28. It is used in automatic degaussing circuit in CRT type televisions.

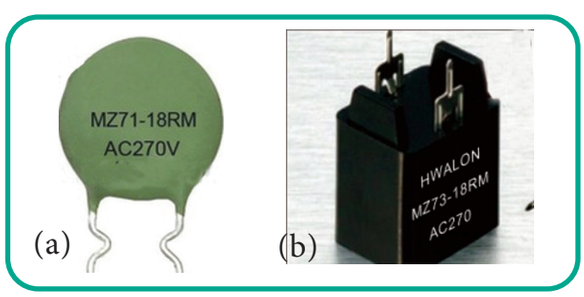

Figure 1.28 Posistors

1.7.8 Negative Temperature Coefficient resistor (NTC)

If the temperature of this resistor increases, its resistance value decreases. Hence it is known as Negative Temperature Coefficient (NTC) resistor. It is also called as Thermistor. To avoid the surge current while switching on a power supply, the NTC type of resistors are used. It is shown in Figure 1.29.

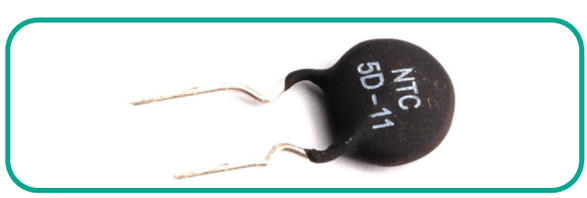

Figure 1.29 Thermistor

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1.8 COLOUR CODING OF RESISTOR

Printing values in small resistors cannot be viewed clearly. So, in small rating resistors, colour is coated on the body of resistors in circular shape. Each colour is allotted a number. This is called as colour coding.



Figure 1.30 Color coding in a resistor

The first colour denotes the value of first digit, second colour denotes the value of second digit and the third colour (called as multiplier) denotes the number of zeros followed by the two digit. The fourth colour denotes tolerance level. If it is gold, the tolerance value of the resistor is 5% and if it is silver the tolerance is 10% of the value. Figure 1.30 shows the resistor with colour code. Table 1.1 shows the colour coding of the resistor.

1.8.1 Tolerance

It is impossible to manufacture resistors to the exact values. For example, if we want to manufacture a resistor to the value of 100 ohms, after the production, the value may be a bit higher or lower. This is due to unavoidable manufacturing process. Hence, there is some lenience in production of resistors. It is referred as tolerance. Fourth colour code is the tolerance code. If it is gold, tolerance is 5%. If it is silver, tolerance is 10%.

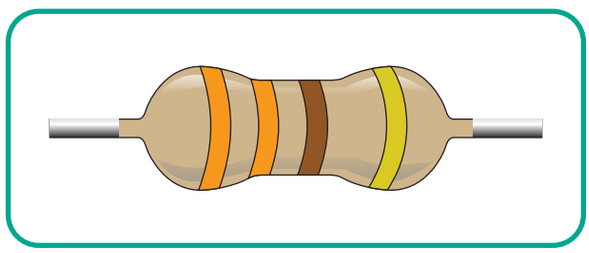
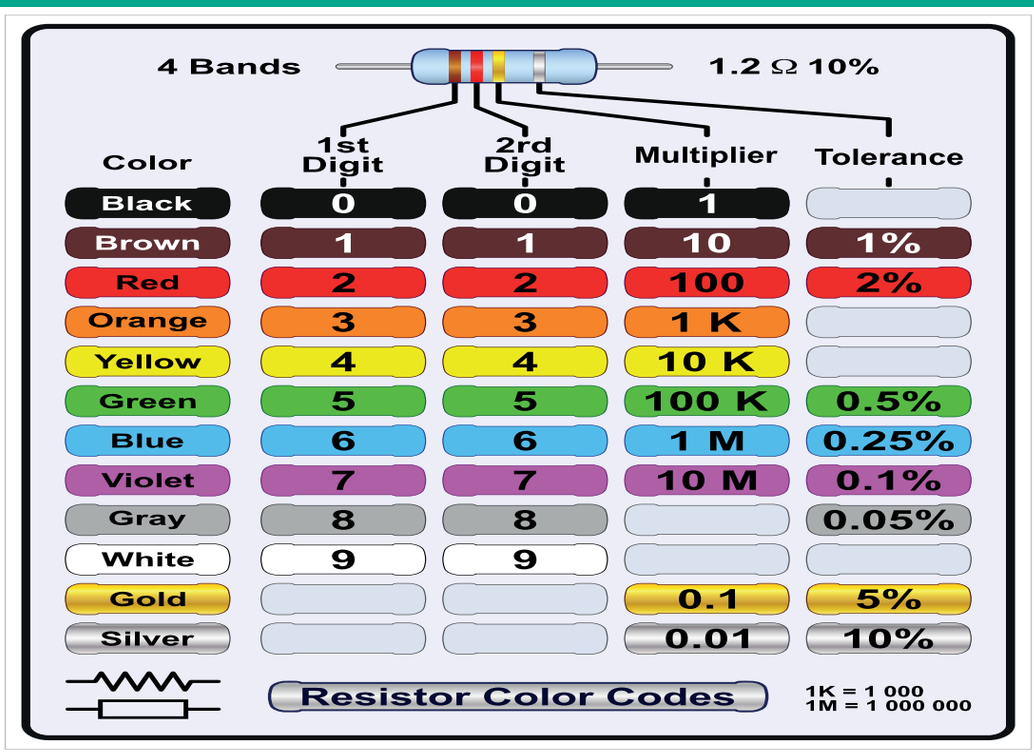


Figure 1.31 Tolerance code – 4th colour from left

Table 1.1 shows the colour coding of the resistor



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Finding the values of resistors using colour codes

Example 1: Brown Black Brown



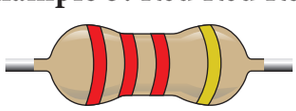
0 1 × 10^1
10 ×10
100 Ω

Example 2: Brown Red Black



2 1 × 10^0
12 × 1
12 Ω

Example 3: Red Red Red



2 2 ×10^2
2200Ω
2.2kΩ

Example 4: Brown Black Green



10 × 10^5
10,00,000Ω
= 1 MΩ

Figure 1.32 Finding the values of the resistors using colour coding

1.9 KIRCHHOFF'S LAWS

It is used to find out the current flow in the network circuits easily where it is not easy to find values using ohm's law. It is applicable for both DC and AC circuits. There are two types of law viz.

1. Current law
2. Voltage law

1.9.1 Current law

The sum of the currents flowing towards a junction is equal to the sum of the currents flowing away from it. This is called Kirchhoff's Current Law.

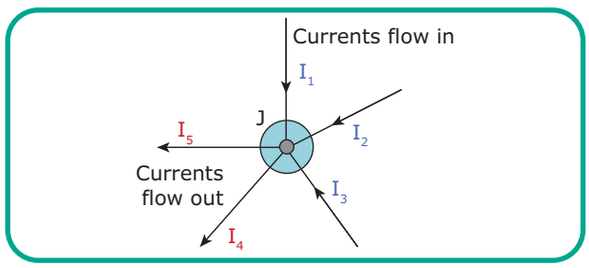


Figure 1.33 Kirchhoff's current law

In the Figure 1.33, J is the junction (or node) formed by five conductors. The current in these conductors are I_1, I_2, I_3, I_4 and I_5. Here, I_1, I_2 *and* I_3 flow towards the junction and I_4 *and* I_5 flow away from the junction. According to Kirchhoff's Current Law,

$$I_1 + I_2 + I_3 = I_4 + I_5$$

i.e. currents flow towards junction = currents flow away from junction.

On the other hand, $I_1 + I_2 + I_3 - I_4 - I_5 = 0$. This is known as Kirchhoff's current law equation.

1.9.2 Voltage law

At any closed circuit, the sum of potential drops across each resistor in a series circuit is equal to the supply voltage given to the circuit. The circuit representing the voltage law is shown in Figure 1.34.

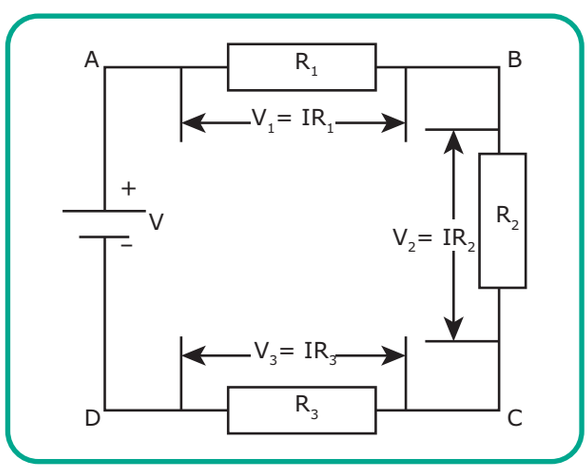


Figure 1.34 Kirchhoff's voltage law

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In a closed circuit, the sum of the voltage drops is equal to the sum of the potential applied. This is called Kirchhoff's voltage law (shortly KVL)

i.e., $V = IR_1 + IR_2 + IR_3$

As per ohm's law

$V = V_1 + V_2 + V_3$

1.10 CAPACITOR

A component which stores electrical energy and discharges when needed is called capacitor.

The unit for measuring capacitance is Farad (FD), which is used to measure higher values.

Other smaller value capacitors are measured using micro-Farad (μF) shortly μF, pico-Farad (pF), and nano-Farad (nF).

The ability to store electrical energy is called as capacitance. Figure 1.35 shows the internal construction of a capacitor. The capacity to store electrical energy is termed as capacitance and the electric device to store it is termed as Capacitor. Like resistors, capacitors are also manufactured with admissible tolerance of 5% - 20%.

1.10.1 Construction

Figure 1.35 shows the parts of the capacitor. In this, an insulator placed between two parallel conducting plates is termed as a dielectric medium. The two parallel plates are termed as electrodes. Based on the insulator used in the capacitors, they are named as paper, ceramic, mica, and polyester capacitors.

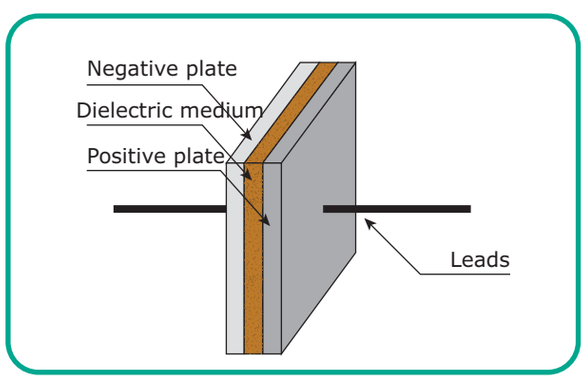

Figure 1.35 Parts of a capacitor

1.10.2 Working of a capacitor

Figure 1.36 shows a capacitor connected in an electrical circuit.

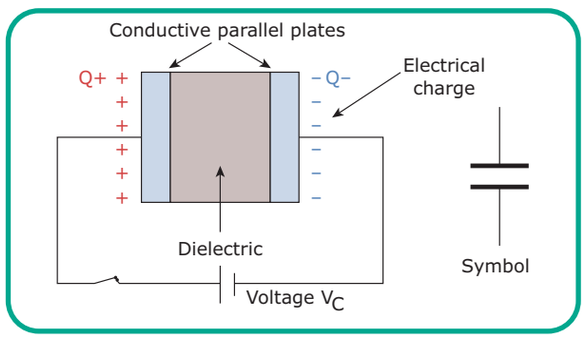

Figure 1.36 Capacitor connected in a circuit.

Charging

When switch S is on, current flows through the capacitor. Due to this, the plate A of the capacitor gets Positive charge and plate B gets Negative charge. Thus, electric field forms across the plates. After complete charging , the current flow will stop. The amount of charge between the plates depends upon the dielectric material and also the distance between the electrodes. The charging limit depends upon the E.M.F. of the battery.

Discharging

If a load is connected to that charged capacitor after removing from the circuit, the electrical energy will discharge. This is known as discharging of capacitor.

1.10.3 Dielectric strength

The maximum point at which the dielectric field withstands the potential difference, without damage is known as di-electric strength.

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1.10.4 Functions of a Capacitor

1. It stores electrical energy particularly DC when connected in parallel.
2. It blocks DC supply when connected in series with DC.
3. It couples AC to the next circuit and blocks DC to that next circuit.
4. It discharges while connected to a load.
5. It bypasses unwanted signals to earth.
6. It filters ripples in the pulsating dc to get pure dc while connected in parallel.
7. It decouples the unwanted signals.
8. It helps in producing signals of various frequencies in oscillator circuits.
9. Presently, very high value ultra capacitors are used in place of batteries for quick charging.
10. Now a days, capacitive type touch screens are widely used.

1.10.5 Capacitance

The capacitance (C) is derived from the ratio between charge (Q - Coulomb) and the potential difference between the two plates(V).

$$C = \frac{Q}{V}$$

$$\text{Capacitance (C)} = \frac{\text{Charge (Q)}}{\text{Voltage (V)}}$$

(C in farad, Q in coulombs, V in volts.)

1.10.6 Classification of Capacitors

These are two main classifications

1. Fixed capacitor
2. Variable capacitor

Fixed capacitor

In fixed capacitor, capacitance value cannot be changed.

Its symbol is shown in Figure 1.37.



Figure 1.37 Symbol of Capacitor

Types of fixed Capacitors

1. Paper capacitor
2. Mica capacitor
3. Polyester capacitor
4. Ceramic capacitor
5. Electrolytic capacitor (polarized and non-polarized)
6. Bipolar Electrolytic Capacitor
7. Tantalum capacitors (metal film capacitors)
8. SMD capacitor
9. Ultra capacitor (or) super capacitor

Ceramic capacitor

Figure 1.38 shows the Ceramic capacitor.

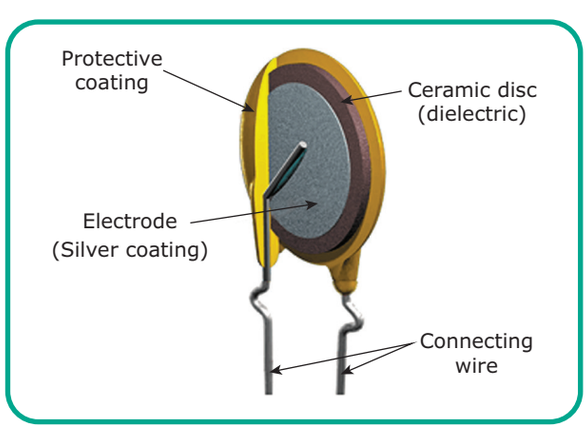

Figure 1.38 Ceramic Capacitor

In this, ceramic is used as dielectric medium. Silver coating is made on both sides of the ceramic. It is also called as Disc Capacitor, because it looks like a small disc.

Available capacitor values are from 100 pF to low value μF. Voltage rating from 16V to 200V.

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Uses

1. Blocking.
2. Coupling.
3. Decoupling.
4. High frequency filtering.

Identifying the values



Figure 1.39 Ceramic capacitor values

Figure 1.39 shows the values of capacitors as 102 and 103.

102 means 10 X 10^2= 1000pF

= 1kilo pico Farad = 1kpF

103 means 10×10^3=10,000pF

= 10 kilo pico Farad = 10kpF

Electrolytic capacitor

Figure 1.40 shows the electrolytic capacitor. In this, aluminium oxide is used as dielectric medium. Pure aluminium foils are used as anode (+). Aluminium paste is coated in the dielectric and it is used as cathode (-).

Precautions

Since it has polarities (+ and -), it has to be connected with DC supply only with correct polarities. Only Negative polarity is printed in the capacitor. The other terminal is taken as Positive terminal. Care must be taken while connecting an electrolytic capacitor in a circuit, i.e., Positive terminal should be connected with Positive terminal of DC and – terminal of capacitor should be connected with –Ve terminal of DC supply.

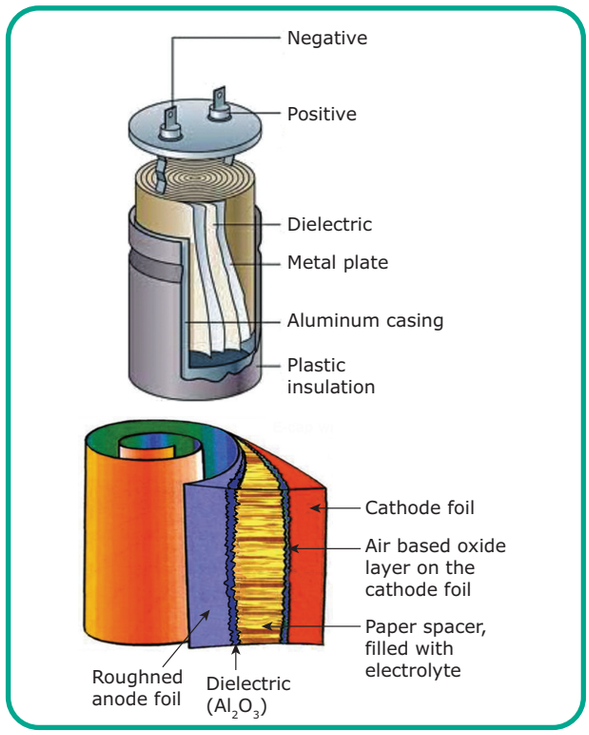

Figure 1.40 Electrolytic capacitor

Available capacitor values are from 0.47µF to 4700µF and voltage rating from 3V to 500V.

Uses

1. Filtering
2. Used in inverters
3. Used for photo flash

SMD Capacitor

It is directly soldered on the copper solder points of the surface of the PCB and is called as SMD capacitor. It is shown in figure 1.41



Figure 1.41 SMD capacitor

Ultra Capacitor

It is a type of capacitor which has higher capacitance value in farad with low

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voltage rating. It is an electric double layer capacitor. It is also called as super capacitors. It uses carbon as electrodes.

They can store 10 to 100 times more electrical energy than electrolytic capacitors.They can accept and deliver charge much faster than batteries, and long lasting many more charge and discharge cycles than rechargeable batteries.

Uses: It is used in DC operated cars, buses, trains, cranes and elevators and static RAM in computers.

Working Voltage

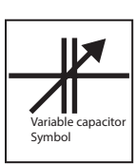
In the Figure 1.42, the voltage mentioned in the capacitor is the maximum voltage to be applied to a capacitor. But it should be connected to two-third of the voltage of the maximum voltage.

In the Figure 1.42, 1,000 micro farad / 25volts is mentioned in the capacitor. 25 V is the maximum voltage to be applied. Two third of 25 V, that is 16 V should be normally applied to this capacitor.



Figure 1.42 Working voltage

Variable Capacitor



In variable capacitor, the capacitance value can be changed within a particular limit.

In this section, different types of variable capacitors used in electronics circuit are discussed.

Ganged Capacitor

Two variable capacitors are arranged in a setup and can be varied through a common shaft is called Ganged capacitor.

It is of two types:

1. Metal gang
2. PVC gang

Metal Gang

Figure 1.43 shows a ganged capacitor.In this, there are two sets of plates and air acts as dielectric medium. One is static (stator) and another set is kept rotating (rotor). Rotor is connected to a shaft. When the shaft is rotated, metal plates mounted on the shaft, moves between fixed metal plates. This varies the value of the capacitance.

If rotor moves outward, the area between stator and rotor is less, capacitance also becomes low value. If rotor moves inside the stator, the area becomes large. Hence capacitance value also becomes high. The minimum capacitance is 49 pF and maximum is 500pF. It consists of two variable capacitors as shown in the Figure 1.43.

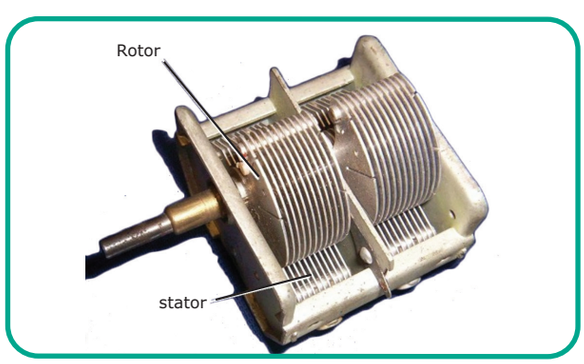


Figure 1.43 Ganged capacitor (Metal)

1.10.7 Capacitor in series

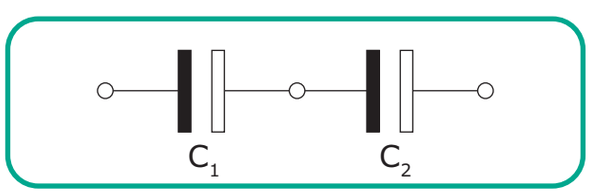


Figure 1.44 Capacitors in series

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Figure 1.44 shows the capacitors connected in series.

The total capacitance is $$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2}$$

$$C = \frac{C_1 C_2}{C_1 + C_2}$$

Problems

Find out the total capacitance, when two capacitors of values 10 μF, 15 μF are connected in series.

Total capacitance $$C = \frac{C_1 C_2}{C_1 + C_2}$$

$$C = \frac{10 \times 15}{25}$$

Total capacitance C = 6 μF

1.10.8 Capacitors in Parallel

Figure 1.45 shows a circuit in which the capacitors are connected in parallel.

The total capacitance is $C = C_1 + C_2$

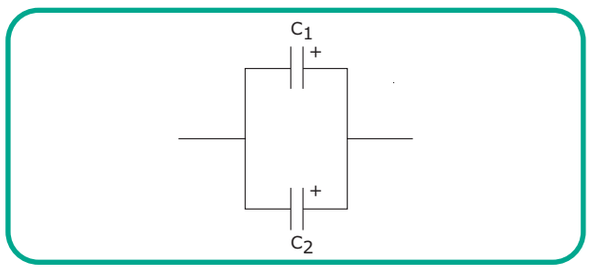

Figure 1.45 Capacitors in parallel

1.10.9 Action of a Capacitor in DC Circuit

Figure 1.46 shows a capacitor connected in a DC circuit.

When a capacitor is connected in DC circuit, the current flow will be high until it is charged fully.

When it is charged completely, the flow of current will be stopped and the voltage in the capacitor will be equal to the EMF in the battery. When a capacitor is connected in series with DC, it blocks the supply.

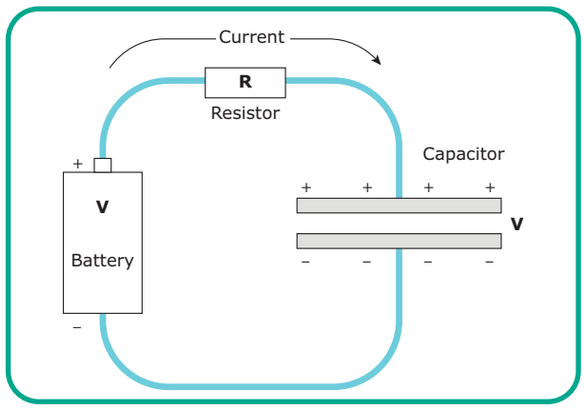

Figure 1.46 Action of a capacitor in DC circuit

1.10.10 Action of a Capacitor in AC Circuit

Figure 1.47 shows a capacitor connected in an AC circuit.

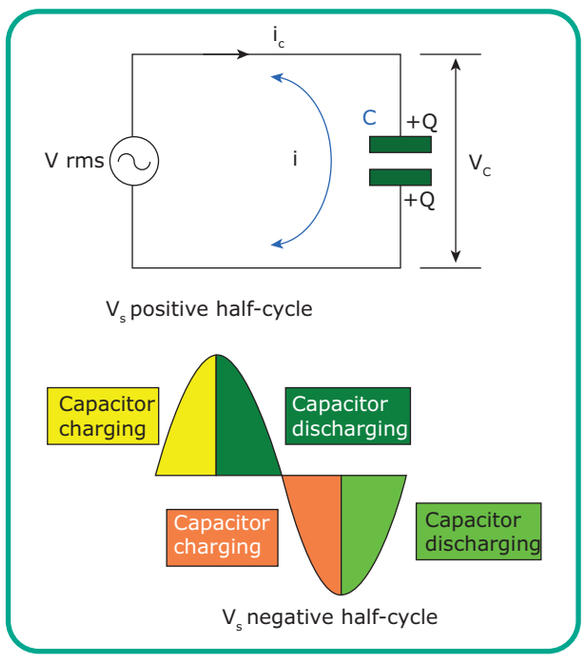

Figure 1.47 Action of capacitor in AC circuit

When a capacitor is used in AC circuit, it will be charged and gets discharged for every quarter cycle, since polarity is changed for every quarter cycle (i.e., 90°).

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LEARNING OUTCOMES

After studying this Chapter, a student can understand the following

1. **Basics of electricity**
2. **Electrical parameters**
3. **Ohm's law**
4. **Kirchhoff's law**
5. **Working of Resistor**
6. **Working of Capacitor**

GLOSSARY

S. No	Terms	Explanation
1	**Ampere**	The unit of electrical current
2	**Volt**	The unit of voltage (potential difference)
3	**Ohm**	The unit of resistance
4	**Hertz**	The unit of frequency
5	**Watt**	The unit of power which equals one joule per second
6	**Direct current**	Electric current flowing in one direction only
7	**Fuse**	A device that protects an electric circuit from excessive current
8	**Alternating current**	An electric current that reverses direction in a circuit at regular intervals

QUESTIONS

I. Choose the best answer from the given four options. 1 mark

1. The unit of current is
   a) Volt b) Ampere
   c) Ohms d) None of these

2. The power can be calculated by
   a) P = I - R b) P = V. I
   c) P = V/I d) P = V/R

3. Two resistors are connected in series, the total resistance value is calculated by
   a) $R = R_1 + R_2$ b) $R = R_1 / R_2$
   c) $R = R_1 \times R_2$ d) $R = R_1 + R_2/R_1$

4. If two resistors 150Ω and 150Ω are connected in parallel, the total resistance is
   a) 50 Ω b) 100 Ω
   c) 200 Ω d) 75 Ω

5. What is the colour coding of a resistor which resistance value is 10,00,000 Ω ?
   a) Brown Black Brown
   b) Brown Black yellow
   c) Brown Black Green
   d) Brown Black Gold

OYN85

6. The unit of wavelength is
   a) Micro Farad b) Ampere
   c) Ohm d) Meter

7. Which of the following is not true?
   a) Current increases while voltage increases
   b) Power increases while resistance increases
   c) Current decreases while voltage decreases
   d) Current increases while resistance decreases

8. The unit of capacitance is
   a) Ampere b) Ohms
   c) Farad d) Watt

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9. When two capacitors are connected in parallel, the total capacitance value is
   a) $C = C_1 + C_2 / C_1 + C_2$
   b) $C = C_1 + C_2$
   c) $C = C_1 + C_2 / C_1.C_2$
   d) $C = C_1 - C_2$

10. Write the odd one
   a) Ohm b) kilo ohm
   c) megawatt d) mega ohm

II. Answer in few sentences. (3 marks)

1. Define Ohm's law.
2. Define open-circuit and short-circuit.
3. Draw symbols for
   i) AC supply
   ii) DC supply
   iii) Resistor
4. What is meant by a resistor?
5. What is meant by tolerance in resistors?
6. If 100 Ohms and 150 Ohms are connected in parallel in a circuit , calculate the total resistance of the circuit.
7. If 15 Ohms and 10 Ohms are connected in series with 50Volts, Calculate the current flow in this circuit.
8. Write the expansion for i) NTC ii) PTC iii) PCB
9. Write short notes on i) SMD capacitor and ii) Ultra capacitor
10. What is meant by variable capacitor? Draw its symbol.

III. Explain in a paragraph. (5 marks)

1. Draw and explain about wire wound resistors.
2. Draw and explain about carbon resistors.
3. Draw and explain about electrolytic capacitors.

IV. Explain in about a Page. 10 marks.

1. Explain Resistor connected in series and resistor connected in parallel
2. Explain colour coding chart of resistor with two example
3. Explain about Kirchoffs laws
4. List out the functions of a capacitor.

Answers

1) **b** 2) **b** 3) **a** 4) **d** 5) **c**

6) **d** 7) **b** 8) **c** 9) **b** 10) **c**

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ELECTRICAL DEVICES

CHAPTER 2

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LEARNING OBJECTIVES

A student can understand the following in this Chapter

1. **Understand the basic working principles of electrical devices viz., cell, inductors, transformers, switches and fuses.**
2. **Understand the functions of microphone and loudspeaker.**

INTRODUCTION

In our day-today life, we are supposed to use many electrical appliances such as water pump, iron box, mixie, grinder, washing machine, UPS, TV etc. In order to understand the basic working principle of these appliances, it is better to know about some of the important electrical devices which are used in the appliances.

In this, we are going to read about

1. Cells
2. Inductors
3. Transformers
4. Switches and Fuses

2.1. CELLS

A device which converts chemical energy into electrical energy is called as a cell. A group of cells connected together is called battery.

In electric and electronic circuits, an electrical cell is denoted by the following symbol as shown in Figure 2.1.

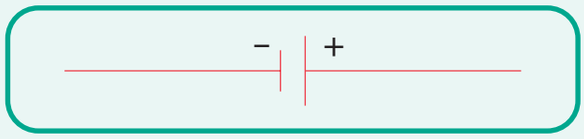

Figure 2.1 Symbol for Cell

When two dissimilar metals or electrodes are immersed in an electrolyte, there will be a potential difference produced between these metals or electrodes. In this, one electrode acts as positive terminal and another electrode acts as negative terminal.

2.1.1. Types of Cells

The cells are classified into two categories. They are,

1. Primary cells
2. Secondary cells

Primary Cells

Primary cells are widely used in clocks, watches, remote controls and calculators.

The cells that cannot be recharged are called as 'primary cells'. Some of the primary cells are Alkaline cell, Lithium cell, Zinc-Carbon cell and dry cell.

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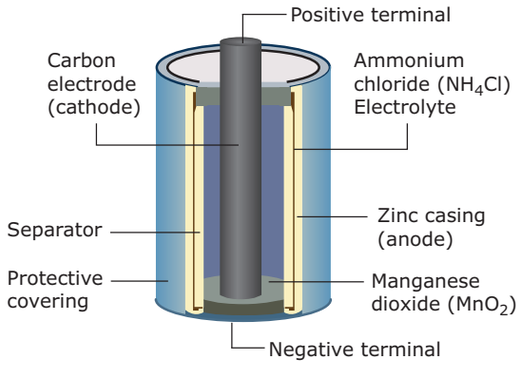

Figure 2.2 **Structure of Primary Cell**

Generally, primary cells (figure 2.2) are available in the voltage rating of 1.5 V, 3 V, 9 V and 12 V and the current rating of 0.2 A, 0.5 A, 1 A and 2 A. "AA" and "AAA" type of cells (1.5V) are used in clocks and remote controls. 1.5 V, 3 V button cells are used in watches and computers, respectively. 9 V cell is used in multimeter and cordless microphone.

Secondary Cells

The cells that can be recharged are called as 'secondary cells'. Some of the secondary cells are lead-acid cell, Lithium ion cell and Nickel Cadmium cell.

Lead-acid cell is widely used in two-wheel and four-wheel vehicles. Lithium ion cells are used in laptops and cell phones. Nickel cadmium cells are used in flash lights, emergency lights and toys.

2.2. INDUCTOR OR COIL

Inductor is the passive component used in electronic circuits. It stores energy in the form of magnetic field and delivers it as and when required. An inductor is usually a coil of copper wire wound around a core of ferromagnetic material. Figure 2.3 shows an inductor or coil.

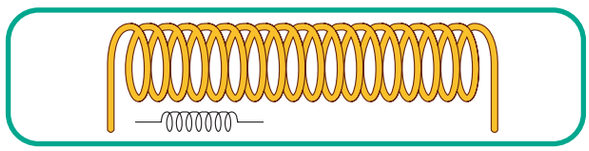

Figure 2.3 **Inductors**

2.2.1 Inductance

Whenever current passes through a coil, magnetic flux is generated around it. This magnetic flux opposes any change in current due to the induced EMF. The opposition to the change in current is known as inductance. The unit of inductance is Henry.

2.2.2 EMF (Electro Magnetic Force)

Electro Magnetic Force is a force that acts between the charged particles and a combination of electrical and magnetic forces. It can be in attractive or repulsive. Fig 2.4 shows an EMF

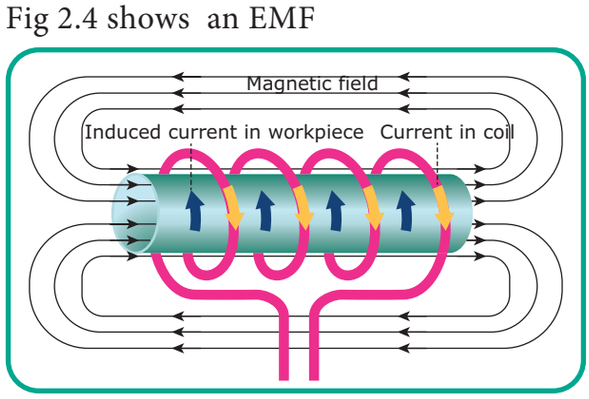

Figure 2.4 **Electro Magnetic Force**

2.2.3 Types of Inductor

Inductor can be divided in two categories.

1. Fixed inductors
2. Variable inductors

Fixed Inductor

The symbol of fixed inductor is shown in Figure 2.5 and can be further divided into three categories depending upon the type of core.

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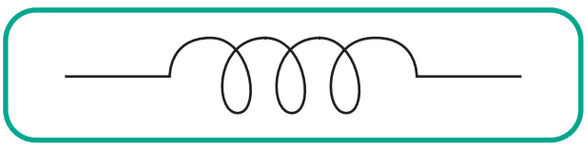

Figure 2.5 Fixed Inductor

They are,

1. Air Core Inductors
2. Iron Core Inductors
3. Ferrite Core Inductors

Variable inductors

In certain application such as tuned circuits, it is required to vary the inductance from minimum value to a maximum value. Ferrite core variable inductors are generally used for this purpose. The variable inductors are shown in Figure 2.6.

2.2.4 Relay

A relay is an electrically operated switch and is shown in Figure 2.7. The current flowing through the coil of a relay creates a magnetic field which attracts the lever and changes the switch contacts. Relay is used in applications to turn ON and OFF a circuit by a low power signal.

Uses: Relays are used in stabilizers, UPS (Uninterrupted power supply) and three phase change over switches.

2.2.5 Action of Coils in AC and DC Circuits

AC Circuits

Since the phase is alternatively changed in AC circuits, the back EMF continuously

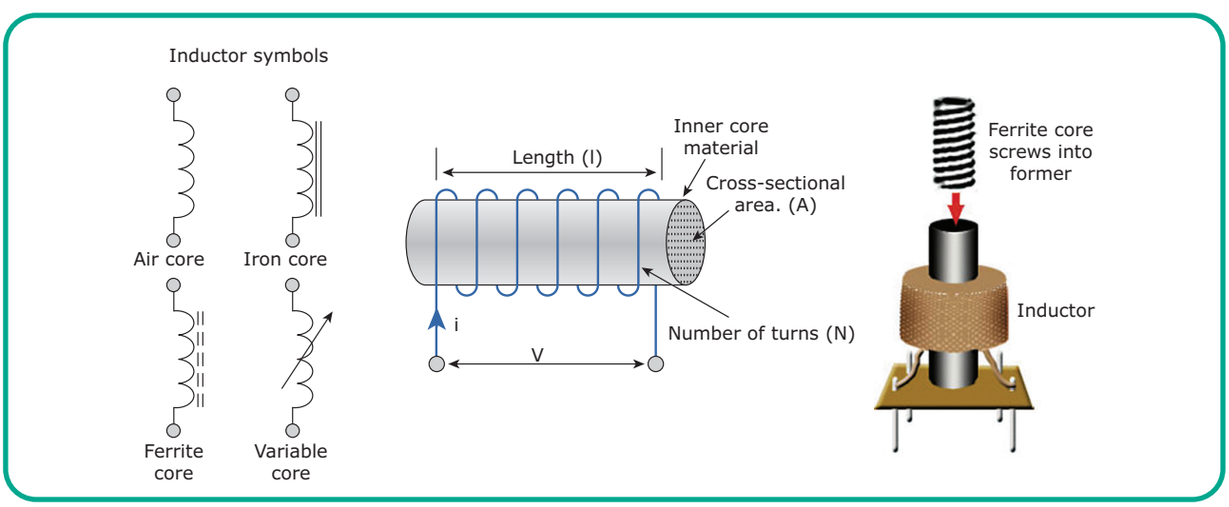

Figure 2.6 Variable Inductors

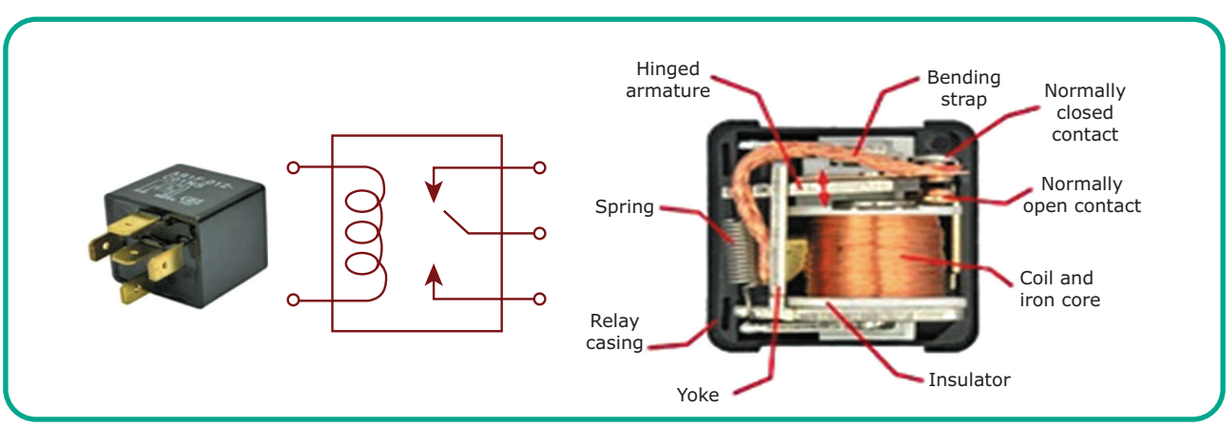

Figure 2.7 Relay

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presents in the coil. This back EMF depends upon the frequency and the core of the coil. Hence, the coils in AC circuits have resistance carried by back EMF along with normal resistance. These two resistances combined together is known as inductive reactance.

$$\text{Inductive Reactance } X_L = 2\pi fL$$

where $\pi = 3.14$, f is the frequency of AC and L is the inductance. In AC circuits, the current flows in the coil lag 90˚ with reference to the voltage.

DC Circuits

When the switch is ON, the back EMF generated opposes the flow of current. The back EMF will get vanished when constant magnetic field is produced, i.e. the back EMF persists only to the fraction of switching on the circuit. When the circuit is switched ON, automatically the back EMF becomes zero. In DC circuits, coils would have only normal resistance. Hence, it may not be taken into consideration.

2.3. TRANSFORMERS

A device which has two or more coils wound on a core is termed as transformer. The electrical energy is transformed from one coil to other through mutual inductance in it.

The symbol of a Transformer is shown in Figure 2.18

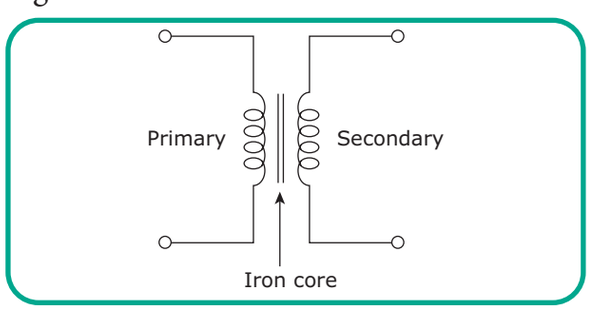

Figure 2.8 Symbol of a Transformer

History

In 1880s, the first commercially-used transformer was built by William Stanley, working under George Westinghouse that was wound to form a core of E-shaped plates in step-up and step-down variations.

2.3.1 Principle of Transformer Construction

Transformer is a static device which contains one primary and one or more secondary coils. The primary and secondary coil have high mutual induction The transformer works on the principle of Faradays Laws of electromagnetic induction and mutual induction. The electrical energy in primary coil produces a magnetic field (flux).This magnetic field strength induces an EMF in the secondary coil. Normally, this happen only in AC circuits. Figure 2.9 shows the parts of the transformer.

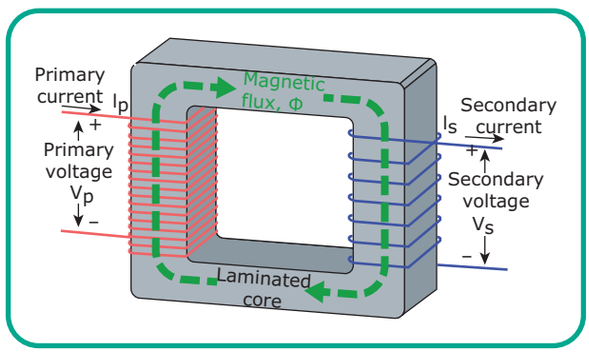

Figure 2.9 Transformer

The AC current flowing through the primary induces an alternating magnetic field. This magnetic field creates an EMF in the secondary. If we are giving DC in the primary, it won't induce any EMF, hence the phase does not get changed. Therefore, the transformer can be used only in AC Circuits.

2.3.2 Turns Ratio

The strength of current induced in the secondary depends upon the number of turns in the secondary coil. That is, the

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Table 2.1 Classifications of Transformer		
Turns ratio	Core	Use
Step-up Transformer	Air Core	Power Transformer
Step-down Transformer	Iron Core	R.F Transformer
Isolating Transformer	Ferrite Core	I.F Transformer
Step-down Transformer	Iron Core	Audio Transformer

induced EMF is directly proportional to the turns in the coil. The voltage ratio between the primary and secondary is equal to the ratio between the number of turns in the primary and secondary.

$$\frac{E_p}{E_s} = \frac{N_p}{N_s}$$

E_p → primary coil voltage

E_S → Secondary coil voltage

N_p → Number of turns in primary coil

N_S → Number of turns in secondary coil

2.3.3 Types of Transformer

Based on the turns ratio, type of the core and the type of application, the transformers are classified as shown in Table 2.1.

Step-up Transformer

In this type, the number of turns in secondary coil must be more than the turns in the primary coil. These types of transformers are used in power generating plants, where the electricity is carried over a long distance and also in Television. The step up transformer is shown in Figure 2.10 and its turns ratio is given in Table 2.2.

Table 2.2 Turns ratio of step-up transformer		
	Primary	**Secondary**
Turns ratio	*1*	*2*
Voltage ratio	*1*	*2*

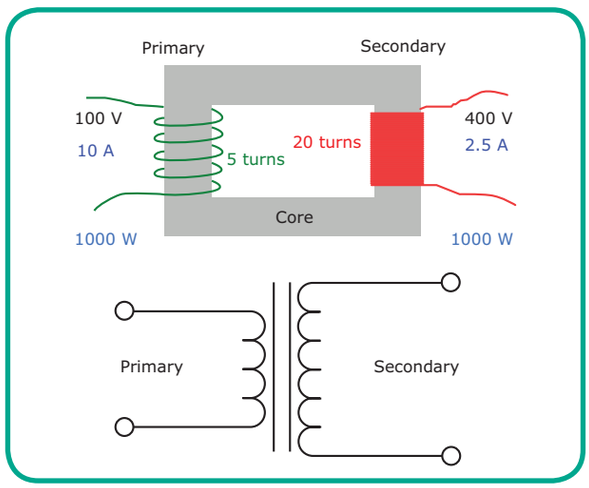

Figure 2.10 Step-up Transformer

Step-down Transformer

In this type, the number of turns in the secondary coil must be less than the number of turns in the primary coil. This type of transformer is used in Radio and TV receivers, eliminators and other video equipment. Figure 2.11 shows a step-down transformer. Table 2.3 summarizes the turns ratio of step-down transformer.

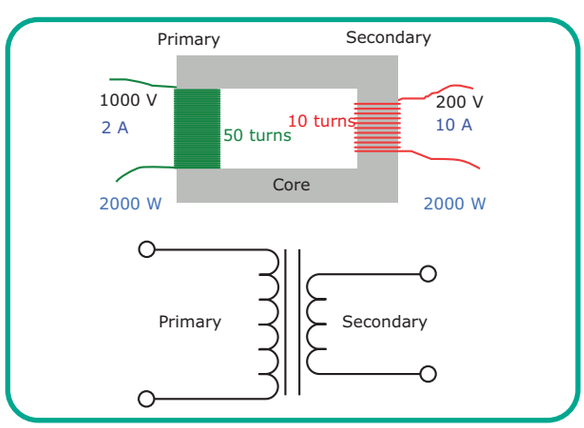

Figure 2.11 Step-down Transformer

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Table 2.3 Turns ratio of step-down transformer		
	Primary	**Secondary**
Turns ratio	*2*	*1*
Voltage ratio	*2*	*1*

Isolating Transformer

This type of transformer has 1:1 ratio of winding. These types of transformer are used mainly in fault finding places. This transformer is used to avoid materials to have direct contact with main supply. Figure 2.12 shows an isolation transformer.

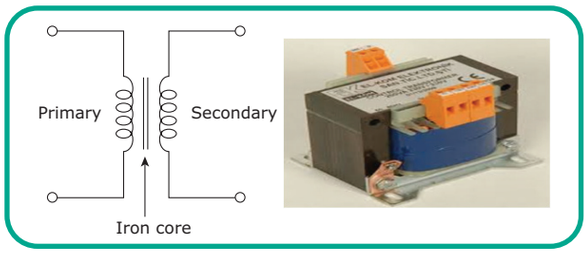

Figure 2.12 Isolating Transformer

Table 2.4 Turns ratio of Isolating transformer		
	Primary	**Secondary**
Turns ratio	*1*	*1*
Voltage ratio	*1*	*1*

2.3.4 Transformer Losses

Even in best transformers, unavoidable losses are occurred. These losses may be reduced using quality materials and cannot be totally nullified. The losses are of three types.

1. **Copper Loss:** The loss appeared because of the resistivity of copper string in the coil.
2. **Hysteresis Loss:** When AC changes its phase, the magnetic phase also gets changed. This causes some loss in the strength of the current. This is known as Hysteresis loss.
3. **Eddy Current Loss:** When current flows in an iron, it will get heated. This heat creates some loss. This loss is said to be Eddy current loss. To minimize this loss, the core should be laminated.

2.4. MICROPHONES AND LOUD SPEAKERS

In this Section, we are going to study about microphones and loud speakers. They may also be called as transducers, because they are converting one form of energy into another form.

2.4.1 Microphone

A device, which converts sound waves into electrical waves, is called as microphone. There are few types based on the construction.

Types of microphone

1. Carbon microphone
2. Ribbon microphone
3. Dynamic microphone
4. Condenser microphone

Let us see some of the important microphones.

Dynamic Microphone

The dynamic microphone can also be called as moving coil microphone, which is shown in Figure 2.13. It is working under the principle of electromagnetic induction. This works on the basis of the following principle which states that "in a magnetic field, a conductor is placed in such a way that it cuts the magnetic field and then inducing an electrical field in it".

In dynamic microphone, between the two-strong magnetic ends a coil spring is placed. A diaphragm is attached along

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with this coil spring. The diaphragm is firmly attached to the body of the microphone. The coil spring laminated so it won't have any contact with other parts. This total setup is fixed in a case.

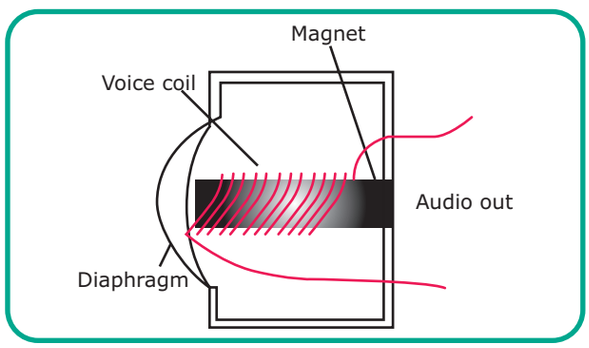

Figure 2.13 Dynamic Microphone

When sound waves strike the diaphragm, the coil attached to it will vibrate front and back. Due to this, the coil cuts the magnetic field and creating electrical signal. The strength of this electrical signal and frequency decides the true deflection of vibration occurred in the diaphragm. This electrical signal is the output of the microphone. The dynamic microphone will give equal frequency response for the sound waves in the range of 50 Hz to 10000 Hz. It is made up of low impedance material.

Condenser Microphone

When the distance between the electrodes of a capacitor gets changed the capacitance also varies. The condenser microphone is working under this principle. A condenser microphone is shown in Figure 2.14. The construction of this microphone is also similar to the construction of a capacitor. In this, one plate is kept static and another plate can vibrate on receiving the sound wave.

The vibrating plate will act as diaphragm. When the sound signal strikes the microphone, the vibrating plate starts slight movement (vibration) in front and back. Due to this, the gap between the two plates gets changed and in turn there is a change in capacitance occurs. The change in capacitance depends upon the sound waves. Hence, the electrical signal produced also gets changed and is taken as output. The condenser microphone is a high impedance microphone.

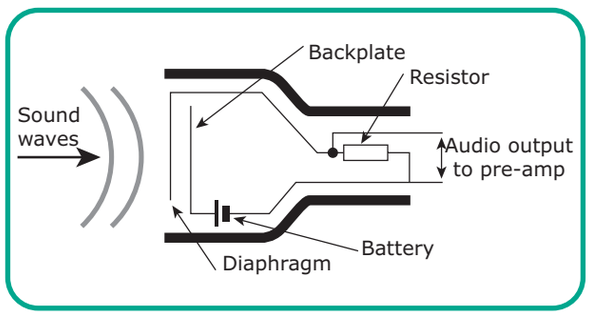

Figure 2.14 Condenser Microphone

2.4.2 Loud Speaker

A material which converts electrical energy into mechanical energy and converting such energy into sound energy is known as loud speaker. Simply to say, the part that converts amplified audio frequency signals back to the original sound is the speaker.

Dynamic Loudspeaker

Figure 2.15 shows a cross sectional view of a Dynamic Loudspeaker.

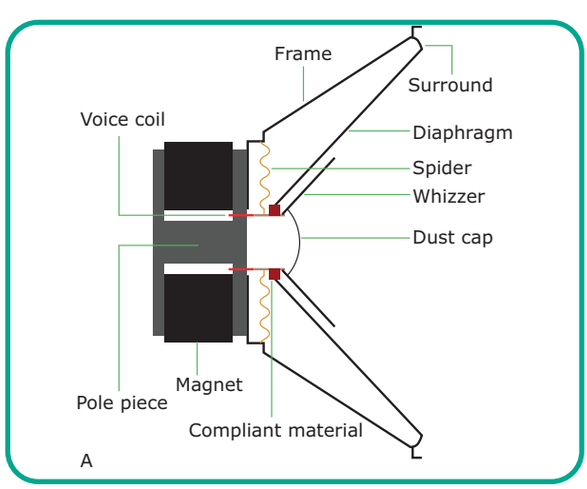

Figure 2.15 Dynamic Loudspeaker

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Voice coil is placed in between the strong magnetic ends in order to fill the air gap. Spider is placed on the voice coil.

Spider helps the voice coil to fill the air gap. Paper cone is used to connect the voice coil with the frame of the speaker and so as vibration will be proper.

When the amplified audio signal is given to the voice coil, it will create variable magnetic field. The force develops in between the static and dynamic magnetic field move the voice coil front and back. Due to this the paper cone gets vibrated.

2.5. FUSES

A fuse is made up of a piece of metal that melts when over-heated. It should be connected in series with the load. Fuse is made up of 37% of lead and 67% of iron. Most common sizes having maximum working voltages are 32 V, 125 V, 600 V to 25000 V. Electronic fuses having a current rating of 0.1 A, 0.5 A, 1 A, 2 A, 3 A, 5 A, 10 A, 100 A and 500 A.

2.5.1 Types of fuses

Fuses can be divided into two main categories, according to the type of input supply voltage. They are,

1. AC fuses
2. DC fuses

There is a little difference between AC and DC fuses in size.

2.5.2 Other Types of Fuses

1. Cartridge Fuse
2. Blade Type Fuse
3. Surface Mount Device (SMD) Fuse
4. Axial Type Fuse
5. Thermal Type Fuse
6. HRC Type Fuse
7. Resettable Type Fuse

Cartridge Fuse

Cartridge fuses are used to protect electrical appliances such as motors, air conditioners, refrigerators, pumps etc., where high voltage rating and current rating are required. Cartridge fuse is shown in Figure 2.16

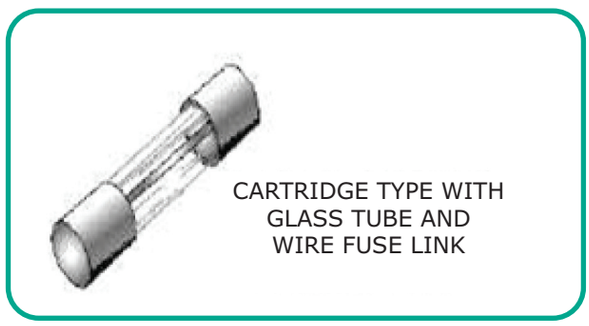

Figure 2.16 Cartridge Fuse

Surface Mount Device (SMD) fuse

This type of fuses directly soldered in the printed circuit board. These fuses are available in low-voltage and low-current ratings. It is the latest method of fuse and also no need to pierce on the PCB. The SMD fuse is shown in Figure 2.17.



Figure 2.17 SMD Fuse

Thermal Type Fuse

The thermal type fuse is used to protect electrical appliances from the damages caused due to over-heating. Thermal fuses are used in coffee makers, refrigerators etc.,

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in the form of thermostats. Figure 2.18 shows the thermal fuse.

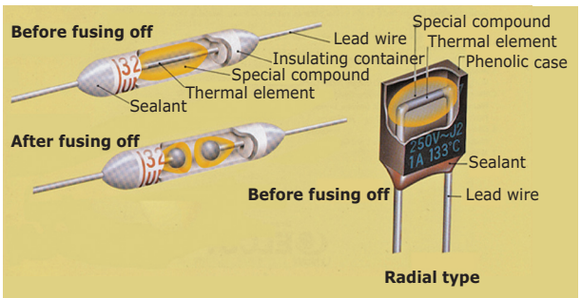

Figure 2.18 Thermal Fuse

2.6 CIRCUIT BREAKER

A circuit breaker is an automobile operated electrical switch designed to protect an electrical circuit from damage caused due to excess current, typically resulting from an over-load or short-circuit. Its basic function is to stop current flow after short-circuit or over-load is detected. There are different types of circuit breakers and are summarized below:

2.6.1 MCB (Miniature Circuit Breaker)

Presently, we use MCB in low-voltage electrical network instead of fuse. MCB is an electromechanical device which protects an electrical circuit from over-current. An MCB is better alternative to fuse, since it does not require replacement once an over-load is detected. Unlike fuse, an MCB can easily reset and thus offers improved operational safety.

Working principle

MCBs are either electromagnetic or a bi-metallic strip. In either case, when turned ON, the breaker allows electrical current to pass from a bottom to an upper terminal across the solenoid or strip. When the current reaches un-safe levels, the magnetic force of the solenoid becomes so strong, that a metal lever within the switch mechanism is thrown and the current gets cut-off. Alternatively, the metal strip bends throwing the switch and disconnecting the connection. To reset the flow of electricity after the problem is resolved, the switch can simply be tuned back to ON, thus reconnecting the circuit. Figure 2.19 shows a layout of MCB.



Figure 2.19 Layout of Miniature Circuit Breaker

2.6.2 ELCB (Earth Leak Circuit Breakers)

An ELCB is a safety device, used in electrical installations with high earth impedance to prevent even minor shock. It detects even small stray voltages on any electrical equipment enclosures and terminates the supply to them. An ELCB is a specialized type of a latching relay that has a provision for incoming mains power connected through its switching contacts. So, the ELCB disconnects the power when earth leakage is detected.

The difference between MCB and Fuse is summarized in Table 2.5.

The ELCB detects fault currents from live to earth (ground) within the installation and protect the circuit. If sufficient voltage appears across the ELCB's sense coil, it will switch off the power and remain off until

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Table 2.5: Difference between Fuse and MCB	
Fuse	**MCB**
Fuse is usually made up of a fuse wire. It is an alloy which has a no melting point	MCB has a tripping circuit
Fuse works on the electrical and thermal properties of the conducting materials.	MCB works on the electromagnetism and switching principle
Fuses can be used only once	MCB can be used a number of times
Fuse cannot be used as an ON/OFF switch	MCB can be used as an ON/OFF switch
Operating time of Fuse is Very less (0.002 sec)	Operating time is comparatively more than that of fuse (0.02-0.05 sec)
Cost of fuse is low	Cost of MCB is high

manually reset. A voltage sensing ELCB does not sense fault currents from live to any other earthed body. A typical ELCB is shown in Figure 2.20.



Figure 2.20 Earth Leak Circuit Breakers

2.6.3 RCCB (Residual Current Circuit Breakers)

A RCCB is one of the essential safety devices when it comes to protection of electrical circuits. It is a current detection device which always detects the fault occurring in the current network and immediately disconnects the circuit.

It is also known as RCD (Residual Current Device) or RCB (Residual Current Breaker)

Classification of RCCB

1. Two pole RCCB (used in single phase supply connection)
2. Four pole RCCB (used in three phase supply connection)

The RCCB Shown in Figure 2.21



Figure 2.21 RCCB

2.7 SWITCHES

These are designed depends upon the contact points (pole) and number of connections (ways).

A device which is used to connect supply from one point to another point (load) is called a switch.

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There are few type of switches based on requirements.

1. Single Pole Single Way
2. Single Pole Two Way
3. Single Pole Multi Way
4. Double Pole Single Way
5. Double Pole Two Way
6. Double Pole Multi Way
7. Multi Pole Multi Way

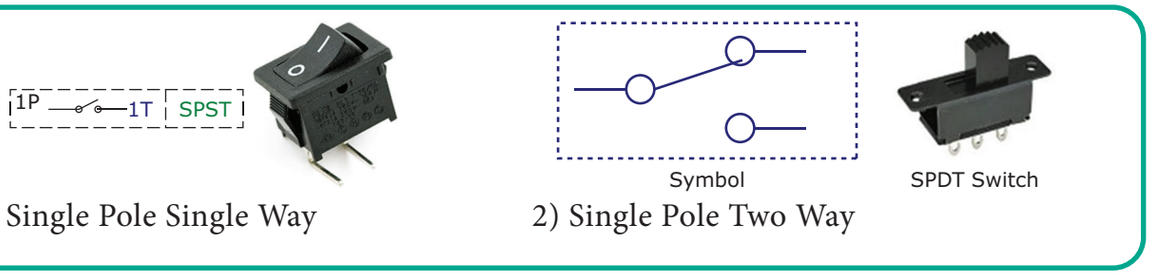

Figure 2.22 Types of Switches

LEARNING OUTCOMES

After studying this Chapter, a student can understand the following

1. **Remembering the concept of primary cells and secondary cells.**
2. **Acquiring depth knowledge about working principles of cells, inductors and transformers.**
3. **Designing and testing of the circuit breakers.**

GLOSSARY

S. No	Terms	Explanation
1	Auto transformer	Transformer that uses a common winding for both primary and secondary windings
2	Electromotive Force	Measured in volts, a force that exists between positive and negative charges
3	Inductors	A device for introducing inductance into a circuit
4	Transducer	Device that converts energy from one form to another

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QUESTIONS

I3RL8

I Choose the best answer 1 Mark

1. A device which converts chemical energy into electrical energy?
   a) Capacitor b) Cell
   c) Resistor d) Transformer
2. Voltaic pile was invented by……..
   a) Graham Bell b) Michael Faraday
   c) Alessandra Volta d) Marconi
3. The unit of an inductor is ……
   a) Ohms b) Farad
   c) Hertz d) Henry
4. Which of the following is a transducer?
   a) Resistor b) Condenser
   c) Transformer d) Microphone
5. Electrical signal can be converted into audio signal by ……
   a) Microphone b) Speaker
   c) Condenser d) Cell
6. Audio signal can be converted into electrical signal by ……..
   a) Transformer b) Microphone
   c) Speaker d) None of these
7. The formula for inductive reactance is _____
   a) $X_L = 2\Pi fL$ b) $X_L = \frac{1}{2\pi L}$
   c) $X_L = 2\Pi\sqrt{fL}$ d) $X_L = \frac{1}{2\pi LC}$
8. Inductor is also known as _____
   a) resistor b) condenser
   c) coil d) diode
9. The ratio of winding in isolating transformer is _____
   a) 1:2 b) 1:1 c) 2:1 d) 2:2
10. Which among these is the least expensive protection for over-current in low-voltage system
    a) Rewirable fuse b) Isolator
    c) Circuit Breaker d) Air Breaker switch

II Answer in few sentences 3 Marks

1. What is meant by a cell?
2. What is meant by secondary cell? Give examples.
3. Define Electromagnetic force.
4. Define Inductor?
5. What is a transformer?
6. What is meant by transducers?
7. What is the function of microphone?
8. Write down the function of loudspeaker?
9. What is switch?
10. What is the function of circuit breaker?

III Explain the following questions 5 Marks

1. How the inductors are classified? Explain.
2. Explain the working of coils in AC and DC circuits?
3. Explain Dynamic loud speaker with diagram.
4. Explain about the losses occurred in a transformer.

IV Briefly explains the following questions 10 Marks

1. Explain the working of a transformer and turns ratio with neat diagram.
2. Explain the working of a dynamic microphone.

Answers

1) **b** 2) **c** 3) **d** 4) **d** 5) **b**
6) **b** 7) **a** 8) **C** 9) **b** 10) **a**

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CHAPTER 3

BASIC PRINCIPLES OF ELECTRONICS

U0RX1

LEARNING OBJECTIVES

A student can understand the following in this Chapter

1. **Knowledge about basic electronic principles**
2. **Atomic structure of elements**
3. **Classification of Elements**
4. **Detailed knowledge of Semiconductors and its working**
5. **Working of PN-junction**

INTRODUCTION

In this fast developing world, "Electronic" is the most important branch of engineering. Electronic devices are used in day to day common man life to big industrial activities. At its peak now robot are replacing human in areas where criticality and safety of human become risk.

The fast growth of this electronic technology offers a great challenge to the beginner, who likes to learn about electronics. This fundamental knowledge about electronics can make easy and simple learning process. The purpose of this chapter is to give basic elementary knowledge in order to understand the following chapters.

Few important activities of electronic devices are

1. Rectification
2. Amplification
3. Control
4. Oscillations
5. Conversion of light into electricity and
6. Conversion of electricity into light etc.

The first step to understand the principles of electronics starts from knowing about an atom, since everything is made up of atom.

3.1. ATOMIC STRUCTURE

According to modern theory, matter is electrical in nature. All the materials are composed of very tiny particles called atoms. The atoms are the root cause for all the matter or material existing in this world.

The atom consists of a central nucleus, contains protons and neutrons as shown in Figure 3.1. A proton is a positively charged particle, where neutron does not have any charge. There is yet

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another particle called electrons which is negative in charge and it is not reside inside the nucleus rather revolving around the nucleus. This is termed as extra nucleus.

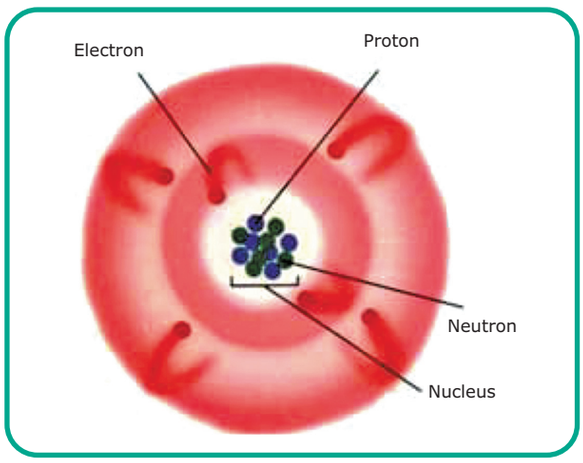

Figure 3.1 **Atomic structure**

The character of any atoms can be defined by three factors.

1. Atomic number
2. Atomic weight
3. Electrical charge (Nucleus and Extra Nucleus)

3.1.1 Atomic Number

Normally at ordinary conditions the number of electrons in the extra nucleus (i.e, orbits) are equal to number of protons present in the nucleus.

Therefore, an atom is neutral as a whole. The number of electrons or protons in an atom is called atomic number.

∴ Atomic Number = No. of Protons (or) No. of Electrons in an atom.

3.1.2 Atomic Weight

The sum of the protons and neutrons decides the entire weight of an atom and is called atomic weight. The electrons are not taken for consideration because it is having negligible mass as compared to protons or neutrons.

Atomic Weight = No. of Protons + No. of Neutrons

The electrons present in the atom is root cause for the action of any type of conduction (say electricity, heat etc).The electrons in an atom revolve around the nucleus in different orbit or paths. The number and arrangement of electrons in any orbit is determined by the following rules.

1. The number of electron in any orbit is given by $2n^2$ where n is the number of orbit.

For Example:

First orbit contains $2x1^2 = 2$ electrons
Second orbit contains $2x2^2 = 8$ electrons
Third orbit contains $2x3^2 = 18$ electrons and so on

2. The last orbit cannot have more than 8 electrons.
3. The last but one orbit cannot have more than 18 electrons.

3.2. STRUCTURE OF ELEMENTS

We have seen all atoms are made up of protons, neutrons and electrons. The difference between types of elements is due to the different number and arrangement of these particles within their atoms. The structure of copper atom is different from carbon atom and hence the two elements have different properties.

The atomic structure can be easily drawn if we know the atomic weight and atomic number of an element.

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For example:

We take copper atom,

Atomic weight = 64
Atomic number = 29
No. of Protons = No of Electrons = 29 and
No of Neutrons = 64-29=35.

The Figure 3.2 shows the structure of copper atom. It has 29 electrons which are arranged in different orbits as follows. The first orbit will have 2 electrons, the second 8 electrons, the third 18 electrons and fourth orbit will have 1 electron. The atomic structure of all known elements can be shown in this way and we can refer few elements.

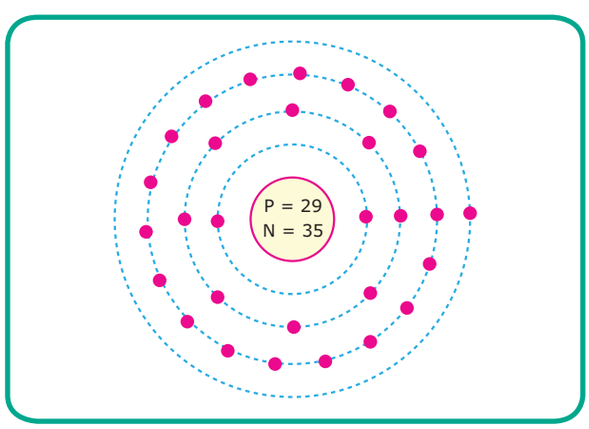

Figure 3.2 Atomic structure of copper

3.2.1 Electron

Since electronics deals with tiny particles called electrons, these small particles require detailed study. *An electron is a negatively charged particle having negligible mass.* Some of the important properties of an electron are:

1. Charge of an electron,
   $e = 1.602 \times 10^{-19}$ coulomb
2. Mass of an electron,
   $n = 9.0 \times 10^{-31}$ kg
3. Radius of an electron,
   $r = 1.9 \times 10^{-15}$ meter

3.2.2 Energy of an Electron

An electron moving around nucleus possesses two types of energies, viz.

Kinetic Energy -due to its motion (relativity)
Potential Energy - due to the charge in the nucleus

The total energy of the electron is the sum of these two energies. The total energy of the electron increases as its distance from the nucleus increases. Hence, the electron in the last orbit possesses high energy than the electrons in the previous orbits. The last orbit electron plays important role in determining the physical, chemical and electrical properties of a material.

Valence Electron

The electrons in the outermost orbit of an atom are known as valence electrons.

The outermost orbit can have maximum of 8 electrons. i.e., the maximum number of valence electrons can be 8. The valence electron determines the physical, chemical and electrical properties of material.

Atomic Structure of Materials

On the basis of electrical conductivity, materials are generally classified into conductors, insulators and semi-conductors. In general one can determine the electrical behaviour of a material from the number of valence electron as under.

Conductor

When the number of valence electron of an atom is less than 4 (i.e., half of the maximum of 8 electron) the material is usually a metal and a conductor. Examples are sodium, magnesium and aluminium which have 1,2 and 3 valence electrons respectively. Is shown in Figure 3.3.

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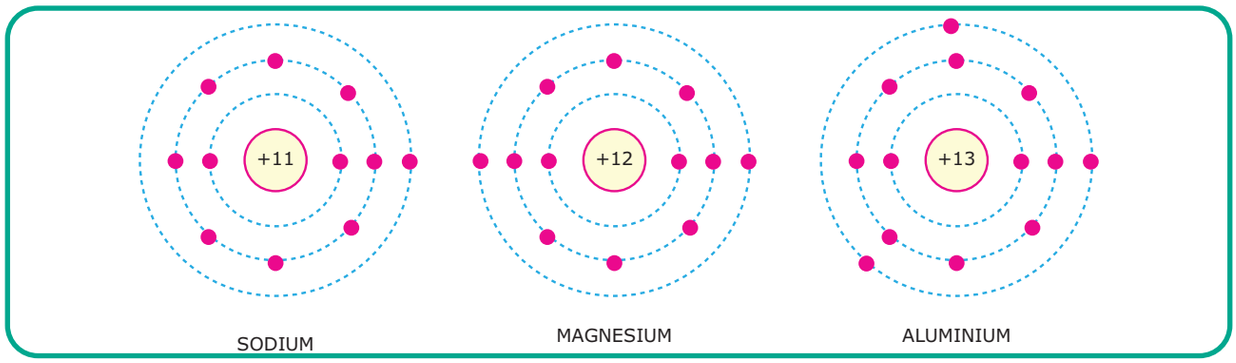

Figure 3.3 Atomic structure of sodium, magnesium and aluminium

Insulator

When number of valence electron of an atom is more than 4, the material is usually a non-metal and an insulator.

Examples are nitrogen, sulphur and neon which have 5, 6 and 8 valence electrons respectively as shown in Figure 3.4.

Semi-Conductor

When the number of valence electrons of an atoms is 4 (i.e., exactly one-half of the maximum of 8 electron), the material has both metal and non-metal properties and is usually a semiconductor. Examples are carbon, silicon and germanium as shown in below Figure 3.5.

3.2.3 Free Electrons

The valence electron of different material possesses different energies. The greater the energy of a valence electron, the lesser it is bound to the nucleus. In certain substance,

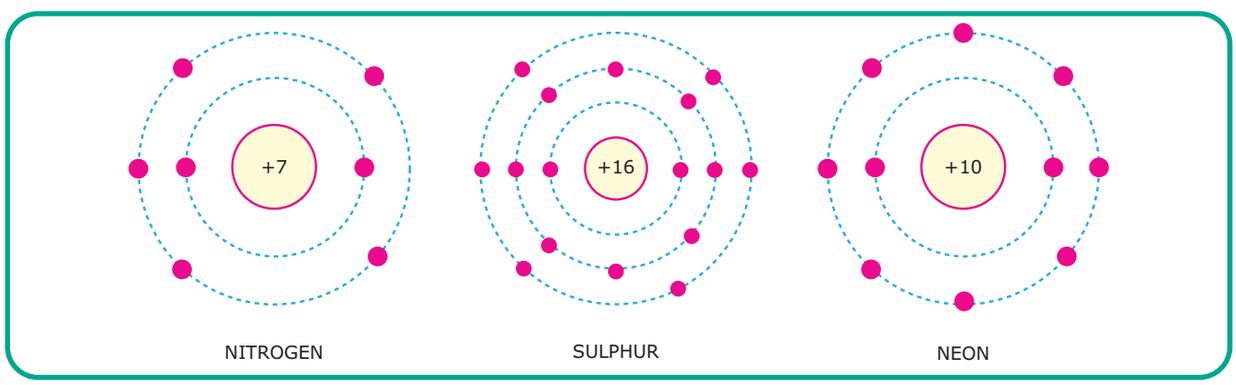

Figure 3.4 Atomic structure of nitrogen, sulphur and neon

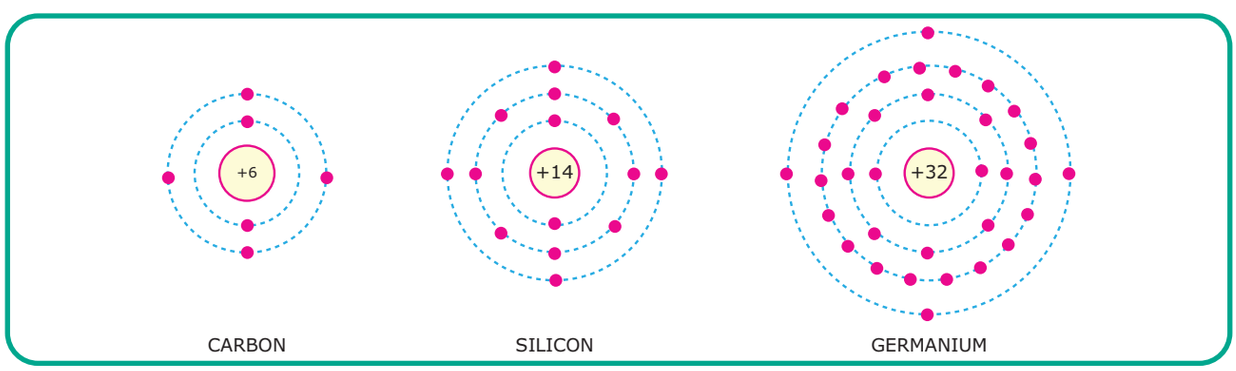

Figure 3.5 Atomic structure of carbon, silicon and germanium

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particularly metals, the valence electron possess so much energy that they are very loosely attached to nucleus. These loosely attached valence electron move at random within the material and are called free electrons.

The valence electrons which are very loosely attached to the nucleus are known as free electron.

The free electrons can be easily removed or detached by applying a small amount of external energy. As a matter of fact, these free electrons which determine the electrical conductivity of the material. On the basis of free electron concept, the conductors, insulators and semiconductors can be defined as under:

1. A conductor is a substance which has a large number of free electrons. When potential difference is applied across a conductor, the free electron move towards positive terminal of supply constituting electric current.
2. An insulator is a substance which has practically no free electrons at ordinary temperature. Therefore an insulator does not conduct current under the influence of potential difference.
3. A semiconductor is a substance which has very few free electrons at room temperature. Under the influence of potential difference, a semi-conductor practically conducts no current.

Vacuum Tubes

Early days of electronics made successful strides by the introduction and working efficiency of the vacuum tubes. During 20th century, a new branch of engineering called "electronics" originated from the electrical engineering, due to the arrival of the vacuum tubes. These tubes have been finding wide applications in radio, television, long distance telephones, sound motion pictures, radar and electronic computers. A typical vacuum tube having three electrodes called triode is shown in Figure 3.6

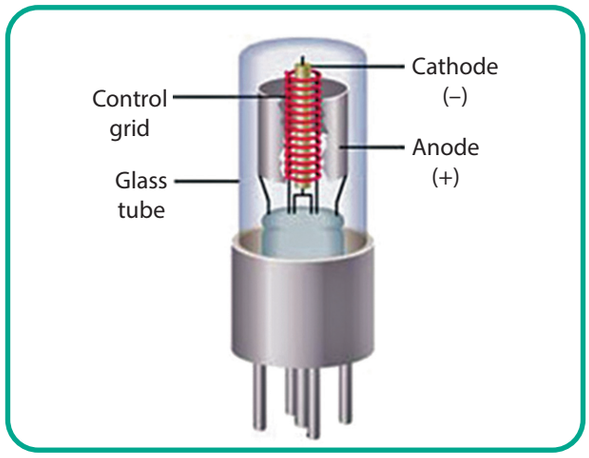

Figure 3.6 Parts of the vacuum tube

Due to its size, slowness in working-speed, cost of production, and above all the emission of heat while on working reduced the life of many electronic instruments.

Continuous research was going on, which paves the way for arrival of semiconductors.

Before studying about semiconductor, it would be better to know about the structure of atom and characteristics of electrons.

Atomic Model

The study of atomic structure is very important for electronics engineering. The size of an atom is so small that it is virtually impossible to see it even through the most powerful microscope. Therefore, we have to employ indirect method for the study of its structure. Though many scientists derived

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atomic theories, Bohr's atomic model is adequate to understand the electronics.

3.3 BOHR'S ATOMIC MODEL

In 1913, Neil Bohr, Danish Physicist gave clear explanation of atomic structure. Bohr postulated the following points about the structure of the atom:



Neil Bohr
(1885 – 1962)

1. An atom consists of positively charged nucleus around which negatively charged electrons revolve in different circular orbits.
2. The electrons can revolve around the nucleus only in certain permitted orbits i.e., orbits of certain radii are allowed.
3. The electrons in each permitted orbit have a certain fixed amount of energy. The larger the orbit (i.e., larger radius), the greater is the energy of electrons.
4. If an electron is given additional energy (e.g., heat, light, etc.), it is lifted to the higher orbit. The atom is said to be in a state of excitation. This state does not lost long, because the electron soon falls back to the original lower orbit. As it falls, it gives back the acquired energy in the form of heat, light or other radiations.

Figure 3.5 shows the structure of silicon atom. It has 14 electrons, 2 in the first, 8 in the second and remaining 4 electrons in third orbit. The first, second, third orbits are also known as K, L and M orbits, respectively.

These electron can revolve only in permitted orbits (i.e., orbits of radii r_1, r_2 and r_3) and not in any orbit. Thus, all radii between r_1 and r_2 or between r_2 and r_3 are forbidden. Each orbit has fixed amount of energy associated with it. If an electron in the first orbit is to be lifted to the second orbit, just the right amount of energy should be supplied to it. When this electron jumps from second orbit to first, it gives back the acquired energy in the form of electromagnetic radiations.

Energy Level

It has already been discussed that each orbit has fixed amount of energy associated with it. The electrons moving in a particular orbit possess the energy of that orbit. The larger the orbit, greater is its energy. It becomes clear that outer orbit electrons possess more energy than the inner orbit electrons.

Figure 3.7 shows the energy of different orbits. This is one way of the representing the energy in orbits and is known as energy band diagram. The first orbit represents first energy level; the second orbit indicates the

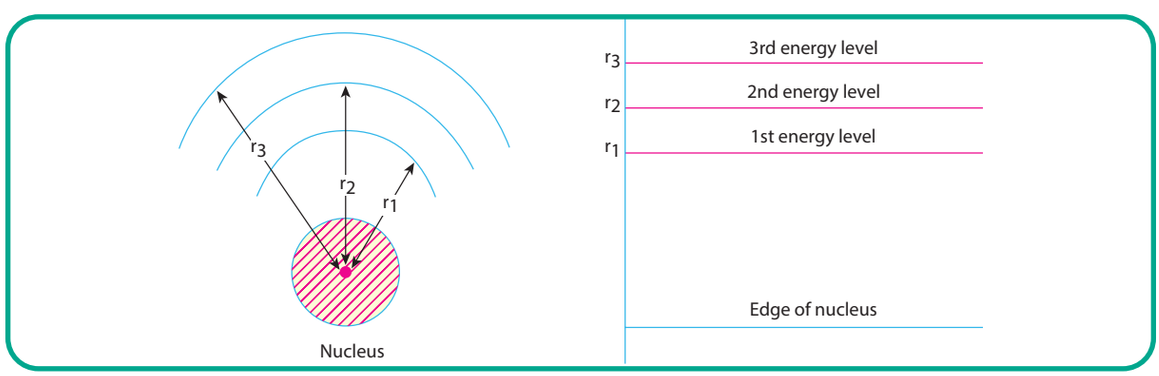

Figure 3.7 Energy level diagram

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second energy level and so on. The larger the orbit of the electron, the greater is its energy and higher is the energy level.

You might have heard about many types of energies used in our day-today life. For all those, electron energy is the base.

Important Energy Bands in Solids

Though there are number of energy bands in the solids, the following are of the important ones.

1. Valence Band

The range of energies (i.e., bands) possessed by valence electron is known as valence band.

The electron in the outermost orbit of an atom is known as valence electron. In a normal atom, valence band has the electron of highest energy. This band may be completely or partially filled. For instance, in case of inert gas, the valence band is full, whereas for other material, it is only partially filled. The partially filled band can accommodate more electrons.

2. Conduction Band

In certain material (e.g. metals) the electrons are loosely attached to the nucleus. Even at ordinary temperature, some of the valence electron may get detached to become free electrons. In fact, these free electrons are responsible for conduction of current in a conductor. For this reason, they are called conduction electrons.

The range of energy (i.e., band) possessed by the conduction electron is known as conduction band.

All electrons in the conduction band are free electrons. If a substance has empty conduction band, it means current conduction is not possible. Generally, insulators have empty conduction band. On the other hand, it is partially filled for conductors.

3. Forbidden Energy Gap

The energy gap between conduction band and the valence band on the energy level diagram is known as forbidden energy gap.

No electron of a solid can stay in a forbidden energy gap as there is no allowed energy state in this region. The width of the forbidden energy gap is a measure of bondage of valence electrons to the atom. The greater the energy gap, more tightly the valence electron are bound to the nucleus. In order to push an electron from the valence band to conduction band (i.e., to make the valence electron free), external energy must be supplied equal to the forbidden energy gap.

a) Conductors: Metals (e.g. Copper, Aluminium) or conductors allow the passage of electric current through them, because of large number of free electrons available in a conductor. In terms of energy band, the valence and conduction bands overlap each other as shown in Figure 3.8.

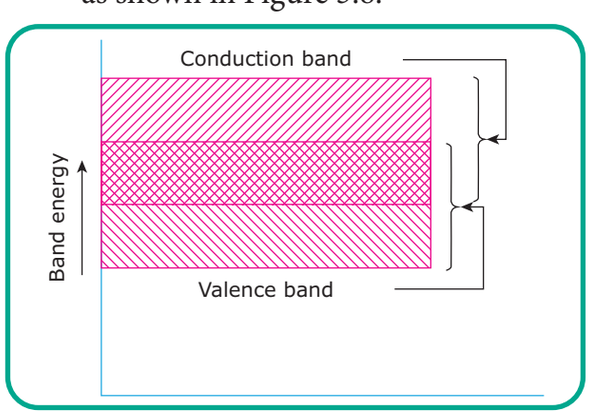

Figure3.8 Energy band of conductors

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(b) Insulators: Figure3.9 shows the forbidden energy gap of the insulators which is very large (15eV), e.g. wood, glass, etc.

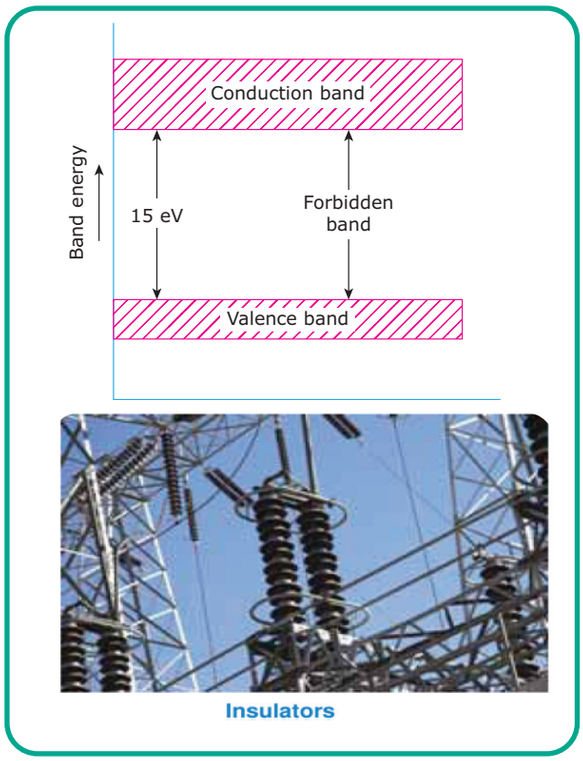

Figure3.9 Insulator and its energy band

c) Semiconductors: Semiconductors (e.g. Germanium, Silicon, Graphene, etc.)are those substance whose electrical property lies in between conductors and insulators. In terms of energy band, the valence band is almost full but the conduction band is empty. Further, the energy gap between valence band and conduction band is very small ($\simeq$, 1eV) as shown in Figure 3.10. Hence, smaller electric field is required to push the electron from the valence band to conduction band.

At low temperature, the valence band is completely full and conduction band is completely empty. Therefore at low temperature semiconductor behaves like an insulator. However, even at room temperature some of electrons cross-over to conduction band giving little conductivity to the semiconductor. As temperature increases, more number of electrons cross-over to the conduction band and the conductivity increases. Because of this, the entire characteristics of semiconductors get changed.

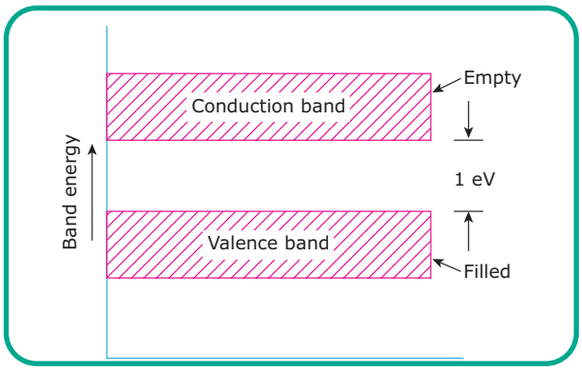

Figure3.10 Energy band of semiconductor

3.4 SEMI-CONDUCTOR

In lower standards you might have studied about the characteristics and principle of conductors, insulators. But you may not studied about semiconductors. Based on its character, it has been defined as semiconductor. But now, this semiconductor is the Back Bone of modern electronics. The character of semiconductor lies in between conductor and insulator.

The earlier period of (1950) electronics (communication equipments like Radio, Television and Amplifiers) which was dominated by vacuum tubes, gas filled tubes were replaced by this semiconductors. Thus reducing the size of equipment considerably. Let we see in detail about this much important semiconductors.

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It is not easy to define a semiconductor, if we want to take into account all its physical characteristics. However, generally a semiconductor is defined on the basis of electrical conductivity as under. A semiconductor is a substance which has resistivity (10^{-4} Ωto 0.5Ω) between conductors and insulators, e.g. Germanium, Silicon, Selenium, Carbon, Graphene, etc. Table 3.1 shows the resistivity of various semiconducting materials.

Table 3.1 Resistivity of Semiconductor Materials

Sl. No.	Substance	Nature	Resistivity
1.	Copper	good conductor	1.7×10^{-8} Ωm
2.	Germanium	semicon-ductor	0.6 Ωm
3.	Glass	insulator	9×10^{11} Ωm
4.	Nichrome	resistance material	10^{-4} Ωm

3.4.1 Properties of Semiconductors

The resistivity of a semiconductor is less than an insulator but more than a conductor.

Semiconductors have negative temperature co-efficient of resistance, i.e., the resistance of the semiconductor decreases with the increase in temperature and vice-versa. For example, germanium is usually an insulator at low temperature but it becomes good conductor at high temperature.

When metallic-impurity (e.g. Arsenic, Gallium, etc.) material is added to the semiconductor material then the current conduction property of the material changes, appreciably. This property is most important and is discussed later in detail.

3.4.2 Bonds in Semiconductors

In semiconductors, bonds are formed by sharing of valence electrons. Such bonds are called covalent bond. In the formation of a covalent bond, each atom contributes equal number of valence electrons and the contributed electrons are shared by the atoms engaged in the formation of the bond. The covalent bond of Germanium is shown in Figure 3.11.

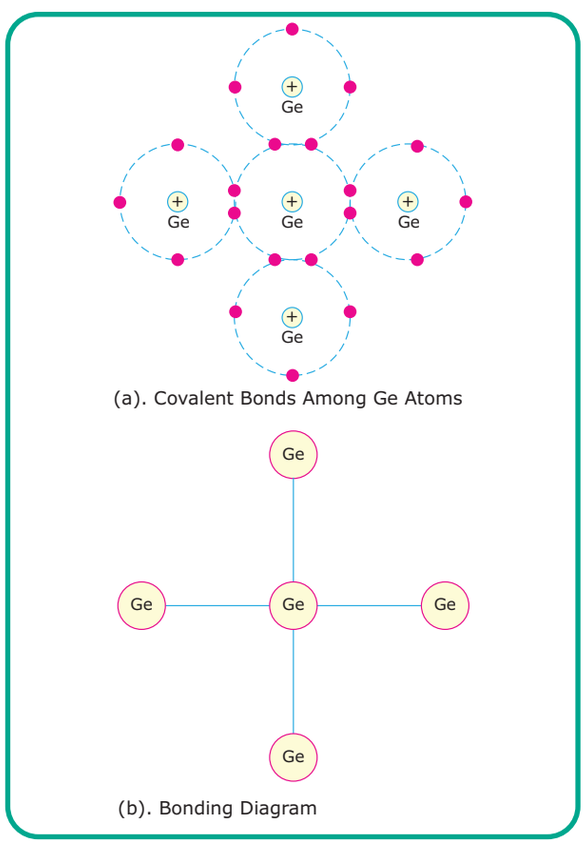

Figure 3.11 Formation of covalent bond

The following points may be noted regarding the covalent bonds:

1. Covalent bonds are formed by sharing of valence electrons.

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2. In the formation of covalent bond, each valence electrons of an atom forms direct bond with the valence electrons of an adjacent atom. For this reason, valence electrons in a semiconductor are not free.

3.4.3 Crystals

A substance in which the atoms or molecules are arranged in orderly pattern is known as a crystal.

All semiconductors have crystalline structure. From the Figure 3.11, it is clear that each atom is surrounded by neighbouring atoms in a repetitive manner; therefore, a piece of Germanium is generally called crystalline structure.

3.4.4 Commonly Used Semiconductor

There are many semiconductors available, but very few of them have practical application in Electronics. The two most frequently used materials are Germanium (Ge) and Silicon (Si). These two are widely used because the energy required to break their covalent bond is very small (i.e., energy required to release an electron from their valence bonds) being about 0.7eV for Germanium and 1.1eV for Silicon. Let us see about these two.

1. **Germanium:** Germanium is the model substance among the semiconductors. The main reason being that it can be purified well and crystallized easily. It is discovered in 1886. It is recovered from the ash of certain coals. The atomic number of germanium is 32, i.e., it has 32 protons and 32 electrons. It is clear that germanium atom has 4 valence electrons i.e., tetravalent element.
2. **Silicon:** Silicon is an element available in most of the common rocks. Actually sand is silicon dioxide. The silicon compounds are chemically reduced to silicon which is 100% pure for use as semiconductors. The atomic number of silicon is 14 and hence it has 14 protons and 14 electrons. It is very clear that silicon atom has four valence electrons i.e. tetravalent element.

3.4.5 Hole Current

At room temperature some of the covalent bond in pure semiconductors breaks, setting up free electrons. Under the influence of electric field, these free electrons constitute electric current. At the same time, another current, the hole current also flows in the semiconductors. When the covalent bond is broken due to thermal energy, the removal of one electron leaves a vacancy, i.e., a missing element in covalent bond. This missing electron is called a hole, which acts as a positive charge. For one electron set free, one hole is created. Therefore, thermal energy creates hole-electron pairs. Hence, as many holes as free electrons are generated. The current conduction by holes can be explained as follows.

The hole shows a missing electron. Suppose the valence electron at L (Figure 3.12) has free electrons due to thermal energy.

This creates a hole in the covalent bond L. Now the hole becomes strong centre of attraction for the electron. So a valence electron (say at M) from nearby covalent bond comes to fill in the hole at L. This results in creation of hole at M.

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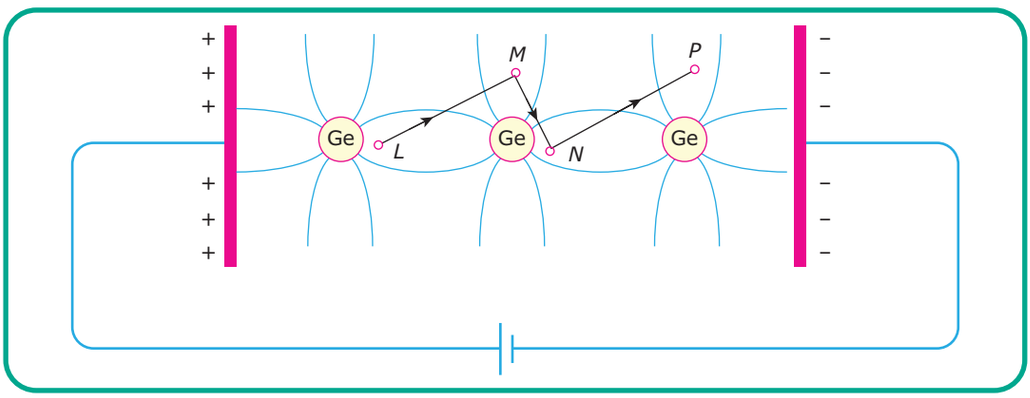

Figure 3.12 Electron and hole current formation in Ge

Another valence electron (say at N) in turn may leave its bond to fill the hole at M, thus creating a hole at N. Thus, the hole having positive charge has moved from L to N i.e., towards the negative terminal of supply. This constitutes the hole current.

Though the hole current is happening due to the movement of electrons from one covalent bond to another bond, it is quite understandable why to call it as hole current. The basic reason for current flow is the presence of holes in the covalent bonds. Therefore, it is more appropriate to consider the current as the movement of holes.

3.4.6 Energy Band description of Hole Current

The hole current can be beautifully explained in terms of energy bands. Suppose due to thermal energy, an electron leaves the valence band and enter into the conduction band as shown in Figure 3.13.

This leaves a vacancy at L. Now, the valence electron at M comes to fill the hole at L. The result is that hole disappears at L and appears at M. Next, the valence electron at N moves to hole at M, consequently a hole is created at N. It is clear that valence electrons move along the path PNML whereas holes move in opposite direction i.e., along the path LMNP as shown in Figure 3.13.

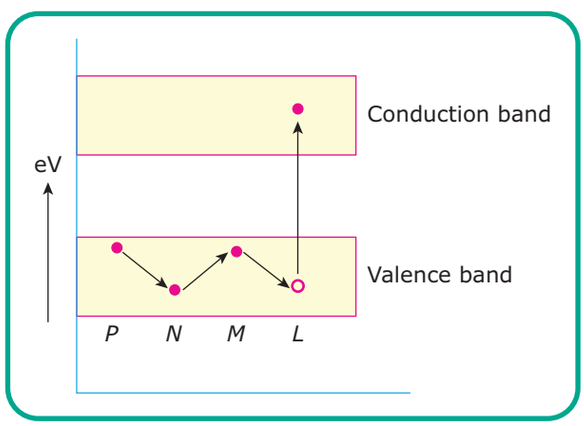

Figure 3.13 Hole movement across the band

3.5 INTRINSIC SEMICONDUCTOR

A semiconductor in an extremely pure form is known as an intrinsic semiconductor. In an intrinsic semiconductor, even at room temperature, hole-electron pairs are created. When electric field is applied across the semiconductor, the current conduction takes place by two processes such as (i) by free electrons and (ii) by holes as shown in the Figure 3.14. The free electrons are produced due to the breaking up of some covalent bonds by thermal energy.

At the same time, holes are created in the covalent bonds, under the influence

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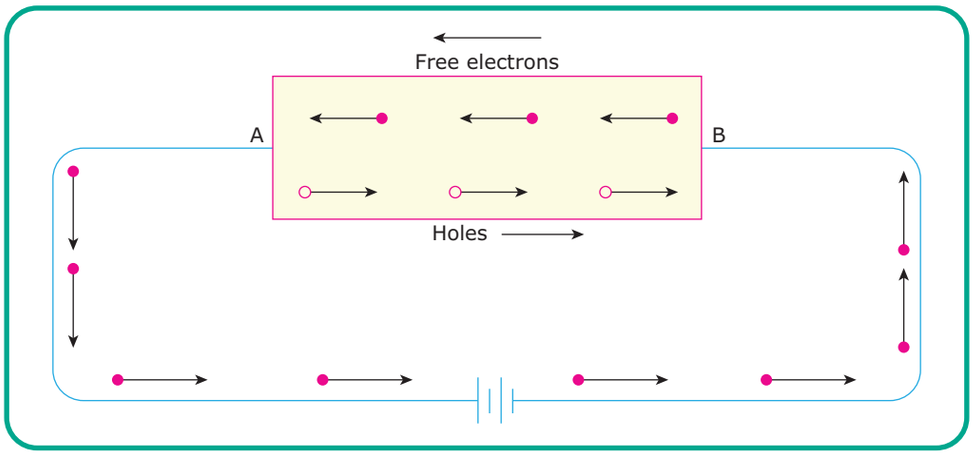

Figure 3.14 Electron-hole current

of electric field. Thus, the conduction in semiconductors is by both electrons and holes. Therefore, the total current inside the semiconductors is the sum of currents due to free electrons and holes.

It may be noted that current in the external wires is fully electronic i.e., by electrons. Then what about holes? Referring to the Figure 3.14, holes being positively charged and move towards the negative potential of supply. As the holes reach the negative terminal B, electrons enter the semiconductor crystal near the terminal and combine with holes, thus cancelling each other. At the same time, the loosely held electrons near by the positive terminal *A* are attracted away from their atoms into the positive terminal. This creates new holes near the positive terminal which again drift towards the negative terminal.

3.5.1 Extrinsic Semiconductors

The pure semiconductor must be altered so as to significantly increase its conductive properties. This is achieved by adding a small amount of suitable impurity to semiconductors. It is then called impurity or extrinsic semiconductors.

The process of adding impurities to a semiconductor is known as doping.

Generally, for 108 atoms of semiconductor, one impurity atom is added.

The purpose of adding impurity is to increase either the number of free electrons or holes in the semiconductor crystal. If the pentavalent impurity (having 5 valence electrons) is added to the semiconductor, a large number of electrons are produced in the semiconductor. On the other hand, addition of trivalent impurity (Having 3 valence electron) to semiconductor generates large number of holes.

Depending upon the type of impurity added extrinsic semiconductors are classified into:

1. N-type Semiconductor
2. P-type Semiconductor

3.6 N-TYPE SEMICONDUCTOR

When a small amount of pentavalent element is added to pure semiconductor, it is known as N-type semiconductors.

The addition of pentavalent impurity provides a large number of free

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electrons in the semiconductor crystal. Typical examples of pentavalent impurities are Arsenic (Atomic No. 33), Antimony (Atomic No.51) and Phosphorous(Atomic No. 15) Such impurities that produce n-type semiconductor are known as donor impurities, because they donate or provide free electrons to the semiconductor crystals.

To explain the formation of n-type semiconductor, consider a pure germanium crystal. We know that germanium atom has four valence electrons. When small amount of pentavalent impurity, like Arsenic is added to Germanium crystal, large number of free electrons available in the crystal. Arsenic is pentavalent i.e., its atom has five valence electrons. An Arsenic atom fits in the Germanium crystal in such a way that its four valence electron form covalent bonds with four Germanium atoms. The fifth valence electron of Arsenic atom finds no place in covalent bond and is thus become free electron as shown in Figure 3.15. Therefore, for each Arsenic atom added, one free electron will be available in the Germanium crystal. Hence, an extremely small amount of Arsenic impurity provides enough atoms to supply millions of free electrons.

Figure 3.15 shows the energy band description of n-type semiconductor. The addition of pentavalent impurity has produced a number of conduction band electrons, i.e., free electrons. Therefore, valence electrons of pentavalent atom form covalent bonds with four neighbouring Germanium atoms. The fifth left-over valence electron of the pentavalent atom cannot be accommodated in the valence band; hence travels to the conduction band.

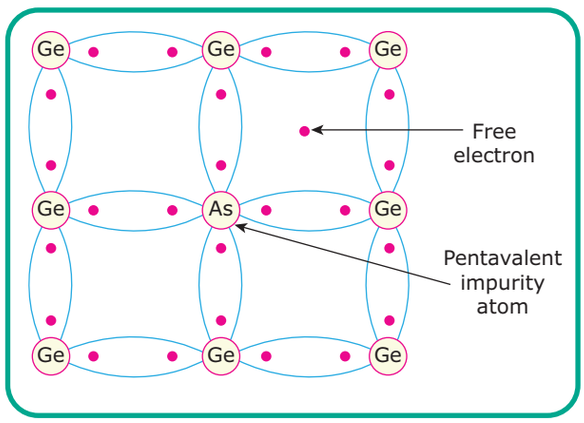

Figure 3.15 Doping of Ge with pentavalent impurity Atom As

The current flow in n-type semiconductor is shown in Figure 3.16. The following points may be noted carefully:

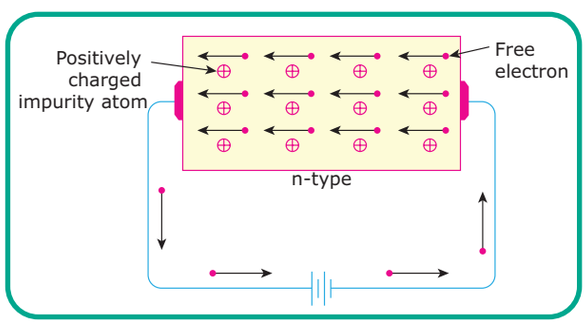

Figure 3.16 Current flow in n-type semiconductor

i. Many new free electrons are produced by the addition of pentavalent impurity.

ii. Thermal energy at room temperature still generates few hole-electron pairs.

However, the number of free electrons provided by the pentavalent impurity far exceeds the number of holes. It is due to this predominance of electrons over holes, hence it is called n-type semiconductors (n-stands for negative).

3.6.1 P-Type Semiconductors

When a small amount of trivalent impurity is added to a pure semiconductor, it is called p-type semiconductor.

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The addition of trivalent impurity provides a large number of holes in the semiconductor. Typical examples of trivalent impurities are Gallium (Atomic No: 31) Indium (Atomic No: 49) and Boron (Atomic No: 5) Such impurities produce p-type semiconductors are known as acceptor impurities, because the holes created can accept the electron.

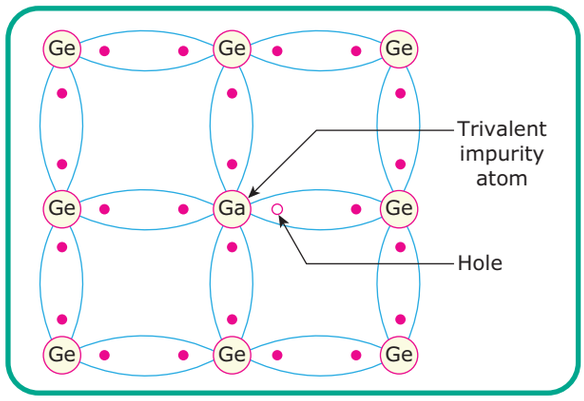

Figure 3.17 P-type semiconductor

In Figure 3.17, Gallium is added with Germanium crystal to form p-type semiconductor. Each atom of gallium fits into the germanium crystal. But, only three covalent bonds can be formed. The fourth bond is incomplete, being short of one electron. The missing electron is called a hole. Therefore, for each Gallium atom added, one hole is created. A small amount of Gallium provides millions of holes.

Hence, in p-type semiconductor, holes are the majority carriers. When potential difference is applied to the p-type semiconductor the holes are shifted from one covalent bond to another. As the holes are positively charged, they are directed towards the negative terminal, constituting what is known as "hole current". The p-type semiconductor and its band structure are shown in Figure 3.18.

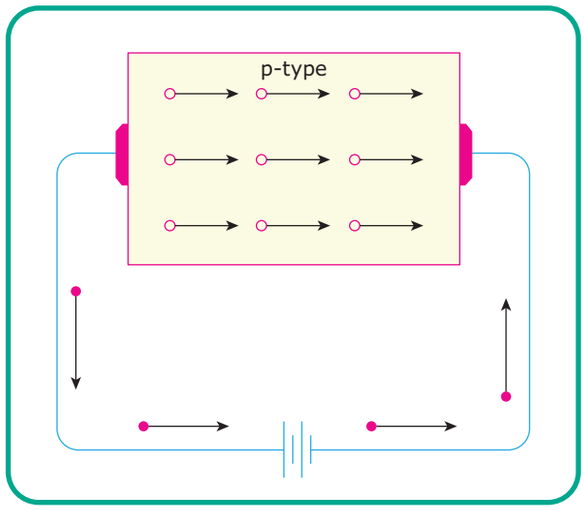

Figure 3.18 Energy band and current flow of P-type semiconductor

3.7 PN JUNCTION

"When a p-type semiconductor is suitably joined to n-type semiconductor, the contact surface is called pn junction"

Figure 3.19 shows the formation of pn junction. To explain the properties of a pn junction, p-type and n-type semiconductor are suitably joined. Keep in mind that n-type material has a high concentration of free electrons while p-type material has a high concentration of holes. Therefore, at the junction, there is a tendency for the free electrons to diffuse over to the p-side and holes to the n-side.

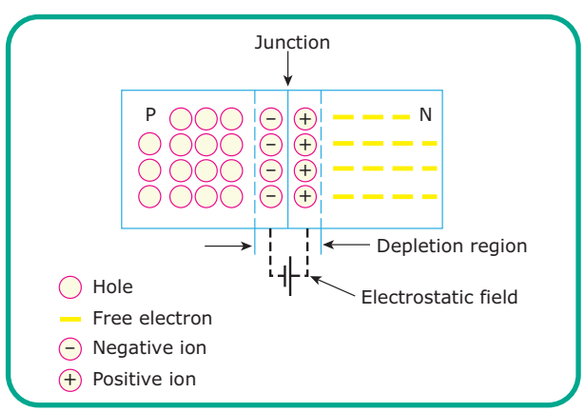

Figure 3.19 PN Junction

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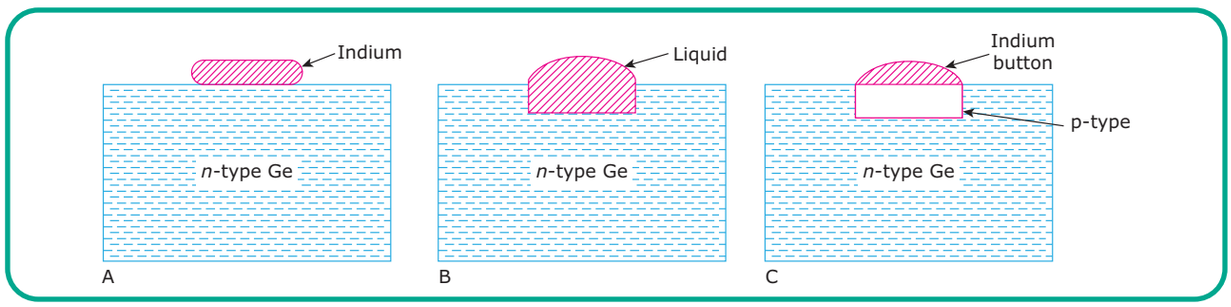

Figure 3.20 Diffusion process

This process is called diffusion as shown in Figure 3.20. The combination of these holes and electrons create a new region between the two layers. This region is called "depletion layer". Only inside this, there is positive charge on 'n' side and negative charge on 'p' side. Because of this a potential is produced in this layer which is called "barrier potential". The barrier potential in directly related to depletion layer.

The barrier potential opposes the flow of majority carriers through the junction and it aids the flow of minority carriers. For both of these opposite effects, no charge carriers will flow through the junction at normal condition. The potential difference across a pn junction can be applied in two ways namely, forward biasing and reverse biasing.

3.7.1 Forward Biasing

To apply forward bias, connect positive terminal of the battery to p-type and negative terminal to n-type as shown in Figure 3.21. Due to this, barrier potential is very much reduced. Positive terminal of the battery repels holes in p-side and negative terminal of the battery repels electrons in n-side. Because of this, current flows in the circuit. This is called "forward current". The magnitude of current depends upon the applied forward voltage.

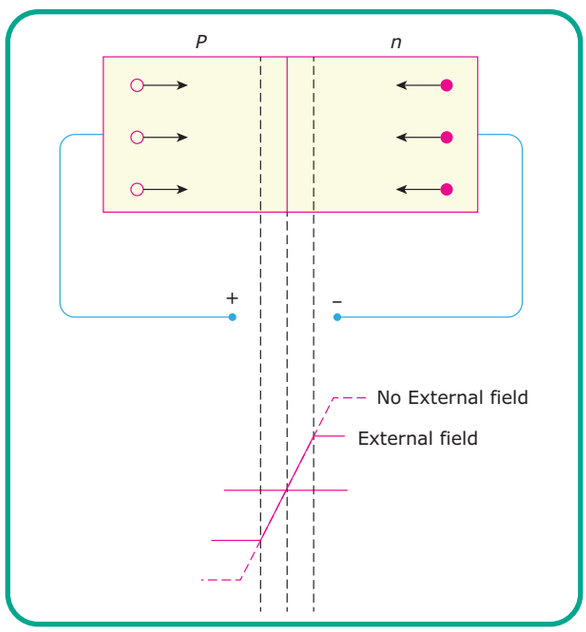

Figure 3.21 Forward bias

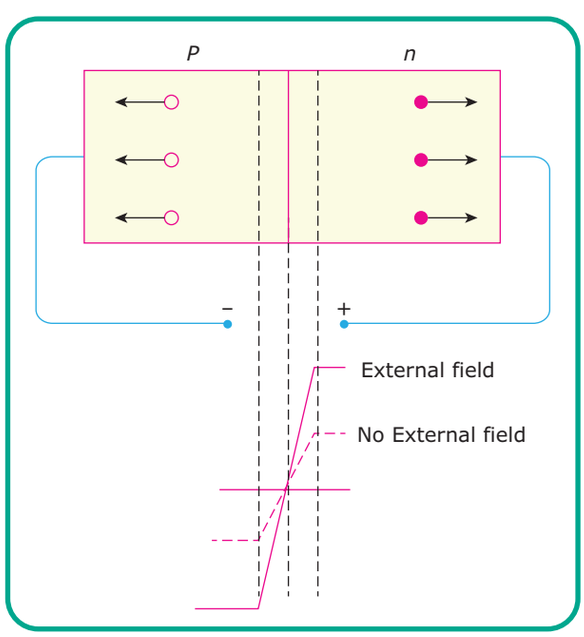

Figure 3.22 Reverse bias

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3.7.2 Reverse Biasing

"When the external voltage applied to the junction is in such a direction that potential barriers is increased, it is called reverse biasing"

To apply reverse bias, connect negative terminal of the battery to p-type and positive terminal to n-type as shown in Figure 3.22. Because of increase in barrier potential the width of the depletion layer is also increased. As a result, the increased potential barrier prevents the flow of charge carriers (majority carriers) across the junction and hence the current does not flow.

LEARNING OUTCOMES

After studying this Chapter, a student can understand the following

1. **Knowledge about basic electronic principles**
2. **Atomic structure of elements.**
3. **Classification of Elements**
4. **Detailed knowledge of Semiconductors and its working**
5. **Working of PN-junction**

GLOSSARY

S. No	Terms	Explanation
1	Acceptor atoms	Trivalent atoms that accept free electrons from pentavalent atoms
2	Atomic number	The number of positive charges or protons in the nucleus of an atom
3	Covalent bond	The way some electrons complete their valence shells by sharing valence electrons with neighbouring atoms
4	Electron	Smallest sub atomic particle of negative charge that orbits the nucleus of an atom
5	Hole	A gap left in the covalent band when a valence electron gains sufficient energy to jump to the conduction band
6	Semiconductor	An element which is neither a good conductor or a good insulator, but rather lies somewhere between the two
7	Proton	Sub atomic particle within the nucleus of an atom. Has a positive charge

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QUESTIONS

I. Choose the right answer from the following questions 1 Mark

1. The atomic weight of an atom is determined by
   (a) No of protons
   (b) No of neutrons
   (c) No of Protons and No of neutrons
   (d) No of Protons or No of electrons

2. The number of protons present in an atom is called as
   (a) isotope number (b) atomic number
   (c) atomic weight (d) none of the above

3. Atomic number of Germanium
   (a) 6 (b) 14
   (c) 29 (d) 32

4. Which of the following element does not have three valence electrons?
   (a) Boron (b) Indium
   (c) Germanium (d) Gallium

5. Which of the following element does not have five valence electrons?
   (a) Phosphorous (b) Arsenic
   (c) Antimony (d) Indium

6. A semiconductor in its pure form is called
   (a) Intrinsic semiconductor
   (b) Extrinsic semiconductor
   (c) P-type semiconductor
   (d) N-type semiconductor

7. Which of the following is donor impurity element?
   (a) Aluminium (b) Boron
   (c) Phosphorous (d) Indium

8. Which of the following is acceptor impurity element?
   (a) Antimony (b) Gallium
   (c) Arsenic (d) Phosphorous

9. In N-type semiconductor free electrons are the ……. Carriers
   (a) Minority (b) Majority
   (c) Magnetic (d) Neutral

10. A doped semiconductor is called
    (a) impure semiconductor
    (b) intrinsic semiconductor
    (c) Pure semiconductor
    (d) Extrinsic semiconductor

II. Answer in one or few Sentences 3 Marks

1. What is an atomic number?
2. What is atomic weight?
3. What is valence electron?
4. Draw the atomic structure of germanium atom.
5. Define Hole current
6. What is meant by doping?
7. What is Semiconductor? Give Example
8. Give Examples for trivalent and pentavalent impuruties.

III Explain the following questions in one or two paragraph. 5 Marks

1. Write short notes on free electrons.
2. Explain energy bands.
3. Explain conductor, semiconductor and insulator.
4. Explain formation of n-type semiconductor with diagram.

IV Describe the following questions in a page. 10 Marks

1. Explain the Bohr's atomic model with neat diagram.
2. Write formation of pn junction with neat diagram.

Answers

1) **c** 2) **b** 3) **d** 4) **c** 5) **d**

6) **a** 7) **c** 8) **b** 9) **b** 10) **d**

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CHAPTER 4

POWER SUPPLY& AMPLIFIER

LEARNING OBJECTIVES

A student can understand the following in this Chapter

1. **Identify the various sections of a power supply**
2. **State the purpose of each section of a power supply**
3. **Describe the purpose of various types of rectifier circuits used in power supply.**
4. **Describe the purpose of the filter circuits used in power supply**
5. **Understand the basic structure of the bipolar junction transistor (BJT)**
6. **Working principles of NPN transistor**
7. **Know the transistor configuration as an amplifier (or) a switch**
8. **Applications of transistor**

4.1. INTRODUCTION

Generally every piece of electronics equipment in the world today is powered from a DC Source. This source may be either a battery or a power supply. Most electronics equipment requires not only a DC power source, but one that is well filtered and well regulated as well.

Three types of electronic power conversion devices are in common use today:

1. AC to DC Rectifier
2. DC to DC Regulator
3. DC to AC inverter.

4.1.1 AC to DC Rectifier

It is a device which rectifies alternative current into direct current.

Applications

1. Radio and television receiver use this type of power supply.
2. It is also used in DVD player.
3. AC to DC power supply is used in all type of amplifiers.

4.1.2 DC to DC Regulator

It is a device which converts a source of direct current (DC) from one voltage level to another.

Application

It is used in cellular phones and laptop computers.

4.1.3 DC to AC inverter

It is a device which converts a source of direct current into alternative current. Solar cell inverter is also perform similar function.

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Application

An uninterruptible power supply uses an inverter to supply AC power when the main power is not available.

Each has its own specific areas of application. Of the three, , AC to DC power supply is the most commonly used and the subject of this lesson.

4.2. POWER SUPPLY BASICS

The basic function of power supply is shown in Figure 4.1.

Transformer: Transformer is used to step down the AC supply voltage (220 V AC, 50 Hz) as per the requirement of the solid state electronic devices.

Rectifier

Rectifier is a device which converts the sinusoidal AC voltage into either positive or negative pulsating DC. It contains unwanted AC components also called ripple. Diodes rectify the signal.

Filter

Filter is a device which passes DC components and blocks AC components of the rectifier output. Resistor, capacitor and inductor (passive components) are used for this purpose.

Voltage Regulator

Regulator or stabilizer is a device that is used to maintain a constant DC output voltage. Zener diode is used as regulator.

4.3. SEMICONDUCTOR DIODE

Semiconductor diode (mostly silicon diode) is used as a rectifier element. It converts alternating current into direct current. Hence let we see the working of semiconductor diode.

A PN junction is known as a semi-conductor or crystal diode

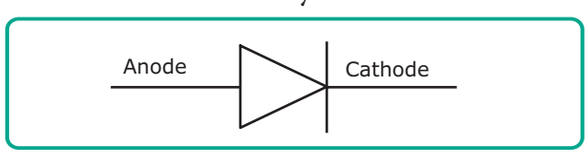

Figure 4.2 Symbol of diode

The character of a crystal diode is to conduct current in one direction only, permits it to be used as a rectifier. A crystal diode is usually represented by the schematic symbol shown in figure 4.2. The arrow in the symbol indicates the direction of conventional current flow.

The crystal diode has two terminals. When it is connected in a circuit, one thing to decide is whether the diode is forward or reverse biased. There is an easy rule to ascertain it. If the external circuit is trying to push the conventional current in the direction of arrow, the diode is forward biased. On the other

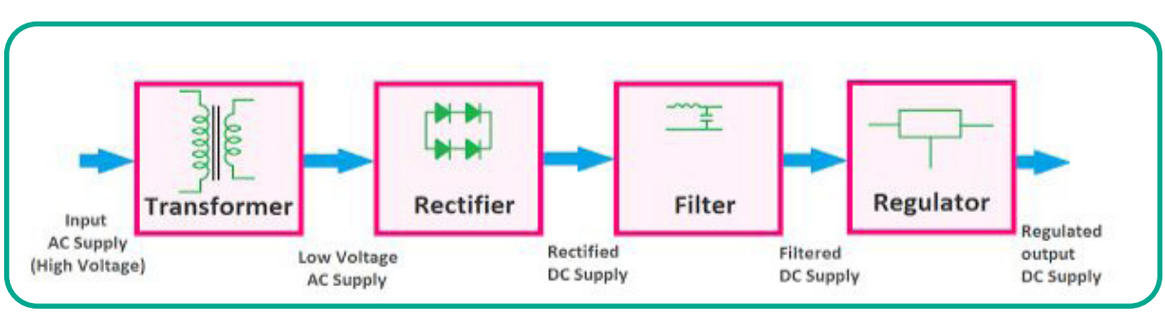

Figure 4.1 Basic power supply

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hand, if the conventional current is trying to flow opposite to arrow head the diode is reverse biased. Putting in simple words:

1. If arrow head (i.e., Anode) of diode symbol is positive with respect to bar (i.e., Cathode) of the symbol the diode is forward biased.
2. If the arrow head (Anode) of diode symbol is negative with respect to bar(Cathode), the diode is reverse biased.

4.3.1 Forward Biasing

To apply forward bias, connect positive terminal of the battery to P-type and negative terminal to N-type as shown in Figure 4.3. Due to this, barrier potential is very much reduced. Positive terminal of the battery repels holes in P-side and negative terminal of the battery repels electrons in N-side. Because of this, current flows in the circuit. This is called "forward current". The magnitude of current depends upon the applied forward voltage.

"When external voltage applied to the junction is in such a direction that it cancels the potential barrier, thus permitting the current flow is called as forward biasing"

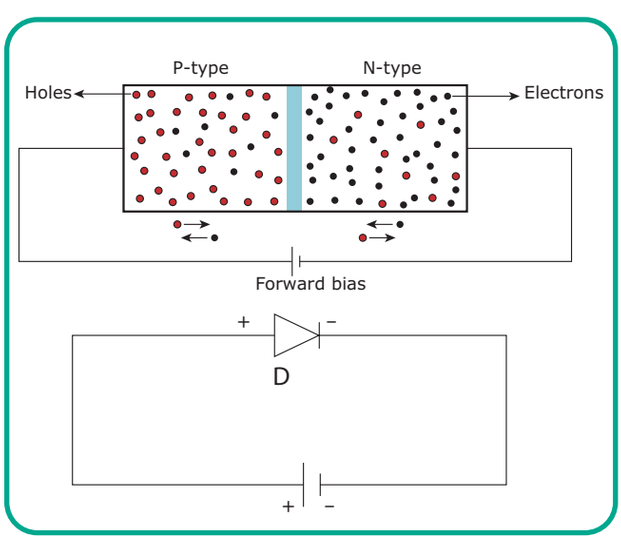

Figure 4.3 Forward Bias

The important term often used with *pn* junction is knee voltage which is explained as follows.

4.3.2 Knee Voltage

"It is the forward voltage at which the current through the junction starts to increase rapidly"

The figure 4.4 shows the characteristics of PN junction diode (forward bias).

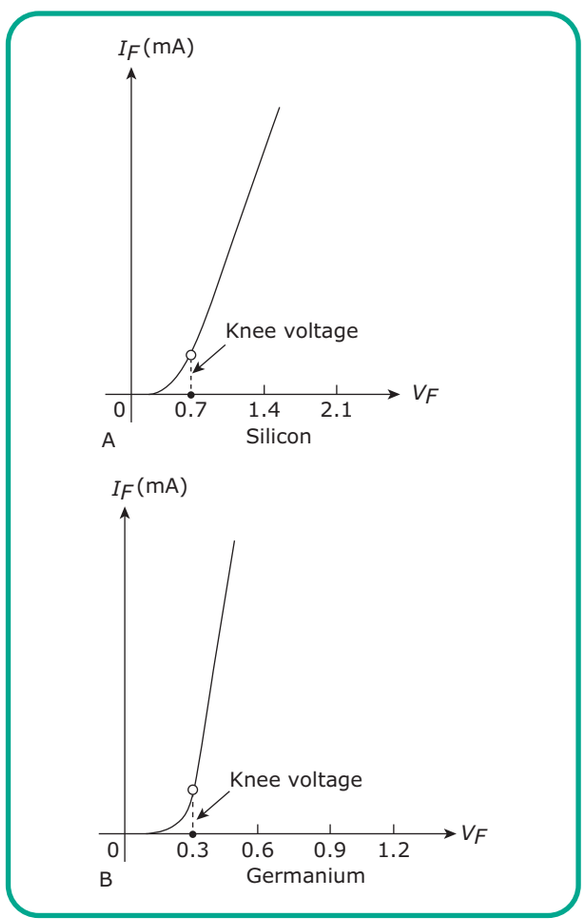

Figure 4.4 Characteristics of PN junction diode (Forward bias)

4.3.3 Reverse Biasing

"When the external voltage applied to the junction is in such a direction that potential barriers is increased, it is called reverse biasing"

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To apply reverse bias, connect negative terminal of the battery to P-type and positive terminal to N-type as shown in Figure 4.5. Because of increase in barrier potential the width of the depletion layer is also increased. As a result, the increased potential barrier prevents the flow of charge carriers (majority carriers) across the junction and hence the current does not flow.

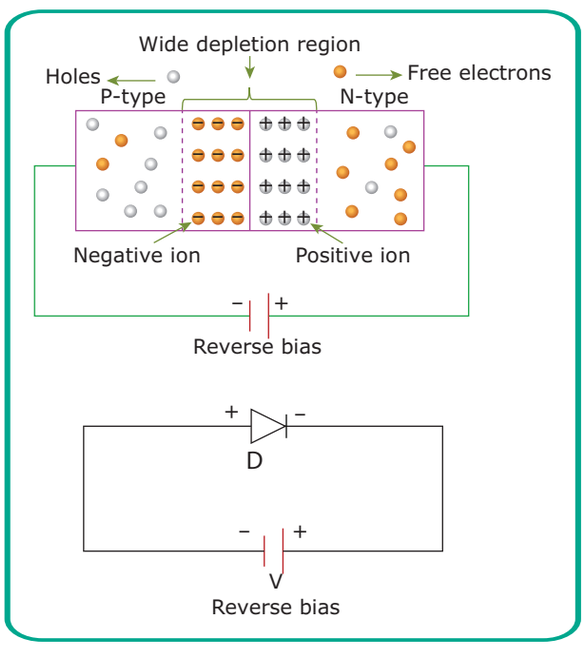

Figure 4.5 Reverse bias

From this, the students can understand the following:

1. *When pn junction is in forward biased condition, current flow occurs.*
2. *When pn junction is in reverse biased condition, no current flow occurs.*

The important term often used with *pn* junction is breakdown voltage which is explained as follows:

4.3.4 Breakdown voltage

"It is the minimum reverse voltage at which PN junction breakdown with sudden rise in reverse current".

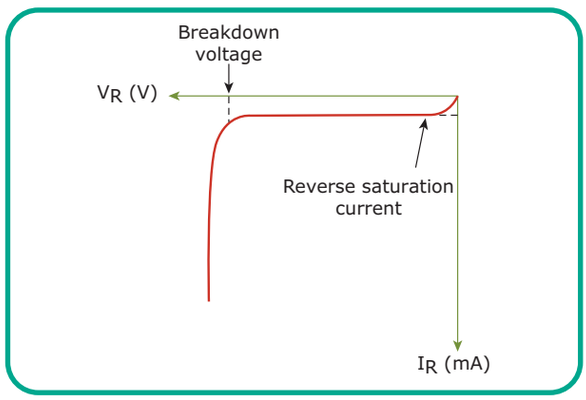

Figure 4.6 Characteristics of PN junction diode (Reverse bias)

The figure 4.6 shows the Characteristics of PN junction diode (Reverse bias)

4.4 RECTIFIER

Rectifier is a device which converts the sinusoidal AC voltage into either postive or negative pulsating DC

4.4.1 Types of rectifier

There are few types of rectifier given in Figure 4.7.

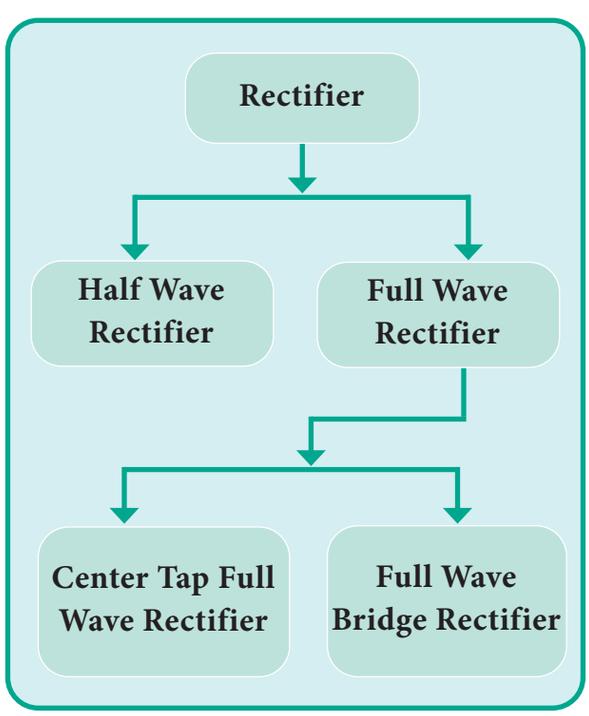

Figure 4.7 Type of Rectifiers

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4.4.2 Half-wave Rectifier

This rectifier converts an AC input voltage into pulsating DC voltage for only one half cycle of the applied voltage. The circuit diagram of the half wave rectifier is shown in Figure 4.8(a).

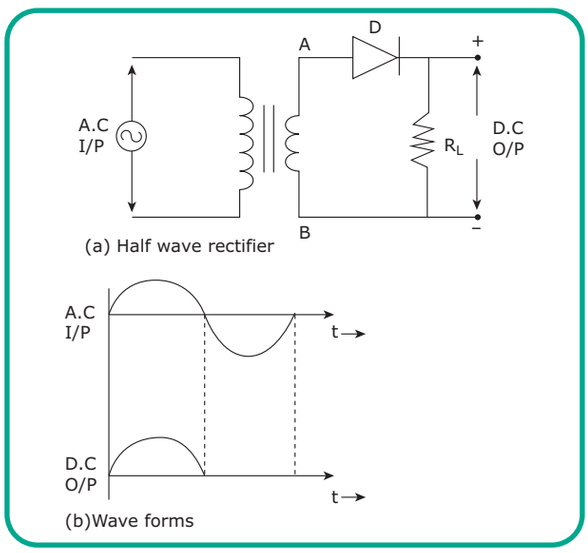

Figure 4.8 Half-wave Rectifier

During the positive half cycle, when the secondary winding of the upper end (A) is positive with respects to the lower end (B), the diode 'D' is under forward bias condition and it conducts current, this Current appears across the load R_L.

During the negative half cycle when the lower-end (B) winding of the secondary is positive with respect to the upper-end (A), the diode D is under reverse-bias condition and it does not conduct current. Hence the current across the load resistance is zero and so no power is delivered during the negative half-cycle. Thus the diode D conduct only one cycle (positive (or) negative) of the AC input so it is called as half wave rectifier.

Figure 4.8(b) shows the output wave forms of half wave rectifier

The output voltage of a half-wave rectifier is calculated using the relationship $\frac{E_{max}}{\pi}$

Where E_{max} is the maximum voltage of the input and π is the phase angle (180°)

$$Ripple\ factor = f\ X\ 1$$

Where f is the frequency.

$$Efficiency = 40.6\%$$

4.4.3 Full-wave Bridge Rectifier

As the centre-tapped transformer is expensive and is difficult to implement, bridge rectifier was developed. In this, four diodes are arranged in the form of a bridge-configuration to produce the desired output. Bridge rectifier are most widely used in high voltage applications. Bridge rectifiers are most widely used in high voltage applications. Figure 4.9 shows the full wave bridge rectifier circuit.

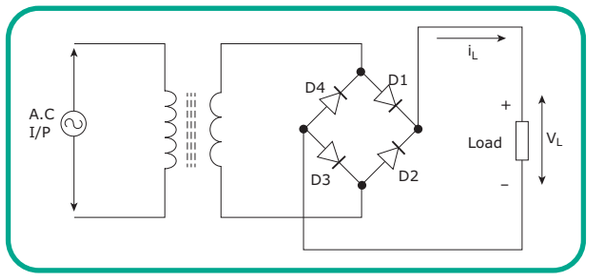

Figure 4.9 Full-wave bridge rectifier circuit

The four diodes labeled D_1, D_2, D_3 and D_4 are arranged in series pairs with only two diodes conducting current during each half-cycle.

During the positive half cycle of the supply, diodes D_1 and D_3 are under forward bias condition and these diodes conduct current and across the load R_L while D_2 and D_4 are reverse-biased and these diodes those not conduct current.

During the negative half cycle of the supply, diodes D_2 and D_4 are under

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forward bias condition and these diodes conduct current and across the load R_L while D_1 and D_3 are reverse-biased and these diodes does not conduct current.

The bridge rectifier is also called the full wave rectifier as it produces an output pulse for each half-cycle of the input sine wave. The input and output waveforms are shown in figure 4.10.

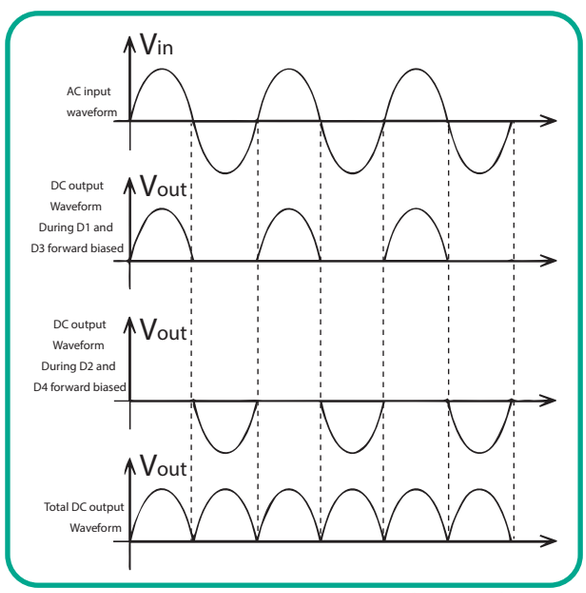

Figure 4.10 Input and output waveforms of bridge rectifier

$$\text{Output of the full wave rectifier} = \frac{2E_{max}}{\pi}$$

$$\therefore \text{ The Average DC Voltage } = 0.637\,E_{max}$$

$$\text{Ripple Factors} = 2 \times f$$

$$\text{Efficiency} = 81.2\%$$

4.5 FILTER CIRCUITS

To remove the AC components or filter-out them in a rectifier circuit, a filter circuit is used. A filter circuit is a device to remove the AC components of the rectifier output (pulsating DC – it is also called ripples), but allows the DC components to reach the load.

A filter circuit consists of passive elements, i.e., inductors, capacitors, resistors and their combinations. Some of the important filters are given below.

1. Inductor or Choke filter
2. Capacitor filter
3. RC filter
4. Inductor-Capacitor filter (LC filter)
5. π filter or CLC filter

4.5.1 CLC Filter or π Filter

Figure 4.11 shows the CLC filter circuit. It consists of one inductor and two capacitor connected across its each end. The three components are arranged in shape of Greek letter pie (π). The input capacitor C_1 is selected to offer very low reactance to the respective frequency, hence major parts of filtering is done by C_1. Most of the remaining ripples are removed by the combining action of L and C_2. This filter is used for the low current equipment.

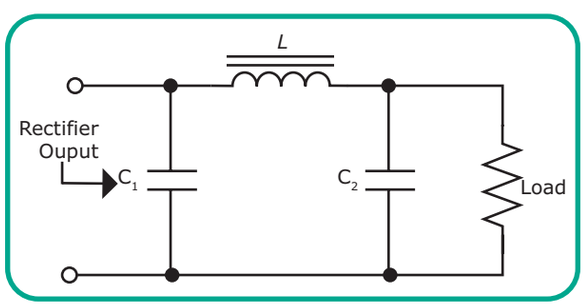

Figure 4.11 CLC (or) Pi Filter

4.6 VOLTAGE REGULATOR

Voltage Regulator is used to maintain a constant DC output voltage Zener diode is used as voltage regulator.

"A properly doped crystal diode which has a sharp breakdown voltage is known as a zener diode."

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It may be seen that it is just like an ordinary diode except that the bar is turned into z-shape.

The figure 4.12(a) shows the symbol of Zener diode. Figure 4.12(b) shows the characteristics of Zener diode. The breakdown or zener voltage depends upon the amount of doping. If the diode is heavily doped, depletion layer will be thin and consequently the breakdown of the junction will occur at a lower reverse voltage. On the other hand, a lightly doped diode has a higher breakdown voltage.

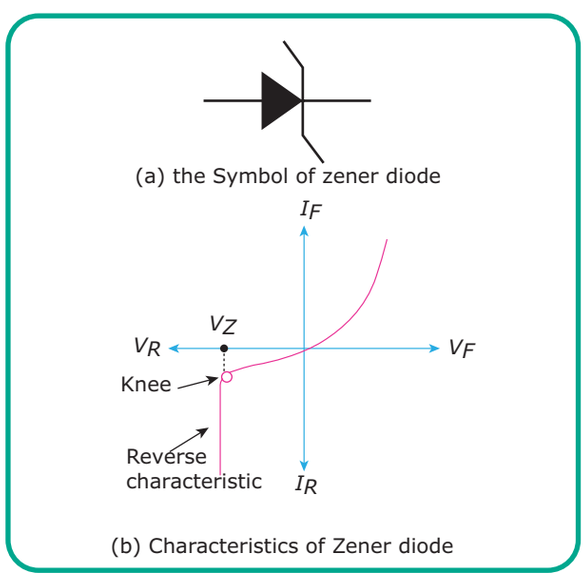


Figure 4.12 Symbol and characteristics of zener diode

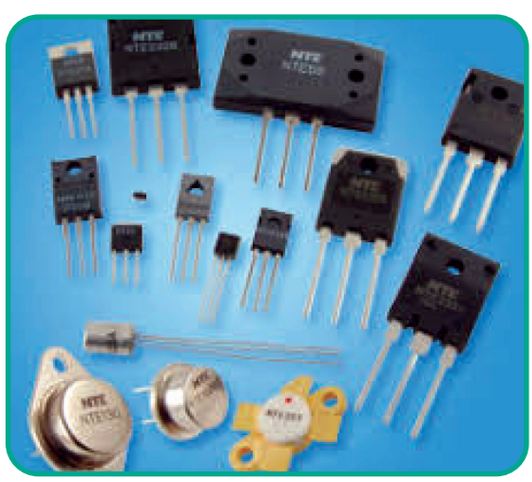
The following points may be noted about the zener diode:

1. A zener diode is like an ordinary diode except that it is properly doped so as to have a sharp breakdown voltage
2. A zener diode is always reverse connected i.e. it is always reverse biased.
3. A zener diode has sharp breakdown voltage, called zener voltage V_Z.
4. When forward biased, its characteristics are just those of ordinary diode.
5. The zener diode is not immediately burnt just because it has entered the breakdown region. As long as the external circuit connected to the diode current to less than burn out value, the diode will not burn out.

4.7. TRANSISTOR

It is made up of semiconductor material such as Si and Ge. Usually, it comprises of three terminals namely, base, emitter and collector for providing connection to the external circuit. Today, some transistors are packaged individually and many transistors are fabricated according to the design of an embedded integrated circuits.

A transistor is a semiconductor device used to amplify or switch electronic signals and electrical power.



Types of Transistors

Types of transistors

1. Bipolar Junction Transistor (BJT)
2. Field Effect Transistor (FET)

Bipolar Junction Transistor

Bipolar junction transistors consists of three semiconductor regions namely Base,

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Emitter, Collector forming two junctions. It is a current controlled device. There are two types of BJT's

1. NPN Transistor
2. PNP Transistor

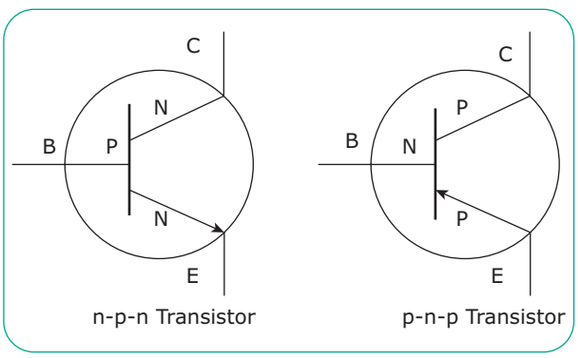

Figure 4.13 NPN and PNP Transistors

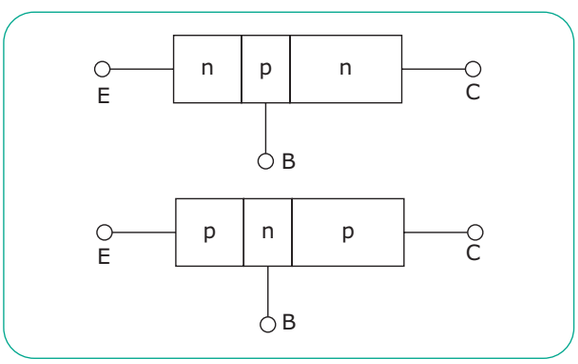

Figure 4.14 NPN and PNP Transistor

Figures 4.13 and 4.14 show the symbol and structure of NPN and PNP transistor, respectively.

4.7.1 SMD Transistor

A SMD transistor is a type of transistor that is directly soldered on the copper points in the surface of printed circuit board.

Advantage of SMD Transistor

1. There is no need to make holes in printed circuit board.
2. Smaller in size.

4.8. SOME FACTS ABOUT THE TRANSISTOR

1. The transistor has three regions, namely emitter, base and collector.
2. The base is much thinner than the emitter while collector is wider than both.
3. Usually the emitter is heavily doped, the base is lightly doped and very thin and the collector is moderately doped to collect majority carriers from the emitter
4. As the emitter is heavily doped, it can inject large number of charge carriers (electrons or holes) into the base.
5. The transistor has two PN junctions termed as the base-emitter junction and the base-collector junction.
6. In order to operate the transistor properly the two junctions must have the correct DC bias voltages.
7. Base-emitter junction is forward biased whereas base-collector junction is reverse biased.
8. The resistance of first junction is very small compared with the second junction. So, forward bias voltage applied to the first junction is very small compared to the second junction.

4.9. TRANSISTORS BIASING

Transistor biasing is the process of setting a transistor DC operating voltage or current condition to the required level. So that, any AC input signal can be amplified correctly by the transistor.

Various methods of transistor biasing

1. Fixed bias.
2. Feedback bias.
3. Voltage divider bias.

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Of these three biasing, voltage divider biasing is most commonly used.

4.9.1 Voltage Divider Bias

This is the most commonly used biasing arrangement, as it provides good bias stability. The emitter resistance R_E provides stabilization. The resistance R_E causes a voltage drop in a direction so as to reverse bias the emitter junction. Since the emitter base junction has to be forward biased, the base voltage is obtained from the supply through R_1-R_2 network. The net forward bias across the emitter base junction is equal to V_B–DC voltage drop across R_E. The DC bias circuit is independent of transistors β to avoid the loss of AC signal. A capacitor having large capacitance is connected across R_E to bypass the unwanted AC fluctuations. Figure 4.15 shows voltage divider method of a transistor.

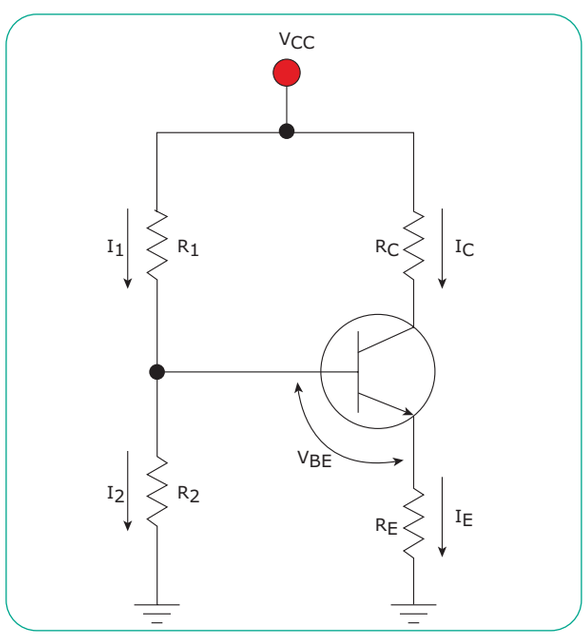

Figure 4.15 Voltage divider bias

4.10 OPERATING MODES OF TRANSISTORS

Depending on the biasing conditions like forward or reverse, BJT's have three major modes of operation namely, active, saturation and cut-off regions.

Active Mode : When Emitter Base junction is forward biased and Collector Base junction is reverse biased then the transistor reaches active mode. Here the transistor acts as an amplifier. In this mode emitter current depends on base current.

Saturation Mode: When both Emitter Base junction and Collector Base junction are forward biased the transistor reaches saturation mode. Here the transistor is " Fully ON " and operating as a closed switch. In this mode both base current and collector are high. Collector current will not depend on base current.

Cutoff Mode: When both Emitter Base junction and Collector Base junction are reverse biased, then the transistor reaches cutoff mode. Here the transistor is " Fully OFF " and operating as an open switch. In this mode base current and collector is zero.

4.11 WORKING OF NPN TRANSISTOR

4.11.1 Working of NPN transistor

Figure 4.16 shows the NPN transistor with forward bias to the emitter-base junction and reverse bias to collector-base junction.

The forward bias causes the electrons in the N-type emitter to flow towards the base. This constitute the emitter current I_E.

As these electrons flow through the p-type base, they tend to combine with holes.

As the base is lightly doped and very thin, only a few electrons (less than 5%) combine with holes to constitute base current I_B. The reminder electrons (more

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than 95%) cross-over into the collector region to constitute collector current I_C.

In this way, almost the entire emitter current flows to the collector circuit. It is clear that emitter current is the sum of collector and base current, i.e. $I_E = I_B + I_C$.

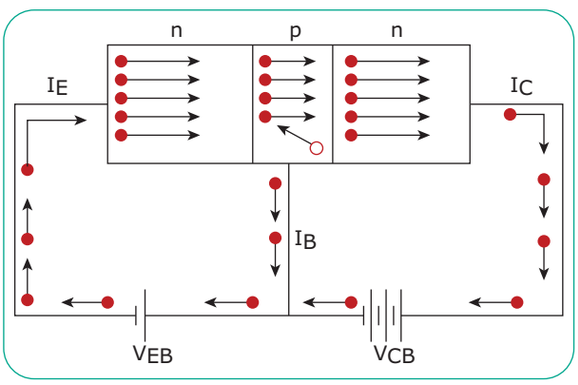

Figure 4.16 Working of NPN transistor

4.12 TRANSISTOR AS A SWITCH

With a zero signal applied to the base of the transistor, it turns OFF acting like an open switch and zero collector current flows through the device.

With a positive signal applied to the base of the transistor, it turns ON acting like a closed switch and maximum circuit current flows through the device.

Figure 4.17 shows how a transistor act as a switch.

4.13 TRANSISTOR AS AN AMPLIFIER

It amplifies the strength of the weak signal. Usually transistor and IC are used for amplification.

Transistor as an Amplifier

With the help of circuit diagram, we explain how a transistor acts as an amplifier.

Figure 4.18 shows the basic circuit of a transistor amplifier. The weak signal to be amplified is applied as the input signal between the emitter-base junction and the output is taken across the load R_L. For faithful amplification, the input circuit is forward biased and the output circuit is reverse biased. For this purpose, we apply dc voltage.

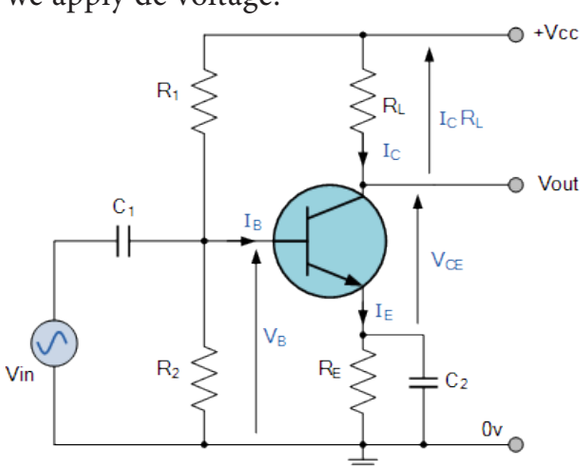

Figure 4.18 Basic Circuit of a transistor amplifier

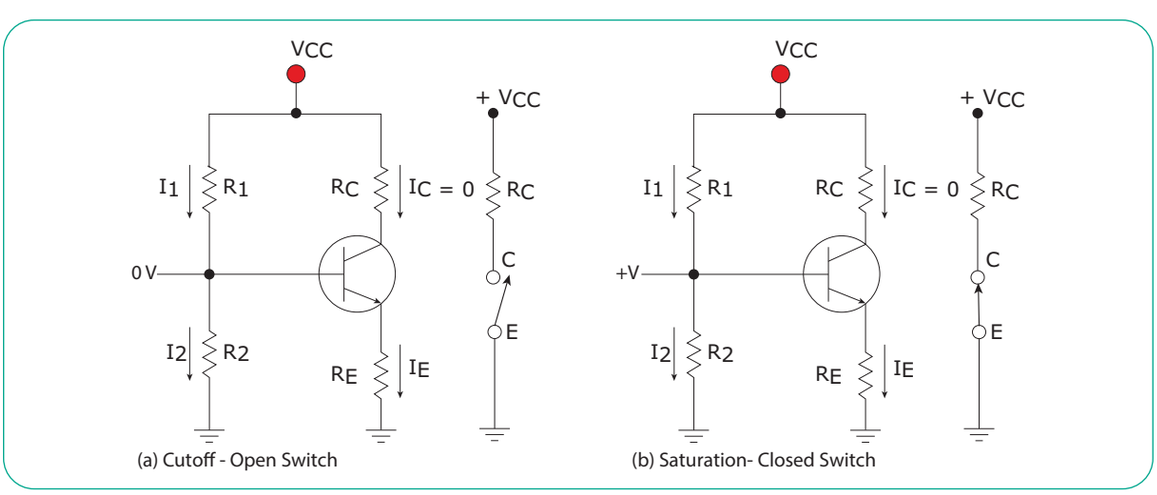

Figure 4.17 Transistor as a switch

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As we know, the input circuit has low resistance; consequently, a small change in the signal voltage occurs at the input circuit lead to an appreciable change in the emitter current. Due to the transistor action, change in emitter current causes a similar change in the collector current. Now, the collector current flows through a high load resistance R_L, which produces a large voltage across R_L.

Thus, the weak signal applied in the input circuit appears in the amplified form in the collector circuit. In this way, transistor acts as an amplifier. For power amplification, heat sinks are used to fix the transistor in order to dissipate the heat generated from the power transistor.

Heat Sink

A metal plate specially designed to conduct and radiate heat from an electronic component. A layer of material place within the outer skin of high-speed aircraft to absorb heat.

4.14. TRANSISTOR CONFIGURATIONS & CLASSIFICATION OF AMPLIFIERS

A transistor is a three terminal device, (i.e., base, emitter, collector). But it require four terminals for connecting it in circuits.

(i.e.) Two terminals for input, two terminals for output.

Hence one of the terminal is made common to the input and output circuits. Common terminal is grounded.

Types of Configuration

Three types of configuration is available

1. *Common Base configuration (CB)*
2. *Common Emitter configuration(CE)*
3. *Common Collector configuration(CC)*

Among the above the Common Emitter configuration is essential. Hence let we see about it

Common Emitter Configuration

Common emitter configuration is shown in the figure 4.19. In this circuit emitter is placed common to both input and output terminals.

It has both current gain and voltage gain. So it is the most widely used circuit in all transistor applications.

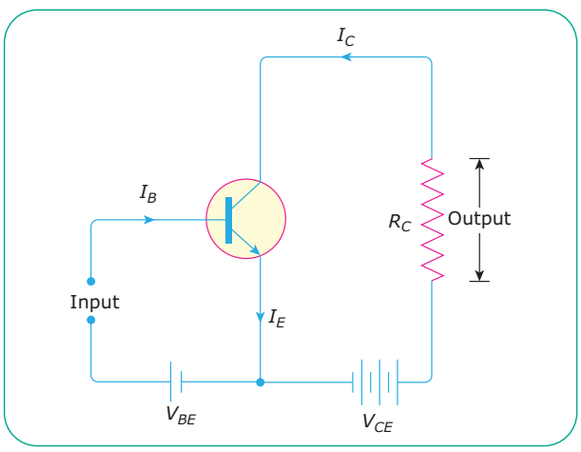

Figure 4.19 Common Emitter configuration

Classification of Transistor amplifiers.

Depending upon the configuration

1. Common base amplifier
2. Common emitter amplifier
3. Common collector amplifier

Depending upon the operations

1. Class A amplifier
2. Class B amplifier
3. Class AB amplifier
4. Class C amplifier

Based on the frequency

1. Radio frequency amplifier
2. Intermediate frequency amplifier

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3. Audio frequency amplifier
4. Ultrasonic amplifier
5. Wide band amplifier
6. Video frequency amplifier
7. Buffer amplifier
8. Operational amplifier

Depending upon the property of their output

1. Voltage amplifier
2. Current amplifier
3. Power amplifier

Depending upon the coupling

1. RC coupled amplifier
2. Direct coupled amplifier
3. Transformer coupled amplifier

Here we study about few amplifiers

1. RC Coupled Amplifier

This is the most popular type of coupled amplifier because it is cheap and provides excellent audio fidelity over a wide range of frequency. It is usually employed for voltage amplification.

Figure 4.20 shows two stages of an RC coupled amplifier. A coupling capacitor C_C is used to connect the output of first-stage to the base (i.e. input) of the second-stage and so on. As the coupling from one stage to next is achieved by a coupling capacitor followed by a connection to a shunt resistor, therefore, such amplifiers are called resistance-capacitance coupled amplifiers.

Operation: When an AC signal is applied to the base of the first transistors, it appears in the amplified form across its collector load R_C. Then, the amplified signal is given to the base of next stage through coupling capacitor C_C. The second stage does further amplification of the signal. In this way, the cascaded (one after another) stages amplify the signal and the overall gain is considerably increased.

Application

RC coupled amplifiers are used in

1. RF Communication
2. Voltage amplifiers
3. Public Address System as pre amplifiers.
4. Small signal amplifiers in Radio and Television Receivers.

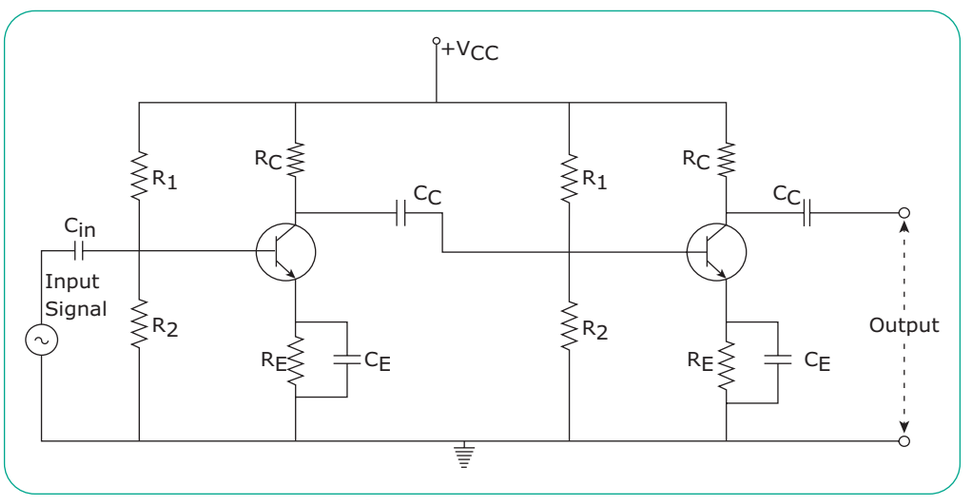

Figure 4.20 Stages of an RC coupled amplifier

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2 Complementary Symmetry Amplifier

Complementary Symmetry is based on the principle of assembling a push-pull class B amplifier without requiring centre-tapped transformers, at the input and output stages.

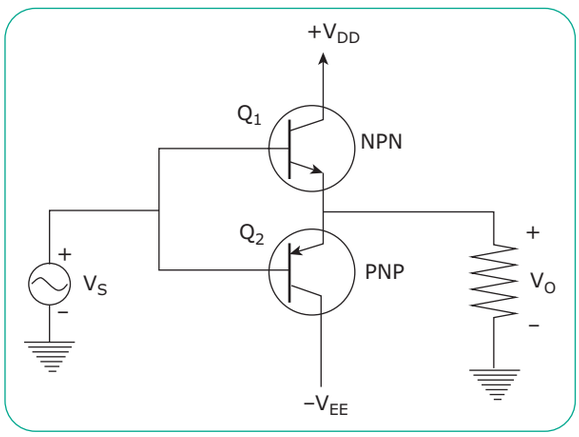

Figure 4.21 Simplified complementary symmetry amplifier

Figure 4.21 shows the transistor push-pull amplifier using complementary symmetry. It employs one NPN and one PNP transistor and requires no centre-tapped transformers. The circuit action is follows. During the positive half cycle of the input signal, transistor Q_1(the NPN transistor) conducts current while Q_2(the PNP transistor) is cut-off. During the negative half cycle of the input signal, transistor Q_2 (the PNP transistor) conducts current while Q_1 (the NPN transistor) is cut-off.

In this way, NPN transistor amplifies the positive half cycles of the signal while the PNP transistor amplifies the negative half cycles of the signal. Note that we generally use an output transformer (not centre tapped) for impedance matching.

Advantages

1. This circuit does not require transformer. It reduces both weight and cost.
2. Equal and opposite input signal voltages are not required.

Disadvantages

1. It is difficult to get a pair of transistors (NPN and PNP) having similar characteristics.
2. It requires both positive and negative supply voltages.

Application

This type of amplifier is used in

1. Stereo amplifiers.
2. Digital Switching designs.

4 Voltage Amplifier and Power Amplifier

Voltage Amplifier

Voltage amplifier improves the low voltage signal to a higher voltage one. The first stage of voltage amplifier is called pre-amplifier. The next stage of voltage amplifier is called driver amplifier. Figure 4.22 shows the Voltage amplifier used in audio circuits.

Power Amplifier

A power amplifier improves a low power signal to a higher power one. Two common examples are audio amplifiers and RF

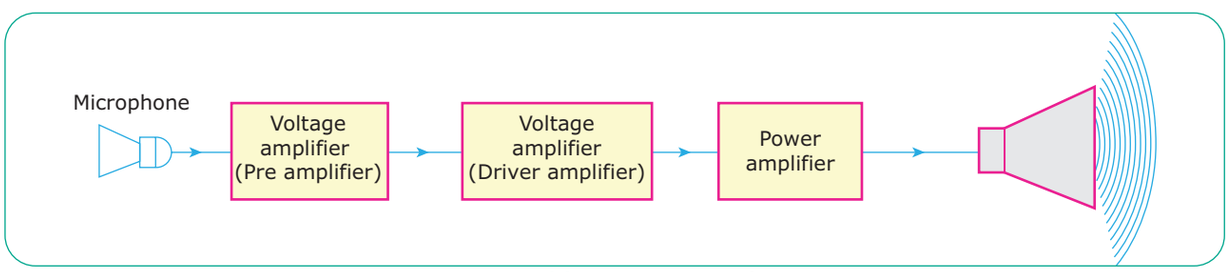

Figure 4.22 Voltage Amplifier

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Table 4.1 Comparison of Voltage and Power Amplifier			
S.NO	**Basic for Comparison**	**Voltage amplifier**	**Power amplifier**
1	Basic	It raises the voltage level	It raises the power level
2	Known as	Small signal amplifier	Large signal amplifier
3	Magnitude of input signal	Small	Comparatively large
4	Types of coupling used	RC Coupling	Transformer Coupling
5	Base region	Thin	Thick
6	Value of Ic	Low (around 1mA)	Quite high (Nearly 100mA)
7	Value of β	Low (5 to 20)	High (100)
8	Physical size of transistor	Small	Large
9	Heat dissipation	Less	More
10	Load Impedance	High (4 kΩ to 10 kΩ)	Low (5 to 20Ω)

power amplifiers. Audio amplifiers are used to drive loud speakers and head phones. RF power amplifiers are used in the final stage of transmitters.

Comparison between voltage and power amplifier is given in the Table 4.1.

4.15 FEED BACK IN AMPLIFIERS

The process of injecting a fraction of output energy back to the input is known as feedback

There are two basics types of feedback in amplifiers

1. Positive Feedback
2. Negative Feedback

4.16 DISTORTION IN AMPLIFIERS

The change in output wave-shape from the input wave-shape of an amplifier is known as distortion.

The distortion can be classified as follows

1. Amplitude distortion
2. Phase distortion
3. Frequency distortion

4.17 APPLICATIONS OF A TRANSISTOR

1. Transistors are used in digital and analog circuits as a switch.
2. Transistor uses in signal amplifier devices.
3. Transistors can be used for oscillator.
4. Cellular phones would be one of the most widely used applications of transistors. Every cell phone uses a transistor amplifier.
5. Transistor uses in power regulator and controllers.
6. Transistors are used in building some of the integrated circuits.(IC).
7. The microprocessor includes more than thousands of transistors in each chip.
8. In military, the transistor's are used in high-power radio frequency (RF) RADAR and walkie talkie.

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LEARNING OUTCOMES

After studying this Chapter, a student can understand the following

1. **Need of power supply**
2. **Types of AC to DC supply**
3. **Efficiency of power conversion**
4. **Power supply applications**
5. **Understanding transistor configurations.**
6. **Analysing the transistor applications.**

GLOSSARY

S. No	Terms	Explanation
1	**Step down transformer**	Transformer in which the output AC voltage is less than the input AC voltage
2	**Rectification**	Process that converts alternating current to direct current
3	**Regulator**	Device or circuit that maintains a desired output under changing conditions
4	**Ripple voltage**	The small variation in DC voltage that remains after filtering in a Power supply
5	**Filter**	Network consisting of capacitors, resistors and inductors used to pass certain frequencies and block others

QUESTIONS

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PART A

I. Choose the Best Answer

1. The output of a rectifier is
   a) Pulsating DC b) Pure DC
   c) Pure AC d) None of the above
2. In a full wave bridge rectifier, if AC supply is 50 Hz then AC ripple in the output is
   a) 50 Hz b) 100 Hz
   c) 25 Hz d) 200 Hz
3. For high voltage applications, we use
   a) Center tap rectifier
   b) Bridge rectifier
   c) Half-wave rectifier
   d) None of the above
4. In filter circuits, we generally use ..... capacitors.
   a) Mica b) Paper
   c) Air d) Electrolytic
5. The maximum rectification efficiency in full wave bridge rectifier is
   a) 100% b) 81.2%
   c) 66.6% d) 40.6%
6. The number of junction in a transistor .....
   a) One
   b) Two
   c) Three
   d) Four

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7 A transistor is a …….. operated device.

a) Current
b) Voltage
c) Both voltage and current
d) None of the above

8. A heat sink is generally used with a transistor to ……

a) Increase the forward current
b) Decrease the forward current
c) Compensate for excessive doping
d) Prevent excess temperature

9. A complementary symmetry amplifier has

a) 1 PNP & 1 NPN transistor
b) 2 PNP transistor
c) 2 NPN transistor
d) 2 P channel FETS

10. The most commonly used transistor arrangement is ……..

a) Common emitter
b) Common base
c) Common collector
d) None of the above

PART B

II. Answer in few sentences 3 Marks

1. What are the types of power conversion?
2. What is rectification?
3. Give the uses of filter circuits.
4. What is meant by a transistor?
5. Give the symbol of PNP and NPN transistor
6. Define an amplifier
7. What are the diffirent modes of transistor?
8. Define feedback
9. What is distortion?
10. Write down the types of distortion occurs in amplifier.

PART C

III. Answer the following Questions.

5 Marks

1. Draw the block diagram of power supply unit and explain each block.
2. Explain half-wave rectifier with circuit diagram.
3. Explain the working principles of NPN transistor
4. Compare voltage amplifiers and power amplifiers.
5. What are the applications of transistor?

PART D

IV. Answer the following Questions.

10 Marks

1. Draw the circuit diagram of bridge rectifier and explain its working function.
2. Explain how transistor works as an amplifier.
3. Explain the working principle of RC coupled amplifier.

Answer Key

1. (a) 2. (b) 3. (b) 4. (d) 5. (b)
6. (b) 7. (c) 8. (d) 9. (a) 10. (a)

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CHAPTER 5

SPECIAL TYPE SEMICONDUCTOR DEVICES

LEARNING OBJECTIVES

While learning this Chapter, the student will

1. **Understand the basic concepts of special type of semiconductor devices.**
2. **Describe the working principles of special semiconductor devices.**
3. **Understand the switching action of Thyristor devices.**
4. **Know about various applications of the semiconductor devices.**

INTRODUCTION

We are experiencing many hoardings, advertising displays, high definition television in our daily routine life. Of course, these devices have very good features with long life and attractive characteristics. Do you have any idea about these devices and their origin? Most of these devices are built around a special type of semiconductor devices called LED, LDR, LCD, photodiode and photo transistor. They are opto-electronic devices.

With these devices we study about the working of FET, MOSFET, SCR, DIAC, TRIAC, IGBT and their application.

5.1 LIGHT EMITTING DIODE (LED)

LED is a PN junction device, which emits light when forward biased, by a phenomenon called electroluminescence. In all semiconductor PN junctions, some energy will be radiated as heat and some in the form of photons.

LEDs are widely used in indicators, smart phones, digital watches, solid state video displays, calculators, digital computers, electronic panels and optical communication system.

Construction

Figure 5.1 shows the construction of LED and its symbol. Here, an *N* type layer is grown on a substrate over which a *P* type layer is deposited by the process called diffusion. The metal anode connection is made at the outer edges of the 'P' layer. It provides more central surface area for the light to escape.

LEDs radiate different colours like red, green, yellow, orange, blue and white depend on material used. Some LEDs emit infrared (invisible) light also. The colour of the emitted light depends on the type of material used as given below.

- Gallium arsenide (*GaAs*)–Infrared Radiation (Invisible)
- Gallium phosphide (*GaP*) –Red or Green

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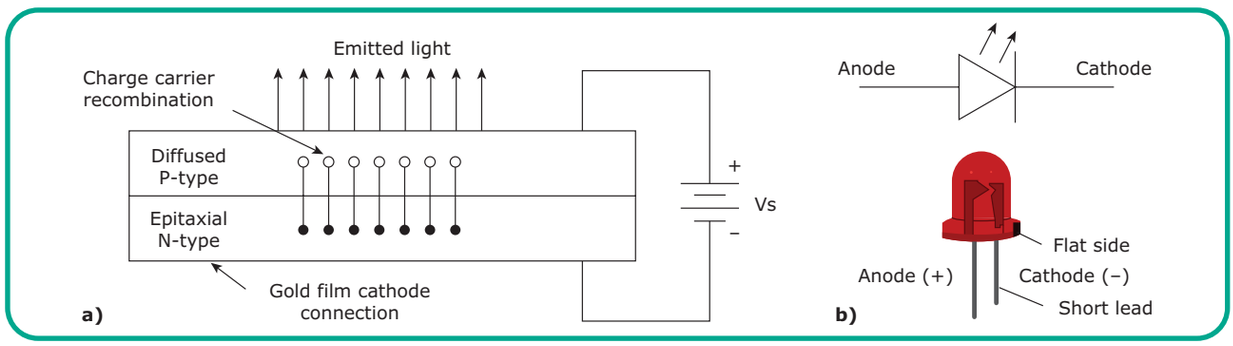

Figure 5.1 Construction and Symbol of LED

- Gallium arsenide phosphide (*GaAsP*)-Red or Yellow

Working Principle

When an LED is forward biased, the electrons and holes move towards the junction and recombination takes place. This makes the electrons lying in the conduction band of *N* region fall into the holes lying in the valence band of *P* region.

The difference of energy between the conduction band and the valance band is radiated in the form of the light energy. The brightness of the emitted light is directly proportional to the forward bias current.

Advantages

- LED can be switched ON and OFF at very fast speed (1 ns).
- Its operating voltage is from 1.5 V to 3.3 V with low current (some mA).
- It has a life time of 1,00,000 hours.
- LEDs are small in size and light in weight.
- They require no heating and warm up time.

5.1.1 Seven Segment LED

LEDs are often grouped to form seven segment displays. They are generally used as numerical indicators and consist of a number of LEDs arranged as seven segments as shown in the Figure 5.2.

The seven LEDs are labelled *A* through *G*. By forward biasing different LEDs, we can display the digits 0 to 9. For example, if LEDs *A,B,C, D and G* are lit (by forward biasing them), then the display will show the number 3.

There are two types of seven segment LED arrangement, they are

- Common Anode Type
- Common Cathode Type

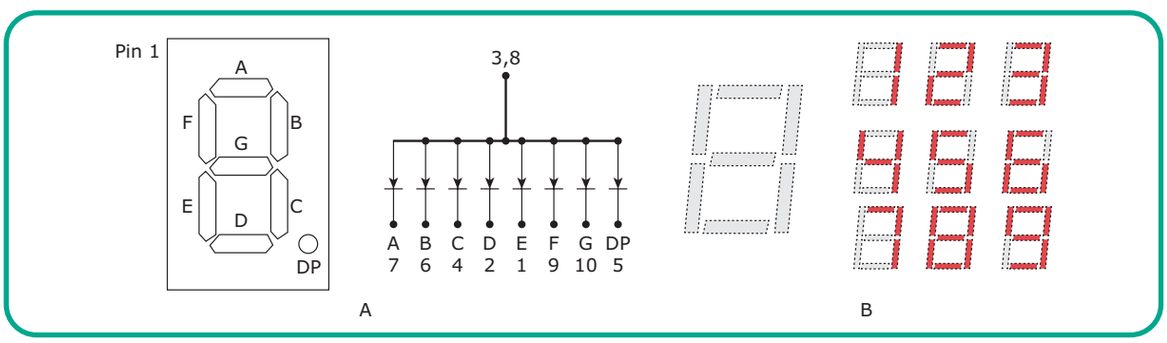

Figure 5.2 Seven Segment LED

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5.2. LIQUID CRYSTAL DISPLAY (LCD)

Liquid Crystal Display (LCD) are used for displaying of numeric and alphanumeric character in dot matrix and segmental displays. There are two types of liquid crystal materials used, they are nematic and cholesteric. In the Nematic Liquid Crystal (NLC), all the molecules align themselves approximately parallel to a unique axis, while retaining the complete translational freedom.

The liquid is normally transparent, but if subjected to a strong electric field, disruption of the well-ordered crystal structure takes place causing the liquid to polarise and turn opaque. The removal of the disruption of the crystal structure regains its original form and the materials become transparent.

They are,

1. Dynamic scattering type
2. Field effect type

5.2.1. Dynamic Scattering LCD

Construction: Figure 5.3 shows the construction of dynamic scattering LCD. The display consists of two glass plates, each coated with tin oxide (SnO_2) on the inside with transparent electrodes separated by a liquid crystal layer of 5 to 50 μm thick. The oxide coating on the front sheet is etched to produce a single or multi-segment pattern of characters with each segment properly insulated from each other.

Working Principle: Figure 5.3 shows the LCD working principle**.** When AC voltage is not applied to the plates of the molecules of liquid crystal, which align themselves in perpendicular (or parallel) direction and appear transparent. When a voltage is applied across the conductive coatings, the arrangement of molecular pattern gets disturbed. As a result, refractive index of the medium of the crystal changes. Therefore, the incident light is reflected in different directions. Now, the liquid appears dark in the white background. The area not enclosed by conducting surfaces remains translucent.

Advantages of LCD

1. The operating voltage required is small (3 to 20 V/AC).
2. They are economical.
3. They have low power consumption.

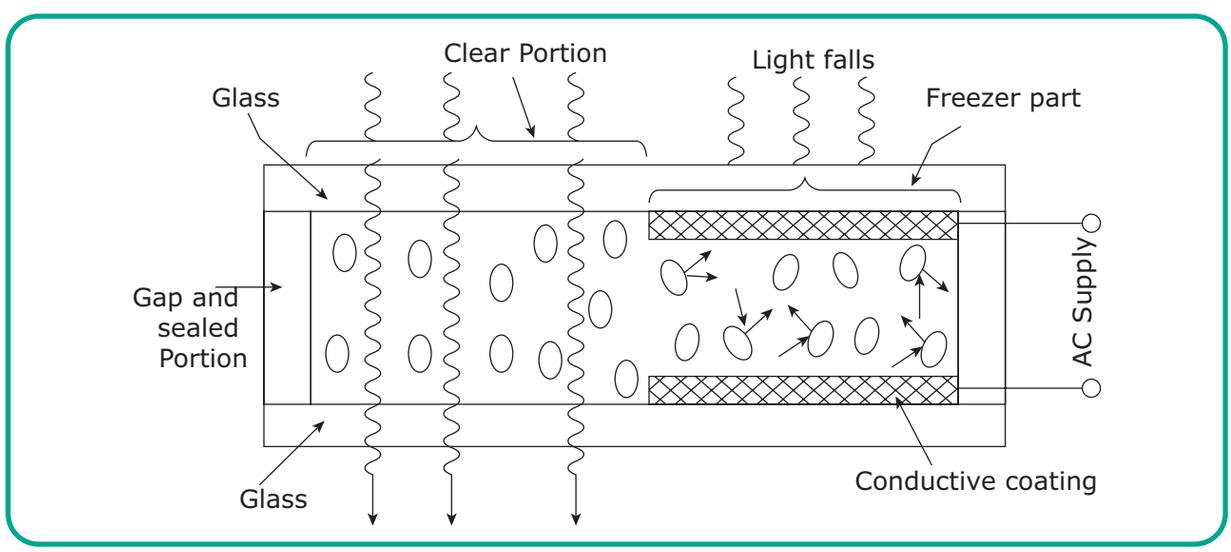

Figure 5.3 LCD Working

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TABLE 5.1	
LED	**LCD**
Consumes more power (10-250 mW per digit)	Consumes less power (10-200 mW per digit)
Good brightness level	Moderate brightness level
Lifetime is around 1,00,000 hours	Lifetime is limited to 50,000 hours due to chemical degradation
Operating voltage range is from 1.5 V to 3.3 V DC	Operating voltage range is from 3 to 20 V AC
Emits light in red, green, orange, yellow, blue and white	Invisible in darkness and requires external illumination

Disadvantages of LCD

1. LCD requires an external or internal light source. (poor visibility in darkness)
2. Its life time is limited due to chemical degeneration.
3. It operates slowly. Turn-On time is few ms.

When used on DC, the life-span is quite small and therefore, they are used with AC supplies having a frequency less than 50 Hz.

Application of LCD

1. It is used in solid state video displays.
2. It is used in laptop computers.
3. It is used in pocket calculators.
4. It is used in instrument displays and digital watches.
5. It can be used as numerical counter for counting items.

Comparison of LED and LCD

Table 5.1 is the comparison between LED and LCD.

5.3. PHOTO TRANSISTOR

Photo transistor is a much more sensitive semiconductor photo device than the PN photodiode. The current produced by a photodiode is very low which cannot be directly used in control applications. Therefore, this current should be amplified before applying to the control circuits. The photo transistor is a light detector which combines a photodiode and a transistor amplifier. When the photo transistor is illuminated, it permits the flow of current.

Figure 5.4 shows the NPN photo-transistor. It is usually connected in common emitter (CE) configuration with base open. A lens focuses the light on the base-collector junction. The modern photo transistor uses efficient light effective materials instead of making a hole and fixing a lens on it. Photo transistor has three terminals, but only two terminals are generally used. Here the base current is supplied by the current created by the light falling on the base-collector junction.

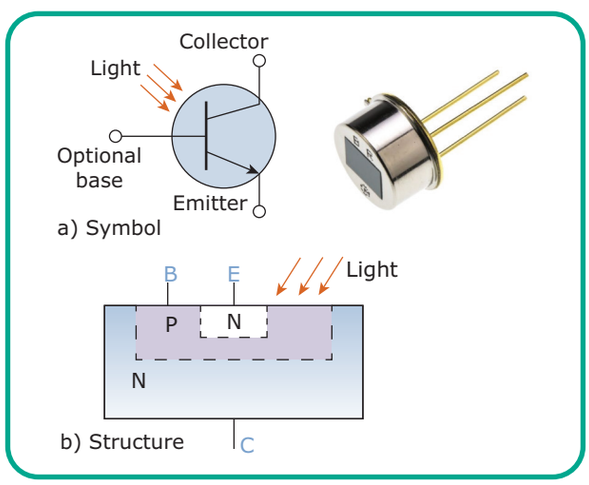

Figure 5.4 NPN Photo Transistor

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The voltage (V_{CE}) applied to the transistor makes emitter-base junction forward biased and collector-base junction reverse biased. When the transistor is kept in darkness, there will be a very few minority charge carrier flow. This makes negligible collector current. When the light is turned '*ON*', and focused at the collector-base junction, the transistor starts conducting and the amplified current starts flowing through the reverse-biased junction. The amount of current flow depends upon the intensity of focused light.

Application

1. They are used in light detection system.
2. They are widely used in high speed reading of computer punching cards.
3. They also used in light operating switches.

5.4. SOLAR CELL

It is widely used in satellites to provide electrical power, when sunlight is incident on a photovoltaic cell. It is converted into electric energy and the energy converter is called solar cell or solar battery. Basically, solar cell is large PN junction diode. It is made up of Silicon and Selenium.

Construction: Figure 5.5 shows the basic construction of PN junction solar cell. It consists of single semiconductor crystals, which has been doped with both *P* and *N* type impurities, thereby forming a *PN* junction. A glass window is provided at the top of the *P* type layer. The thickness of the *P* layer is small, so that the incident light can easily reach the junction of the diode. A nickel plated ring is provided around the *P* layer, which acts as a positive terminal. A metal contact provided at the bottom of the *N-layer*, acts as negative terminal.

Working Principle: The sunlight incident on the glass plate passes through and reaches the junction. An incident light photon at the junction may collide with a valence electron and impart sufficient energy to make a transition to the conduction band. As a result, an electron-hole pair is formed. The newly formed electrons are minority carriers in the *P* region. They move freely across the junction. Similarly, holes formed in the *N-region* cross the junction in the opposite direction. The flow of these electrons and

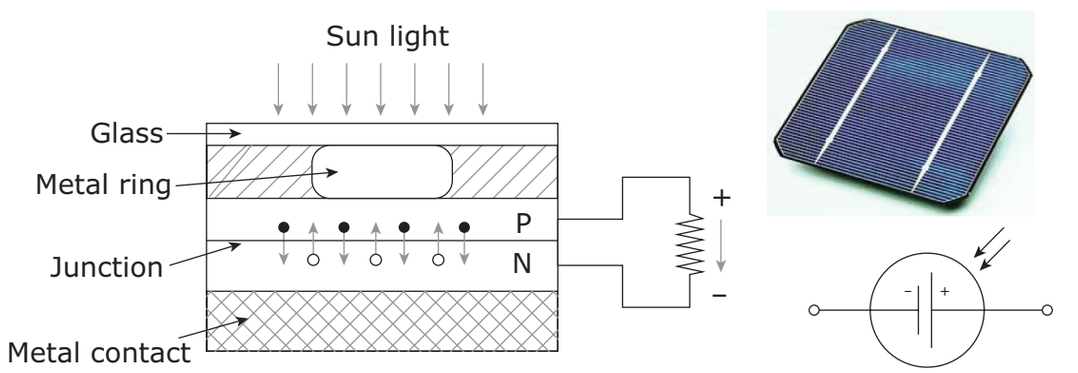

Figure 5.5 Basic Construction of PN Junction Solar Cell

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holes across the junction is in a direction opposite to the conventional forward current in a *PN* junction. Further, it leads to the accumulation of majority carriers on both sides of the junction.

In bright sunlight, 0.6 V is developed by a single solar cell. The amount of power the cell can deliver depends on the extent of its active surface. An average cell will produce about 30 mW per square inch of surface, operating in a load of 4 Ω. To increase the power output, large banks of cells are used in series and parallel combinations.

Application

1. It is used to provide electrical power to satellites and space vehicles
2. It is used to energize these storage cells
3. It is also used in home for electrical requirements.

5.5. FIELD EFFECT TRANSISTOR (FET)

In the previous Chapters, we have discussed about the Bipolar Junction Transistor (BJT). They are controlled by both electrons and holes and called current operated devices. BJT has two main disadvantages; first, it has low input impedance because of forward biased emitter junction. Secondly, it has considerable noise level.

To overcome the above problems, FET can be developed and become important electronic device in the integrated circuit (IC) technology. The FET is a device in which the flow of current through the conducting region is controlled by an electric field (voltage).

There are two types of field effect transistor,

1. Junction Field Effect Transistor (JFET)
2. Metal Oxide Semiconductor Field Effect Transistor(MOSFET)

5.5.1 Junction Field Effect Transistor (JFET)

JFET is a three terminal semiconductor device in which current conduction is by one type of carrier (i.e.) electrons or holes. It is a unipolar device. It has high input impedance and low noise level.

There are two types of JFET. They are

1. N-Channel JFET
2. P-Channel JFET

N-Channel JFET

Construction: Figure 5.6 shows the construction of n-channel JFET and its symbol. It consists of a uniformly doped N-type semiconductor bar made of silicon. On both sides of this N-type semiconductor bar, two heavily doped P-type regions are formed by diffusion. The two P-regions are internally connected and a single lead is taken out, which is called Gate (*G*). Ohmic contacts are made at the two N-type semi-conductor bar. One lead is called as Source(*S*) and the other as Drain (*D*). These two terminals may be interchanged. The source(*S*) is a terminal through which the majority carriers (electrons in the *N* type bar) enter the bar. The drain (*D*) is a terminal through which the majority carriers leave the bar.

Since the two P-regions are heavily doped and N-type bar is lightly doped, two depletion layers are formed in the N-type bar as shown in Figure 5.6. The region between the two layers is called channel. The majority carriers move from source to drain through this channel. The

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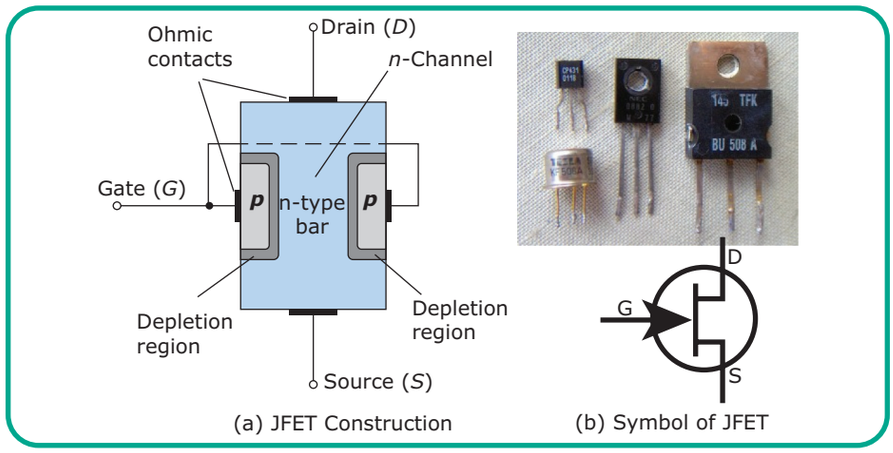

Figure 5.6 **Construction of N-Channel JFET and its Symbol**

Table 5.2 Comparison of BJT and JFET

S.No	BJT	JFET
1.	Bipolar device (current conduction by both type of carriers i.e. majority and minority -electrons and holes)	Unipolar device (current conduction is only due to one type of majority carrier either electron or hole)
2.	Current driven device	Voltage driven device
3.	Low Input impedance	High Input impedance
4.	High noise level	Low noise level
5.	Low Power gain	High Power gain
6.	Low switching speed	High switching speed
7.	Less thermal stability	Better thermal stability
8.	Emitter and collector terminals are not interchangeable	Source and drain terminals are interchangeable

gate terminal controls the flow of majority carriers from source to drain.

Advantages

1. The JFET has higher input impedance.
2. It is a low power consumption device.
3. It can be fabricated in small size area.

Disadvantages

1. The JFET is relatively low gain bandwidth product.
2. Its voltage gain is low.

Application

1. The JFET is used as a constant current source.
2. It is used as buffer amplifier.
3. It is used as electronic switch.

5.6. METAL OXIDE SEMICONDUCTOR FIELD EFFECT TRANSISTOR (MOSFET)

The MOSFET is an abbreviation of Metal Oxide Semiconductor Field Effect Transistor.

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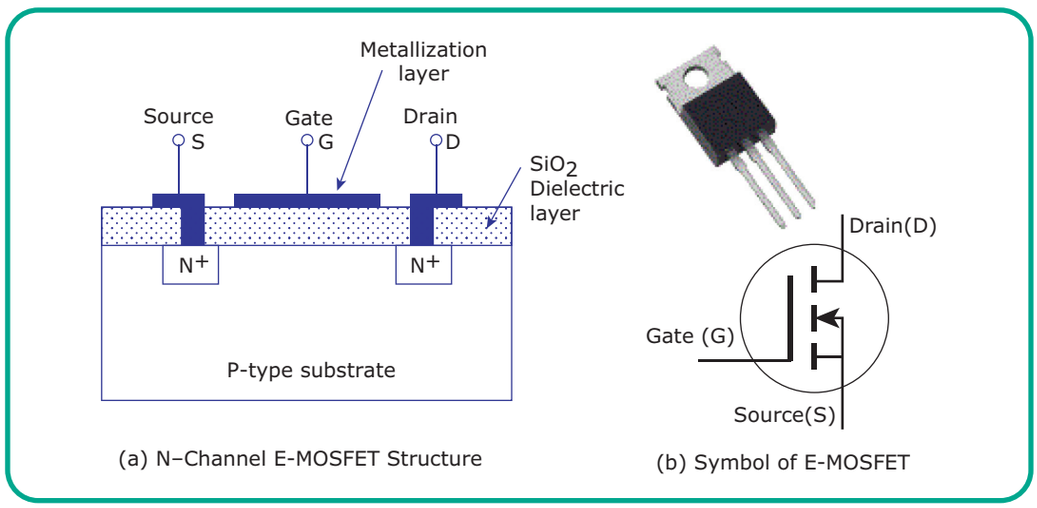

Figure 5.7 Construction of N-Channel E-MOSFET and Its Symbol

In MOSFET, the gate is insulated from the channel by using SiO_2 layer. The input impedance of MOSFET is high, because the gate current is extremely small. It is also called as Insulated Gate FET (IGFET).

History: MOSFET, largely superseded the JFET and has profound effect on digital electronic development, which was invented by Dawankahng and Martin Atalla in 1959. There are two types of MOSFET. They are

1. Enhancement MOSFET (E-MOSFET).
2. Depletion MOSFET (DE-MOSFET).

5.6.1 Enhancement MOSFET (E-MOSFET)

The enhancement MOSFET works only in enhancement mode. It does not conduct when gate to source voltage (V_{GS}) is equal to zero, therefore it is called as 'normally OFF MOSFET'. It is widely used in digital circuits. There are two types of enhancement MOSFET. They are

1. N-channel E-MOSFET
2. P-channel E-MOSFET

N-Channel E-MOSFET

Figure 5.7 shows the construction and symbol of n-channel E-MOSFET. It consists of lightly doped *P* type substrate into which two highly doped N-type regions are diffused. These two *N* regions act as Source (*S*) and Drain (*D*). A thin layer of SiO_2 is grown over its surface then a metal contact is provided at the top of the SiO_2layer, which acts as a Gate (*G*). The oxide layer provides high input impedance (10^{10} Ω to 10^{15} Ω) to the MOSFET.

Application

1. MOSFET is widely used for switching and amplifying the signals.
2. It is used in FM radio and TV receivers (for mixer operation).
3. It is used in computer memories.

5.7. SILICON CONTROLLED RECTIFIER (SCR)

SCR is a three terminal and three junction semiconductor device acts as true electronic switch. It is a unidirectional device. It converts AC to DC and controls the amount of power fed to the load. It contains the

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features of a rectifier and transistor. SCR is widely used device in the Thyristor family, so it is commonly called as Thyristor.

Construction: SCR consists of four semiconductor layers forming a PNPN-structure as shown in the Figure 5.11. There are three junctions namely J_1, J_2, J_3. SCR have three leads, they are anode (A), cathode (K) and gate (G). The end P-layer acts as anode, the end N-layer acts as cathode and the P-layer nearer to cathode acts as gate.

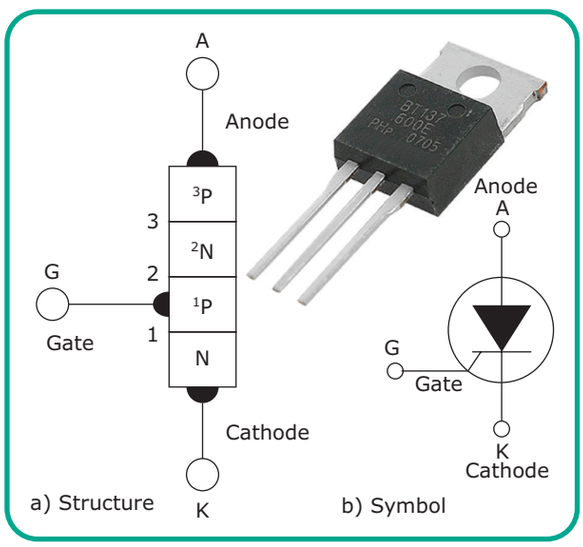

Figure 5.8: **SCR Structure and Symbol**

Working Principle: In the normal operating conditions of SCR, the anode (A) is always kept at high positive potential with respect to cathode (K), and gate (G) is at small positive potential with respect to cathode. A load resistor (R_L) is connected in series with Anode (A). The working of SCR can be studied under the following two conditions.

1. *When Gate is Open*

Figure 5.9 shows, the forward biasing of SCR (Anode kept positive with respect to cathode). Here no gate voltage ($V_G = 0$) is applied. The supply voltage V forward biases the junction J_1 and J_3 and reverse biases the junction J_2. So no current flows through SCR. Therefore the SCR is in 'OFF' state. It offers very high resistance.

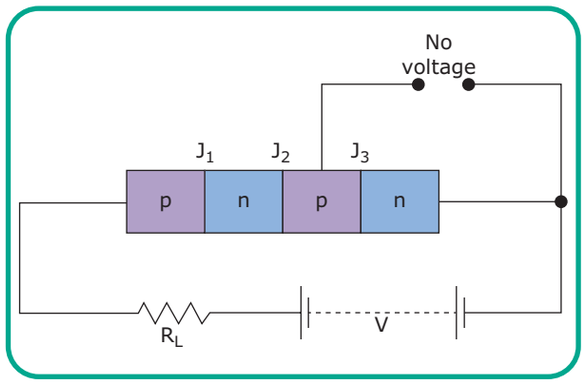

Figure 5.9 **Forward Biasing of SCR**

When supply voltage is gradually increased to a particular voltage called forward break over voltage, the reverse biased junction J_2 breaks down. The SCR now conducts heavily and is said to be in 'ON' state.

2. *When Gate is applied positive voltage with respect to cathode*

Figure 5.10 shows the small positive voltage applied to the gate. Now the junction J_3 is forward biased and junction J_2 is reverse biased. The electrons from N-layer (cathode) start moving across junction J_3 towards left, whereas holes from P-layer (Gate) move towards, right, consequently, the electrons from junction J_3 are attracted across junction J_2 and gate current starts flowing. This makes the anode current to increase. This increased anode current in turn makes more electrons available at junction J_2. This process continues and in short time the junction J_2 breaks down and SCR starts conducting heavily. Once the SCR starts conducting the gate loses its control. Even if gate voltage is removed, the anode current does not decrease at all. The only way to stop conducting is to reduce the supply voltage (V) to zero.

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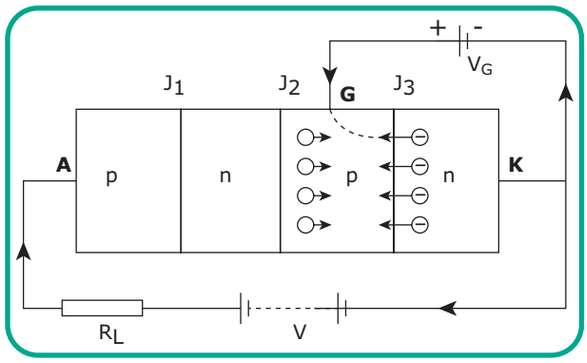

Figure 5.10 SCR with Gate Voltage

Application of SCR

1. The SCR is used in the circuit of AC voltage stabilizer.
2. It can be used as switch.
3. It is used in inverters.

5.8. DIAC

The DIAC is a bidirectional semiconductor switching device. It can be switched 'ON' using both polarities. DIAC is a short version of DIODE Alternating Current. It is widely used as a triggering device of a Triac, especially, for AC switches, dimmer application and starter circuits in fluorescent lamps.

Construction: Figure 5.11 shows the structure and symbol of DIAC. The DIAC is a two terminal device, namely MT_1, MT_2. It is a combination of parallel semiconductor layers ($P_1N_1P_2N_2$, $P_2N_1P_1N_3$) connected in anti-parallel. The DIAC can be configured to conduct in both the directions. The structure of DIAC is similar to transistor, but no terminal attached to the base layer.

Application of DIAC

1. Used as Triggering device in TRIAC Power Control System.
2. Used in Lamp Dimmer Circuit.
3. Used in Heater Control Circuit.
4. Used in Motor Speed Control.

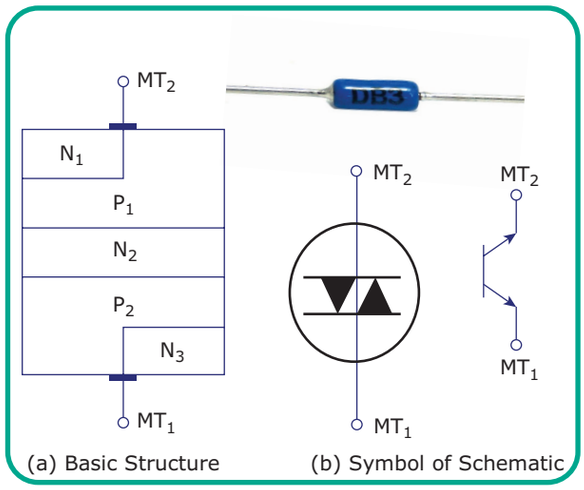

Figure 5.11 Basic Structure and Symbol of DIAC

5.9. TRIAC

TRIAC is a three terminal semiconductor switching device. They are MT_1, MT_2 and gate. Here, the gate terminal is used to control the *AC* in a load. TRIAC is a short version of TRIODE AC switch. The flow of current in TRIAC is bi-directional that means current can flow in both directions.

Construction: The structure and symbol of TRIAC is shown in the Figure 5.12. It comprises of two SCRs connected in the anti-parallel direction. It acts as a switch for both the directions. From the diagram we can understand that the MT_1 and gate terminals are close to each other. The gate provides control over conduction in either direction.

Application of TRIAC

1. It can be used as a static switch to turn AC power ON and OFF.
2. It is used for motor speed control.
3. It is used for illumination control.
4. It is used for heater control.
5. It is used for phase control.

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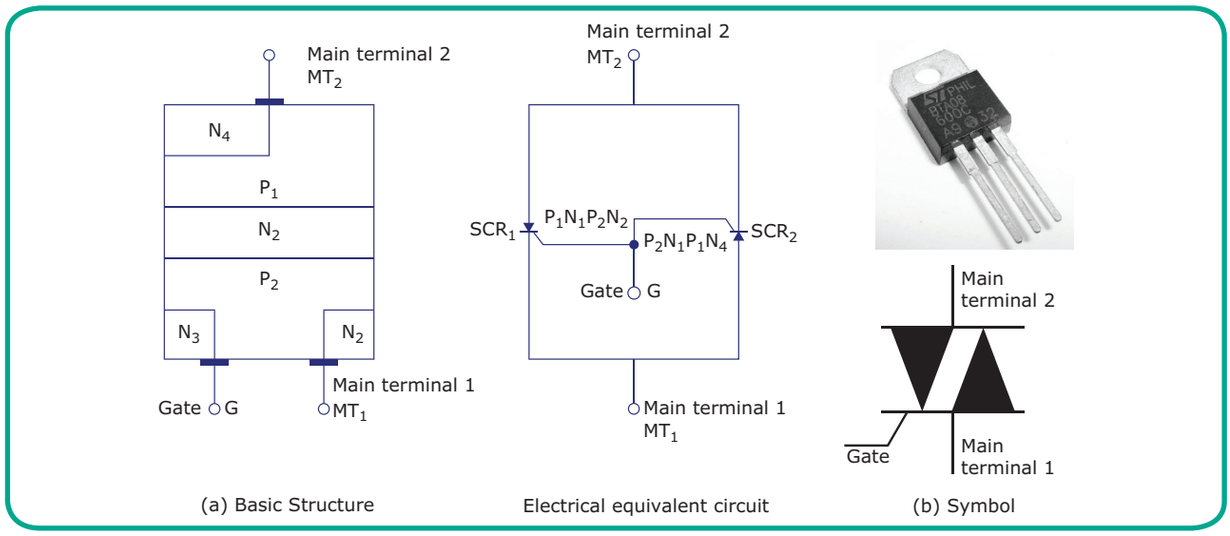

Figure 5.12 **TRIAC**

5.10. INSULATED GATE BIPOLAR TRANSISTOR (IGBT)

IGBT is a three terminal semiconductor device with huge bipolar current carrying capability. So, this device is designed to make use of the benefits of both BJT and MOSFET devices in the form of monolithic.

IGBT has several applications in power electronics, particularly, PWM, UPS, SMPS and other power circuits. It increases the efficiency, dynamic performance and reduces the level of the audible noise. IGBT are also named as bipolar MOS transistor and conductivity modulated field effect transistor (COMFET).

Construction: Figure 5.13 shows the structure, equivalent circuit and symbol of an IGBT. It is similar to the structure of MOSFET and the main difference is the presence of p+ layer that is added to the drain side. This p+ layer is also called injecting layer. The next layer is n+ layer also called as buffer layer. There is a p-n junction J_1 between the injecting layer and the buffer layer. There are two more p-n junctions J_2 and J_3 as shown in Figure 5.13. The junction J_1 blocks reverse voltage. The junction J_2 blocks forward voltage when IGBT is OFF.

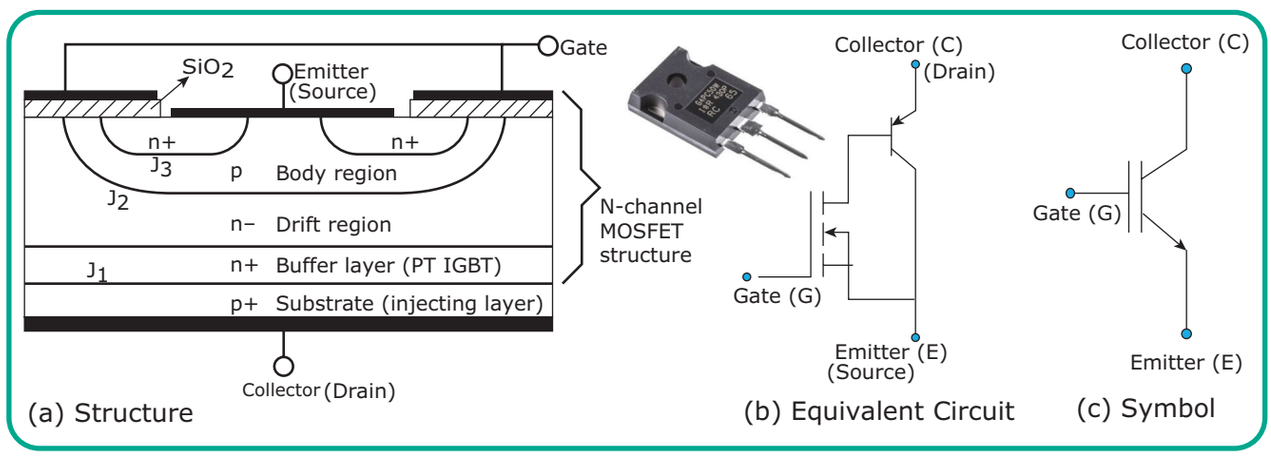

Figure 5.13 **Insulated Gate Bipolar Transistor**

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Application of IGBT

1. The IGBT is used in medium to high power application like SMPS, traction motor control etc.
2. Large IGBT modules consist of many devices in parallel have the capability to control current in hundreds of amperes with blocking voltage of 6500 V.

5.11 INTEGRATED CIRCUIT (IC)

Introduction

A simple electronic circuit can be designed easily because it requires few discrete electronic components and connections. However, designing a complex electronic circuit is difficult, as it requires more number of electronic components and their connections. It is also time taking to built such complex circuits and their reliability is also less. These difficulties can be overcome with integrated circuits. The Figure 5.14 shows the IC

What is an IC ?

The multiple electronic components are interconnected on a single chip of semiconductor material, then that chip is called as an Integrated circuit (IC). It consists of both active (transistor, diode) and passive (resistor, capacitor) components.

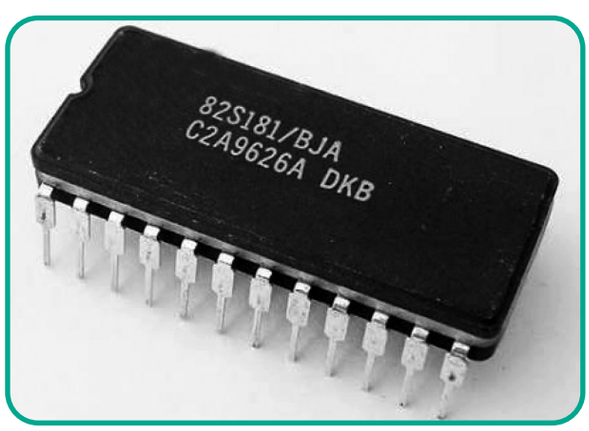

Figure 5.14 Integrated Circuit (IC)

Advantages of ICs

1. Compact Size : For a given functionality, the circuit can be fabricated into smaller size by using ICs, compared to that built using a discrete circuit.
2. Lesser Weight : A circuit built with ICs weighs lesser when compared to the weight of a discrete circuit that is used for implementing the same function of IC.
3. Low Power Consumption : ICs consume lower power than a traditional circuit, because of their smaller size and construction.
4. Reduced Cost: ICs are available at much reduced cost than discrete circuits because of their fabrication technologies and usage of lesser material than discrete circuits.
5. Increased Reliability : Since they employ lesser connections, ICs offer increased reliability compared to digital circuits.
6. Improved Operating Speeds: ICs operate at improved speeds because of their switching speeds and lesser power consumption.

Disadvantages of ICs

1. If one component in an integrated circuits fails it means the whole circuit has to be replaced
2. It is difficult to be achieve low temperature coefficient
3. It can be handled an only a limited amount of power
4. Coils or inductor cannot be fabricated
5. Low noise and high voltage operation are not easily obtained

Types of Integrated Circuit

1. Analog Integrated Circuit
2. Digital Integrated Circuit

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LEARNING OUTCOMES

After learning this Chapter, the student will

1. **Apply the concept of special type semiconductor devices to design various circuits.**
2. **Acquire the basic knowledge in opto-electronic devices and Thyristor devices.**
3. **Understand how to control the power using Thyristor type devices.**
4. **Design, fabricate and test small electronic circuit.**

GLOSSARY

S. No	Terms	Explanation
1	Diffusion	The intermingling of substances by the natural movement of their particles
2	Electroluminescence	Luminescence produced electrically by the application of a voltage
3	Gate	The controlling terminal of a FET. A voltage on the gate control the current flow between the source and drain
4	Indicators	A thing that indicates the state or level of something
5	Intensity	The measurable amount of a property such as force, brightness or a magnetic field
6	Monolithic	Solid state circuit composed of active and passive components formed in a single chip
7	Nematic	Relating to or denoting a state of liquid crystal in which the molecules are oriented in parallel but not arranged in well-defined planes
8	Optoelectronics	Technology concerned with the combined use of electronics and light

QUESTIONS

PART A

I Choose the best answer 1 Mark

1. Which of the following material finds application in yellow LED?
   a) Gallium arsenide
   b) Gallium phosphide
   c) Gallium arsenide phosphide
   d) Phosphorous

VKHB2

2. A liquid crystal display can
   a) Emit light
   b) Generate light
   c) Alter the externally available illumination
   d) attract light

3. The power consumption of LCD is
   a) Very low b) Low
   c) High d) Very high

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4. Which material widely used in solar cell production?
   a) Carbon b) Lead
   c) Copper d) Selenium

5. For satellites the source of energy is
   a) Fuel cells b) Edison cells
   c) Cryogenic storage d) Solar cell

6. A JFET is also called ..... transistor
   a) Unipolar b) Bipolar
   c) Unijunction d) Bi-junction

7. Gate of MOSFET is insulated with layer of .....
   a) SiO_2 b) Si c) O_2 d) H_2O

8. The control element of an SCR is .....
   a) Cathode b) Anode
   c) Anode supply d) Gate

9. The device that does not have gate terminal is ……
   a) TRIAC b) FET c) SCR d) DIAC

10. An IGBT is also known as
   a) MOIGT b) COMFET
   c) GOMFET d) JFET

PART B

II Answer in few sentences 3 Marks

1. What are the advantages of LED?
2. How will you display number 9 in seven segment display?
3. What are the disadvantages of LCD?
4. State any three applications of MOSFET.
5. What is DIAC?
6. Draw the symbol of TRIAC. Mention its terminals.
7. Write any three application of TRIAC.
8. What is the function of IGBT?

PART C

III Explain the following questions 5 Marks

1. Write short notes on seven segment display.
2. Compare LED and LCD.
3. Explain the working principle of solar cell.
4. Compare BJT and JFET.
5. Explain the advantages of IC.

PART D

IV Answer the following questions in detail. 10 Marks

1. Explain the construction and working of LED
2. Explain the construction and working principle of LCD with neat diagram.
3. Write in detail the working of SCR with biasing diagram.

ANSWERS

1. (c)	2. (c)	3. (a)	4. (d)
5.(d)	6. (a)	7. (a)	8. (d)
9.(d)	10. (b)		

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CHAPTER 6

OSCILLATORS

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LEARNING OBJECTIVES

While learning this Chapter, the student will

1. **Understand fundamental principles of oscillator circuits using positive feedback.**
2. **Working principles of crystal oscillators.**
3. **Understand the multivibrator functions and their types.**
4. **Study the applications of oscillator in various fields.**

6.1. OSCILLATORS

Have you heard the sound from FM radio receiver or a beeper or a horn? How the sound is generated? What is the source of the sound? All these questions have only one answer, i. e. the sound is generated by an oscillator.

Any circuit, which is used to generate an ac voltage without an ac input is called an oscillator. The oscillator circuit needs energy from a DC source. It is widely used in electronic equipment. For example, in Radio and Television receivers, oscillators are used to generate high frequency wave called carrier wave. Oscillator generates both sinusoidal (sine) and non-sinusoidal (square, rectangle, triangular, sawtooth, etc.) waveforms.

History of Oscillator

In 1912, E. H. Armstrong and Lee Deforests developed a new device audion (triode vacuum tube), by coupling one terminal of the device to another. Armstrong achieved the first electronic amplifier with large gain. He called the process "regeneration" (positive feedback). Further, he had made the first electronic oscillator. These two made a revolution in radio broadcasting.

Armstrong had created components necessary to make continuous wave (CW) radio practicable. Primarily, at that time radio was similar to wireless telegraphy (i.e., dots and dashes) and hence CW radio was used to transmit audio information. With Armstrong oscillator, CW signals at high frequencies in the range of kHz to MHz could be easily generated.


E. H. Armstrong

CLASSIFICATION OF OSCILLATORS

Oscillators are classified based on different methods and are summarized in the following sub-sections.

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6.1.1. According to the Waveforms Generated

Sinusoidal oscillator: If the output voltage is a sine wave function of time the oscillator is called as "sinusoidal" or Harmonic oscillator. Positive feedback and negative resistance oscillators belong to this category. The waveform generated by the sinusoidal oscillator is shown in Figure 6.1(a)

Non sinusoidal (or) Relaxation Oscillator: This type of oscillators has non-sinusoidal output such as a square, triangular and sawtooth waveforms. The waveform generated by Non sinusoidal oscillator shown in Figure 6.1(b)

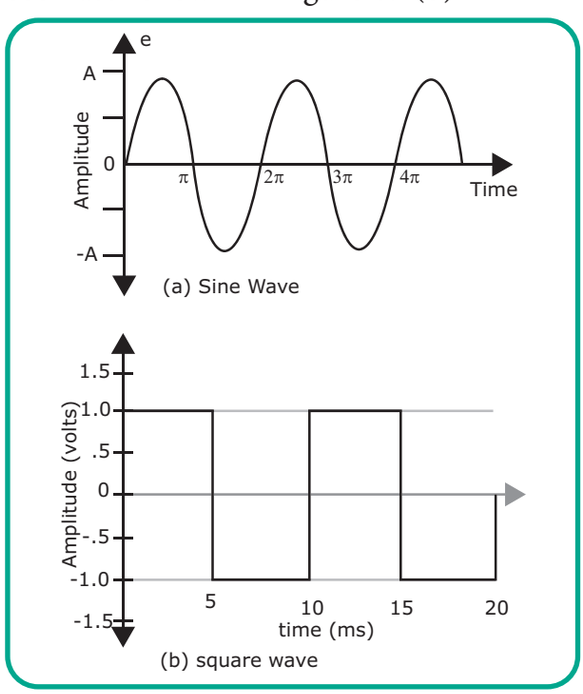

Figure 6.1 (a) Sine Wave, (b) square wave

6.1.2. According to the Fundamental Mechanism Used

1. Negative Resistance Oscillators
2. Feedback Oscillators

Negative resistance oscillator has the negative resistance amplifying device to neutralize the positive resistance of the oscillator. Feedback oscillator uses positive feedback in the feedback amplifiers to satisfy the Barkhausen criterion

6.1.3. According to the Frequency Generated

1. Audio frequency (AF) oscillator: 20Hz to 20 kHz
2. Radio frequency (RF) oscillator 20 kHz-30 MHz
3. Very high frequency (VHF) oscillator: 30 MHz-300 MHz
4. Ultra high frequency (UHF) oscillator: 300 MHz-3 GHz
5. Microwave frequency oscillator: above 3GHz

6.2. TYPES OF SINUSOIDAL OSCILLATION

Sinusoidal oscillation can be of two types

1. Damped oscillation
2. Undamped oscillation

6.2.1. Damped Oscillation

Figure 6.2(a) shows the damped oscillation. In this type of oscillators, during each oscillation, some energy is lost due to electrical losses (I^2R).The amplitude of the oscillation reduced to zero, when no compensating arrangement for the electrical losses is provided.

6.2.2. Undamped Oscillation

Figure 6.2(b) shows the undamped oscillations. In these types, the amplitude of each oscillation remains constant with time. Although the electrical system in which these oscillations are being generated has losses, but now right amount of energy

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is being supplied to overcome these losses. Therefore, the generated wave remains constant. It is also called as sustained oscillations. These continuous waves are produced by electronic oscillator circuits for utilizing in various electronic equipment.

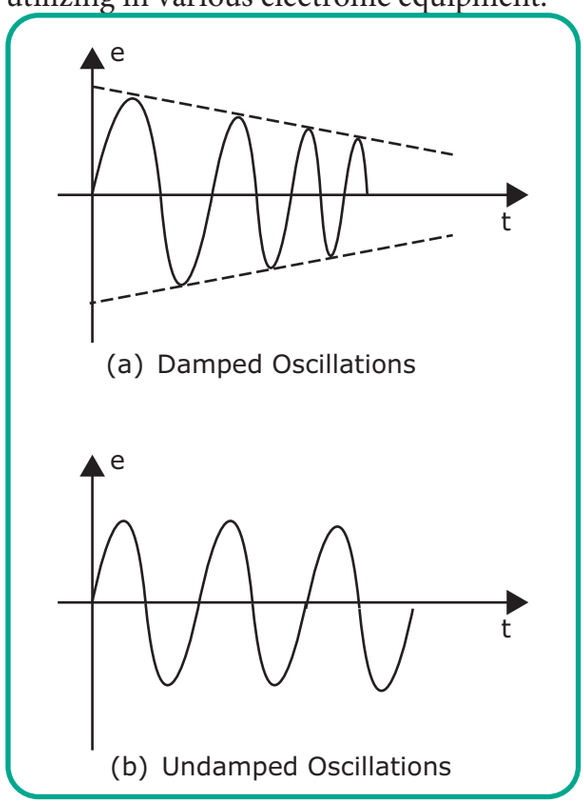

Figure 6.2 **Damped and Undamped Oscillations**

6.3. ESSENTIAL PARTS OF AN OSCILLATOR

Figure 6.3 shows the block diagram of an oscillator. Its essential components are:

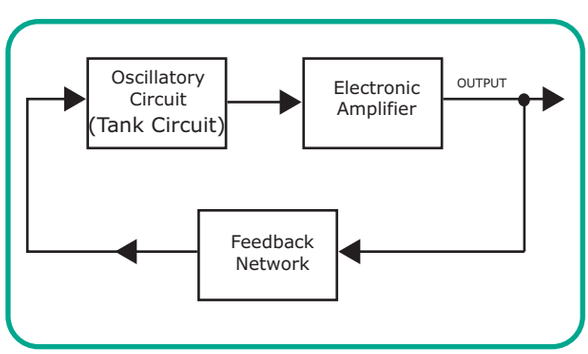

Figure 6.3 **Block Diagram of an Oscillator**

Tank Circuit: It consists of inductor or coil (L) and capacitor (C). The frequency of oscillation depends upon the values of inductance of the coil and capacitance of the capacitor.

Transistor Amplifier: The transistor amplifier receives DC power from the battery and changes it into AC power for supplying to the tank circuit. The main function of the amplifier is to amplify the generated oscillation from the tank circuit.

Feedback Circuit: This circuit provides positive feedback to the oscillator. It gives a part of amplifier output to the tank circuit in correct phase to make oscillation as undamped (constant amplitude).

6.4. FEEDBACK IN OSCILLATOR

In feedback, a part of the output signal is fedback to the amplifier input in such a way that the feedback signal re-generates, re-amplifies and sustain the feedback to maintain a constant output Signal.

Commonly an oscillator is constructed from an amplifier that has part of its output signal feedback to the input. This is done in such a way to keep the amplifier producing signal without the need for any external signal input as shown in the Figure 6.4. Here, the DC supply is converted into AC signal.

6.4.1. Positive Feedback

The feedback in the amplifier section of an oscillator must be positive feedback. Here a fraction of the amplifier output signal is feed-back as input. Note that the feedback signal is in phase with the input signal. As a result, the amplitude of the signal is increased.

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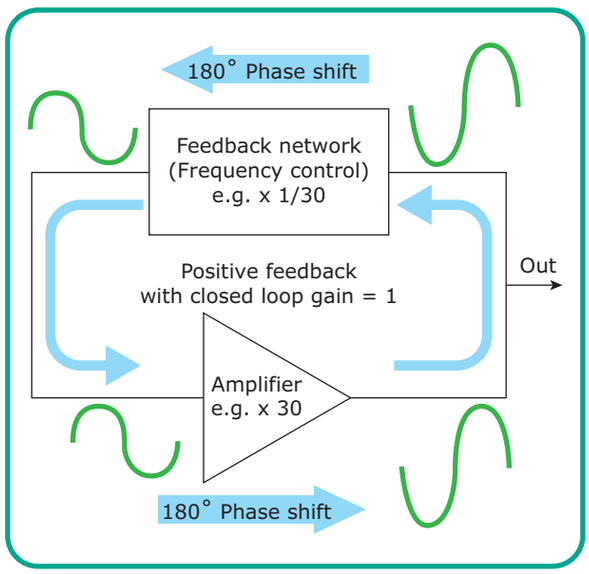

Figure 6.4 **Positive Feedback**

For example, common emitter amplifier creates a phase shift of 180° between its input and output. Similarly, the positive feedback loop also produce a 180° phase shift in the signal feedback from output to input in order to provide positive feedback.

The result of small amount of positive feedback in amplifiers results in higher gain, at the cost of increased noise and distortion. If the amount of positive feedback is large enough, the result is oscillation where the amplifier circuit produces its own signal.

6.4.2. Using Positive Feedback

When an amplifier is operating without feedback is called as "open-loop" mode and with feedback *(either +ve or -ve)*, is known as "closed-loop" mode. In ordinary amplifiers, negative feedback is used to provide advantages in bandwidth, distortion and noise generation, and in these circuits the closed-loop gain of the amplifier is much less than the open-loop gain. However, when positive feedback is used in an amplifier system, the closed-loop gain (with feedback) will be greater than the open-loop gain; the amplifier gain is now increased by the feedback. Additional effect of positive feedback are reduced bandwidth, (but this does not a matter in an oscillator producing a sine wave having a single frequency), and increased distortion. However, even severe distortion in the amplifier is allowed in some sine wave oscillator designs, where it does not affect the shape of the output waveform.

In oscillators using positive feedback, it is important that amplitude of the oscillator output remains stable. Therefore, the closed loop gain must be 1 (unity). In other words, the gain within the loop (provided by the amplifier) should exactly match the losses (caused by the feedback circuit) within the loop. In this way, there will be no increase or decrease in the amplitude of the output signal as shown in the waveform 6.5.

This is achieved by Barkhausen criteria given by $|A\beta| = 1$.

where A is the amplifier gain and β is the transfer function of feedback.

6.4.3. The Condition for Oscillation

Positive feedback must occur at a frequency where the voltage gain of the amplifier is equal to the losses (attenuation) occurring in the feedback path. For example, 1/30 of the output signal feedback to be in phase with the input at a particular frequency, and the gain of the amplifier (with feedback) is 30 times or more, thus oscillation should take place. The conditions for oscillation are, (i) the oscillations should take place at one particular frequency and (ii) the amplified output of the oscillation should be constant.

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There are many different oscillator designs in use, each design achieving the above criteria in different ways; some designers are particularly suited to producing certain wave shapes or work best within certain band of frequencies. Whatever design is used, the way of achieving a signal of constant frequency and constant amplitude, by using one or more of the following three basic methods.

Method 1: Make sure that positive feedback occurs only at one frequency of oscillation. This may be achieved by ensuring that only signal of the required frequency are feedback or by ensuring feedback signal is the correct in-phase at only one frequency.

Method 2: Make sure that sufficient amplification for oscillation can take place only the required frequency by using an amplifier that has an extremely narrow bandwidth extending to the frequency of oscillation only.

Method 3: Use amplifiers in "Switch mode" to switch the output between two set voltage levels together with some form of time delay to control the time at which the amplifiers switch-on or off, thus controlling the period of the signal produced.

Methods 1 and 2 are used extensively in sine wave oscillators.

Method 3 is used in square wave generators (multivibrator).

6.4.4. Constant Amplitude

As shown in Figure 6.4, oscillators must have an amplifier, a positive feedback loop and some method of controlling the frequency of oscillation. In RF sine wave oscillator, the frequency may be controlled by an LC tuned circuit, but as well as controlling the frequency of oscillation, there must be some means, such as negative feedback for stabilizing the amplitude of signal produced.

Without this stabilization, the oscillations would either die away and stop (damped oscillation) or rapidly increased in amplitude until the amplifier produces severe distortions due to the transistors within the amplifier becoming "saturated" as shown in Figure 6.5. To produce constant amplitude output the gain of the amplifier is automatically controlled during oscillation.

6.5. TYPES OF OSCILLATOR

There are several types of transistor oscillators commonly used in electronic circuits. Three important types of oscillators are

1. Hartley Oscillator,
2. RC Phase Shift Oscillator,
3. Crystal Oscillator

6.5.1. Crystal Oscillator

The transistor crystal oscillator resembles Colpitts oscillator modified to act as crystal oscillator. The only change is the addition of

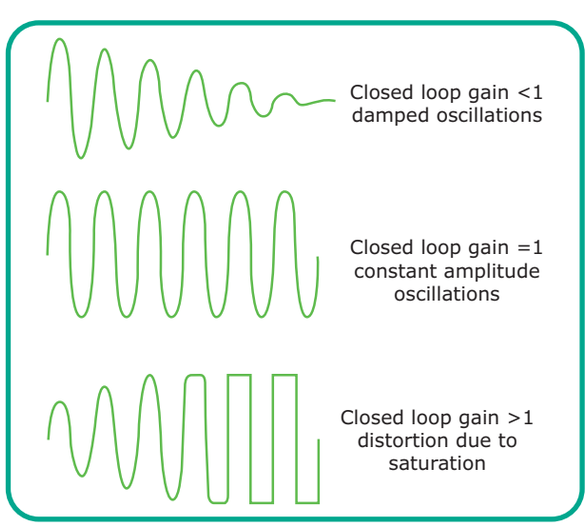

Figure 6.5 Constant Amplitude

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the crystal (Y) in the feedback network. It replaces the LC resonant circuit.

History: Piezoelectricity was discovered by Jacques and Pierre Curie in 1880. Paul Langevin first investigated quartz resonators for use in sonar during World War I. The first crystal controlled oscillator using a crystal of Rochelle salt was built in 1917 and patented in 1918 by Alexander M. Nicholson at Bell Lab, although his priority was disputed by Walter Guyton Cady. Cady built first quartz crystal oscillator in 1921.


W. G. Cady

The crystal is a thin slice of piezoelectric material, such as quartz, tourmaline and Rochelle salt, which exhibits a property called piezoelectric effect. It means the crystal reacts to any mechanical stress by producing electric charge, in the converse effect, an electric field results in mechanical strain. The advantage of the crystal is its very high Q as a resonant circuit, which results in good frequency stability for the oscillator.

Circuit Description: In the circuit shown in Figure 6.6, the resistors R_1 and R_2 form the voltage divider network, while the emitter resistor R_E stabilizes the circuit. Further, C_E acts as an AC by pass capacitor, while the coupling capacitor C_i is used to block DC signal propagation between collector and base terminals. The RF coil in the circuit which offers dual advantages, as it provides even the DC bias and frees the circuit output from being affected by the AC signal on the power lines.

Working Principle: When the supply is switched 'ON', the capacitor C_1 is charged. It fully charged, then starts discharging through the crystal and produces oscillation. The frequency of the oscillation depends upon the values of C_1, C_2 and the RLC values of the crystal. If the frequency of the oscillation is equal to its crystal resonant frequency, the circuit produces more stable oscillations.

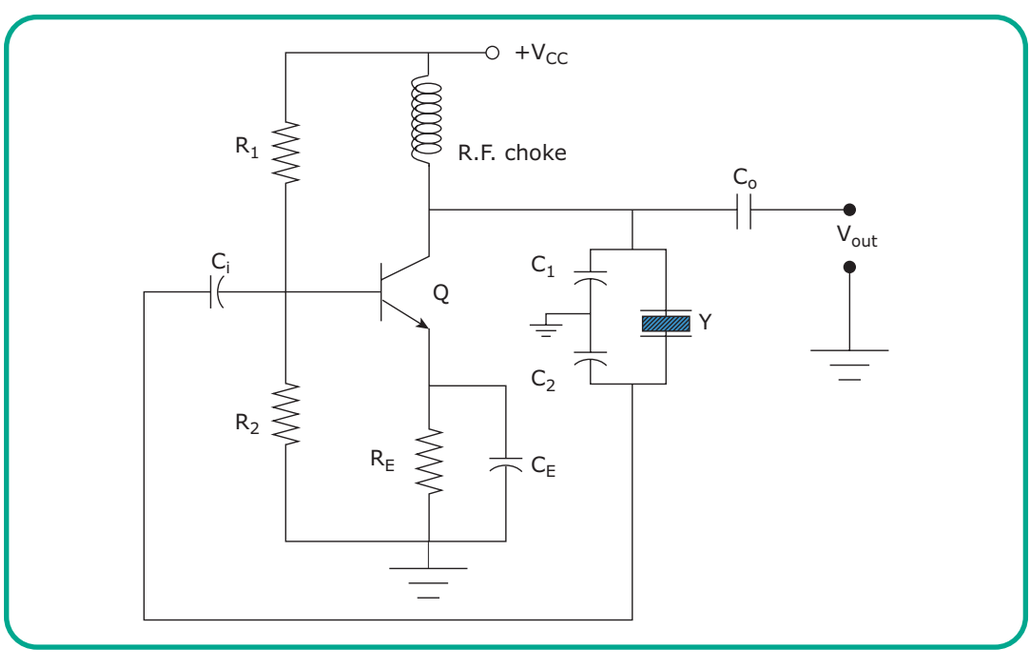

Figure 6.6 Crystal Oscillator

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The crystal frequency is dependent on temperature.

Advantages

1. High 'Q' factor
2. Excellent frequency stability
3. Simple circuit

Disadvantages

1. Not to be used as tuned oscillators
2. Crystal is fragile type, hence it is used only in low power circuits

6.5.2. Application of crystal oscillator

Crystal oscillators are used in the microprocessor and microcontroller for providing the clock signals. It generates clock pulses required for the synchronization of all the internal operations. The use of crystal oscillator in military and aerospace is to establish an efficient communication system for navigation purpose in the guidance systems.

The oscillator is used in research and measurement of celestrial navigation, space tracking purpose, and the timing signal in the measuring instruments and medical devices. There is variety of industrial applications of crystal oscillator such as computers, digital systems, marine, modems, sensors, telecommunications and disk drives. It is used in automotive field by engine controlling, stereo and in GPS system. It is also used in consumer applications like TV systems, PCs, video games, toys, radio systems and cellular phones.

6.6. MULTIVIBRATORS

Multivibrators are two stage switching circuits in which the output of the first stage is fed to the input of the second stage and vice versa. The outputs of the two stages are complementary (high or low). A specific characteristic of multivibrator is that it uses passive elements like resistor and capacitor to determine the output state.

Multivibrators are of three types namely

1. Astable multivibrator
2. Monostable multivibrator
3. Bistable multivibrator

6.6.1. Astable Multivibrator

The astable or free running multivibrator generates square wave without any external triggering pulse. It has no stable states, i.e. it has two quasi-stable states. It switches back and forth from one state to the other, remaining in each state for a time depending upon the discharging of a capacitive circuit.

6.6.2. Monostable Multivibrator

Monostable multivibrator has one stable and one quasi-stable. It is also known as one- shot multivibrator. In this, the output pulse duration is determined by the RC time constant and is given as $1.11 * R * C$. This multivibrator cannot generate square waves of its own like an astable multivibrator. One external triggering pulse will cause it to generate the rectangular waves.

6.6.3. Bistable Multivibrator

The bistable multivibrator has two stable states. A triggering pulse is applied to the circuit causes it to switch from one state to other. Another trigger pulse is then required to switch the circuit back to its original state.

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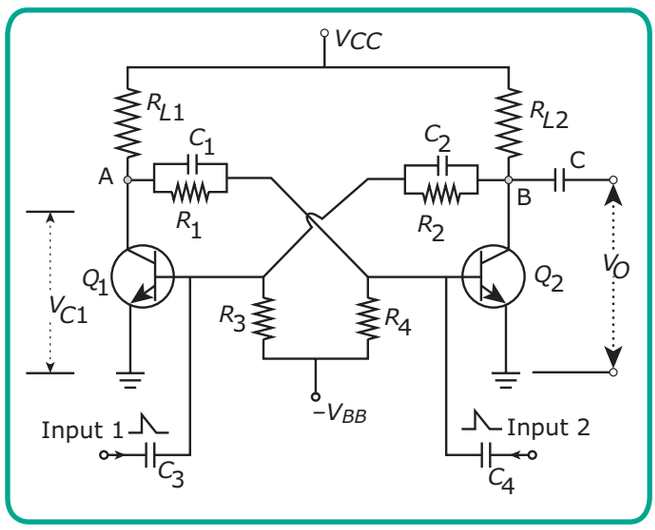

Figure 6.7 **Bistable Multivibrator**

Construction: Figure 6.7 shows the circuit of a bistable multivibrator using two NPN transistors. In this circuit, the output of a transistor Q_2 is coupled to the base of transistor Q_1 through a resistor R_2. Similarly, the output of Q_1 is coupled to the base of Q_2 through resistor R_1. The main purpose of capacitors C_1 and C_2 is to improve the switching characteristic of the circuit by passing the high frequency components of the square wave pulses. This allows fast rise and fall times, so that these square waves will not be distorted. C_1 and C_2 are called commutating capacitors or speed up capacitors.

Working Principle: When the circuit is switched-ON, one of the transistors will start conduct slightly higher than the other. This transistor is thus driven into saturation (i.e. ON). Then, because of the regenerative feedback action, the other transistor is taken into cut-off (i.e. OFF) state. Let us consider transistor Q_1 is ON and Q_2 is OFF. It is a stable state of the circuit and will remain in this state till a trigger pulse is applied from outside. A positive triggering pulse applied to the reset input (base of Q_2) increases its forward bias, thereby turning transistor Q_2 ON, and there is an increase in collector current and decrease in collector voltage occur. The fall in the collector voltage is coupled to the base of Q_1, which in turn turned OFF. The circuit is then in its second stable state until a positive trigger pulse is applied to the base of Q_1.

A similar action can be achieved by applying a negative pulse at the set input for transition from the first stable state to the second stable state and by applying a negative pulse at the reset input, reverse transition can be obtained.

Applications

1. It is used in computer memory circuits.
2. It is used as memory element in shift registers, counters and so on.
3. It can also be used as a frequency divider.

LEARNING OUTCOMES

Through this Chapter, the student will

1. **Acquire basic knowledge in sinusoidal and non sinusoidal waves.**
2. **Understand how the oscillator circuit is essential for communication equipment.**
3. **Understand the use of positive feedback in an oscillator.**
4. **Understand bistable multivibrator as the foundation of digital electronics.**

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QUESTIONS

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PART A

I Choose the correct answer 1Mark

1. An oscillator converts ……..
   a) AC power into DC power
   b) DC power into AC power
   c) Mechanical power into AC power
   d) AC power into Mechanical power

2. In an LC transistor oscillator, the active device is ……
   a) LC tank circuit b) Biasing circuit
   c) Transistor d) RC circuit

3. An oscillator produces ……. oscillations
   a) Damped b) Undamped
   c) Modulated d) None of the above

4. Crystal oscillator is commonly used in ……..
   a) Radio receivers b) Radio transmitters
   c) TV receivers d) TV transmitters

5. In a crystal, the piezoelectric effect causes ……..
   a) A voltage is developed because of mechanical stress
   b) A change in resistance occurs because of temperature
   c) change in frequency occurs because of temperature
   d) change in current occurs because of temperature

6. The crystal oscillator frequency is very stable due to …….. of the crystal.
   a) Rigidity b) Vibrations
   c) Low Q d) High Q

7. Astable multivibrator is …….. in any state.
   a) Stable b) Unstable
   c) Saturated d) Unsaturated

8. Bistable multivibrator is ……. in any state.
   a) Stable b) Unstable
   c) Saturated d) Independent

9. A monostable multivibrator has ……..
   a) Unstable state b) One stable state
   c) Two stable state d) Multistable state

10. Circuit which consists of a quasi-stable state is called …….
    a) Bistable circuit b) Monostable circuit
    c) Tristable circuit d) Tristate circuit

PART B

II Answer in few sentences 3 Marks

1. What is an oscillator? How is it classified?
2. What is meant by piezoelectric effect?
3. How will you produce square wave?
4. What are the types of transistor oscillator?
5. What is positive feedback in an oscillator?
6. What is multivibrator? Give its types.
7. Give merits and demerits of crystal oscillator.

PART C

III Explain the following questions 5 Marks

1. Explain damped and undamped oscillation with waveform diagram.
2. Draw and explain the essentials parts of an oscillator.
3. Write short notes on Astable and Monostable multivibrators.
4. Why positive feedback is much needed in an oscillator function? Justify it.

PART D

IV Answer the following questions in detail 10 Marks

1. Draw and explain the working functions of crystal oscillator.
2. Explain the construction and working principle of bistable multivibrator with circuit diagram.

ANSWERS

1. (b) 2. (c) 3. (b) 4.(a) 5. (a)
6. (d) 7. (b) 8. (a) 9. (b) 10. (b)

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DIGITAL ELECTRONICS

CHAPTER 7

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LEARNING OBJECTIVES

After the completion of this Chapter, the student will

1. **Understand the basic concepts of analog and digital signals**
2. **Understand the functions of digital circuit**
3. **Know about the number system**
4. **Understand the conversion of number system and basic of arithmetic operations**
5. **Develop the skill of converting one code format into other code formats**

INTRODUCTION

The branch of electronics, which deals with digital circuits, is called digital electronics. Over the past several decades, digital electronics have been utilized in the design and manufacturing of various industrial, commercial and household electronic gadgets. Due to the proliferation of digital electronics, it is very important to inculcate the basic knowledge of digital electronics to develop conceptual knowledge and practical experience among the stakeholders.

Electronic systems can be classified into two types of systems in which the mode of electron transfer from one end to another end differs. They are,

1. Analog system
2. Digital system

In electronics there are two types of signal.

1. Analog signals
2. Digital signals

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7.1. ANALOG AND DIGITAL SIGNALS

i) Analog Signals

A continuously varying signal(voltage or current) is called as an analog signal.

Example: Sinusoidal waves.

A sample of analog signal that varies with time is shown in Figure 7.1.

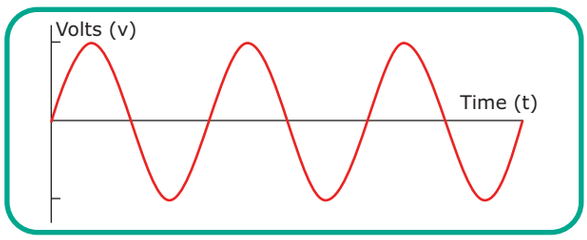

Figure7.1 **Representation of an Analog signal**

ii) Digital Signal

A signal (voltage or current) that can have only two discrete values is called a digital signal. Example: Square wave. The digital waveform is shown in Figure 7.2.

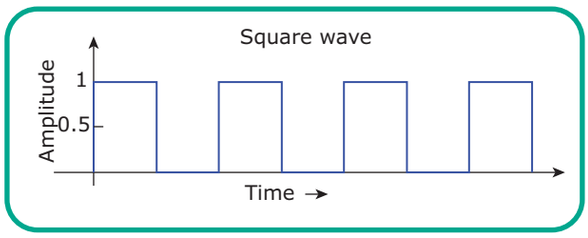

Figure 7.2 **Representation of Digital Signal**

Digital operations have two states (i.e. ON or OFF) and hence it is more simple and reliable than many valued analog operations.

7.2 DIGITAL CIRCUITS

An electronic circuit that handles only a digital signal is called a digital circuit.

Example: Digital calculator, Digital computer

The digital operation is a two state operation (i.e. ON or OFF, 1 or 0) and therefore a digital circuit uses only two digits 1 and 0 in the binary number system. In order to understand the concepts in digital circuits, First we discuss about the data representation and the number system in the following.

7.3 DATA REPRESENTATION

Computer handles data in the form of '0'(Zero) and '1' (One). Any kind of data like number, alphabet, special character should be converted to '0' or '1' which can be understood by the Computer. '0' and '1' that the Computer can understand is called Machine language. '0' or '1' are called 'Binary Digits'(BIT). Therefore, the study of data representation in the computer is important.

1. A bit is the short form of Binary digit which can be '0' or '1'. It is the basic unit of data in computers.
2. A nibble is a collection of 4 bits (Binary digits).
3. A collection of 8 bits is called Byte. A byte is considered as the basic unit of measuring the memory size in the computer.
4. Word length refers to the number of bits processed by a Computer's CPU. For example, a word length can have 8 bits, 16 bits, 32 bits and 64 bits (Present day Computers use 32 bits or 64 bits)

Computer memory (Main Memory and Secondary Storage)is normally represented in terms of KiloByte (KB) or MegaByte (MB). In decimal system, 1 Kilo

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Table 7.1 Memory Size (Read 2^10 as 2 power 10)		
Name	Abbr	Size
Kilo	K	2^10=1,024
Mega	M	2^20=1,048,576
Giga	G	2^30=1,073,741,824
Tera	T	2^40=1,099,511,627,776
Peta	P	2^50=1,125,899,906,842,624
Exa	E	2^60=1,152,921,504,606,846,976
Zetta	Z	2^70=1,180,591,620,717,411,303,424
Yotta	Y	2^80=1,208,925,819,614,629,174,706,176

represents 1000, that is , 10^3 . In binary system, 1 KiloByte represents 1024 bytes that is 2^{10}. The following table represents the various memory sizes:

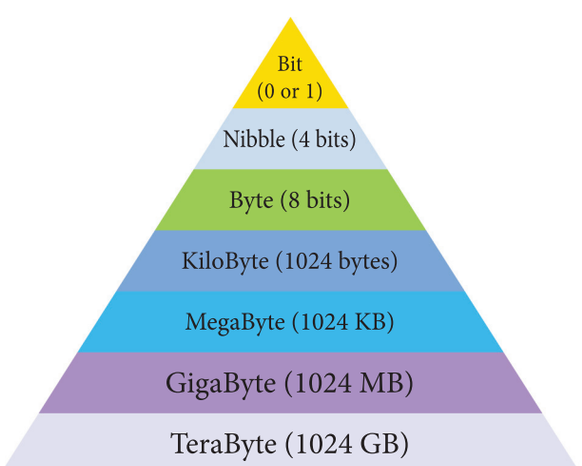

Figure 7.3 Data Representation

Bytes are used to represent characters in a text. Different types of coding schemes are used to represent the character set and numbers. The most commonly used coding scheme is the American Standard Code for Information Interchange (ASCII).

7.4 NUMBER SYSTEM

In digital electronics the number system is used for representing the information. It is commonly used to count any activity or articles. In practical life, we are using decimal number system.Other number systems are Binary, Octal and Hexadecimal number system. Each number system is uniquely identified by its base value or radix. Radix or base is the count of number of digits in each number system.

Computers, microprocessor and digital electronic devices do not process decimal numbers. Instead, they work with binary number, which use only the two digits'0' and'1'.

People do not like working with binary numbers, owing to their very lengthy combinations of digits, while representing larger decimal values.

As a result, octal and hexadecimal numbers are widely used to compress long strings of binary numbers. Types of number systems are given below.

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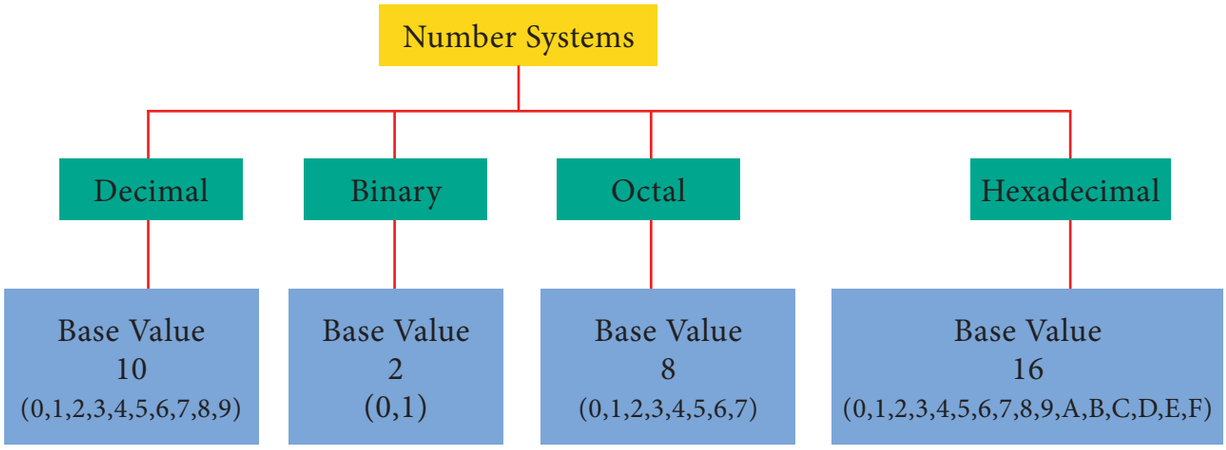


7.4.1 Decimal Number System

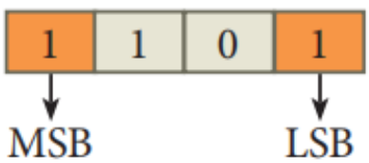
Decimal number consists of 0,1,2,3,4,5,6,7,8,9 (10 numbers). It is the oldest and most popular number system used in our day to day life. It has radix or base of 10.

Example : 345_{10}

7.4.2 Binary Number

Binary number contains only two numbers of '0' and '1'. It has radix or base of 2.

Example: 1101_2



The left most bit in the binary number is called as Most Significant Bit (MSB) and it has the largest positional weight.

The right most bit in the binary number is called as Least Significant Bit(LSB) and it has the smallest positional weight.

7.4.3 Octal Number System

Octal number system contains only eight numbers of 0,1,2,3,4,5,6 and 7. It has a radix or base of 7.

Example: 7612_8

7.4.4 Hexadecimal Number System

Hexadecimal number or Hex number system contains only sixteen numbers of 0,1,2,3,4,5,6,7,8,9,A,B,C,D,E, and F. The first 10 symbols are the same as in the decimal system, 0 to 9 and the remaining 6 symbols are taken from the first 6 letter of the alphabet sequence, A to F, where A represents 10, B is 11, C is 12, D is 13, E is 14 and F is 15. It has a radix or base of 16.

Example: $508D_{16}$

The table shows the Binary, Octal,Hexadecimal equivalent of Decimal Numbers.

Decimal	Binary	Octal	Hexadecimal
0	0000	000	0000
1	0001	001	0001
2	0010	002	0002
3	0011	003	0003
4	0100	004	0004
5	0101	005	0005
6	0110	006	0006
7	0111	007	0007
8	1000	010	0008
9	1001	011	0009
10	1010	012	A

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11	1011	013	B
12	1100	014	C
13	1101	015	D
14	1110	016	E
15	1111	017	F

7.4.5 BCD (Binary Coded Decimal) Number

A nibble is a string of 4 bits. BCD numbers express each decimal digit as nibble. It is a decimal number represented in binary form with 0 and 1. The lowest number is 0000 (0) and the highest number is 1001(9)

Example: $1000\ 0111_{BCD}$

Place Value

The binary, octal, decimal, and hexadecimal numbers are weighted numbers. Hence, every number system can be converted into any other number system through a process called conversion. After conversion, the weight of the number should not be varied. The weight of each number is represented as follows.

Decimal Number System

Number	2	8	5	7	.4	5
Weight of each digit	10^3	10^2	10^1	10^0	$.10^{-1}$	10^{-2}

Binary Number System

Number	1	0	1	1	.0	1
Weight of each digit	2^3	2^2	2^1	2^0	$.2^{-1}$	2^{-2}

Octal Number System

Number	7	3	5	6.	3	2
Weight of each digit	8^3	8^2	8^1	8^0	$.8^{-1}$	8^{-2}

Hexadecimal Number System

Number	8	A	B	5	.	C	9
Weight of each digit	16^3	16^2	16^1	16^0	.	16^{-1}	16^{-2}

7.5 CONVERSIONS

Conversion of binary number from one number format to another number format can be performed by adapting some rules and regulations. Some of the important conversion processes are explained below. For the conversion of integer and fractional number, separate conversion methods are used.

7.5.1 Decimal to Binary Conversion

To convert Decimal to Binary "Repeated division by 2 method" can be used the decimal number is divided by 2, and writing down the remainder after each division. The remainders are taken in reverse order to form the binary number.

Example: Conversion of 26_{10} to its equivalent binary number

$$\begin{array}{r|l} 2 & 26 \\ 2 & 13 - 0 \\ 2 & 6 - 1 \\ 2 & 3 - 0 \\ & 1 - 1 \end{array}$$

Hence, $11010_2 = 26_{10}$

7.5.2 Binary to Decimal Conversion

To convert binary number to its equivalent decimal number, multiply each binary digit by its weight and then add the resulting products.

Example: Conversion of 1101_2 to its equivalent decimal number.

1	0	1	1
2^3	2^2	2^1	2^0

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Equivalent decimal number

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

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

$= 8 + 0 + 2 + 1 = 11$

Hence, $1011_2 = 11_{10}$

7.5.3 Decimal to Octal Conversion

To convert decimal to octal, "Repeated division by 8 method" can be used. decimal to octal conversion, the decimal number is divided by 8, and writes down the remainder after each division. The remainders are taken in reverse order to form the octal number.

Example: Conversion of the decimal number 408 to its equivalent octal number.

8|408
8|51 – 0
8|6 – 3

Hence, $408_{10} = 630_8$

7.5.4 Octal to Decimal Conversion

To convert an octal number to its equivalent decimal number, multiply each octal digit by its weight and then add the resulting products.

Example: Conversion of an octal number 375 into its equivalent decimal number.

The weight of 5 is 8^0, 7 is 8^1 and 3 is 8^2.

Hence, the equivalent decimal number is

$= (3x8^2)+(7x8^1)+(5x8^0)$

$= (3x64)+(7x8)+(5x1)$

$= 192+56+5= 253$

Hence, $375_8 = 253_{10}$

7.5.5 Decimal to Hexadecimal Conversion

To convert Decimal to Hexadecimal, "Repeated division by 16 method" can be used. The decimal number is divided by 16 and write down the remainder after each division. The remainders are taken in reverse order to form the hexadecimal number.

Example: Conversion of a decimal number 4538 to its equivalent hexadecimal number.

16|4538
16|283 – 10
16|17 – 11
1 – 1

Hence, $4538_{10} = 11BA_{16}$

7.5.6 Hexadecimal to Decimal Conversion

To convert the hexadecimal to its equivalent decimal number, multiply each hexadecimal digit by its weight and then add the resulting products.

Example: Conversion of a hexadecimal number of B35 to its equivalent decimal number.

The weight of B is 16^2, 3 is 16^1 and 5 is 16^0

Hence its equivalent Decimal number is

$= (Bx16^2)+(3x16^1)+(5x16^0)$

$= (11x256)+(3x16)+(5x1)$

$= 2816+48+5$

$=2869$

Hence, $B35_{16} = 2869_{10}$

7.5.7 Octal to Binary Conversion

In this conversion, each octal digit is converted into its equivalent three digit binary form. The octal number and its

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equivalent three digit binary numbers are shown in the Table 7.2.

Table 7.2: Conversion of Octal into Equivalent Binary Number

Octal number	Equivalent Binary number
0	000
1	001
2	010
3	011
4	100
5	101
6	110
7	111

Example: Conversion of an octal number 43 to its equivalent binary number.

$$\begin{array}{cc} 4 & 3 \\ 100 & 011 \end{array}$$

$$43_8 = 100011_2$$

7.5.8 Binary to Octal Conversion

The binary numbers are grouped as 3-bit from left to right. If there is any binary digit left with one or two bits then sufficient numbers of zero are added to the left most side of the binary number. Then, grouped 3-bit number is converted into an equivalent octal number.

Example: Conversion of a binary number of 010111011 to its equivalent octal number.

$$\begin{array}{ccc} \underline{010} & \underline{111} & \underline{011} \\ 2 & 7 & 3 \end{array}$$

Hence, $010111011_2 = 273_8$

7.5.9 Hexadecimal to Binary Conversion

In this conversion, each hexadecimal digit is converted into its equivalent four digit binary form.

The hexadecimal number and its equivalent 4 digit binary numbers are shown in the Table 7.3.

Table 7.3: Conversion of Hexadecimal into Equivalent Binary Number

Hexadecimal Number	Equivalent Binary Number
0	0000
1	0001
2	0010
3	0011
4	0100
5	0101
6	0110
7	0111
8	1000
9	1001
A	1010
B	1011
C	1100
D	1101
E	1110
F	1111

Example: Conversion of a hexadecimal number 7B3 into its equivalent binary number.

$$\begin{array}{ccc} 7 & B & 3 \\ 0111 & 1011 & 0011 \end{array}$$

Hence, $7B3_{16} = 011110110011_2$

Note: Delete the left most zeros.

7.5.10 Binary to Hexadecimal Conversion

In this conversion, the binary number is arranged in group of 4 bits. Suppose the binary number grouping is not completed with the 4 digits, sufficient numbers of zero are added to the left most side of the binary number.

Example: Conversion of a binary number 110110101011100 into its equivalent hexadecimal number.

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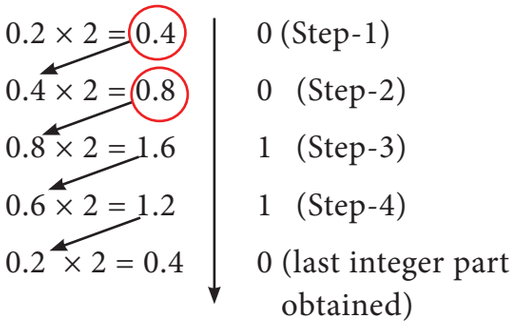
0110 1101 0101 1100

6 D 5 C

Hence, $110110101011100_2 = 6D5C_{16}$

7.5.11 Fractional Decimal to Binary Conversion

The method of "Repeated multiplication by 2" has to used to convert the decimal fractions.



Note: Fraction repeats, the product is the same as in the first step.

Write the integer parts from top to bottom to obtain the equivalent fractional binary number. Hence $(0.2)_{10} = (0.00110011\ldots)_2$

7.5.12 Decimal to BCD Conversion

In this Conversion, each decimal digit is converted into its equivalent 4 digits binary form (BCD).

Example: Conversion of a decimal number 892 to its equivalent BCD number.

8 9 2

1000 1001 0010

Hence, $892_{10} = 100010010010_{BCD}$

7.5.13 BCD to Decimal Conversion

In this method, each BCD number grouped in the form of 4 digit binary pattern is converted into its equivalent decimal number.

Example: Convert a BCD number100100111000 to its equivalent decimal number.

1001 0011 1000

9 3 8

Hence, $100100111000_{BCD} = 938_{10}$

7.6 BINARY ADDITION AND SUBTRACTION

A logic circuit can be used to perform arithmetic functions like addition, subtraction, multiplication, division etc. For performing these operations, compliment method of number patterns are used. First, we will see the complement methods in order to understand the basic arithmetic operations.

7.6.1 One's Complement Method

In one's complement method, each binary bit of the number is changed from 0 to 1 or 1 to 0 depending on the existing bit value.

For instance, the binary number is $A_3 A_2 A_1 A_0 = 0010$, its corresponding one's complement number is $\overline{A}_3 \overline{A}_2 \overline{A}_1 \overline{A}_0 = 1101$

The same principle will apply for number having any bit length and its corresponding one's complement number can be obtained by complement each bit.

7.6.2 Two's Complement Method

The two's complement of a binary number is the number that results when we add '1' to the one's complement number. The formula for two's complement of a binary number is given below.

Two's complement number = one's complement +1

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For instance, to find the two's complement number of 0101, the following procedure is employed.

$0101 \Rightarrow 1010$ (1's *complement*)

$1010+1 \Rightarrow 1011$ (2's *complement*)

7.6.3 Binary Addition

For binary addition, the arithmetic rules used are given below.

1. 0+0=0
2. 0+1=1, No carry is formed
3. 1+0=1, i.e. carry=0
4. 1+1=0,with a carry of 1, and sum = 0 i.e. $1+1 = 10_2$.

This is a binary number10 and not the decimal number ten. Here, the first digit 0 is called sum and next digit 1 is called carry.

Examples:

1. Add the binary numbers 1011 and 1100

$$\begin{array}{r} 1011+ \\ 1100 \\ \hline 10111 \end{array}$$

Sum=0111, and Carry=1

2. Add the binary number 11101 with 11011001.

$$\begin{array}{ll} \text{The first number} & = 00011101 + \\ \text{The second number} & = \underline{11011001} \\ \text{Result} & = \underline{11110110} \end{array}$$

7.6.4 Binary Subtraction

The general rules for carrying out the binary subtraction are given below.

1. 0-0=0
2. 1-0=1
3. 1-1=0
4. 0-1=1,with a borrow of 1 from the next higher bit.
5. 10-1=1

Example: Subtract 0111 from 1011

$$\begin{array}{rl} 1011 & => 11_{10} \\ \underline{0111} & => \underline{7_{10}} \\ 0100 & => 4_{10} \end{array}$$

First column => 1-1 =0

Second column =>1-1 = 0

Third column =>0-1 = 10-1 = 1

Forth column => After borrowing, the fourth column becomes 0

Hence, 0-0=0

$1011_2 - 0111_2 = 0100_2$

7.7 BINARY CODES

All digital circuits operate with only two states namely, High and Low or ON and OFF or 1 and 0. In binary number system, the number of bits required goes on increasing as the numbers become larger and larger. So, some special binary codes are required to represent alphabets and special characters. Based on these points, different types of binary code have been developed.

They are,

1. BCD codes
2. Gray codes
3. Excess 3 code
4. ASCII code

7.7.1 BCD - 8421 Code Conversion

A group of bits (usually four) which are used to represent decimal numbers 0 to 9 are called BCD(Binary Coded Decimal) codes. The most popular BCD code is 8421 code. The 8421 indicates the binary weights of the four bits ($2^3, 2^2, 2^1, 2^0$). Using the four bits with weights 8,4,2,1, we can easily represent the decimal numbers 0 to 9 as given in the Table 7.4.

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Table 7.4: Conversion of Decimal Number into BCD Code	
Decimal Numbers	BCD Code
0	0000
1	0001
2	0010
3	0011
4	0100
5	0101
6	0110
7	0111
8	1000
9	1001
10	0001 0000
56	0101 0110
963	1001 0110 0011

7.7.2 Gray Code

The gray code is not a weighted code. Therefore it is not suitable for arithmetic operations, but finds applications in input/output devices and in some types of analog to digital converters.

Table 7.5: Gray code conversion		
Decimal numbers	Binary code	Gray code
0	0000	0000
1	0001	0001
2	0010	0011
3	0011	0010
4	0100	0110
5	0101	0111
6	0110	0101
7	0111	0100
8	1000	1100
9	1001	1101
10	1010	1111
11	1011	1110
12	1100	1010
13	1101	1011
14	1110	1001
15	1111	1000

The gray code is a minimum change code in which only one bit in the code group changes when moving from one step to the next. The gray code is also called as reflected binary code, which has a special property of containing two adjacent code numbers that differ by only one bit. The gray code representation for the decimal numbers 0 to 15, together with the binary code is given in the Table 7.5.

7.7.3 Excess-3 Code

The excess-3 code is another BCD code used in earlier computers. The excess-3 code is not a weighted code. It is a self-complementing code and helps in performing subtraction operations in digital computers. The excess–3 code is also a reflection code.

An excess–3 code is obtained by adding 3 to each digit of a decimal number. For example, to encode the decimal number 6 into an excess–3 code, we must first add 3, in order to obtain 9. The 9 is then encoded into its equivalent 4 bit binary code 1001.

Example: Conversion of the decimal number 548 to its equivalent excess-3 code.

Decimal number	5	4	8
Add 3 to each bit	+3	+3	+3
Sum	= 8	7	11

Hence, the equivalent excess-3code 1000 0111 1011

The representation of Excess-3 code for the decimal numbers is given in the Table 7.6.

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Table 7.6: Excess-3 Code of Decimal Number	
Decimal Number	Excess-3 Code
0	0011
1	0100
2	0101
3	0110
4	0111
5	1000
6	1001
7	1010
8	1011
9	1100

7.7.4 Binary to Gray Conversion

To convert a given binary number to its equivalent gray code, the following rules are applied.

1. The MSB of the gray code is same as the MSB of the binary.
2. Coding starts from left to right, add each adjacent pair of bits to get the next bit of the gray code. Omit the carry, if occurs.

Example: Conversion of the binary number 1011 to gray code.

Step1: The MSB in gray code is same as the MSB of the binary

1 0 1 1 Binary
↓
1 1 Gray

Step2: Add the left most bit to the adjacent one.

1 + 0 1 1 Binary
↓
1 1 Gray

Step3: Add the next adjacent pair.

1 0+ 1 1 Binary
↓
1 1 1 1 Gray

Step4: Add the next adjacent pair and omit the carry.

1 0 1+ 1 Binary
↓
1 1 1 0 Gray

Hence, $(1011)_2 = (1110)_G$

Suffix 'G' is used to represent the Gray code.

7.7.5 Gray to Binary Conversion

To convert a given Gray code number into equivalent binary, the following rules are applied.

1. The MSB of the binary is same as the MSB of the Gray.
2. Coding from left to right, add the binary digit generated to the adjacent gray bit to get the next bit of the binary. Omit the carry if occurs.

Example: convert the gray code 1110 to its equivalent binary.

Step1: The MSB in binary is same as the MSB of the gray

1 1 1 0 Gray
↓
1 Binary

Step2: Add the binary digit generated to the adjacent bit of the Gray code.

1 1 1 0 Gray
↗+↓
1 0 Binary

Step 3: Add the binary digit generated to the adjacent bit of Gray codes.

1 1 1 0 Gray
↗+↓
1 0 1 Binary

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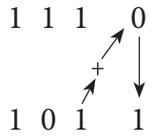
Step 4: Add the binary digit generated to the adjacent bit of gray code.



Hence, $(1110)_G = (1011)_2$

7.8 ADVANTAGES AND DISADVANTAGES OF DIGITAL ELECTRONICS

7.8.1 Advantage

1. Very simple logic the lead to identify the faults very easily
2. Immune to noise
3. Flexibility of programming
4. Design and testing is very simple compared to analog electronics
5. Achieve very high speed switching

Disadvantage

1. High energy consumption than analog electronic circuits
2. Higher cost of design
3. Portability is difficult
4. Real world signals need conversion
5. Less accurate than the analog electronics

LEARNING OUTCOMES

Student will capable of

1. **Remembering of the difference between analog and digital signals.**
2. **Conversion of one number system into another number system.**
3. **Understanding of basic digital circuits.**
4. **Designing and testing of small digital application circuits.**

GLOSSARY

S. No	Terms	Explanation
1	**BCD**	Binary Coded Decimal. Four bit code used to portray each digit of a display numbers by its 4 binary equivalent
2	**Binary**	A number system having only two symbols, 0 and 1.
3	**Digital**	Relating to devices or circuits that have outputs of only two discrete levels. Example: 0 or 1, high or low, on or off, true or false etc
4	**LSB**	Least Significant Bit. Right most bit (smallest weight) of a binary expressed quantity
5	**MSB**	Most Significant Bit. Left most binary bit (largest weight) of a binary expressed quantity

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QUESTIONS

PART A

I. Choose the best answer 1 Mark

1. The number of levels in a digital signals
   a) One b) Two c) Eight d) Ten
2. A sinewave is a
   a) analog signal
   b) digital signal
   c) both digital and analog signal
   d) neither digital nor analog.
3. In computer memory, 1Kilobyte is equivalent to _____ bytes?
   a) 1000 b) 1024 c) 2000 d) 3024
4. How many numbers are there in octal number?
   a) 10 b) 2 c) 8 d) 16
5. In the following numbers which one is not an OCTAL number?
   a) 56 b) 32 c) 43 d) 86
6. Decimal number 15 in binary system can be written as
   a) 1111 b) 1000 c) 1110 d) 1100
7. The equivalent Decimal value for the Binary 10101_2 is ……..
   a) 13 b) 19 c) 21 d) 23
8. The equivalent Octal value for the Decimal 19 is represented by
   a) 21 b) 23 c) 25 d) 22
9. The 1's complement of 0010 is ……...
   a) 0010 b) 1101 c) 0111 d) 1111
10. The 2's complement of 1110 is ……...
    a) 0010 b) 1101 c) 0010 d) 1111

II. Answer in few sentence 3 Mark

1. What is digital electronic?
2. What is binary number system?
3. What is digital signal? Give Example
4. Convert the decimal number 18 into binary number.
5. Convert the decimal number 96 into octal number.
6. Convert the decimal number 228 into hexa-decimal number.
7. Why digital system is reliable?
8. Write the types of binary code
9. Define gray code?
10. Convert the binary number 1101_2 into decimal number.

III Answer the following questions with suitable examples. 5 Marks

1. Write a short note on analog and digital signals?
2. Explain Binary number system.
3. What are the advantages and disadvantages of digital electronics?
4. Convert the gray code 1110 into its equivalent binary.

IV. Answer the following questions with neat sketches. 10 Marks

1. Discuss in detail the concepts of binary codes.
2. Explain in detail about the number system.

ANSWERS

1. **(b)** 2. **(a)** 3. **(b)** 4. **(c)** 5. **(d)**
6. **(a)** 7. **(c)** 8. **(b)** 9. **(b)** 10. **(d)**

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FUNDAMENTALS OF COMPUTER SYSTEM

CHAPTER 8

S0M9E

LEARNING OBJECTIVES

A student can understand the following in this chapter

1. Fundamentals of computer system
2. Basic Concepts of Operating System
3. Concepts of Motherboard
4. Function of CPU
5. Working of Hard disk drive.

8.1. FUNDAMENTALS OF COMPUTER SYSTEM

8.1.1. Introduction

In this modern world, 'computer' is the powerful and frequently using word for performing the day-today activities. Through the computer, we can view and feel all the activities of the real-world in a display virtually. Because, with the help of computer, we can watch all incidents (Political, Scientific, Climate, Sports etc.,) happening not only around us but in any part of the world. Above all the Computer is a slave to do our routine activities. In the present scenario, without two electronic gadgets, the World may become stand still. Those are none other than Computer and Cell-phone.

Computer is an electronic device that process the input according to the set of instructions provided to it and gives the desired output at a very fast rate.

8.1.2. History of Computer

Many centuries ago humans try to develop machine to perform some calculations. The speed of this development increased after the arrival of numerals.

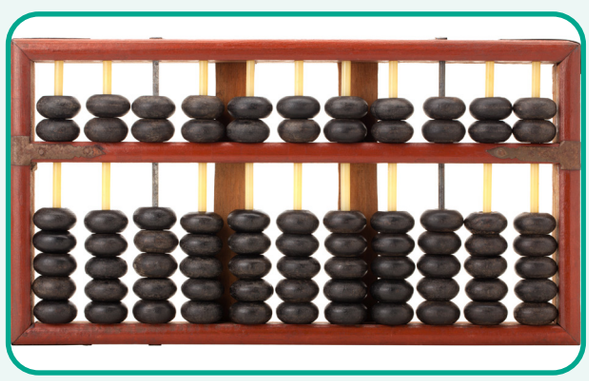

Figure 8.1: ABACUS

Figure 8.1 shows the ABACUS, the first calculating tool developed by human. The credit belongs to Chinese, some says it is Babylonians and Egyptians, but it is not actually known. Many calculating tools were derived or developed after the arrival of ABACUS, like Slide rule, Pascal calculating machine, Nappier Bones, etc.

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Among these, the most important one is 'Analytical Engine' a mechanical device as shown in Figure 8.2, which was developed by the British mathematician Mr. Charles Babbage (1791-1871). It was developed by using gear wheels. Moving of each tooth rotates the numeral form 0-9.This way the counter was set.

The simple example to understand this concept is 'speedometer' used in vehicles. By keeping this as the base, the first electronic calculating machine i.e. 'calculator' was developed. From this, computer was developed. Hence, a 'computer' is nothing but a developed-stage of a calculator.

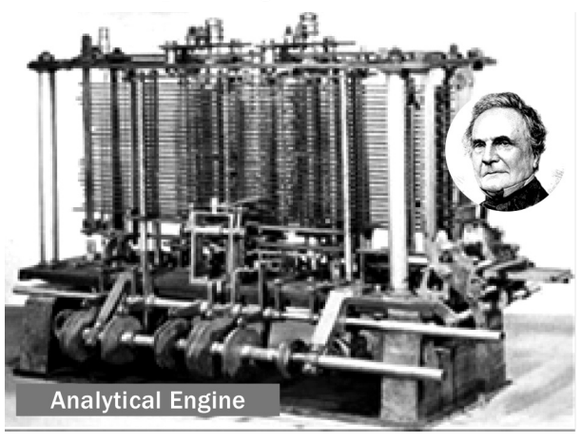


Figure 8.2 Analytical Engine

In simple terms, we can say calculator is a small calculating machine and computer is a big calculating machine.

Why?

Because calculator is small in size. Computer is big in size?

Before entering into the computer field, we have to keep two important basic things in our mind.

Basically computer is a fool. It is an idiot. It cannot do anything on its own.

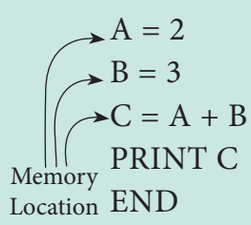
Computer never do mistakes. (Unless or otherwise we did a mistake....)

Clearly to say computer cannot think on its own.

For example: If you want to add 2, 3, etc., by switching on the computer if you give 2 + 3 = 5. You can't get the answer as '5'. Because the computer unable to understand what is '2' or '3'. So, we have to instruct the computer as like a child who is doing first standard or second standard to perform the above addition, as like the following format.

Keep the value of '2' in your memory. Leave three fingers and start to count three, four, five, etc.

Just like the same we have to instruct the computer. For your easy understanding there is an example.



In the mathematical A = 2 means, the value of 'A' is 2, whereas in computer terminology A = 2 means, we are asking the computer to keep the value of '2' in the memory location called 'A'. B = 3 means keep the value of 3 in the memory location called 'B'.

Likewise, we have to define each and everything to its memory. The memory location is nothing but an IC. Similarly, even the addition of 1-1000 numbers can be done very easily and quickly. The computer takes just a fraction of a second (Micro Second).

Since the computer be able to perform such a big task, without committing any error, that too with high speed, is termed as big calculating machine.

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This is the first major difference between Calculator and Computer.

Yet another big difference is there. Let we see it later.

Now let us see the evolution of computer (i.e., generation of computer).

8.2. GENERATION OF COMPUTER

No.	Generation	Main Component used	Merits/Demerits
1	First Generation computer (1940-56)	 **Vacuum tube**	• Big in size • Consumed more power • Malfunction due to overheat • Machine Language was used
	First Generation Computers - ENIAC , EDVAC , UNIVAC 1 ENIAC weighed about 27 tons, size 8 feet × 100 feet × 3 feet and consumed around 150 watts of power		
2	Second Generation Computer (1956 – 1963)	 **Transistors**	• Smaller compared to First Generation • Generated Less Heat • Consumed less power compared to first generation • Machine language as well as Assembly language was used.
	Second Generation Computers IBM 1401, IBM 1620, UNIVAC 1108		
3	Third Generation Computer (1964 – 1971)	 **Integrated Circuits (IC)**	• Computers were smaller, faster and more reliable • Consumed less power • High Level Languages were used
	Third Generation Computers IBM 360 series, Honeywell 6000 series		
4.	Fourth Generation Computer (1971 of above)	 **Microprocessor Very Large Scale Integrated Circuits (VLSI)**	• Smaller and Faster • Microcomputer series such as IBM and APPLE were developed • Portable Computers were introduced.
5.	Fifth Generation Computer 1980 - till date	 Ultra Large Scale Integration (ULSI)	• Parallel Processing • Super conductors • Computers size was drastically reduced. • Can recognise Images and Graphics • Introduction of Artificial Intelligence and Expert Systems • Able to solve high complex problems including decision making and logical reasoning

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Apart from human, the term *language* is used or needed is only in computer field.

Why the computer need a language?

If a human want to converse with other, certainly he/she is in need of a language. Likewise, if we want to interact with the computer, we are in need of a language.

Generation of Language

Hence, during the development of first generation computer, there was a language and along with generations of computer the language were also developed, concurrently.

First Generation Language

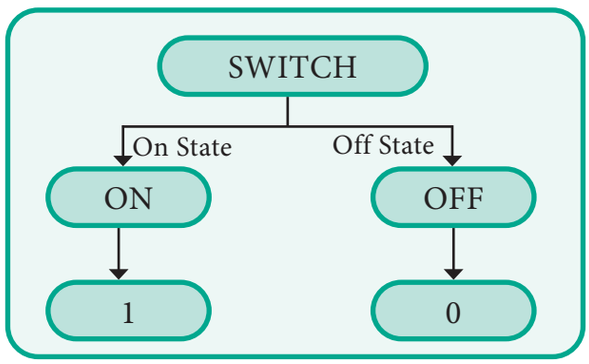
The name of the first generation language is called as **'Machine language'**.

What is meant by machine language? Here, the word machine denotes the computer. Basically, this machine is an electrical machine. So, the 'Machine Language' can also be called as 'Electrical language'. How about this Electrical language?

To understand this, let we take a SWITCH as shown in below. In how many modes we can operate a switch?

Normally a switch can be operated in two states.

1. 1. ON – state
2. 2. OFF - state



NOTE: Switch cannot be operated in any other modes.

When there is supply (ON-state), it is denoted by the letter (numeral) '1' and if there is no supply (OFF-state), it is denoted by the letter '0'.

So, in electrical language, there are only two (1, 0) digits, which are the direct electrical notations and thus machine language is nothing but 1s and 0s. Hence, during the period of first generation computer, they were able to interact with the computer only by using 1s and 0s. During the first generation computer, this machine language was used as shown in Table.

Decimal No	Machine Lang
0	0000
1	0001
2	0010
3	0011
4	0100
5	0101

Since the computer doesn't know anything other than this 1s and 0s, any other alphabets or letters should be converted into this 1s and 0s. This becomes much laborious and tough for the people to understand and follow. Hence, along with second generation

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computer the second generation language was also developed.

Second Generation Language

The name of the second generation language is **'Assembly Language'** as shown in table. In this, we can use both alphabets and also numbers but only in the form of abbreviations.

Instead of

ADDITION → ADD

SUBTRACTION → SUB

MULTIPLICATION → MUL

DIVISION→DIV……etc.,

Likewise, we can give only three or four letter words. Because, those days computer was just like three year old child.

Eg: As we use to teach a small child with CAT, RAT, BAT & BALL.

The words which are more than 3 or 4 letters should be abbreviated and used. Keeping so many abbreviations in memory is very tough and more to say abbreviations don't have any meaning also. Hence, this was also very tough for the people to understand and lead to the next generation language.

Third Generation Language

The name of the third generation language is called as **High Level Language** (HLL). In this, we are having:

BASIC, FORTRAN, PASCAL, 'C', PROLOG, ALGOL, PL-I, C++….

Likewise, thousand and odd languages are there.

We have seen, the previous two generation languages were so tough to understand and follow.

What is the development and advantage in third generation?

In this, we can write any type of instruction to the computer just in the form of English like sentence.

Example:
IF AGE >18 ALLOW THE PERSON TO VOTE

If we ask the meaning for the above sentence, any one can say.

No one can believe, if the above sentence is written in computer language. But, this is a typical COBOL language statement. Like this, in all the High Level Languages, we can write any instruction in simple English like sentences.

Now tell me, which generation language is easy?

Certainly the third generation is quite easier than previous two. After the arrival of third generation language many start to learn, interact and extract work from the computer. Further, the development was going on and fourth generation was developed.

Fourth Generation Language

The name of the fourth generation language is Application language or packages. In this, there are so many numbers of languages as given below.

FoxBASE, FoxPro, EXCEL, ACCESS, POWER POINT, MS –WORD …etc.

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We have seen that the III generation language itself becomes more easy to use.

Then, what is the added development in fourth generation language?

A question may arise in your mind, why the computer cannot be operated as like a calculator? like addition, subtraction, multiplication and division directly.

As we have seen earlier in third generation language even a small procedure can be executed only by writing four or five lines (instruction).But in fourth generation language we can execute few things directly (even without writing few lines).

For Example, in FoxPro language after giving a question mark ?10 + 20 and press enter. You will get the answer as 30. Whereas in COBOL(III- generation language), if you give as like above, it won't give you the answer. Because here in III-generation if we give10 + 20, the computer cannot understand what is meant by this 10 and 20 (since the computer doesn't know anything on its own).

Then, how it becomes possible in fourth generation language like FoxPro? Even, there the computer doesn't know anything, then how the answer 30 comes.

Please remember whatever we are giving to the computer it should be referred to its memory.

So in FoxPro, if we give any value after giving a question mark(?), it will be referred to a memory as shown in below Figure 8.3

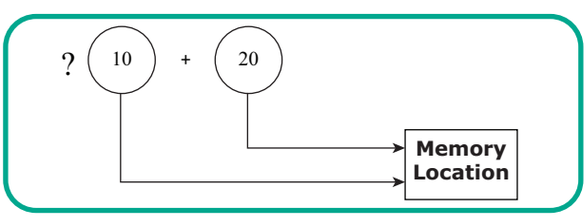

Figure 8.3

These referring instructions were given inside the FoxPro language itself. Hence, it is enough to give remaining instructions. But in third generation language, no such referring instructions were written inside the language. So we have to instruct the computer from minimum level.

If we want to understand the advantage of fourth generation language, it is better to understand the difference between the both.

8.4. MAJOR PARTS OF COMPUTER

To be precise, only one particular part is said to be computer. To understand this let us see the working of each part illustrated in Figure 8.7

1. KEY BOARD: It is a device which is used to give any data or instruction to the computer.
2. MOUSE: Mouse is used to select the instruction to the computer by clicking the icons.
3. MONITOR (OR) VDU: This will show what we are giving and what the computer is doing.
4. CPU (System Unit or Central Processing Unit): This is the part which is going to execute all the instructions given by us. So to say, this is the heart and brain of the computer. (The other parts keyboards, mouse, VDU are peripherals as like human hands and legs)

8.4.1. Hardware Parts of Computer

With reference to the computer, the parts which we able to see through our eyes are

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called as Hardware parts of computer, as shown in Figure 8.4.

Example: Keyboard, Mouse, VDU, CPU and even the parts inside these, right from IC to small screw.

8.4.2. Software Parts of Computer

With reference to the computer the parts which we unable to see through our eyes are termed as software parts of computer.

Example: All languages, program, even a single instruction that we are giving to the computer.

8.5. CLASSIFICATION OF COMPUTER PARTS

The computer parts are classified into three categories based on its functions

1. Input Devices (I/P)
2. Output Devices (O/P)
3. Both (I/P) and (O/P)

Input Device	Output Device
1. Key Board 2. Mouse 3. Light Pen	1. VDU (or) Monitor 2. Printer 3. Plotter

Both (I/P) & (O/P) Device

1. Touch Screen
2. Compact Disk
3. Hard Disc
4. Memory Card
5. Pen Drive

Till this, we have seen the peripherals of computer. Now let us see the working of computer i.e., CPU.

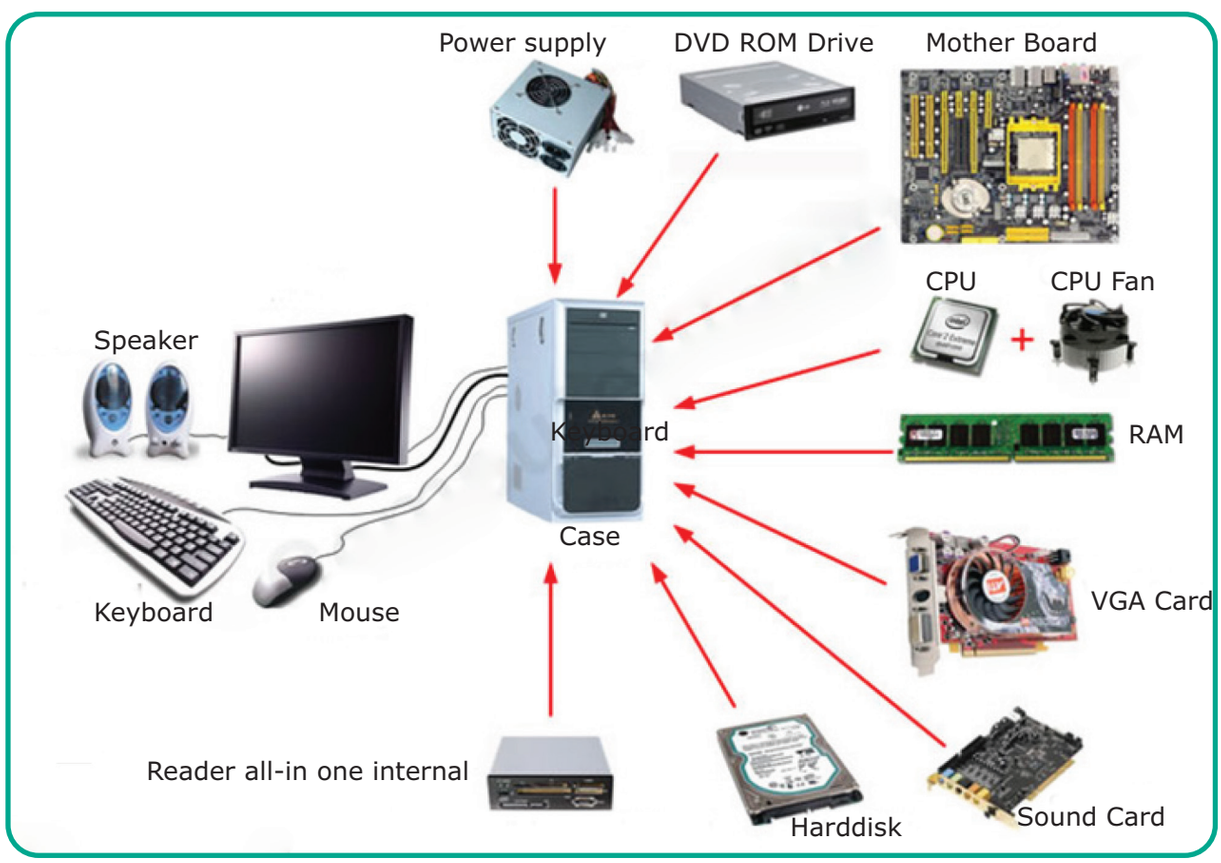

Figure 8.4 Parts of the Hardware

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Figure 8.5: Types of Computer based on Working Method or Technology



Figure 8.6: Types of Computers based on performance and memory

8.6. CLASSIFICATION OF COMPUTER

Computers are classified into two broad categories.

1. Based on Working Method (Technology)
2. Based on (size) performance and Memory

Based on Work Method there are three types as shown in Figure 8.5

1. Analog Computer
2. Digital Computer
3. Hybrid Computer (Here Hybrid is easy to carry – i.e., Laptop)

Based on (size) Performance and Memory Figure 8.6.

1. Micro Computer
2. Mini Computer
3. Main Frame Computer
4. Super Computer

8.7. MAJOR DIVISION OF CPU

The CPU consists of three major divisions as shown in Figure 8.7. They are,

1. ALU
2. MEMORY UNIT
3. CONTROL UNIT

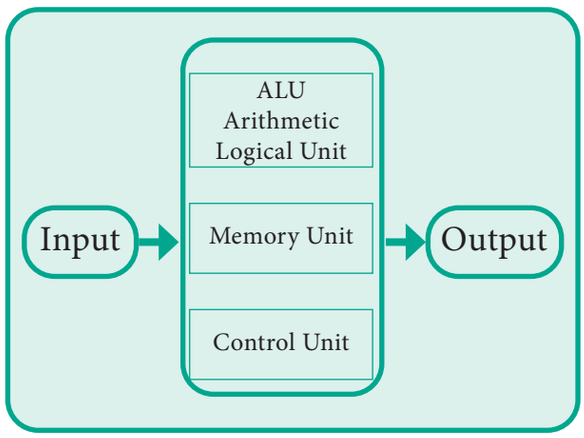

Figure 8.7: Major Division of Central Processing Unit

8.7.1. ALU

What is meant by Arithmetic?

In general, Arithmetic means operations using numbers like Addition, Subtraction,

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Multiplication, division, etc. In computer, any type of calculation is known as Arithmetic operations.

LOGIC →What is meant by this?

To say, the speciality of computer lies in this word. Let us see regarding this in a different way.

What do you mean by this word logic?

For example: Assume that there is a long-standing issue in your area where you are residing. You and your friends decided to find a solution for it. What will be your first step? You start to discuss among with your friends regarding that issue. By the time, everyone will say their suggestion. For Example assumed that 10 of your friends are involved in that discussion. All the 10 will give their suggestions. Each suggestions might be a solution for that problem. But among the ten we can select only one as 'final' (i.e. decision) solution. The following illustration shown in Figure 8.8 simply explains the concept "logic".

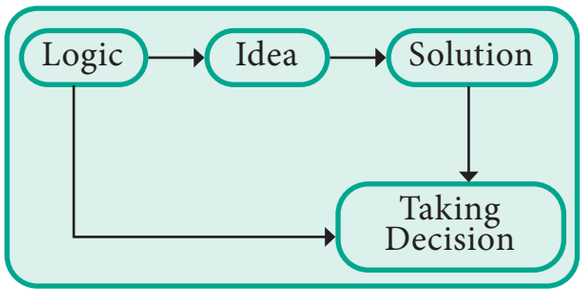


Figure 8.8: Illustration of Logic

With reference to the above example and illustration, Logic is nothing but an idea, idea is nothing but a solution and solution is nothing but taking decision.

Hence, logic is nothing but taking decision.

If so! Whether the computer has decision taking capacity?

If not, there is no use of thinking about all these things.

Logical Capability → Decision taking capacity

We may think., How foolish computer be able to take decision? How it possible?

Let us think... In general, while we are taking decision, in how many ways we can take decision?

For example:

Assume that your friend is inviting you for a movie.

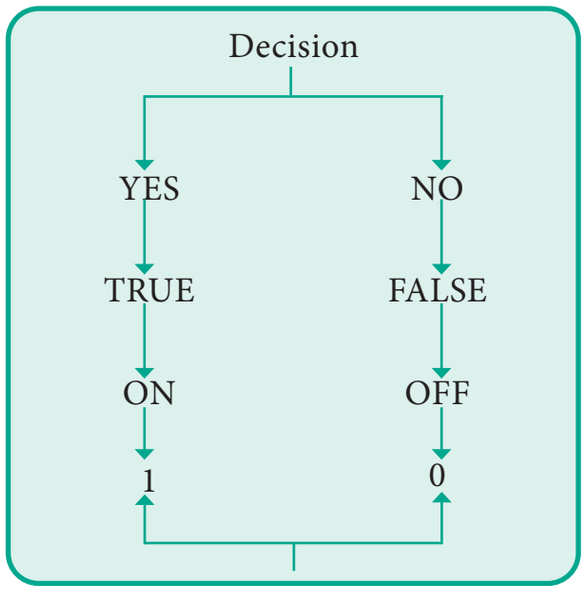
What you will say?

If you intent, you say yes, otherwise, Sorry no.

Otherwise, is there is any other option?

Usually we say, let us see, which is not at all an answer, because any answer should give finite result.

So, for any action, there are only two possible answers.



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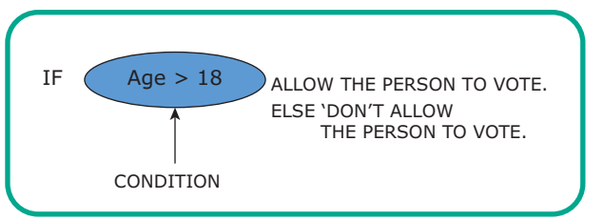
At last where we came? We come to the 1, 0, i.e., the machine language.

Till date the computer directly knows only one thing, i.e., the Machine Language

Go through the following statement

Example:



NOTE: whenever we are coming across a condition, we have to take a decision

While the computer is reading the above particular statement, it has to take decision.

1. When the given condition is true, (i.e., the person age is more than 18) it receives '1' pulse. When it receives '1' pulse, the computer continuously reads the remaining part of the statement after the conditions and do, accordingly.
2. When the given condition is false (i.e., the person age is below 18), it receives a '0' pulse. On receiving the '0' pulse, the computer terminates that particular line (it won't continue that line) and starts to read the next line.

   Because of this, while you are writing program you will be instructed to write, 'what to be done if the condition is true', must be immediately followed the condition, and 'what to be done if the condition is false ', in the next line.

   Though the decision taking capacity is in the form of machine language, i.e., 1, 0 ., the computer can take the decision directly.

   Because of this logical capability, the computer is said to be superior than the calculator.

   This is the second major difference between calculator and computer.

   The action of ALU can also be explained through yet another example.

Example: IF BASICPAY> 2000 CALCULATE HRA = 20 * BASICPAY/100.

From the above example,



So, wherever the computer reads this line, this will be carried out by the arithmetic logical unit.

8.7.2. Memory Unit

This is yet another important division of CPU. Normally this is classified into two broad categories.

1. Internal Memory
2. External Memory

Internal Memory

The memories which are kept inside the CPU (or) on mother board are known as Internal Memory. There are five types,

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such as ROM, RAM, PROM, EPROM and EEPROM. All are nothing but IC's. Let us see the purpose and usage of each memory device in following sections.

ROM →Read Only Memory

From the above expansion itself, we could understand that the content of this IC can be read only. The function and working of this IC can be easily explained through the following example.

Let we take a calculator:

Switch on the calculator.

What you will get on the screen?

'0'

But you didn't press zero. Then, how the zero comes?

Whether it came automatically?

No, someone is making it to display.

Just like the same, whenever we are switching on the computer, the computer has to do something on its own to get ready.

We know basically the computer cannot do anything on its own.

Then, it is doing something means, the necessary command is delivered from a particular memory. That particular memory is called as ROM.

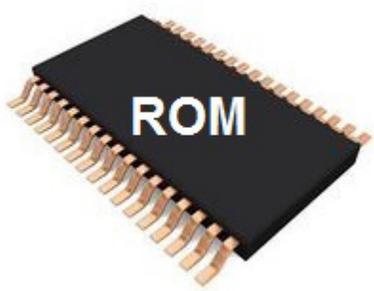

Figure 8.9: **ROM-IC**

This is an IC (Integrated Circuit), whenever we are switching ON the computer, the pointer will enter into this memory, read the content and do accordingly.Initially, it will do a self-test, which is called as POST(Power On Self-Test). After performing POST, it will hand over the charge to us. Then only, we can give anything to the computer.

After storing the necessary instruction, the IC will be sealed. Then, the content cannot be altered, deleted and changed. But, can only be read. Because of this it is called as Read Only Memory or permanent memory. Without this ROM, no calculator or computer can get ready.

RAM →Random Access Memory

Random means without any proper order. Let we see the purpose of this memory. Let we again take calculator for example.

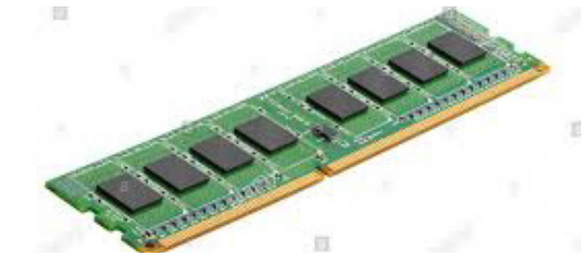

Figure 8.10: **RAM**

Assume that you want to perform the addition of 5, 10 in the calculator. What we will do?

Step1 : Switch ON the calculator.
:You can get '0' on the screen.

Step2 :Now press'5'.
:5 will be displayed on the screen.

Step3 : Next press '+'.

Step4 : For '10' you have to press'1'.

Now what will happen to that '5' it is not on the screen, then where it would

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be. Certainly, these numbers have gone to a memory and that particular memory is RAM. Since we cannot find the location where it is going is called as Random Access Memory.

As like the calculator, the computer is also having RAM. After the computer got ready whatever be the thing that we are giving, it should go to a memory and that particular memory is RAM. But, it will lose or the content of this memory will get erased when the computer is switched OFF or due to power failure. Hence, it is called as temporary memory or volatile memory. But it is live memory.

Without the concern of the RAM nothing can be done in the computer

If we are seeing something on the monitor, it is understand that, the content present from the RAM. Hence, the capacity of RAM is much important. Even the configuration of the computer is decided by the capacity of the RAM. So, without this ROM and RAM, no calculator or computer can work.

PROM→Programmable Read Only Memory



Figure 8.11: PROM

This is like a ROM. The purpose of this IC is also the same as ROM. The difference between ROM and PROM is, in PROM we can (a software engineer) store the necessary booting(POST) instruction. But it can be done only once. After that the content cannot be altered, deleted or changed.

EPROM→Erasable Programmable Read Only Memory



Figure 8.12: EPROM

The purpose and use of this memory is similar to ROM and PROM. The difference is, the content of this memory can be erased by passing ultra violet rays through a small hole provided on the top surface of the IC. Again it can be re-programmed.

EEPROM→Electrically Erasable Programmable Read Only Memory



Figure 8.13: EEPROM

This is also same like EPROM. Here the content of this IC can be erased by passing external electrical pulse through a particular pin of the IC. And again it can be re-programmed. From the above, ROM, PROM, EPROM and EEPROM are doing the same work and hence any one can be used in the computer. In majority of recent computers, EPROM is used as Booting IC and RAM is the live memory.

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So far, we have seen the purpose and working of internal memory. For your notice, we cannot store anything permanent in this.

External Memory

If we want to store anything permanent it can be stored only under external memory. There are few types of external memory as listed below.

a. Floppy Disc
b. Hard Disc
c. Magnetic Tape
d. Compact Disc
e. Pen Drive
f. Memory Card

From the above, floppy disc is totally out-dated. CD, Hard disc, pen-drive and memory-card are widely used. Let us see about the capacity of these. When we talk about any capacity it should have its own unit. Normally. the unit of memory is 'Byte'. It is better to know about hierarchical structure of it. The memory capacity is mentioned in the following units summarized in Table 8.1.

Table 8.1: Memory Capacity

0	Bit
1	Bit
8Bits	1 Byte
1024 Bytes	1 kilo Byte
1024 KB	1 Mega Byte
1024 MB	1 Giga Byte
1024 GB	1 Terra Byte

8.7.3. Control Unit

In general, the computer is doing various activities, besides; some activities are handling by many peripherals. In order to monitor and control all these, a system is used, which is called as control unit.

Controls Input Device

Assume that you are typing a matter consists of many pages. While you are typing speedy, we press one or more keys at a time. That moment, the respective letters altogether try to enter into the RAM, which is not possible. By that time the control unit will take charge and block it and give a beep sound. On hearing beep sound, we can able to identify that we are doing something wrongly. Thus, the control unit is controlling the input device, i.e., keyboard.

Controls Output Device

Assume that you typed around 50 pages of a matter. Now, the matter is in RAM and you want to take a print-out. On giving print command, all the 50 pages content will try to go to the printer, which is not possible. Here too, the printer and CPU are interfaced through a set of wires. If it is possible to travel or send data with reference to the capacity of the wire, all the pages tend to go at a time. This is elucidated by the following example.

Example:

- Assume a class room
- Evening closing bell rang.
- There is only one door in the class room.
- What the students will do?
- Everyone will tend to go-out of the class through the single door.
- By that time if a master is there, he will control them and regulate to go one by one.

Just like students, here all the pages will tend to go to the printer, which is not possible. Here, the control unit is taking charge, regulate and send little by little to the printer. Thus, the control unit controls the output device.

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Controls both I/P and O/P Devices

E.g.: Assume that there is a movie in a pen-drive and you want to view it.

After inserting the pen-drive into the respective slot, you will click the particular icon. Now, the entire movie will try to go to the RAM (Live Memory). Once again, the pen-drive (External Memory) and the RAM (Internal Memory) are connected through set of wires, which cannot transfer much data at a time. Now, the control unit will take charge, regulate and send little by little to RAM. Then, the control unit controls both input and output devices.

Thus, the control unit controls the entire system. Without the concern of the control unit, nothing can be done in the system.

Control unit – Is as like a father in a family.

8.8. COMPILERS AND INTERPRETERS

We studied, till date the computer knows only one language,i.e., machine language. But we know only High Level Languages and Application Languages, which the computer does not know. But, we both want to interact. How this become possible?

Example:

- *Assume that our prime minister is going to RUSSIA to meet the Russians president.*
- *Our PM knows Hindi and English. And the Russian president knows only RUSSIAN language.*
- *But, both want to converse.*
- *How?*
- *You can see a man (translator) who knows both Russian and English will sit near to them. He will translate English to Russian and vice versa.*

Just as like the above, we need a translator to translate our High Level Languages and Application Languages into corresponding machine language.The compilers and interpreters are here used as translator.

Oh….fine…

- Whether it is software or hardware?

Absolutely, it is a software written in one particular high level language.

Then, why we should need both, compiler and interpreters?

To understand this let we see the working method of compiler and interpreter.

Compiler: Compiler means taking together. This will take entire program (whatever be the number of lines) and convert it into machine language. Wherever the mistake, just it will mark it and go to next line. After completing the entire program, it will list out the errors at the last.

Interpreter: The interpreter will read line by line. If there is a mistake in the first line, it will stop there and the error will be displayed. It can go to the next line, only after the particular line gets corrected.

This is the difference between Compiler and Interpreter.

NOTE: Along with each High Level Language and Application language either Compiler or Interpreter will be attached. Widely compilers are used.

8.9. OPERATING SYSTEM

The word system denotes computer. Hence Operating System means operating computer. In this, we are going to see actually how the computer gets operated.

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Before going further, recollect the following.

- Basically computer never do anything on its own.
- ROM, RAM (Internal Memory).
- Hard disc (External Memory)…etc.

Operating System helps us to do some important and vital operations (like copy, delete, etc.) before entering into any particular language and after coming-out. It forms a bridge in between the user and the computer.
Let us see why?

Whenever we are switching on the computer what it will do?

It will read the content of ROM and do accordingly. After finishing the POST it will hand over the charge to the RAM. Now we can start to give instruction to the computer.



If we want to interact with the computer, we are in need of a language. Without a language we cannot give even single instruction or interact with the computer.

i.e., the speciality of computer.

If so, I need a language. Where are they?

- They all in external memory. To select a particular language, we have to give a command to the computer. But, even that particular command should also be in one particular language. Now, I don't have any language on my hand.
- Everything is get locked in the external memory, then, what can we do?
- In order to understand this, let me try to explain you through an old story.

A family of rats are living in a house and there is a CAT also. The cat catches a rat per day, as its food. Due to this the rats are so worried and decided to find a solution. They conversed a meeting. While on discussion a rat says, let we tie a bell on the cat neck. So that on getting the bell sound we could run away. Yes good idea, all the other rats appreciate that particular rat. It brought a rope and a bell and asks other rats., come-on go and tie the bell. Each rat is asking other rat to perform the task. Now the rats realised that they cannot able to execute the task on their own.

A Rat can tie the bell to the CAT, when only a third person helps them.

Now our situation is also the same. In order to bring any one of the language from the external memory, someone has to help us. Here, that particular helping hand is this Operating System.

If it so …whether it is a hardware or a software?

- **Absolutely it is software.**

If it is software, it should be stored in a particular memory permanently. Permanent in the sense, it should be stored only in external memory. So, whenever we are switching on the computer, this operating system which is normally in the hard disk should be loaded to the RAM, to serve the user instruction.

Whether it can be loaded automatically to the RAM? Certainly, Not. If so where would be the command? It should be in ROM. After performing the POST the next command is to seek the hard disk (or any external memory) in the computer and

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to search for operating system program. On finding that, bring it and load it in the RAM. These sequences of commands will be in ROM. Now, the Operating System will be loaded to the RAM. (You can see it on the monitor as,"Loading Windows", because Windows is the operating system).

Earlier there was an operating system named as DOS (Disk Operating System). It was developed as PC-DOS (Personnel computer DOS) and then, Microsoft Company entered into the Operating System development and released MS-DOS (Version 1 to 6). These were up to the years 1993-94. Then, Windows operating system evolved. But, truly speaking till now the windows is working on the platform of MS-DOS. The difference is, in DOS, we have to type commands to execute few things like COPY to Copy files, DEL to delete files, MD to create directory (say folders), CD to change folders, etc., whereas in Windows these operations are performed by selecting the respective menus or icons.

Loading Operating System either from hard-disk or from any other external memory to the RAM is known as Booting process.

Now the computer is ready to take our commands or instructions.

Operating system plays a role of a bridge between the user and the computer. Operating System is the tool connecting user with the computer. It is responsible for entire operation carried over by the computer. In computer, any software can be executed through the Operating System. Operating System is a software which is permanently installed in secondary memory, called Hard disk. Hence, Operating System is a very important tool to handle any type of input, output and both input/output devices as shown in Figure 8.14.

DO YOU KNOW?

Can a computer or a Smart Phone (Mobile Phone) work without an Operating System..? The Answer is… No



Figure 8.14: Operating System

LEARNING OUTCOMES

After studying this chapter, a student can understand the following

1. **Fundamentals of computer system**
2. **Basic Concepts of Operating System**
3. **Concepts of Motherboard**
4. **Function of CPU**
5. **Working of Hard disk drive.**

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QUESTIONS

PART A

I. Choose the Best Answer

1. The first calculating tool developed by human.....
   (a) Slide Rule (b) Nappier Bones
   (c) Abacus (d) Analytical Engine

2. Who developed Analytical Engine?
   (a) Blaise Pascal
   (b) Newton
   (c) Neil Bohr
   (d) Charles Babbage

C2RD8

3. Who is father of Computer?
   (a) Blaise Pascal (b) Charles Babbage
   (c) Bill Gates (d) John Nappier

4. What is the name of the first computer?
   (a) IBM (b) Microsoft
   (c) ENIAC (d) DELL

5. With reference to the computer Machine language is .....
   (a) High level language
   (b) Low Level Language
   (c) Very High level language
   (d) None of the above

6. With reference to the computer the parts which we cannot see through our eyes are termed as .....
   (a) Hardware
   (b) Software
   (c) Both Hardware & Software
   (d) None of the above

7. Write the Odd one from the following.
   (a) Monitor (b) Printer
   (c) Mouse (d) Plotter

8. Which is the Live memory among the below?
   (a) ROM (b) RAM
   (c) PROM (d) EPROM

9. Choose the odd one
   (a) Bit (b) Byte
   (c) Kilowatt (d) Megabyte

10. Compilers & Interpreters are .....
    (a) Hardware parts (b) Language
    (c) Translators (d) Operating System

PART B

II. Write answers in One or Two sentences. (3 marks)

1. Define computer.
2. Write down the names of the generation of computer.
3. Write down the major divisions of CPU.
4. What is the difference between Compiler and Interpreter?
5. Define arithmetic operations in computer.

PART C

III. Explain in One or Two Paragraphs. (5 marks)

1. Write about generations of computer.
2. Define the working of ROM & RAM.
3. Define Operating System.

PART D

IV. Write answers in detail. (10 marks)

1. Explain in detail the generations of languages.
2. Explain the working of CPU with neat diagram.

ANSWERS

1. **(c)** 2. **(d)** 3. **(b)** 4. **(c)** 5. **(b)**
6. **(b)** 7. **(c)** 8. **(b)** 9. **(c)** 10. **(c)**

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OVER VIEW OF OPERATING SYSTEM & MOTHER BOARD

CHAPTER 9

LEARNING OBJECTIVES

A student can understand the following in this chapter

1. Over view of Operating System and Booting
2. OS Types-Functions, Components, Characters
3. Mother Board-Types, Compenents, Functions
4. CPU Features
5. Memory-RAM, HDD

9.1 OVER VIEW OF OPERATING SYSTEM

Tim Paterson, a designer and engineer at Seattle Computer Products Company needed a way to test a new computer chip, a 16-bit Intel 8086. As a result, he wrote the QDOS -- Quick and Dirty Operating System. This is the first Operating System.

By that time, IBM (International Business Machines) manufactured a PC (Personnel Computer) using INTEL new chip 8088 and approached Bill gates to create an Operating System for their PC-XT(8088 is named as Extended Technology-XT). Rather of writing new OS, Bill gates purchased the QDOS from Tim Paterson and modified the existing QDOS and released a new Operating System called PC-DOS and then later renamed it as Micro Soft Disk Operating System and got license rights.

Microsoft turned it into **Microsoft** Disk Operating System, or MS-DOS, which they introduced on July 27, 1981, which has Character User Interface(CUI) It was developed in parallel under 3 names following the seller: PC - DOS for IBM, DR - DOS for Novell and MS-DOS for all other firms (marketed by Microsoft).

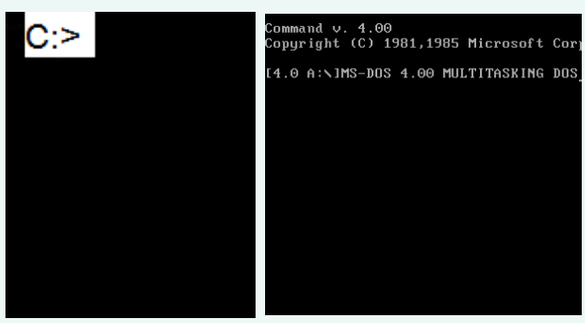

Figure 9.1: Command Prompt

After the MS-DOS is loaded into the RAM, the user will get the Command Prompt as shown in the Figure 9.1. Usually this will be called as “C” prompt. If the PC is booted with the help of floppy disk, it will show you A:> i.e., “A” prompt, whereas ‘C’ denotes name of Hard disk.

Out of this effort, each and every installation fetched a lot of money to Bill

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gates and thus his company Micro Soft start to flourish. He introduced various versions of MS-DOS like MS-DOS 1, 2, 3, 3.1, 3.2, 4, 4.1, 6, 6.1, 6.2, etc. Among these, some versions are very powerful and compatible with all other existing software.

Around 1993, Microsoft introduced a new concept in communicating with PC's. Instead of typing the command at the command prompt, an icon can be clicked or tapped to execute the same. This concept is called Graphic User Interface (GUI). This concept is the basic root of developing Windows which becomes much user friendly nowadays.

9.2 NEED FOR OPERATING SYSTEM

Operating System has become essential to enable the users to design applications without knowing the computer's internal structure of the hardware. Operating System manages all the Software and Hardware. Most of the time, there are many different computer programmes running at the same time, they all need to access the Computers, CPU, Memory and Storage. The need of Operating System is basically - an interface between the user and the hardware, which is diagrammatically shown in Figure 9.2.

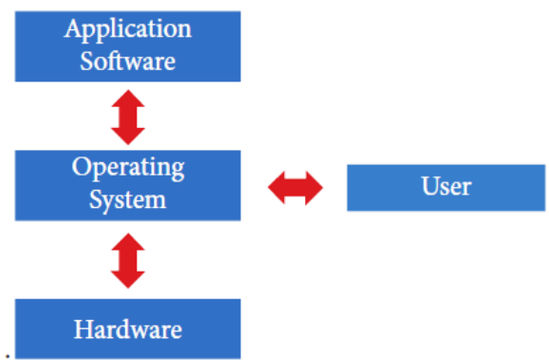

Figure 9.2: Need of Operating System

9.3. BOOTING OF OPERATING SYSTEM (COMPUTER)

An Operating system (OS) is a basic software that makes the computer to work. When a computer is switched on, there is no information in its RAM. At the same time, in ROM, the pre-written program called POST (Power on Self-Test) will be executed first. This program checks the conditions of the devices like RAM, keyboard, etc., for proper functioning and their readiness for operation. If these devices are ready, then the BIOS (Basic Input Output System) gets executed. This process is called Booting. Thereafter, a program called "Bootstrap Loader" transfers OS from hard disk into main memory. Now, the OS gets loaded (Windows/Linux, etc.,) and will get executed. Booting process is of two types as shown in Figure 9.3.

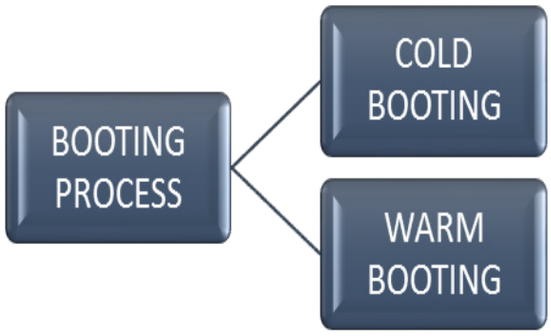

Figure 9.3 : Two types of Booting process

9.3.1. Cold Booting

When the system starts from initial state i.e. it is switched on, we call it cold booting or Hard Booting. When the user presses the Power button, the instructions are read from the ROM to initiate the booting process.

9.3.2. Warm Booting:

When the system restarts or when Reset button is pressed, we call it Warm Booting or Soft Booting. The system does not start

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from initial state and so all diagnostic tests need not be carried out in this case. There are chances of data loss and system damage as the data might not have been stored properly.

9.4. TYPES OF OPERATING SYSTEM BASED ON PROCESS CAPABILITY

Operating System can be classified into the following types depending on their processing capabilities.

9.4.1. Single User Operating System

An operating system allows only a single user to perform a task at a time. It is called as a Single user and single Task operating system. For a user, a task is a function such as printing a document, writing a file to disk, editing a file or downloading a file etc. MS-DOS is an example for a single user and single task Operating System.

Initially, Windows was also served as single user system upto the version Windows 98. Really, windows executed its GUI by keeping DOS at its back ground. Windows introduced new product in the Millennium year, called Windows-NT, which has the advantage of sharing one system with other through NT (LAN Cabling).

- MS-DOS - an operating system without a graphical user interface. Windows was an application that allowed you to interact with MS-DOS through a graphical user interface.
- Windows NT - an operating system with its own graphical user interface. So, it does not need an additional application to provide said graphical user interface.

9.4.2. Multi-User Operating System

It is used in computers and laptops that allow same data and applications to be accessed by multiple users at the same time. The users can also communicate with each other (see Figure 9.4).

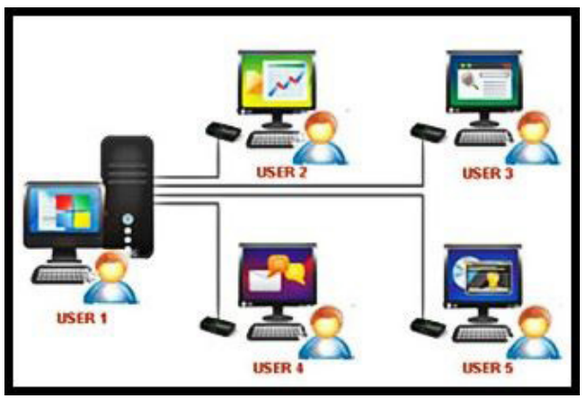

Figure 9.4 : Multi user

But, when we are talking about multi-user system, let us remember the UNIX and LINUX Operating Systems, which are dedicated multi-user operating system. Windows NT, Windows XP, Vista, Linux, UNIX and the present Windows-10 are also multi-user and multi-tasking Operating System.

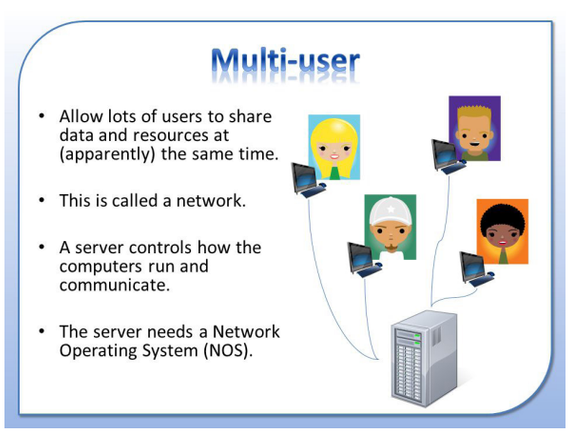

Figure 9.5: Features of Multi-user

Figure 9.5. clearly shows the features of the multi-user operating system.

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9.5. FUNCTIONS / KEY FEATURES OF OPERATING SYSTEM

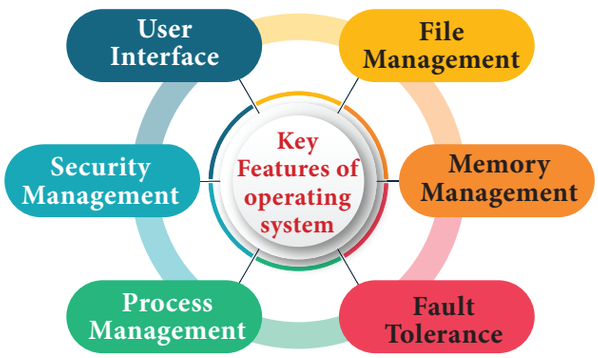

Figure 9.6 : Key features of Operating System

Figure 9.6 shows the various key features of Operating System and are summarized as follows:

- User Interface
- Memory Management
- File Management
- Process Management
- Security Management
- Fault Tolerance
- Multi processing
- Time sharing
- Distributed operating system

9.5.1. User Interface (UI)

User interface is one of the significant features in Operating System and the only way the user can make interaction with a computer. If the computer interface is not user-friendly, the user slowly reduces the computer usage from their normal life.

This is the main reason for the key success of GUI (Graphical User Interface) based Operating System. The GUI is a window-based system with a pointing device to direct I/O, choose from menus, make the selections, and a keyboard to enter text. Every feature is in vibrant colours to attract the users very easily. Beginners are impressed by the help and pop up window message boxes. Icons are playing vital role of the particular application. Now, Linux distribution is also available as GUI based Operating System.

9.5.2. Memory Management

Memory Management is the process of controlling and coordinating computer's main memory and assigning memory block (space) to various running programs to optimize overall computer performance. The memory management involves the allocation of specific memory blocks to individual programs based on user demands. At the application level, memory management ensures the availability of adequate memory for each running program at all times.

The objective of Memory Management process is to improve both the utilization of the CPU and the speed of the computer's response to its users via main memory. For these reasons the computers must keep several programs in main memory that associates with many different Memory Management schemes.

The Operating System is responsible for the following activities in connection with memory management:

- Keeping track of the portions of memory is currently being used by the respective user.
- Determining the processes (or parts of processes) and data to move in and out of memory.
- Allocation and de-allocation of memory blocks as needed by the program in main memory. (Garbage Collection)

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9.5.3. Process management

Process management is a function that includes in creating and deleting the processes and providing mechanisms for processes to communicate and synchronize with each other. A process is the unit of work (program) in a computer. A word-processing program being run by an individual user on a computer is a process. A system task, such as sending output to a printer or screen, can also be called as a Process. Computers consist of a collection of processes and are classified as two categories:

- Operating System processes, which are executed by system code
- User Processes, which are execute by user code

All these processes can potentially execute concurrently on a single CPU. A process needs certain resources including CPU time, memory, files and I/O devices to finish its task. The Operating System is responsible for the activities associated with the process management such as, Scheduling processes and threads on the CPUs.

9.5.4. Security Management

The major challenge in computer and software industry is to protect user's legitimate data from hackers. The Operating System provides three levels of securities to the user end. They are

1. File access level
2. System level
3. Network level

In order to access the files created by other users, one should have the access permission. Permissions can either be granted by the creator of the file or by the administrator of the system. System level security is offered by the password in a multi-user environment. Both windows and Linux offer the password facility. Network security is an indefinable one. So, people from all over the world try to provide such a security. All the above levels of security features are provided only by the Operating System.

9.5.5. Fault Tolerance

The Operating Systems should be robust. When there is a fault, the Operating System should not crash, instead the Operating System have fault tolerance capabilities and retain the existing state of system.

9.5.6. File Management

File management is an important function of OS, which handles the data storage techniques. The operating System manages the files, folders and directory systems on a computer. Any type of data in a computer is stored in the form of files and directories /folders through File Allocation Table (FAT). The FAT stores general information about files like filename, type (text or binary), size, starting address and access mode (sequential/indexed/indexed-sequential/direct/relative). The file manager of the operating system helps to create, edit, copy, allocate memory to the files and also updates the FAT. The OS also takes care of the files that are opened with proper access rights to read or edit them. There are few other file management techniques available like Next Generation File System (NTFS) and ext2(Linux).

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9.5.7. Multi-Processing

This is a one of the features of Operating System. It has two or more processors for a single running process (job). Processing takes place in parallel (simultaneously) is known as parallel processing. Each processor works on different parts of the same task or on two or more different tasks. Since the execution takes place in parallel, this feature is used for high speed execution which increases the power of computing.

9.5.8. Time-sharing

This is a one of the features of Operating Systems. It allows execution of multiple tasks or processes concurrently. For each task, a fixed time is allocated. This division of time is called Time- sharing. The processor switches rapidly between various processes after a time is elapsed or the process is completed. For example, assume that there are three processes called P1, P2, P3 and time allocated for each process 30, 40, 50 minutes respectively. If the process P1 completes within 20 minutes, then processor takes the next process P2 for the execution. If the process P2 could not complete within 40 minutes, then the current process P2 will be paused and switch over to the next process P3.

9.5.9. Distributed Operating Systems

This feature takes care of the data and application that are stored and processed on multiple physical locations across the world over the digital network (internet/intranet). The Distributed Operating System is used to access shared data and files that reside in any machine around the world. The user can handle the data from different locations as shown in Figure 9.7. The users can access as such, if it is available on their own computer. The advantages of distributed Operating System are as follows:

- A user at one location can make use of all the resources available at another location over the network.
- Many computer resources can be added easily in the network.
- Improves the interaction with the customers and clients.
- Reduces the load on the host computer.



Figure 9.7 : Distributed Operating Systems

9.6. PROMINENT OPERATING SYSTEMS

Prominent OS are as follows:

- UNIX
- Microsoft Windows
- Linux
- iOS
- Android

Modern operating systems use a Graphical User Interface (GUI). A GUI lets the user to click icons, buttons, menus and everything, which are clearly displayed on the screen using a combination of graphics and text elements. OS can be either proprietary with a commercial license or can be open source. Each Operating System's GUI has a different look and feel,

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so if the user wants to switch over a different Operating System, it may seem unfamiliar at first. However, modern Operating Systems are designed to be ease of use and most of the basic principles are the same. Figure 9.8 shows some of the Operating System.

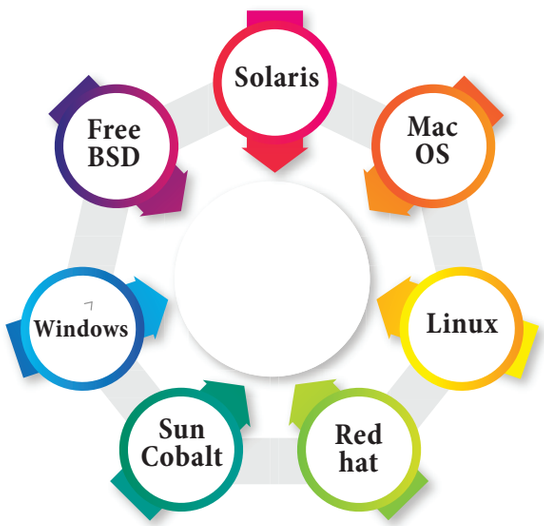

Figure 9.8: Various Operating Systems

Figure 9.9 shows the Operating System companies, which holds Proprietary Licence or open source free licence for their Operating.

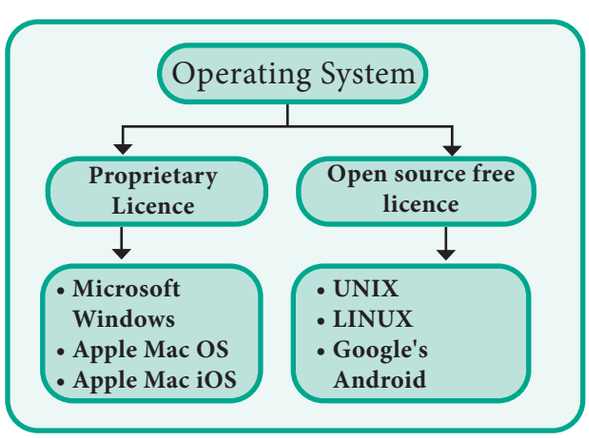

Figure 9.9 : License/Open Source Operating Systems

9.6.1. UNIX

UNIX is a family of multitasking, multi-user operating systems that derive originally from AT&T Bell Labs, where the development began in the 1970s by Ken Thompson and Dennis Ritchie.

9.6.2. Linux

Linux is a family of open-source operating systems. It can be modified and distributed by anyone around the world. This is different from proprietary software like Windows, which can only be modified by the company that owns it. The main advantage of Linux operating system is that it is open source. There are many versions and their updates. Most of the servers run on Linux because it is easy to customize. Figure 9.10 shows Ubuntu Linux Opening Screen.



Figure 9.10 Ubuntu Linux Opening Screen

There are a few different distributions of Linux, like Ubuntu, Mint, Fedora, RedHat, Debian, Google's Android, Chrome OS, and Chromium OS as shown in Figure 9.11, which are popular among users.

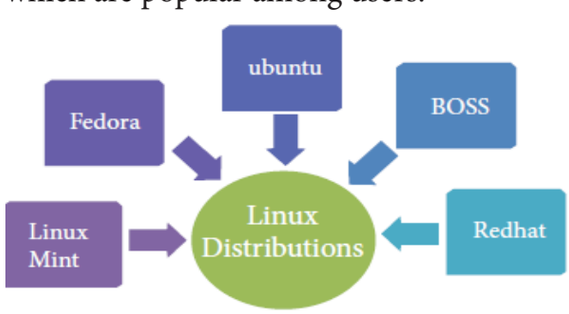

Figure 9.11 Linux Distributions

The Linux operating system was originated in 1991, as a project of "Linus Torvalds" from a university student of Finland. He posted information about his

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project on a news group for computer students and programmers. He received support and assistance from a large pool of volunteers, who succeeded in creating a complete and functional Operating System. Linux is similar to the UNIX operating system.

9.6.3. Microsoft Windows

Microsoft Windows is a family of proprietary operating systems designed by Microsoft Corporation and primarily targeted to Intel and AMD architecture-based computers. Figures 9.12 show the Windows basic screens.

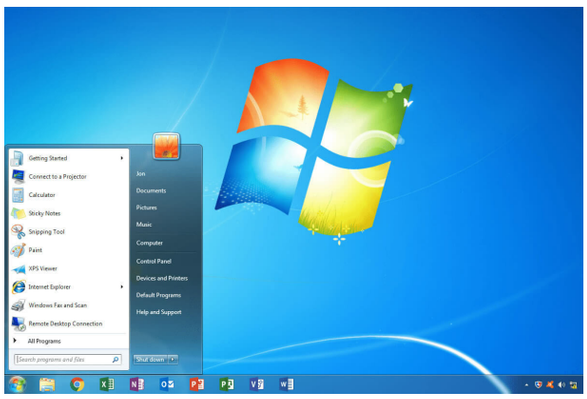

Figure 9.12 : Windows Screen

9.6.4. Macintosh – Operating System (Mac OS)

The Macintosh Operating System (Mac OS) is an operating system (OS) designed by Apple Inc. to be installed and operated on the Apple Macintosh series of computers. Introduced in 1984, it is the first Graphical User Interface (GUI) based OS that has been released as multiple different versions.

9.6.5. Android

Android OS is a linux based mobile OS that primarily runs on smart phones and tablets. Android was released under Apache V2 open source license. This allows for many variation of OS to be developed for other devices such gaming consoles and digital cameras.

9.7. COMPONENTS OF OPERATING SYSTEM

9.7.1. Device Driver

In computing, a device driver is a computer program that operates or controls a particular type of device that is attached to a computer. A driver provides a software interface to hardware devices, enabling operating systems and other computer programs to access hardware functions without needing to know precise details about the hardware being used.

A driver communicates with the device through the computer bus or communications subsystem to which the hardware is connected. When a calling program invokes a routine in the driver, the driver issues commands to the device. Once the device sends data back to the driver, the driver may invoke routines in the original calling program.

Drivers are hardware dependent and operating-system-specific. They usually provide the interrupt handling required for any necessary asynchronous time-dependent hardware interface.

9.7.2. Kernel

The kernel is the core of an operating system. It is the software responsible for running programs and providing secure access to the machines hardware.

A kernel is the most fundamental component of a computer operating system. A comparison of system kernels can provide insight into the design and architectural choices made by the developers of particular operating systems.

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The Linux kernel developed by contributors worldwide is a free and open-source, monolithic, modular (i.e., it supports the insertion and removal at runtime of loadable kernel objects), Unix-like operating system kernel.

9.7.3. Shell

In computing, a shell is a user interface for access to an operating system's services. In general, operating system shells use either a command-line interface (CLI) or graphical user interface (GUI), depending on the computer's role and particular operation. It is named a shell because it is the outermost layer around the operating system.

Command-line shells require the user to be familiar with commands and their calling syntax to understand concepts about the shell-specific scripting language (for example, bash).

Graphical shells place a low burden on beginning computer users, and are characterized as being easy to use. Since they also come with certain disadvantages, most GUI-enabled operating systems also provide CLI shells.

9.8 CHARACTERISTICS/ FEATURES OF COMPUTER

1. **Speed:** A computer is a very fast device. The computer takes a fraction of seconds to perform any operation. The speed of computer is measured in micro seconds (10^{-3}), Milliseconds (10^{-6}), nanoseconds (10^{-9}) and even Pico seconds (10^{-12}). A powerful computer is capable of performing about 3-4 million simple operations per second.
2. **Accuracy:** The accuracy of computer is very high and the degree of a particular computer depends upon its design. But for a particular computer, each and every calculation is performed with the same accuracy. Errors can occur in a computer but these are mainly due to human rather than technological weakness.
3. **Storage Capacity :** Computers can store data and instruction with a lot of volume and very high efficiency.

9.9 LIMITATION/DRAWBACK OF COMPUTER

1. **No I.Q. :** Computer is not a magical device. It performs only those works which man can does but the main difference is that computer can work those operations with very high speed and reliable accuracy. It has no any intelligence quality or thinking power
2. **No Feeling:** Because computer is only a machine, it has no feeling like human being. It has no brain for thinking as man can does. Man had successes to make computer memory be different inventions of technology but he couldn't make heart.
3. **Data Machine Readable :** Computer data is read by machine, meaning data obtained from the computer can be read by the computer itself.
4. It required power to operate.
5. Problem may occur due to system breakdown.

9.10. POWER SUPPLY

A power supply is an electrical & electronic device that supplies electric power to an electrical load. The primary function of a

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power supply is to convert electric current from a source to the correct voltage, current, and frequency to the load.

Types of Power supply: Power supply is broadly classified into two types.

1. Unregulated Power supply
2. Regulated Power supply.

9.10.1. Unregulated Power supply

Unregulated power supply is not used widely because voltage is fluctuating in this type which may harm electronic equipments.

9.10.2. Regulated Power supply

Regulated Power supply gives constant voltage and current. So it is used in all electronic equipments presently.

Two types of Regulated power supplies are here listed below.

1. **Linear Power Supply**
2. **Switched Mode Power supply (SMPS)**

9.10.3 Linear power supply

A linear regulated power supply regulates the output voltage by dropping excess voltage in a series dissipative component. They use a moderately complex regulator circuit to achieve very low load and line regulation. Its nothing but a Regulated Power Supply.

9.10.4 Switched Mode Power Supply (SMPS)

A switched mode power supply (SMPS) is a type of power supply that uses semiconductor switching techniques, rather than standard linear methods to provide the required output voltage. The basic switching converter consists of a power switching stage and a control circuit. The main advantage of the switching power supply is greater efficiency (up to 96%) than linear regulators because the switching transistor dissipates little power when acting as a switch. Model of SMPS in Figure 9.13



Figure 9.13 : Switched Mode Power supply

9.10.5 Uninterruptible Power Supply (UPS):

An **Uninterruptible Power Supply** (UPS) is defined as an electrical and electronic equipment which can be used as an immediate power source to the connected load when there is any failure in the main input power source. Figure 9.14 shows the uninterruptible power supply.



Figure 9.14 : Uninterruptible Power Supply (UPS)

9.10.6 Printed Circuit Boards (PCB)

Printed circuit boards are used to mechanically support and electrically connect electronic components. PCB's use conductive pathways, tracks etched

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from copper sheets laminated onto a non-conductive substrate that does not conduct electricity.

Types of PCB's:

PCBs are classified into three types:

1. Single layer PCB - figure 9.15(a)
2. Double layer PCB – figure 9.15(b)
3. Multilayer PCB – figure 9.15(c)

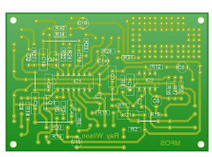

Figure 9.15 (a) : Single layer PCB

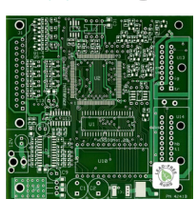

Figure 9.15 (b) : Double layer PCB

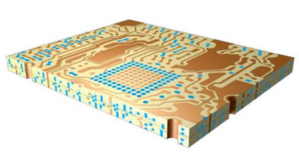

Figure 9.15(c) : Multi layer PCB

9.11. INTRODUCTION TO MOTHER BOARD

The motherboard is comprehensive in all aspects and it contains provisions to connect any kind of components to meet application requirements. The motherboard is self-sufficient to meet all requirements and it is a single board to manage all the functions, unlike backplane which has provision to connect to multiple extension boards to hold more components. The name mother in the motherboard is attributed to its character as it takes a leadership role to manage all the components connected to it.

Mouse, keypads are connected to USB ports on the motherboard. Many boards have a provision of expansion to connect to additional devices. Heat sinks and fan points are available in the modern motherboard to transfer excess heat.

9.11.1. Types of Motherboard

Motherboards are present in Desktop, Laptop, Tablet, and Smartphone and the components and functionalities are the same. But the size of the components and the way they are accommodated on the board varies due to space availability.

Though different motherboards have varying capabilities, limitations, features, Physical size/shapes (form factor), they are identified mostly by their form factors. Each manufacturer has come out with its form factor to suit the design of computers. Motherboard manufactured to suit IBM and its compatible computers fit into other case sizes as well. Motherboards built using ATX form factors were used in most of the computers manufactured in 2005 including IBM and Apple.

Below are few importanat types of Motherboards:

9.11.2. Brief Comparison of the Motherboard Form Factors.

Table 9.2 shows the comparison few of the most popular motherboard form factors.

9.12 MOTHERBOARD COMPONENTS AND THEIR FUNCTIONS

There are many components found in a motherboard. Some of them are major motherboard components while others

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Table 9.1 : Comparison of Mother Board Form Factors			
Form Factor	**Manufacturer/Date**	**Dimensions**	**Applications**
Standard-ATX	Intel 1995	12 × 13 in	Workstation/Desktop
Mini-LPX	Intel 1997	9.6 × 9.6 in	Small Form Factor
Mini-ITX	VIA 2001	6.7 × 6.7 in	Small Form Factor

are not. The following is a motherboard components list.

Major Motherboard Components

Figure 9.16 shows Mother Board and its components

1. CPU (Central Processing Unit) chip
2. RAM (Random Access Memory) slots
3. Southbridge/northbridge
4. BIOS (Basic Input/Output System)
5. I/O port
6. USB (Universal Serial Bus)
7. CPU slot
8. PCI (Peripheral Component Interconnect) slot
9. AGP (Accelerated Graphics Port) slot
10. ISA (Industry Standard Architecture) slot
11. Parallel port
12. FDC (Floppy-Disk Controller)
13. IDE (Integrated Drive Electronics) controller
14. CMOS (Complementary Metal-oxide-semiconductor) battery
15. Power supply connector
16. Mouse and keyboard ports
17. DIP (Dual In-line Package) switch
18. Jumper
19. Heat sink (cooling system)
20. Clock generator

1. CPU (Central Processing Unit) chip

CPU is the electronic circuitry in a computer that executes instructions that make up a program. It is also known as a central processor or the main processor. The CPU executes the basic logic, arithmetic, controlling as well as input/output (I/O) operations specified by the instructions in the desktop programs.

2. RAM (Random Access Memory) slots

RAM is a kind of computer memory that can be read and written. It is mainly used to save data and machine code, Of course temporarily. A RAM device permits data to be read or written in nearly the same amount of time no matter where the data's physical location is in the memory. Compared to the direct-access storage devices like hard drives, CD/DVD and magnetic tapes, RAM media is much faster for data reading and writing.

3. Southbridge/northbridge

They are the two chips in the core logic chipset on the motherboard.

1. South Bridge
2. North Bridge

Typically, the south bridge implements the slower capabilities of

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the motherboard than the north bridge chipset in computer architecture.

The north bridge, also known as host bridge or Memory Controller Hub, is connected directly to the CPU via the front-side bus (FSB). It is responsible for tasks requiring the highest performance. Together with the south bridge, they manage communications between the CPU and other motherboard components.

4. BIOS (Basic Input/Output System)

BIOS, also called system BIOS, PC BIOS or ROM BIOS, is firmware that is used to perform hardware initialization during the booting process; and to provide runtime services for operating system and programs. The BIOS firmware is the first software to run when powered on; it is re-installed on a PC's system board.

5. I/O port

Input/output ports are the connections between the CPU and peripheral devices on a motherboard. There are two complementary methods to perform input and output processes: memory-mapped I/O (MMIO) and port-mapped I/O (PMIO). Alternatively, you can use dedicated I/O processors, called channels on mainframe computers, which execute their own instructions.

6. USB (Universal Serial Bus)

USB is an industry standard that creates specifications for connectors, cables and protocols for connection; power supply (interfacing) and communication among computers, computer peripherals as well as other desktops. There are many USB hardware including several different connectors, of which USB-C is the latest kind.

7. CPU slot

A CPU slot, also called a CPU socket or Processor socket, contains one or more mechanical components that provide mechanical and electrical connections between the PCB and a microprocessor (CPU). Therefore, you can install a CPU on a motherboard without soldering.

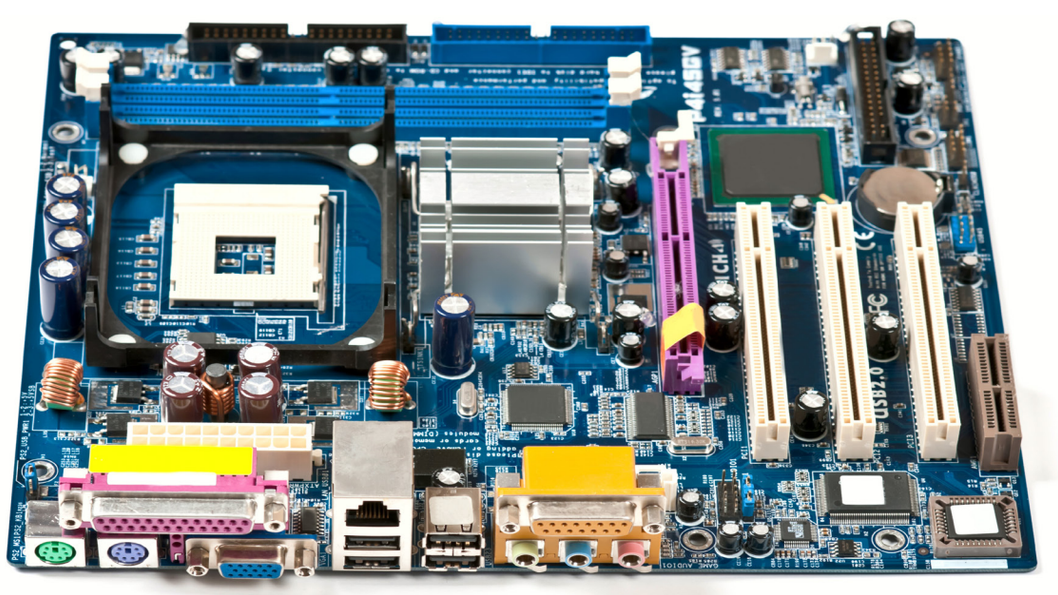

Figure 9.16: Components of Mother Board

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8. PCI (Peripheral Component Interconnect) slot

Peripheral Component Interconnect is a local computer bus for connecting hardware to a computer. It supports all the functions of a processor bus. PCI is usually been called Conventional PCI to distinguish it from its successor PCI Express (PCIe, PCI-e or PCI-E).

9. AGP (Accelerated Graphics Port) slot

AGP was designed as a high-speed point-to-point channel for connecting a video card (graphics card) to a computer system. Primarily, it was used to assist in the acceleration of 3D computer graphics. AGP is originally designed to be a descendant of the PCI series of connections for video cards. Yet, it was replaced by the PCIe slots.

10. ISA (Industry Standard Architecture) slot

There was an attempt to extend ISA into a 32-bit bus, called Extended Industry Standard Architecture (EISA). The attempt wasn't very successful and the EISA was largely replaced by the later VESA Local Bus and the PCI bus, Which has modified 32 bits bus what we have today.

11. Parallel port

A parallel port is a kind of interface for attaching peripherals on desktops. The name of this kind of port is derived from the way the data is sent. That is, the parallel ports send multiple bits of data at the same time. Serial interfaces, on the contrary, send bits one data at once. To achieve parallel data transfer, there are multiple data lines in the parallel port cables. The parallel port cable is larger than the cable of a contemporary serial port, which only has one data line within. The components of mother boards is shown in figure 9.16.

12. FDC (Floppy-Disk Controller)

FDC is a special-purpose chip and associated disk controller circuitry. It controls and directs reading from and writing to a computer's floppy disk drive (FDD).

13. IDE (Integrated Drive Electronics) controller

The devices used for connecting IDE, Ethernet, FireWire, USB and other systems can be called host adapter. So, the IDE controller refers to the host adapter. A host adapter, also called a host controller or a host bus adapter (HBA), connects a computer (acting as the host system) to other network and storage devices.

Tip: Host adapter is usually used to indicate devices connecting SCSI, Fibre Channel and SATA devices.

14. CMOS (Complementary Metal-oxide-semiconductor) battery

CMOS battery, also called memory battery, clock battery or real-time clock (RTC), is generally a CR2032 lithium coin cell. The lifespan of the CMOS battery is estimated to be three years when the power supply unit (PSU) is unplugged or switch off.

15. Power supply connector

A power supply provides the necessary electrical power to let the computer to work. It takes standard 110-Volt AC (Alternative Current) power to DC (Direct Current) power of 12 Volt, 5 Volt, 3.3 Volt, etc.

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16. Mouse and keyboard ports

All computers have a keyboard port connected directly to the motherboard. Many PCs use the PS/2-style connectors for both keyboard and mouse; and the connectors are marked clearly for different usage.

17. DIP (Dual In-line Package) switch

A DIP switch is a manual electric switch packaged with others in a standard dual in-line package. The term may refer to an individual switch or the whole unit. The DIP switch is designed to be used on a printed circuit board (motherboard) together with other electronic **motherboard components**. It is usually used to customize the behavior of an electronic device for specific situations.

18. Jumper

A jumper is a short length of conductor that is used to close, open or bypass part of an electronic circuit as shown in Figure 9.17. Typically, jumpers are used to set up or configure printed circuit boards like the motherboard.

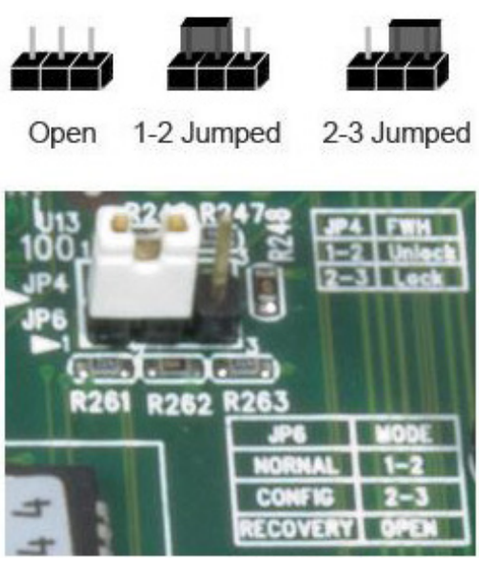

Figure 9.17 : Jumper

A jumper may also be referred to as a jumper shunt or shunt.

Jumpers manually configure computer peripherals, such as the motherboard, hard drives, modems, sound cards, and other components. For example, if your motherboard supported intrusion detection, a jumper can be set to enable or disable this feature.

19. Heat Sink (cooling system)

A heat sink is a passive heat exchanger that transfers the heat generated by **parts of motherboard** into a fluid medium like liquid or air. The fluid medium will dissipate away from the device. Thus, the temperature of the device is kept within a tolerable range. On the motherboard, the heatsink is usually used to cool CPU, GPU (graphics processing unit), chipsets and RAM modules.

20. Clock generator

A clock generator is an electronic oscillator (circuit) that produces a clock signal for usage in synchronizing a circuit's operation. The clock signal ranges between high and low frequencies, thus creating a metronome for the coordination of actions.

9.12.1. The two main components of Mother Board

After reading the above contents, you can figure out **that the two main components on the motherboard are CPU and RAM**. They also list in the first two locations in the above. Actually, the above **motherboard components** are listed mainly based on their importance on the motherboard. Yet, that is just our personal opinion. Those components' importance is different in different situations.

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9.13. BUS

A bus is a high-speed internal connection. Buses are used to send control signals and data between the processor and other components. It connects the processor to the RAM, to the hard drive, to the video processor, to the I/O drives, and to all the other components of the computer. For example, a bus carries data between a CPU and the system memory via the motherboard. shown in figure 9.18.

Three types of bus are there:

1. Address bus
2. Data bus or local bus
3. Control bus.

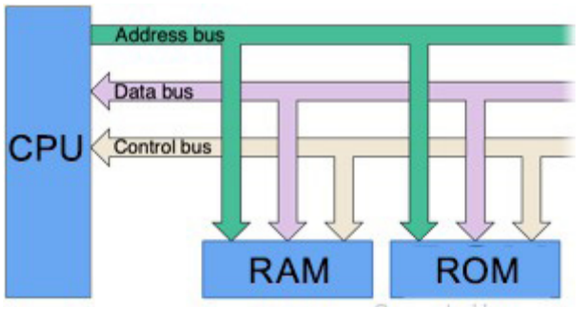

Figure 9.18 : Bus

9.13.1. Bus speed

The motherboard's bus transfers data between parts. The term "bus speed" refers to how quickly the system bus can move data from one computer component to the other. The faster the bus, the more data it can move within a given amount of time.

Bus width refers to the number of bits that can be sent to the CPU simultaneously, and bus speed refers to the number of times a group of bits can be sent each second. A bus cycle occurs every time data travels from memory to the CPU.

The speed of the bus, measured in megahertz (MHz), refers to how much data can move across the bus simultaneously. Bus speed usually refers to the speed of the front side bus (FSB), which connects the CPU to the northbridge. FSB speeds can range from 66 MHz to over 800 MHz.

9.14 BIOS CHIP

Short for Basic Input/Output System, the BIOS (pronounced bye-oss) is a ROM chip found on motherboards that allows you to access and set up your computer system at the most basic level. The picture below is an example of what a BIOS chip may look like on a computer motherboard

9.15 EXPANSION SLOTS

An expansion slot is a socket on the motherboard that is used to insert an expansion card (or circuit board), which provides additional features to a computer such as video, sound, advanced graphics, Ethernet or memory.

- AGP - Video card.
- AMR - Modem, sound card.
- PCI - Network card, SCSI, sound card, video card.
- PCI Express - Video card, modem, sound card, network card.
- VESA - Video card.

Many of the expansion card slots above are obsolete. You're most likely only going to encounter AGP, PCI, and PCI Express when working with computers today. Figure 9.19 shows the control board consists of expansion slots, ports and expansion card.

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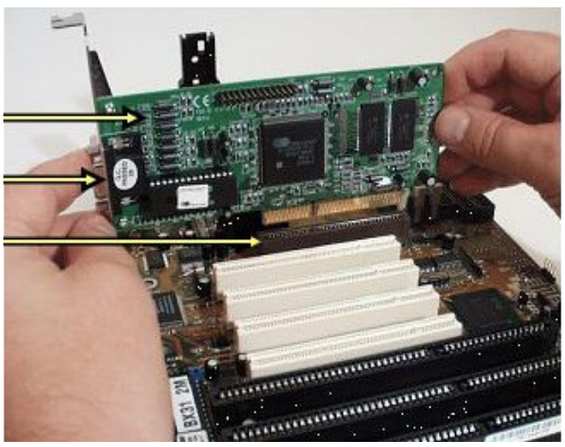

Figure 9.19 : Expansion slots

9.15.1 Expansion Cards

Alternatively called an adapter card, add-on card, expansion board, internal card, interface adapter, or card. An expansion card is a PCB that fits into an expansion slot on the motherboard. It is an internal card that gives a computer additional capabilities, such as enhanced video performance via a graphics card.Expansion cards can sometimes be called daughterboards. Figure 9.20 shows the expansion card.

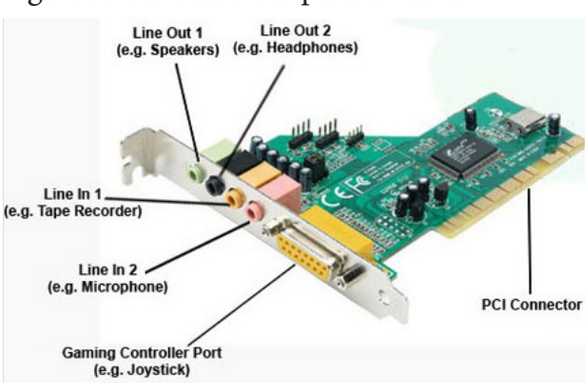

Figure 9.20. Expansion cards

9.15.2 Types of expansion cards in a computer

Interface card (ATA, Bluetooth, EIDE, FireWire, IDE, parallel, RAID, SCSI, serial, and USB).

- MIDI
- Modem
- MPEG decoder
- Network card
- Sound card
- Tuner card
- Video capture card
- Video card

9.16. MEMORY SLOTS

A memory slot, memory socket, or RAM slot allows RAM (computer memory) to be inserted into the computer. Most motherboards have two to four memory slots, which determine the type of RAM used with the computer. The most common RAM types are SDRAM and DDR for desktop computers and SODIMM for laptop computers, each having various types and speeds. The picture below is an example of what memory slots may look like inside a desktop computer. In this picture, there are three open and available slots for three memory sticks. figure 9.21 shows the RAM Chip which is inserted in memory slots.

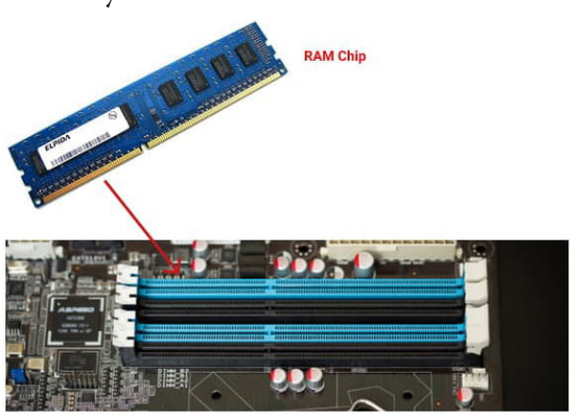

Figure 9.21 : Memory slots

9.17. FRONT PANEL CONNECTOR

Alternatively referred to as the fpanel or the system panel connector or system panel header controls a computer power button, reset button, and LED's. The System panel cables, as shown in the picture are

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two wire cables that are color-coded to help identify where they connect to the motherboard system panel connector. The black or white wire is the GND (ground) wire and the colored wire is the powered wire. The cables, colors, and connections vary depending on the computer case and motherboard you have, however, generally include the cables mentioned below show in figure 9.22.

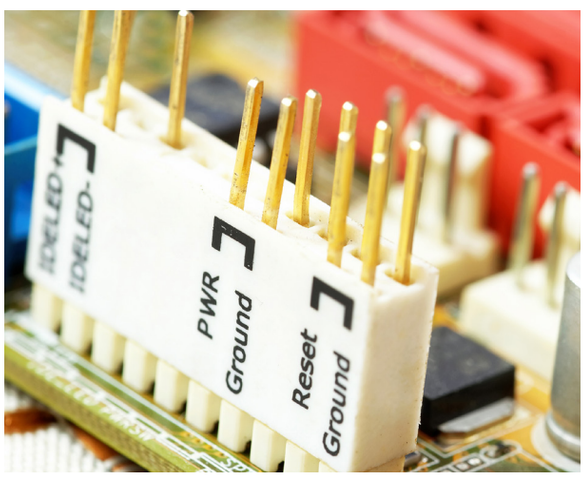

Figure 9.22 : Front Panel Connector

9.17.1. Types of system panel cables

- HDD LED (IDE LED) - The LED activity light for the hard drive. This indicator is the light that flashes as information is being written to and read from the hard drive.
- PLED (Power LED) - The LED power light, which indicates when the computer is on, off, or in Standby.
- PWRSW (Power SW) - Controls the power button that allows you to turn on and off the computer.
- Reset SW - Handles the reset button to restart the computer.
- Speaker - The internal speaker used to sound the beep noises you hear from your computer when it is booting.

With most computer motherboards, the system panel cables are connected directly to the motherboard. However, some motherboard manufacturers include a Q-Connector with the motherboard. With a Q-Connector, the user can connect the system panel cables away from the motherboard and then connect the Q-Connector to the motherboard.

9.18. INPUT OUTPUT PORTS

A connection point that acts as interface between the computer and external devices like mouse, printer, modem, etc. is called port. shown in figure 9.23.

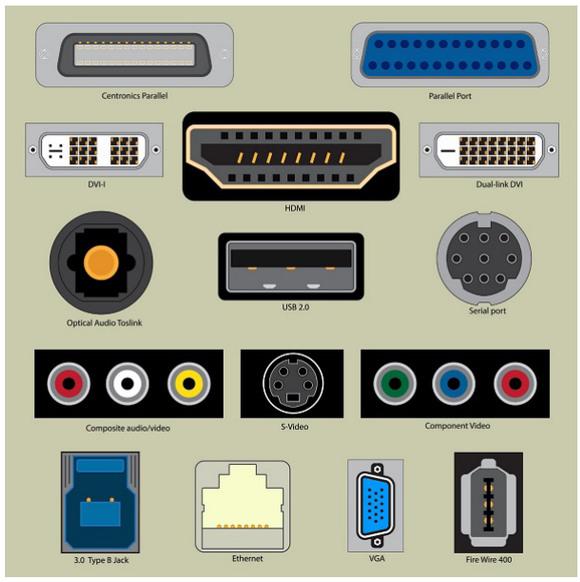

Figure 9.23 : Input Output Ports

Ports are two types

- Internal port – It connects the motherboard to internal devices like hard disk drive, CD drive, internal modem, etc.
- External port – It connects the motherboard to external devices like modem, mouse, printer, flash drives, etc.

Let us look at some of the most commonly used ports.

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9.18.1 Serial Port

Serial ports transmit data sequentially one bit at a time. So they need only one wire to transmit 8 bits. However it also makes them slower. Serial ports are usually 9-pin or 25-pin male connectors. They are also known as COM (communication) ports or RS323C ports. Shown in figure 9.24



Figure 9.24 : Serial Port

9.18.2 Parallel Port

Parallel ports can send or receive 8 bits or 1 byte at a time. Parallel ports come in form of 25-pin female pins and are used to connect printer, scanner, external hard disk drive, etc. Shown in figure 9.25.



Figure 9.25 : Parallel port

9.18.3 USB Port

USB stands for Universal Serial Bus. It is the industry standard for short distance digital data connection. USB port is a standardized port to connect a variety of devices like printer, camera, keyboard, speaker, etc. Shown in figure 9.26.

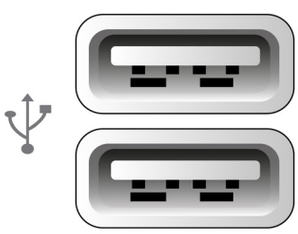

Figure 9.26 : USB port

9.18.4 PS-2 Port

PS/2 stands for Personal System/2. It is a female 6-pin port standard that connects to the male mini-DIN cable. PS/2 was introduced by IBM to connect mouse and keyboard to personal computers. This port is now mostly obsolete, though some systems compatible with IBM may have this port.

9.18.5 Infrared Port

Infrared port is a port that enables wireless exchange of data within a radius of 10m. Two devices that have infrared ports are placed facing each other so that beams of infrared lights can be used to share data.

9.18.6 Bluetooth Port

Bluetooth is a telecommunication specification that facilitates wireless connection between phones, computers and other digital devices over short range wireless connection. Bluetooth port enables synchronization between Bluetooth-enabled devices. There are two types of Bluetooth ports

- Incoming – It is used to receive connection from Bluetooth devices.
- Outgoing – It is used to request connection to other Bluetooth devices.

9.19 BIOS/CMOS SETTING

CMOS (short for complementary metal-oxide-semiconductor) is the term usually used to describe the small amount of memory on a computer motherboard that stores the BIOS settings. Some of these BIOS settings include the system time and date as well as hardware settings.

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In order to access BIOS on a Windows PC, you must press your BIOS key set by your manufacturer which could be F10, F2, F12, F1, or DEL. If your PC goes through its power on self-test startup too quickly, you can also enter BIOS through Windows 10's advanced start menu recovery settings.

9.20. INTRODUCTION TO PROCESSOR

A processor (CPU) is the logic circuitry that responds to and processes the basic instructions that drive a computer. The CPU is seen as the main and most crucial integrated circuitry (IC) chip in a computer, as it is responsible for interpreting most of computers commands

9.20.1. CPU Basics

A CPU is often referred to as the brains of a computer. It is the part of your computer that receives instructions, performs calculations, and executes actions. Specifically, a CPU has four functions: to fetch, decode, execute, and store instructions. First, it fetches instructions from your computer's memory.

The five basic operations that a computer performs are input, storage, processing, output and control.

9.20.2 Types of CPU

Single-core CPU. It is the oldest type of CPU which is available and employed in most of the personal and official computers.

- Dual-core CPU.
- Quad-core CPU.
- Hexa Core processors.
- Octa-core processors.
- Deca-core processor.

This CPU is placed on the CPU socket center around the VRM section of the motherboard connected with the other hardware elements inside the computer cabinet. The CPU is a square shape chip in view, consisting of a thin layer of thousands of transistors as shown in figure 9.27.

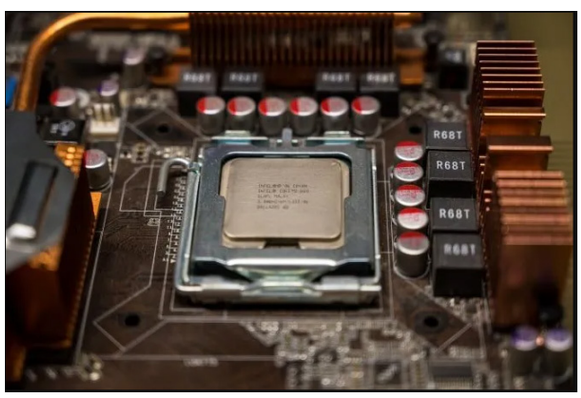

Figure 9.27 : CPU

9.21 THE FUNCTION OF CPU

1. The CPU receives the data when the computer inputs the data through input devices such as a keyboard or mouse. Figure 9.28. shows the basic function of CPU.
2. After this, the CPU process these input data by performing calculations and technical algorithm.
3. And then CPU provides the processed data through output devices such as on the monitor screen.
4. The CPU also stores the process data in the form of a cache for future use.

9.21.1. Concept of Program Execution

Execution in computer and software engineering is the process by which a computer or virtual machine reads and

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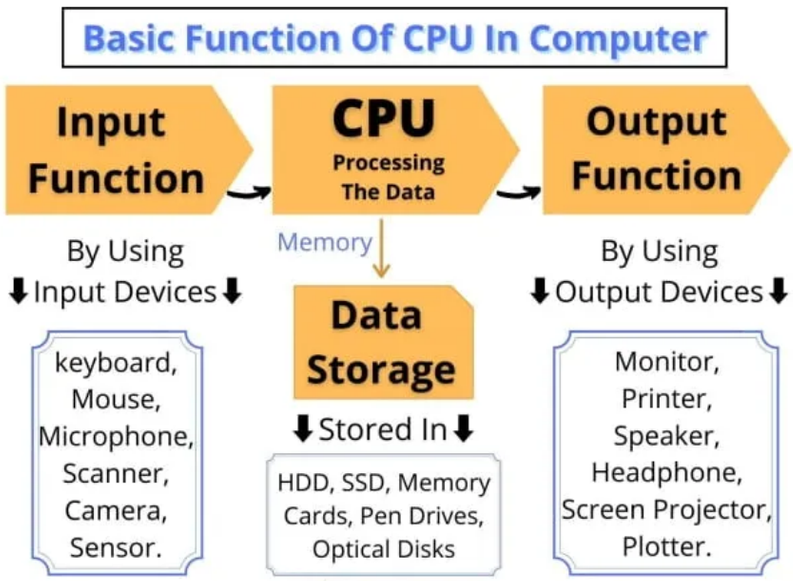

Figure 9.28 : Functions of CPU

acts on the instructions of a computer program. Each instruction of a program is a description of a particular action which must be carried out, in order for a specific problem to be solved. Execution involves repeatedly following a 'fetch–decode–execute' cycle for each instruction. As the executing machine follows the instructions, specific effects are produced in accordance with the semantics of those instructions.

Programs for a computer may be executed in a batch process without human interaction or a user may type commands in an interactive session of an interpreter. In this case, the "commands" are simply program instructions, whose execution is chained together.

The term run is used almost synonymously. A related meaning of both "to run" and "to execute" refers to the specific action of a user starting (or launching or invoking) a program, as in "Please run the application."

9.21.2 Process

Prior to execution, any program must be written first. This is generally termed as source code, which is then compiled at compile time (and statically linked at link time) to produce an executable. This executable is then invoked, most often by an operating system, which loads the program into memory (load time), possibly performs dynamic linking, and then begins execution by moving control to the entry point of the program; all these steps depend on the Application Binary Interface of the operating system. At this point execution begins and the program enters run time. The program then runs until it ends, either normal termination or a crash.

9.21.3 Executable

Executable code, an executable file, or an executable program, sometimes simply referred to as an executable or binary, is a list of instructions and data to cause a computer "to perform indicated tasks according to

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encoded instructions", as opposed to a data file that must be interpreted (parsed) by a program to be meaningful.

The exact interpretation depends upon the use. "Instructions" is traditionally taken to mean machine code instructions for a physical CPU. In some contexts, a file containing scripting instructions (such as byte code) may also be considered executable.

9.22 COMMON CPU COMPONENTS

The central processing unit (CPU) consists of six main components:

1. Control Unit (Cu)
2. Arithmetic Logic Unit (Alu)
3. Registers
4. Cache
5. Buses
6. Clock

All components work together to allow processing and system control. Figure 9.29 shows the components of CPU.

9.22.1 Control unit

The CU provides several functions:

- it fetches, decodes and executes instructions
- it issues control signals that control hardware
- it moves data around the system

9.22.2 Arithmetic logic unit

The ALU has two main functions:

- It performs arithmetic and logical operations (decisions). The ALU is where calculations are done and where decisions are made.
- It acts as a gateway between primary memory and secondary storage . Data transferred between them passes through the ALU.

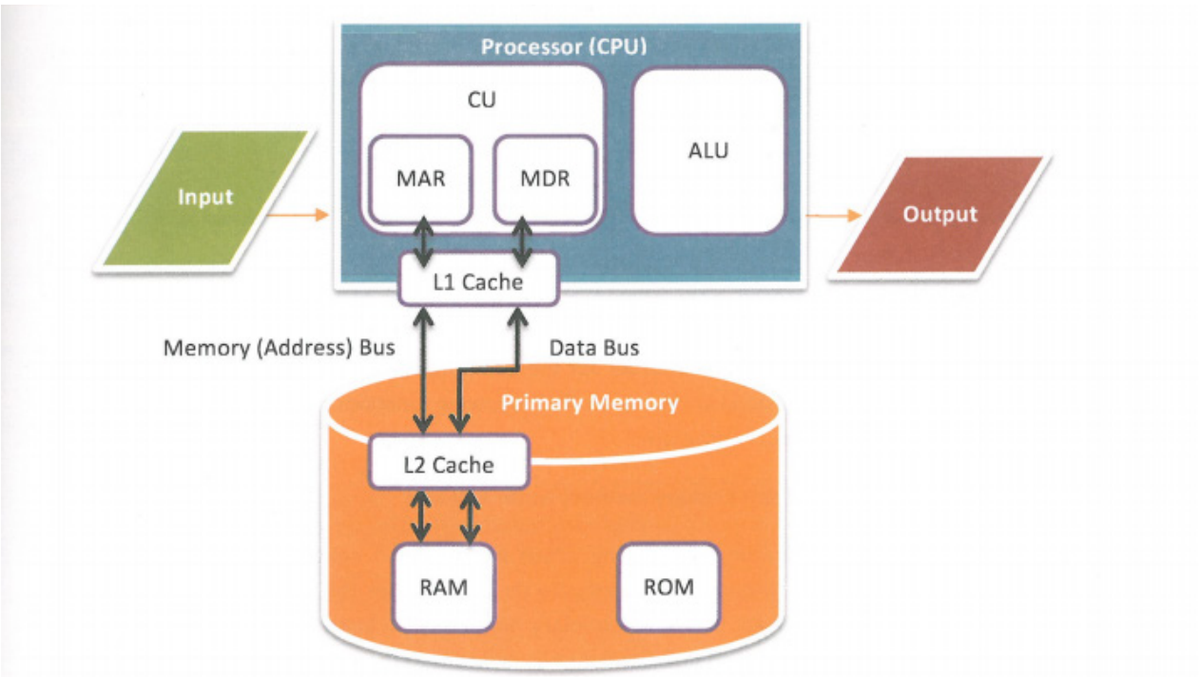

Figure 9.29 : CPU components

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The ALU performs calculations and makes logical decisions.

9.22.3 Registers

Registers are small amounts of high-speed memory contained within the CPU. They are used by the processor to store small amounts of data that are needed during processing, such as:

- the address of the next instruction to be executed
- the current instruction being decoded
- the results of calculations

Different processors have different numbers of registers for different purposes, but most have some, or all, of the following:

- program counter
- memory address register (MAR)
- memory data register (MDR)
- current instruction register (CIR)
- accumulator (ACC)

9.22.4 Cache

Cache is a small amount of high-speed random access memory (RAM) built directly within the processor. It is used to temporarily hold data and instructions that the processor is likely to reuse. This allows for faster processing as the processor does not have to wait for the data and instructions to be fetched from the RAM.

9.22.5 Buses

A bus is a high-speed internal connection. Buses are used to send control signals and data between the processor and other components. Three types of bus are used:

- Address bus - carries memory addresses from the processor to other components such as primary memory and input/output devices.
- Data bus - carries the actual data between the processor and other components.
- Control bus - carries control signals from the processor to other components. The control bus also carries the clock's pulses.

9.22.6 Clock

The CPU contains a clock which is used to coordinate all of the computer's components. The clock sends out a regular electrical pulse which synchronises (keeps in time) all the components.

The frequency of the pulses is known as the clock speed. Clock speed is measured in hertz. The higher the frequency, the more instructions can be performed in any given moment of time.

In the 1980s, processors commonly ran at a rate of between 3 megahertz (MHz) to 5 MHz, which is 3 million to 5 million pulses or cycles per second. Today, processors commonly run at a rate of 3 gigahertz (GHz) to 5 GHz, which is 3 billion to 5 billion pulses or cycles per second.

9.23 REGISTER ORGANISATION

A register can hold the instruction, address location, or operands. Sometimes, the instruction has register as a part of itself.

9.23.1 Types of Registers

As we have discussed above, registers can be organized into two main categories i.e.

1. User-Visible Registers
2. Control and Status Registers.

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Although we can't separate the registers in the processors clearly among these two categories.

9.24 CPU FEATURES

The CPU performs basic arithmetic, logic, controlling, and input/output (I/O) operations specified by the instructions in the program. This contrasts with external components such as main memory and I/O circuitry, and specialized processors such as graphics processing units (GPUs).

9.25. TYPES OF CPU – 32 BIT AND 64 BIT

What Are 32-Bit and 64-Bit?

When it comes to computers, the difference between 32-bit and a 64-bit is all about processing power. Computers with 32-bit processors are older, slower, and less secure, while a 64-bit processor is newer, faster, and more secure.

But what do the numbers 32 and 64 even mean?

Your computer's central processing unit (CPU) functions like the brain of your computer. It controls all the communication and the flow of data to and from the other parts of your computer. Some computers use two or more processors. However, there are only two main categories of processors now: 32-bit processors and 64-bit processors. The type of processor that your computer uses affects its overall performance and what kind of software it can utilize.

Most computers made in the 1990s to early 2000s have a 32-bit system that can access 2^32 (or 4,294,967,296) bytes (units of digital information) of RAM (random access memory). Meanwhile, a 64-bit processor can handle 2^64 (or 18,446,744,073,709,551,616) bytes of RAM. In other words, a 64-bit processor can process more data than 4 billion 32-bit processors combined.

1. Intel

Intel stands for "Integrated Electronics". Intel Corporation is an American multinational corporation and technology company headquartered in Santa Clara, California, in Silicon Valley. It was invented by Robert Noyce. It is the developer of the first x86 processor -Intel 8086.

If we talk on a scale of 1-10, Intel processors come at a scale of 4-10. These processors have good CPU performance and almost all Intel processors come with iGPU. This processor also clocks higher than AMD processors, at the cost of higher power consumption and battery life. Thus, for short workloads and single-core boosts especially in laptops, newer Intel-powered laptops can be used when battery life is not a concern. If we talk about Desktop, and you want to change processor, motherboard or socket's compatibility, then Intel has fewer options available for that in comparison to AMD processor due to frequent motherboard and chipset changes.

Example – Intel Xeon, Intel Core i series, Intel Core m series

2. Advanced Micro Devices (AMD)

AMD stands for Advanced Micro Devices. It is an American multinational semiconductor company based in Santa Clara, California. It was invented by Jerry Sanders, Jack Gifford, John Carey. It started supplying x86 processors as a

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Table 9.2 Difference between Intel and AMD.	
Intel	**AMD**
Less expensive than AMD Processor at the lower range.	Less expensive than Intel at a higher range.
Less efficient than AMD.	More efficient than Intel.
Can heat up when used with Clock Speed Boost(14 nm)	Is generally cooler due to smaller lithography(TSMC 7nm is similar to Intel 10 nm)
IPC (Rocket Lake) is lower than AMD (Zen 3)	IPC(Zen 3) is higher than Intel (Rocket Lake)
Clock speed reaches and surpassed 5.0 GHz	The clock speed can reach 5.0 GHz but results in more heat
It has symmetric multiprocessing capabilities of up to 4 sockets/28 cores.	It has symmetric multiprocessing capabilities of up to 8 sockets/128 cores.

second source manufacturer and became a competitor with Am386.

On a scale of 1-10, AMD processors come at 5-10. It is cheaper than Intel Processors at a similar range. These processors are efficient compared to the current generation Core series. If we talk about the desktop, mobile, and you only want to do normal gaming and for everyday use, then Ryzen APU is the way to go. For heavier tasks like video editing, 3D modelling, etc, Ryzen 7 or 9 CPUs or Thread ripper should be preferred.

For Ryzen Desktop CPUs and APUs in the AM4 platform, the motherboard chipset should be checked for support otherwise PC may not boot, although it can be easily solved with motherboards with USB BIOS flashing for newer processors.

Example – AMD Ryzen, AMD Threadripper, AMD FX-Series, AMD EPYC, AMD Opteron, AMD Athlon 64

Note:

This book was written before the release of Alder Lake and successor to Zen 3 and thus may not reflect future changes.

Difference between Intel and AMD

Table 9.2 shows the difference between Intel and AMD.

9.26. INTRODUCTION TO MEMORY

Computer memory is of two basic types– Primary memory (RAM and ROM) and Secondary memory (hard drive, CD, etc). Random Access Memory (RAM) is primary-volatile memory and Read-Only Memory (ROM) is primary-non-volatile memory.

There are two main types of RAM: Dynamic RAM (DRAM) and Static RAM (SRAM).

- DRAM (pronounced DEE-RAM), is widely used as a computer's main memory.
- SRAM (pronounced ES-RAM) is made up of four to six transistors.

9.27. DIFFERENT TYPES OF RAM (RANDOM ACCESS MEMORY)

RAM (Random Access Memory) is a part of computer's Main Memory which is

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directly accessible by CPU. RAM is used to Read and Write data into it which is accessed by CPU randomly. RAM is volatile in nature, it means if the power goes off, the stored information is lost. RAM is used to store the data that is currently processed by the CPU. Most of the programs and data that are modifiable are stored in RAM.

Integrated RAM chips are available in two form:

1. SRAM(Static RAM)
2. RAM(Dynamic RAM)

1. SRAM :

The SRAM memories consist of circuits capable of retaining the stored information as long as the power is applied. That means this type of memory requires constant power. SRAM memories are used to build Cache Memory.

2. DRAM :

DRAM stores the binary information in the form of electric charges applied to capacitors. The stored information on the capacitors tends to lose over a period of time and thus the capacitors must be periodically recharged to retain their usage. The main memory is generally made up of DRAM chips.

Types of DRAM

There are mainly five types of DRAM

1. Asynchronous DRAM (ADRAM)

The DRAM described above is the asynchronous type DRAM. The timing of the memory device is controlled asynchronously. A specialized memory controller circuit generates the necessary control signals to control the timing. The CPU must take into account the delay in the response of the memory.

2. Synchronous DRAM (SDRAM)

These RAM chips' access speed is directly synchronized with the CPU's clock. For this, the memory chips remain ready for operation when the CPU expects them to be ready. These memories operate at the CPU-memory bus without imposing wait states. SDRAM is commercially available as modules incorporating multiple SDRAM chips and forming the required capacity for the modules.

3. Double-Data-Rate SDRAM (DDR SDRAM)

This faster version of SDRAM performs its operations on both edges of the clock signal; whereas a standard SDRAM performs its operations on the rising edge of the clock signal. Since they transfer data on both edges of the clock, the data transfer rate is doubled. To access the data at high rate, the memory cells are organized into two groups. Each group is accessed separately. It has been available in different iterations over time, including DDR2 SDRAM, DDR3 SDRAM and DDR4 SDRAM.

5. Cache DRAM (CDRAM)

This memory is a special type DRAM memory with an on-chip cache memory (SRAM) that acts as a high-speed buffer for the main DRAM.

Table 9.3 shows the differences between SRAM and DRAM

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Table 9.3 : Differences between SRAM and DRAM	
SRAM	**DRAM**
1. SRAM has lower access time, so it is faster compared to DRAM.	1. DRAM has higher access time, so it is slower than SRAM.
2. SRAM is costlier than DRAM.	2. DRAM costs less compared to SRAM.
3. SRAM requires constant power supply, which means this type of memory consumes more power.	3. DRAM offers reduced power consumption, due to the fact that the information is stored in the capacitor.
4. Due to complex Internal circuitry, less storage capacity is available compared to the same physical size of DRAM memory chip.	4. Due to the small internal circuitry in the one-bit memory cell of DRAM, the large storage capacity is available.
5. SRAM has low packaging density.	5. DRAM has high packaging density.

9.28. INTRODUCTION OF HARD DISK DRIVE

A hard disk drive (HDD), popularly known as a hard disk/drive (HD), a fixed disk/drive data storage device on your computer – the primary and the largest storage device in fact. It is a piece of hardware that houses the operating system, different software assets and a majority of the other files in your computer.

Have you seen the "C: drive" in your computer? That's your hard disk drive. Though "C drive" is not the technically correct name for a hard disk drive (and refers to only one part of the HDD), it is colloquially used as a popular substitute.

9.28.1. Why are hard disk drives used?

The primary purpose of a hard disk drive is to store digital data on its 'platters' (magnetic-substance coated disks that rotate rapidly) and retrieve the information when needed. It uses random-access to retrieve information (relevant data can be accessed in any order and not sequentially) and retains the data even when the computer is turned off, providing you what is known as "non-volatile storage".

External hard disk drives are used to extend the storage capacity of a system. Since external hard disk drives are easily portable, they allow you to carry important files with you and access them on the go. They are also used to create backups of important data and files on a computer and store elsewhere. Creating and storing backups is in fact, an important function of external hard disk drives. This is because all programs, applications and files within a computer can be corrupted and lost forever if the internal hard disk drive fails.

9.28.2. Logical Drive

A hard disk contains a stack of platters, circular metal disks that are mounted inside the hard disk drive and coated with magnetic material, sealed in a metal case or unit. Fixed in a horizontal or vertical position, the hard disk has electromagnetic read or write heads above and below the platters. The structure of Logical drive is shown in figure 9.30.

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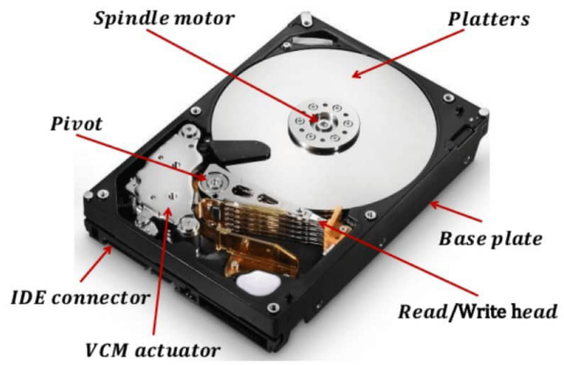

Figure 9.30 : Structure of Logical drive

9.29 PRINCIPLE AND WORKING OF HARD DISK

Principle of Hard Disk

A hard disk typically works on the principle of simple magnetism to store the data and information. A hard drive typically consists of a large plate that is usually made up of a magnetic material and is known as a platter. The figure 9.31 shows the working of HDD. The platter is usually constructed in a circular shape. The surface of the magnetic plate is divided into billions of tiny compartments. The magnetization of the tiny areas can be performed independently. Magnetized tiny area of the plate denotes a binary high and is equivalent to binary value one (1); whereas, the demagnetized tiny area denotes a binary low and is equivalent to binary value zero(0). This indicates that the letters, numbers, and other forms of data stored by the hard disk drive are a combination of binary values, i.e., zeroes or ones. The smallest portion of the information stored by the hard disk drive is known as a bit. The process of magnetization of materials is typically preferred to store information in the disks as it does not get affected by switching off the power supply. The data is retained by the drive even if it is not connected to the power supply for a long time period. The magnetized portion of the hard disk tends to stay magnetized until it is externally demagnetized, thereby allowing reliable storage of data.

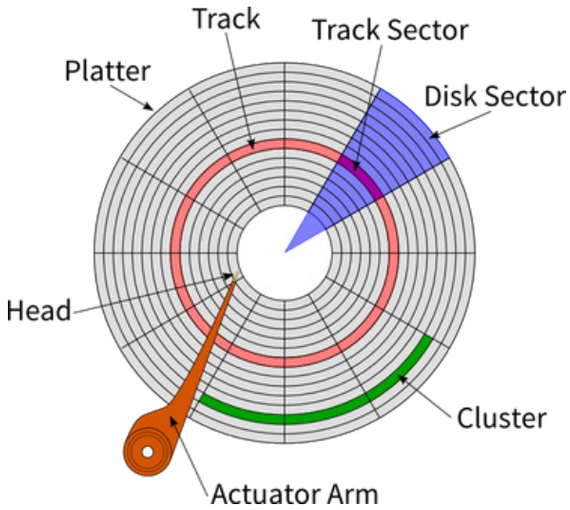

Figure 9.31 : Working of HDD

9.29.1. Physical & Logical Components of HDD

The hard drive, which typically provides storage for data and applications within a computer, has four key components inside its casing the platter (for storing data), the spindle (for spinning the platters), the read/write arm (for reading and writing data) and the actuator (for controlling the actions of the read/write arm). Only the most technically proficient IT professionals should attempt to work on the components inside a hard drive as shown in Figure 9.32

Platter: A typical HDD consists of one or more flat circular disks called platters. The data is Recorded on these platters in binary codes (0s and 1s). The set of rotating platters is sealed in a case, called Head Disk Assembly (HDA). A

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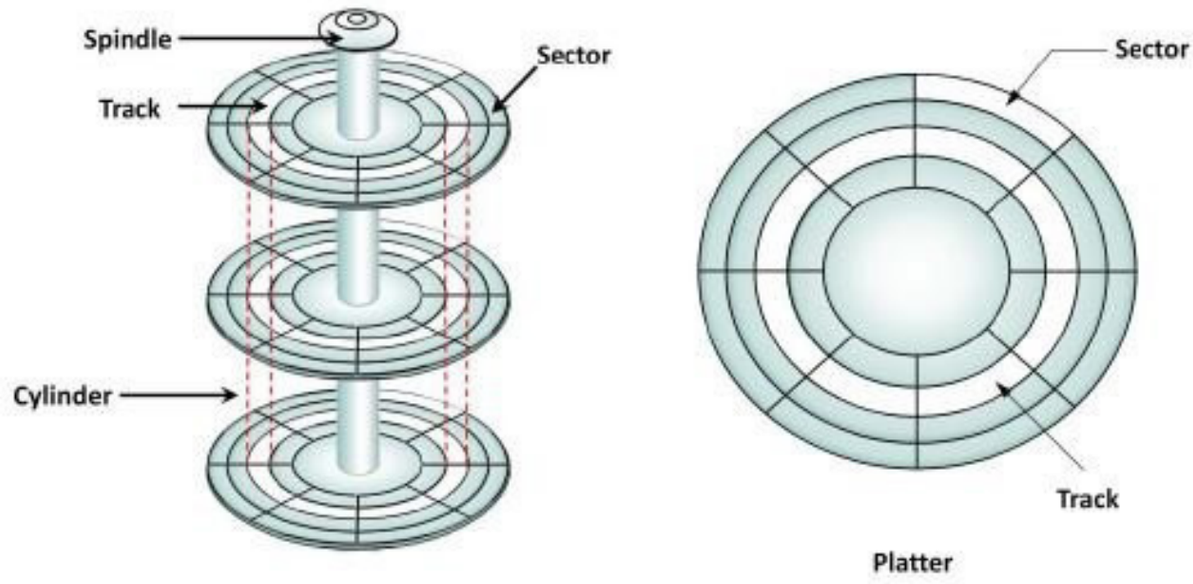

Figure 9.32 : Components of HDD

platter is a rigid, round disk coated with magnetic material on both surfaces (top and bottom). The data is encoded by polarizing the magnetic area or domains of the disk surface. Data can be written to or read from both surfaces of the platter. The number of platters and the storage capacity of each platter determine the total capacity of the drive.

Spindle: A spindle connects all the platters and is connected to a motor. The motor of the Spindle rotates with a constant speed. The disk platter spins at a speed of several thousands of revolutions per minute (rpm). Common spindle speeds are 5,400 rpm, 7,200 rpm, 10,000 rpm, and 15,000 rpm. The speed of the platter increases with the improvement in technology; Although the extent to which it can be improved is limited.

Read/write head: Read/write (R/W) heads, read and write data from or to the platters. Drives have two R/W heads per platter, one for each surface of the platter. The R/W head changes the magnetic polarization on the surface of the platter when writing data. While reading data, the head detects the magnetic polarization on the surface of the platter.

During reads and writes, the R/W head senses the magnetic polarization and never touches the surface of the platter. When the spindle rotates, a microscopic air gap is maintained between the R/W heads and the platters, known as the head flying height. This air gap is removed when the spindle stops rotating and the R/W head rests on a special area on the platter near the spindle. This area is called the landing zone. The landing zone is coated with a lubricant to reduce friction between the head and the platter.

The logic on the disk drive ensures that heads are moved to the landing zone before they touch the surface. If the

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drive malfunctions and the R/W head accidentally touches the surface of the platter outside the landing zone, a head crash occurs. In a head crash, the magnetic coating on the platter is scratched and may cause damage to the R/W head. A head crash generally results in data loss.

Actuator arm assembly: R/W heads are mounted on the actuator arm assembly, which positions the R/W head at the location on the platter where the data needs to be written or read. The R/W heads for all platters on a drive are attached to one actuator arm assembly and move across the platters simultaneously.

Drive controller board: The controller is a printed circuit board, mounted at the bottom of a disk drive. It consists of a microprocessor, internal memory, circuitry, and firmware. The firmware controls the power supplied to the spindle motor as well as controls the speed of the motor. It also manages the communication between the drive and the compute system. In addition, it controls the R/W operations by moving the actuator arm and switching between different R/W heads, and performs the optimization of data access.

9.29.2. Other Components

As well as the casing on the outside of the hard disk that holds all of the components together, the front-end circuit board controls input and output signals in tandem with the ports at the end of the drive. No matter what the type of drive, it has one port for a power supply and one port for transferring data and instructions to and from the rest of the system.

9.30 PERFORMANCE OF HDD

The performance of a hard drive is most effectively measured by how fast data can be transferred from the spinning media (platters) through the read/write head and passed to a host computer. This is commonly referred to as data throughput and usually measured in gigabytes (or gigabits) per second.

Types of HDD

The Hard Drive is connected to the motherboard via an interface cable. There are three main types of Hard Drive interface including the older IDE (Integrated Drive Electronics) also called PATA (Parallel ATA), the new SATA (Serial ATA), and SCSI (Small Computer System Interface) which is mainly used on servers and in industry.

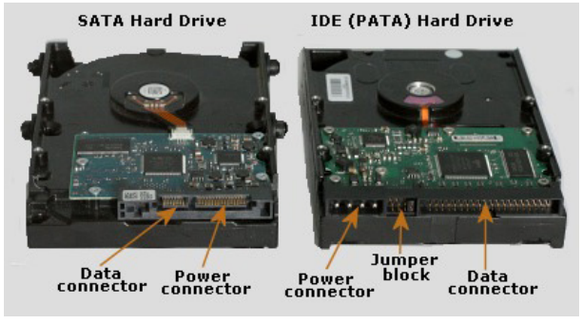

Figure 9.33 : SATA and IDE

The two main types of Hard Drive on a Home Computer include the older IDE Hard Drive, and the new SATA Hard Drive which are shown in figure 9.33. They are both the same size and look identical except for the power and data connectors.

Hard Drives are mechanical devices with moving parts which can fail resulting in the loss of all your data although they are relatively cheap and easy to replace. You may also want to add more Hard Drives to your computer for additional storage space.

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First you need to look at your computer's motherboard or look in your motherboard manual and determine if it contains the older IDE connectors or the newer SATA connectors. The motherboard may even contain both types of connector are shown in figure 9.34.

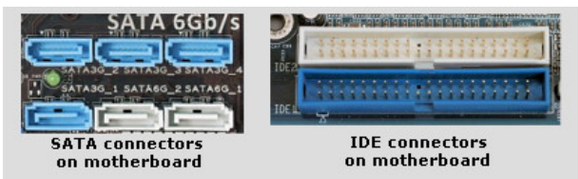

Figure 9.34 : SATA and IDE connectors on mother board

If the motherboard has IDE connectors then you will need an IDE (PATA) Hard Drive. There are usually two IDE connectors on the motherboard and each connector can control up to two drives allowing a total of four drives to be connected in total. A newer computer will most likely have SATA connectors which allow one drive per SATA connector. If you intend to add more internal Hard Drives to your computer then you will not only need a spare data connector but will also need room to install the Drive into the case.

9.30.1. HDD Speeds

The best physical HDD speeds to use are typically 5400rpm for laptops, and 7200rpm for desktops. Higher speed drives typically generate too much heat, noise, vibration, or draw too much power when used a laptop, but there are a few exceptions.

What is RPM? RPM stands for revolutions per minute, and it's used to measure the rotational speeds of hard disk platters. All other things being equal, faster spinning platters will translate to quicker hard disk drives. In fact, the RPM of a hard disk drive makes the biggest impact on its overall speed.

External connection types:

External hard drives can use a number of different connections like:

USB, USB C (a.k.a. USB Type-C)
eSATA, Firewire (400 or 800)
Thunderbolt.

9.31 USB

USB is the most common connection type for external Hard Disk Drives are shown in figure 9.35. It is extremely easy to use.

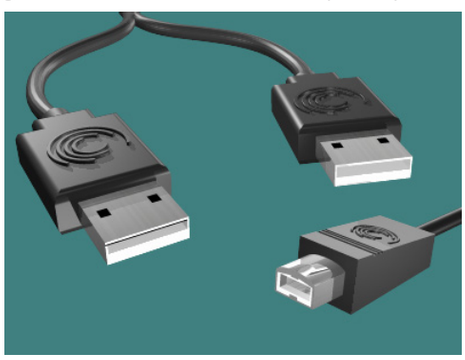

Figure 9.35 : USB

LEARNING OUTCOMES

After studying this chapter, a student can understand the following

1. **Fundamentals of computer system**
2. **Basic Concepts of Operating System**
3. **Concepts of Motherboard**
4. **Function of CPU**
5. **Working of Hard disk drive.**

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QUESTIONS

I Choose the best answer

1. _____ is an interface between the user and the hardware
   a) CPU b) OS c) ALU d) CU
2. Which of the following is not an Operating System?
   a) Linux b) Windows
   c) Unix d) Oracle
3. Which one of the following is a Single user Operating System
   a) Linux b) Windows
   c) Mac d) DOS
4. _____ in a computer that executes instructions that make up a program
   a) Input unit b) Output unit
   c) Memory unit d) CPU
5. The best physical HDD speeds to use are typically _____ for laptops.
   a) 5400 rpm b) 7200 rpm
   c) 6400 rpm d) 8200 rpm
6. Macintosh OS is Introduced in the year _____
   a) 1984 b) 1970 c) 1982 d) 1988
7. The efficiency of SMPS is _____ greater than linear regulators.
   a) upto 90% b) upto 96%
   c) upto 85% d) upto 88%
8. Which battery is used inside the computer
   a) Nickel – cadmium b) CMOS
   c) Alkaline d) Lithium
9. _____ are the connections between the CPU and peripheral devices on a mother board
   a) Serial port b) USB ports
   c) I/O Ports d) HDMI port
10. Parallel ports can send or Receive _____ bits at a time
    a) 2 b) 4 c) 8 d) 12

II Answer in few sentences.

1. What is the need for operating system?
2. Brief about Single User Operating System.
3. Brief about Multi User Operating System.
4. What are the key Functions of Operating System?
5. Define Microsoft windows.
6. What are the characteristics of a computer?
7. Give the expansion of the following
   a) SMPS b) USB c). GUI
8. What is expansion slot?
9. What is port? Give its types.
10. Define cache.

III Explain the following questions

1. Explain booting of operating system
2. Explain the types of operating system based on process capability
3. Explain the difference between SRAM and DRAM
4. Draw the linux Distributions diagram and explain
5. Compare the Mother board form factors.

IV Briefly explains the following questions

1. Explain any five functions of Mother board components.
2. Give detailed explanation about types of RAM
3. Explain key features of operating system(any five).

Answers:

1. (b) 2. (d) 3. (d) 4. (d) 5. (a)
6. (a) 7. (b) 8. (b) 9. (a) 10. (c)

COMPUTER NETWORKS ESSENTIALS

CHAPTER 10

DGNAW

LEARNING OBJECTIVES

A student can understand the following in this chapter

1. Concept of Network Technology
2. Structures of Network Topology
3. Configuration of cable
4. Use of Network device and peripherals
5. Concept of windows server 2019
6. Concept of Linux server
7. Basics of IT security
8. Use of Firewalls
9. Structures of ITIL

10.1 NETWORK CONCEPT AND TECHNOLOGY

10.1.1 Concept of Networking

Introduction

Computer networking refers to the study and analysis of the communication process among various computing devices or computer systems that are linked or networked together to exchange information and share resources. Let us see the various concept of computer network.

What is a Computer Network?

Today computer networks are everywhere. You will find them in homes, offices, factories, hospitals, leisure centres etc. A network is a method to interconnect group of people or things capable of sharing meaningful information with one another. All data networks consist of nodes, individual computers or digital device using the network and links, the physical connections (either wired or wireless) that carry messages between nodes. Computer networks can also include multiple devices/ mediums which help in the communication between two different devices,These are known as Network devices and include things such as routers, switches, hubs, and bridges are shown in Figure 10.1.

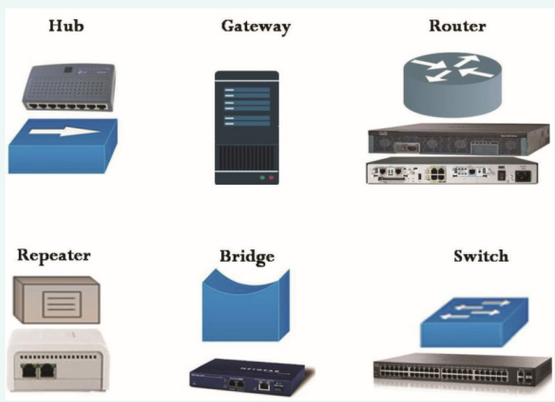

Figure 10.1: Network Devices

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10.2 NETWORK TECHNOLOGIES

Computer networks can be logically classified into:

1. Peer to Peer networks
2. Client server networks

10.2.1 Peer to Peer networks

A peer-to-peer network is a technology that allows you to connect two or more computers to one system. This connection allows you to easily share data without having to use a separate server for your file-sharing. Each end-computer that connects to this network becomes a 'peer' and is allowed to receive or send files to other computers in its network. This enables you to work collaboratively to perform certain tasks that need group attention, and it also allows you to provide services to another peer. The Peer to Peer network shown in Figure 10.2

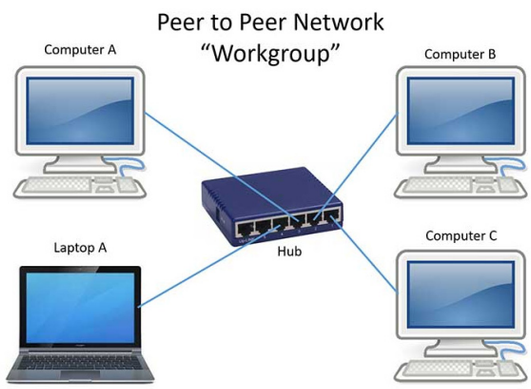

Figure 10.2: Peer to Peer networks

10.2.2 Client server networks

A client server computer network model is made-up of client computers and server computers. Now we need to understand the terms "client computer" and "server computer". The Client Server Network is shown in Figure 10.3

Client computer

A computer which is seeking any resource from another computer is a client computer. For Example: Downloading a file from a File Server, Browsing Internet etc.

Server computer

If a computer has a resource to serve to another computer, it is a server computer. A server computer is installed with appropriate Operating System and related software to serve the network clients with one or more services.

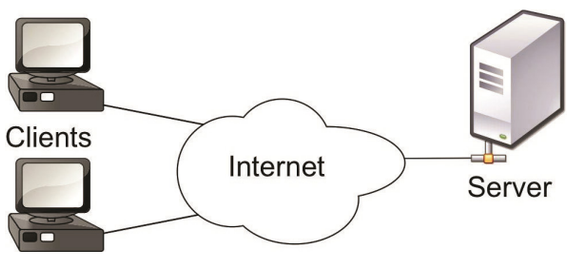

Figure 10.3 : Client Server Network

In a client server network, high-end servers, installed with the Network Operating System (Server Operating System) and the related software, serve the clients continuously on a network, by providing them with specific services upon request. The Client Server network model is widely used network model.

10.3 TYPES OF NETWORKING

There are mainly three types of computer networks based on their size:

1. Local Area Network (LAN)
2. Metropolitan Area Network (MAN)
3. Wide Area network (WAN)

10.3.1 Local Area Network (LAN)

Local Area network is a group of computers connected with each other in a small place such as school, hospital, apartment

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etc. LAN due to their small size are considerably faster, their speed can range anywhere from 100 to 1000Mbps. LANs are not limited to wire connection, there is a new evolution to the LANs that allows local Area Network to work on a wireless connection. The Local Area Network is shown in Figure 10.4.

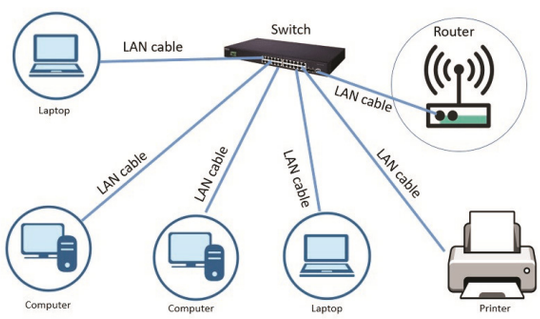

Figure 10.4: Local Area Network (LAN)

10.3.2 Metropolitan Area Network (MAN)

MAN network covers larger area by connecting LANs to a larger network of computers with each other through telephone lines. The size of the Metropolitan Area Network is larger than Notes LANs and smaller than WANs (wide area networks), a MAN covers the larger area of a city or town. MAN speed ranges upto 100 Mbps. The Figure 10.5 shows the Metropolitan Area Network.

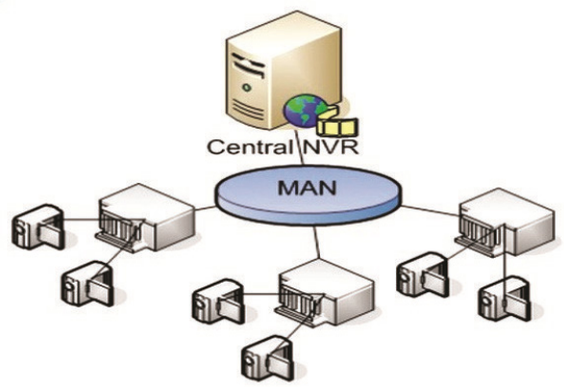

Figure 10.5: Metropolitan Area Network

10.3.3 Wide Area network (WAN)

Wide Area Network provides long distance transmission of data. The size of the WAN is larger than LAN and MAN. A WAN can cover a country, continent or even a whole world. Internet connection is an example of WAN. The speed of WAN can range anywhere from 10-20 Mbps. The Figure 10.6 shows the Wide Area Network (WAN)

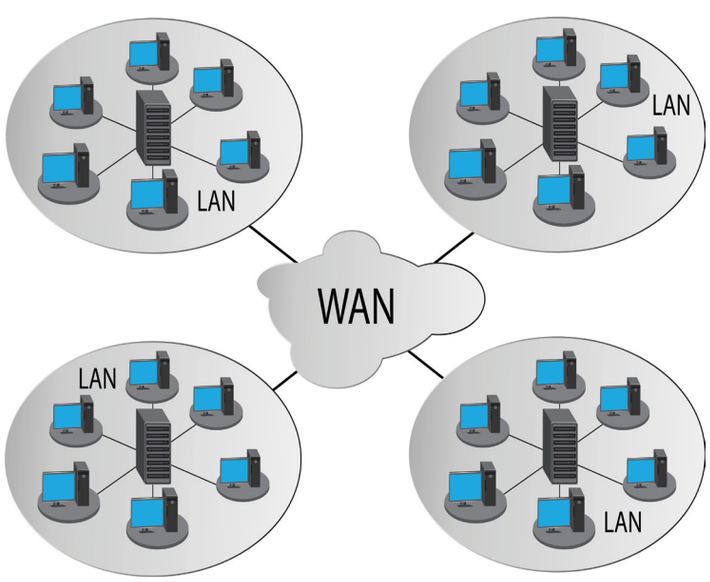

Figure 10.6: Wide Area Network (WAN)

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The major differences between LAN, MAN and WAN:

Table 10.1 Differences between LAN, MAN and WAN

S.No.	Key	LAN	MAN	WAN
1	Definition	LAN stands for Local Area Network.	MAN stands for Metropolitan Area Network.	WAN stands for Wide Area Network.
2	Ownership	LAN is often owned by private organizations.	MAN ownership can be private or public.	WAN ownership can be private or public.
3	Speed	LAN speed is quite high.	MAN speed is average.	WAN speed is lower than LAN.
4	Delay	Network Propagation Delay is short in LAN.	Network Propagation Delay is moderate	Network Propagation Delay is longer in WAN.
5	Congestion	LAN has low congestion as compared to WAN.	MAN has higher congestion than LAN.	WAN has higher congestion than MAN and LAN.
6	Fault Tolerance	Fault Tolerance of LAN is higher than WAN.	Fault Tolerance of MAN is lower than LAN.	Fault tolerance of WAN is lower than LAN and MAN.
7	Maintenance	Designing and maintaining LAN is easy and less costly than WAN.	Designing and maintaining WAN is complex and costly than LAN.	Designing and maintaining WAN is complex and more costly than LAN and MAN.

10.4 NETWORK TOPOLOGY

The way in which you connect a computer into a network is known as topology. There are five topologies. They are:

1. BUS
2. RING
3. STAR
4. HYBRID
5. MESH

10.4.1 BUS Topology

Bus topology is a network type in which every computer and network device is connected to a single cable. It transmits the data from one end to another in single direction. No bi-directional feature is in the bus topology. The Figure 10.7 shows the Bus topology with shared backbone cable.

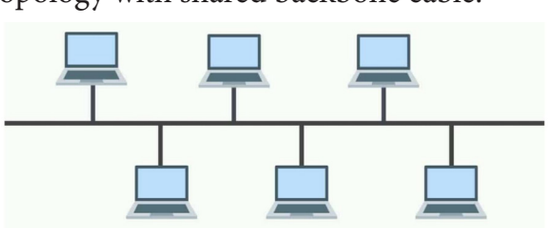

Figure 10.7: A bus topology with shared backbone cable

10.4.2 RING Topology

A network topology in which every node has exactly two branches connected to it. It features a logically closed loop. Data packets travel in a single direction around

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the ring from one network device to the next. All messages travel through a ring in the same direction (effectively either clockwise or counter clock wise). A failure in any cable or device breaks the loop and can take down the entire network. A ring topology comprises of stations connected with each forming a ring is shown in Figure 10.8.

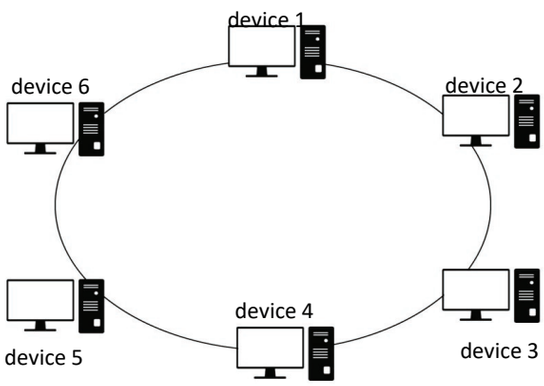

Figure 10.8: A ring topology comprises of stations connected with each forming a ring

10.4.3 STAR Topology

In a star topology each node has a dedicated set of wires connecting it to a central network hub. since all traffic passes through the hub, the hub becomes a central point for isolating network problems and gathering network statistics. A star topology having five system connected to hub is shown in Figure 10.9.

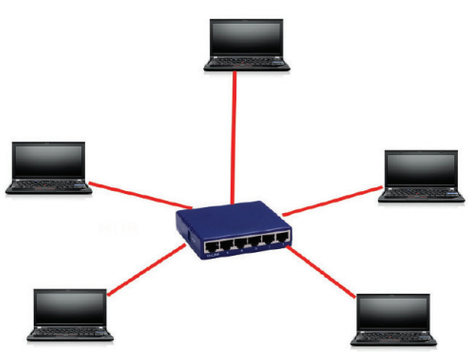

Figure 10.9: A star topology having five systems connected to a hub

10.4.4 Hybrid Topology

A combination of two or more topology is known as hybrid topology. For example, a combination of star and mesh topology is known as hybrid topology is shown in Figure 10.10.

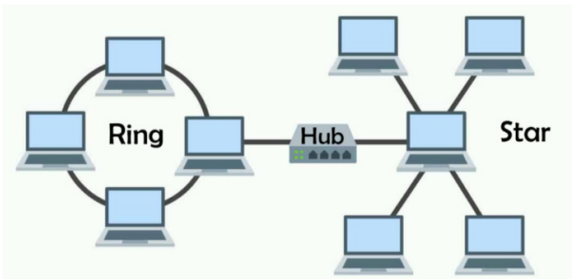

Fig 10.10 Hybrid Topology model

10.4.5 MESH Topology

A network topology in which there are at least two nodes with two or more paths between them. Messages sent on a network can take any of several possible paths from source to destination. Some WAN like the internet employ Mesh routing. Figure 10.11 shows the Mesh Topology

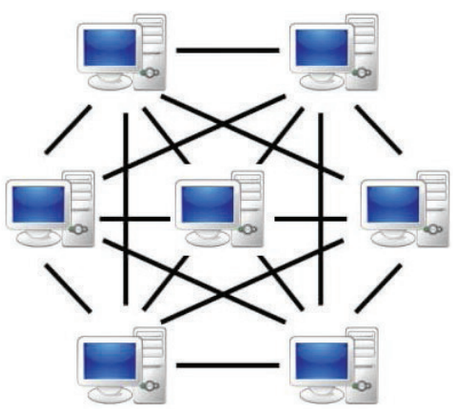

Figure 10.11: Mesh Topology

10.5. PROTOCOL AND IP ADDRESS

10.5.1 Concept of protocol

Network protocols break larger processes into discrete, narrowly defined functions and tasks across every level of the

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network. To successfully send and receive information, devices on both sides of a communication exchange must accept and follow protocol conventions. Support for network protocols can be built into software, hardware, or both.

10.5.2 Protocol

A protocol is a standard set of rules that allow electronic devices to communicate with each other. These rules include what type of data may be transmitted, what commands are used to send and receive data, and how data transfers are confirmed. Examples: TCP, IP, UDP, FTP, HTTP, HTTPS

1. Transmission control protocol (TCP)

Transmission control protocol is used for communication over a network. In TCP data is broken down into small packets and then sent to the destination. However, IP makes sure that packets are transmitted to the right address.

2. Internet Protocol (IP)

An Internet Protocol address (IP address) is a numerical label assigned to each device connected to a computer network that uses the Internet Protocol for communication. An IP address serves two main functions:

i) Host or Network Interface Identification and

ii) Location addressing.



Figure 10.12: An example of 192.168.1 Street

The Figure 10.12 shows an example of 192.168.1 street. To send and direct data across a network, computers need to be able to identify destinations and origins. This identification is an IP - Internet Protocol address. An IP address is just a set of four numbers between 0 and 255, separated by dots. An example of an IP address is 173.194.43.7. An IP address is similar to a street address. Parts of the address describe where in the world the building is located, another part narrows it down to a state or city, then the area within that state or city, then the location on the street.

The complete addresses for each of these houses is:

192.168.1.20, 192.168.1.21, and 192.168.1.22.

UDP3.

UDP Stands for "User Datagram Protocol." It is part of the TCP/IP suite of protocols used for data transferring. UDP protocol is typically used for streaming media.

4. FTP

File transfer protocol is basically used for transferring files to different networks. There may be a mass of files such as text files, multimedia files, etc. This way of file transfer is quicker than other methods.

5. HTTP

HTTP (Hypertext Transfer Protocol) is based on client and server model. HTTP is used for making a connection between the web client and web server. HTTP shows information in web pages.

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10.6 TCP/IP MODEL – 4 LAYERS

It stands for Transmission Control Protocol/ Internet Protocol. The TCP/IP model is a concise version of the OSI model. It contains four layers. The layers are:

1. Network Access/Link Layer
2. Internet Layer
3. Host-to-Host/Transport Layer
4. Process/Application Layer

10.6.1 The Network Access Layer

Network Access Layer is the first layer of the four-layer TCP/ IP model. It helps you to define details of how data should be sent using the network. It also includes how bits should optically be signalled by hardware devices which directly interfaces with a network medium, like coaxial, optical, coaxial, fibre, or twisted pair cables. This layer defines how the data should be sent physically through the network. This layer is responsible for the transmission of the data between two devices on the same network.

10.6.2 Internet Layer

An internet layer is a second layer of TCP/ IP layers of the TCP/IP model. It is also known as a network layer. The main work of this layer is to send the packets from any network, and any computer till they reach the destination irrespective of the route they take. The Internet layer offers the functional and procedural Notes method for transferring variable length data sequences from one node to another with the help of various networks. Message delivery at the network layer does not give any guaranteed to be reliable network layer protocol.

Layer-management protocols that belong to the network layer are:

- Routing protocols
- Multicast group management
- Network-layer address assignment.

10.6.3 Transport Layer

Transport layer builds on the network layer in order to provide data transport from a process on a source system machine to a process on a destination system. It is hosted using single or multiple networks and also maintains the quality-of-service functions.

It determines how much data should be sent where and at what rate. This layer builds on the message which are received from the application layer. It helps ensure that data units are delivered error-free and in sequence. Transport layer helps you to control the reliability of a link through flow control, error control, and segmentation or de-segmentation. The transport layer also offers an acknowledgment of the successful data transmission and sends the next data in case no errors occurred. TCP is the best-known example of the transport layer.

Important functions of Transport Layers:

- It divides the message received from the session layer into segments and numbers them to make a sequence.
- Transport layer makes sure that the message is delivered to the correct process on the destination machine.
- It also makes sure that the entire message arrives without any error else it should be retransmitted.

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10.6.4 Application Layer

Application layer interacts with software applications to implement a communicating component. The interpretation of data by the application program is always outside the scope of the OSI model. Example of the application layer is an application such as file transfer, email, remote login, etc.

The functions of the Application Layers:

- Application-layer helps you to identify communication partners, determining resource availability, and synchronizing communication.
- It allows users to log on to a remote host.
- This layer provides various e-mail services.

Advantages of the TCP/IP model

- It helps you to establish/set up a connection between different types of computers.
- It operates independently of the operating system.
- It supports many routing-protocols.
- It enables the internet working between the organizations.
- TCP/IP model has a highly scalable client-server architecture.
- It can be operated independently.
- Supports a number of routing protocols.
- It can be used to establish a connection between two computers.

Disadvantages of the TCP/IP model

- TCP/IP is a complicated model to set up and manage.
- The transport layer does not guarantee delivery of packets.
- Replacing protocol in TCP/IP is not easy.
- It has no clear separation from its services, interfaces, and protocols.

10.7 DATA TRANSMISSION

Transmission mode means transferring of data between two devices. It is also known as communication mode. Buses and networks are designed to allow communication to occur between individual devices that are interconnected. There are three types of transmission mode:

- Simplex Mode
- Half-Duplex Mode
- Full-Duplex Mode

10.7.1 Simplex Mode

In Simplex mode, the communication is unidirectional. Only one of the two devices on a link can transmit, the other can only receive. The simplex mode can use the entire capacity of the channel to send data in one direction.

Example: Pager.

10.7.2 Half-Duplex Mode

In half-duplex mode, each station can both transmit and receive, but not at the same time. When one device is sending, the other can only receive, and vice versa. The half-duplex mode is used in cases where there is no need for communication in both direction at the same time. The entire capacity of the channel can be utilized for each direction.

Example: Walkie- talkie in which message is sent one at a time and messages are sent in both the directions.

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10.7.3 Full-Duplex Mode

In full-duplex mode, both stations can transmit and receive simultaneously. Figure 10.13 shows the Full Duplex Mode. In full-duplex mode, signals going in one direction share the capacity of the link with signals going in other direction, this sharing can occur in two ways:

- Either the link must contain two physically separate transmission paths, one for sending and other for receiving or the capacity is divided between signals travelling in both directions.
- Full-duplex mode is used when communication in both direction is required all the time. The capacity of the channel, however, must be divided between the two directions.

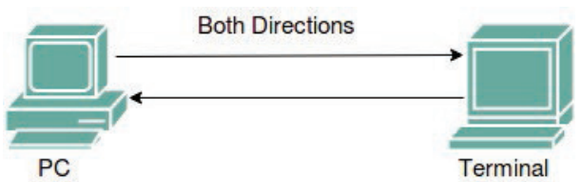

Figure 10.13: **Full-Duplex Mode**

10.8 INTER-NETWORK

An Inter-Network can be defined as two or more computer networks (typically Local Area Networks LAN) which are connected together, using Network Routers. Each network in an Inter-Network has its own Network Address, which is different from other networks in the Inter-Network. Network Address is used to identify the networks inside an Inter-network. Inter-Network allows different users at different geographical locations of an organization to share data, resources and to communicate. Modern businesses cannot even function without Inter-Network. The different types of Inter-Network are:

1. Internet
2. Intranet and
3. Extranet

10.8.1 Internet

Internet is a worldwide, publicly accessible computer network of interconnected

Difference between Simplex, Half duplex and Full Duplex Transmission Modes:

Table 10.2 Difference between Simplex, Half Duplex and Full Duplex

SIMPLEX	HALF DUPLEX	FULL DUPLEX
A uni-directional communication	A two-way directional communication but one at a time.	A two-way directional communication simultaneously.
Sender can send the data but that sender can't receive the data.	Sender can send the data and also can receive the data but one at a time.	Sender can send the data and also can receive the data simultaneously.
Provides less performance than half duplex and full duplex	Provides less performance than full duplex.	Provides better performance than simplex and half duplex mode.
Example: Pager	Example: Walkie Talkie.	Example: Cellphone.

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computer networks (inter-network) that transmit data using the standard Internet Protocol (IP). Largest Internetwork in the world is Internet.

Advantages of Internet

- An Internet connection provides many people with ability to work from home or have a virtual office.
- Can provide online education to the student with the help of the Internet.
- With Internet, one is able to access information quickly and easily.

Disadvantages of Internet

- Access to Internet is not restricted and information is available to anyone across the world.
- If the file server breaks down, the files on the server become inaccessible.
- There is danger of hacking or availability of malicious viruses.

10.8.2 Intranet

An intranet is a private network that is contained within an enterprise. Typical intranet for a business organization consists of many interlinked local area networks (LAN) and use any Wide Area Network (WAN) technology for network connectivity. The main purpose of an intranet is to share company information and computing resources among employees.

Advantages of Intranet

- It reduces emails and meetings
- Improves employee engagement and knowledge sharing
- Helps an organization to build an internal collaborative culture.
- Increases productivity in an organization.

Disadvantages of Intranet

- Intranet can be very costly and time-consuming to implement.
- Poor user experience results in low usage rates.
- Hard to measure success and effectiveness.

10.8.3 Extranet

An Extranet can be viewed as part of a company's intranet that is extended to users outside the company like suppliers, vendors, partners, customers, or other business associates. Extranet is required for normal day-to-day business activities. For example, placing purchase order to registered vendors, billing & invoices, payments related activities, joint venture related activities, product brochures for partners, discounted price lists for partners etc.

Advantages of Extranet

- An extranet greatly improves flexibility by making applications and information available to customers, clients and partners, allowing all the involved parties to operate with convenience.
- With proper implementation, an extranet can help improve an organizations security by creating different access levels, consequently controlling who can access company data.

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Disadvantages of Extranet

- Time is required to train users on how to work with the network.
- The network is pron to misuse.
- Maintenance cost of the network is high.

Information can be shared outside the local network due to one faulty or compromised machine.Figure 10.14 shows the Overview of Inter-Network

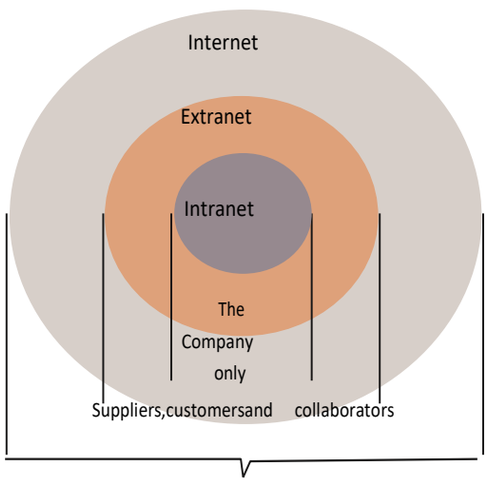

Figure 10.14: Overview of Inter-Network

The world

- **Intranet** is shared content accessed by members within a single organization.
- **Extranet** is shared content accessed by groups through cross-enterprise boundaries.
- **Internet** is global communication accessed through the Web.

10.9 NETWORK DEVICES

Hardware devices that are used to connect computers, printers, fax machines and other electronic devices to a network are called network devices. These devices transfer data in a fast, secure and correct way over same or different networks. Network devices may be inter-network or intra-network.

10.9.1 Repeaters

A repeater operates at the physical layer. Its job is to regenerate the signal over the same network before the signal becomes too weak or corrupted so as to extend the length to which the signal can be transmitted over the same network. They do not amplify the signal. When the signal becomes weak, they copy the signal bit by bit and regenerate it at the original strength. It is a 2-port device.

10.9.2 Hub

A hub is basically a multiport repeater. A hub connects multiple wires coming from different branches. Figure 10.15 shows the Network Hub.

Computer A wants to send a message to computer B. It sends the message through the Ethernet cable to the hub, then the hub repeats the message to all of the connected computers. The various types of Hub are:

1. Active Hub
2. Passive Hub
3. Intelligent Hub

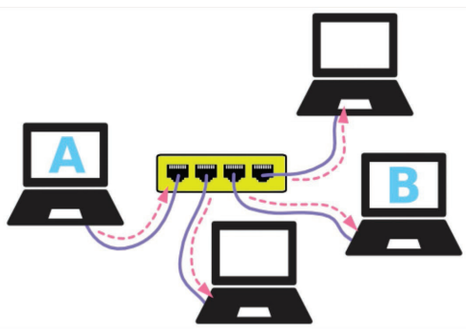

Figure 10.15: A Network Hub

Active Hub

These are the hubs which have their own power supply and can clean, boost, and relay the signal along with the network. It serves both as a repeater as well as wiring

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centre. These are used to extend the maximum distance between nodes.

Passive Hub

These are the hubs which collect wiring from nodes and power supply from active hub. These hubs relay signals onto the network without cleaning and boosting them and can't be used to extend the distance between nodes.

Intelligent Hub

It works like active hubs and include remote management capabilities. They also provide flexible data rates to network devices. It also enables an administrator to monitor the traffic passing through the hub and to configure each port in the hub.

10.9.3 Switch

A switch is a multiport bridge with a buffer and a design that can boost its efficiency and performance. The switch can perform error checking before forwarding data, that makes it very efficient as it does not forward packets that have errors and forward good packets selectively to correct port only. Instead of repeating all messages that come in, a switch only sends the message to the intended destination. For example: Using a switch, computer A sends a message to computer B - the other computers do not see the message. Those computers can send other messages at the same time without interfering. Fig 10.16 shows various computers connected to a switch.

Switches do have a limitation though they only know about the addresses of equipment that is plugged directly into them

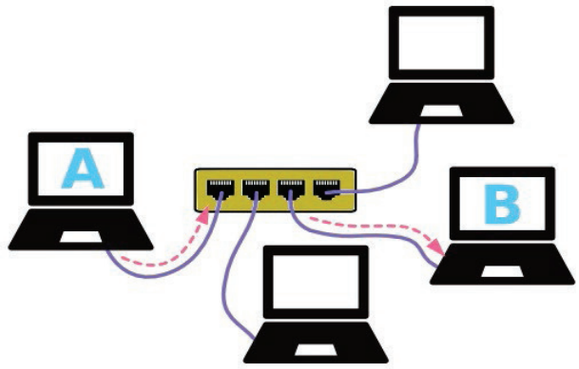

Figure 10.16: Switch

10.9.4 Router

A router is a network layer hardware device that transmits data from one LAN to another if both networks support the same set of protocols. So, a router is typically connected to at least two LANs and the internet service provider (ISP). It receives its data in the form of packets, which are data frames with their destination address added.

10.9.5 Gateway

Gateway is a network device used to connect two or more dissimilar networks. A gateway usually is a computer with

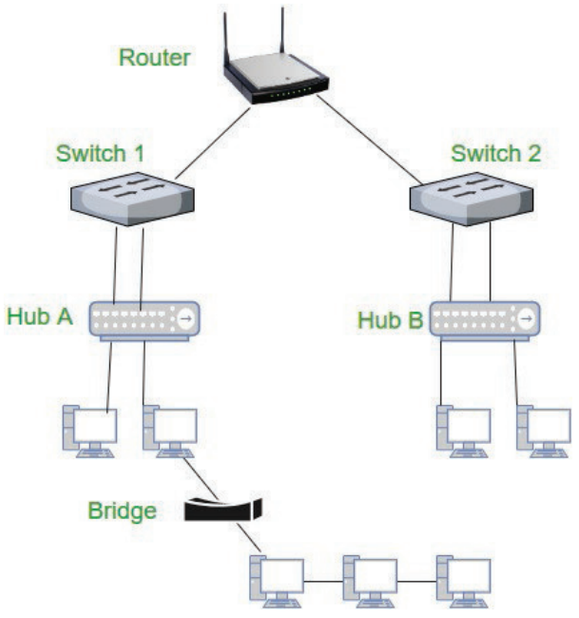

Figure 10.17: Gateway

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multiple NICs connected to different networks. It is a passage to connect two networks together that may work upon different networking models. They basically work as the messenger agents that take data from one system, interpret it, and transfer it to another system. Figure 10.17 shows the model of gateway.

10.10. NETWORK TRANSMISSION MEDIUM

In data communication terminology, a transmission medium is a physical path between the transmitter and the receiver i.e., it is the channel through which data is sent from one place to another. Figure 10.18 shows the types of transmission media. Transmission Media is broadly classified into the following types:

1. Guided Media
2. Unguided Media

10.10.1 Guided Media

It is also referred to as Wired or Bounded transmission media. Signals being transmitted are directed and confined in a narrow pathway by using physical links.

Features:

- High Speed
- Secure
- Used for comparatively shorter distances

There are 3 major types of Guided Media:

1. Coaxial Cable
2. Twisted Pair Cable
3. Optical Fibre Cable

1. Coaxial Cable

It has an outer plastic covering containing 2 parallel conductors each having a separate insulated protection cover. The coaxial cable transmits information in two modes: Baseband mode (dedicated cable bandwidth) and Broadband mode (cable bandwidth is split into separate ranges). Cable TVs and Analog television networks widely use Coaxial cables.

Ethernet cable was named after the substance luminiferous ether, that acts as a medium for transmission of electromagnetic waves. Figure 10.19 shows the Coaxial Cable.

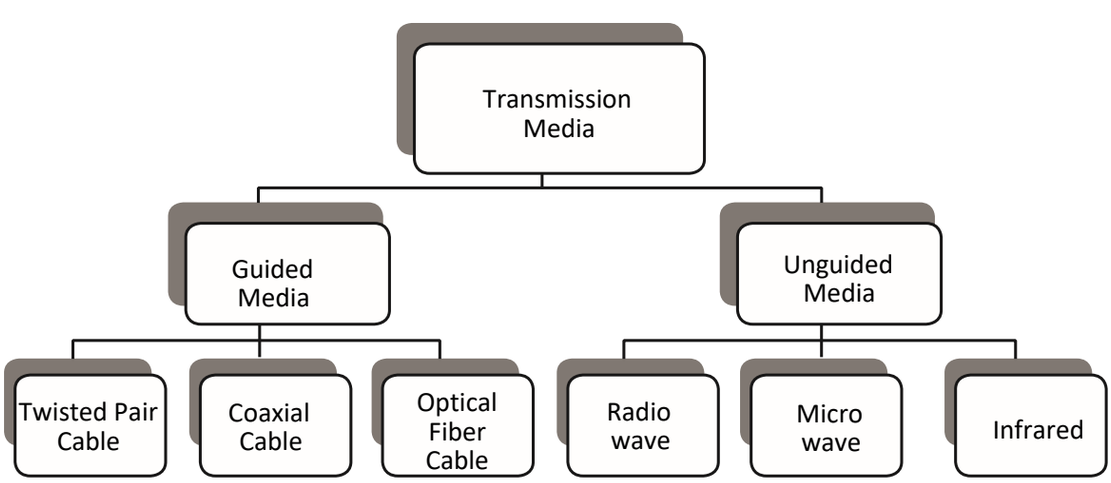

Figure10.18: Types of Transmission Media

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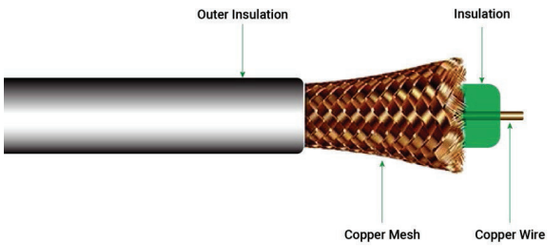

Figure 10.19: Coaxial Cable

Advantages

- High Bandwidth
- Better noise immunity
- Easy to install and expand
- Inexpensive

Disadvantages

- Single cable failure can disrupt the entire network

2. Twisted Pair Cable

It consists of 2 separately insulated conductor wires wound about each other. Generally, several such pairs are bundled together in a protective sheath. They are the most widely used Transmission Media. Figure 10.20 shows the Twisted pair cable.

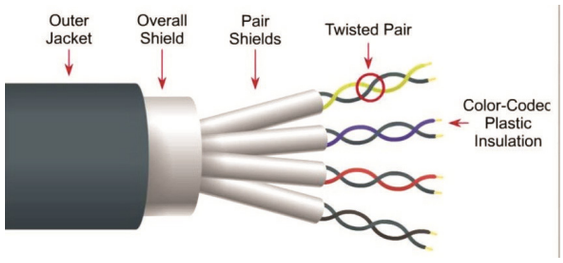

Figure 10.20: Twisted Pair Cable

Twisted Pair is of two types:

- Unshielded Twisted Pair (UTP)
- Shielded Twisted Pair (STP)

Unshielded Twisted Pair (UTP)

This type of cable has the ability to block interference and does not depend on a physical shield for this purpose. It is used for telephonic applications.

Advantages:

- Least expensive
- Easy to install
- High-speed capacity

Disadvantages:

- Susceptible to external interference
- Lower capacity and performance in comparison to STP
- Short distance transmission due to attenuation

Applications:

- Used in telephone connections and LAN networks

3. Shielded Twisted Pair (STP):

- This type of cable consists of a special jacket (a copper braid covering or a foil shield) to block external interference. It is used in fast-data-rate Ethernet and in voice and data channels of telephone lines.

Advantages:

- Better performance at a higher data rate in comparison to UTP
- Eliminates crosstalk
- Comparatively faster

Disadvantages:

- Comparatively difficult to install and manufacture
- More expensive, Bulky

4. Optical Fibre Cable

It uses the concept of reflection of light through a core made up of glass or plastic. The core is surrounded by a less dense glass or plastic covering called the cladding. It is used for the transmission of large volumes of data. The cable can be unidirectional or bidirectional. The WDM (Wavelength Division Multiplexer) supports two modes, namely unidirectional and bidirectional mode. Figure 10.21 shows the optical fibre cable.

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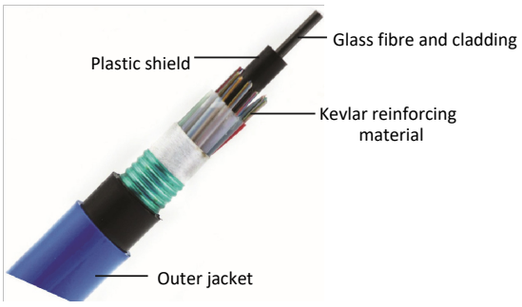

Figure 10.21: **Optical Fibre Cable**

Advantages

- Increased capacity and bandwidth
- Lightweight
- Less signal attenuation
- Immunity to electromagnetic interference
- Resistance to corrosive materials

The word Li – Fi was first used by Harald Haas. He is a professor at the Edinburgh University.

Disadvantages

- Difficult to install and maintain
- High cost, Fragile

10.10.2 Unguided Media

It is also referred to as Wireless or Unbounded transmission media. No physical medium is required for the transmission of electromagnetic signals.

Features:

- The signal is broadcasted through air
- Less Secure
- Used for larger distances

The various types of Signals transmitted through unguided media are:

1. Radio waves
2. Infra-red
3. Wi-fi
4. Li-fi
5. Bluetooth

1. Radio waves

These are easy to generate and can penetrate through buildings. The sending and receiving antennas need not be aligned. Frequency Range:3KHz – 1GHz. AM and FM radios and cordless phones use Radio waves for transmission. Further Categorized as:

1. Terrestrial and
2. Satellite.

2. Infrared

Infrared waves are used for very short distance communication. They cannot penetrate through obstacles. This prevents interference between systems. Frequency Range:300GHz – 400THz. It is used in TV remotes, wireless mouse, keyboard, printer, etc.

3. Wi-Fi

Wi-Fi (Wireless Fidelity) Wi-Fi networks are used commonly and these connect every possible device together. WiFi has been developed to facilitate wireless local area networking in the 2.4GHz or 5.2GHZ bands. There are issues related to security threat in Wi-Fi, but the same can be prevented using the several security measures that are available. The common security methods include WEP, WPA and WPA2.

4. Light Fidelity (Li-Fi)

Li-Fi stands for Light Fidelity. Li-Fi is a wireless communication technology which uses light to transmit data rather than radio frequencies like Bluetooth. Means it makes use of light waves to deliver data. Li-Fi provides higher speeds than Wi-Fi. It is fully networked, bidirectional and high-speed wireless technology. When Li-Fi technology is used in all the lights in and around a building then it provides a large area of coverage than a single Wi-Fi router.

5. Bluetooth

Bluetooth is a short-range wireless communication technology which uses radio waves to transmit information. It is a high speed and low power communication technology to connect gadgets wireless without requiring cable connection. It is used for exchanging data between fixed and mobile devices/ computers over short distances. It works well in a short distance for the devices to stay connected, when

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the range extends it fails to maintain connectivity. The range and transmission speeds of Bluetooth are lower than Wi-Fi.

10.11. SERVER

A server is a computer program or device that provides a service to another computer program and its user, also known as the client. In a data center, the physical computer that a server program runs on is also referred to as a server.

10.11.1. Windows server - History

Windows Server 2019 is the eighth version of the Windows Server operating system by Microsoft, as part of the Windows NT family of operating systems. It is the second version of the server operating system based on the Windows 10 platform, after Windows Server 2016. It was announced on March 20, 2018 for the first Windows Insider preview release, and was released internationally on October 2, 2018. It was succeeded by Windows Server 2022 on August 18, 2021

10.11.2. Windows Server 2019 Editions

The Windows 2019 for consumers there are three Editions:

❍ Essentials ❍ Standard ❍ Datacenter

Each of these versions is having specific applications and this Windows 16 does not have foundations edition.

10.11.3. Hardware Requirements For The Server 2019

CPU Socket	1.4 GHz (64-bit processor) or faster for single core 1.3 GHz (64-bit processor) or faster for multi-core
Memory	2 GB Required. 4 GB if you deploy windows server essentials as a Virtual machine. Hard disk and available storage space: 160 GB hard disk with a 60 GB system partition.
Network Adaptor	Gigabit Ethernet adapter (10/100/1000 baseT PHY/ MAC)
Internet	Some functionality may require Internet access or a Microsoft account
Supported Operating Systems	Windows 10, Windows 8.1, Windows 8, Windows 7, Macintosh OS X Version 10.5 to 10.8.
Router	A router or firewall that supports IPv4 NAT or IPv6
Additional Requirement	DVD –RAM Drive

10.12 INSTALL AND CONFIGURE ACTIVE DIRECTORY DOMAIN SERVICES (AD DS)

10.12.1 Overview of the Active Directory Domain Services (Ad Ds)

The Active Directory Domain Services is a central role allows constructing a scalable and centralized windows network. This service manages login information of users, security permissions, organizational units, computer, groups and various network services. This lets the IT managers to structure the users into logical hierarchical units.

10.12.2 Active Directory

As the name suggests, the Active Directory is an origin or database that stores objects such as clusters, PCs, printers, file stocks, group strategies, and file authorizations. The greatest central role of the Active Directory

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is to handle user verification in the domain network. It completes this by letting only legitimate users to log into the network. Moreover, the Active Directory centralizes protection by saving user accounts and their PINs in one location, instead of storing them in client computers. IT administrators have the rights to generate and delete users, configure or allow users to change their PINs, which determine how users interact with their Computers in the domain atmosphere. Deprived of an Active Directory, IT managers are required to set up native users on each PC and rearrange the password for every user on their computers.

10.12.3. Active Directory Objects Categories

Active Directory objects can be categorized into two main categories:

- **Container objects:** These are objects that contain extra objects inside them, like Forests, Trees, Domains, and structural units.
- **Leaf Objects:** These are objects that do not contain other objects, such as users, printers, and computers.

10.13. INTRODUCTION TO LINUX

Many operating systems were developed to be like Unix but none of them got the popularity as Linux. **Linux is the clone of Unix**. Linux is **a family of free and open-source operating systems based on the Linux kernel**. Operating systems based on Linux are known as Linux distributions or distros. Examples include Debian, Ubuntu, Fedora, CentOS, Gentoo, Arch Linux, and many others, (Figure 10.22).

10.13.1. Introduction to Linux server

A Linux server is an efficient, powerful variant of the Linux open source operating system (OS). Linux servers are built to address the ever-increasing requirements of business applications like system and network administration, Web services and database management.

Linux servers are often preferred over other server operating systems because of their reputation for security, consistency and flexibility.

Some examples of Linux server operating systems are CentOS, Ubuntu Server, Gentoo, Debian, Slackware, and so on. Linux is considered the best option for operating servers because there is no need for a graphical user interface; all commands can be executed via command prompt. This helps users to attain maximum system performance Some of the benefits of Linux are as follows:



Figure 10.22: Varius Linux Server OS Logos

- **Stability:** There is no need for periodic reboots to maintain efficiency levels. Linux systems, if accurately configured, can generally operate until hardware failure or system shutdown.

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- **Efficiency:** Linux offers consistent high performance on networks and servers. It has the ability to manage huge user volumes as well as parallel connections.
- **Security:** Linux provides top-notch security. Efficient firewalls as well as versatile file access permission systems avoid unwanted access or viruses.
- **Networking:** It provides exceptional networking features. It is customizable to several apps in addition to being safe.
- **Flexibility:** Because it is open source, the source code is readily available to all users. Users can customize it as per their requirements.
- **Technical Support:** Linux offers some of the best technical support available. It is being used by various consultants and commercial distributors, as well as an active community of developers.
- **Multitasking:** Multitasking, or the ability to run multiple programs or tasks simultaneously, is supported by Linux.

10.13.2. File Structure of Linux

The Linux File Hierarchy Structure or the File system Hierarchy Standard (FHS) defines the directory structure and directory contents in Linux-like operating systems. It is maintained by the Linux Foundation.

- In the FHS, all files and directories appear under the root directory /, even if they are stored on different physical or virtual devices.
- Some of these directories only exist on a particular system if certain subsystems, such as the X Window System, are installed.
- Most of these directories exist in all UNIX operating systems and are generally used in much the same way; however, the descriptions here are those used specifically for the FHS, and are not considered authoritative for platforms other than Linux

Table 10.3 Directory & Description

No.	Directory & Description
1	**/** This is the root directory which should contain only the directories needed at the top level of the file structure
2	**/bin** This is where the executable files are located. These files are available to all users
3	**/dev** These are device drivers
4	**/etc** Supervisor directory commands, configuration files, disk configuration files, valid user lists, groups, ethernet, hosts, where to send critical messages
5	**/lib** Contains shared library files and sometimes other kernel-related files
6	**/boot** Contains files for booting the system
7	**/home** Contains the home directory for users and other accounts
8	**/mnt** Used to mount other temporary file systems, such as cdrom and floppy for the CDROM drive and floppy diskette drive, respectively
9	**/proc** Contains all processes marked as a file by process number or other information that is dynamic to the system

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10	**/tmp** Holds temporary files used between system boots
11	**/usr** Used for miscellaneous purposes, and can be used by many users. Includes administrative commands, shared files, library files, and others
12	**/var** Typically contains variable-length files such as log and print files and any other type of file that may contain a variable amount of data
13	**/sbin** Contains binary (executable) files, usually for system administration. For example, fdisk and ifconfigutlities
14	**/kernel** Contains kernel files

10.14. OVERVIEW OF LINUX SERVER MANAGEMENT

A **Linux server** is a **server** built on the **Linux** open-source operating system. It offers businesses a low-cost option for delivering content, apps and services to their clients. Because **Linux** is open-source, users also benefit from a strong community of resources and advocates. Figure 10.23 shows the Linux Server Management.

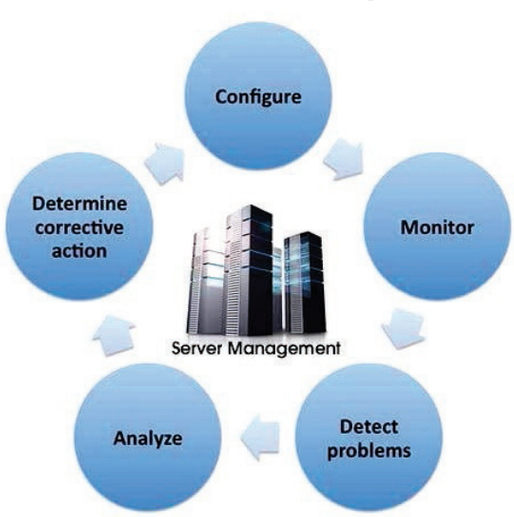

Figure 10.23 : Linux Server Management

Alerts	Set up and configure alerts to be notified on various events on server (CPU limit, hard drive limit, log file errors), when system parameters exceed the threshold value.
Processes	Manage all running processes listed with detailed information and a possibility to cancel.
Service	Manage a list of all available system services, see status. Start, stop, and restart services. Set default services launched when the system starts.
Software	Automatically install and update necessary software and packages.
Users Domains Databases Files Server Cloning	Fully manage active users on your server. Activate and deactivate users, provide/revoke SSH access. Complete domain management. Create and delete domains, subdomains, and aliases. Manage databases on your servers, including user access. Transfer, copy, download, and synchronize files and directories. Clone your server with additional file synchronization if needed.

10.14.1. Linux terminal

Here we know Linux basics to get new users on their feet, covers getting started with the terminal, the Linux command line, and executing commands. The terminal is an interface in which you can type and execute text based commands. Another benefit is allowing access too many more commands and scripts. Let's get started by going over what a terminal emulator.

10.14.2 Terminal Emulator

A terminal emulator is a program that allows the use of the terminal in a graphical environment. As most people use an OS with a graphical user interface (GUI) for

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their day-to-day computer needs, the use of a terminal emulator is a necessity for most Linux server users.

Here are some free, commonly-used terminal emulators by operating system:

Mac OS X : Terminal (default), iTerm 2

Windows : PuTTY

Linux : Terminal, KDE Konsole, XTerm

Each terminal emulator has its own set of features, but all of the listed ones work great and are easy to use.

The Shell

In a Linux system, the shell is a command-line interface that interprets a user's commands and script files, and tells the server's operating system what to do with them. There are several shells that are widely used, such as Bourne shell (sh) and C shell (csh). Each shell has its own feature set and intricacies, regarding how commands are interpreted, but they all feature input and output redirection, variables, and condition-testing, among other things.

The Command Prompt

When you first login to a server, you will typically be greeted by the Message of the Day (MOTD), which is typically an informational message that includes miscellaneous information such as the version of the Linux distribution that the server is running. After the MOTD, you will be dropped into the command prompt, or shell prompt, which is where you can issue commands to the server.

The information that is presented at the command prompt can be customized by the user, but here is an example of the default Ubuntu 14.04 command prompt:

stud@webapp:~$

Here is a breakdown of the composition of the command prompt:

- stud : The *username* of the current user
- webapp: The *hostname* of the server
- ~ : The *current directory*. In bash, which is the default shell, the ~, or tilde, is a special character that expands to the path of the current user's *home directory*; in this case, it represents /home/stud
- $: The prompt symbol. This denotes the end of the command prompt, after which the user's keyboard input will appear

Here is an example of what the command prompt might look like, if logged in as root and in the */var/log* directory:

root@webapp:/var/log#

Note that the symbol that ends the command prompt is a #, which is the standard prompt symbol for root.

10.14.3 LINUX server management commands

A system administrator manages configuration, upkeep and reliable operations of computer operations. Sysadmin handles servers, has to manage system performance and security without exceeding the budget to meet users need.

1. Uptime

Linux comes with the uptime tool, which allows you to check how long the system has been running and to see how many

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users are logged in at a given time. The tool also displays the average load on the system in 1-, 5-, and 15-minute intervals.

$ uptime

```
viktor@viktor-VirtualBox:~$ uptime
 00:23:20 up 4 min,  1 user,  load average: 0.72, 0.73, 0.35
viktor@viktor-VirtualBox:~$
```

2. Users

The users command will list all users currently logged in.

$ users

```
viktor@viktor-VirtualBox:~$ users
viktor
viktor@viktor-VirtualBox:~$
```

This command does not contain many options. The only options available the help and version features

3. W

The w command is a tool defined by just a single character. This tool is used for checking the system condition. The w command will display the current users logged in, as well as the processes and load averages for each user. This command also reports login name, login time, tty name, JCPU, PCPU, and commands.

$ w

```
viktor@viktor-VirtualBox:~$ w
 02:14:46 up  8:35,  1 user,  load average: 0.02, 0.02, 0.00
USER     TTY      FROM             LOGIN@   IDLE   JCPU   PCPU WHAT
viktor   tty7     :0               17:56    8:35m  5.40s  0.22s /usr/lib/gnome-session/gnome-session-bina
viktor@viktor-VirtualBox:~$
```

The w command comes with a handful of options. The -h option will display the output without any header entries. $ w -h

```
viktor@viktor-VirtualBox:~$ w -h
viktor   tty7     :0               17:56    8:37m  6.23s  0.22s /usr/lib/gnome-session/gnome-session-bina
viktor@viktor-VirtualBox:~$
```

4. who

The who command will return the current user's name, date, time, and host information. However, unlike the w command, this command will not print what the user is doing

$ who

```
viktor@viktor-VirtualBox:~$ who
viktor   tty7         2020-06-23 21:56 (:0)
viktor@viktor-VirtualBox:~$
```

For a comprehensive output, use the -a flag.

$ who -a

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5. cp

The cp tool is the quintessential tool for copying files and directories. Note that the source can be multiple files or directories.

$ cp <options><source><destination>

In this example, a file will be copied into a target directory. The -v flag stands for verbose mode.

10.15. FUNDAMENTALS OF IT SECURITY

10.15.1. Concept of Security

Security is the state of being free from danger or threat. Security, in information technology (IT), is the defence of digital information and IT assets against internal and external, malicious and accidental threats. This defence includes detection, prevention and response to threats through the use of security policies, software tools and IT service. Figure 10.24 shows the levels of security threats.

10.15.2. IT Security

Information Security describe the process for ensuring confidentiality, integrity and availability of data is maintained in the event of an incident.

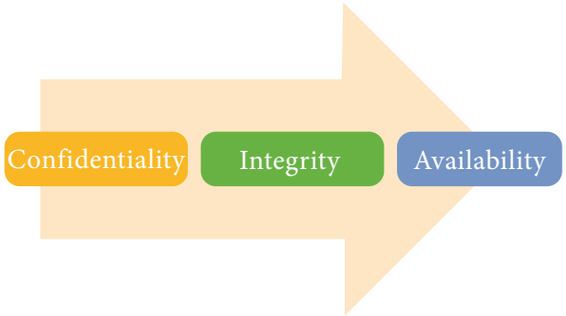

Figure10.25 Information Security

The term "Information security" means protecting information and information systems from unauthorized access, use, disclosure, disruption, modification, or destruction in order to provide Integrity, Confidentiality and Availability (Figure 10.25).

Integrity, which means guarding against improper information modification or destruction, and includes ensuring information non repudiation and authenticity

Confidentiality, which means preserving authorized restrictions on access and disclosure, including means for protecting personal privacy and proprietary information and

Availability, which means ensuring timely and reliable access to and use of information.

10.15.3 Data Threats

A threat indicates the potential for a violation of security.

Virus

A computer virus is a program that spreads by first infecting files or the system areas of a computer or network router's hard drive and then making copies of itself. Some viruses are harmless, others may damage data files, and some may destroy files. Viruses used to be spread when people shared floppy disks and other portable media, now viruses are primarily spread through email messages.

Viruses often require some sort of user action (e.g., opening an email attachment or visiting a malicious web page) to spread.

A virus is simply a computer program--it can do anything that any other program you run on your computer can do. Some viruses are designed to deliberately damage files, and others may just spread to other computers.

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Malware

Malware, short for malicious software, is a blanket term for viruses, worms, trojans and other harmful computer programs hackers use to wreak destruction and gain access to sensitive information

Trojan Horse

Trojan is different from viruses and worms. Trojan is neither self-replicating nor it copies itself into other files.

Infection is through opening an email attachment or downloading and running a file from the Internet.

Worm

A worm is a type of virus that can spread without human interaction. Worms often spread from computer to computer and take up valuable memory and network bandwidth, which can cause a computer to stop responding. Worms can also allow attackers to gain access to your computer remotely.

A worm is a standalone piece of malicious software that reproduces itself and spreads from computer to computer.

Cyber Attack

A cyberattack is a malicious and deliberate attempt by an individual or organization to breach the information system of another individual or organization. Usually, the attacker seeks some type of benefit from disrupting the victim's network.

10.15.4. File Security

Because of its multiuser nature, it is expected that many different people will store their files on the same computer. It is understood that some files may be shared while others are private, and the operating system has a mechanism to prevent others from reading your private files.

- Users and group
- Permissions for regular files
- Permissions for directories

Simple Ways to Keep Files Safe

1. Regularly backup your files. If a virus infects your operating system, it's often necessary to completely wipe your computer and re-install programs. 2. Use an external hard drive
2. Store files in the cloud.
3. Control access to your files
4. Encrypt your hard drive.

Access Control

The ability to permit or deny the use of an object by a subject.

It provides 3 essential services

- Authentication (identification of a user)
- Authorisation (who is allowed to use a service)
- Accountability (what did a user do)

Strong Authentication

- An absolute requirement

Two-factor authentication

- Passwords (something you know)
- Tokens (something you have)

Examples:

- Passwords
- Tokens
- Tickets
- Restricted access
- PINs
- Biometrics
- Certificates

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File security of local computers and portable devices

As we process our works, save our personal documents, photos, media files and account info on computer, Pad or mobile phones either with or without network, it is more important for us to protect our data from the local devices. You might leak out data by the following situations:

1. You work on LAN and share your folders with others.
2. You and other people use the same computer.
3. It is a public place, you use Wifi network and so do others.
4. You save files on USB, flash drive, pen drive or removable hard drives.

10.16. ANTIVIRUS

Antivirus is the data security software which provides extremely advanced protection from unknown viruses, spywares, malware, worms, Trojans and other internet threats. Antivirus doesn't just provide protection from unknown threats but also features like firewall (for blocking inappropriate website), Parental Control (Putting a check on Children's internet activity), Email Protection (Scanning incoming & outgoing mails and block specific files in outgoing attachments).

Example of Antivirus software Kaspersky, Bitdefender, Norton 360, BullGuard Premium, AVG Antivirus, Webroot SecureAnywhere, McAfee, Panda Antivirus, VIPRE Internet Security.

10.17. CONCEPT OF INTERNET SECURITY

Internet security refers to securing communication over the internet.

Antivirus software protects against computer-based malware like viruses and trojans. Internet security protects against

10.17.1. Software for Internet Security

Many internet security suites offer both an antivirus engine and internet security protection in the same product. Many antivirus/internet security packages have:

Phishing, spyware, and ransomware protection

Secure browser extension

Identity theft insurance

VPN

Firewall

Dark web monitoring

Password manager

Encrypted cloud storage

Whatever you do online – on your PC, Mac & Android devices Internet security suite helps protect you from malware, webcam spies, financial scammers & more.

Blocks viruses, cryptolockers, attacks & more

Prevents online trackers collecting your data

Detects spyware hiding on your Android device

Protects payments, with bank-grade encryption

Blocks unauthorized access to your webcam

Encrypts data you send & receive online – VPN

Internet antivirus software are Kaspersky Internet Security,Bitdefender Internet security, Norton Internet Security, F-Secure

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Internet Security, AVG Internet Security, BullGuard Internet Security, Avast Internet Security, McAfee Internet Security

10.18. FIREWALL

A firewall is a network security device that monitors incoming and outgoing network traffic and decides whether to allow or block specific traffic based on a defined set of security rules. They establish a barrier between secured and controlled internal networks that can be trusted and untrusted outside networks, such as the Internet.

10.18.1. Types of Firewall

A firewall can be hardware, software, or both.

Hardware Firewall

In this type of firewall, firewall is installed in a dedicated device. This device only runs the firewall. Since all resources of the device are available only for the firewall, it filters the traffic blazingly fast and accurate. It also offers several additional security features such as encryption and logging.

Hardware firewalls are complex in configuration. Only experienced network administrators can configure these firewalls. Besides configuration, hardware firewalls also cost a lot of money as they use dedicated device.

Fast speed and max accuracy are the advantages of the hardware firewall while high cost and complex configuration are the disadvantages of this firewall.

Software firewall

In this type of firewall, firewall is installed in a regular device. This device runs the firewall as the application software. Since this firewall accesses device resources in shared environment through the base system, it provides less speed and accuracy than the hardware firewall. Unlike hardware firewall, it provides limited features and functions.

Software firewalls are easier in configuration. An average network user can easily customize these firewalls to meet his security requirements. Since software firewalls do not require any additional hardware to run, they do not increase the network cost.

Low cost and easier configuration are the advantages of the software firewall while slow speed, less accuracy and lack of additional features are the disadvantages of this firewall.

10.19. INTRODUCTION TO ITIL V3

ITIL, an acronym for Information Technology Infrastructure Library, is a set of detailed practices for IT service management (ITSM) that focuses on aligning IT services with the needs of business. ITIL V3 (Version 3) released by Axelos in MAY 2007 is a globally recognized, world leading framework .for IT Service Management that delivers business value. ITIL V3 provides support and flexible foundation to the organization which intends to integrate various approaches into their service management operating models. ITIL helps IT sector to solve business issues, improve the capability of IT and implements new capabilities to provide business value.

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ITIL is a framework that teaches the best practices to implement ITSM in an organization. ITSM (IT Service Management) is a set of practices, policies and procedures that help to manage the services delivered to end users.

LEARNING OUTCOMES

After studying this chapter, a student can understand the following

1) Concept of Network Technology
2) Structures of Network Topology
3) Configuration of cable
4) Use of Network device and peripherals
5) Concept of windows server 2019
6) Concept of Linux server
7) Basics of IT security
8) Use of Firewalls
9) Structures of ITIL

QUESTIONS

YVQXP

I Choose the best answer

1. Which of the following have lowest tolerance?
   a. WAN b. LAN
   c. MAN d. PAN
2. The speed of wide area network can range from ----------
   a. 20 Mbps – 30 Mbps
   b. 10 Mbps – 20 Mbps
   c. 30 Mbps – 40 Mbps
   d 100 Mbps – 1000 Mbps
3. Which layer is the second layer of TCP/IP Model?
   a. Process/Application Layer
   b. Host to Host/ Transport Layer
   c. Internet Layer
   d. Network Access/Link Layer
4. ---------- is example for Half duplex mode transmission.
   a. Pager b. Walkie – talkie
   c. Telephone d. Cell phone
5. _____ is example for Simplex mode transmission.
   a. Pager b. Walkie – talkie
   c. Telephone d. Cell phone
6. Which one is not an unguided transmission media ?
   a. Radio wave b. Micro wave
   c. Coaxial cable d. Infrared
7. In which of the following directories does the configuration files are present ?
   a. /bin/ b. /root/
   c. /etc/ d. /dev/

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8. Identify the OS which is not based on Linux.

   a. Ubuntu b. BSD

   c. CentOS d. Gentoo

9. A computer ---------- is a malicious code which self – replicates by copying itself to other programs.

   a. Worm b. Program

   c. Virus d. none of these

10. Antivirus software is an example of

    a. a security software

    b. an operating system

    c. an office suite

    d. business software

II Answer in few sentences.

1. What is a computer network ?
2. What are the types of computer networks based on their size?
3. Define : Bus Topology
4. Write the important functions of the Transport layers.
5. What are the advantages of internet ?
6. What are the disadvantages of extranet ?
7. What are the various types of Hub ?
8. What is a Ruler in a computer network ?
9. What is IT security?
10. What is a antivirus ?

III Explain the following questions

1. Explain the difference between LAN and WAN.
2. What are the advantages of Transmission Control Protocol (TCP)?
3. Explain the difference between the transmission modes.
4. Explain the types of transmission media.

IV Briefly explains the following questions

1. Explain about Network Topology.
2. Explain the Classification of computer network.
3. Explain Firewall and its types.

Answers

1. (a) 2. (b) 3. (c) 4. (b) 5. (a)

6. (b) 7. (c) 8. (d) 9. (c) 10. (a)

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Model Question Paper

Time: 3.00 hours Total marks: 90

I. Choose the correct answer from the given four options. Answer all the questions. 15 X 1 =15

1. The unit of current is _____
   a) Volt b) Amper
   c)Ohms d) Watt

2. Write the odd one
   a) ohm b) mega ohm
   c) kilo ohm d) mega watt

3. The unit of an inductor is _____
   a) Ohms B) Farad
   C) Hertz D) Henry

4. The ratio of winding in isolating transformer is _____
   a) 1:1 b) 2:1
   c) 1:2 d) 2:2

5. The atomic number germanium
   a) 6 b) 14
   c) 29 d) 32

6. In N-type semiconductor free electrons are the _____ carries
   a) minority b) majority
   c) magnetic d) netural

7. The maximum rectification efficiency in full wave rectifier
   a) 100% b) 81.2%
   c) 66.6% d) 40.6%

8. A Complementary symmetry amplifier has
   a) 1NPN & 1PNP Transistor
   b) 2 PNP Transistor
   c) 2 NPN Transistor
   d) 2 P Channel FETS

9. An IGBT is also known as
   a) MOIGT b) COMFET
   c) GOMFET d) all of the above

10. Atomic number of Silicon is
    a) 6 b) 14
    c) 29 d) 32

11. Circuit which consists of a quasistable state is called
    a) bistable circuit
    b) monostable circuit
    c) tristable circuit
    d) tristate circuit

12. The number of levels in a digital signals
    a) one b) two
    c) ten d) eight

13. In computer memory 1 kilobyte is equivalent to _____ byte.
    a) 1000
    b) 1024
    c) 2000
    d) 3024

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14. The efficiency of SMPS is _____ greater than linear regulators.
    a) upto 90% b) upto 96%
    c) upto 85% d) upto 88%

15. The speed of wide area network can range from _____
    a) 20-30Mbps b) 10-20 Mbps
    c) 30-40Mbps d) 100-1000Mbps

II. Answer any ten questions in few Sentences (question No:24 compulsory) 10 X 3 = 30

16. Write the expansion for
    i) NTC ii) PTC iii) PCB
17. Define electro magnetic force.
18. what the function of circuit breaker?
19. What is meant by doping?
20. Write down the types of distortion occurs in amplifier.
21. Draw the symbol of TRIAC. Mention it terminals.
22. What is meant by piezoelectric effect?
23. Define gray code.
24. What is difference between compiler and interpreters?
25. Give the expansion of the following
    i. SMPS ii. USB iii. GUI
26. What are components of operating system?
27. Define bus topology.
28. Define basic concept of Networking.

III. Explain any five questions in a paragraph (question No:35 compulsory) 5 X 5 = 25

29. Draw and explain about electrolytic capacitors.
30. Explain about the losses occurred in a transformer.
31. Explain energy band.
32. What are the advantages and disadvantages of digital electronics?
33. Define the working of ROM and RAM.
34. Draw the Linux Distributions diagram and explain.
35. Explain the difference between LAN and WAN.

IV. Answer The Following Question With Neat Sketches. 2 X 10 = 20

36. a) Explain the Resistors connected in series circuit and Resistors connected in parallel circuit

    (OR)

    b) Explain the working principle of RC coupled amplifier.

37. a) Draw and explain the working functions of crystal oscillator.

    (OR)

    b) Explain about network topology.

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Basic Electronics Engineering

PRACTICAL

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CONTENTS

Experiment 1.	Measurement of AC, DC voltages and DC current using multimeter
Experiment 2.	Finding resistance value - color coding and multimeter
Experiment 3.	Testing of Passive Components
Experiment 4.	Testing of Diodes and Transistors
Experiment 5.	Practice on Soldering and Desoldering techniques
Experiment 6.	Construction of 6V DC power supply (bridge rectifier)
Experiment 7.	Voltage regulators using Zener Diode
Experiment 8.	Assembling and disassembling of desktop computer
Experiment 9.	Assembling and disassembling of laptop
Experiment 10.	Identification and installation of mother board parts
Experiment 11.	Installation of CPU and RAM modules
Experiment 12.	Printer and Scanner installation
Experiment 13.	Installation and post configuration of Windows server
Experiment 14.	Install active Directory and Domain
Experiment 15.	Installation of Anti virus
Experiment 16.	Install ubuntu linux Server
Experiment 17.	Post installation process of Ubuntu Linux Server
Experiment 18.	Networking

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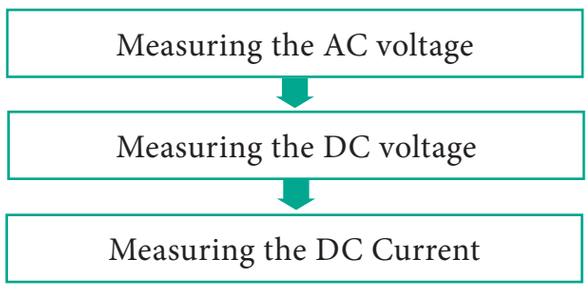
1 MEASUREMENT OF AC, DC VOLTAGES AND DC CURRENT USING MULTIMETER

AIM:

- To understand the method of measuring the AC, DC voltages and DC Current.

Practical Flow Diagram



Tools and Equipment Required

Section/ Activity Title	S. No	Name of the tools/ equipment	Range/Value	Quantity
Measurement of AC, DC voltage and DC current	1	Multimeter (DM)	---	1
	2	Regulated Power Supply (RPS)	(0-30)V / 2A	1
	3	FM Radio	Single channel	1
	4	Mini motor	6V or 12 V	1
	5	Tapped Transformer	0-12V 1Amp	1
	6	Resistor	1KΩ	1
	7	Bread board	---	1
	8	Jumper wire	M-M,F-F.M-F	Each 2 Bunch

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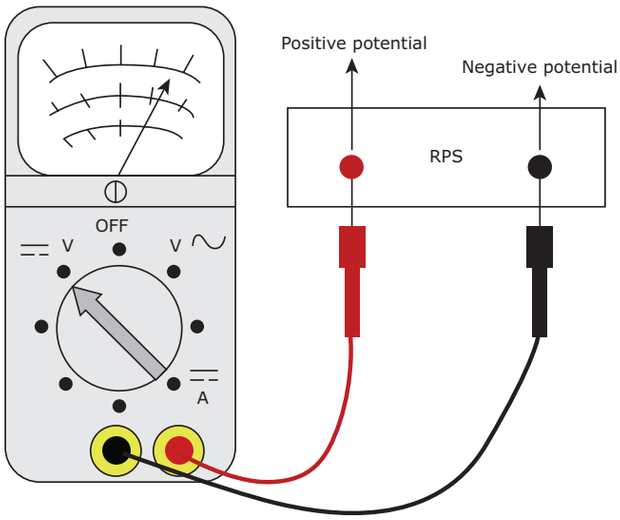
PROCEDURE:

Section 1: Measurement of DC voltage

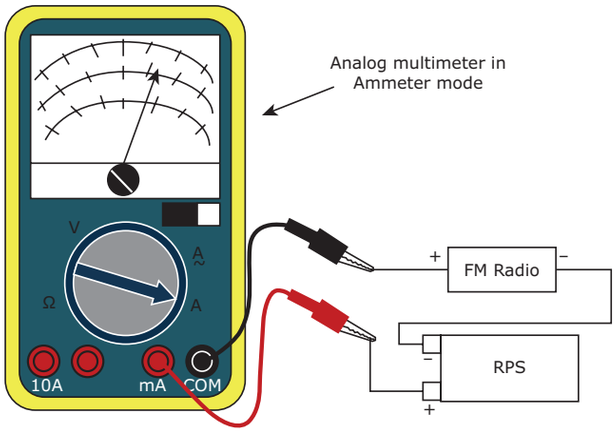


Sl. No	Meter Range	Multimeter Reading (DC Voltage)	
		Without Load	With Load
1			
2			
3			
4			
5			

Measuring DC voltages:

1. Connect the Regulated Power Supply (RPS) with Multimeter as shown in Figure.
2. Vary the potentiometer in RPS to get five different voltage values.
3. Tabulate the voltage values.

Section 2: Measurement of DC Current



Sl. No	Meter Range	Multimeter Reading (DCA)	
		Without Load	With Load
1			
2			
3			
4			
5			

Measuring DC currents:

1. Select 250 mA range in multimeter.
2. Connect the Regulated Power Supply (RPS) with Multimeter via an FM radio as shown in Figure.
3. Vary the DC supply voltage from 6 to 12 volts by varying potentiometer in RPS, to get different current values.
4. Tabulate the DC current values

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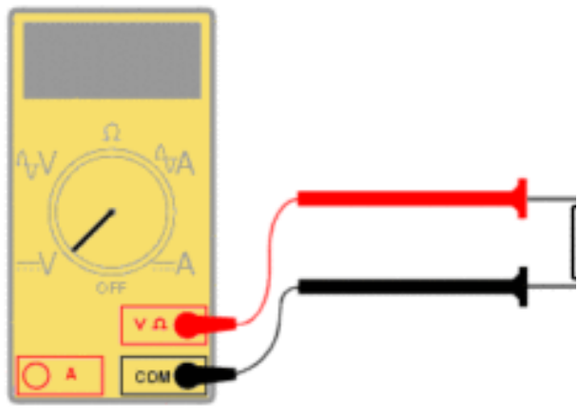
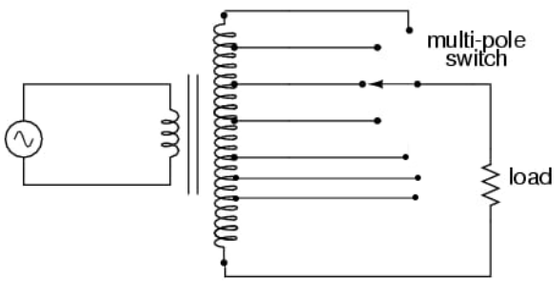
Section 3: Measurement of AC voltage





S. No	Transformer Secondary winding (value)	Meter Range	Multimeter Reading (ACV)	
			Without Load	With Load
1	1.5V			
2	3V			
3	4.5V			
4	6V			
5	7.5V			
6	9V			
7	11V			
8	12V			



Measuring AC voltages:

1. Tapped Transformer primary has only two terminals. But secondary has leads eight terminals.
2. Check the transformer's label to find which side is the primary and which is the secondary.
3. The windings are to be tested. The polarity of probes doesn't matter.
4. Plug the transformer into the electric socket.
5. Select the range on the multimeter to read AC voltage.
6. Read the primary and secondary voltages.
7. Tabulate the AC voltage values in both windings.

RESULT

Thus, I understood the AC, DC voltages and DC current are measured through multimeter.

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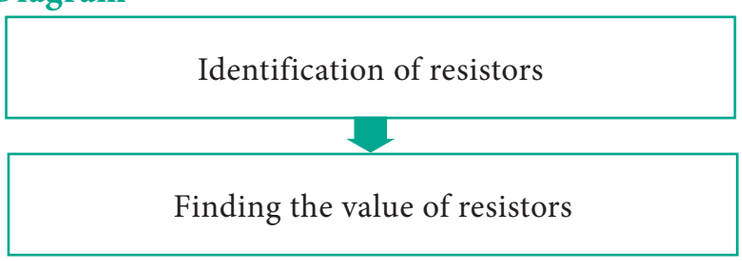
FINDING RESISTANCE VALUES USING - COLOR CODING AND MULTIMETER

2

AIM:

1. Finding of Resistor value using color code
2. Verification of Resistor value using Multimeter.

Practical Flow Diagram



Tools and equipment required:

Activity Title	S. No	Name of the apparatus/ components	Range/Value	Quantity
Identification & Finding the value of Resistors.	1	Resistors - Different Values	1/2 watt	As required
	2	Bread board	800 pin	1
	3	Analog / Digital Multi-meter		1
	4	Jumper wire	M-M,M-F,F-F	Each 2 Bunch

Safety measures:

1. Make sure the Multimeter probes are inserted in proper polarity.
2. Keep the Multimeter range in Ω position.
3. Avoid touching the terminals of the resistor with your finger while measuring the resistance value

PROCEDURE:

Section 1: Identification of Resistors.

1. Take the resistor from given package & place it on your Breadboard
2. Make sure that always tolerance ring should come to the right side, while calculating the colour-code value.
3. Write down the resistor band colour for each of the resistor using chart.
4. Determine theoretical values using color code.

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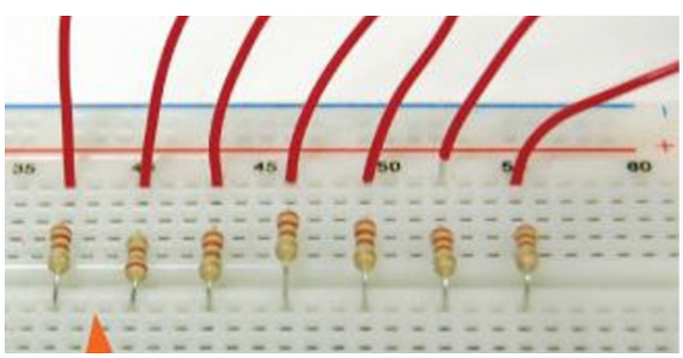
Section 2: Testing of Resistors.

1. Turn on the multimeter and select the required Ω range.
2. Measure the value of resistors one by one using multimeter and tabulate the same.
3. If theoretical and measured values are nearly same, the resistor is said to be in working condition.

Tabulation:

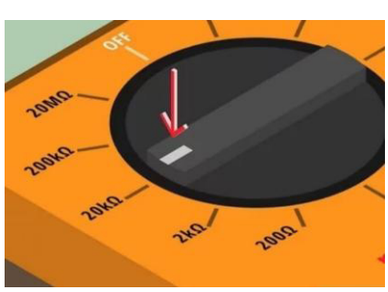
S.No	Color Coding			Theotrical value	Practical value	Good / Bad
	1st Ring	2nd Ring	3rd Ring			
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						

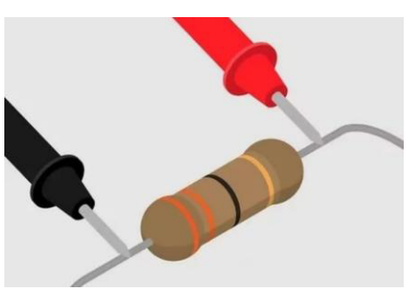
Layout



Connection Diagram







RESULT:

The comparison of the resistor values using colour code and multimeter testing is verified.

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TESTING OF PASSIVE COMPONENTS

3

AIM:

1. To understand the method of calculating the value of voltage and current, when resistors are connected in series and parallel
2. To learn method of testing of passive components like capacitor, Relay and Speaker.
3. To learn about basic difference between resistors in series and parallel connection.
4. To understand the usage of Multimeter, Ammeter and Voltmeter.

Practical Flow Diagram

Read the voltage and current level, when resistors are connected in series

↓

Read the voltage and current level, when resistors are connected in Parallel

↓

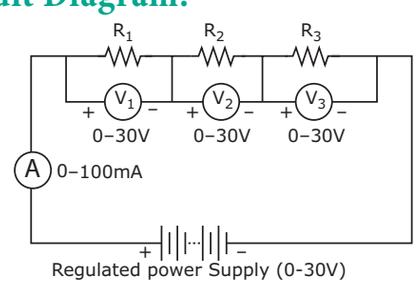
Testing of capacitor, relay and speaker

Section/ Activity Title	Sl. No	Name of the tools/ equipment	Range/Value	Quantity
TESTING OF RESISTORS, CAPACITOR, RELAY & SPEAKER	1	Multimeter (DM)	---	1
	2	Regulated Power Supply (RPS)	(0-30)V	1
	3	Voltmeter	0-30 V DC	3
	4	Ammeter	0-100 mA	3
	5	Resistor	Three Different values	1
	6	Capacitor	1000 µF/25 V	1
	7	Relay	12 volts NC or NO	1
	8	Bread board	800 Pin	1
	9	Jumper wire	M-M,M-F,F-F	Each 2 Set
	10	FM Radio		1

PROCEDURE:

Section 1: To Read the voltage and current level, when resistors are connected in series.

Circuit Diagram:



Procedure:

Resistors in series:

1. Connect the components as per the circuit diagram.
2. Switch ON the power supply.
3. Measure the voltage across each resistor (V_1,V_2,V_3).
4. Measure the total current (I).

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5. Repeat the same procedure for different input DC voltages.
6. Tabulate the readings.

Tabular Column:

S. No	Vin (Volts)	V_1 (Volts)	V_2 (Volts)	V_3 (Volts)	V_t (V)
1					
2					
3					
4					
5					

I = _____mA constant

Calculate the values of given Resistors:

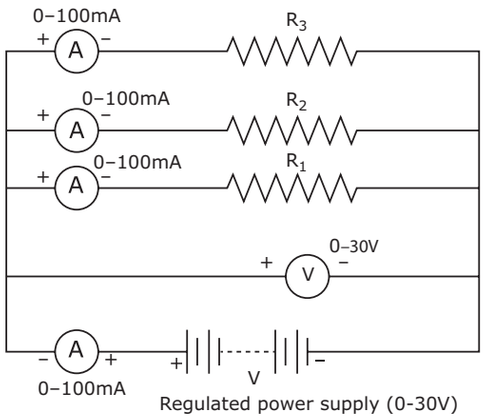
S.No	Given Resistor	Value in Ohms
1	**R_1**	
2	**R_2**	
3	**R_3**	
Total Resistance		

Total Resistance, R = $R_1 + R_2 + R_3$

R_T = _____

Section 2: To read the voltage and current level, when resistors are connected in Parallel .

Circuit Diagram:



Procedure:

Resistors in parallel:

1. Connect the components as per the circuit diagram.
2. Switch ON the power supply and give fixed DC voltage to the circuit.
3. Measure the current flow through each resistor (I_1, I_2, I_3).
4. Measure the supply voltage (V).
5. Repeat the same procedure for different input DC voltages.
6. Tabulate the readings

Tabular Column:

S. No	I_{in} (A)	I_1 (DC mA)	I_2 (DC mA)	I_3 (DC mA)	I_{out} (A)
1					
2					
3					
4					
5					

V=_____V Constant

Calculate the values of given Resistors:

S.NO	Given Resistor	Value in Ohms
1	R_1	
2	R_2	
3	R_3	
	Total Resistance	

Total Resistance, $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$

R_T = _____

Section 3: Testing of capacitor, relay and speaker

1. Testing of capacitor

Procedure: Test a electrolytic Capacitor using Digital Multimeter – Resistance Mode

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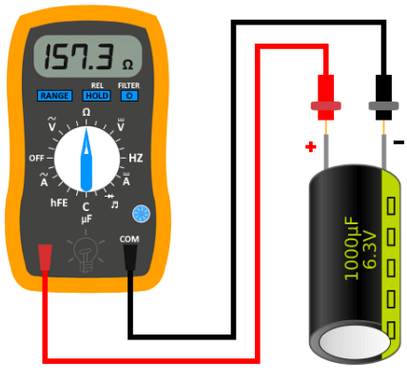
To test a capacitor by Digital Multimeter, follow the steps given below.

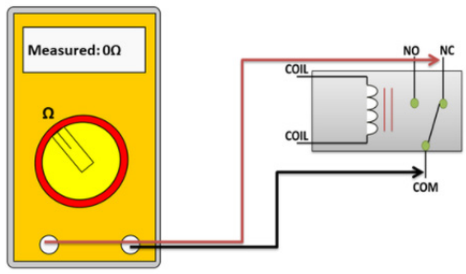
1. Keep the multimeter in ohm mode.
2. Make sure the capacitor is fully discharged.
3. Set the meter on the Ohmic range (Set it at least on 1000 Ohm = 1kΩ).
4. Connect the multimeter probes to the capacitor terminals (Negative to Negative and Positive to Positive).
5. Digital multimeter will show some numbers for a second. Note the reading.
6. And then immediately it will return to the OL (Open Line) or infinity "∞" or high value. Follow the steps 3 to 5 test other capacitors. If it satisfy the condition then Capacitor is in good condition
7. If meter reading shows 0 Ω, the capacitor is said to be short.
8. If meter reading shows ∞ Ω, the capacitor is said to be open.

Note : Non polarity capacitor are connected in either way we can check the readings on the DMM.

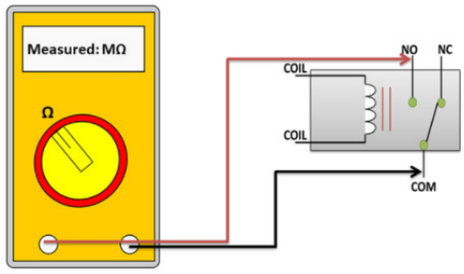


Sl. No	CAPACITOR	Value	Key used in Multimeter	Result
1	C =			
2	C =			
3	C =			

4. Testing of Relay



Normally Closed Terminal



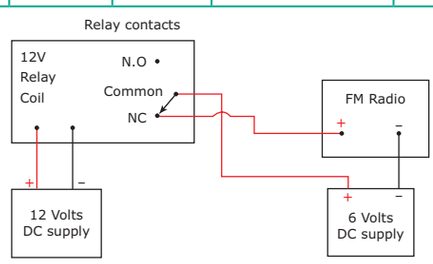
Normally Opened Terminal

First, Set the mode of multimeter to the **Resistor mode**. Then connect the Red and Black probe of the multimeter to the coil of the relay:

- The value of resistance for type 1 relay should be between 30Ω to 150Ω.
- For type 2 relay, the resistance value should be between 300Ω to 900Ω.
- And for the type 3 relay, the resistance value should be between 20Ω to 450Ω.

Along with it, N/O and COM contacts must show 0 Ω, which means it is open-circuited when no input is given.

Sl. No	Relay Coil	Value	Key used in Multimeter	Result
1	N/O			
2	N/C			



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Procedure:

1. Connect the relay coil with 12 volts dc supply.
2. Connect the relay N/C. switch with +ve input of FM radio (Load).
3. While giving the 12V supply, the Relay coil gets magnetized. Coil attracts the small metal lever, which brings the relay contacts to ON position.
4. You can hear the click sound from relay. It denotes the N/C terminal gets on.
5. The FM radio will work, after the relay turns on the relay switch.

5. Testing of Speaker



- Check the label at the back of the magnet to see the impedance of the speaker. The most common are: 2Ω, 4Ω, 8Ω, and 16Ω.
- Set the multimeter to Ohms range (resistance), and place one probe in the one terminal and another probe in the another terminal of the speaker. If everything is ok, there is have a resistance reading.
- If speaker has in the label 4 Ohms, multimeter should read anywhere between 2 and 3.6 Ohms.
- The measured resistance of an 8 Ohms speaker can be between 4.8 and 8 Ohms.
- A 16 Ohms could have a resistance between 10 and 16 Ohms.
- In some cases, it can go as low as 8 Ohms and be considered good. The reason for such wide tolerances is due to "**Direct Current Resistance or DCR**"
- If the reading is a little resistance close to zero, it means that the coil is shorted internally.
- If the reading is a high value or "OL" or ∞, then the coil is open circuit.

Sl. No	Ohm	Value	Key used in Multimeter	Result
1	2Ω			
2	4Ω			
3	8Ω			
4	16Ω			

NOTE: It is very simple to test the Woofer and tweeter. Just, keep the positive and negative terminal of the multimeter in the respective positive, negative terminals of the speaker. If there is a noise, the speaker is in good condition the normal speaker does not have polarity.

RESULT:

Thus I understood the method of testing resistor which are in series and parallel and other passive devices.

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TESTING OF DIODES & TRANSISTORS

4

AIM:

Testing of Diodes and Transistor using Multimeter.

Practical Flow Diagram

Testing of diode using multimeter

↓

Forward bias & Reverse bias

↓

Testing of Transistor using multimeter

Safety measures:

1. Be sure to keep the probe of multimeter with proper polarity.
2. The multimeter which requires more than one Milli Ampere current while keeping in ohm meter range, should not be used for testing of transistor.

Tools and equipment required:

Activity Title	Name of the apparatus/ components	Range/ Value	Quantity
Testing of Diode & Transistor	Multimeter		1
	Diode	IN4007	1
	Zener Diode	6V or 12 V	As required
	Transistor	BC 548 (NPN)	1
	Transistor	BC 558 (PNP)	1

Procedure: Testing of diode / Zener diode using Analog multimeter.

Section 1: Forward bias

1. Keep the selector switch in X1 Ohm's range and set 0 Ω adjustment in the multimeter.
2. Connect positive probe of the meter with cathode and negative probe with anode.
3. If the meter reading is approximately 7 Ω, the diode is said to be in good condition. This is knowing as forward bias testing
4. If the meter reading shows 0 value (Ω), diode is said to be short.
5. If the meter reading shows high value (Ω), i.e., the needle does not move, diode is said to be open.
6. If the meter reading shows some reading above 7 Ω, i.e., 100 or 5k, it means the diode has high 'forward bias resistance'

Section 2: Reverse bias

1. Connect Anode with Red test probe and Cathode with black test probe. If the meter reading is high value (Ω), the diode is said to be in good condition. This is known as reverse bias testing.
2. If the meter reading shows 0 value (Ω), diode is said to be short
3. If the meter reading shows some reading that is 300Ω or 6 KΩ, the diode is said to be Leaky.

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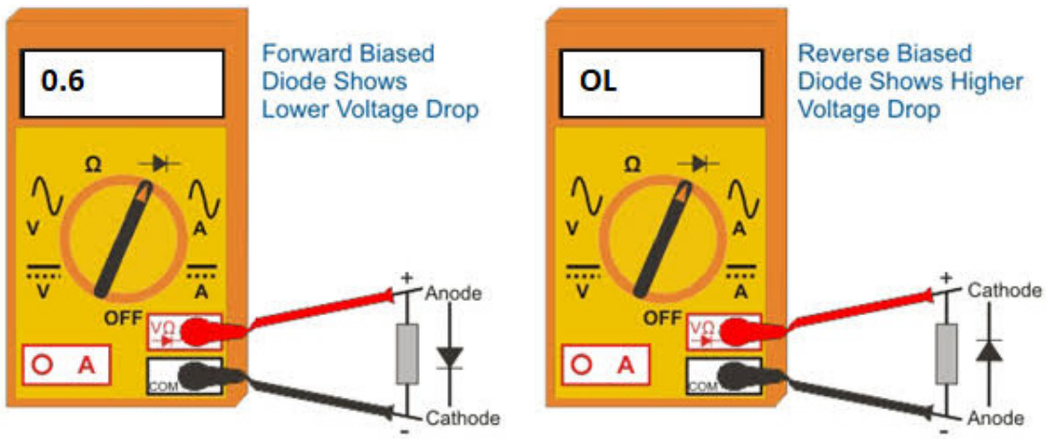
Connection Diagram



Tabular column : (Draw separate tabular column and do test for each diode)

S.No	Testing	Meter selector switch position	Anode	Cathode	Meter Reading	Result
1	Forward Bias	X 1	+ ve Probe	- ve Probe		
2	Reverse Bias	From X1 to X1K	- ve Probe	+ ve Probe		
					Final Result	

Section 3 : Testing of Transistor

Take the NPN Transistor

1. Keep the selector switch in X1 ohm's range set 0Ω adjustment in the multimeter.
2. Connect Base of the transistor with black test probe and Emitter of the transistor with Red test Probe. If the meter reading is approximately 7Ω, the transistor is said to be in good condition.
3. Connect Base of the transistor with black test probe and collector with Red test probe. If the meter reading is approximately 7 Ω, the transistor is said to be in good condition. Now, keep select or switch X 1K in ohm's range and set 0Ω adjustment.
4. Connect Base of the transistor with Red test probe and Emitter with black test probe. If the needle remains unmoved, i.e., meter reading is ∞Ω, then the transistor is said to be in good condition.
5. Connect collector with Red test probe and Emitter with Black test probe. If the needle remains unmoved, that is, meter reading is ∞Ω, the transistor is said to be in good condition.
6. Connect collector of the transistor with Black test probe and Emitter with Red test probe. If the needle remains unmoved, i.e., meter reading is ∞Ω, the transistor is said to be in good condition.

   In the above test 3 to 6, if the meter is reading is 0Ω, the transistor is said to be in short.

   In the above test 3 to 6, if the meter reading shows some Ohms such as 100Ω or 2 KΩ, the transistor is said to be in leaky.

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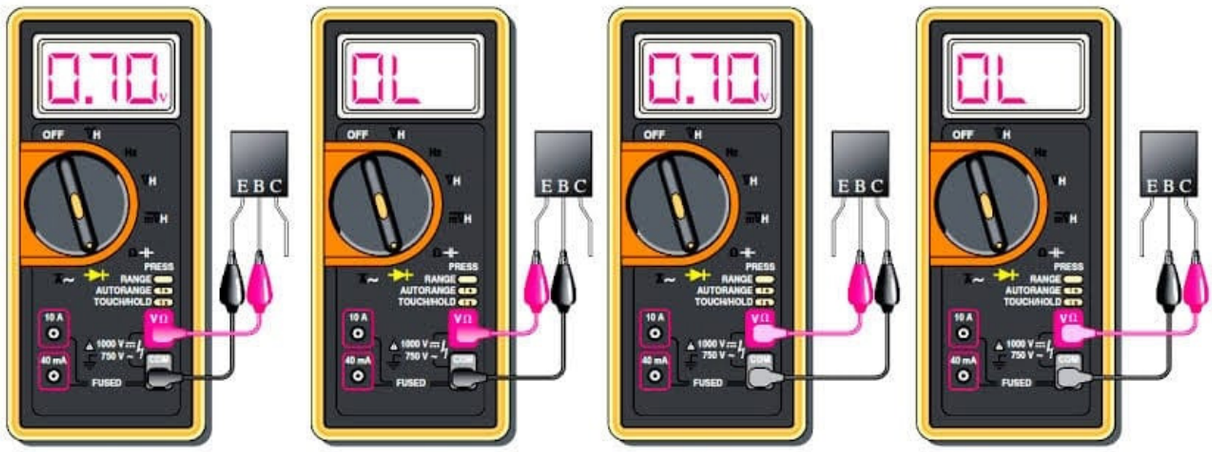
For the PNP transistor, change the polarities while testing.



(a) Forward-bias test of the BE junction (b) Reverse-bias test of the BE junction (c) Forward-bias test of the BC junction (d) Reverse-bias test of the BC junction

Tabular Column: transistor Testing (NPN- BC548)

S.No	Selector switch position	Emitter	Base	Collector	Meter Reading	Result
1	X 1	+ ve Probe	- ve Probe	…….		
2	X 1	…….	- ve Probe	+ ve Probe		
3	X 1 K	- ve Probe	+ ve Probe	……..		
4	X 1 K	……..	+ ve Probe	- ve Probe		
5	X 1 K	- ve Probe	……..	+ ve Probe		
6	X 1 K	+ ve Probe	……..	-ve Probe		
Final Result: Good Condition. This transistor can be used in circuits.						

Tabular Column: transistor Testing (PNP- BC558)

S.No	Selector switch position	Emitter	Base	Collector	Meter Reading	Result
1	X 1	- ve Probe	+ ve Probe	…….		
2	X 1	…….	+ ve Probe	- ve Probe		
3	X 1 K	+ ve Probe	- ve Probe	……..		
4	X 1 K	……..	- ve Probe	+ ve Probe		
5	X 1 K	- ve Probe	……..	+ ve Probe		
6	X 1 K	+ ve Probe	……..	-ve Probe		
Final Result: Good Condition. This transistor can be used in circuits.						

RESULT:

Thus, I understood the testing of Diodes and Transistor using multimeter

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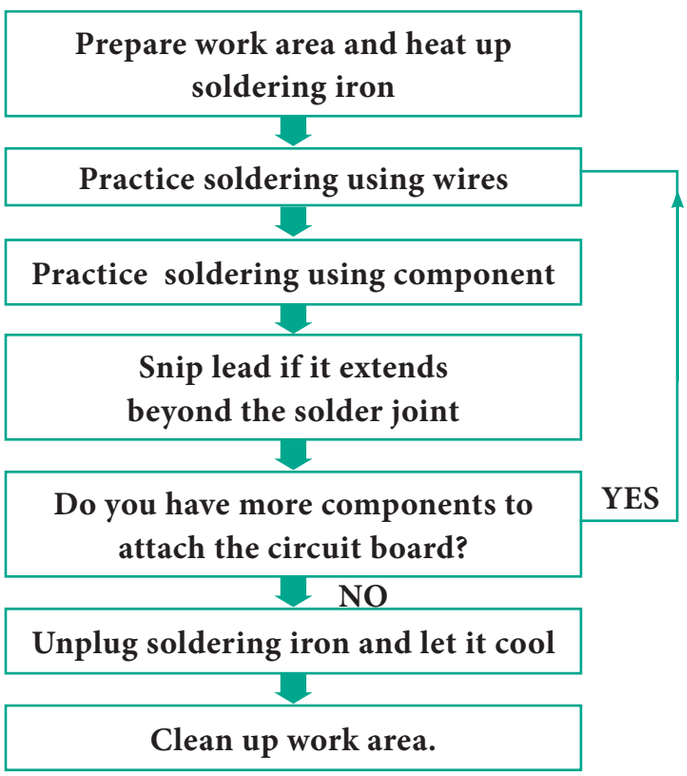
PRACTICE ON SOLDERING & DESOLDERING TECHNIQUES

5

AIM:

1. Practice soldering using wires & Electronic components on PCB.
2. Practice desoldering using desoldering Pump with Wick

Practical Flow Diagram



Safety measures:

1. Switch ON the soldering iron and wait for few minutes to heat up.
2. Keep the soldering iron always in its stand while not in use.
3. Keep a small piece of wet sponge. This is used to clean the tip of the iron.
4. Touch the tip of the iron with soldering wire, if it melts, the iron is sufficiently heated.
5. Don't touch the tip of the soldering iron, as this heats up to 400°F (180°C).
6. Bit of smoke will come out during soldering. don't inhale the smoke.
7. Wash your hands after soldering work finished, because the soldering material contains some harmful hazards

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Tools and equipment required:

Activity Title	S. No	Name of the apparatus/ components	Range/Value	Quantity
Soldering	1	Soldering Iron	25 Watts	1
	2	Dot board	4"x 4"	1
	3	Group board, leg strip	4"x 4"	1
	4	Electronic components		As required
	5	Soldering Lead	0.5 m	
	6	Soldering Paste	1 small box	
	7	Hookup wire	1 m	
	8	Long Nose Plier		1
	9	Nose Cutter		1
	10	Isopropyl Alcohol (IPA)		As required
Desoldering	11	Desoldering Pump		1
	12	Desoldering Wick		1

Procedure: Soldering practice using wires.

Section 1: Prepare your iron.

1. Switch on the soldering iron.
2. Coat the soldering iron tip thoroughly with solder to cover the entire tip.
3. Once entire tip is coated, wipe it off with a wet sponge to get rid of any excess flux
4. Remove the Insulation from both ends of the wire.
5. Apply the flux on the Insulated copper wire
6. Heat up soldering iron, touch the tip to one end of the wire with solder and hold it for 3-4seconds
7. Once the end of the wire is fully coated,repeat step 1, 2 & 3 on the other end of the wire
8. Bring the two tinned wires together, place them on top of one another and touch it with the soldering iron tip.
9. Remove the soldering iron and allow for the solder to cool

Procedure: Soldering practice using components.

Section 1 Prepare surface & components.

1. Tinning to be done in the copper pad on the PCB and components.
2. Take the component and place them on holes of the PCB.
3. Touch the tip of the iron to the copper pad and the component lead.
4. Hold the soldering iron in place for 3-4seconds to ensure that sufficient heat to the pad and lead.
5. Remove the soldering iron and allow the solder to cool

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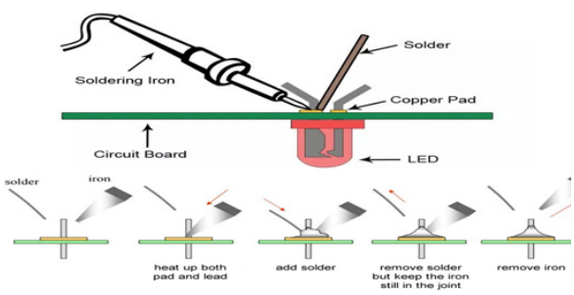
Section 2 Inspect the joint & cleanup.

1. Check the soldered joints,shorts with adjacent pads or poor flow.
2. Train the wire using a nose plier and cut at the top of the solder joint.
3. Clean the excess flux residue from the board using Isopropyl Alcohol.



Procedure: Desoldering Technique.

Section 1 Desoldering using Pump

1. Try priming and activating the pump for few times before using it for desoldering purpose.
2. Firmly gorse the desoldering pump with your hand.
3. Depress the plunger until it locks in place.
4. Priming the pump give spring loaded piston for suction to activate the pump, press the backside button.
5. This release the spring loaded piston which create a burst at suction of the nozzle.
6. Prime the desoldering pump by depressing the plunger.
7. Heat the solder joint until the solder is liquefied. Add solder on to the soldering iron's tip.
8. Position the pump's nozzle as close to the molten solder as possible.
9. Press the side button to activate the pump.
10. Repeat the process until the joint is cleaned.



Section 2 Desoldering using Wick

1. Place the desoldering wick over the solder to be recovered, push the heated soldering iron tip in to the desoldering wick, the solder till be absorbed
2. Remove the desoldering wick after the solder has been absorbed
3. Cut off the used section of the wick using Nose cutter
4. Repeat the above steps if the solder is not removed completely.

RESULT :

Thus, the method of soldering and desoldering are clearly understood

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CONSTRUCTION OF 6V DC POWER SUPPLY (BRIDGE RECTIFIER)

6

AIM

To construct the 6V DC power supply (Bridge Rectifier) and measure the Input AC Main voltage and Output DC Voltage.

Practical Flow Diagram

Measure the AC input voltage

↓

Measure the DC output voltage

Tools and equipment required

Activity Title	S. No	Name of the apparatus/ components	Range/Value	Quantity
Bridge Rectifier	1	Diode	IN4007	4
	2	Stepdown Transformer	0V – 6V (0.5Amp)	1
	3	Resistor	100Ω/ 1watt	1
	4	Electrolytic Capacitor	1000 µfd/25V	2
	5	Bread board	800 pins	1
	6	Multi-meter		1
	7	AC Mains card	3 pins	1

Safety measures:

1. Check the diodes are connected properly.
2. Terminals of the wires should be made intact.
3. Step down transformer is to be used.

Procedure:

Section 1: Measuring the AC input voltage

1. Construct the Bridge rectifier circuit as per the circuit diagram.
2. Connect the Primary side of the Transformer to the AC mains and secondary to the input of the circuit.
3. Switch ON the AC Main supply.
4. Measure the AC Input Voltage at secondary winding of the transformer using multimeter and tabulate.

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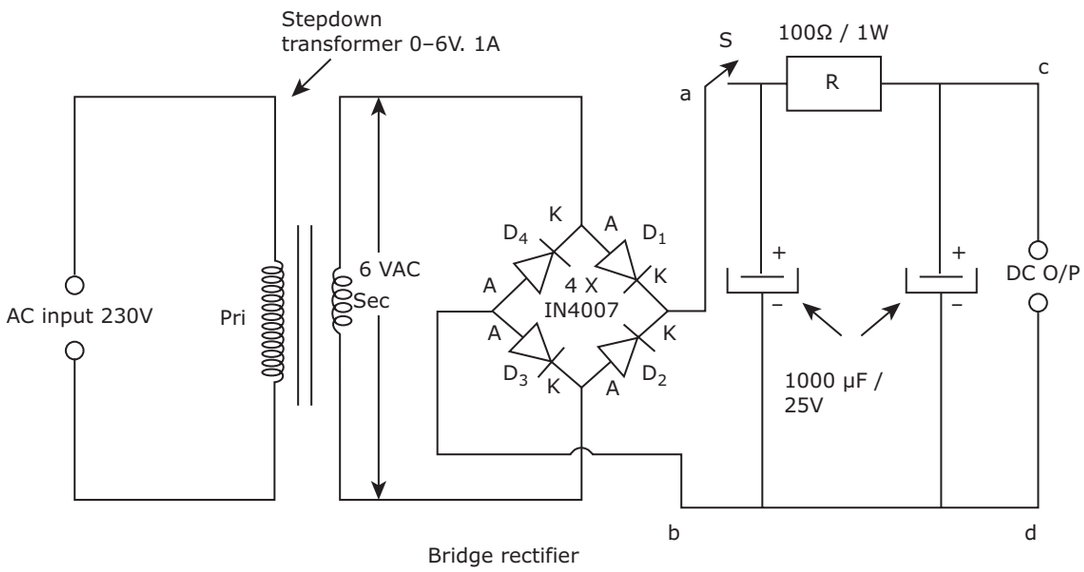
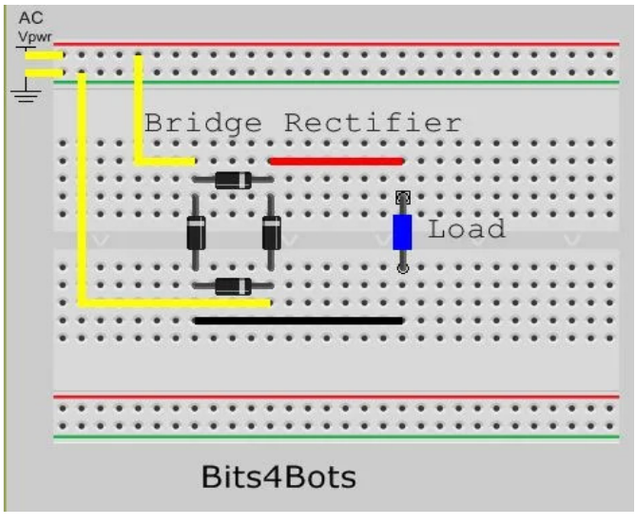
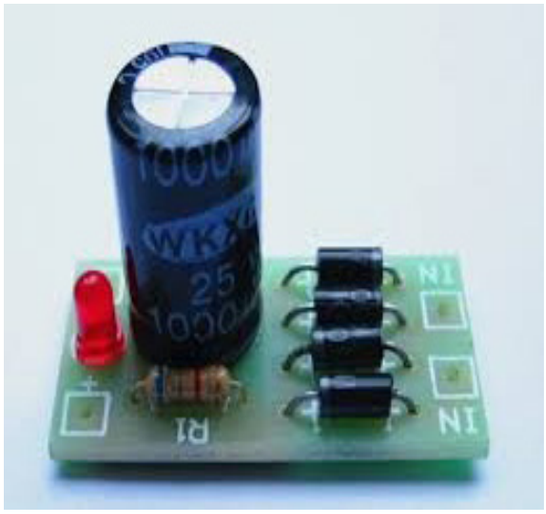
Circuit Diagram:







Section 2 : Measuring the DC output voltage

1. Measure the DC Output Voltage using Multimeter and record the reading in tabular column.
2. Switch off the power supply and disconnect it from AC mains.

Tabulation:

S.No	AC Input Voltage	DC Output voltage	
		Without Filter	With Filter
1			
2			
3			

RESULT:

The construction of bridge rectifier is done and input/output voltages are measured.

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VOLTAGE REGULATORS USING ZENER DIODE

7

AIM:

To construct voltage regulator using Zener diode

Practical flow diagram:

Zener diode circuit connection & tabulation

Tools and equipment required:

Activity Title	S. No	Name of the apparatus/ components	Range/Value	Quantity
Zener Regulator	1	Regulated power supply	0-30V DC	1
	2	Zener Diode	IN4739A (9V)	1
	3	Resistor	1KΩ	1
	4	Load Resistor	47 KΩ	1
	5	Digital Multi-meter (DM)		1
	6	Bread board		1

Safety measures:

1. The terminal of Zener diode should be properly identified.
2. Do not switch on the power supply unless you have checked the circuit connections
3. Power supply voltage should be zero before starting the experiment.
4. Should ensure that the applied voltages & currents do not exceed the rating of the diode.
5. Ensure no loose contacts at the junctions.

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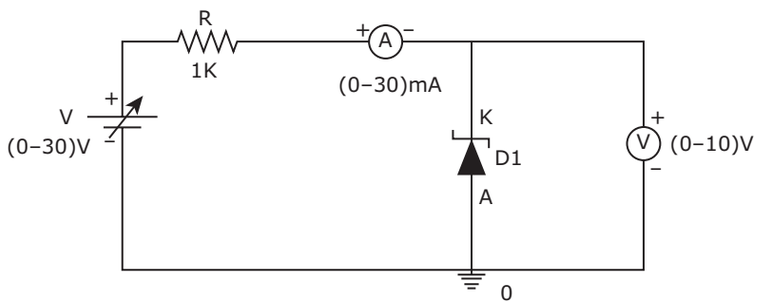
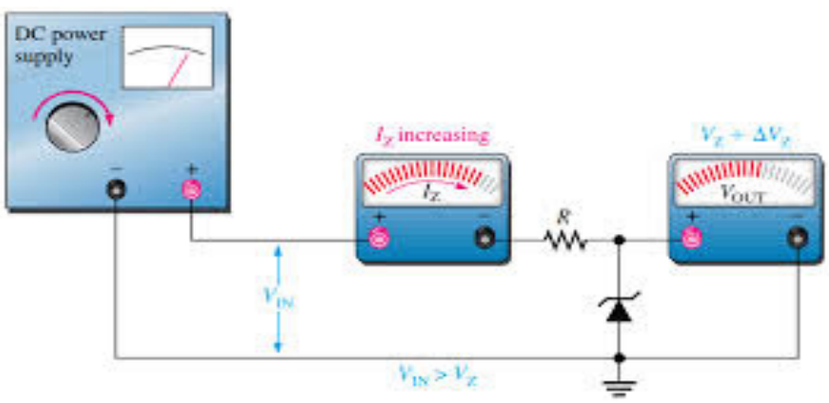
Section 1: Zener diode Circuit connection & tabulation

Circuit Diagram:





Procedure:

1. Connect the components as per the circuit diagram.
2. Ensure that the polarities of the power supply and the meter as per the circuit diagram.
3. Vary the supply voltage and note down the corresponding value in the tabular column.

Tabulation:

S.No	Input Voltage	Regulated Output Voltage
1		
2		
3		
4		
5		

RESULT :

Thus, the voltage regulator using Zener diode is constructed and input and output voltage are tabulated.

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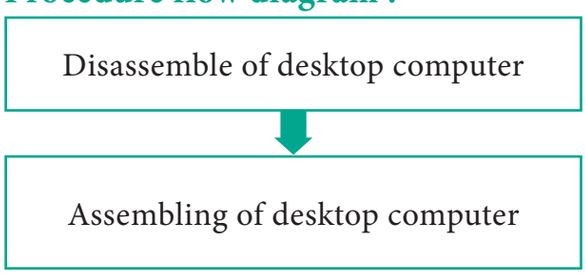
8 ASSEMBLING AND DISASSEMBLING OF DESKTOP COMPUTER

AIM:

To understand the step by step approach of disassembling and assembling a desktop computer.

Procedure flow diagram :



Safety measures:

1. Always disconnect and unplug all sources of power before disassemble the computer.
2. Some parts can store charge even after power has been disconnected. Allow sometimes for these to discharge naturally.
3. Never disassemble individual parts like power supply or Monitor.
4. Take care of Sharp edges on your computer case, while it can cause cuts or injury

Tools &Equipment required:

Activity Title	S. No	Name of the apparatus/ components	Range/Value	Quantity
Disassembling & Assembling Desktop computer	1	CPU	Any configuration	1
	2	Monitor	LCD	1
	3	Keyboard	101 keys	1
	4	Mouse		1
	5	Speakers		1
	6	Hand Tools		1 set
	7	Diagnostic Tool		1 set
	8	ESD Tool		1 set
	9	Cleaning Tool		1 set
	10	Anti- Static Wrist Strap		1

Procedure:

Section 1: Disassemble - Desktop computer.

1. Turn off the computer and unplug the power cord
2. Disconnect the peripheral items attached to the computer, such as the keyboard, mouse, monitor, headphones, and any external drives attached to the computer.
3. Remove at least one of the side covers, usually the right side as you face the front of the computer.
4. Disconnect all the connectors, then remove any card readers and

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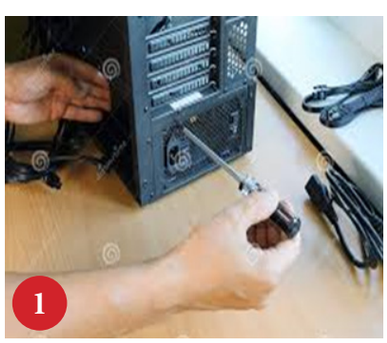
internal DVD players. These are usually screwed into place.

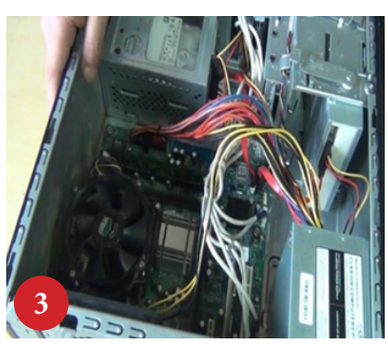
5. Remove any standalone fans. This is a good time to remove any dust.
6. Disconnect the cables and remove the storage drive (HDD).
7. Remove the memory (RAM) modules by pushing the clips on both ends of the module down. This will cause the module to pop up for easy removal.
8. Remove the power supply unit by unplugging the remaining connectors, then unscrewing the unit from the frame
9. Remove Micro Processor (CPU) from Motherboard carefully by lifting the lever.
10. Remove any adapter or expansion cards from the motherboard.
11. Disconnect all the cables from the motherboard, then unscrew it from the frame by loosening each screw a little bit before going around again to loosen each screw properly. This prevents any potential warping of the motherboard by gradually releasing the tension on it.
12. All the components should now be out of the computer case.

Section 2: Assembling - Desktop computer.

1. If we are rebuilding the computer, insert the components in the opposite order we removed them.
2. The first step for assembling of the computer system starts with motherboard.
3. Install the processor in the socket. Once the processor is mounted, the heat sink will be attached on the top of the processor.













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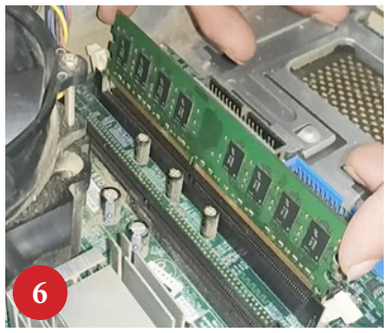



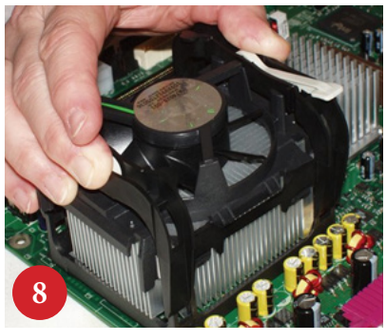

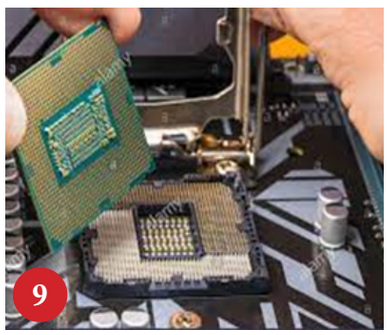





4. The CPU fan is also attached on top of the heat sink.
5. Now the motherboard is to be fixed vertically in the cabinet and screws are fixed from behind of the motherboard.
6. Install memory modules in the motherboard.
7. Now line up the power supply unit at top back of the cabinet and screw it. The power connectors for motherboard power supply and CPU fan power supply are to be connected.
8. Install cabinet cooling fan in the cabinet, and its power connector is to be connected from SMPS.
9. Install HDD, CD/DVD inside the CPU cabinet and screw it.
10. Now select the appropriate data cable and connect one end of the cable to its drive socket and another end at its appropriate connector on the motherboard.
11. For SATA hard disk drive or CD/DVD drives use SATA cable and its power cable, else use IDE data cable.
12. Do the Proper Jumper settings as per the usage requirement.
13. Plug all the cables as we insert the components, most item will plug into the motherboard and the power supply unit.
14. Close the case and put the screws back in their place.
15. Lastly, connect every external device such as the keyboard, mouse, monitor, etc., and turn on the computer.

RESULT:

Thus, I understood the entire process of disassembling and assembling a Desktop computer.

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9 ASSEMBLING AND DISASSEMBLING OF LAPTOP

AIM:

To understand the step by step approach of disassembling and assembling a Laptop.

Practical flow diagram :

Disassemble method of Laptop

↓

Assemble Laptop

Safety Measures:

1. Always disconnect and unplug all sources of power before disassemble the computer
2. Some parts can store charge even after power has been disconnected. Allow sometime for these to discharge naturally.
3. Never disassemble individual parts like power supply or Monitor.

Tools & Equipment required:

Activity Title	S. No	Name of the apparatus/ components	Range/Value	Quantity
Disassembling& Assembling a Laptop	1	Laptop	Any configuration	1
	2	Hand Tools		1 set
	3	Diagnostic Tool		1 set
	4	ESD Tool		1 set
	5	Cleaning Tool		1 set
	6	Anti- Static Wrist Strap		1

Procedure:

Section 1: Disassemble methods of LAPTOP.

1. Unplug the laptop from AC Adapter.
2. Turn the laptop upside down.
3. Remove the battery by moving the locking slider to the unlock position. Then pull the battery straight-out.
4. Press the power button for at least five seconds to discharge any remaining electricity in the system.
5. Remove the back panels by unscrewing all the available screws.
6. Many components will be immediately accessible after removing the covers. Generally, you can remove the storage drive, memory, and wireless card first.
7. Disconnect the cables, then remove the storage drive.
8. Remove the memory modules by pressing down on the clips that hold each module in place, using finger or a spudger tool.
9. The small gold-tipped cover near the wireless card is the wireless antenna. Try this off with the flathead screwdriver, then remove the wireless card using clips.
10. Next step is to remove the hinge cover plate and keyboard.
11. Remove the screws found under the hinge cover plate to remove the keyboard.

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12. Remove any other cables in the area under the keyboard. The connectors move either up or forward. If the cable has a small plastic plug, it just pulls out.
13. To remove the laptop screen, remove the antenna cable and the LCD data cable that connects from the area that housed the keyboard to the bottom edge of the screen.
14. Take out the screws that connect the display to the hinge area and gently remove the display assembly.
15. To remove the screen, remove the very small screw on the side of the LCD screen.
16. Now we can access the fluorescent lamp inverter.
17. Remove the touchpad and continue to remove screws and disconnect the cable attached to the mother board.
18. After the screws have been removed, the motherboard will come out with no resistance, if there is resistance, check for more screws.

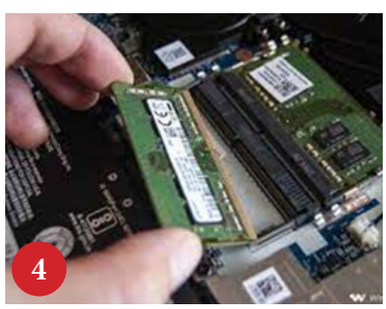
Section 2: Assemble - LAPTOP.

1. To reassemble your laptop, do each step in reverse order given in disassembling.
2. Be sure that connectors are seated securely. Cables aren't kinked or stretched
3. All screws go back into their correct holes.

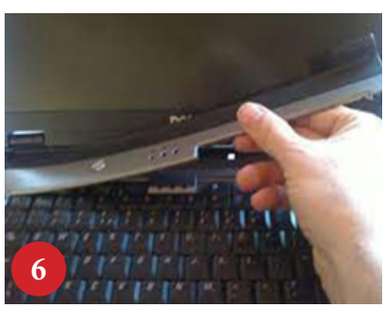


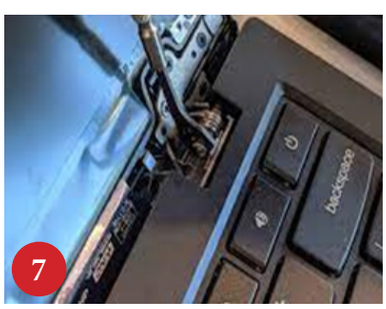


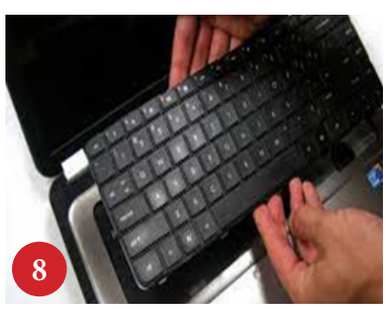














RESULT :

Thus, I understood the entire process of disassemble and assemble a Laptop.

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IDENTIFICATION AND INSTALLATION OF MOTHER BOARD PARTS

10

AIM:

To identify the components of Motherboard.

To understand the methods of installing a motherboard in desktop computer

Practical flow diagram :

Identification of Mother Board parts

↓

Installation of mother board

Tools & Equipment required:

Activity Title	S. No	Name of the apparatus/ components	Range/Value	Quantity
Installation and identification of mother board	1	Desktop Computer	Any configuration	1
	2	Screw Driver Set		1
	3	ESD KIT (Anti-static Wrist Wraps,Anti static covers,Anti static mat)		As required
	4	Magnifying Lens		1 Nos
	5	Sticky Labels		As required

Safety measures:

1. Care must be taken while handling a mother board, even a slightest impact may damage any one of the tiny components on the mother board.
2. Never keep Mother board on top of one another.
3. Always place Mother board on a Anti-static surface.
4. Ensure ESD while working with Mother Board.

Procedure:

Section 1: Identification of Motherboard Parts.

1. Place the Mother Board on Anti-static Mat.
2. Identify and Record components found on the Mother Board.
3. If any components doesn't have details consult your teacher and record in Tabular Column
4. Get the identified and recorded specifications of the components found on the mother board checked by your class teacher

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S.No	Name of Part	Specification
1	Mother Board Type	
2	Chipset Used in the Mother Board	
3	Types of CPU	
4	Types of processor slot	
5	CPU Speed	
6	RAM Type	
7	RAM Slots	
8	ROM Type	
9	CMOS Battery Type	
10	BIOS Details	
11	PCI Slots	
12	Jumper Slots	
13	SATA Connector	
14	ATX Power Connector	
15	24 Pin Power Connector	
16	RJ-45 Slot	
17	USB Ports (No of USB Ports & Type)	
18	DVI Connector	
19	HDMI Port	
20	Audio Ports & Connectors (No of Audio Port & Connection, Type of Connector)	

Section 2: Installing a Motherboard in Desktop computer

Procedure:

1. Before Installing Motherboard turn the computer off and disconnect the power card from the Main.
2. Make sure the PC cabinet supports the formfactor of your computer.
3. Make sure the Jumper setting are correct.
4. Install Pegs or standoffs to prevent the motherboard short.
5. Screw up gently, tighten them all, and make sure they are fixed firmly with the cabinet.
6. Make sure the Motherboard holes align with standoffs on the cabinet.
7. Make sure the rear Motherboard ports line-up with the I/O shield.
8. Install CPU, RAM Modules etc., if not already installed.
9. Connect the power connector, CPU connector and Front panel connectors and cabinet fan.
10. Connect the SATA Cables to the motherboard from the Hard disk drive, CD drive etc.
11. Connect the keyboard, Monitor and power to the computer and verify all the connections with your teacher.

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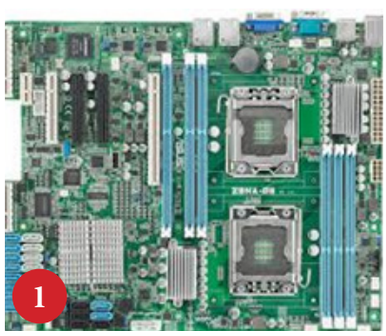
12. Now Boot the computer by switch ON.
13. Keep verify the CMOS setup, CPU, Memory and Drives settings with your teacher.
14. Check other setting such as Date, Time and saves the settings then exit the CMOS setup.
15. Reboot the computer.

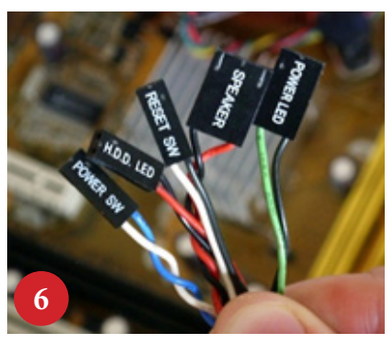


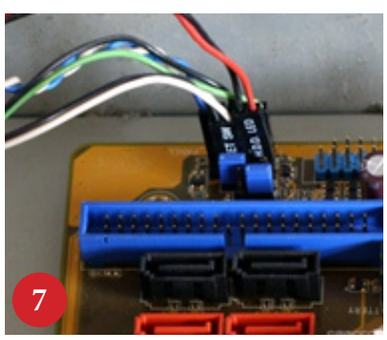


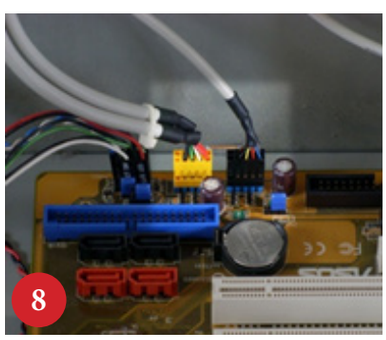


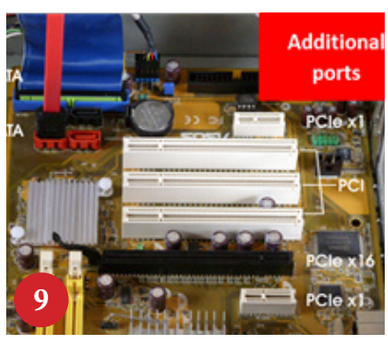


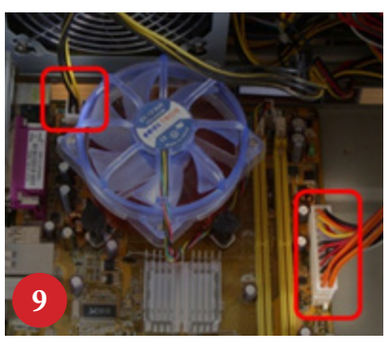












RESULT:

Thus, the identification of motherboard parts is clearly understood and installed successfully.

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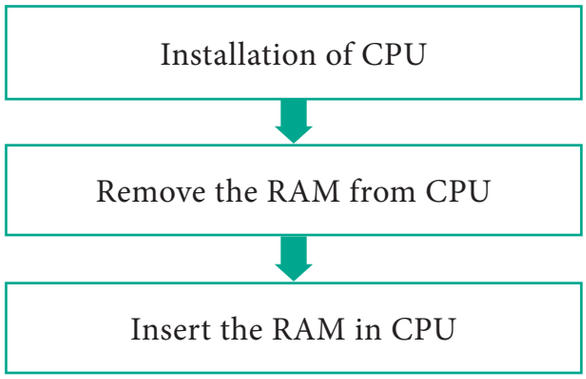
11 INSTALLATION OF CPU AND RAM MODULES

Aim:

To understand the installation of CPU and RAM strip on mother board.

Practical flow diagram :



Tools and equipment required:

Activity Title	S. No	Name of the apparatus/ components	Range/Value	Quantity
Installation of CPU and RAM module	1	Processor		1
	2	Desktop computer		1
	3	Heat sink with cooling fan		1
	4	RAM module 2		As required
	5	EST Kit		1
	6	Screw driver set		1

Safety measures:

1. Always handle the CPU with care.
2. Hold the CPU only by it edges/sides.
3. Never touch the bottom or top metal portion of the processor.
4. Keep CPU in the anti-static safety bag until it is ready to install.

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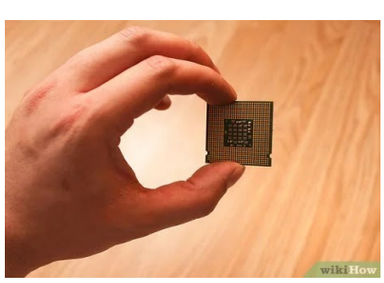
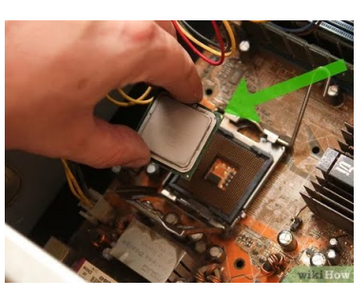
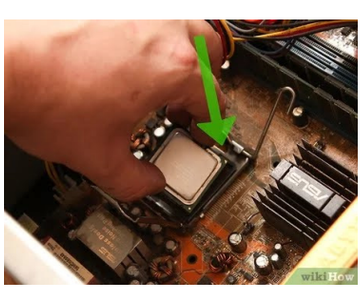
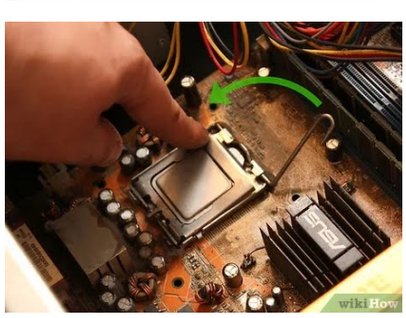
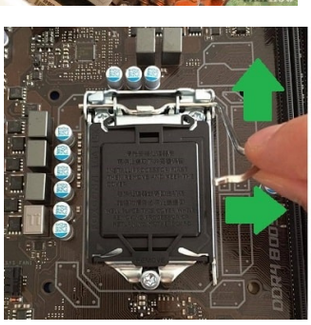
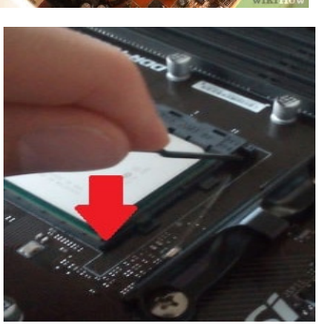
5. Never install the heat sink without thermal compound.
6. Ensure that the power cable of the fan cannot become snagged in the fan blades.

Procedure:

Section 1: Installation of CPU

1. Ensure that power to the computer is OFF and the computer is unplugged.
2. Place an antistatic wrist strap around your wrist and attach the other end to a ground or unpainted metal part of the computer. Otherwise use an anti-static glove
3. Locate the CPU socket on the mother board.
4. Pull the retention arm up to a 90^0 angle, then lift it up.
5. Gently move the handle until the socket covers fully open.
6. Do not touch the CPU socket.
7. Remove the processor from package, taking care to hold it at the edges.
8. A socket & CPU have triangle marking or notches which indicates pin No:1
9. Line up the triangle or notches on the processor with the socket for proper alignment
10. Gently place the processor into the socket, don't insert it at any angle.
11. Do not apply force on the processor to keep in the socket. It may bend or break pins.
12. Once the processor has been properly inserted, close the socket cover, then lower the retention and clip it back into the hook.
13. Ensure that the processor is securely held in place.

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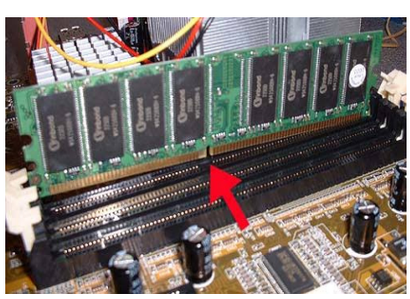
Installation of RAM module

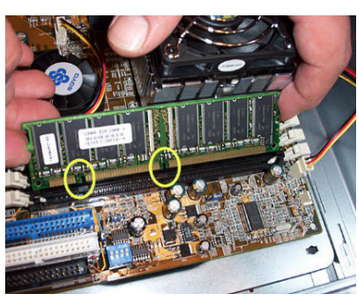
Section 2: Remove the RAM from CPU

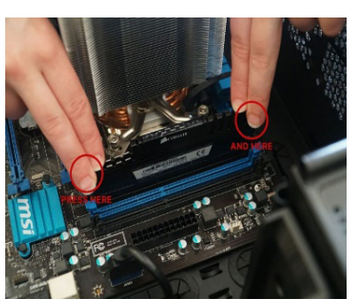
1. Shutdown & turn off the computer
2. Unplug and open the PC side panel
3. Locate the memory slots in your mother board
4. Toggle the plastic retention clips at either end of the memory slot to open them
5. Remove any dust from the memory slots by vacuuming gently.
6. Carefully remove the RAM from the shielded package.

Section 3: Insert the RAM in CPU

1. Make sure to line up your RAM that the Pins and cut outs match with the slot before placing it.
2. Place the RAM in the slot properly and press it downwards.
3. Apply firm and equal downward pressure to each side of the RAM until it seated securely.
4. When the RAM module is fully depressed, the locking tabs at each side should click back into place.
5. Remove the anti-static wrist strap, and fix the PC side panel.
6. Plug the power cable and switch ON the computer.
7. Check the installed RAM module memory size in system properties.
8. Get the work checked by your class teacher.
9. Repeat the same steps for placing other RAM modules.







RESULT:

Thus, the installation of CPU and RAM module on the motherboard were known and installed.

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12 PRINTER & SCANNER INSTALLATION

AIM:

To understand method of installing the printer and Scanner.

Practical Flow Diagram :

Installation of Printer

↓

Installation of Scanner

Tools and Equipment Required:

Activity Title	S. No	Name of the apparatus/ components	Range/Value	Quantity
Install the printer & scanner	1	Desktop Computer	Any Configuration	1
	2	Printer	laser	1
	3	Scanner	300-600 dpi	1
	4	Screw Driver Set		1
	5	Antistatic Wrist Wraps		As required

Safety measures:

1. Use the electrical mains card supplied with the printer.
2. Do not allow metal or liquids to touch the internal parts of the printer.
3. If the printer is making an unusual noise switch off the printer.
4. Install and operate the printer in a well ventilated area.
5. Do not touch the hot surfaces in the paper path.

Procedure:

Section 1:Installation of Printer

1. Connect the Printer to the computer using a USB Cable.
2. Connect the Power Plug to a power outlet
3. Switch on the computer and the printer





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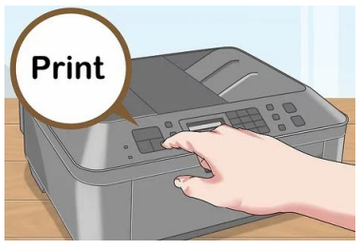
4. Insert the Printer CD in the CD drive
5. If the CD does not start automatically, open "My Computer".
6. Double click the CD Drive and the click the set-up or Install file.



7. Follow the Installation wizard and complete the Installation.
8. Right click the printer and click properties.
9. Click the print test page button to make sure that if it is working.



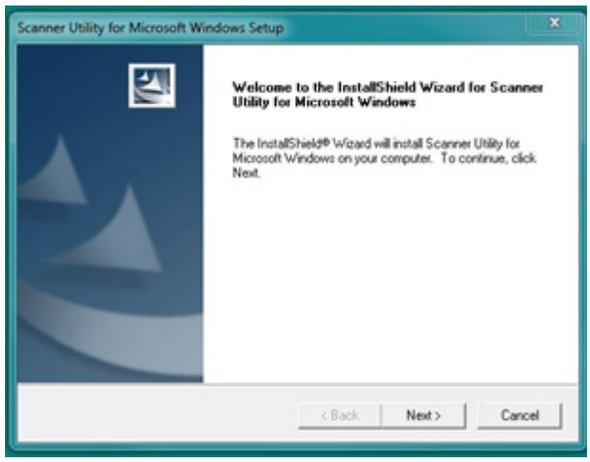
10. Get the work checked by your class teacher.

Section 2 : Installation of Scanner

1. Connect the power cord of the scanner.
2. Connect the USB to Scanner and Computer.
3. Switch ON the scanner.
4. Insert the Device Driver CD on PC.



5. Boot up the computer and wait for few seconds to recognize the device, (Make sure that the USB cable is securely connected on both end).
6. Installation wizard appears on the screw and follow the procedures to install the scanner.
7. After installation completed, default setting and option for scanner can be configured.



8. Ensure that the scanner software is properly installed and all the setting are properly configured with the help of your class teacher.
9. Place a single page on the flat bed of the scanner and close the lid.
10. Select your Scanner for the setting option of a page.
11. Click Scanner and view that the scanned output on the computer is correct
12. Edit the scanned file, and then save it to the destination folder.

RESULT:

Thus, I understood how to install the Printer & Scanner.

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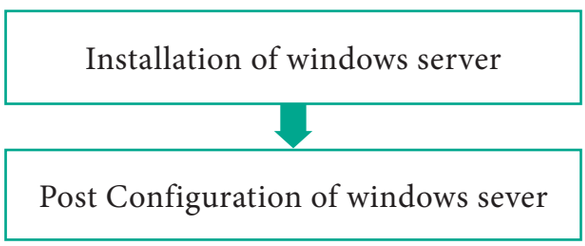
INSTALLATION AND POST CONFIGURATION OF WINDOWS SERVER

13

AIM:

1. To understand the step by step approach of installation of windows server 2019.
2. To understand the post configuration of windows server 2019 .

Procedure flow diagram :



Tools and equipment required:

S. No	Name of the apparatus/ components	Range/Value	Quantity
1	Desktop computer/Laptop		1
2	Window server 2019		1

Procedure :

Session 1 :Installation Of Windows Server

Step 1: Turn on your monitor and server of computer.

Update the BIOS as needed referring to "BIOS Update" Before Starting Setup.

Step 2: Boot from a backup DVD or Windows Server 2019 DVD-ROM.

Press any key to boot from CD or DVD is displayed on the top of the screen and Press<Enter>key to start the system from the installation media.



Step3: If you are using a backup DVD, the following screen will appear. Choose the Language you use In case that "Windows Setup" window does not appear, <Enter> key was not pressed correctly in Reboot the server and go back to Step2.

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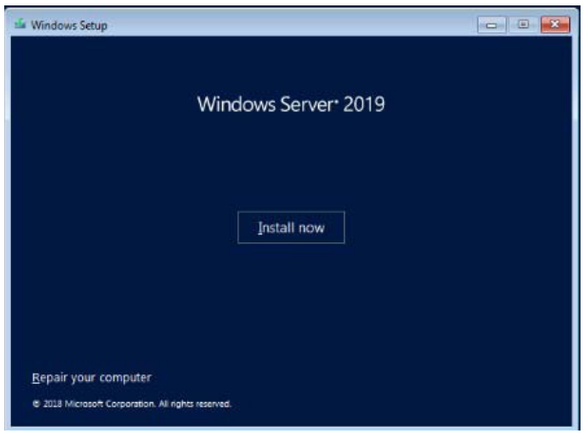
Step 4: After rebooting from ISO the following screen appears. Select the language, format and input method.



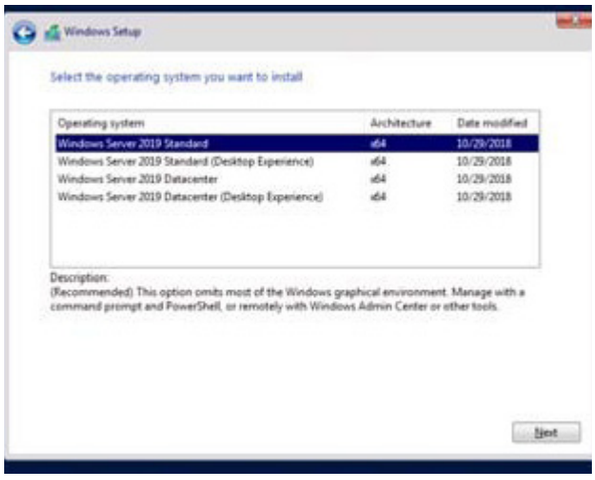
Click Next and Click Install now.



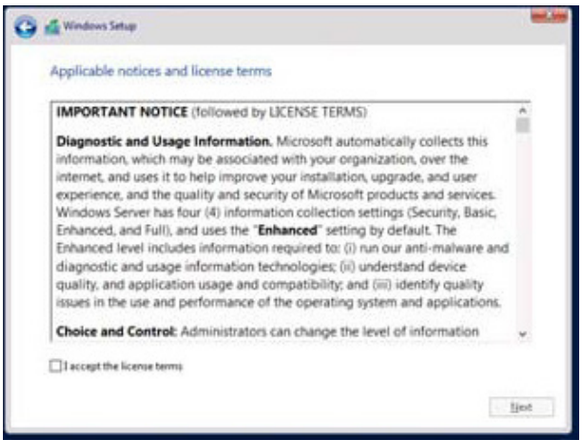
Step: 5 Enter the product key and click Next. If you are using a backup DVD-ROM, this screen does not appear.



Step 6: Select the operating system you want to install and click Next.



Step 7: Read the license terms carefully. Agree, check I accept the license terms and click Next.



Step 8 : Select the type of installation you want. Custom: Install Windows only (advanced) is selected below.

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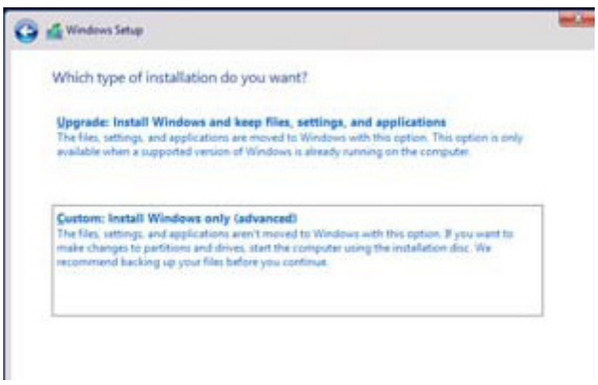
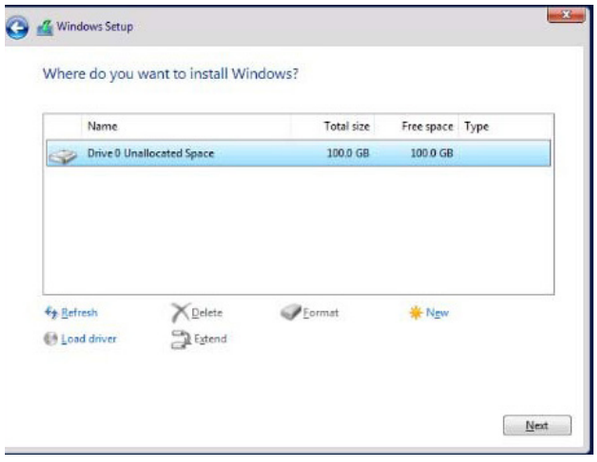
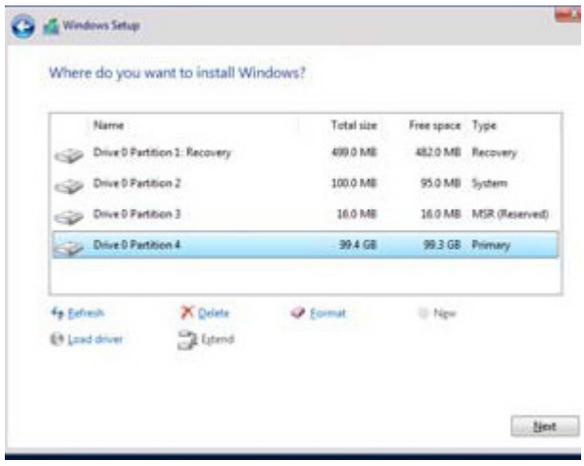


Step 9

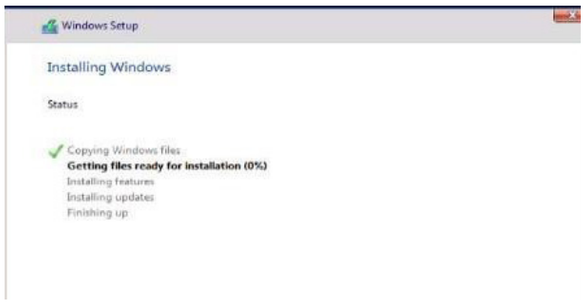
Click New. If a partition already exit, go to Step7. NEW is not displayed on the screen, click Drive Options (advanced). Then Specify the partition size in the text box, and the click Apply.



Step 10 : Select the partition created in Step9, and then click Next.

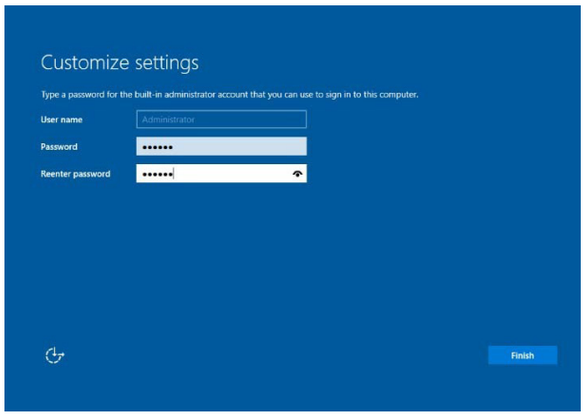


Step 11 : If Starter Pack DVD is in the drive, change I to the OS disk, and then click Refresh. When the following message appears, Windows installation starts automatically. When the installation is done, the system will automatically restart. After the system restart, continued the Windows Setup.



Step 12 :After installation of Windows the Desktop experience finally.

Set according to operating system selected. Type a password and click Finish. Finally you will see your windows desktop.



Session 2 : POST INSTALLATION OF WINDOWS SERVER

Step 1: Log on to the server using Administrator privileges.

Step 2: After Logging on as administrator Server Manager Console automatically opens, If it is not loaded automatically, press start button on your keyboard and select Server Manager.

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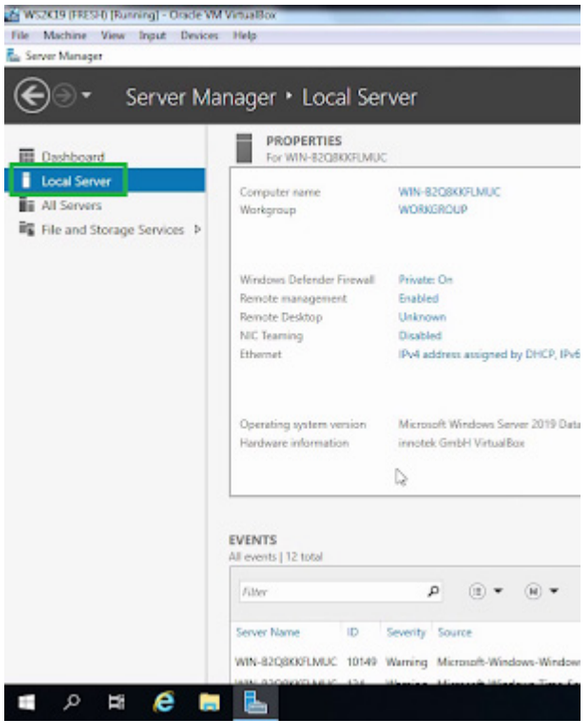
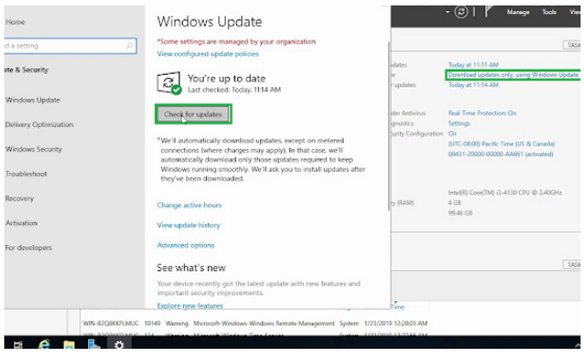
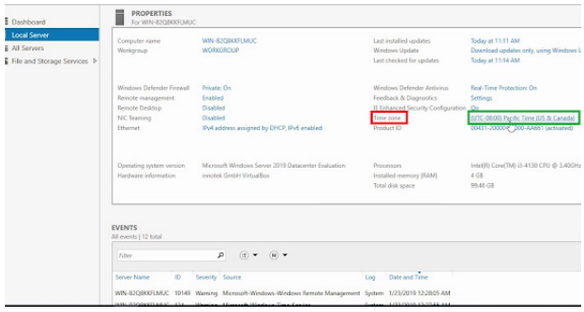
Step 3: In Server Manager window click on the local server in the left sidebar.



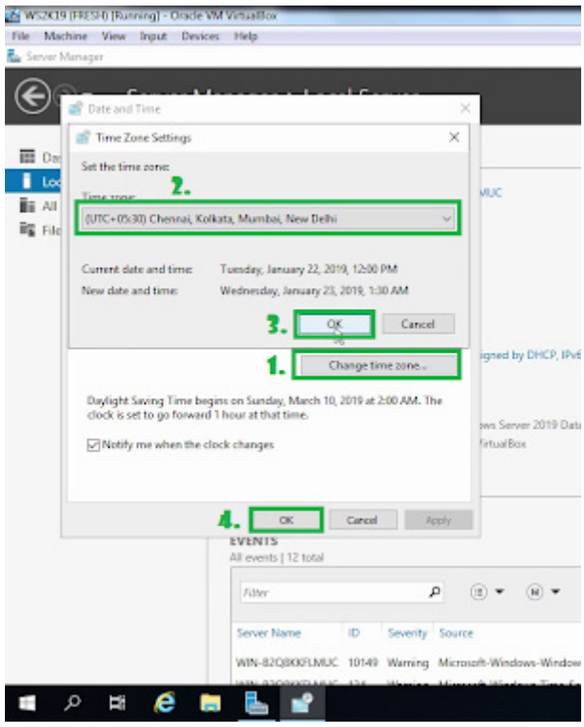
Step 4: Click on the value of Windows Update. That will open Windows Update Settings console. Click on "Check for updates" to check for windows update. If any update is available it will display there and you will have option to install the update as well. Now close the settings close.



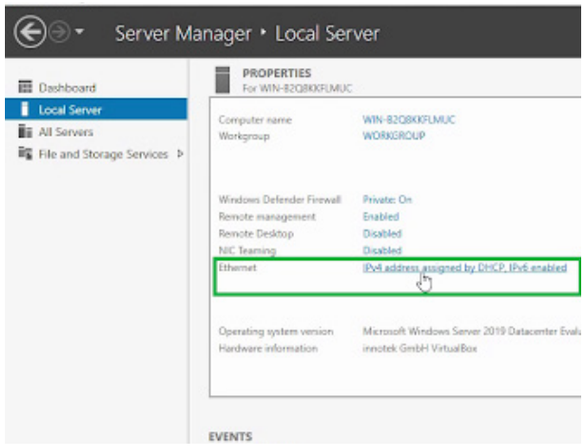
Step 5: Click on the value of Time Zone. Select your time zone.



Select correct time zone for your server then click on OK button to close the console.



Step 6: Click on the Ethernet value, the network connection windows appears.



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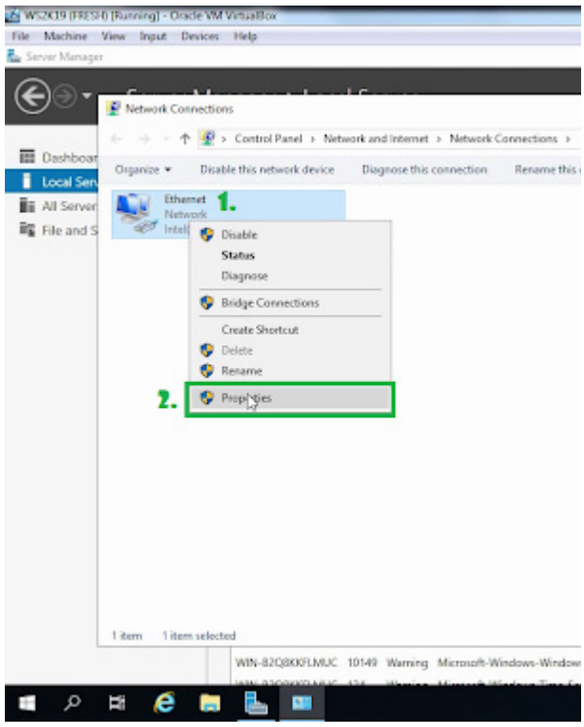
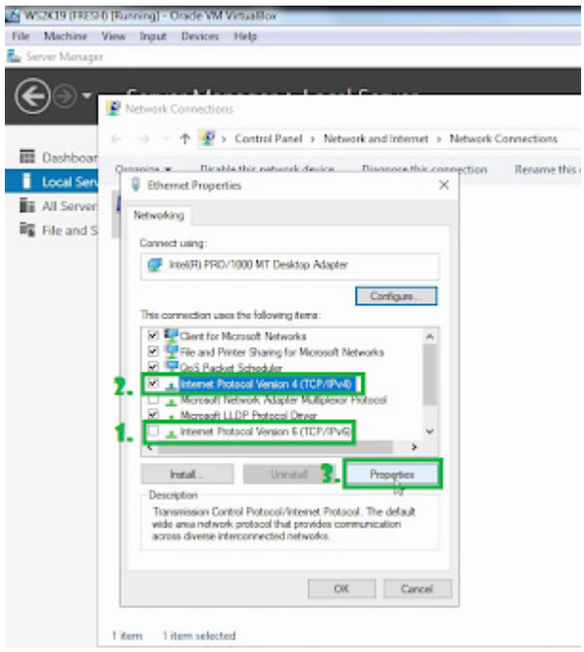
Right-click the Ethernet connection and, from the context menu, select Properties. The Ethernet Properties sheet appears.



Step 7: Unselect all the properties of Internet Protocol Version 6 (TCP/IPv6). Now Select Internet Protocol Version 4 (TCP/IPv4). The Internet Protocol Version 4 (TCP/IPv4) Properties sheet appears.



Note that servers should be configured with static IP address. Select the Use the following IP address option and, in the text boxes, type the following values:

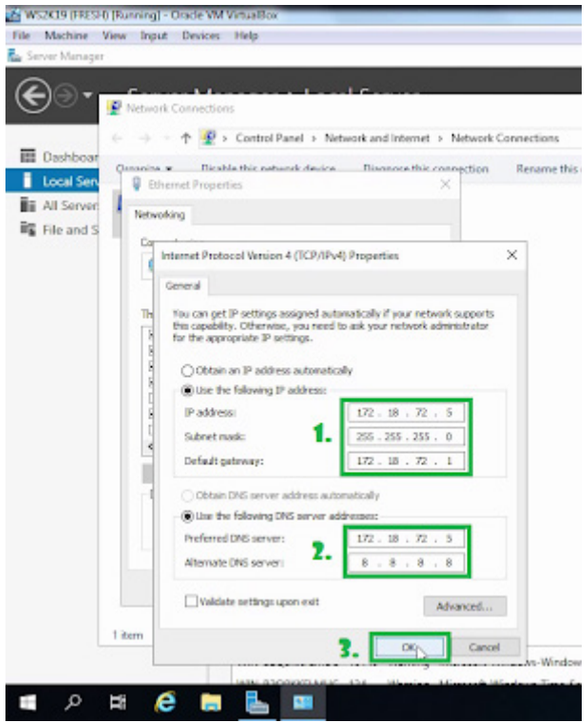
- IP address: 172.18.72.5
- Subnet mask: 255.255.0.0
- Default gateway: 172.18.72.1

Select the Use the following DNS server addresses option and, in the text boxes, type the following values:

- Preferred DNS server: 172.18.72.5
- Alternate DNS server: 8.8.8.8

Click OK to close the Internet Protocol Version 4 (TCP/IPv4) Properties sheet.

Click OK to close the Ethernet Properties sheet.



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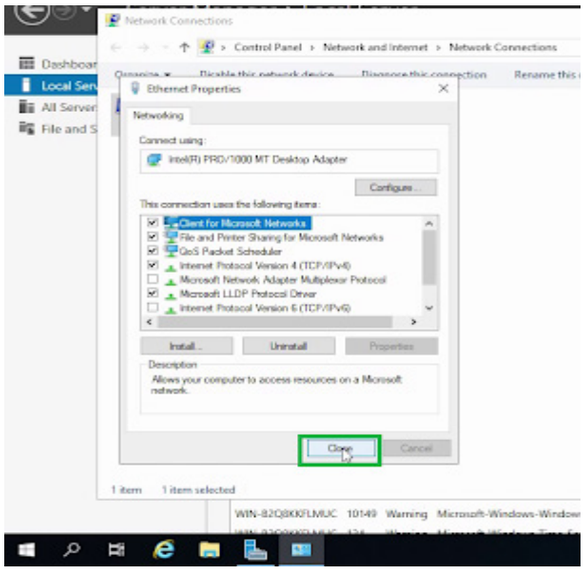
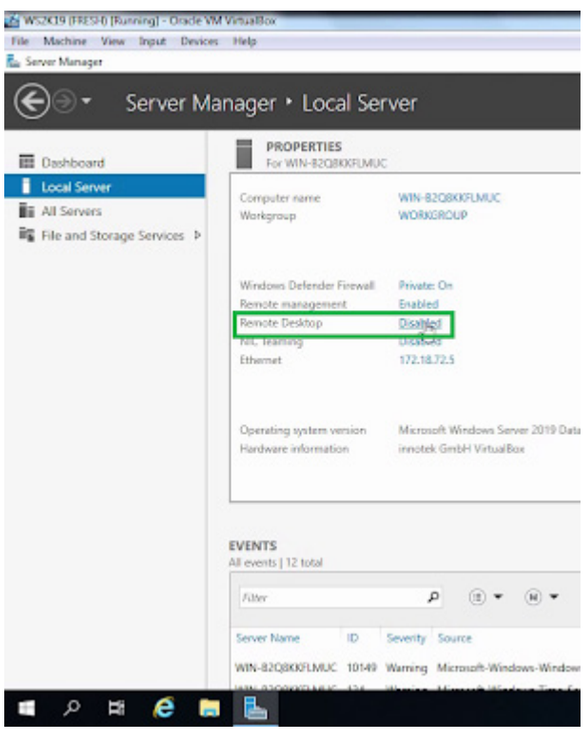
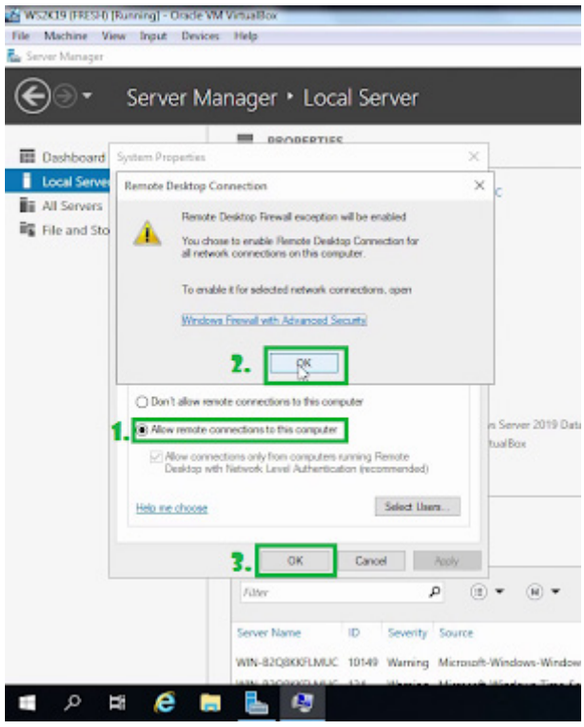


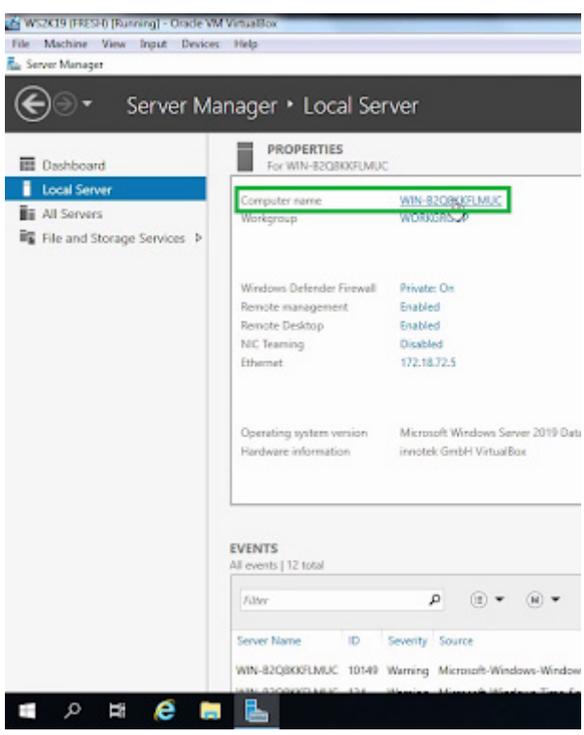
Step 8 : Click on the value of Remote Desktop. System Properties windows appears. Select Allow remote connection to this computer. (It will also add firewall exception for remote desktop port).



Step 9 :Click on OK. Click on Apply and OK button to close the console.



Step 10: Click on the value of computer name.



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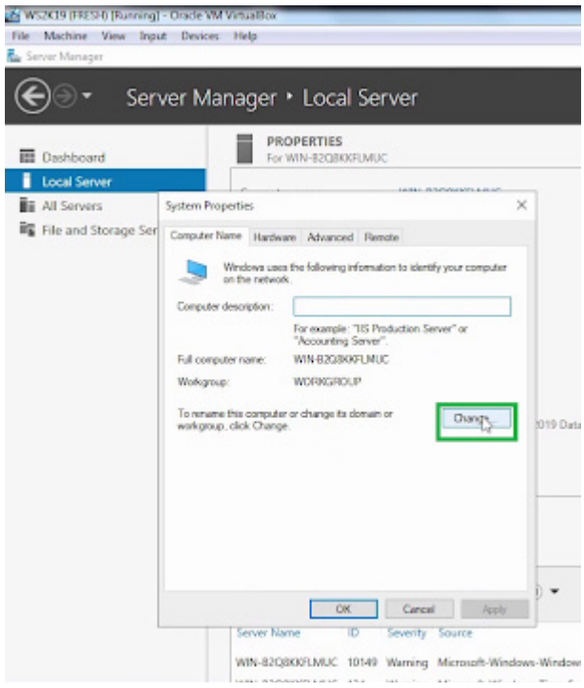
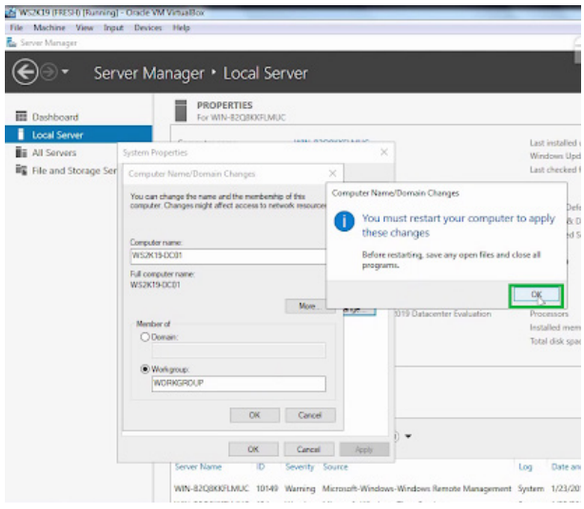
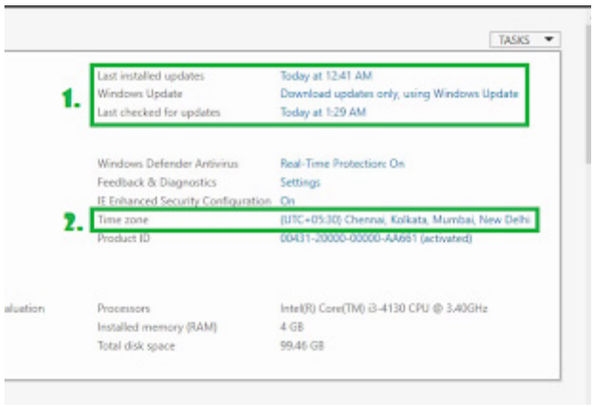


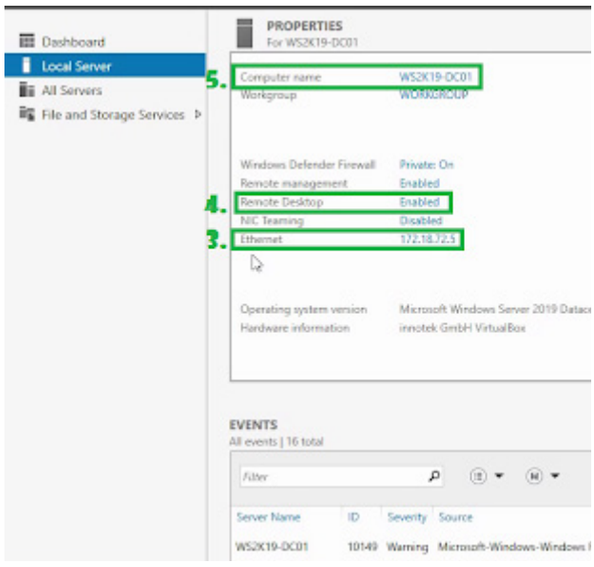
System properties windows appear, click on the change button for specifying the server name.

Type the name which you want to set for this windows server 2019 computer. Click on OK button. Click on OK again to restart the server. Before restarting save your work.



After restart, login to server using administrator user account and password. Open server manager console click on local server.





You have successfully completed the post-installation configuration tasks for Windows Server 2019.

RESULT:

Thus, I understood the step by step approach of install the windows server and post configuration of the server.

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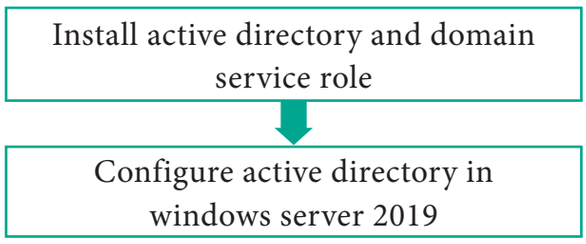
14 INSTALL ACTIVE DIRECTORY AND DOMAIN

Aim:

To understand the Installation of Active Directory and Domain Services in Windows Server 2019.

Procedure flow diagram :



Tools and equipment required:

Activity Title	S. No	Name of the apparatus/ components	Range/Value	Quantity
Active Directory and Domain	1	Server Computer	Nil	1

Safety measures:

1. Keep your windows server up to date.
2. Protect Domain administrator account.
3. Securing Domain Controllers against Attack.

Procedure:

Section 1: Install Active Directory and Domain Service Role.

1. Log in to Windows Server 2019 with a local administrator account.
2. Click the **Start** menu and find **Server Manager** in the list of installed apps and click it.
3. In Server Manager, click the **Manage** menu in the top-right corner and select **Add Roles and Features** from the menu.

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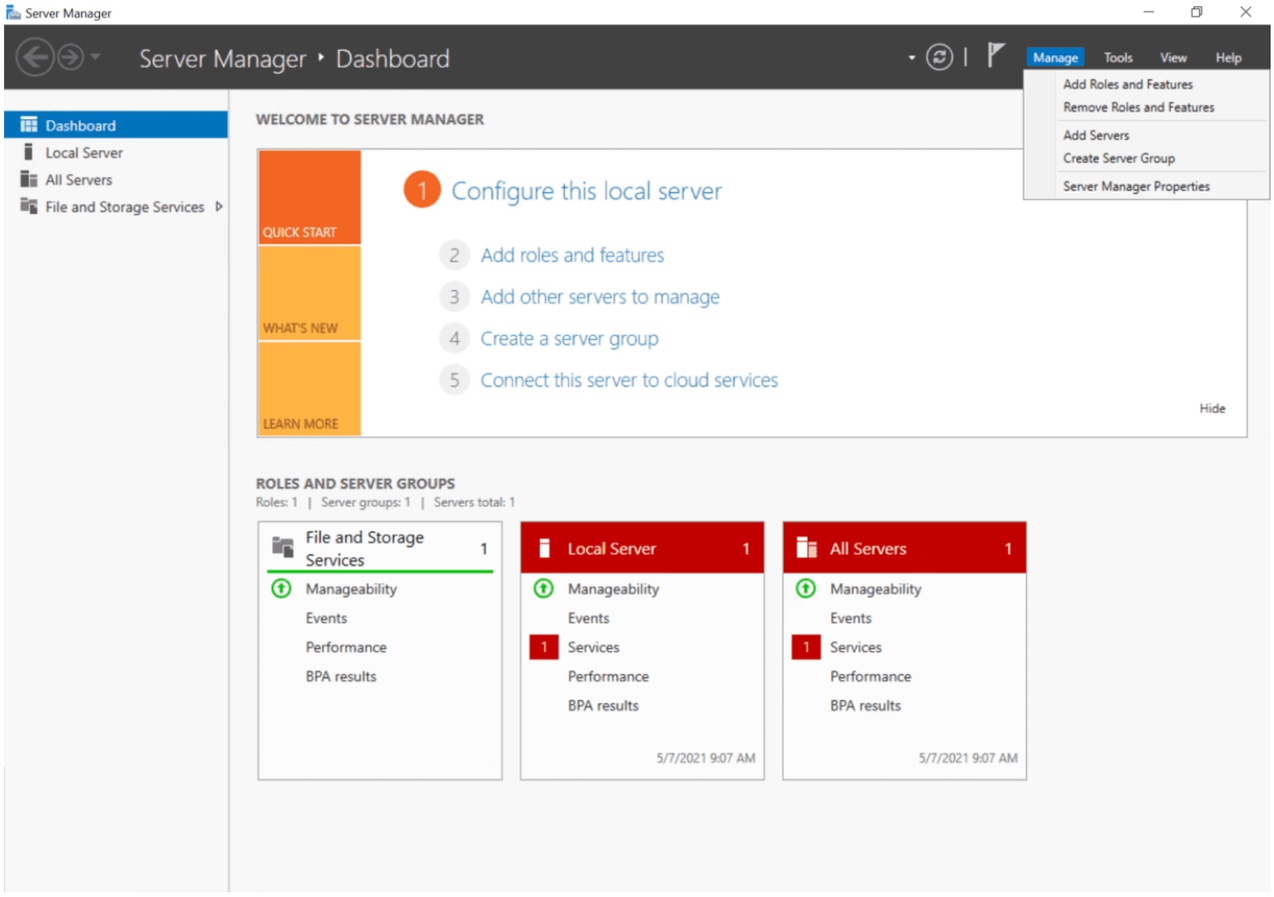
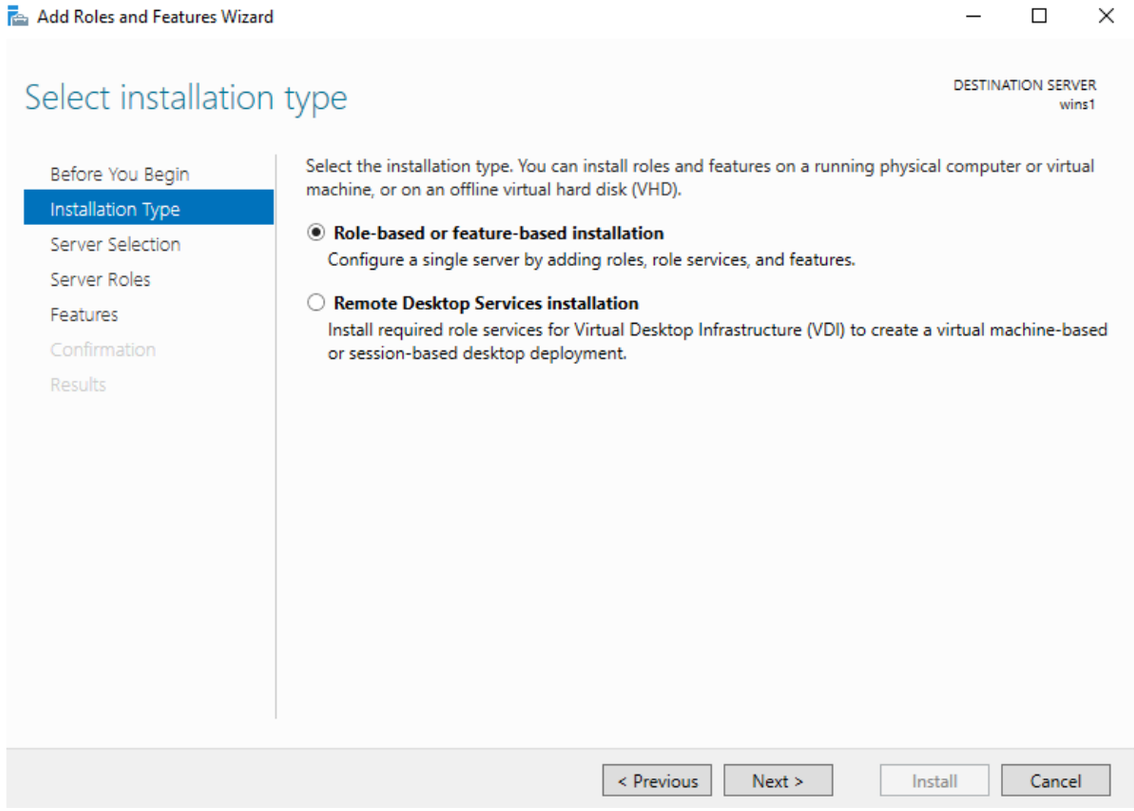


4. In the Add Roles and Features Wizard, click **Next** on the Before You Begin screen.



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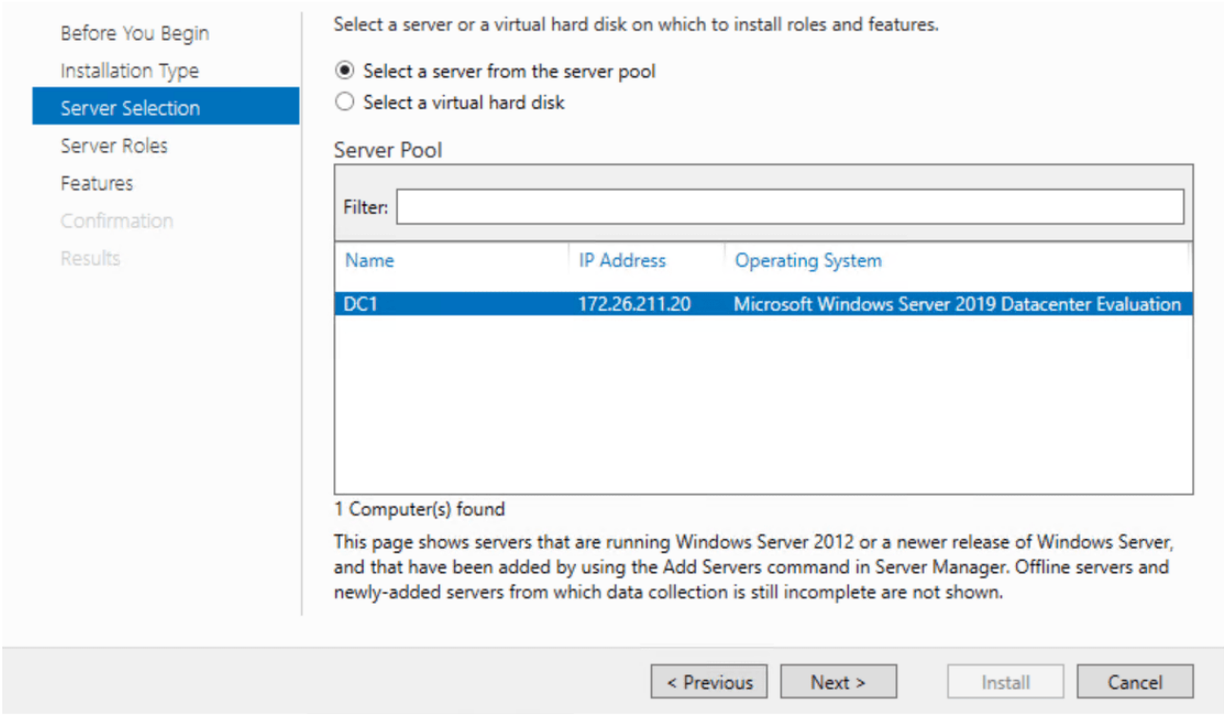
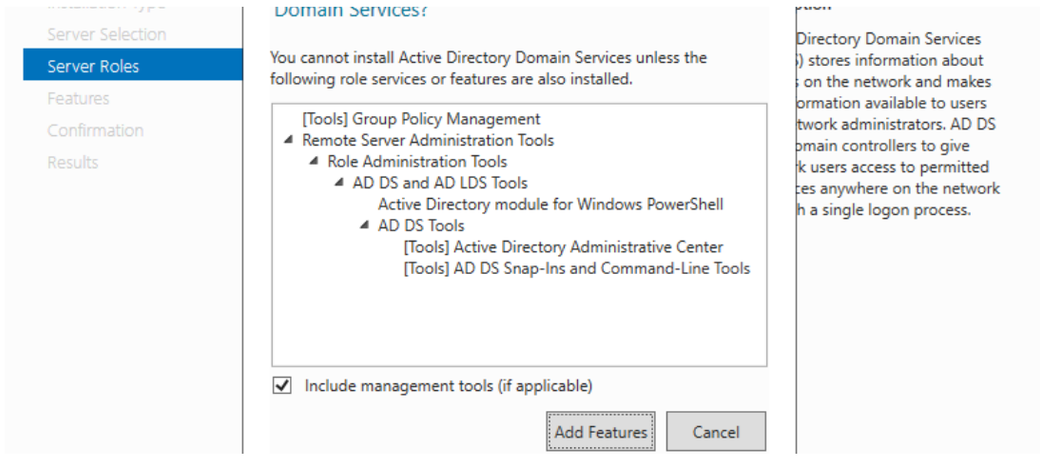
5. On the Installation Type screen, make sure that **Role-based or feature-based, installation** is selected and click **Next**.



6. On the Server Selection screen, make sure that your Windows Server is selected in the list and click **Next**.

7. On the Server Roles screen, check **Active Directory Domain Services** in the list of roles.



8. In the Add Roles and Features Wizard popup dialog, make sure that it **includes management tools (if applicable)** is checked and then click **Add Features**.

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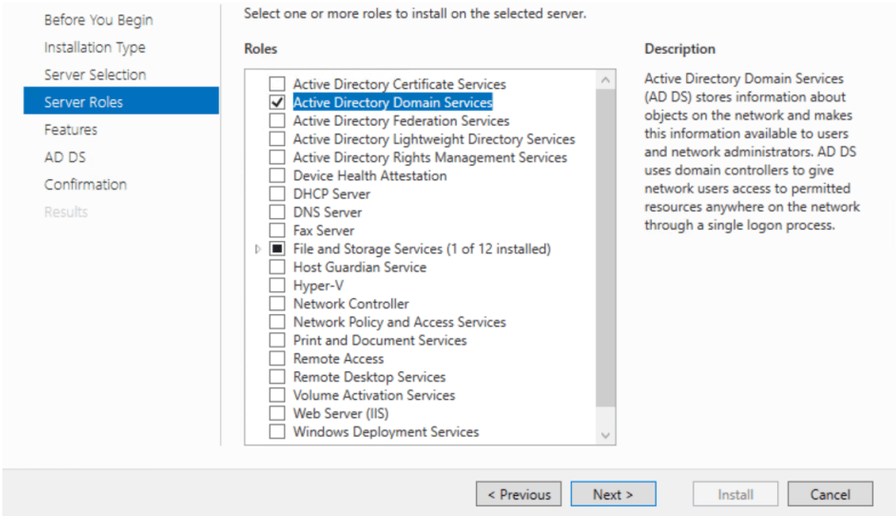
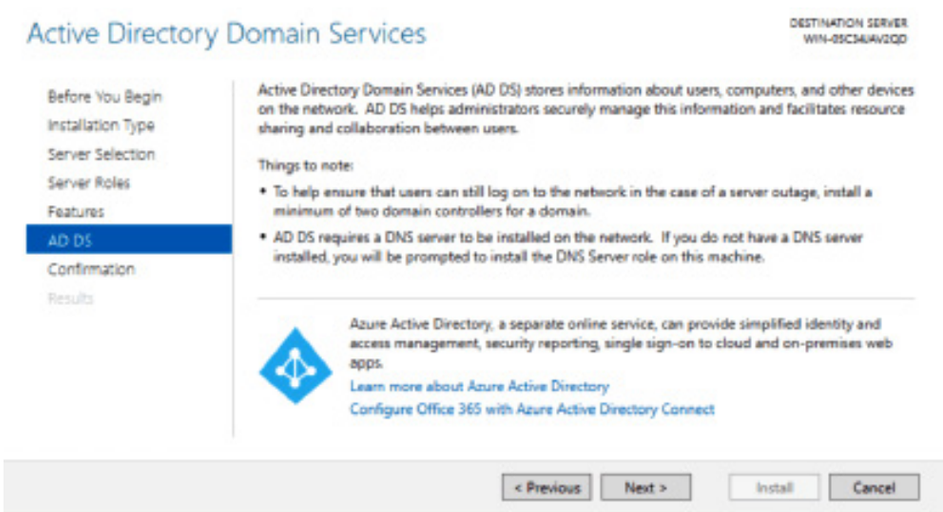
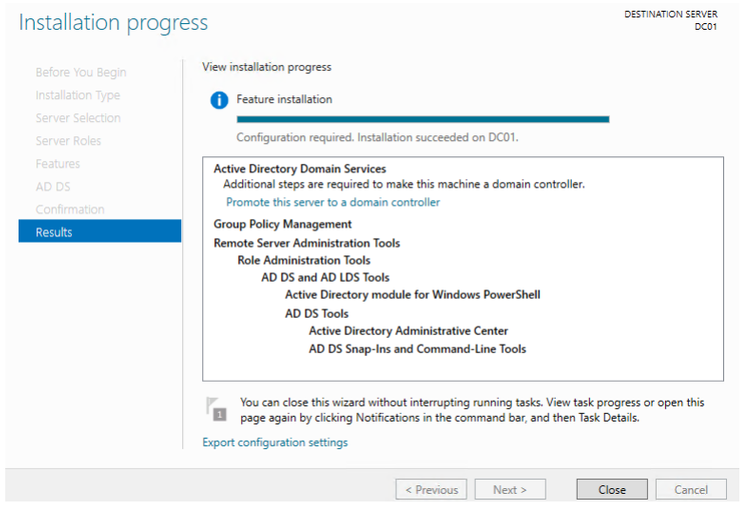


9. Click- **Next** on the Server Roles screen to continue then click **Next** on the Features screen.

10. Read the information on the ADDS screen and click -**Next.**



11. Now click **Install** on the Confirmation screen.



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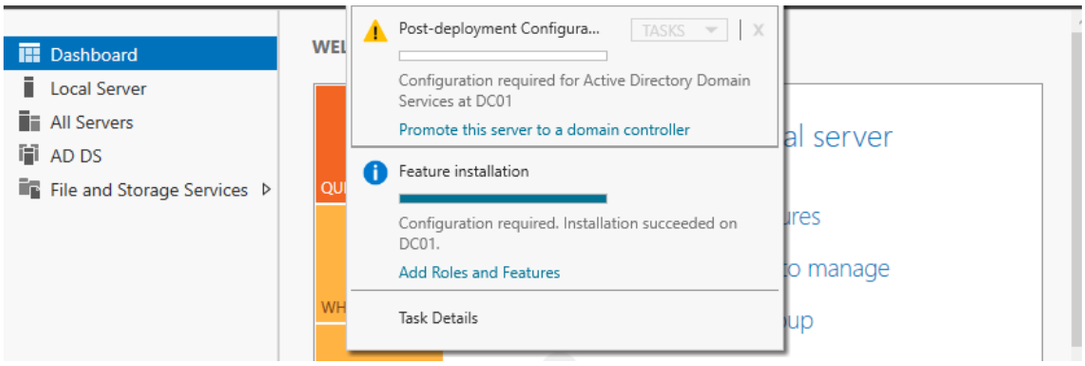
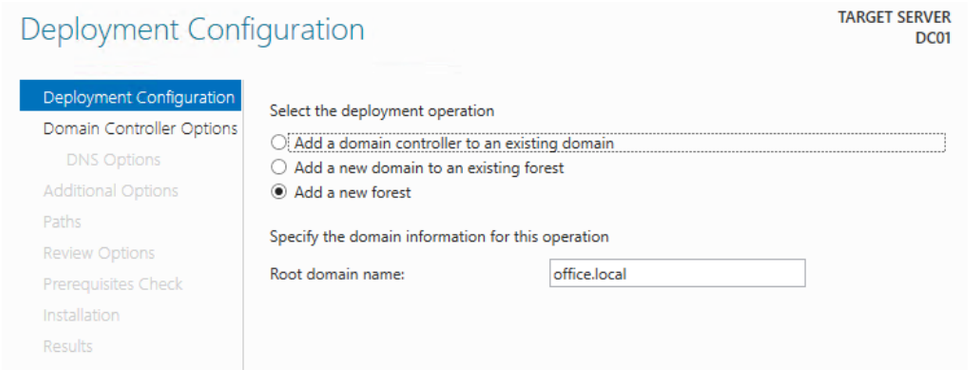
12. When the installation is complete, click **Close** in the Add Roles and Features Wizard.

Section 2: Configure Active Directory in Windows Server 2019

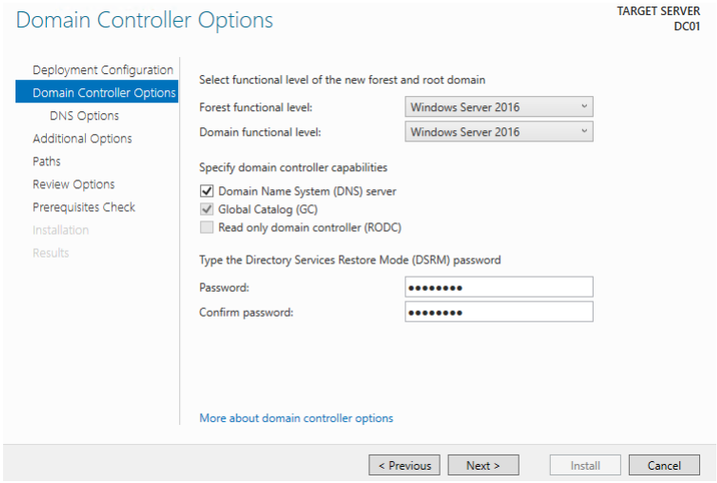
1. In Server Manager, you should see a yellow exclamation mark by the notifications flag in the top-right corner. Click it and then click **Promote this server to a domain controller.**



2. In the Active Directory Domain Services Configuration Wizard dialog, check **Add a new forest** under *Select the deployment operation*.



3. In the *Root domain name* box, type the Fully Qualified Domain Name (FQDN) for your new AD forest. Click **Next** to continue.



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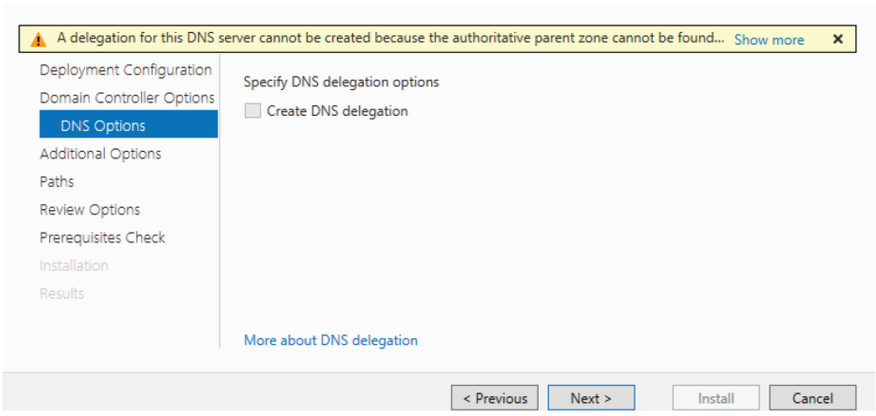
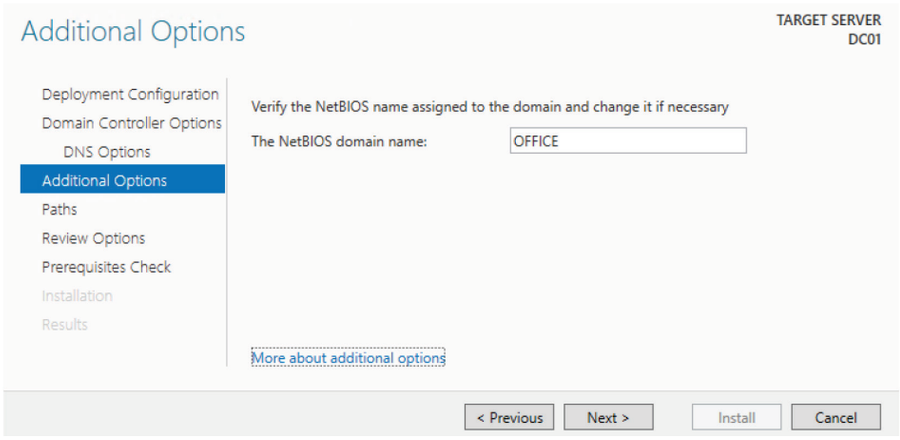
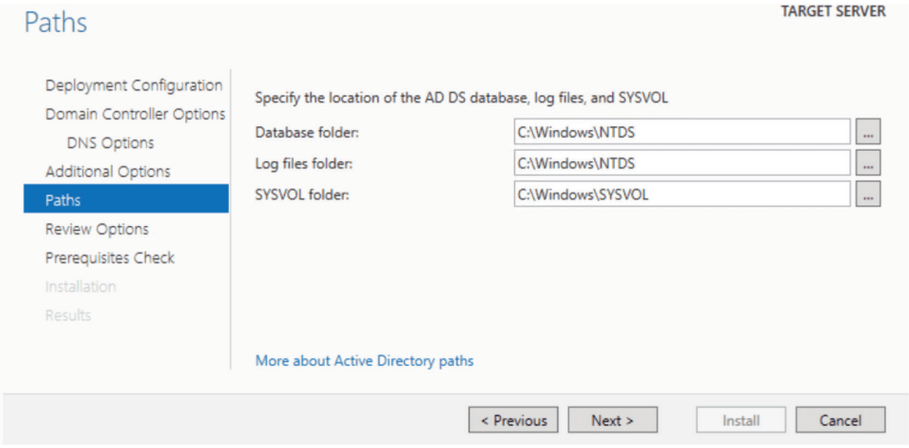
4. On the Domain Controller Options screen, type and confirm a Directory Services Restore Mode (DSRM) password. You will need this if you want to restore AD from backup. Click **Next** to continue.



5. On the DNS Options screen, you can safely ignore the delegation warning and click **Next**.



6. On the Additional Options screen, click **Next** to accept the assigned Net BIOS name.
7. Click **Next** again on the Paths screen to accept the default database, log files, and SYSVOL folder locations.



8. Now click **Next** on the Review Options screen.

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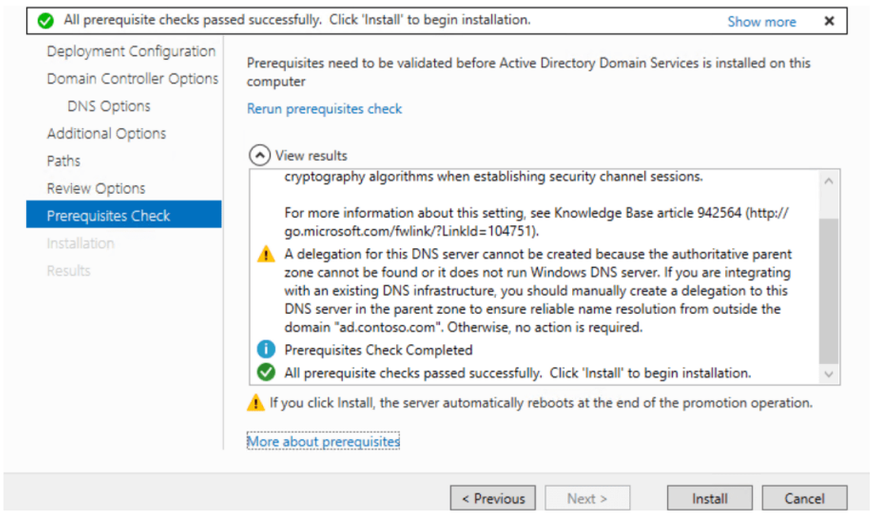
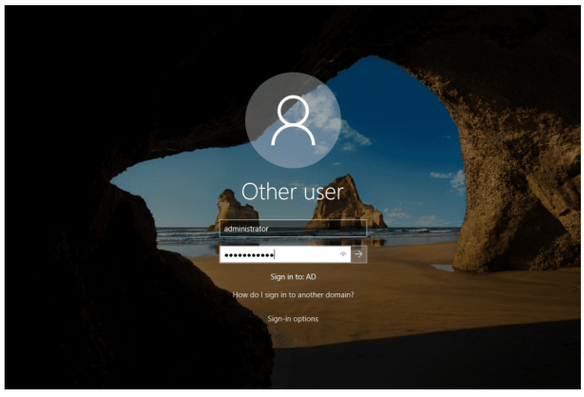
9. The wizard will run some prerequisite checks to make sure AD can be installed on the server. Hopefully your server will pass the checks and you can continue installing AD.



10. Now click **Install** to configure AD on the server. The server will automatically reboot to complete the install process.

11. Once Windows Server has rebooted, you will need to log in with the domain administrator account.



12. After server finishes its reboot process, your first domain controller will be ready to use and you can leverage all the features such as ADUC and ADAC.

RESULT:

Thus, the installation process of Active Directory and Domain services is clearly understood.

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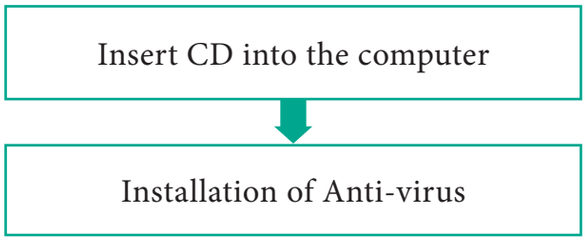
15 INSTALLATION OF ANTI-VIRUS

Aim:

To understand the Installation of Anti-Virus.

Practical flow diagram :



Tools and equipment required:

S. No	Name of the apparatus/ components	Range/Value	Quantity
1	Desktop computer	System	1
2	Anti-Virus Package	CD	1

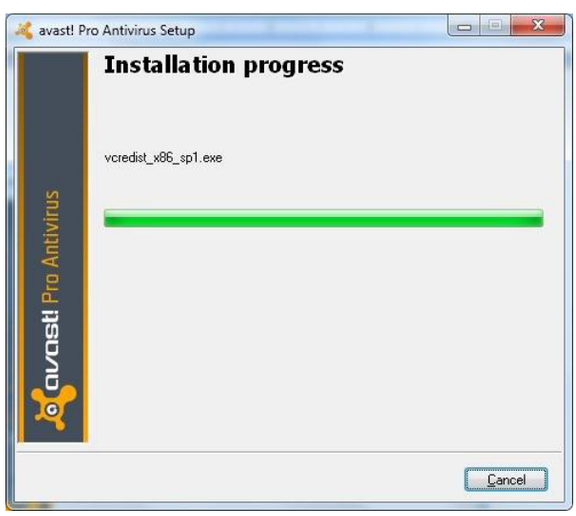
Safety precaution

1. Take sure that no other virus protection software are installed which may interface with each other
2. You should have an established internet connection

Procedure:

Section 1: Insert CD into the computer

1. If the Anti-Virus Software is a Package, insert CD into CD drive of the Computer and the installation process starts automatically
2. Double click an setup-exe file to run the installation process



Section 2: Installation of Anti-virus

3. Follow the steps for installing Anti-Virus by clicking the "yes" to user account authorizing and license agreement.

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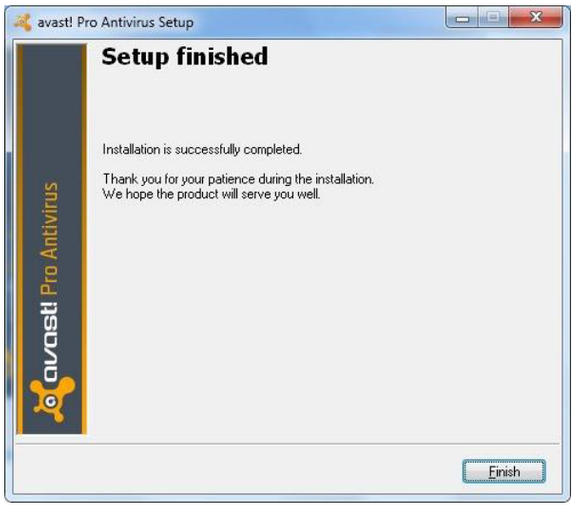
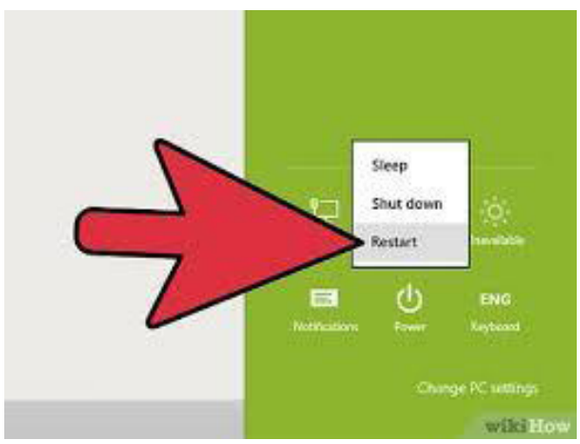


4. Register the Anti-Virus product by entering the necessary details.
5. Enter the product serial key and click on “ok”.
6. A message will be displayed “your product has been registered”



7. Restart your computer and Scan your computer for finding threats in it by using Quick scan or full scan or scheduled scan



RESULT:

Thus, I understood how to install the Anti-Virus on computer.

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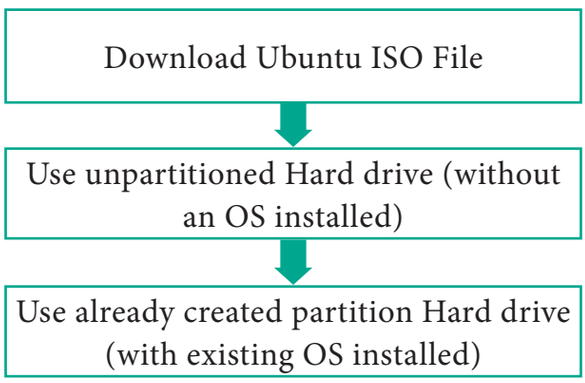
16 INSTALL UBUNTU LINUX OS

Aim :

To understand the Installation process of Ubuntu Linux.

Procedure flow diagram:



Tools and equipment required:

Activity Title	S. No	Name of the apparatus/ components	Range/Value	Quantity
Installation of Ubuntu Linux	1	Operating system	Ubuntu Linux	1
	2	Digital computer	I3 or I5 Processor based system 64 Bit	1
	3	Keyboard	108 keys	1
	4	Mouse	Optical	1
	5	Monitor	LCD	1

System requirements (recommended):

1. 2 GHz dual-core processor
2. 4GB memory
3. 25GB available disk space for storage (less if installing the minimal version)
4. DVD drive or USB port (At least a 4GB USB drive).
5. Optionally internet access is helpful.

Safety measures:

1. Install anti-virus software and scan all shared files for viruses
2. Enable the software firewall, if it isn't already enabled by default.
3. Keep your system updated.
4. Use strong passwords.

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5. Make backups regularly, in case something goes wrong and you have to restore from the backup.
6. Install software applications only from trusted sources. The most trusted source for Linux is the software repository for your distribution. Look there first for the application you want.
7. Use security-related plugins for your browser that protect your data, credentials and privacy.

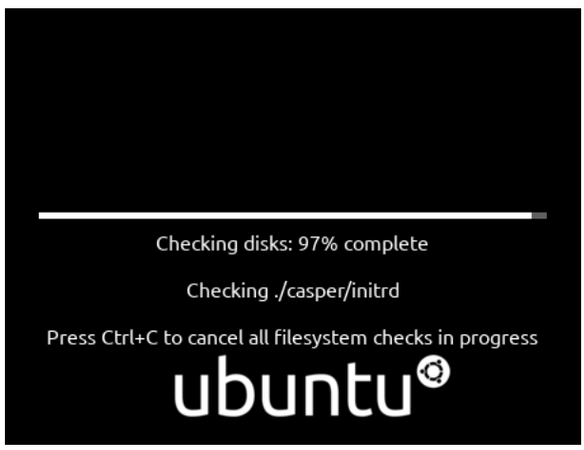
Procedure:

Section 1: Download the Ubuntu 20.04 LTS ISO File

1. The Ubuntu installation ISO image can be downloaded using the following link for the x64 bit system only.

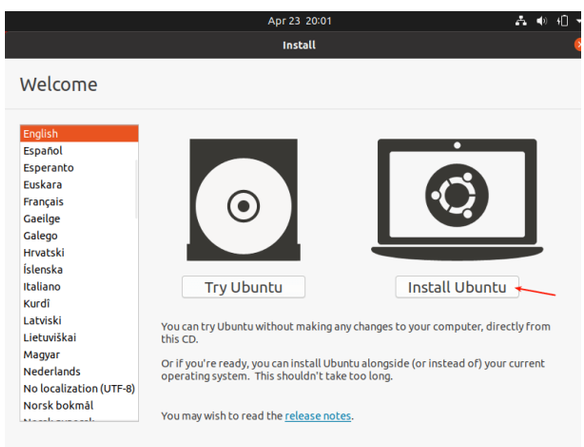
   https://releases.ubuntu.com/20.04/

2. Once you find the version you need, click the green Download button. You'll be taken to a thank-you page, and your download should start. (We will download and install Ubuntu 20.04 for desktops.)
3. The download is an .iso file. You can use it to create a bootable USB drive.
4. Save the file to a location of your choice.
5. Once you have obtained the Ubuntu 20.04 desktop image, create a bootable media using Rufus tool or create a bootable USB drive using LiveUSB Creator called Unetbootin
6. Next, insert the bootable DVD or USB into the appropriate drive on your machine. Then start the computer and instruct the BIOS by pressing a special function key (F2, F8, F9 or F10, F11, F12) to boot-up from the inserted USB/CD drive.
7. Once the BIOS detects the bootable media, it boots from it. After a successful boot, the installer will check your disk (file system), press Ctrl+C to skip this process.



8. When disk checking is complete or if you have canceled it, after a few seconds, you should see the **Ubuntu 20.04** welcome page as shown in the following screenshot.

   Select **Install Ubuntu.**



9. Next, choose your **keyboard** layout and click **Continue**.

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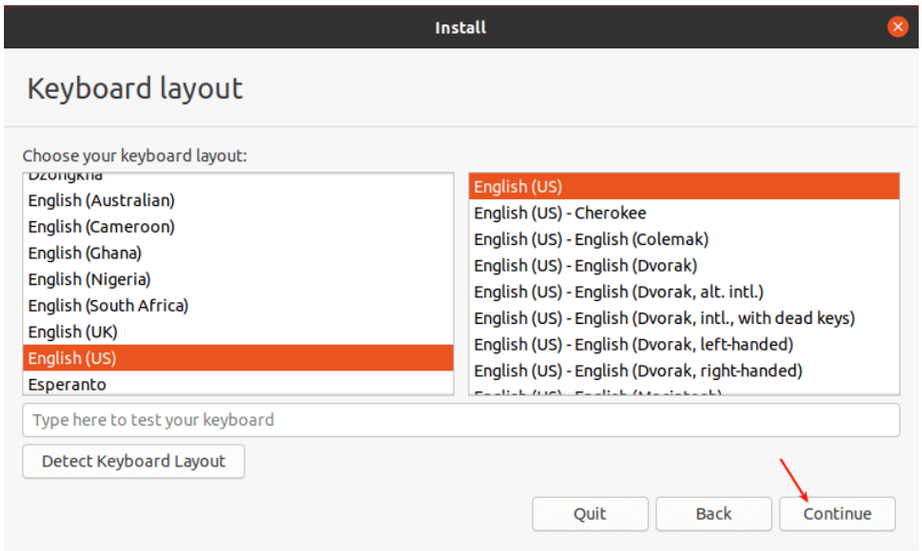
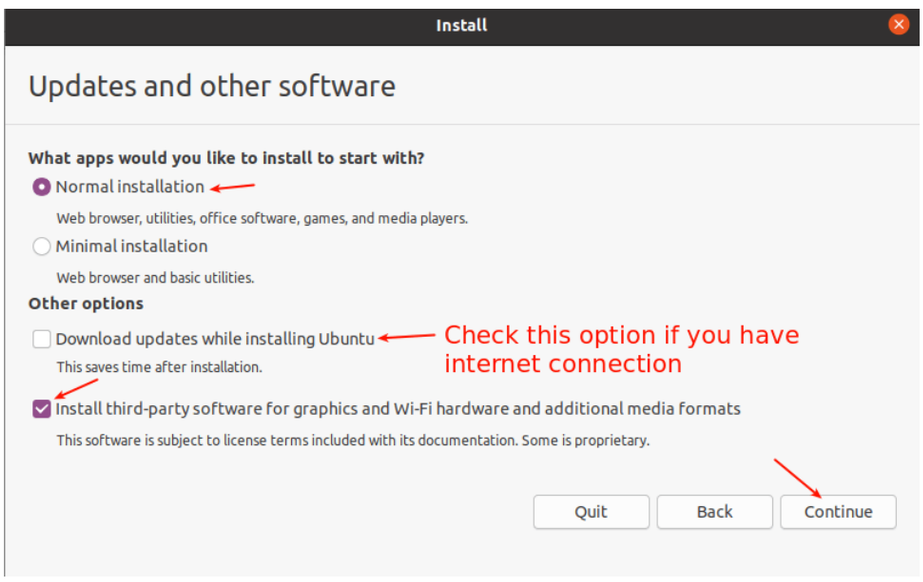


10. After that, choose the apps you want to install based on the installation type (normal or minimal installation). Also, check the option to install updates during the installation process and where to install third-party software.



11. Now choose the actual installation type. This is normally the most confusing part, especially for new Linux users. There are two scenarios we will consider here

12. First is using an unpartitioned hard drive with no operating system installed. Then secondly, we will also consider how to install on an already partitioned hard drive (with an existing OS e.g **Ubuntu 18.04**)

Section 2:Using an Unpartitioned Hard drive (without an OS installed)

1. For this scenario, you need to set up partitions manually so choose **Something else** and click **Continue**.

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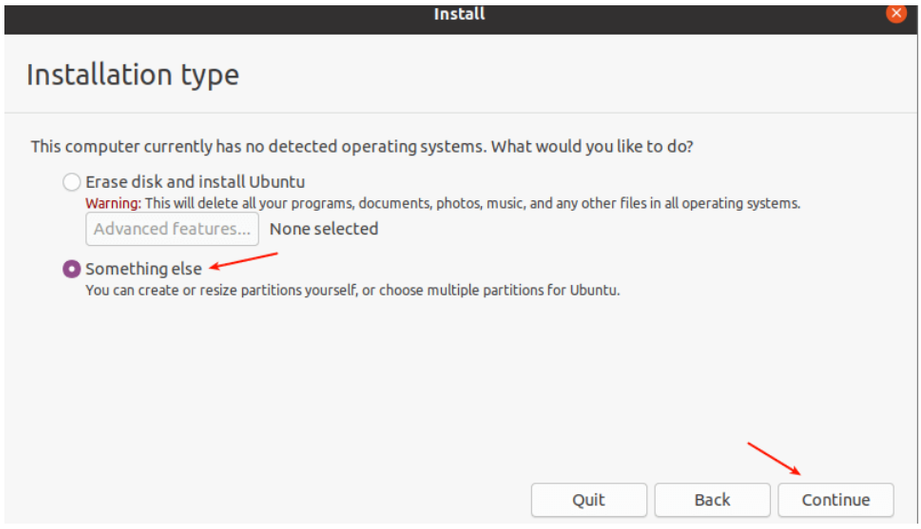
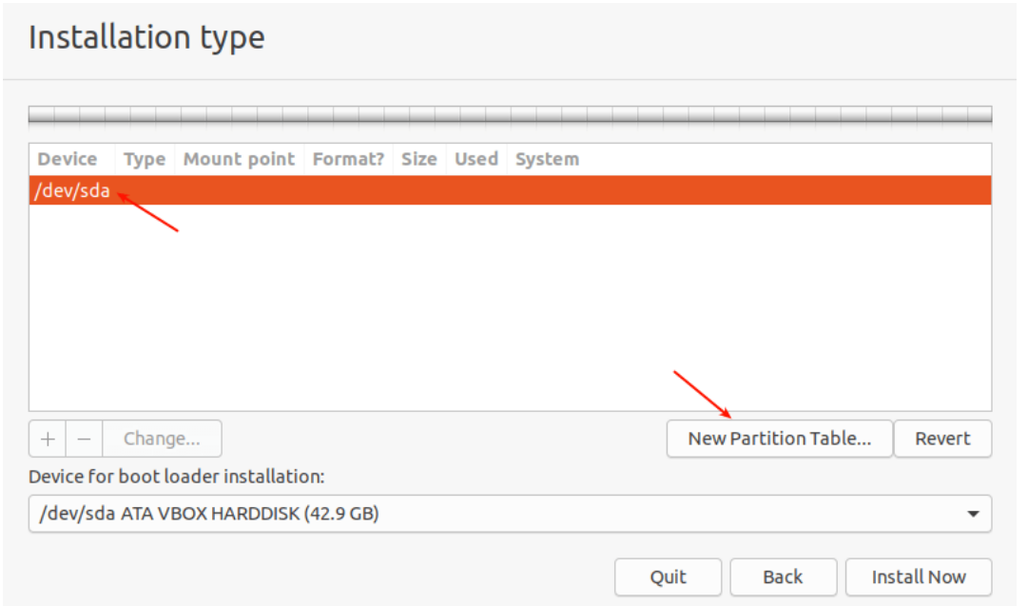
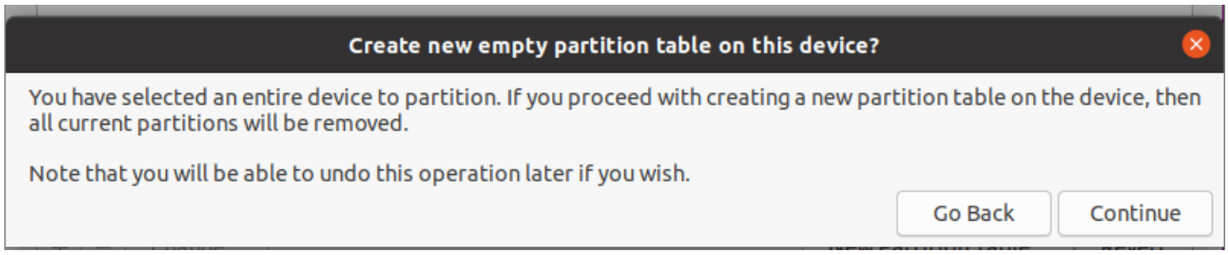


2. Now you need to partition your hard drive for the installation. Simply select/click on the unpartitioned storage device from the list of available storage devices. Then click **New Partition Table**.

   Note that the installer will auto-select the device on which the boot-loader will be installed as shown in the following screenshot.

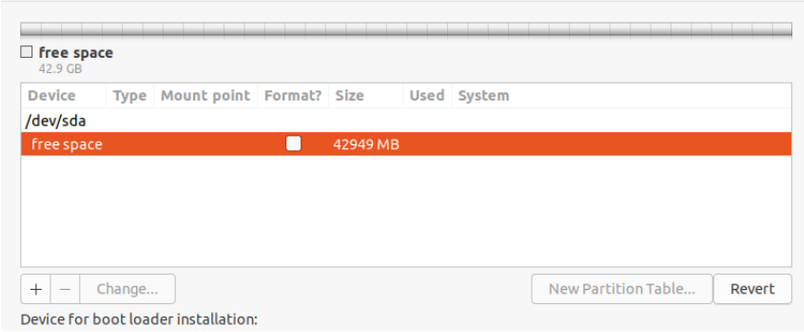


3. Next, click **Continue** from the pop-up window to create an empty partition table on the device.

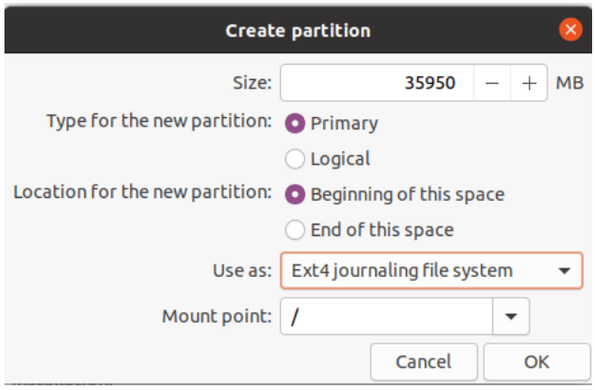


z_XI_EM_ELEC_EQUIP_PRACTICALS_2022.indd 236 12/29/2022 6:54:21 PM

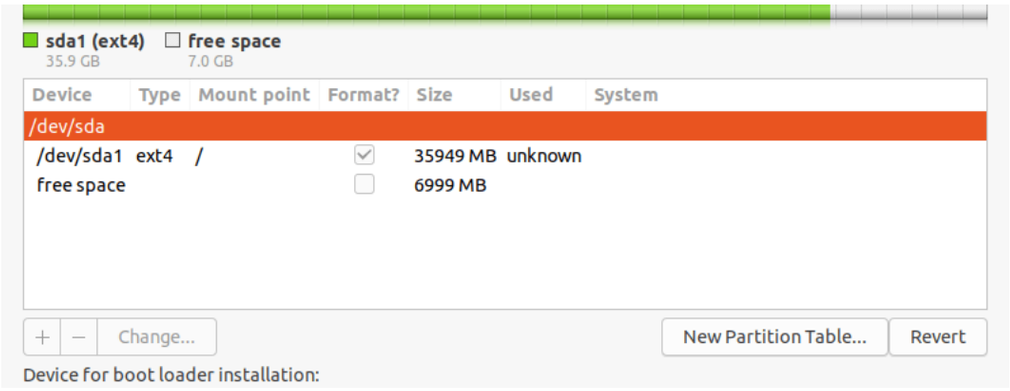
4. Now you should be able to see the free space created equivalent to the capacity of the hard drive. Double click on the free space to create a partition as described next.



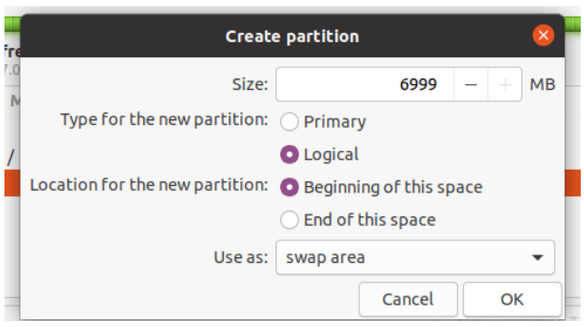
5. To create a `root(/)` partition (where the base system files will be installed), enter the size of the new partition out of the total free space. Then set the file system type to **EXT4** and the mount point to / from the drop-down list.



6. Now the new partition should appear in the list of partition as shown in the next screenshot.

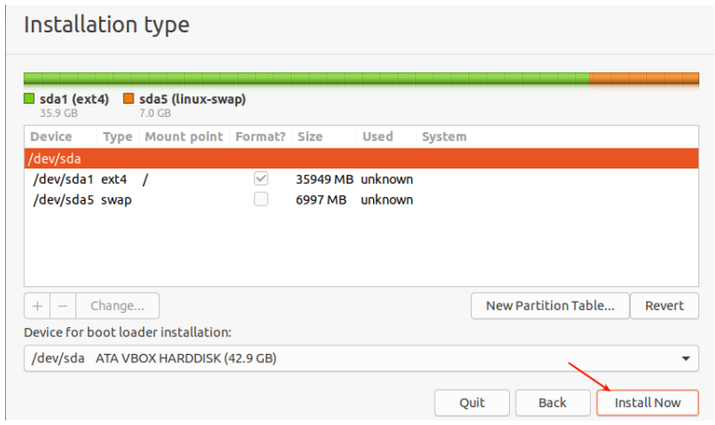


7. Next, you need to create a **swap** partition/area. Double click on the current free space to create a new partition to be used as swap area. Then enter the swap **partition size** and set **swap area** as shown in the following screenshot.

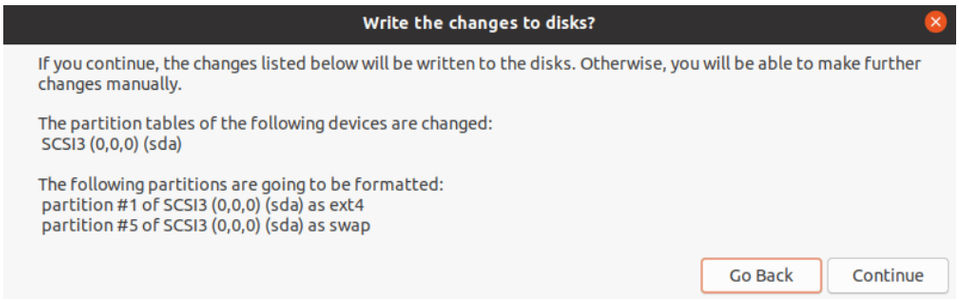


z_XI_EM_ELEC_EQUIP_PRACTICALS_2022.indd 237 12/29/2022 6:54:21 PM

8. At this point, you should see two partitions created, the root partition and the swap partition. Next, click **Install Now**.

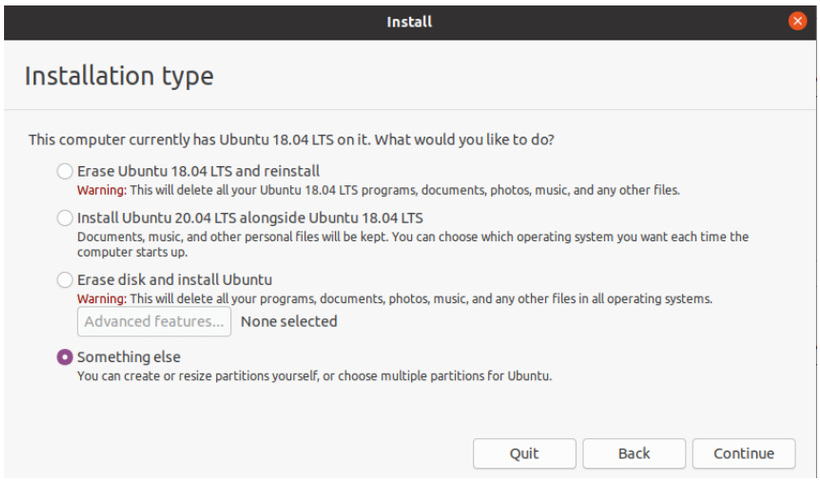


9. You will be prompted to permit the installer to write the recent changes concerning partitioning to disk. Click **Continue** to proceed.



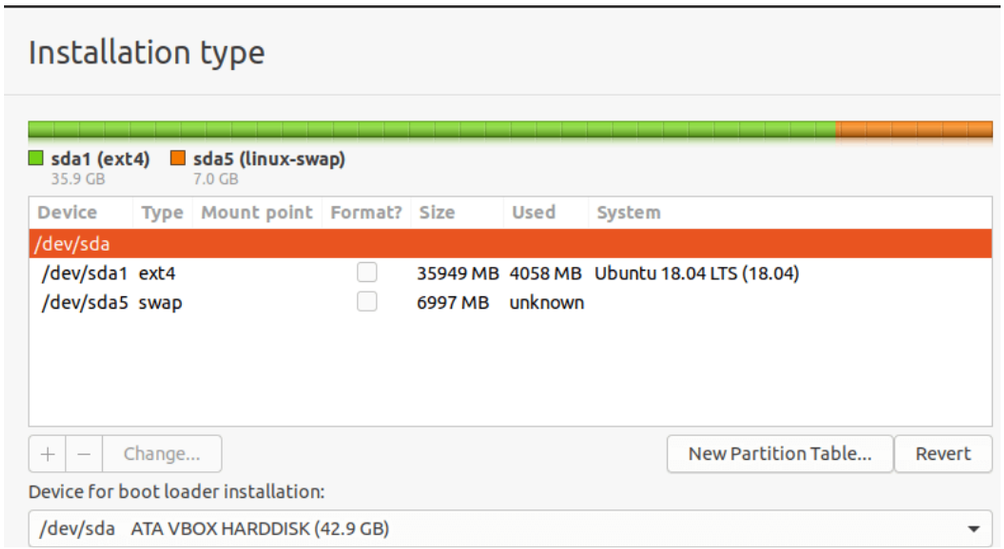
Section 3 :Use already created Partition Hard drive (with an existing OS installed)

1. For this scenario, you will use the existing partitions, choose **Something** else and click **Continue**.

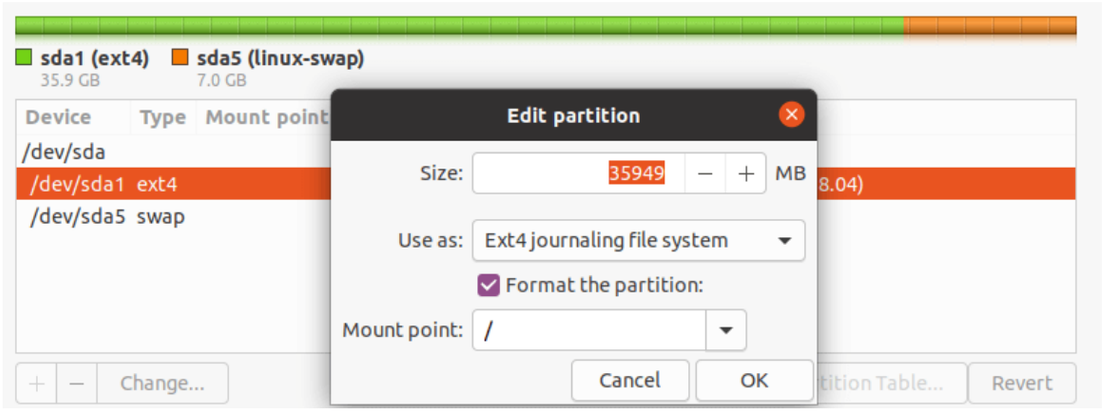


2. Then you should see your existing partitions for example, as shown in the following screenshot. Doubleclick on the partition with the previous OS installation, **Ubuntu 18.04** in our case.

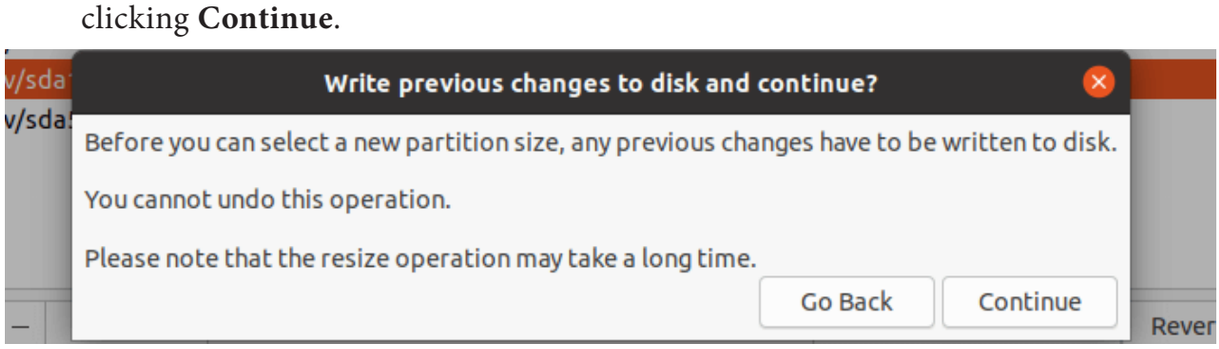
z_XI_EM_ELEC_EQUIP_PRACTICALS_2022.indd 238 12/29/2022 6:54:21 PM



3. Next, edit the partition and set the file system size, file system type to **Ext4**, and then check the format option and set the mount pointto `root(/)`.

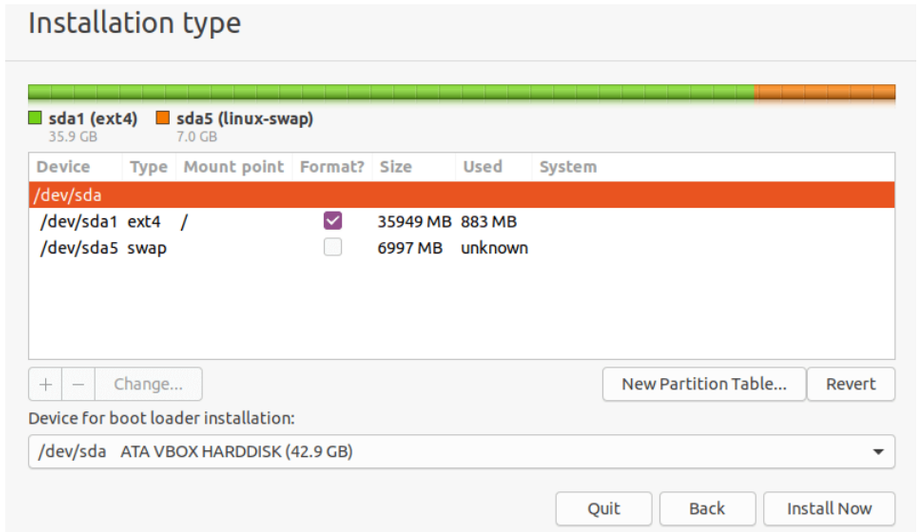


4. Accept the changes in the hard drive partition table, in the next pop-up window by clicking **Continue**.

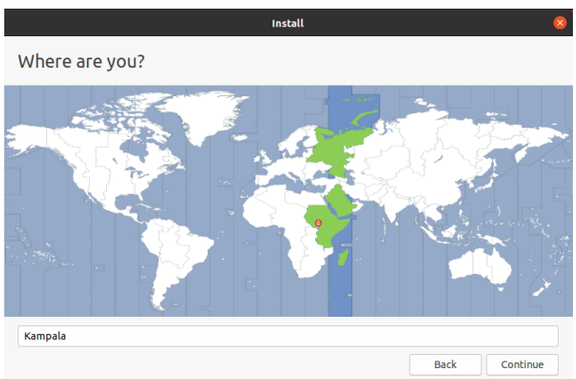


5. Now you should have a root and swap partition as shown in the following screenshot. Note that the swap partition will be auto-detected by the installer. So click Install Now to proceed.

z_XI_EM_ELEC_EQUIP_PRACTICALS_2022.indd 239 12/29/2022 6:54:21 PM

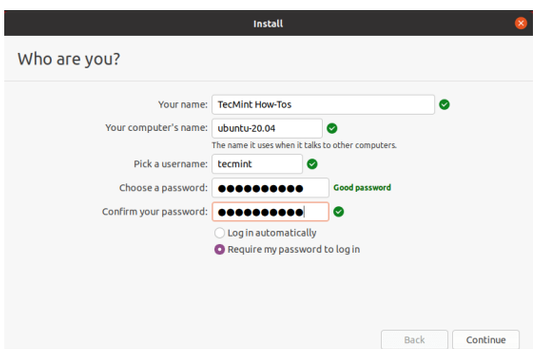


6. Next, select your **location** and click **Continue**

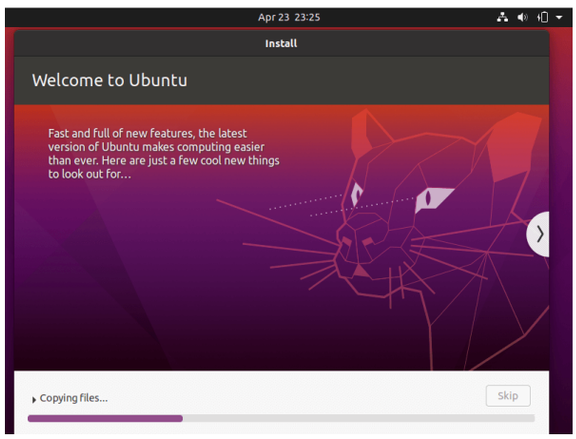


Section 4 :Create User Account

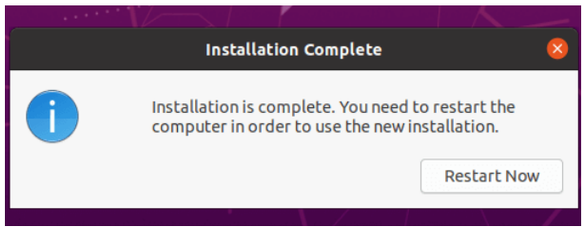
1. Provide your user details for system account creation. Enter your full name, computer name and username, and a strong, secure password as shown in the following screenshot. Then click Continue.



2. Now the actual base system installation will begin as shown in the following screenshot. Wait for it to finish.



3. Once the system installation is complete, **reboot** your system by clicking **Restart Now**. Remember to remove the installation media, otherwise, the system will still boot from it.



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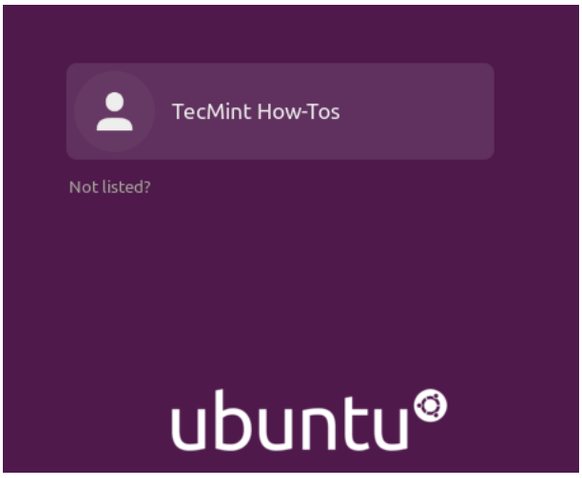
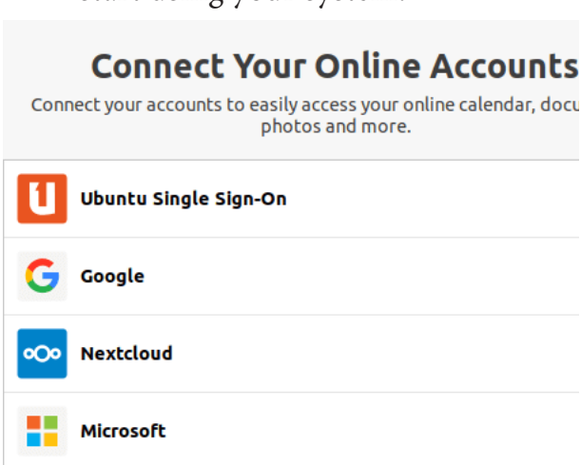
4. After the restart, click on your name from the interface below

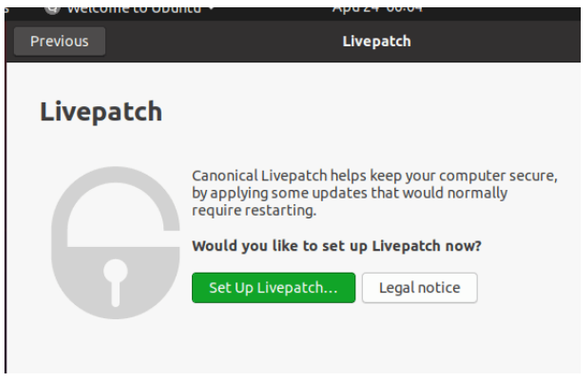


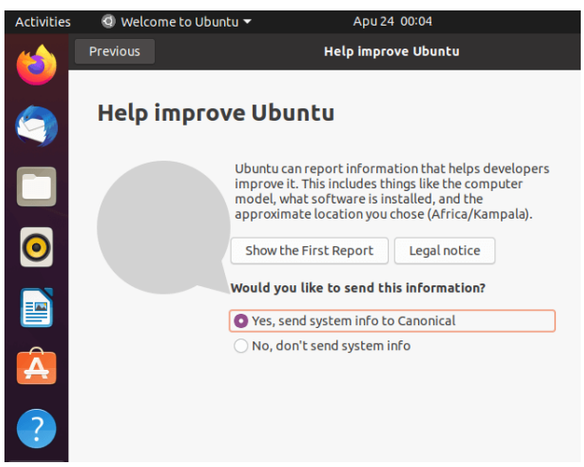
5. Then log into your new **Ubuntu 20.04** installation by providing the correct password you entered during the user creation step.

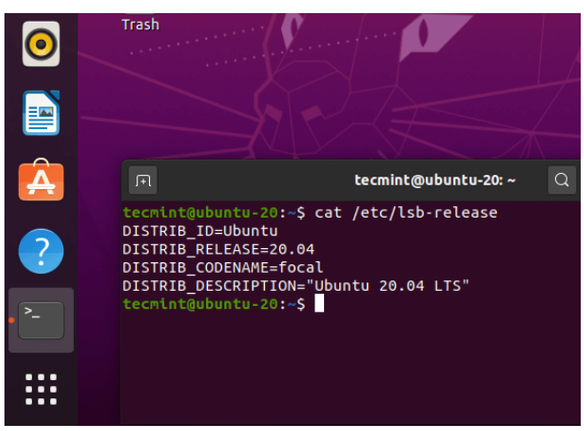
Then log into your new **Ubuntu 20.04** installation by providing the correct password you entered during the user creation step.

6. After login, follow the on-screen instructions to connect to online accounts (or skip), set up Livepatch (or click Next), accept the option to send usage information to Canonical (or click Next), then one you see Ready to go, click Done to start using your system.









7. Installed **Ubuntu 20.04 LTS** on your computer

RESULT:

Thus, the installation process of Ubuntu Linux is clearly understood.

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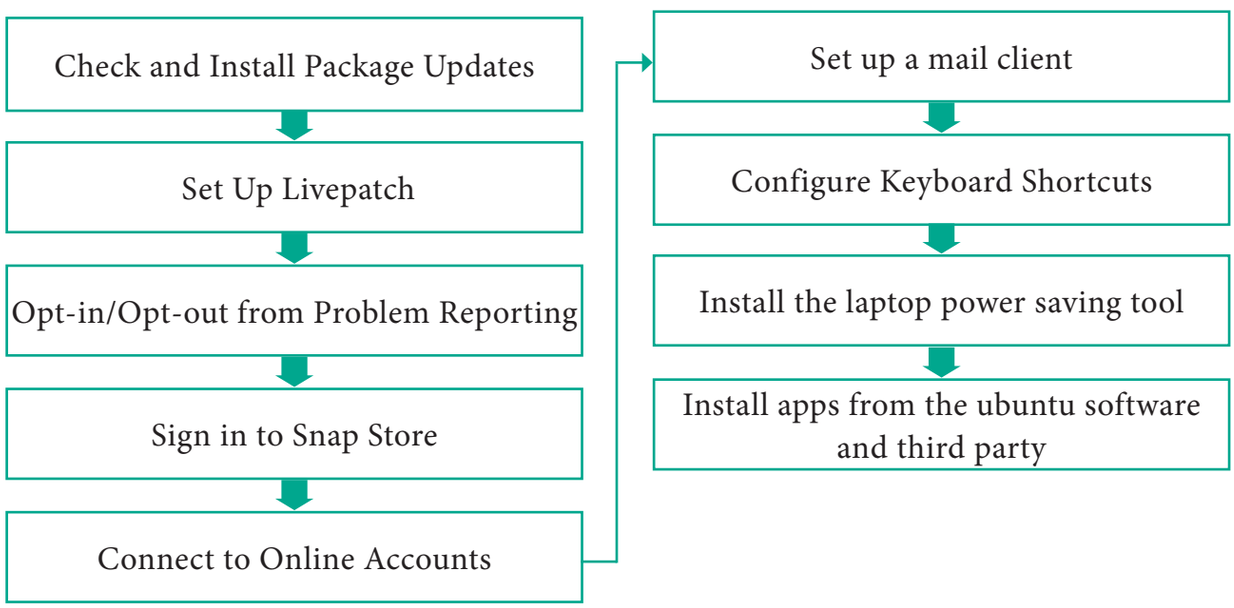
17 POST INSTALLATION PROCESS OF UBUNTU LINUX SERVER

AIM:

To understand the post installation process of Ubuntu Linux server

Procedure flow diagram :



Tools and equipment required :

Activity title	S.No	Name of the apparatus / Components	Range/Value	Quantity
Post Installation of Ubuntu Linux	1	Operating system	Ubuntu linux	1
	2	Digital computer	I3 or I5 processor based system 64 bit	1
	3	Key board	108 keys	1
	4	Mouse	Optical	1
	5	Monitor	LCD	1

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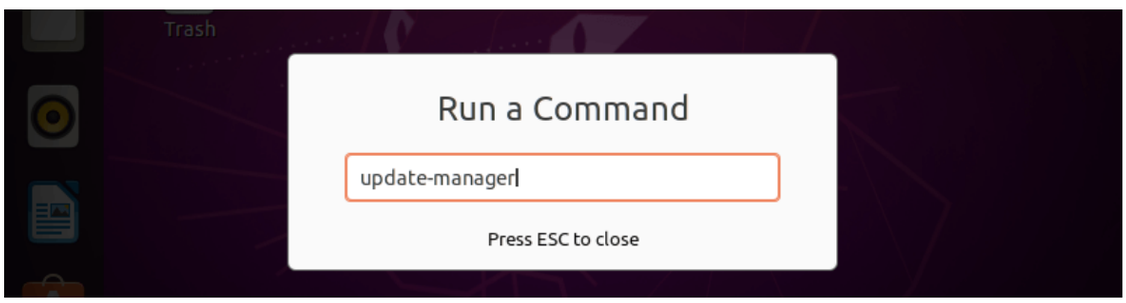
Procedure:

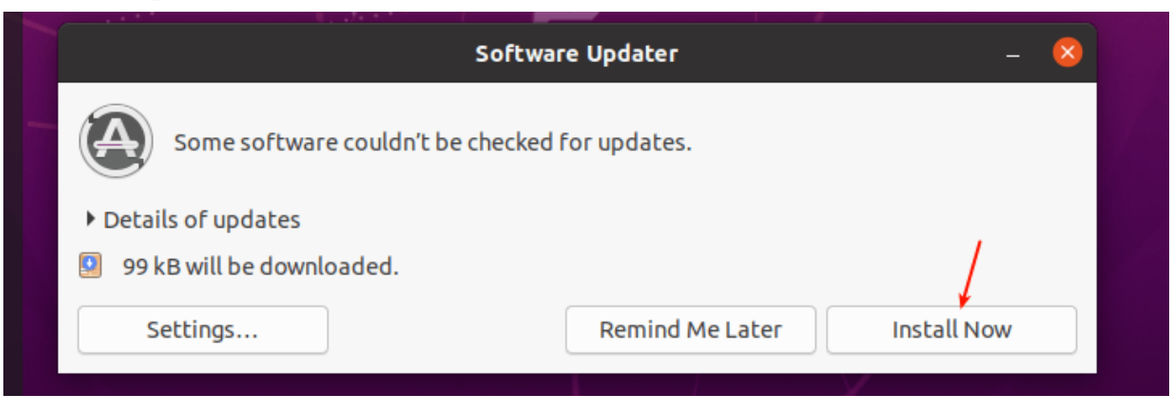
SECTION 1. Check and Install Package Updates

The first step is to check and install updates to keep your computer's software up to date. This is the single most important task you need to do to protect your system.

To install updates, open the **Update Manager** by pressing 'Alt+F2', then enter '**update-manager**' and hit **Enter**.



After the **Update Manager** opens up, if there are updates to be installed, you can review and select pending updates and also check for new updates. Click the '**Install Updates**' button to upgrade the selected packages, you will be prompted to enter your password, provide it to proceed.



Alternatively, open a terminal window and simply run the following commands.

$ sudo apt-get update && sudo apt-get dist-upgrade

Note that **Ubuntu** will keep notifying you for security updates and non-security updates on a daily and weekly basis respectively. You can also configure your system to automatically install updates, under the **Update Manager**.

SECTION 2. Set Up Live patch

Live patch (or **Canonical Live patch Service**) enables Ubuntu users to apply critical kernel patches without rebooting. This also helps to keep your system secure by applying security updates without a system restart. It is free for personal use with up to 3 machines. To enable it, all you need is an **Ubuntu One** account.

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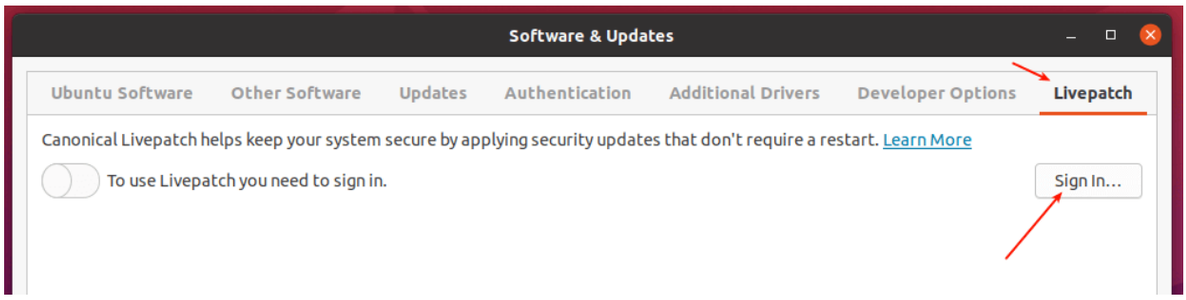
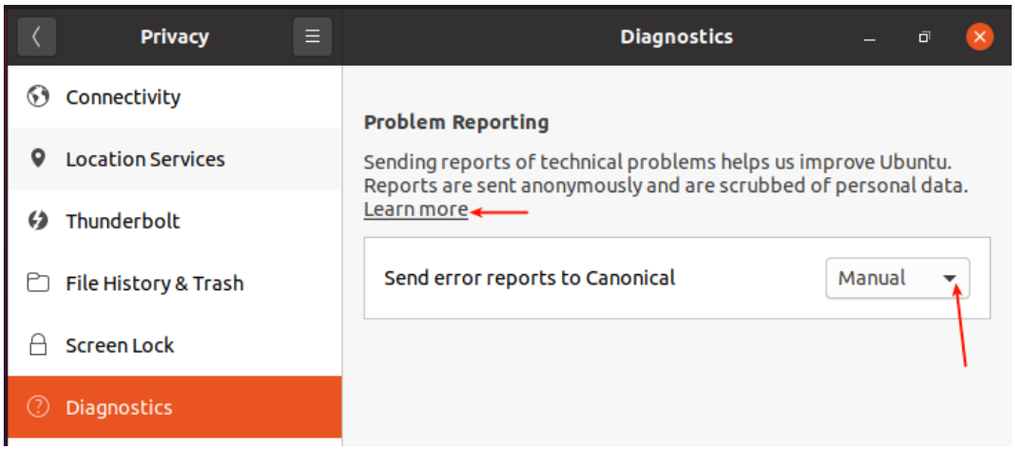
Go to **Activities**, search for **Live patch** and open it, or simply open **Software & Updates** and click on the **Live patch** tab. If you have an **Ubuntu One** account, simply **Sign in**, otherwise create one.



SECTION 3. Opt-in/Opt-out from Problem Reporting

Canonical uses reports of technical problems to help improve Ubuntu. You can choose to send error reports to the Ubuntu developers or not. To edit the settings, click on **Activities**, search and open **Settings**, then go to **Privacy**, then **Diagnostics**.

By default, sending error reports is configured to be done Manually. You can also choose **Never** (not to send at all) or **Automatic** (so that the system keeps sending error reports automatically every time they happen).



SECTION 4. Sign in to Snap Store

If you have a **Snap Store** account, you can get access to private snaps, from app developers. Alternatively, use your **Ubuntu One** account to sign in. But you do not need an account to install public snaps.

To sign into **Snap Store**, open **Ubuntu Software**, click on the **menu** option, then click on **Sign in**.

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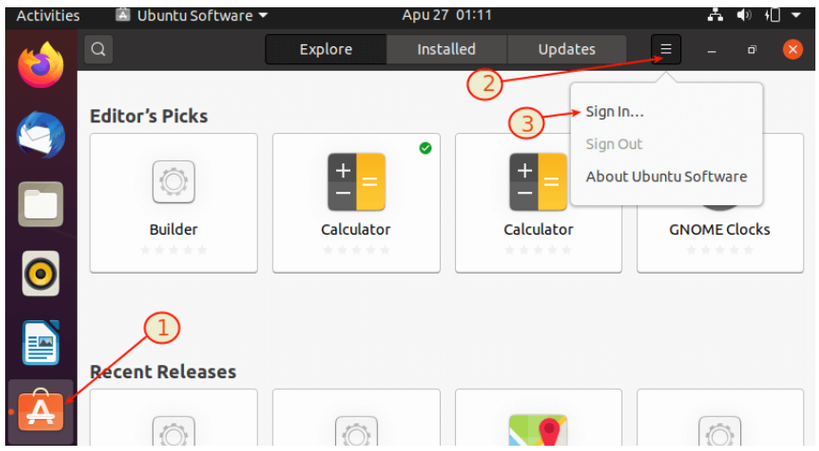
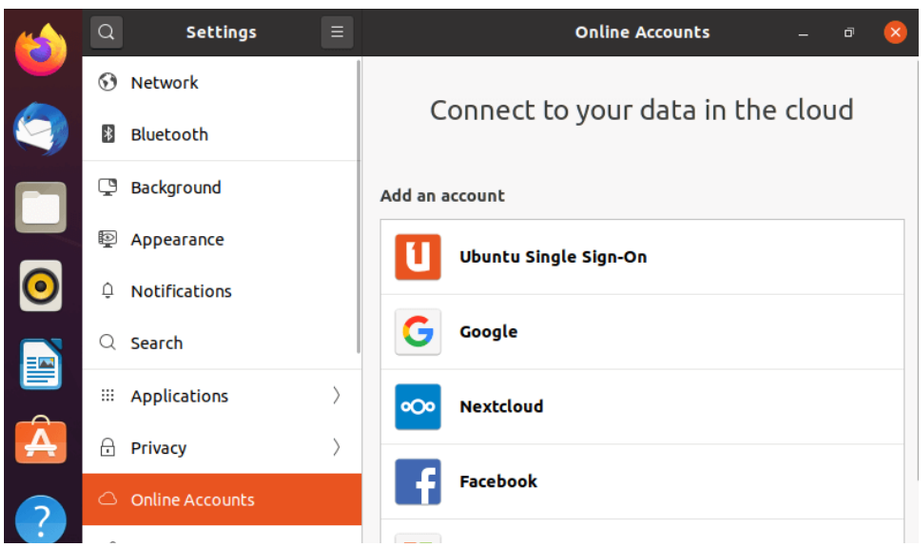


SECTION 5. Connect to Online Accounts

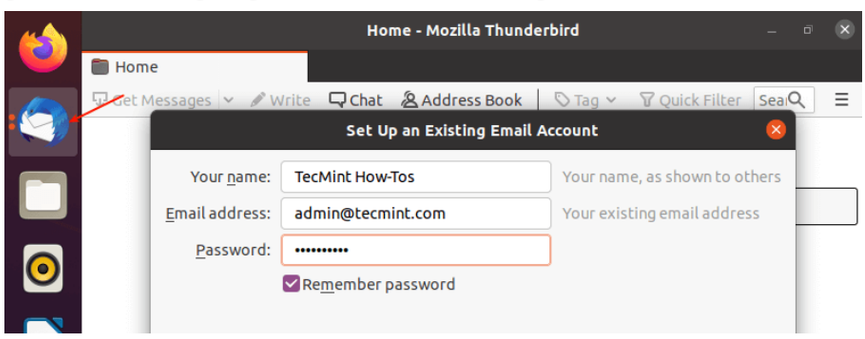
Next, sign in to your online accounts to enable you to connect to your data in the cloud. Go to **Activities**, search and open **Settings**, then click on **Online Accounts**.



SECTION 6. Set Up a Mail Client

By default, **Ubuntu** ships with **Thunderbird** Mail application, which offers cutting edge features such as speed, privacy, and latest technologies.

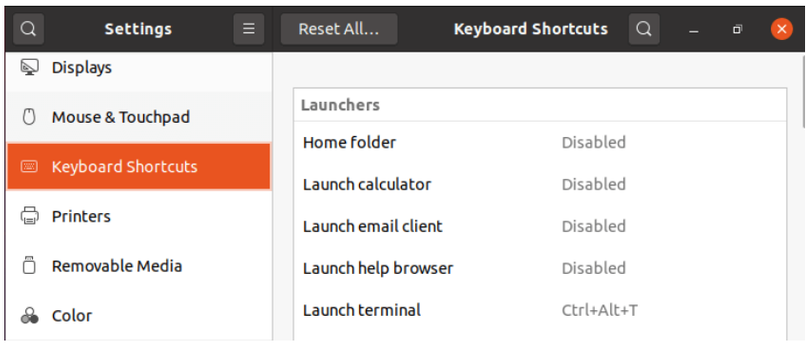
To open it, click on the **Thunderbird** icon and set up an existing email account or do a manual configuration as highlighted in the following screenshot.



z_XI_EM_ELEC_EQUIP_PRACTICALS_2022.indd 245 12/29/2022 6:54:22 PM

SECTION 7. Configure Keyboard Shortcuts

Using **keyboard** shortcuts can increase your productivity and save you lots of time when using a computer. To set your keyboard shortcuts, under **Settings**, simply click on **Keyboard Shortcuts**.



SECTION 8. Install Laptop Power Saving Tools

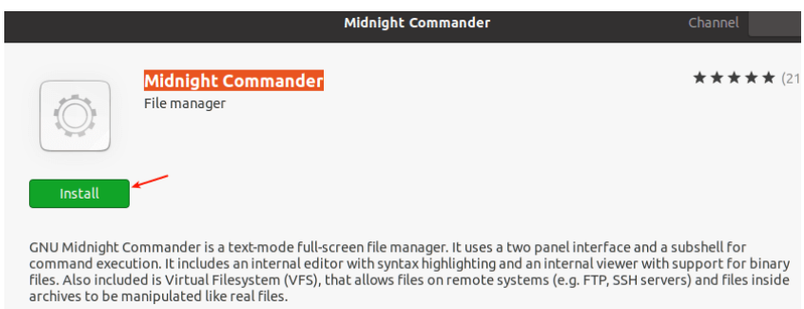
If you are using a laptop, then you might want to install **Laptop Mode Tools**, a simple and configurable laptop power-saving tool for Linux systems. It helps to extend your laptop's battery life in so many ways. It also allows you to tweak some other power-related settings using a configuration file.

```
$ sudo apt install laptop-mode-tools
```

SECTION 9. Install Apps from the Ubuntu Software and Third-party

Last but not least, go ahead and install more software that you intend to use. You can do this from the **Ubuntu Software** (or install apps from third-party repositories).

Simply open the **Ubuntu Software** and use the search feature to find the software you want. For example, to install midnight commander, click on the search icon, type its name, and click on it.



RESULT:

Thus the post installation process of Ubuntu Linux server is understood.

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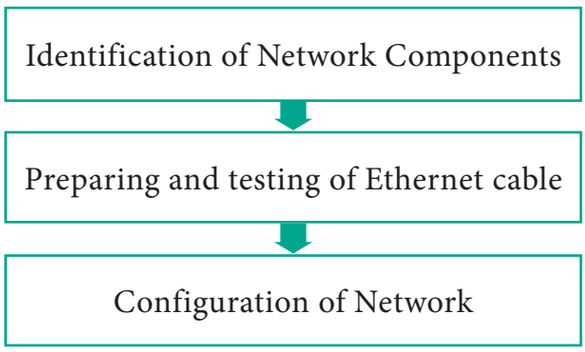
18 NETWORKING

Aim:

1. To learn how to identify the network components.
2. To learn the method to prepare and test the Ethernet cable
3. To understand steps of configuring the network

Procedure flow diagram :



Tools and equipments required:

Activity	S. No.	Name of the equipments	Range	Value
Identification of network components	1	Network Port	RJ 45	1
	2	Routers		1
	3	Repeaters		1
	4	Hub		1
	5	Switch		1
	6	Network Interface Cards		1
	7	Bridges		1
Preparation and testing of ethernet cables	9	Unshielded twist pair	CAT 5e / CAT 6e	1
	10	Modular connector		1
	11	Crimping tool		1
	12	Cable tester		1

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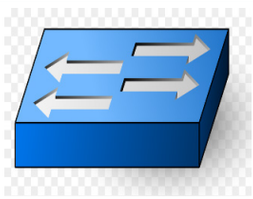
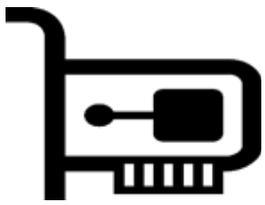
PROCEDURE :

Section – 1 :

Identification of Network Components

S. No.	Network Component	Function	Diagram	Symbols
1	Network cable	Network cables are used to connect and transfer data as well as information between computers, routers, switches and storage area networks.	 L	-
2	Routers	Receives and sends data on computer networks		
s3	Repeaters	It receives signal and transmits and also it covers long distance.		
4	Hub	Used to connect multiple devices in a network. They are used to connect computer in LAN.		
5	Switch	Used to send, receive and forward the data through network.		
6	Network Interface Cards	It provides full time connection to a network. It enables network connection for the devices.		
7	Bridges	Used to interconnect two LANs that are operating two different networking protocols		

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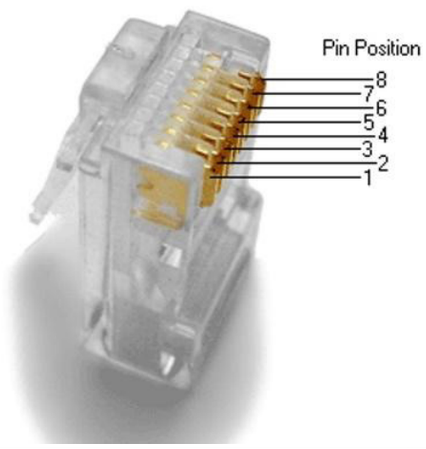
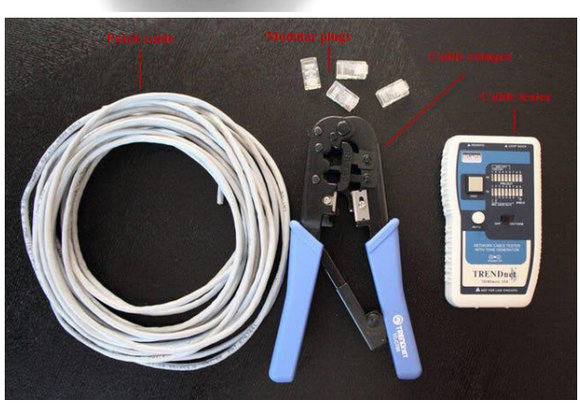
Section – 2

Preparing and testing of Ethernet cable

There are four pairs of wires in an Ethernet cable, and an Ethernet connector (8P8C) has eight pin slots. Each pin is identified by a number, starting from left to right, with the clip facing away from you.

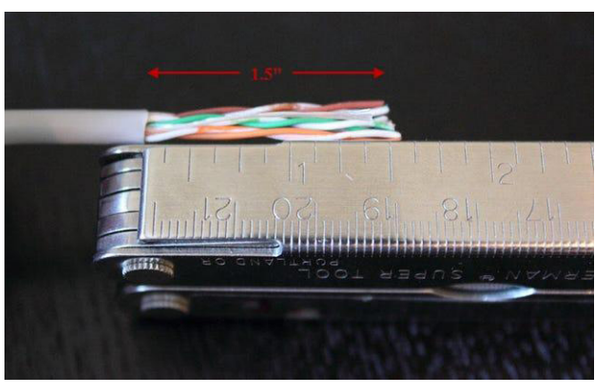




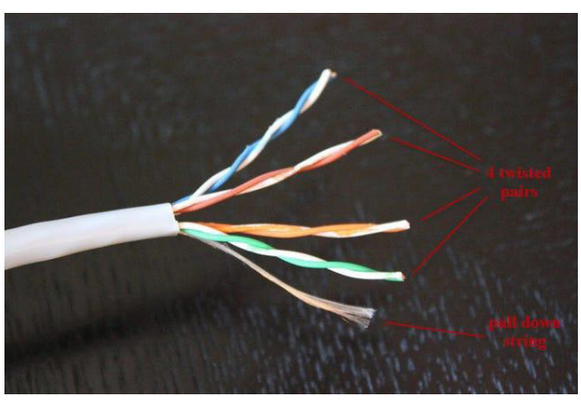
The two standards for wiring Ethernet cables are T568A and T568B. T568B is the most common and is what we'll be using for our straight Ethernet cable. The tables below show the proper orientation of the coloured wires to the pins.

Pin Range	T568A Standard Colours	T568B Standard Colours
Pin 1	White/Green	White/Orange
Pin 2	Green	Orange
Pin 3	White/Orange	White/Green
Pin 4	Blue	Blue
Pin 5	White/Blue	White/Blue
Pin 6	Orange	Green
Pin7	White/Brown	White/Brown
Pin 8	Brown	Brown

Step 1: Strip the cable jacket about 1.5 inch down from the end.



Step 2: Spread the four pairs of twisted wire apart. For Cat 5e, you can use the pull string to strip the jacket farther down if you need to, then cut the pull string. Cat 6 cables have a spine that will also need to be cut.



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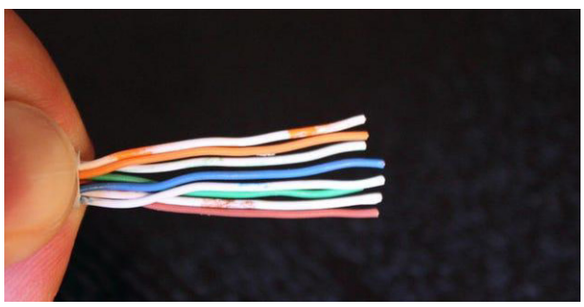
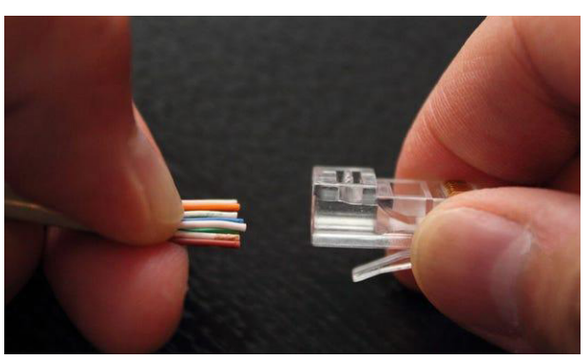
Step 3: Untwist the wire pairs and neatly align them in the T568B orientation. Be sure not to untwist them any farther down the cable than where the jacket begins; we want to leave as much of the cable twisted as possible.



Step 4: Cut the wires as straight as possible, about 0.5 inch above the end of the jacket.

Step 5: Carefully insert the wires all the way into the modular connector, making sure that each wire passes through the appropriate guides inside the connector.



Step 6: Push the connector inside the crimping tool and squeeze the crimper all the way down.

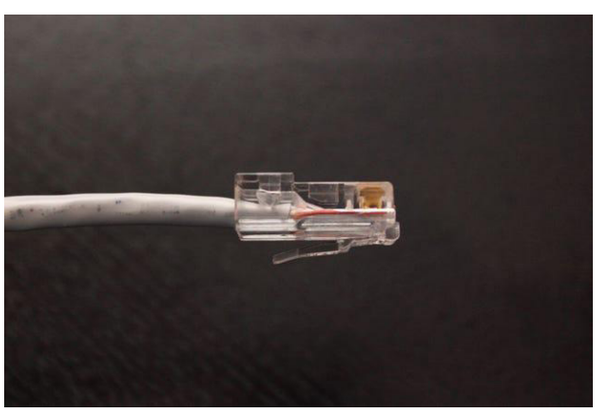


Step 7: Repeat steps 1-6 for the other end of the cable.

Step 8: To make sure you've successfully terminated each end of the cable, use a cable tester to test each pin.



When you're all done, the connectors should look like this:



That's it. For crossover cables, simply make one end of the cable a T568A and the other end a T568B. Now you can make Ethernet cables of any length, fix broken connectors, or make yourself a crossover cable.

Section – 3

Configuration of Network.

How to Setup or Configure LAN Internet Connection to Laptop or Desktop PC

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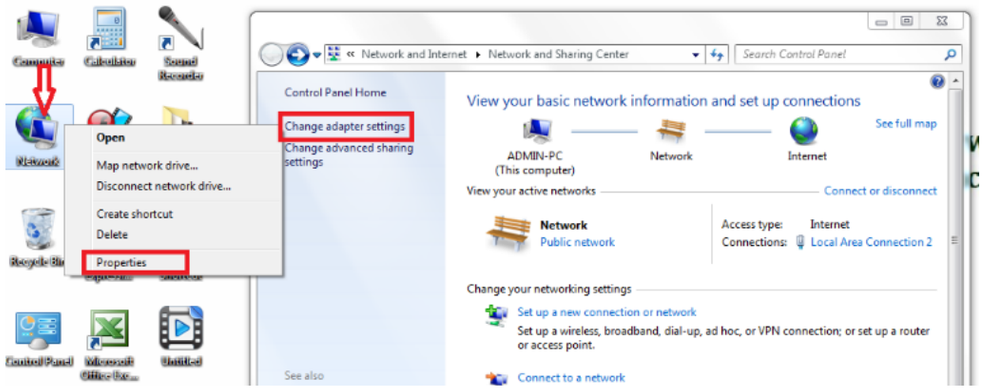
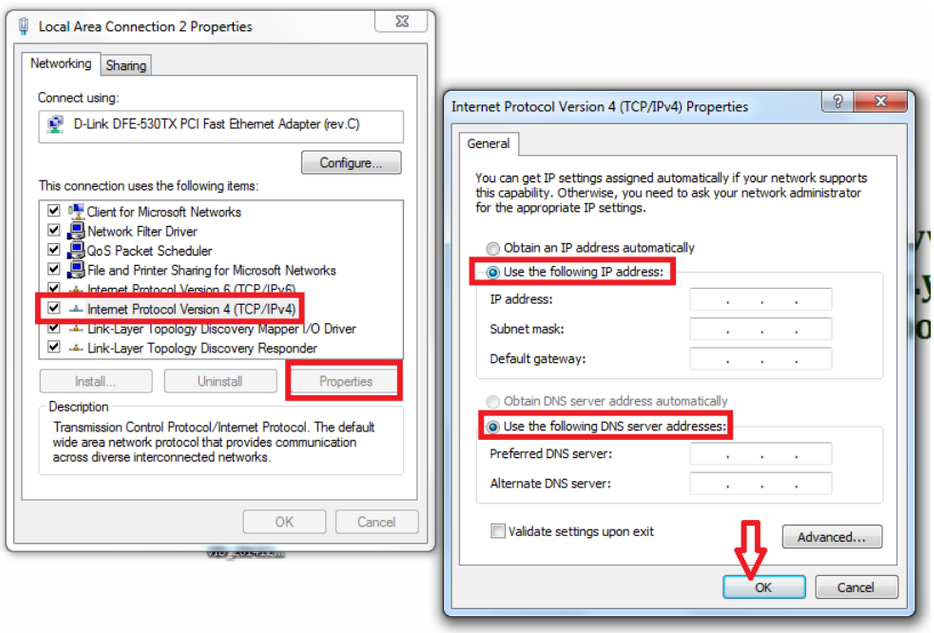


1. Connect internet LAN cable into your laptop or desktop LAN port
2. In your desktop screen right click on "Network" – "Properties" – and click on "change adapter settings"
3. Now Right click on "Local Area Connection" – "Properties"
4. Select "Internet Protocol Version 4 (TCP/IPv4)" and click on "Properties"



5. Check on "Use the following IP Address" and fill your IP given by internet service provider, if you don't know! ask IP to service provider.
6. After fill up click "Ok" and open login page of internet connection (if you don't know ask service provider) and enter your username and password than click on "login or submit".

RESULT

Thus, I understood how to identify the different network components, prepare and test the ethernet cables and configure the network.

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