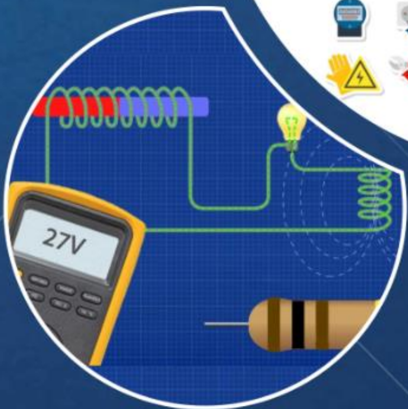
Draft Study Material

JUNIOR FIELD TECHNICIAN HOME APPLIANCES

(Job Role)

(Qualification Pack: Ref. Id. ELE/Q3117)
Sector: Electronics

(Grade IX)



PSS CENTRAL INSTITUTE OF VOCATIONAL EDUCATION
(a constituent unit of NCERT, under Ministry of Education, Government of India)
Shyamla Hills, Bhopal - 462 002, M.P., India

Preface

Vocational Education is a dynamic and evolving field, and ensuring that every student has access to quality learning materials is of paramount importance. The journey of the PSS Central Institute of Vocational Education (PSSCIVE) toward producing comprehensive and inclusive study material is rigorous and time-consuming, requiring thorough research, expert consultation, and publication by the National Council of Educational Research and Training (NCERT). However, the absence of finalized study material should not impede the educational progress of our students. In response to this necessity, we present the draft study material, a provisional yet comprehensive guide, designed to bridge the gap between teaching and learning, until the official version of the study material is made available by the NCERT. The draft study material provides a structured and accessible set of materials for teachers and students to utilize in the interim period. The content is aligned with the prescribed curriculum to ensure that students remain on track with their learning objectives.

The contents of the modules are curated to provide continuity in education and maintain the momentum of teaching-learning in vocational education. It encompasses essential concepts and skills aligned with the curriculum and educational standards. We extend our gratitude to the academicians, vocational educators, subject matter experts, industry experts, academic consultants, and all other people who contributed their expertise and insights to the creation of the draft study material.

Teachers are encouraged to use the draft modules of the study material as a guide and supplement their teaching with additional resources and activities that cater to their students' unique learning styles and needs. Collaboration and feedback are vital; therefore, we welcome suggestions for improvement, especially by the teachers, in improving upon the content of the study material.

Deepak Paliwal
(Joint Director)
PSSCIVE, Bhopal

Date: 06 September, 2024

STUDY MATERIAL DEVELOPMENT COMMITTEE

Members

Deepak D. Shudhalwar, Professor (CSE), Head, Department of Engineering and Deepak D. Shudhalwar, Professor (CSE), Head, Department of Engineering and Technology, PSSCIVE, NCERT, Bhopal, Madhya Pradesh

Kavita Kamerikar, Assistant Professor Telecom (Contractual), Department of Engineering and Technology, PSSCIVE, NCERT, Bhopal

Rita Jain, Professor in Electronic and Communication, LNCT, Bhopal and Director (COI IOT), Workspace, Bhopal

Member Coordinator

Deepak D. Shudhalwar, Professor (CSE), Head, Department of Engineering and Technology, PSSCIVE, NCERT, Bhopal, Madhya Pradesh

Table of Contents

Module 1 Fundamentals of Electrical and Electronics

Module Overview

This Module is designed to provide a foundational understanding of key concepts essential for anyone working in the field of electrical and electronics devices and appliances. Throughout this unit, important topics are covered like roles and responsibilities of a Junior Field Technician in Home Appliances, the basics of electrical and electronics circuits, fundamental concepts of LED technology, and the essential tools, equipment, and measuring instruments used in the industry.

The unit begins with an exploration of the vital role played by Junior Field Technicians in the maintenance and troubleshooting of home appliances. Some insights are given in this unit about the responsibilities involved in ensuring the smooth functioning of various household devices and appliances, understanding the working of their electrical and electronic systems, and addressing common issues that may arise.

Moving on, the unit covers the basics of electrical circuits, providing the understanding of the fundamental principles that govern the flow of electrical current, circuit components, circuit analysis techniques, and the laws that govern electrical circuits.

The unit then extends to the field of electronic circuits, where the core concepts of basis of electronic devices are covered. The basic electronic components like resistor, capacitor, inductor is covered here. This unit provides basic knowledge about working of semiconductor devices like PN junction diodes, LED, transistors, integrated circuits including their applications.

To complement the theoretical knowledge, the unit covers the practical aspect of the field technician by exploring the various tools, equipment, and measuring instruments used by professionals in the field of electrical and electronics circuits. This hands-on approach will enhance the skills in handling and utilizing the tools of the trade effectively.

Learning Outcomes

After completing this module, you will be able to:

- Identify and describe the key duties, responsibilities, and workplace expectations of a junior field technician in technical support and maintenance roles.
- Understand the fundamental principles of electrical circuits, including voltage, current, resistance, and their relationships within series and parallel circuits.
- Explain the essential components and functions of electronic circuits, including diodes, transistors, capacitors, and their roles in modern electronics.
- Demonstrate the correct use of tools, equipment, and measuring instruments for diagnosing and troubleshooting electronic and electrical systems.

Module Structure
Session 1: Roles and Responsibilities of Junior Field Technician
Session 2: Basics of Electrical Circuits
Session 3: Basics of Electronics Circuits
Session 4: Tools, Equipment and Measuring Instruments

Session 1: Roles and Responsibilities of Junior Field Technician

The electronics industry is the sector that produces electronic devices. It emerged in the 20th century and is today one of the largest global industries. Contemporary society uses a vast array of electronic devices built-in automated or semi-automated factories operated by the industry.

Electronics industry, the business of creating, designing, producing, and selling devices such as radios, televisions, stereos, computers, semiconductors, transistors, and integrated circuits etc. The electronics industry transformed factories, offices, and homes, emerging as a key economic sector that rivalled the chemical, steel, and auto industries in size.

The electronics sector produces electronic equipment and consumer electronics and manufactures electrical components for a variety of products. Common items in the electronics sector include mobile devices, televisions, and circuit boards. Industries within the electronics sector include telecommunications, networking, electronic components, industrial electronics, and consumer electronics.

1.1. Growth in the Electronics Sector

The electronics sector is growing rapidly as a result of increasing demand from emerging market economies. As a result, many countries are increasingly producing more electronics, and investment in the foreign production of electronics has increased dramatically.

Electronics sector growth is accelerated by increased consumer spending around the world. As developing economies grow, consumer demand for electronics also grows. Countries that produce electronics now have strong consumer bases that can afford new electronic products. At the same time, increased competition is driving the costs of electronics production down, making products even cheaper for individuals.

The supportive role of the electronics sector in providing equipment and components for other industries is also a factor of growth as consumers demand more automobiles, energy-efficient homes, and medical technologies.

1.2 Application of Electronics in Different Fields

The various electronics applications are

Consumer Electronics – The devices and equipment meant for daily use are known as customer electronics; this industry is widely applicable to the common people. Some of its applications included office gadgets like computers, scanners, calculators, FAX machines, projectors etc.

It also includes home appliances like washing machines, refrigerators, microwaves, TVs, vacuum cleaners, video games, loudspeakers etc. and some advanced storage devices such as HDD jukebox, DVDs etc. The Figure 1.1 given below shows the various products of consumer electronics field.

Fig. 1.1: Consumer Electronics

Industrial applications of electronics – Electronics engineering has a huge impact on the smooth functioning of the industries as it is used in various systems, grids and processing units. For example, smart electric systems collect information from the communication technology department, and several machines use automation and motor control systems using electronics; also, it is used in extracting 3D images from 2D using image processing systems. The electronic equipment used in industries are shown below in Figure 1.2.

Fig. 1.2: Industrial applications

Robotics and artificial intelligence – Apart from image processing that involves computer graphics, electronic systems are also used in artificial intelligence and robotics technologies for inspection, navigation and assembly. Virtual reality and face gesture recognition are computer-based, and these developments have been possible because of electronics engineering. The use of these technologies is shown below in Figure 1.3.

Fig. 1.3: Robotics industry application

Medical applications – For data recording and physiological analysis, advanced, sophisticated instruments are being developed using the latest technologies and electronics engineering, and these instruments are very useful in diagnosing diseases and for healing purposes.

Electronics play a vital role in the functioning of medical instruments; for instance, the stethoscope is used to listen to the inner sounds of the human or animal body, a glucose meter for checking sugar levels, a pacemaker for dropping and increasing heartbeat count and so on. Different types of applications are shown in Figure 1.4.

Fig. 1.4: Medical applications

Defence and Aerospace – Electronics technology has been used extensively in the defence and aeronautical systems, which include missile launching systems, cockpit controllers, military radars, aircraft systems, rocket launchers for space and many more. These applications are depicted in the given Figure 1.5.

Fig.1.5: Defence and Aerospace applications

Automobiles – Electronics are widely used in the latest automobile technologies, like anti-collision units, anti-lock braking systems, traction controls, window regulators and several electronic control units. Use of electronics in the automobile sector can be easily understood by the Figure 1.6 given below.

Fig.1.6: Automobiles applications

1.3 Size and Scope of Electronic Industry

The electronics sector appears to be overgrowing, owing to increased demand from developing countries. Before the virus outbreak, due to increased demand, electronics production skyrocketed, accompanied by a surge in investment.

The global electronic products market is expected to be worth nearly $1,191.2 billion in 2020, with a Compound Annual Growth Rate (CAGR) of 5.4 percent since 2015. The increase is primarily due to the increasing demand for various electronic products as employees and students have transitioned to online.

Consumer Electronics Market size was valued at over USD 1 trillion in 2020 and is estimated to grow at a CAGR of more than 8% from 2021 to 2027. Rapidly increasing internet penetration across the globe will drive the market growth.

Consumer electronics are electronic equipment for non-commercial use. Consumer electronics include devices that provide one or more functionalities such as computers, laptops, mobile devices, smart wearables, television sets, refrigerators, smartphones, and home appliances.

Continuous investments by market players in R&D for the development of new consumer electronic products with enhanced features will fuel the industry growth of consumer electronics.

Regardless of its merits, the electronic industry faces disruptive forces that will test its business model and ability to survive and thrive.

The global electronic industries are the fastest-growing sector, worth trillions of dollars, and play a critical role in driving consumers to purchase innovative and smart electronic products. The global market for electronic components is expected to grow at a compound annual growth rate (CAGR) of about 4.8 percent from 2020 to 2025.

Electronic industries have always been at the forefront of the most recent technological innovations to reduce costs and improve efficiency with such a large future market potential. Many SMEs have found it challenging to keep up with the trends/changes as technology has advanced faster.

For example, top players such as Apple, Samsung, Microsoft, and Intel, to name a few, are investing heavily in new cutting-edge technology to expand their technological capabilities and remain competitive. They are the leading example of an IR4.0 (industrial Revolution 4.0) Eco-friendly system.

The integration of digital tools and technologies has increased revenue and productivity, improved product quality, reduced waste, and operational costs, and met the most recent customer/global demands.

1.4 Recent Trends in Electronic Industry

Here are some predictions for the specific trends that are likely to have the most significant impact in 2022. The most important trends in 2022 will likely focus on the convergence of technology trends as tools emerge that let us combine them in new and amazing ways. The Figure 1.7 below shows different trends in the electronic industry nowadays.

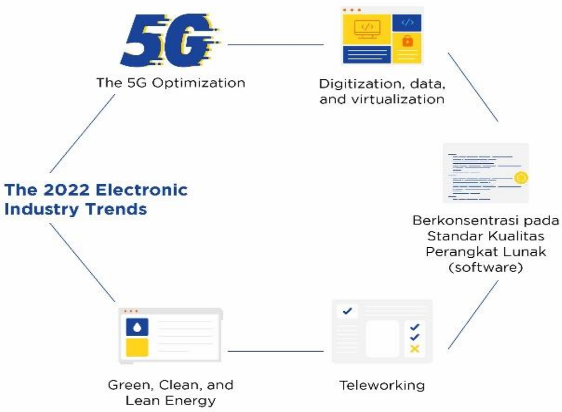


Fig. 1.7: Trends in electronics industry

1.5G Optimization – 5G is laying the groundwork for a fully digitalized and connected world. We have seen many new field trials and an increasing number of commercial rollouts over the last two years. Furthermore, we are seeing 5G being adopted in various industries, ranging from manufacturing to healthcare. (Figure 1.8)

With its high output and ultralow latency, 5G can access many high-value areas such as 3D robotic control, virtual reality monitoring, and remote medical control that previous technologies could not. 5G is redefining and accelerating industries like automotive, entertainment, computing, and manufacturing. It will eventually change the way we work and live.

Fig. 1.8: 5G Optimization

2.Digitization, data, and virtualization – Many of us witnessed the virtualization of our offices and workplaces in 2020 and 2021, as remote working arrangements were quickly implemented. This was simply a crisis-driven acceleration of a much longer-term trend. In 2022, we'll be more familiar with the concept of a **"metaverse"** - persistent digital worlds that exist alongside the physical world we live in. (Figure 1.9).

Fig. 1.9: Digitization, data, and virtualization

3.Concentrate on Software Quality Standards – The focus on quality will be the trend for 2022 and beyond. Software solutions will be integrated into our daily lives and the majority of the goods and appliances we use. (Figure 1.10) As a result, software must meet the quality standards of the manufacturing industry.

Fig. 1.10: Concentrate on Software Quality Standards

4.Teleworking – Teleworking will continue to grow in 2022, bringing advances in software development. Companies worldwide will need to support hybrid forms of team management and collaboration to increase the productivity of their workforces. (Figure 1.11) As the trend of conducting online meetings and video sales calls continues, this new standard will grow even more in 2022.

Fig. 1.11: Teleworking

5.Green, Clean, and Lean Energy – Renewable energy was the only type of energy that saw an increase in use during the pandemic. As industries shut down and people stayed at home, global non-renewable energy consumption decreased, resulting in an 8% reduction in emissions. As a result, increased investment in renewable energy generation is expected in the coming years.

According to the International Energy Agency (IEA), 40% more renewable energy was generated and used in 2020 than the previous year. This trend is expected to continue through 2022. (Figure 1.12) Overall, the cost of generating renewable energy from various sources, such as onshore and offshore wind, solar, and tidal, has decreased by

7 to 16%. This will be highly beneficial to countries and businesses attempting to meet emissions targets such as becoming carbon neutral or even carbon negative.

Fig. 1.12: Green, Clean, and Lean Energy

1.5 Futuristic Trends in Electronics Manufacturing

1. Advanced Materials – The semiconductor industry has been reliant on silicon for decades, but there is a limit to how far you can etch, lithograph, and pattern a silicon material. As a result, innovation to increase the performance of integrated circuits is coming from new materials and architectures. (Figure 1.13) Start-ups and scaleups are developing silicon alternatives and other semiconductor materials or composites for high performance and efficiency.

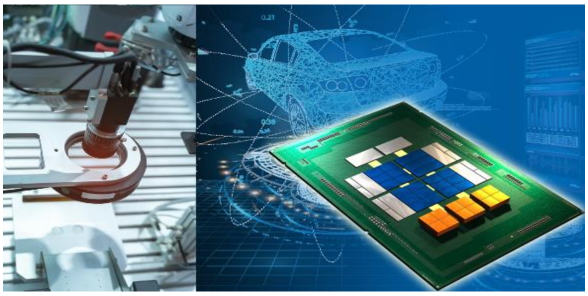


Fig. 1.13: Advanced Materials

2.Organic Electronics – Organic Electronics offer massive advantages over traditional inorganic electronics. They are cost-effective, flexible, indissoluble, optically transparent, lightweight, and consume low power. In addition, the rise in awareness for sustainable development and eco-friendly manufacturing attracts manufacturers to opt for organic electronics. (Figure 1.14) Designing circuits with microbial components or producing devices with biodegradable and recyclable materials is seen to be the next electronics manufacturing trend.

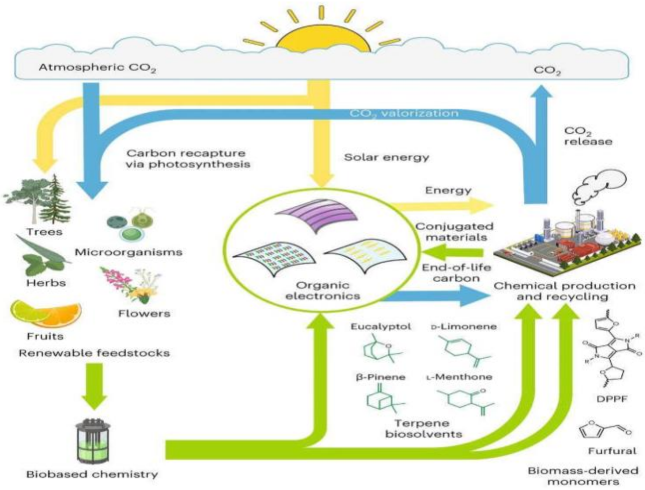


Fig. 1.14: Organic Electronics

3.Artificial Intelligence – AI-powered solutions are gaining popularity in every sector. AI impacts the growth of semiconductor manufacturing in two ways, one is by building demand for innovative AI-capable electronics components, and two, enhancing the product manufacturing and design processes. (Figure 1.15) The conventional methods have limitations to reshaping product development cycles, improving product design processes, and reducing defects. But the application of AI is solving all these limitations.

Fig. 1.15: Artificial Intelligence

4. Internet of Things – The rapid growth of the Internet of Things represents an unprecedented opportunity for the electronics manufacturing industry. It re-evaluates the fabrication process and manages practices that are found to be difficult to achieve with conventional approaches. In other ways, the IoT enables electronic manufacturing machines to self-process and store data while being digitally connected. Continuous improvements in the fabrication of sensors are also required since sensors are the key components that enable IoT applications. (Figure 1.16) Further, the transition to 5G-enabled devices requires flawless, innovative chips with more efficient architectures at lower costs.

Fig. 1.16: Internet of Things

5.Embedded Systems – Embedded systems are an unavoidable part of any electronic device nowadays and it has a crucial role in deciding the speed, security, size, and power of the devices. Since we are in the transition phase of a connected world, there is high demand for embedded systems. (Figure 1.17) So, the designing and manufacturing sector of such systems is undergoing numerous innovations to improve performance, security, and connectivity capabilities.

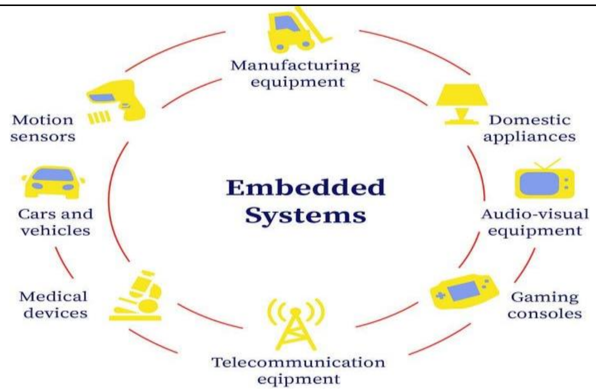


Fig. 1.17: Embedded Systems

6.Printed Electronics – Printing electronics components on a semiconductor substrate is the most effective way to reduce the overall cost of the manufacturing process. So, manufacturers are always trying to tackle this challenge by searching for new technologies and advancements in conventional printing technologies. (Figure 1.18) Unlike traditional semiconductors that use tiny wires as circuits, printed electronics rely on conductive inks and often flexible films. Further, the advancements in printing technologies allow the flexible hybrid electronics field to obtain enough momentum. Therefore, start-ups and scaleups are developing solutions for advanced printing technologies.

Fig. 1.18: Printed Electronics

7.Advanced IC Packaging – In recent years, chip packaging has become a hot topic along with chip design. The traditional way to scale a device based on Moore's law has limitations nowadays. The other way to get the benefits of scaling is to put multiple complex devices in an advanced package. (Figure 1.19) So, semiconductor manufacturers develop new advanced IC packaging technologies to provide greater silicon integration in increasingly miniaturized packages. This also enables manufacturers to offer customization and improve yields by vertically stacking modular components.

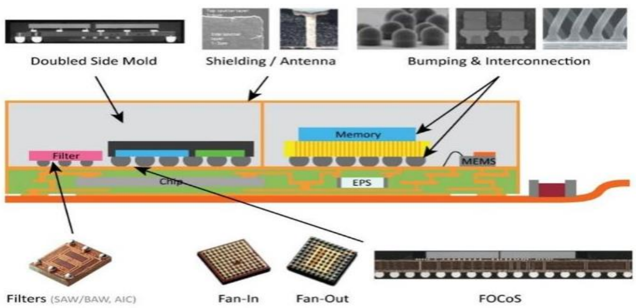


Fig. 1.19: Advanced IC Packaging

8.Additive Manufacturing – 3D Printing in electronics manufacturing eliminates the need for flat circuit boards. It enables new innovative designs and shapes that cannot be produced through conventional means. 3D printers also fabricate electronic components as a single, continuous part, effectively creating fully functional electronics that require little or no assembly. (Figure 1.20) Consequently, the implementation of this electronics manufacturing trend speeds up prototyping, offers mass customization, and decentralizes parts production.

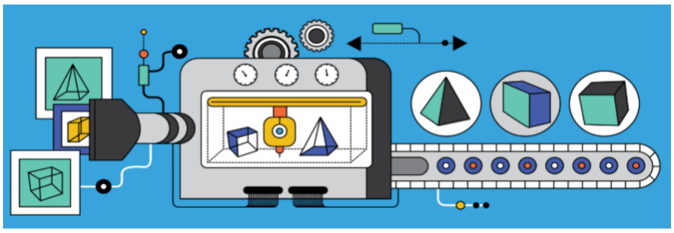


Fig. 1.20: Additive Manufacturing

1.6 Role and responsibilities of Junior Field Technician Home Appliances

Junior Field Technician Home Appliances identifies the cause of issues or malfunctions with household appliances and fixes them. They troubleshoot, disassemble, repair, and install a range of home appliances, such as LED bulbs, electric iron, fans, coolers and other comparable appliances. To install and fix these appliances, technicians require an understanding of fundamental electronic components as well as the use of power and hand tools.

The work of Junior Field Technician Home Appliances is dependent on the type of equipment they are skilled in, to install and provide support related to typical small home appliances. Technicians generally conduct site visits to install or repair these appliances. The individual at work is responsible for rectifying faults in the appliances at customers' premises. The technician receives the faulty appliance, diagnoses the problems, performs repair as required, resolves issues, ensures effective functioning of all the parts and checks the working of the appliance before confirming to the customer. This job requires the individual to have attention to details, patience, ability to listen, steady hands, basic skills and customer orientation. Technicians must use a clean levelled platform to work with different types of equipment used for checking and repairs.

Role and responsibilities of Junior Field Technician Home Appliances can be summarized as following:

1.Installing the newly purchased appliance
2.Diagnosing the problem for a malfunction
3.Assessing possible causes
4.Rectifying minor problems
5.Replacing faulty modules for failed parts
6.Recommending factory repairs for bigger faults

Summary

This chapter covers the electronic industry's growth, applications, and recent trends, including 5G, digitization, and green energy. The chapter outlines the roles of Junior Field Technicians in home appliances, involving tasks like installation, diagnosing malfunctions, addressing issues, and recommending repairs. These technicians play a vital role in ensuring the proper functioning of household appliances, requiring skills like attention to detail and technical proficiency.

Check Your Progress

A. Multiple Choice Questions

1. What role does the electronics sector play in supporting other industries, as mentioned in Chapter? (a) Restricting growth (b) Hindering innovation (c) Providing equipment and components (d) Isolating from global markets
2. What is the main factor contributing to the rapid growth of the electronics sector? (a) Decreased consumer spending (b) Reduced competition (c) Increased demand from emerging market economies (d) Decline in foreign investment
3. Which industry is NOT mentioned as a part of the electronics sector in the chapter? (a) Telecommunications (b) Automotive (c) Chemical (d) Consumer electronics
4. What is the expected worth of the global electronic products market in 2020? (a) $1,191.2 billion (b) $500 billion (c) $2 trillion (d) $800 billion
5. What is the Consumer Electronics Market's estimated Compound Annual Growth Rate (CAGR) from 2021 to 2027? (a) 4% (b) 5.4% (c) 8% (d) 10%
6. Which trend is NOT mentioned in the section on recent trends in the electronic industry? (a) 5G Optimization (b) Virtualization (c) Additive Manufacturing (d) Internet of Things
7. What is the focus of the trend "Green, Clean, and Lean Energy" in the electronic industry? (a) Increased use of non-renewable energy (b) Reduced emissions (c) Higher production costs (d) Decline in renewable energy investment
8. Which is a futuristic trend in electronics manufacturing? (a) Increased use of silicon (b) Virtual reality (c) 3D Printing (d) Traditional IC Packaging
9. What is the primary responsibility of Junior Field Technician Home Appliances? (a) Designing electronic components (b) Troubleshooting and fixing household appliances (c) Developing software solutions (d) Conducting market research for electronics
10. What skill is NOT mentioned as essential for Junior Field Technician Home Appliances? (a) Attention to details (b) Basic skills in electronics (c) Artistic creativity (d) Customer orientation

B. Fill in the Blanks

1. The electronics industry is the sector that produces ________.
2. The electronics sector manufactures a variety of products, including mobile devices, televisions, and _______.
3. The global market for electronic components is expected to grow at a compound annual growth rate (CAGR) of about_____from 2020 to 2025.
4. The role of a Junior Field Technician Home Appliances involves identifying, ______, and installing household appliances
5. Consumer electronics are electronic equipment for __________.
6. The integration of digital tools and technologies has increased ________, improved product quality, reduced waste, and operational costs, and met the most recent ________.
7. With its ___________, 5G can access many high-value areas

8. According to the International Energy Agency (IEA), _______renewable energy was generated and used in 2020 more than the previous year.
9. Printing electronics components on a semiconductor substrate is the most effective way to reduce the overall cost of the _______.
10. The work of Junior Field Technician Home Appliances is dependent on the ________they are skilled in.

C. State whether True or False

1. The electronics sector produces only industrial electronics and does not contribute to consumer electronics.
2. Consumer electronics include devices like washing machines, refrigerators, and microwaves.
3. The electronics sector's growth is not influenced by consumer spending but solely by foreign investment.
4. The global electronic products market is expected to be worth approximately $1,191.2 billion in 2020.
5. The metaverse is a concept representing persistent digital worlds that exist alongside the physical world.
6. Quality standards in software development are not a significant trend in the electronics industry.
7. Teleworking is expected to decline in 2022 as companies move away from online meetings and video calls.
8. Green, Clean, and Lean Energy trends resulted in an 8% increase in emissions during the pandemic.
9. Advanced IC packaging technologies aim to provide greater silicon integration in increasingly miniaturized packages.
10. 3D Printing in electronics manufacturing does not eliminate the need for flat circuit boards.

D. Answer the following questions in short

1. What is the electronics industry, and when did it emerge?
2. Name two common items produced in the electronics sector.
3. What factors contribute to the growth of the electronics sector?
4. Give an example of a consumer electronics device.
5. Briefly explain the trends in the electronics industry for 2022.
6. How does 5G impact various industries, according to the content?
7. What is the primary focus of software quality standards in 2022?
8. What are some futuristic trends in electronics manufacturing mentioned in the content?
9. What are the roles and responsibilities of a Junior Field Technician Home Appliances?
10. What skills are essential for a Junior Field Technician Home Appliances?

Session 2: Basics of Electrical Circuits

Electrical circuits form the basic structure of electronic appliances. Circuits consist of components like resistors, capacitors, and conductive pathways, allowing electric current flow. Key concepts include Ohm's Law (V = IR) and circuit types: series and parallel. Learning circuit symbols aids in interpreting circuit diagrams, enabling comprehension of device functionality.

2.1 Electric Circuits

An electric circuit is a path made by the interconnection of electrical components. Electrons from a voltage or current source flow along this path. The following Figure 2.1 lists the elements present in a basic electric circuit.

	A Source that provides electrical pressure known as voltage or Electromagnetic force (EMF) to electrical equipment to enable them to work. *Example:* Battery
	A device in a circuit which consumes electric power is called load. *Example:* Bulb
	A Conductor that connects the supply source and the load. *Example:* Wires

Fig. 2.1: Electric circuit constituents

2.2 Open and Closed Circuit

Open circuit – An open circuit is a circuit in which the path is incomplete which means there is no flow of current.

Closed circuit – A closed circuit is a circuit in which the path is complete and there is a flow of current in the entire path.

Connections in open and closed circuits are shown below in Figure 2.2.

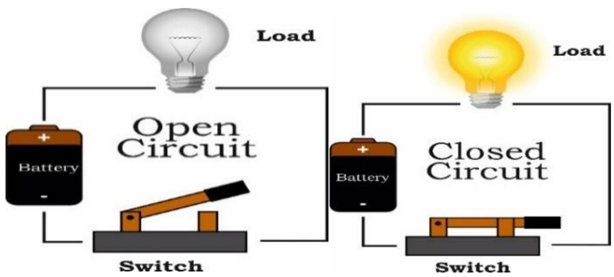


Fig 2.2: (a) Open circuit (b) Closed circuit

In a typical circuit, a battery provides voltage for the load through wires. For example, the required voltage for a bulb to glow is provided by a battery. The following Figure 2.3 shows such an electric circuit.

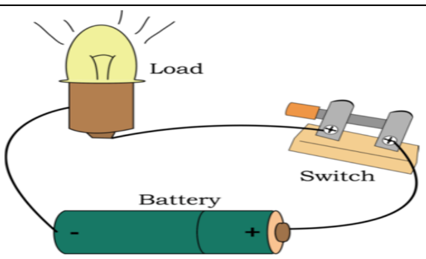


Fig. 2.3: Electric circuit

Activity 1

Practical Activity 2.1. To prepare an electric circuit to analyse the state of open and closed circuits.

Material Required

9 volts battery, connecting wire, resistor, lamp, wire stripper, wire cutter, and switch.

Procedure

Step 1. Take a battery; identify the positive and negative terminals of the battery.

Step 2. Cut the required length of wire using a wire cutter and then strip the insulation of ends using a wire stripper.

Step 3. Take a lamp, observe its two terminals, connect stripped wire to both the terminals.

Step 4. Now, take one of the terminals of the lamp and connect one end of the resistor to the stripped wire of the lamp.

Step 5. Then, again cut and strip the required length of wire, then using this stripped wire connect the other end of the resistor to the positive terminal of the battery.

Step 6. Next, we will connect the remaining terminal of the lamp to one of the ends of the switch.

Step 7. And then connect the other end of the switch to the negative terminal of the battery.

Step 8. Turn ON the lamp using a switch and observe that the circuit is working properly. It is shown in Figure 2.4 and 2.5 given below.

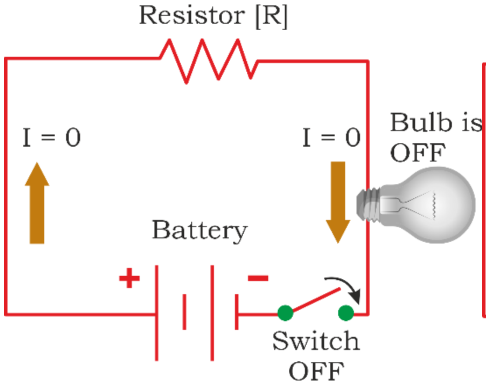


Fig. 2.4: Open circuit

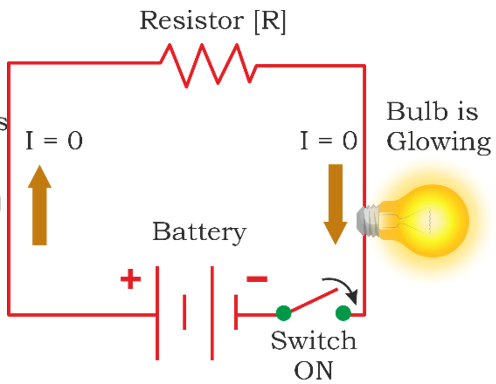


Fig. 2.5: Close circuit

While repairing the electric appliances, one needs to test the continuity of various electrical and electronic components. To test the components, a test lamp can be used. Let us learn the procedure to make a test lamp using the activity.

Activity 2

Practical Activity 2.2. To construct a test lamp.

Material Required

1 bulb, 1 bulb holder, wire, wire cutter, wire stripper, plug

Procedure

Step 1. Cut the wire into two pieces using a wire cutter, making each two meters long.

Step 2. Now, you have two pieces of wire. Each wire is two meters in length. Strip the insulation of the wire terminals.

Step 3. Connect these wires in the bulb holder.

Step 4. Now, you have a bulb holder in which wires are connected as shown Figure 2.6.

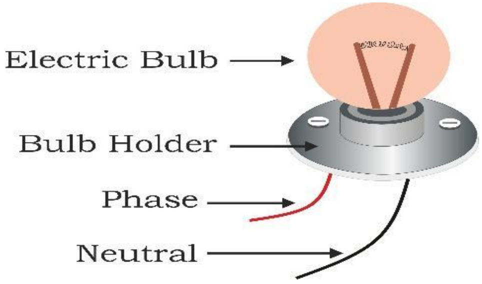


Fig. 2.6: Electric AC bulb with two terminals

Step 5. Connect the terminal of one wire to the plug as shown in Figure 2.7.

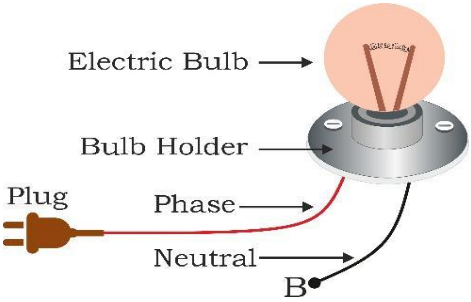


Fig. 2.7: Electric plug is connected to a phase wire

Step 6. Leave one wire free for testing i.e. terminal A and B are used for testing as shown in Figure 2.8.

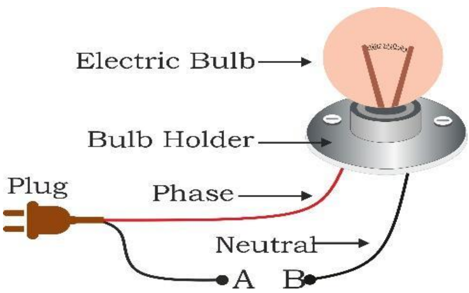


Fig. 2.8: Neutral terminal have two terminal A and B

Step 7. Insert the plug in the socket as shown in Figure 2.9.

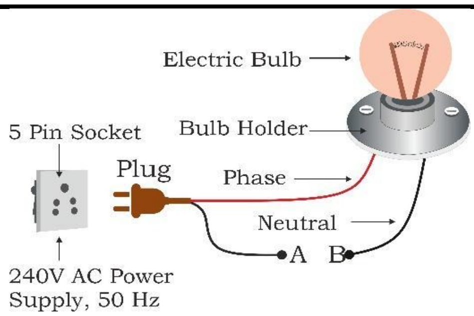


Fig. 2.9: Electric Plug is connected to the AC socket

Step 8. Now, check the continuity of the path in a circuit or component using point A and B. If the bulb is ON that means, circuit is complete or continuous.

Caution – Don't come in direct contact with electric power.

Assignment

Consider a battery of 9V, fixed resistor of 3-ohm, bulb or LED of 5 watt connect them as per the circuit diagram shown in Figure 2.10. Find out the voltage, current, resistance, power in a given circuit.

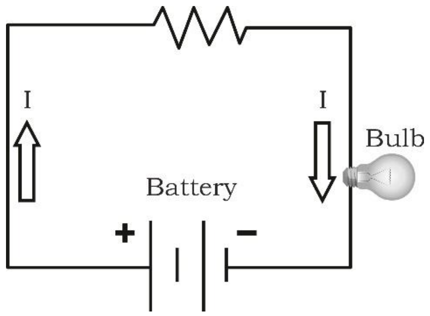


Fig. 2.10: Electric circuit

2.3 Types of Electric Circuits

An electric circuit is classified into two types - Series circuit and Parallel circuit.

Series Circuit

In this type of a circuit, all components are connected as a chain and

Current flowing through each one of them is the same all over the circuit. There is a single route through which the current flows. So, the current passes through each and every component.

Suppose, a battery and two electric bulbs are connected along a single path in such a way that it will form a close circuit. Therefore, current flowing through each bulb remains the same, whereas voltage will divide across each bulb.

Opening or breaking any point in a series circuit causes the whole circuit to stop functioning, which then needs to be replaced. Suppose, if one of the bulbs is fused, the electric path becomes incomplete, and another bulb is also turning off.

Series circuits are used in a variety of applications. These include thermostats, water heaters, refrigerators, and most light switches. Figure 2.11 shows the bulbs connected in series. Figure 2.11 (a) shows circuit diagrams and Figure 2.11 (b) shows schematic diagram of series connection.

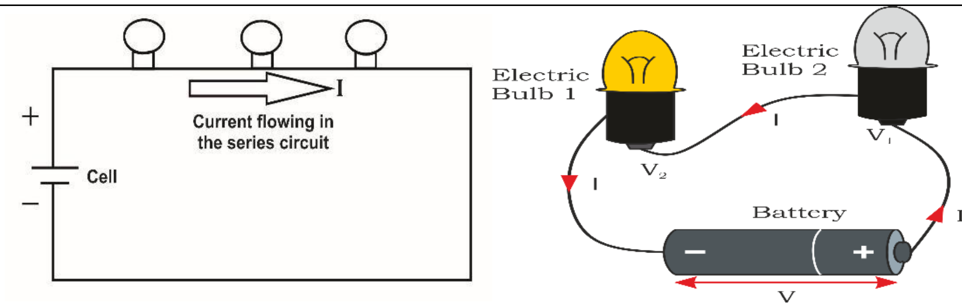


Fig. 2.11: A series circuit (a) Circuit diagram (b) Schematic Diagram

Parallel Circuit

In this type of a circuit, two or more than two components are connected in parallel. In a parallel circuit, the components are of the same voltage. The current flow varies across the components.

Suppose, a battery is connected to two electric bulbs in such a way that each bulb is placed in a separate path forming a close circuit with a common battery. Therefore, current flowing through each bulb divides, whereas voltage across each bulb remains the same.

If any point of the circuit gets damaged, only that part needs to be replaced. Suppose, if one of the bulbs is fused, only one electric path breaks, another bulb connected in another path will not get affected. Parallel circuits are the standard circuits found in home electrical wiring and offer distinct advantages over other circuits. Figure 2.12 shows the circuit diagram of parallel connection in symbolic as well as actual connected components.

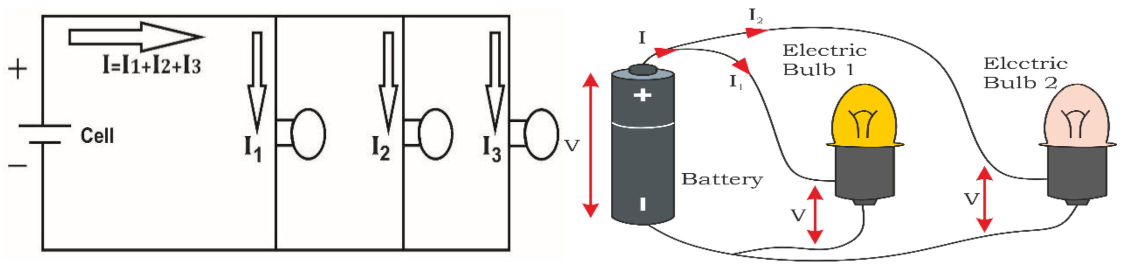


Fig. 2.12: A parallel circuit (a) Circuit diagram (b) Schematic Diagram

Comparison and Similarities of series and parallel circuits

The table 2.1 below general comparison of series and parallel circuits.

Table 2.1 Difference between series and parallel circuits

Series Circuit	***Parallel Circuit***
Has one pathway.	May have two or more pathways.
Current is the same anywhere in the circuit.	Current splits and passes through pathway and then add up again.
The voltage is shared in ratio to resistance.	Voltage across each pathway equals suppl voltage
Resistance adds up and so fewer current draws in the circuit and battery last longer.	The total resistance is less than the leas resistance, current drawn is less but th battery life is short.
If one bulb fuses than the circuit	If one bulb gets fuses still the circuit remain

becomes incomplete.	complete and the other bulb glows.
Resistance Equivalent Req. = R1 + R2 + R3 + ... + Rn	Resistance Equivalent Req. = 1/R1 + 1/R2 + 1/R3 + ... + 1/Rn

Similarities between Series and Parallel Circuits - Both the circuits either series or parallel have the same aim of converting electrical energy into heat, sound etc.

2.4 Parameters of Electric Circuit

Electricity comes into existence whenever there is a flow of electric charge between any two components. The main parameters associated with electricity are as follows.

Voltage

Let us understand the concept of voltage. Consider a situation, a person needs to pick a stone from one-point A and drop it at point B. To complete this task, he has to do some work as shown in Figure 2.13.

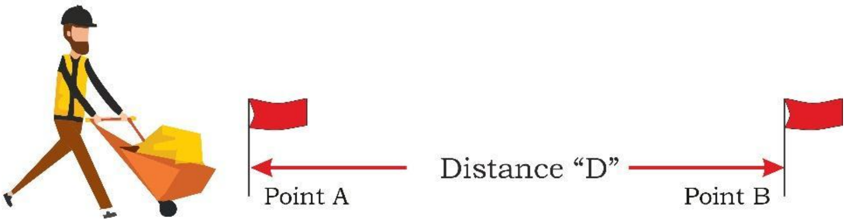


Fig. 2.13: Work to be done to move the raw material from point A to point B

In the same way, voltage is amount of work done required to move one coulomb charge from one-point A to point B. Mathematical expression for voltage is written as:

V=W/Q

where,

'V' is the voltage,

'W' is the work in joule,

'Q' is the charge in coulomb

Alessandro Volta (1745–1827)

Voltage establishes a potential difference in an electric circuit between two points i.e. one point is at higher potential and other at lower potential.

In an electric circuit, the battery is used as a source of electric potential. Inside a battery, stored chemical energy provides the energy required to move the electrons in an electric circuit. Typical, general-purpose battery is shown in Figure 2.14.

Fig. 2.14: General-purpose battery

When a voltage source such as a battery is connected to an electric circuit, negatively charged particles(electrons) are pulled towards higher potential (+) or positive terminal of the battery, while positively charged particles are pulled towards lower potential (-) or negative terminal of the battery. Therefore, the current in a wire or resistor always flows from higher voltage towards lower voltage as shown in Figure 2.15.

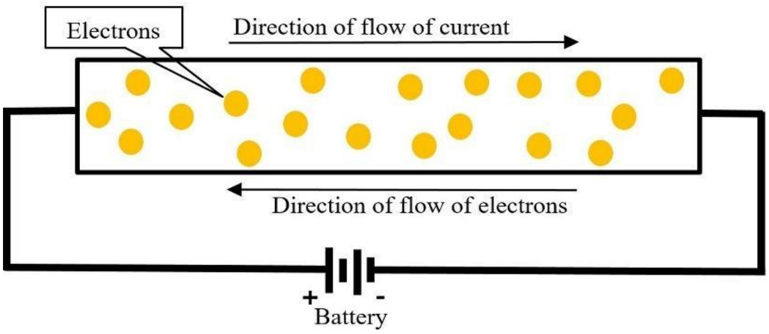


Fig. 2.15: Flow of electrons on application of DC supply

*A voltmeter is used to measure the voltage or potential difference between two points in an electric circuit. Value of voltage is measured in volt or joules per coulomb. Symbolic representation of voltage is **'V'** or **'v'**. When one joule of work is done to move one coulomb charge from one point to another point the potential difference between two points is said to be one volt.*

Let's look at the hydraulic or heat analogy shown below in Figure 2.16 to understand it better.

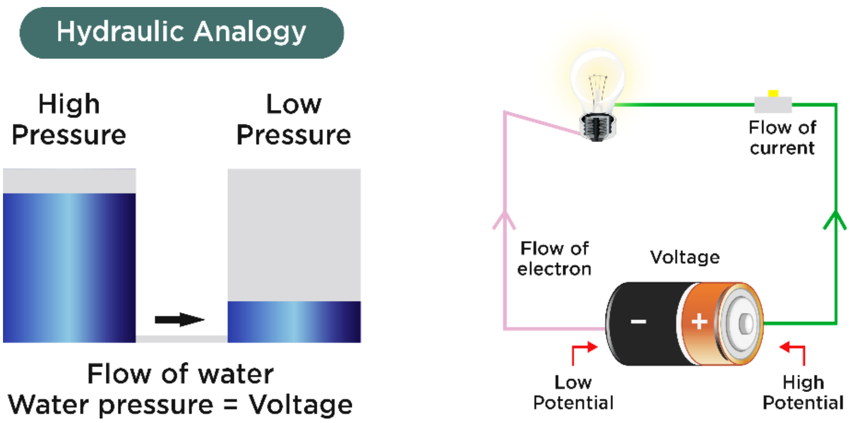


Fig. 2.16: Hydraulic or heat analogy of voltage

Keynote: A force that causes electricity to move across a wire/cable is known as voltage. Volt is the unit of voltage and is denoted with letter V.

Example – How much work is required to move charge of 2 C across two points having a potential difference 12 V?

Solution – Given, amount of charge Q, that flows between two points at potential difference V (= 12 V) is 2 C. Thus, the amount of work done 'W' in moving the charge is

W = VQ

= 12 V × 2 C

= 24 J

Assignment 1

Calculate the amount of work required to move a 5 C charge between the two points having a potential difference 10 V.

Assignment 2

Calculate the amount of charge required when the 24 J of work is performing to move charge in potential difference of 8V.

Electric Current

The flow of electric charges is called *electric current*. The electrons carry charges with them. These electrons flow from one place to another. The amount of current flowing from one place to another determines the amount of charge flowing through a section of conductor in a specific time. Measuring unit of current is ampere (A). Symbolic representation of current is 'I'. Mathematically, it can be written as,

I= Q/t

Where,

'I' is the current,

'Q' is the amount of charge in coulombs

't' is the time in seconds

André-Marie Ampère (1775–1836)

If one coulomb charge passes through a cross-section area 'A' in one second, then it will represent the current of 1 ampere. It shown in Figure 2.17. Conventionally, the direction of current is taken as opposite to the flow of electrons.

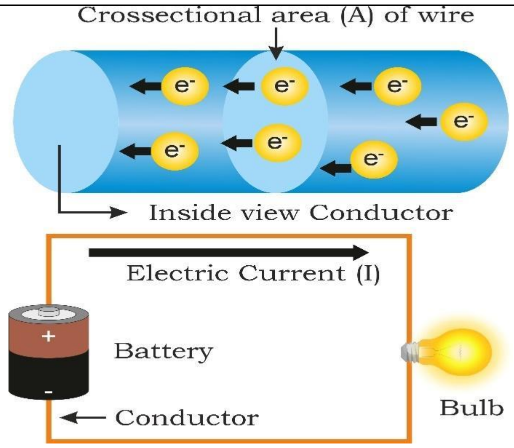


Fig. 2.17 Flow of charge through a cross section 'A'

Electric current, or simply current, is the flow of electric charge carried through electrons moving across wires. It is shown in Figure 2.18. Ampere is the unit of current and is denoted with letter I.

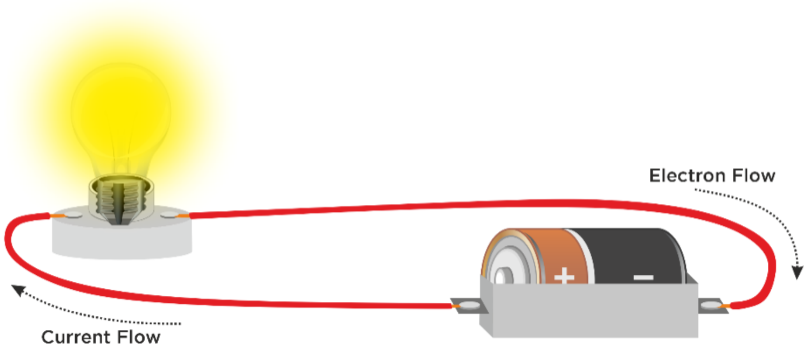


Fig. 2.18: current flow in the circuit

Example – Calculate the amount of current flowing through a wire. When the amount of charge is 5 coulombs and the time is 10 seconds.

Solution – We will use the relation between the current, charge and time.

I= Q/t

I= 5/10

I= 0.5 Ampere

Assignment 3

Calculate the amount of current drawn by radio. When the amount of charge flow is 120 coulombs in 1 minute.

Assignment 4

Consider an electric circuit in which LED is used for indication. While observing it was found that, the rate of charge used by the LED is 180 coulombs in 2.5 minutes. Calculate the current drawn by the LED.

Assignment 5

What are the basic elements required to form an electric circuit?

AC and DC Current

Depending upon the movement of electrons in an electric circuit, current can be classified as (1) Direct current (DC) (2) Alternating current (AC)

The main difference between AC and DC lies in the direction in which the electrons flow. In DC, the electrons flow steadily in a single direction, while electrons keep switching directions, going forward and then backwards in AC.

(1) Direct Current (DC)

It is unidirectional in nature, that is movement of electrons takes place only in one direction. This means that current flow only in one direction. Typical, electric circuit having a DC voltage source and DC current characteristics of DC current flowing through the circuit are shown in Figure 2.19.

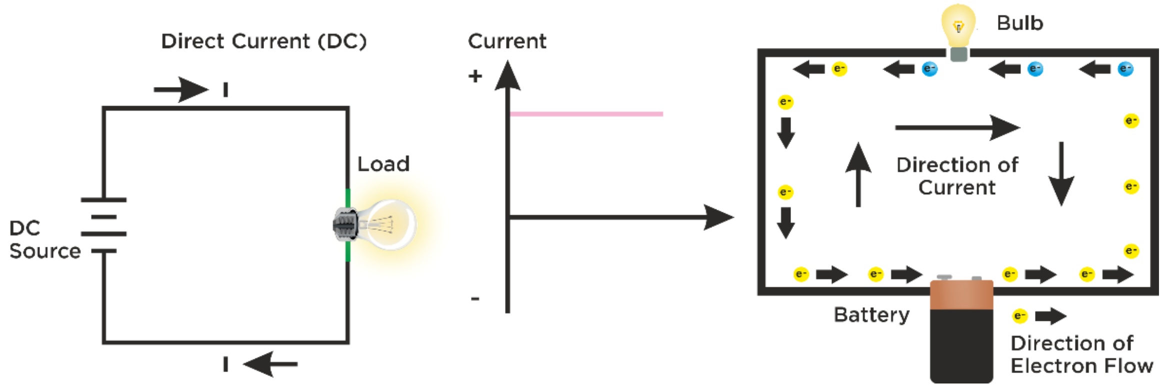


Fig. 2.19: DC Current flowing through the circuit

DC voltage sources such as batteries and cells produce direct current. Typical DC voltage sources are shown in Figure 2.20. Direct current is used in wall clocks, remote control, motor vehicles, cell phones and many more.

Fig. 2.20: Various sources of DC voltage source

(2) Alternating current (AC)

It is bidirectional in nature, that is movement of electrons takes place in two directions. This means that current flows in two directions. Figure 2.21 & Figure 2.22 shows typical AC source is applied in an electric circuit and the AC current flowing through the circuit.

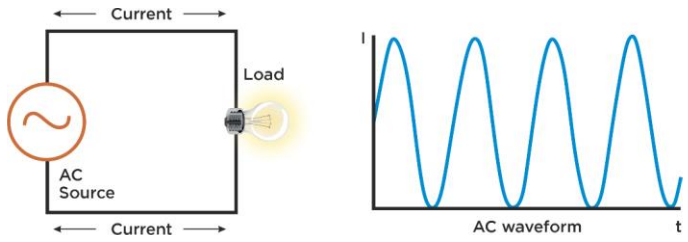


Fig. 2.21: AC Current flowing through the circuit

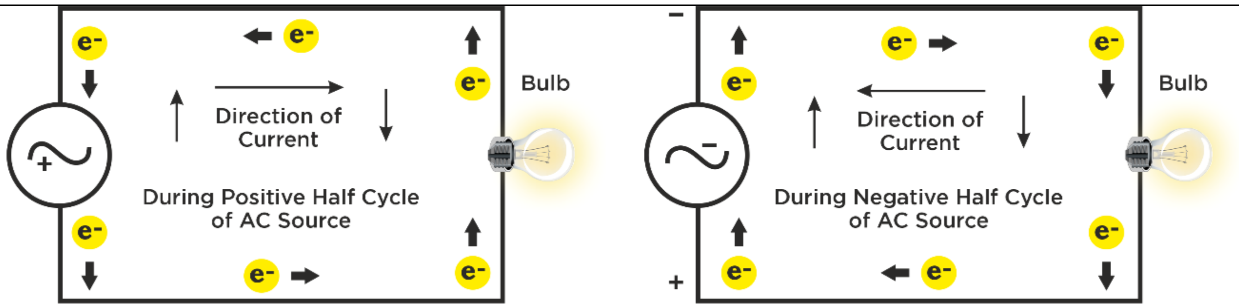


Fig. 2.22: (a) Positive half of AC source is applied in an electric circuit (b) Negative half of AC source is applied in an electric circuit

An AC voltage source like an AC generator produces alternating current. Hydel power plants, thermal power plants and many more are the places where AC voltage is generated. In India, standard AC generating frequency (f) of alternating current is 50 hertz. Generators at the power plants work continuously to produce AC voltage. As a backup for a few hours' diesel generators are used to provide power supply for appliances in case of power cut or unavailability of generating power supply. Alternating current is used in ceiling fan, coolers, washing machines and many more. Various AC generators are shown in Figure 2.23.

Fig. 2.23: Various AC generators

Difference between AC and DC current

The table 2.2 below compares the behaviour of AC and DC current

Table 2.2 Difference between AC and DC current

DC Current	***AC Current***
DC can be defined as the flow of current in which the drift of electrons remains steady in a single direction.	AC current can be defined as the flow of current in which electrons keep switching directions, going either forward or backward.
The magnitude of induced current remains constant.	The magnitude of induced current varies with time.
Types of DC signals are pure DC and pulsating DC. (Figure 2.24)	Types of AC signals are sinusoidal, triangular, square wave signals (Figure 2.25)

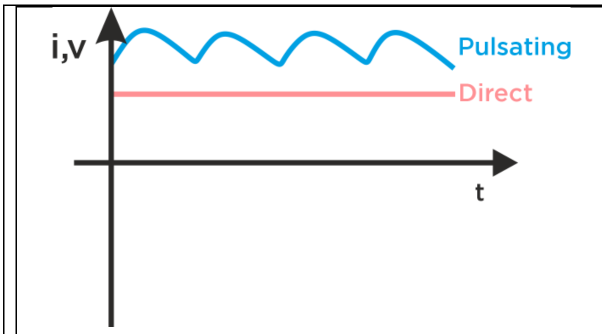


Fig. 2.24

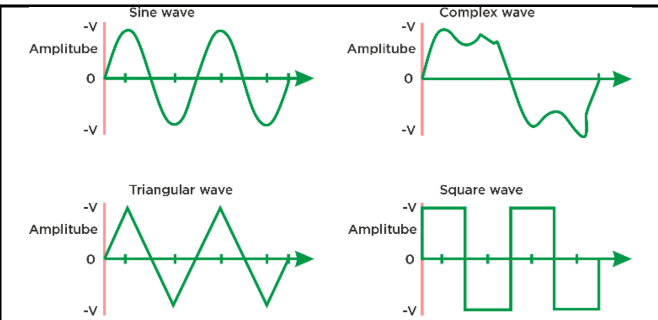


Fig. 2.25

Know More...

Frequency can be defined as *"the number of cycles in one second"*. In Figure 2.26, point A to point B represents one cycle. Hertz (Hz) is the measuring unit of frequency.

Example: 50 Hz represents 50 cycles in 1 second.

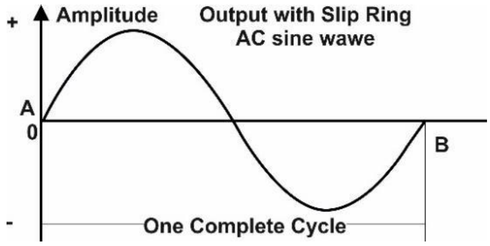


Fig. 2.26: Cycle of AC signal

Assignment 6

Prepare a list of gadgets in tabular form; this table will have two columns. In the first column list out the gadgets, which work on the alternating current and in the second column list out the gadgets, which work on the direct current.

Electric Power – It is the rate of doing work, which means *"amount of work done in one second"*. It is represented by the symbol 'P'. The SI unit of power is the watt (W). It is named in honour of Scottish inventor James Watt (1736-1819). One Watt is equal to one joule per second.

P = Work done per unit time = QV/t = V x I

Where,

'Q' is electric charge in coulombs

't' is time in seconds

'I' is electric current in amperes

'V' is electric potential or voltage in volts

$P=W/t$ or $P=I^2R$

Where,

'W' is the work done in joules

't' is the time in seconds

Know More...

Consider an object placed on the ground surface, if you lift the object 1m above the ground surface with a force of 1 newton. The amount of energy required represents 1 joule as shown in Figure 2.27.

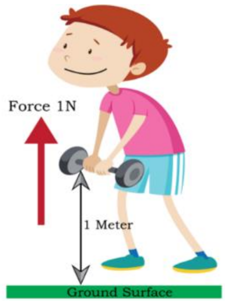


Fig. 2.27: Person lifting the object

Consider an electric bulb in the circuit, if it is of 60 watt that means that it will do 60 joules of work in one second. Likewise, some of the appliances with wattage are shown in Figure 2.28.

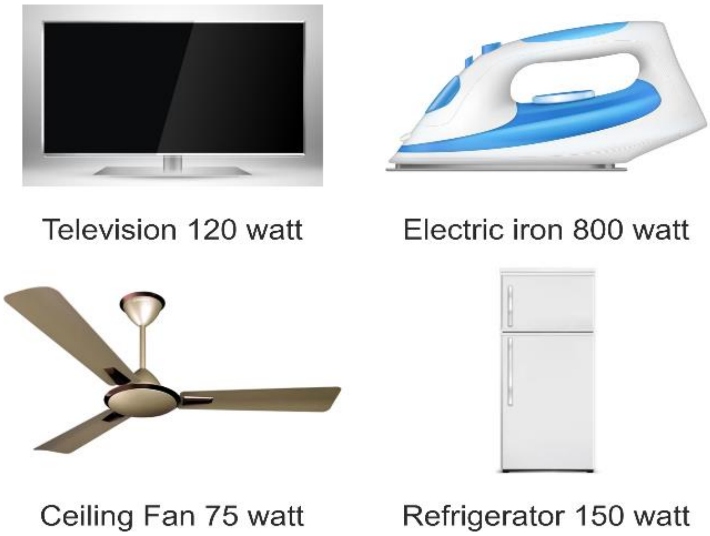


Fig. 2.28: Electric appliances with their wattage

> ***Keynote:*** *The electrical energy transferred by an electrical circuit, per unit time is its power. The unit of power is watt. An electrical circuit produces work when electricity flows through it.*
>
> *For instance, a fan's blades rotate when electricity passes through them, a bulb glows when it is connected with the electric supply and a refrigerator's contents cool when electricity passes through them. Thus, an appliance produces some work when electricity passes through it.*

2.3 Circuit Elements

All electronic devices are made up of components such as resistors, capacitors, power supplies, and circuit chips. If you were to open up your television or cell phone you'd see similar things inside. When you turn on your electronic gadget, electricity runs through it giving it the power to do everything you expect it to do.

An electric or electronic circuit forms the core part for functioning of any electrical or electronic home appliances. A circuit is built up using various components. These components can be classified into three types (1) active components, (2) passive components (3) electromechanical components.

1. Active Components

Active components depend on a source of energy to perform their functions. These components can amplify current and can produce a power gain. The examples of active components can be given as Diode, Light Emitting Diode (LED), Transistor and Integrated Circuit (IC). Figure 2.29 shows the various active components used in the circuit.

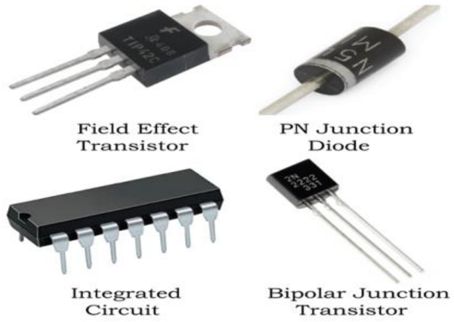


Fig. 2.29: Active components

2. Passive Components

Passive components are those components which can perform their specific functions without any power source. These components are incapable of controlling current. The examples of passive components are Thermistor, Inductor, Capacitor, Resistor, Transformer. Figure 2.30 shows the various passive components used in the circuit.

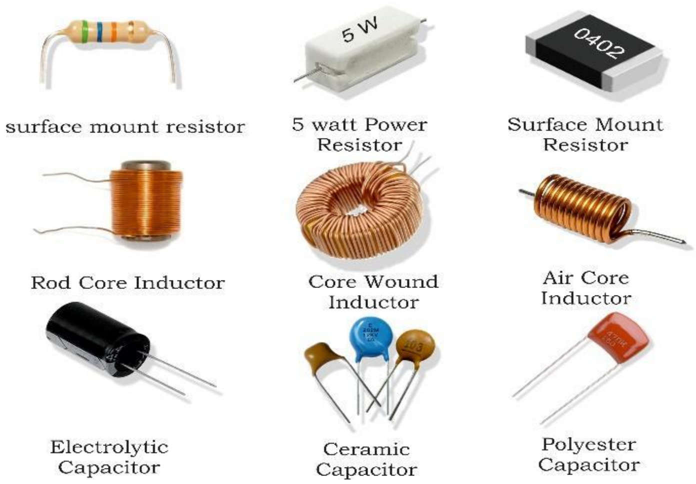


Fig. 2.30: Passive components

Important note ☟ *Active components are those that **deliver** or **produce energy** or power in the form of a voltage or current. (Figure 2.31) Passive components are those that **utilize or store energy** in the form of voltage or current.*

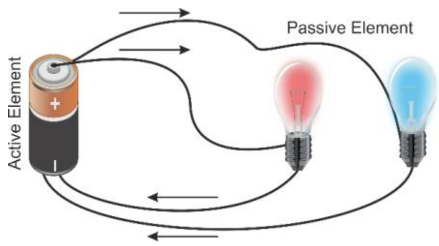


Fig. 2.31: produce energy

3. Electromechanical Components

Electromechanical components convert electric energy into mechanical energy (mechanical movement) or vice versa for carrying out electric operations. The examples of electromechanical components can be given as Timer, Starter, Connector. Figure 2.32 shows the various electromechanical components used in the circuit.

Fig. 2.32: Electromechanical components

2.4 Ohm's Law

According to Ohm's law the voltage across a conductor is directly proportional to the current flowing through it, provided all physical conditions and temperatures remain constant.

Mathematically, this current-voltage relationship is written as,

V = IR

In the equation, V is the voltage across a conductor in Volts (V), I is current flowing in conductor in Ampere(A) and the constant of proportionality, R is called Resistance and has units of ohms, with the symbol Ω.

The same formula can be rewritten in order to calculate the current and resistance respectively as shown in the following Figure 2.33.

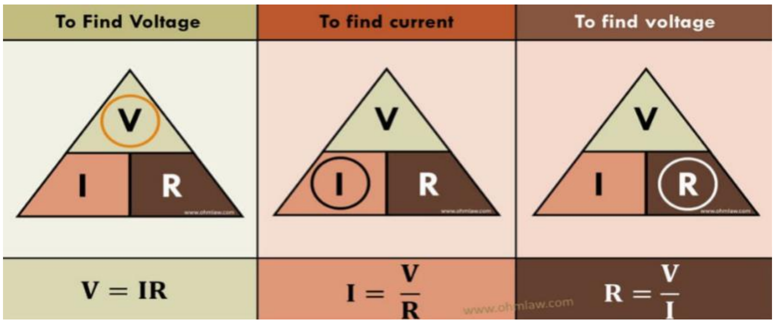


Fig. 2.33: Ohm's law

Power Fact: The standard units of measurement for electrical current, voltage, and resistance are given below:

Electrical Quantity	***Symbol***	***Unit of Measurement***
Current	*I*	*ampere (A)*
Voltage	*V*	*volt (V)*
Resistance	*R*	*ohm (Ω)*

Practical Activity: To verify Ohm's law.

Material Required – Nichrome wire of length 0.5m, ammeter, voltmeter, four cells of 1.5 V each, plug key, connecting wires, and a piece of sandpaper.

It is shown in Figure 2.34 Circuit diagram.

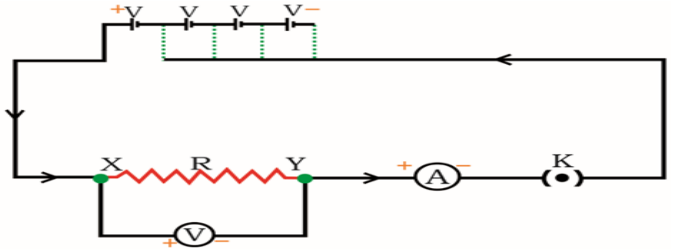


Fig. 2.34: Circuit diagram of Ohm's Law

Procedure

Step 1. Set up a circuit as shown in Figure 2.35, consisting of a nichrome wire XY of length, say 0.5 m, an ammeter, a voltmeter and four cells of 1.5 V each. (Nichrome is an alloy of nickel, chromium, manganese, and iron metals.)

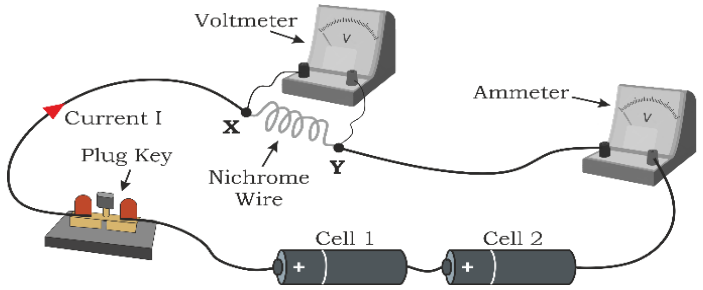


Fig. 2.35: Ohm's law setup

Step 2. Firstly, use only one cell as the source in the circuit. Note the reading in the ammeter I, for the current and reading of the voltmeter V for the potential difference across the nichrome wire XY in the circuit. Tabulate them in the Table 1 given.

Step 3. Next, connect two cells in the circuit and note the respective readings of the ammeter and voltmeter for the values of current through the nichrome wire and potential difference across the nichrome wire.

Step 4. Repeat the above steps using three cells and then four cells in the circuit separately.

Step 5. Calculate the ratio of V to I for each pair of potential difference V and current I.

Table 1

S. No.	Number of Cell used in the circuit	Current through the nichrome wire, I (ampere)	Potential difference across the nichrome wire, V (volt)	V/I (volt/ampere)
1.	One			
2.	Two			
3.	Three			
4.	Four			

Step 6. Plot a graph between V and I, and observe the nature of the graph.

Precautions
1. All the electrical connections must be neat and tight.
2. Voltmeter and ammeter must be of proper range.
3. The key should be inserted only while taking readings.

Problems on Ohm's Law

Some of the solved examples to better understand the ohms law are as follows:

Example 1: A 10 V battery is connected to an electric bulb having resistance 20 Ω. Find the current flowing through the electric bulb.

Solution – Given,

V= 10 V
R = 20 Ω

The current flowing through an electric bulb is given by
V = I R
I = V/R
I = 10/20
I = 0.5 A
So, the current flowing through the bulb is 0.5 A.

Example 2: An electric iron having resistance 40 Ω is connected to a supply voltage. The current flowing through the electric iron is 6 A. Find the voltage applied to the electric iron.

Solution – Here, I = 6 A, R = 40 Ω

Voltage equation is given by

V = I R
So, Voltage is expressed as V = 6 × 40,
V = 240 V

Example 3: A 110 V voltage source supplies power to a halogen light. The current flowing through the halogen light is 5 A. Find the resistance of the halogen light.

Solution – Here, V=110V, I=5A

The resistance is given by

R = V / I

R = 110/5
R = 22 Ω
so, the resistance of halogen light is 22 Ω.

2.5 Basic Components of an Electric Circuit

The basic components that are used frequently in any electric circuits are listed in table 2.3.

Table: 2.3 Electric Circuit Components

Component Name	Component Image
Resistor – It is used to resist or limit the flow of current in the circuit.	

Capacitor – It is made up of one or more pairs of conductors and an insulator separating them and is used to store energy in the form of electric field.	
Inductor – It consists of a coil or a wire loop and is used to store energy in the form of a magnetic field.	
Starter – A device that is used to start, stop, reverse and protect a motor. It controls the supply of electric power to the motor.	
Motor – It is an electrical component which is used to transform electrical energy into mechanical energy to produce linear or rotary force.	
Switch – It is a component used to make or break connections in an electrical circuit.	
Relay – It is a switch that controls an electrical circuit by opening and closing contacts in another circuit, electromechanically or electronically.	
Transformer – It is an electrical device that transforms one AC voltage level to other AC voltage level.	

Summary

This chapter is focused on electric circuits, explaining components like voltage sources, loads, and conductors. It covers open and closed circuits, series and parallel configurations, and key parameters like voltage, current, and power. The chapter classifies circuit elements into active, passive, and electromechanical components, citing examples. Ohm's Law (I = V/R) is discussed, and fundamental circuit components such as resistors, capacitors, inductors, starters, motors, switches, relays, and transformers are outlined with their functions. This serves as a foundational guide to electrical circuit principles.

Check Your Progress

A. Multiple Choice Questions

1. What is the role of a voltage source in an electric circuit? (a) Consumes electrical power (b) Provides electrical pressure (c) Connects the supply and load (d) Acts as a switch
2. What is an open circuit? (a) A circuit with no components (b) A complete circuit with current flow (c) A circuit with incomplete path (d) A parallel circuit
3. In a series circuit, what happens if any point is opened or broken? (a) Only that part stops functioning (b) The entire circuit stops functioning (c) Voltage increases (d) Current decreases
4. What unit is used to measure voltage? (a) Watt (b) Ampere (c) Volt (d) Ohm
5. Which type of circuit has components connected in a chain with the same current flowing through each? (a) Parallel circuit (b) Series circuit (c) Closed circuit (d) Open circuit
6. What does Ohm's Law state? (a) Voltage is proportional to current (b) Resistance is dependent on voltage (c) Current is directly proportional to resistance (d) Voltage equals current times resistance
7. Which component stores energy in the form of an electric field? (a) Inductor (b) Capacitor (c) Resistor (d) Transformer
8. What is the function of a relay? (a) Limits current flow (b) Stores electrical energy (c) Controls an electrical circuit by opening and closing contacts (d) Transforms AC voltage levels
9. What is the purpose of a switch in an electrical circuit? (a) Stores energy (b) Makes or breaks connections (c) Controls motor speed (d) Transforms voltage
10. What is the main parameter associated with electricity that produces work in an electrical circuit? (a) Voltage (b) Current (c) Power (d) Resistance

B. Fill in the blanks

1. An electric circuit is a path made by the interconnection of ________.
2. In a closed circuit, the path is complete, and there is a flow of current in the ________.
3. In a series circuit, all components are connected in a chain, and the current flowing through each one of them is______.
4. Voltage is the force that causes electricity to move across a wire or cable, measured in ______.
5. The flow of ________ carried through electrons moving across wires is known as current, measured in units of amperes (A).
6. The two types of current flows in an electric circuit are alternating current (AC) and ________.
7. The electrical energy transferred by an electrical circuit, per unit time, is its _______, measured in units of watts.
8. Active components in a circuit depend on a _________ and can amplify current.
9. According to _________, the flow of current through a conducting material is directly proportional to the conductor's voltage.
10. A resistor is used to resist or limit the ________.

C. State whether True or False

1. In a parallel circuit, components are connected in series, and the current flow is the same across all components.
2. Electromechanical components, such as Timer, Starter, and Connector, convert electric energy into mechanical energy or vice versa.
3. The unit of voltage is the volt, and it represents the electrical pressure provided by a source like a battery.
4. Active components in a circuit, such as Diode, LED, Transistor, and Integrated Circuit, depend on an external energy source to perform their functions.
5. Passive components, including Thermistor, Inductor, Capacitor, Resistor, and Transformer, perform their functions without requiring an external power source.\
6. In a series circuit, all components are connected in parallel, and the current flowing through each is the same.
7. A closed circuit is a circuit in which there is no flow of current due to an incomplete path.
8. Ohm's law states that resistance (R) is constant and independent of the current flowing through it.
9. Electric circuits transform electrical energy into various forms of work, such as the rotation of a fan's blades or the glow of a bulb.
10. The unit of power, watt, measures the electrical energy transferred by a circuit per unit time.

D. Answer the following questions in short

1. Define an electric circuit and identify its basic components.
2. Differentiate between an open circuit and a closed circuit. Provide examples of each.
3. Explain the characteristics of a series circuit and a parallel circuit.
4. How does the current flow in each type?
5. Define voltage and current in an electric circuit.
6. Outline the main parameters associated with electricity in a circuit.
7. Classify electric circuit components into active, passive, and electromechanical categories. Provide examples for each.
8. State Ohm's law and its mathematical equation. Explain the relationship between current, voltage, and resistance.
9. Describe the functions of various electric circuit components such as resistors, capacitors, inductors, starters, motors, switches, relays, and transformers.
10. Differentiate between AC and DC current. Identify and define the types of energy associated with electromechanical components in an electric circuit.

Session 3: Basics of Electronics Circuits

Electronic circuits form the backbone of modern technology. Comprised of components like resistors, capacitors, and transistors, these circuits enable tasks such as signal amplification and switching. Learning basic concepts like voltage, current, and resistance, as well as interpreting circuit diagrams, is crucial for technician jobs for understanding the device functionality in electronic appliances.

3.1 Resistance

Resistance is a fundamental property in electronics that impedes the flow of electrical current through a conductor. It is measured in ohms (Ω) and represents the opposition to the flow of electric charge. According to Ohm's law, 1Ω resistance allows 1A of current to flow from one point to the other with a 1V voltage difference.

Resistance arises due to collisions between moving electrons and the atoms of the conducting material. Materials with high resistance, such as insulators, restrict the flow of current, while materials with low resistance, like metals, allow current to flow more freely. Resistors are electronic components specifically designed to introduce resistance into a circuit and are widely used for various purposes, such as limiting current, dividing voltage, and controlling the flow of electricity. Resistance plays a critical role in determining the behaviour of electrical circuits, influencing factors like voltage, current, and power. Understanding resistance is essential for designing and analysing electronic circuits to ensure proper functionality and performance.

3.1.1 Resistor

A resistor is a passive electronic component that limits the flow of electric current in a circuit. It is commonly used to control the amount of current, reduce voltage levels, divide voltage, or provide a specific resistance value for a circuit. Resistors are characterized by their resistance value, measured in ohms (Ω), which indicates how much they impede the flow of current.

They come in various types and configurations, such as fixed resistors with a constant resistance value, variable resistors (potentiometers or rheostats) that can adjust resistance, and specialized resistors like light-dependent resistors (LDRs) or thermistors, whose resistance changes with light intensity or temperature, respectively. Resistors are typically made from materials like carbon, metal oxide, or metal film, and their resistance value is determined by factors such as the material used, its length, width, and temperature. Understanding the role of resistors is essential in electronics design, as they help regulate current flow and ensure the proper operation of circuits.

Properties of resistors

Resistors, fundamental components in electronics, possess several properties that determine their behaviour and suitability for various applications.

Resistance Value – Perhaps the most crucial property, resistance is measured in ohms (Ω) and indicates how much a resistor impedes the flow of electric current. Resistors come in a wide range of resistance values, from fractions of an ohm to several Mega ohms, allowing for precise control over current flow in a circuit.

Power Rating – This property indicates the maximum amount of power a resistor can dissipate without overheating or damage. It is typically specified in watts (W) and depends on the resistor's physical size and construction. Resistors with higher power ratings can handle greater amounts of electrical energy safely.

Tolerance – Tolerance refers to the range within which the actual resistance of a resistor may vary from its nominal, or rated, resistance value. It is expressed as a percentage and accounts for manufacturing variations. Resistors with tighter tolerances offer greater precision but may be more expensive.

Temperature Coefficient – The resistance of some resistors changes with temperature. The temperature coefficient, expressed in parts per million per degree Celsius (ppm/°C), quantifies this change. A lower temperature coefficient indicates that the resistance change is minimal over a specified temperature range, ensuring stability in varying thermal conditions.

3.1.2 Types of Resistors

There are numerous types of resistors that are available and can be used in electronic circuits. These different types of resistors have different properties depending upon their manufacture and construction. There are different types of resistors available for various applications. The resistors are available in different shapes, size, and materials. It is illustrated below in Figure 3.1.

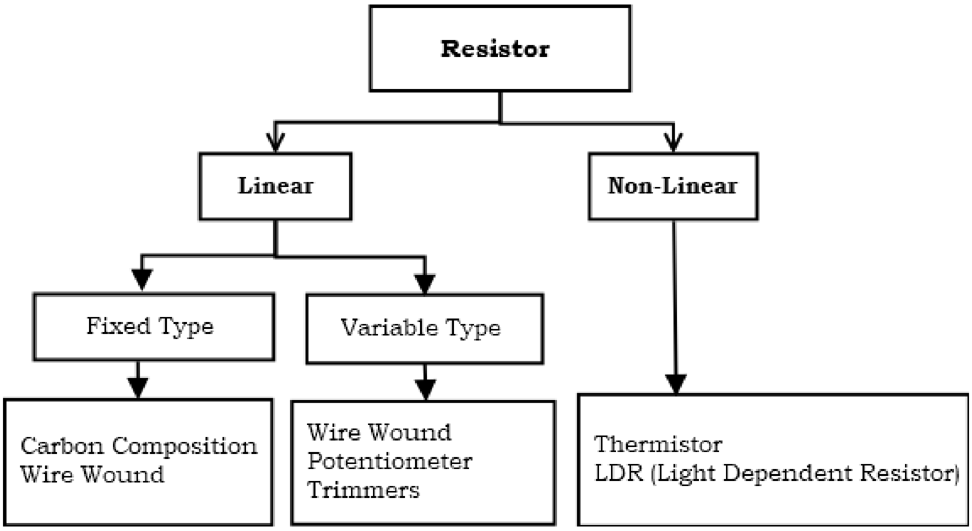
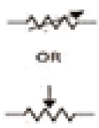


Fig. 3.1 Types of resistors

Different types of resistors that are commonly used are given in the following table 3.1.

Table 3.1: Types of resistors

Type of Resistor	Symbol	Image
Carbon Resistor – This is made from a blend of carbon or graphite powder, insulation filler, and a resin binder. The ratio of insulation material determines the resistance. The resistor consists of a rod-shaped insulating powder with metal caps on both ends. Conductor wires are attached for circuit connection via soldering. A plastic coat with color-coded bands indicates resistance value. They range from 1 ohm to 25 mega ohms		

and power ratings from ¼ watt to 5 watts.		
Wire wound Resistor – Wire wound resistors are made by wrapping a resistive wire around an insulating core or rod. Typically, the resistance wire comprises materials like Tungsten, manganic, Nichrome, or nickel-chromium alloy, while the core can be porcelain, Bakelite, press bond paper, or ceramic clay.		
Light Dependent Resistor (LDR) – LDR, or Light Dependent Resistor, is a type of resistor whose resistance varies with light intensity. In essence, it's a resistor that changes its resistance when exposed to light. LDRs are also known as Photo Resistors or Photoconductive Cells. These resistors are made using materials called photoconductors, such as cadmium sulphide or lead sulphide.		
Variable Resistor – Variable resistors allow for adjustment via a dial, knob, screw, or manual method. They feature a sliding arm connected to a shaft, enabling resistance adjustment by arm rotation. Also known asPotentiometers, Rheostats and Trimmers.		

3.1.3 Carbon resistors

Carbon resistors are widely used in electronics due to their versatility and cost-effectiveness. They consist of a solid cylindrical resistor element with wire leads or metal end caps embedded within. Available in various sizes, their power dissipation ranges typically from 1 watt down to 1/8 watt.

While metals and alloys like nichrome, brass, platinum, and tungsten are also used for resistance, they often lack the high electrical resistivity of carbon. This can result in bulkier components when aiming for higher resistance values. However, carbon resistors offer precise resistance measurements, making them ideal for calibration and comparison purposes as shown in Figure 3.2.

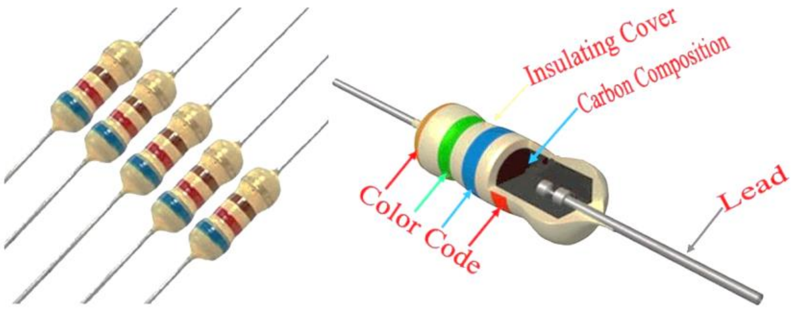


Fig. 3.2: Construction of a carbon resistor

In practical applications, carbon resistors are preferred for their affordability, compactness, and suitability for direct printing onto circuit boards. They provide reliable resistance within practical requirements. Compared to metal wires, carbon is abundantly available, contributing to its low cost. For instance, a dozen resistors can be purchased for just 2 rupees at any electronic component store.

3.1.4 Colour coding of Carbon resistors

Colour coding was formulated to identify small sized resistors on which the resistance value could not be printed. Colour bands should be read from that end which has the bands nearest to it.

1. The 1st and 2nd bands stand for the first two digits.
2. The 3rd band represents the power-of-ten multiplier (the number of zeros after the second digit).
3. The 4th band represents the manufacturer's tolerance (accuracy of the resistor).

This coding is explained with the help of an example in Figure 3.3.

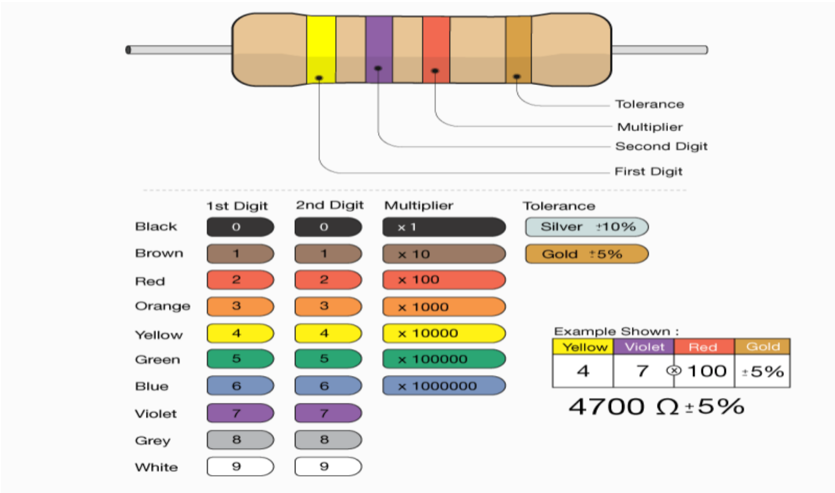


Fig. 3.3: Resistors colour codes

Activity 1

Practical Activity 3.1. Calculate resistance value of a resistor.

Material Required – Colour coded resistors, Notepad.

Procedure

Specification of Four Band Resistor

Step 1. In a 4-band resistor, three colour bands are at left side of the resistor and at some distance the remaining single band at the right.

Step 2. First colour band of the resistor is considered as the first numeric digit of resistance value. For the resistor shown in Figure 3.4, the first band is yellow, so the first number is 4.

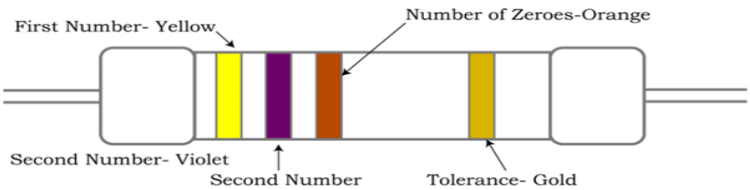


Fig. 3.4: Four band Resistor Specification

Step 3. The second colour band gives the second number. This band is violet in colour making the second digit 7.

Step 4. The third colour band is called the multiplier and gives the number of zeros, in this case it will be 1000 (three zeros because the colour code is orange).

Step 5. Therefore, the value of the resistor is 47000Ω or 47kΩ.

Step 6. The fourth colour band gives the tolerance.

Step 7. The tolerance defines the upper and lower limit of resistance value. Consider a 100Ω resistor its tolerance value can be defined in following table.

Tolerance value of resistor

Tolerance	Colour	Stated	Allowed Upper Value	Allowed Lower Value
+/- 5%	Gold	100Ω	105Ω	95Ω
+/- 10%	Silver	100Ω	50Ω	90Ω

Know More....

These resistors are combined together to connect in series or parallel or combination of them.

Series connection of resistors – In this connection, current remain same in each resistor, but voltage divides across each resistor as shown in Figure 3.5 given below.

$R_{equivalent} = R_1 + R_2 + R_3 + ...$

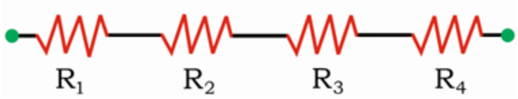


Fig. 3.5: Series connection of resistors

Parallel connection of resistors – In this connection, voltage across each resistor remain but current divides in each branch as shown in following Figure 3.6.

$1/R_{equivalent} = 1/R_1 + 1/R_2 + 1/R_3 + ...$

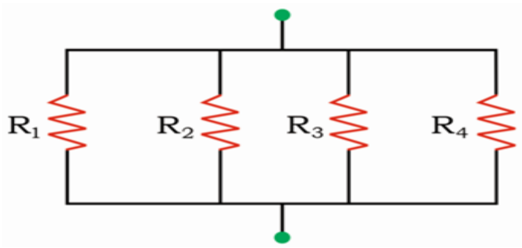


Fig. 3.6: Parallel connection of resistors

3.1.5 Functions of resistor

Resistors are primarily used in circuits to regulate the current flow to various segments. Consider an LED light, for example. An LED is destroyed if it receives an excessive amount of current. So, to limit the current, a resistor is used. When a resistor experiences current flow, energy is lost and the resistor heats up. The effort required by the battery to push the electrons through the resistor is converted into thermal energy within the resistor. The principle governing the operation of resistors can also be applied to heating elements found in hair dryers, irons, toasters, heaters, and electric stoves that distribute voltage.

3.2 Capacitor

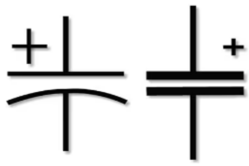
A capacitor is a device which is made up of one or more pairs of conductors and an insulator separating them. It is a passive electrical component with two terminals and is utilized to store energy in an electric field. The conductors can be made of thin films, foils, a conductive electrolyte and so on. The non-conducting dielectric functions to raise the charge capacity of the capacitor. It can be made of glass, plastic film, air, paper, an oxide layer and so on. The unit of capacitance, which is the property that capacitors possess, is called the farad (F). One farad is defined as the capacitance of a capacitor that stores one coulomb of charge when a voltage of one volt is applied across it.

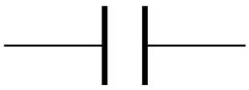
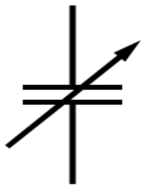
However, capacitors typically have capacitance values much smaller than one farad. Therefore, subunits of the farad are commonly used, such as microfarads (µF), nanofarads (nF), and picofarads (pF), to express capacitance in electronic circuits. For example, one microfarad (µF) is equal to 10-6 farads, one nanofarad (nF) is equal to 10-9 farads, and one picofarad (pF) is equal to 10-12 farads. These subunits are more practical for representing the small capacitance values commonly encountered in electronics. Capacitors are extensively used in electrical circuits of general electrical devices.

3.2.1 Types of capacitors

Capacitors are essential components in electronics, storing and releasing electrical energy. They come in various types, each with unique characteristics. Ceramic capacitors offer stability and versatility, electrolytic capacitors provide high capacitance values, while film capacitors offer reliability, mica capacitors excel in precision. Each type serves specific purposes, enabling efficient design across electronic systems. The table 3.2 given below illustrates some commonly used types of capacitors.

Table 3.2: Types of capacitors

Name of capacitor	Symbol	Image
Electrolytic Capacitor – This is a polarized capacitor with high capacitance per volume. They consist of an anode made of aluminum foil or tantalum, separated by a thin dielectric oxide layer, and a conductive electrolyte as the cathode. Widely used in electronics for their large capacitance values. They require correct polarity to function properly and avoid damage from reverse voltage or overvoltage.		
Mica Capacitors – Mica capacitors are known for their precision, stability, and suitability for high-temperature applications. They are composed of alternating layers of mica sheets and metal foil electrodes. Mica capacitors offer low losses, high insulation resistance, and negligible dielectric absorption. They are commonly used in radio frequency (RF) circuits, high-voltage applications, and precision electronic equipment where accuracy is essential.		

Ceramic Capacitor – These capacitors are made of ceramic material with a metalized layer. They are known for their stability, reliability, and versatility. Ceramic capacitors are suitable for high-frequency applications due to their low parasitic effects and low equivalent series resistance (ESR). They come in a wide range of capacitance values and compact sizes, making them ideal for use in filters, decoupling circuits, timing circuits, and RF applications.		
Film capacitors – Consist of a thin plastic film as the dielectric material between the metal foil electrodes. They are available in various materials such as polyester (Mylar), polypropylene, and polycarbonate. Film capacitors offer excellent stability, low losses, and high insulation resistance. They are commonly used in audio circuits, motor run capacitors, power factor correction, and pulse applications.		
Variable Capacitor – The capacitors whose capacitance value can be varied continuously are called variable capacitors. It consists of 2 sets of semi-circle plates out of which one set is fixed called a stator and another set is movably called a rotor. It is commonly used capacitor radio turning circuits		

3.2.2 Polarity of capacitors

The polarity of capacitors refers to the orientation of their terminals in a circuit. Unlike resistors, which can be connected in either direction, capacitors are polarized components, meaning they have a designated positive (+) and negative (-) terminal. This polarity is crucial for their proper function and must be observed during circuit assembly.

Polarized capacitors, like electrolytic capacitors, have a specific positive terminal marked on their casing, indicating the side connected to the higher voltage in the circuit. Connecting electrolytic capacitors in reverse polarity can lead to catastrophic failure, causing leakage, venting, or even explosion. The longer lead is taken as the positive terminal (anode) of the electrolytic capacitor and the shorter one is taken as the negative terminal (cathode) as shown in Figure 3.7.

Fig. 3.7: Polarity of electrolytic capacitor

Non-polarized capacitors, on the other hand, do not have a specific polarity and can be connected in either direction like mica capacitor, ceramic capacitor, film capacitor, etc. Understanding and observing capacitor polarity is essential for ensuring the reliability and safety of electronic circuits.

3.2.3 Functions of a Capacitor

Functions of capacitor in electronic circuits are as follows:

1. Storing electrical energy.
2. Avoid stepping over the electric circuit which are using coil like power supply, adapter, lamps.
3. Capacitors have various fundamental applications in circuit configuration, giving adaptable filter options, noise decrease, and power stockpiling and detecting abilities for designers.

Capacitors are utilized for: Creating delay/time interval in timing circuits by utilizing the charging time of capacitor

1. to smooth differing DC power supplies by going about as a repository of charge
2. in filter circuits since they effectively pass AC flags yet they block DC signals

3.2.4 Construction of Capacitor

The parallel plate capacitor is the simplest form of a capacitor. The construction of the capacitor is very simple. A capacitor is made of two electrically conductive plates placed close to each other, but they do not touch each other. These conductive plates are normally made of materials such as aluminium, brass, or copper.

The conductive plates of a capacitor are separated by a small distance. The empty space between these plates is filled with a non-conductive material or electric insulator or dielectric region. The non-conductive material or region between the two plates may be an air, vacuum, glass, liquid, or solid. This non-conductive material is called dielectric.

The two conductive plates of the capacitor are good conductors of electricity. Therefore, they can easily pass the electric current through them. The conductive plates of the capacitor also hold the electric charge. In capacitors, these plates are mainly used to hold or store the electric charge.

A dielectric material or medium is the poor conductor of electricity. They cannot pass electric current through them. In capacitors, the dielectric medium or material block the flow of charge carriers (especially electrons) between the conductive plates. As a result, the electric charges that try to move from one plate to another plate will be trapped within the plate because of the strong resistance from the dielectric.

Dielectric material does not allow the flow of charge carriers, but they allow the electric force, electric charge, or electric field produced by the charged particles (electrons). As a result, when charge is built up on the two plates, a strong electric field is generated between the two plates. Figure 3.8 shows the construction of the capacitor.

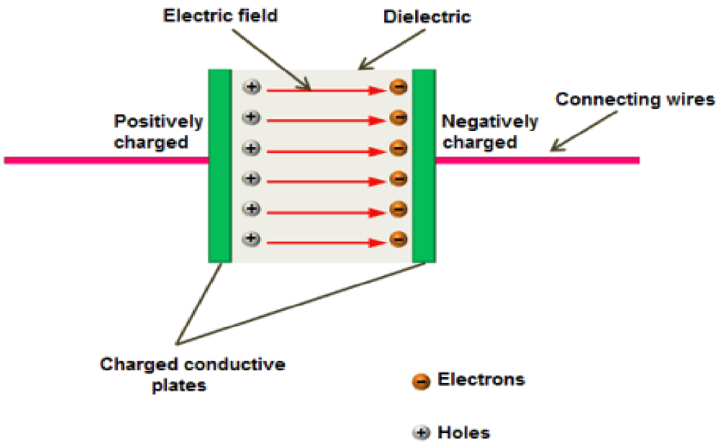


Fig. 3.8: Construction of Capacitor

3.2.5 Working of Capacitor

When voltage is applied to the capacitor in such a way that, the positive terminal of the battery is connected to the left side plate of the capacitor and the negative terminal of the battery is connected to the right side plate of the capacitor, the charging of capacitor takes place. The working of parallel plate capacitor is explained in Figure 3.9.

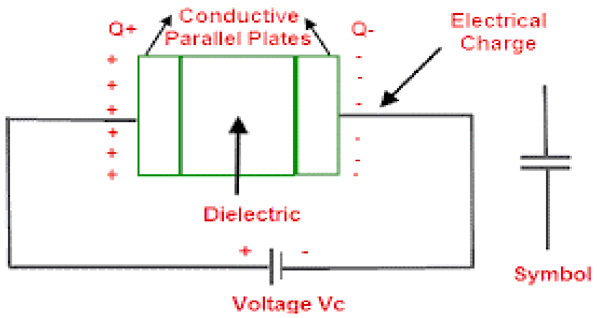


Fig. 3.9: Working of Capacitor

Because of this supply voltage, a large number of electrons start moving from the negative terminal of the battery through the conductive wire. When these electrons reach the right-side plate of the capacitor, they experience a strong opposition from dielectric material. The dielectric material or medium present between the plates will strongly oppose the movement of electrons from the right-side plate. As a result, a large number of electrons are trapped or build up on the right-side plate of the capacitor.

Because of the gaining of excess electrons from outside, the number of electrons (negative charge carriers) on the right-side plate will become higher than the number of protons (positive charge carriers). As a result, the right-side plate of the capacitor becomes negatively charged.

On the other hand, the electrons on the left side plate experience a strong attractive force from the positive terminal of the battery. As a result, the electrons leave left side plate and attracted or moved towards the positive terminal of the battery.

The negative charge builds on the right-side plate creates a strong negative electric field. This strong negative electric field also pushes the like charges or electrons on the left plate.

Because of the loss of large number of electrons from the left side plate, the number of protons (positive charge carriers) will become higher than the number of electrons (negative charge carriers). As a result, the left side plate of the capacitor becomes positively charged. Thus, both the conductive plates of a capacitor are charged.

The positive and negative charges on the both plates exert force on each other. However, they do not touch each other.

Because of the excess number of electrons on one plate and shortage of electrons on another plate, a potential difference or voltage is established between the plates. As the capacitor continues to charge, the voltage produced between the plates increases.

The voltage produced between the plates opposes the source voltage. As a result, when the capacitor is fully charged (voltage between the plates is equal to the source voltage), the capacitor stops charging. Because at this point, the energy of source voltage and the capacitor voltage are equal. As a result, the electrons or electric field on the right-side plate repels the electrons coming from the voltage source.

Therefore, to further charge the capacitor, we need to increase the voltage to a higher level. When voltage applied to the capacitor is increased to a higher level. The charge again starts building on the conductive plates of the capacitor until it reaches the new voltage level. When the voltage produced between the plates reaches the new source voltage level, it again stops charging.

3.2.6 Capacitance of a Capacitor

The capacitor's ability to store an electrical charge on its plates is called its capacitance. The unit of capacitance is Farad (F) and it is denoted by the symbol C. It is always positive.

A capacitor is said to have the capacitance of one Farad when a charge of one Coulomb is stored on the plates by a voltage of one volt. Sub-multiples of Farad are commonly used, such as micro-farads, Nano-farads and pico-farads, as Farad is a big unit of measurement.

Standard Units of Capacitance

Microfarad (μF) 1μF = 1/1,000,000 = 0.000001 = 10^{-6} F

Nano farad (nF) 1nF = 1/1,000,000,000 = 0.000000001 = 10^{-9}F

Picofarad (pF) 1pF = 1/1,000,000,000,000 = 0.000000000001 = 10^{-12} F

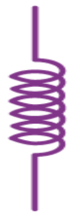
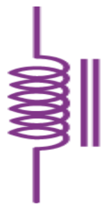
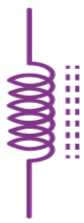
3.3 Inductor

An inductor is a passive electronic component that stores energy in the form of a magnetic field when current flows through it. It consists of a coil of wire wound around a core, which can be made of various materials such as air, iron, ferrite, or powdered iron. The amount of inductance, measured in henries (H), depends on factors like the number of turns in the coil, the core material, and the coil's physical dimensions. Inductors resist changes in current flow, causing voltage to be induced across them when the current changes. They are commonly used in electronic circuits for various purposes, including energy storage, filtering, tuning, and impedance matching. Inductors play critical roles in applications ranging from power supplies and transformers to signal processing and radio frequency circuits. Understanding the principles and characteristics of inductors is essential for designing and analyzing electronic circuits effectively.

3.3.1 Types of Inductors

Different types of inductors used in electronics and electrical circuits are shown in the table 3.3 given below.

Table 3.3: Types of Inductors

Name of inductor	Symbol	Image
Air core Inductor – This type of inductor uses a coil of wire wound around a non-magnetic core, such as air or plastic. Air core inductors are widely used in radio frequency (RF) circuits and high-frequency applications due to their low magnetic interference and high Q factor.		
Iron core Inductor – Iron core inductors have a coil wound around a core made of laminated iron or iron powder. They are commonly used in power applications, such as transformers and inductors for power supplies, due to their high inductance and ability to handle high currents.		
Ferrite core Inductor – Ferrite core inductors have a coil wound around a core made of ferrite material, a type of ceramic with high magnetic permeability. These inductors are used in power supplies, filters, and RF applications due to their high inductance and ability to handle high currents.		

3.3.2 Functions of inductor

Inductors are utilized widely with capacitors and resistors to make channels for analog circuits and in signal handling. Alone, inductor capacities as a low-pass filter, since the impedance of the inductor increments as the frequency of signal increases. At the point when consolidated with a capacitor, whose impedance diminishes as the frequency of signal increments, a notched filter can be made that permits a specific frequency range to go through.

An inductor associated with a capacitor frames a tuned circuit, which goes about as a resonator for oscillating current. Tuned circuits are generally utilized as a part of radio frequency hardware, for example, radio transmitters and receivers, as thin bandpass filters which can select a particular

1. frequency from a combined signal. They are also used in electronic oscillators to produce sinusoidal signs.
2. Transformer is formed by coupling flux using inductors of different number of turns and is used in power transmission systems
3. Inductors restrict exchanging currents /fault currents. This is why they are used in electrical transmission systems and are alluded as reactors

3.4 Diode

A diode is a basic electronic component that allows electric current to flow in one direction while blocking it in the opposite direction. It acts as a one-way valve for electricity in a circuit. Diodes are commonly used in electronic devices for various purposes, such as rectification (converting alternating current to direct current), voltage regulation, signal modulation, and light emission (in the case of light-emitting diodes or LEDs). They are essential building blocks in electronics and play a crucial role in controlling the flow of electricity in circuits

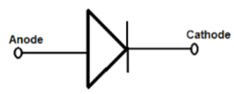
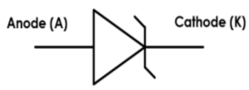
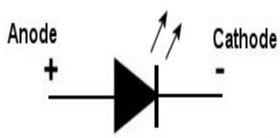
A diode is a particular electronic device with two electrodes called anode and cathode. Most diodes are prepared with semiconductor materials, for example, silicon, germanium, or selenium.

The diode is formed by combining n-type and p-type semiconductor materials. These n and p sides are created using a technique called doping. The p-n junction will be protected using glass/plastic cover. Anode is the one with more holes, which is p-side and cathode is the one with more electrons which is the n-side. Current can only flow from P to N side. Current flows in forward bias when the p-side's voltage is higher than that of the n-side.

3.4.1 Types of diodes

Diodes come in various types, each designed for specific applications. Common types include the standard silicon diode, which allows current to flow in one direction, and the Zener diode, used for voltage regulation. Light-emitting diodes (LEDs) emit light when current passes through them, while Schottky diodes offer fast switching capabilities. These diverse types of diodes serve essential roles in electronics, from rectifying currents to controlling voltage and producing light. It is illustrated below in table 3.4.

Table 3.4: Types of diodes

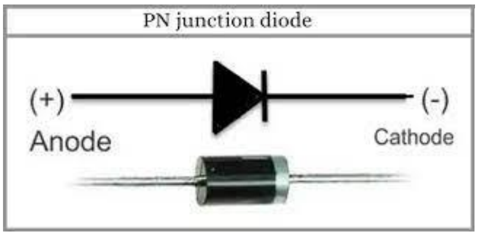
Name of diode	Symbol	Image
PN junction diode – PN junction diodes, made of semiconductor materials like silicon or germanium, allow current flow in one direction and block it in the opposite direction, essential for rectification, signal demodulation, and voltage regulation in electronic circuits.		
Zener diode – Zener diodes made from semiconductor materials like silicon or germanium, regulate voltage by maintaining a constant voltage drop across their terminals when reverse-biased, serving as voltage references and overvoltage protection devices.		
Light emitting diode (LED) – LEDs, composed of semiconductor materials such as gallium arsenide, gallium phosphide, or indium gallium nitride, emit light when current passes through them, widely used for indicators, displays, and lighting due to their energy efficiency and colour versatility.		

Schottky diodes – Schottky diodes formed by the junction of a metal and a semiconductor material like silicon or gallium arsenide, offer low forward voltage drop and fast switching characteristics, making them ideal for high-frequency circuits, rectification, and voltage clamping applications in electronics.		

3.5 P-N Junction Diode

The PN junction diode is the most common diode used in electronics. It is made up of semiconductor material. It is always conducted in one direction and hence used for rectification. The PN junction diode has two terminals namely anode and cathode. The current flows from anode to cathode.

The PN junction diode conducts only when it is connected in forward bias. The symbolic representation of the PN junction diode is shown in Figure 3.10. The arrow head represents the positive potential, and the bar shows the negative potential of the diode.



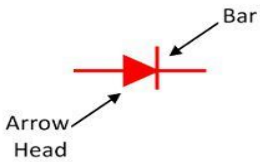


Fig. 3.10: PN Junction Diode and its symbol

3.5.1 Construction and working of P-N Junction Diode

The PN junction diode has a P-type and N-type semiconductor material which is joined by the process of alloying. Thus, both the ends of the diode have different properties. The electrons are the majority charge carrier of the N-type material, and the holes are the majority charge carrier of the p-type semiconductor material. The region in which both the p-type and n-type material meets is known as the depletion region. This region does not have any free electrons because electrons and holes combine with each other in this region.

The depletion region is very thin, and it does not allow the current to flow through it. The PN junction starts conducting when the forward bias is applied across the junction. The forward bias means the P-type material is connected to the positive terminal of the battery and the N-type material is connected to the negative supply.

The forward bias creates the electric field which reduces the depletion region of the PN-junction diode. When the potential barrier is completely reduced, it creates the conducting path for the flow of current. Thus, large current starts flowing, and this current is called the forward current. The above-mentioned process is explained as shown in Figure 3.11.

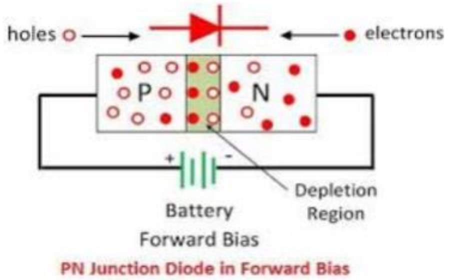


Fig. 3.11: P-N Junction Diode working in forward bias

3.5.2 Functions of P-N Junction diode

The function of the diode is to conduct current when it is forward biased as mentioned before and, in this state, the diode acts as a short circuit or it is turned on. When the n-side is at higher potential than the p-side diode doesn't conduct and this is known as reverse bias. At this time the diode acts as an open circuit or it is in an off state as shown in Figure 3.12.

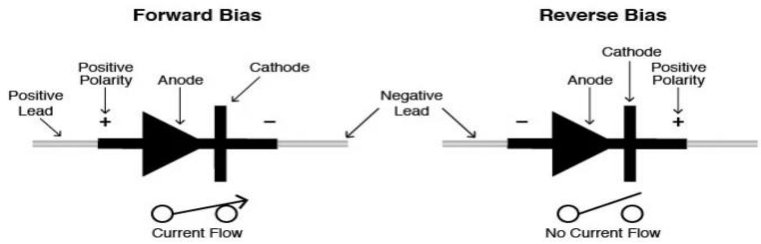


Fig. 3.12: function of P-N Junction Diode in forward and reverse bias

3.5.3 Applications of P-N Junction diode

Some common applications of PN junction diodes are as follows:

Rectification

PN junction diodes are widely used in rectifier circuits to convert alternating current (AC) to direct current (DC) in power supplies for electronic devices.

Signal Clipping and Clamping

PN junction diodes are employed in clipping and clamping circuits to limit the amplitude of input signals, ensuring they remain within predetermined voltage levels.

Voltage Multiplier

PN junction diodes, particularly in combination with capacitors, are utilized in voltage multiplier circuits, to generate high-voltage outputs from low-voltage inputs.

Switching

PN junction diodes can be used as switches in electronic circuits to control the flow of current, allowing current to pass in one direction while blocking it in the reverse direction.

Voltage Limiting

PN junction diodes are employed in voltage limiting circuits to protect sensitive electronic components from excessive voltage by clamping the voltage level to a safe threshold.

3.6 Light Emitting Diode (LED)

Diodes which produce light when current flows through it are known as light emitting diode (LED). A light producing diode (LED) is a two-lead semiconductor light source.

When they are applied with a suitable voltage the electrons and holes combine and energy is emitted as photons/light. LED image and symbol are depicted as shown in Figure 3.13.

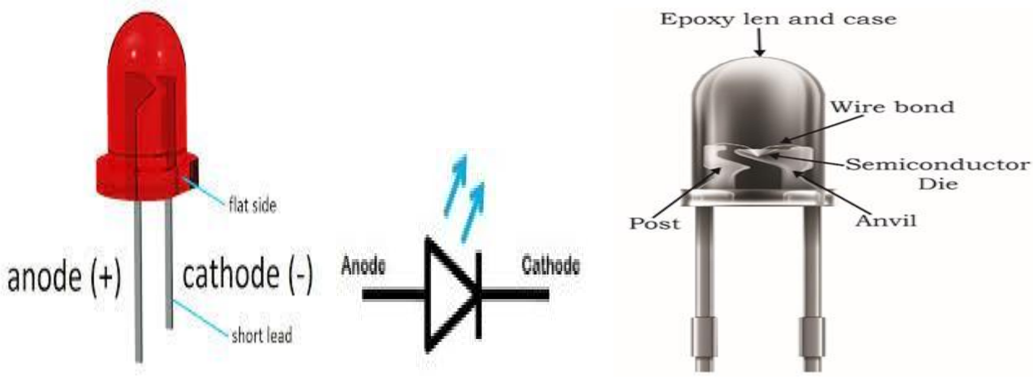


Fig 3.13: (a) Light emitted diode (LED) (b) symbol of LED (c) Internal parts of LED

Advantages of LED

1. Very low voltage and current is adequate to drive run the LED.
2. Voltage ranges from 1 to 2 volts.
3. Current ranges from 5 to 20 milliamperes.
4. Total power yield will be under 150 milliwatts.
5. The response time is very less (around 10 nanoseconds)
6. The device does not require any warming and warm up time.
7. Miniature in dimension and henceforth light weight.
8. Have a rough structure and thus can withstand stun and vibrations.
9. An LED has a life expectancy of over 20 years.

Disadvantages

1. A slight overabundance in voltage or current can harm the gadget.
2. The gadget is known to have a substantially more extensive data transmission contrasted with the laser.
3. The temperature relies upon the radiant yield power and wavelength

Function of LED

Four important functions are:

1. LEDs are used in signalling systems like traffic signals road diction signals etc.

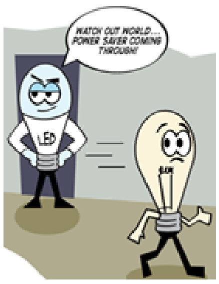
Used in LED bulbs to provide sufficient light in night /in dark rooms etc.

In human vision measurement.

LED is used in light sensors in reverse bias condition to detect narrow banded lights.

Powerful fact…

Why LEDs are good choice?
1.Long life
2.Durable
3.High efficiency
4.Low energy use
5.Compact size
6.No UV issue



The light from LEDs can be tweaked rapidly so they are utilized broadly in optical fiber and free space optics correspondences. LEDs' are used in road lights, presentations, backdrop illumination and many more applications. Infra-red LED produces light which is invisible to humans and are used in remote controls. They can be used in optical disconnection of higher voltage frameworks from low voltage circuits.

3.7 Transistors

A Transistor is a three-terminal semiconductor device used for amplifying or switching electrical signals in electronic circuits. It consists of three regions: the emitter, base, and collector. By controlling the base current, a transistor can amplify signals or act as a switch. They are commonly used in various applications like audio amplifiers and digital logic circuits due to their high gain and fast switching speeds. The transistor is a standout amongst the most vital gadgets in electronics. The common transistor looks like as shown in Figure 3.14.

Fig. 3.14 Transistor image

3.7.1 Types of Transistor

Transistors come in two types: NPN and PNP, with each type having different doping polarities. The symbol of NPN and PNP transistors are shown in Figure 3.15. Outward arrow on the emitter side is an indication of an NPN transistor and the inward arrow on the emitter side is indication of PNP transistor.

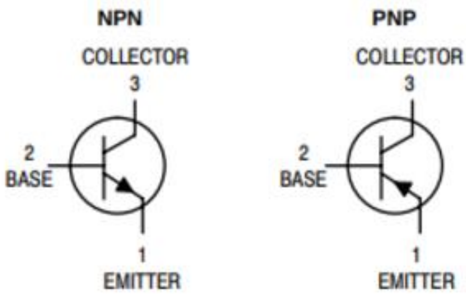


Fig. 3.15: Symbols of NPN and PNP transistors

NPN Transistor

In an NPN transistor, the middle layer (base) is made of P-type semiconductor material, sandwiched between two layers of N-type semiconductor material (collector and emitter).

When a small current flow from the base to the emitter (forward bias), it controls a much larger current flowing from the collector to the emitter. NPN transistors are commonly used in amplification circuits, digital logic circuits, and switching applications due to their ease of use and versatility. The example of NPN transistors are 2N2222, BC547 as shown in Figure 3.16.

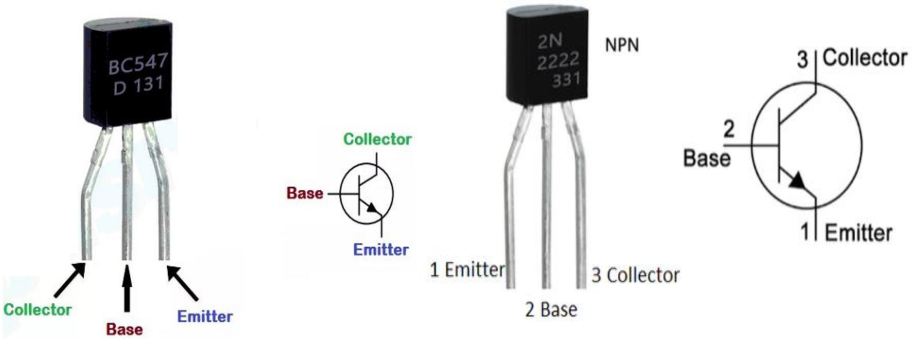


Fig. 3.16: NPN transistors-BC547 and 2N2222

PNP Transistor:

In a PNP transistor, the middle layer (base) is N-type semiconductor material, sandwiched between two layers of P-type semiconductor material (collector and emitter).

When a small current flow from the emitter to the base (forward bias), it controls a much larger current flowing from the emitter to the collector. PNP transistors are also used in amplification circuits, digital logic circuits, and switching applications. The example of PNP transistors are 2N3906, BC557 as shown in Figure 3.17.

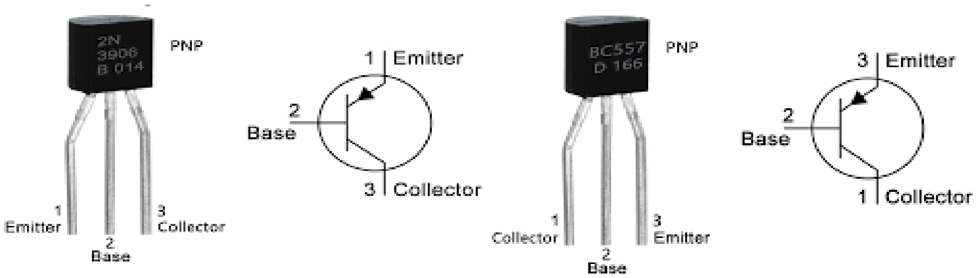


Fig. 3.17: PNP transistors-2N3906, BC557

3.7.2 Transistor Operating Modes

Transistors operate in four main modes: cutoff, active, saturation and reverse active. These modes determine how the transistor controls the flow of current between its terminals. The working of transistor in these modes is given as follows:

Cutoff Mode

In cutoff mode, the transistor is effectively "off," and no current flows between the collector and emitter terminals. This mode occurs when the base-emitter junction is reverse-biased, preventing the flow of majority charge carriers (electrons for NPN transistors, holes for PNP transistors) from the emitter to the base.

The transistor acts as an open switch, with a high resistance between the collector and emitter.

Active Mode

In active mode, the transistor is "on," and current flows between the collector and emitter terminals. This mode occurs when a small forward bias voltage is applied to the base-emitter junction, allowing a controlled amount of majority charge carriers to flow from the emitter to the base. The transistor amplifies the input signal applied to the base, controlling the larger current flowing between the collector and emitter.

Saturation Mode

In saturation mode, the transistor is fully "on," and maximum current flows between the collector and emitter terminals. This mode occurs when the base-emitter junction is heavily forward-biased, allowing a large number of majority charge carriers to flow from the emitter to the base. The transistor acts as a closed switch, with a low resistance between the collector and emitter, allowing maximum current flow.

Reverse-Active

A backward current proportional to base current (flowing into base) flows from emitter to collector. It is illustrated below in Figure 3.18.

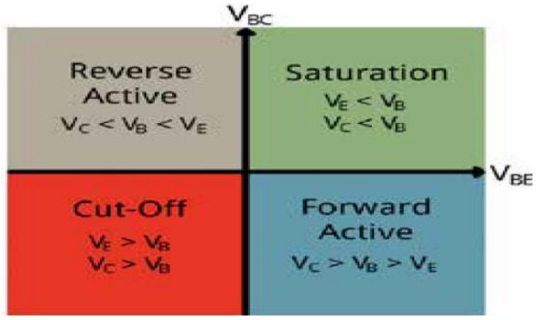


Fig. 3.18 Diode operation modes

3.7.3 Applications of transistor

A transistor is a semiconductor with a strong and non-moving part to pass a charge. It can amplify (increase) and switch electrical power and electronic signals. The most important applications of transistors are as follows:

The transistor as an amplifier

The transistor works as an amplifier by controlling a larger current between its collector and emitter terminals in response to a small input current at its base. This amplification is achieved by modulating the transistor's conductivity, which magnifies the input signal to produce a stronger output signal.

Let's consider a simple example using a transistor amplifier in an audio circuit.

Imagine there is a small microphone that produces a weak electrical signal when speak into it. This weak signal needs to be boosted so that it can drive a speaker and produce sound loud enough for people to hear. Here's where the transistor amplifier comes in: the weak electrical signal from the microphone is fed into the base of the transistor. This small signal controls the flow of a much larger current between the collector and emitter terminals of the transistor.

For instance, if you whisper into the microphone (weak signal), the transistor amplifies this whisper into a louder sound by controlling a bigger flow of electricity through it. As a result, the amplified signal drives the speaker, producing a louder sound that's audible to everyone. So, the transistor effectively acts as a signal booster, amplifying the weak signal from the microphone to a level that's suitable for driving the speaker.

The transistor as switch

A transistor can work as a switch by controlling the flow of current between its terminals. When a small voltage is applied to the base terminal, it allows current to flow between the other two terminals, acting like a closed switch. When no voltage is applied, it blocks current flow, acting like an open switch. This switching ability is crucial in digital circuits, where transistors represent binary states (on/off) used in computers and electronic devices.

Imagine that there is an LED that has to be to turn on and off with a switch. By connecting the LED to a transistor and applying a small voltage to the transistor's base terminal, control can be done on whether the LED is on or off. When the voltage is applied, the transistor acts like a switch, allowing current to flow through the LED and turning it on. When the voltage is removed, the transistor switches off, cutting off the current flow and turning off the LED. This simple setup demonstrates how a transistor can function as a switch, controlling the flow of electricity in electronic circuits.

3.8 Integrated Circuit (IC)

Integrated circuits (ICs), also known as microchips or chips, are tiny electronic devices made up of semiconductor materials, such as silicon. These circuits contain a large number of electronic components, such as transistors, diodes, resistors, and capacitors, all fabricated onto a single chip of semiconductor material. Figure 3.19 shows the Integrated Circuit.

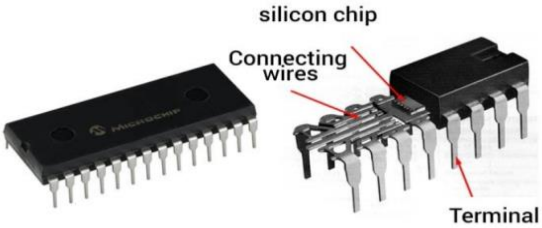


Fig. 3.19 Integrated Circuit

ICs revolutionized the field of electronics by making it possible to miniaturize electronic circuits. Before ICs, electronic circuits were made up of individual components connected by wires, which took up a lot of space and were prone to errors.

The invention of ICs allowed engineers to pack thousands, millions, or even billions of electronic components onto a single chip, greatly reducing the size and cost of electronic devices while increasing their reliability and performance. This miniaturization has led to the development of smaller, faster, and more powerful electronic devices, such as computers, smartphones, digital cameras, and many other consumer electronics.

There are different types of ICs, each designed for specific purposes. For example, analog ICs are used for processing continuous signals, such as those found in sound or radio waves, while digital ICs are used for processing discrete signals, like the 0s and 1s in computer binary code.

Integrated circuits are the backbone of modern electronics, enabling the creation of the sophisticated devices that we rely on in our daily lives.

Summary

The chapter gives a basic idea of key electronic components. Resistance, measured in ohms (Ω), hinders current flow, and resistors regulate it. Capacitors store energy in an electric field, while inductors store it in a magnetic field. Diodes allow one-way current flow, and Light Emitting Diodes (LEDs) emit light when powered. The chapter introduces transistors, controlling current flow in different modes, and concludes with Integrated Circuits (ICs)—semiconductor wafers performing various tasks. ICs embody miniaturization, cost reduction, and enhanced performance in electronic circuits.

Check Your Progress

A. Multiple Choice questions

1. What is the unit of resistance? (a) Volt (b) Ampere (c) Ohm (d) Watt
2. What is the primary function of a resistor in a circuit? (a) Amplify signals (b) Store energy (c) Regulate current flow (d) Emit light
3. Which electronic component stores energy in an electric field? (a) Resistor (b) Inductor (c) Capacitor (d) Diode
4. What is the primary function of a diode? (a) Amplify signals (b) Store energy (c) Control current flow (d) Emit light
5. What is the mode where a transistor acts like a short circuit from collector to emitter? (a) Saturation (b) Cut-off (c) Active (d) Reverse-Active
6. What is the purpose of Integrated Circuits (ICs)? (a) Emit light (b) Regulate current (c) Perform high-level tasks (d) Store energy
7. Which component is used to regulate the current flow in circuits, preventing damage to devices like LEDs? (a) Resistor (b) Capacitor (c) Inductor (d) Diode
8. What does a Light Emitting Diode (LED) do when current flows through it? (a) Amplify signals (b) Store energy (c) Emit light (d) Control current flow
9. What is the unit of capacitance? (a) Ohm (b) Farad (c) Volt (d) Ampere
10. Which type of capacitor does not have a polarity? (a) Electrolytic (b) Tantalum (c) Polar (d) Ceramic

B. Fill in the blanks

1. Resistance is the obstruction caused by a substance to current flow, measured in ______ and denoted by the symbol Ω.
2. Resistors, the most common electronic components, are ______ used to implement electrical resistance in electronic circuits.
3. Colour coding of resistors is a method to identify their_____.
4. Resistors are essential in circuits to _______, preventing damage to components like LEDs, where excess current can be destructive.
5. A capacitor, a device with two terminals separated by an _______, stores energy in an electric field.
6. Inductors store energy in a magnetic field and resist changes in ______.
7. A diode, with two electrodes (anode and cathode), allows current flow in one direction and ______.
8. Light Emitting Diodes (LEDs) produce______ when current flows through them.
9. A transistor, a three-terminal device, can amplify and ________.
10. Integrated Circuits (ICs) are small plates of semiconductor material containing thousands or millions of tiny components like __________.

C. State whether True or False

1. Resistance is the facilitation of current flow in a substance, measured in Volts (V).
2. Resistors are active components used to amplify electronic signals.
3. The 4th band in the color coding of resistors represents the power-of-ten multiplier.

4. Capacitors store energy in an electric field and are measured in Farads (F).
5. Inductors resist changes in electric current by inducing a voltage in the conductor.
6. Diodes allow current to flow in both directions and act as open circuits in reverse bias.
7. Light Emitting Diodes (LEDs) are used in optical fiber communications and produce sound waves.
8. Transistors have only two modes of operation: saturation and cut off.
9. Integrated Circuits (ICs) are made of discrete electronic components.
10. Transistors have three terminals: base, emitter, and collector.

D. Answer the following questions in short

1. Explain the primary function of a resistor in an electronic circuit.
2. What is the purpose of colour coding in resistors, and how is it interpreted?
3. Define a capacitor and its basic construction.
4. Explain the relationship between voltage, charge, and capacitance in a capacitor.
5. Describe the basic structure and function of an inductor.
6. What is the role of a diode in an electronic circuit, and how does it function in both forward and reverse bias?
7. What are the advantages and disadvantages of Light Emitting Diodes (LEDs)?
8. How does a transistor operate, and what are its different modes?
9. In what applications can transistors be used as amplifiers?
10. Explain the concept of Integrated Circuits (ICs) and their advantages in electronic circuits.

Chapter 4. Tools, Equipment and Measuring Instruments

Tools, equipment, and measuring instruments are essential for tasks of installation or repairing in electronics and electrical appliances. Common tools include screwdrivers and wrenches for fastening, while equipment like drills and saws aid in cutting and shaping materials. Measuring instruments like rulers and callipers ensure accurate measurements, while specialized tools such as multimeters and oscilloscopes are used for electrical testing and signal analysis. These tools enhance efficiency and accuracy in various tasks.

4.1 Common hands tools

Hand tools are absolutely necessary for daily tasks. Since ancient times, people have utilized them to carry out a variety of beneficial tasks. There are many varieties of hand tools that are suitable for any type of task. Certain tools are designed for a particular purpose, while others are multipurpose.

Understanding their design and appropriate use is crucial if you want the best results from your work. Many errors and injuries can result from carelessness or ignorance.

When using hand tools, accuracy and proper use are more crucial than productivity. A craftsman must select the appropriate tools for the job based on the nature of the work that needs to be done. He needs to know which tool is best for the job. If not, work output and quality will deteriorate.

Some Common hands tools that are used frequently are described as follows:

Cutter

Cutters are hand tools made for cutting a variety of materials, including thin metal sheets and wires. They are available in various varieties, such as cable cutters, wire strippers, and diagonal cutters. The image of the most used type of cutter is shown below in Figure 4.1.

Fig. 4.1: Cutter

Use: Wire strippers are useful for removing insulation, and diagonal cutters work well for cutting wires. Thick wires and cables are the intended use for cable cutters.

Scissors

Description: Scissors are cutting tools with two opposing blades that pivot around a fulcrum. They are commonly used for cutting paper, fabric, or other thin materials. The image of the most used type of cutter is shown below in Figure 4.2.

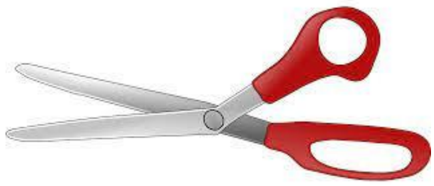


Fig. 4.2: Scissors

Use: Scissors are versatile and can be used for a variety of tasks, from crafting and office work to cutting packaging materials.

Screwdriver

A screwdriver is a hand tool used for turning screws. It typically consists of a handle and a shaft with a tip that fits into the screw's head. Screwdrivers are very important and are used to tighten the screws, bolts, and nuts. They come in various shapes and also can be altered as per the size of the bolt. The image of the screwdriver is depicted below in Figure 4.3.

Fig. 4.3: Screwdriver

Use: Screwdrivers come in various types, such as flathead and Phillips, and are essential for assembling and disassembling items held together by screws.

Combination Pliers

Combination pliers are versatile hand tools that combine features of both cutting pliers and gripping pliers. They often have a cutting edge and serrated jaws for gripping. It is shown below in Figure 4.4.

Fig. 4.4: Combination pliers

Use: Combination pliers are useful for gripping, twisting, bending, and cutting various materials, making them an essential tool for electricians, mechanics, and DIY enthusiasts.

4.2 Measuring Instruments

A device or mechanism used to determine the present value of the quantity under measurement is classified as a Measuring Instrument. It acts as a user 's interface between the physical world and the information world.

Phase Tester

A phase tester, also known as a voltage tester, is used to determine the presence or absence of an electrical voltage in a circuit. It looks like as shown in following Figure 4.5.

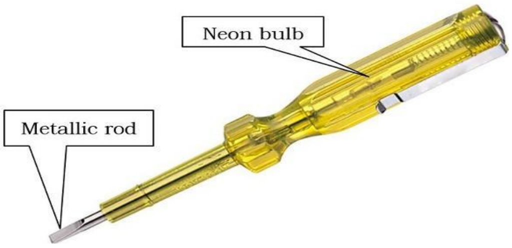


Fig. 4.5: Phase Tester

Use: It helps ensure that electrical circuits are de-energized before maintenance or repair work, preventing accidents.

Earth Tester

An earth tester measures the resistance between the grounding system and the Earth. It ensures that electrical systems have a proper ground connection. The image of the earth tester is shown in Figure 4.6.

Fig. 4.6: Earth Tester

Use: Used to maintain electrical safety by verifying that the grounding system is functioning correctly.

Watt Meter

A watt meter measures electrical power consumption in watts, helping users monitor and control energy usage as shown in Figure 4.7

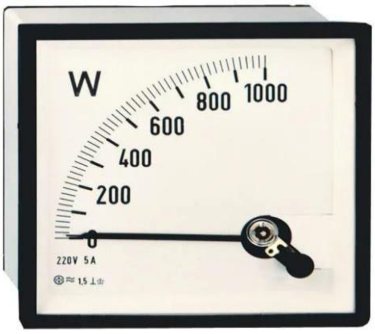


Fig. 4.7: Watt meter

Use: Useful for assessing the power consumption of electrical appliances and optimizing energy efficiency.

Energy Meter

An energy meter measures the total electrical energy consumed over time, typically in kilowatt-hours (kWh). It is shown in the following Figure 4.8.

Fig. 4.8: Energy meter

Use: Essential for utility billing and monitoring energy consumption in residential, commercial, and industrial settings.

Multi-meter

A multi-meter is a versatile instrument that combines multiple measurement functions, including voltage, current, and resistance. The real view of multi-meter is shown in Figure 4.9.

Fig. 4.9: Multi meter

Use: Widely used for troubleshooting electrical circuits, checking continuity, and measuring various electrical parameters.

Clamp Meter

A clamp meter is an electrical test instrument that combines a current sensor and a simple digital multimeter. Current is measured by clamps. Voltage is measured by probes. Electrical meters with hinged jaws enable technicians to measure current in a circuit without disconnecting or de-energizing it by clamping the jaws around a wire, cable, or other conductor at any point in the electrical system.

A clamp meter measures current by clamping around a conductor without the need for direct contact. Its different parts and design are shown in following Figure 4.10.

Fig. 4.10: Clamp meter

Use: Ideal for measuring AC current in live electrical circuits safely, especially in situations where accessing the conductor is challenging.

4.3 Measurements Using Multimeter

Different measurements can be performed using a multimeter like voltage, current, resistance etc. The position of knob on the multimeter for these measurements are shown in Figure 4.11.

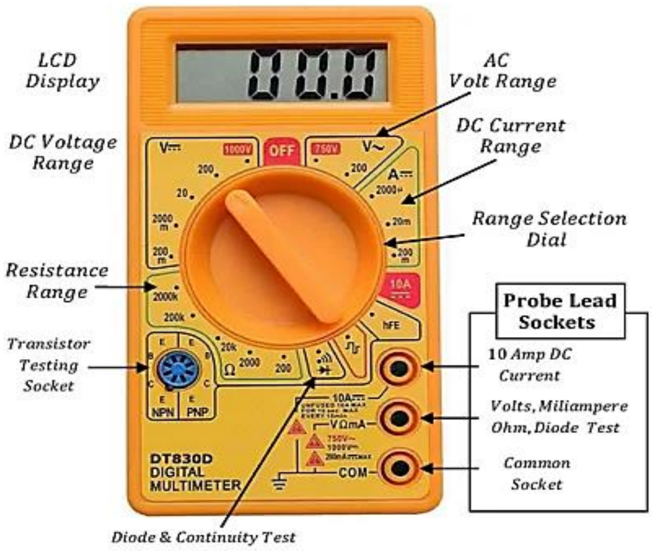


Fig. 4.11: Measurements Using Multimeter

4.3.1 Measurement of AC and DC voltage

Measuring AC (Alternating Current) and DC (Direct Current) voltage using a multimeter involves setting the multimeter to the appropriate mode and connecting the probes to the circuit being measured. Here's a step-by-step guide:

Measurement of AC Voltage

Set the Selector Switch – Turn the selector switch to the AC voltage (V~) setting. This is usually denoted by a "~" symbol.

Select the Range – Choose the appropriate voltage range on the multimeter. Start with a higher range and then adjust as needed.

Connect the Probes – Connect the red probe to the positive (+) terminal and the black probe to the negative (-) terminal. If measuring across a component, connect the probes to the two points in the circuit.

Take the Reading – Place the probes at the points in the circuit where you want to measure AC voltage. The multi meter will display the AC voltage in volts on the screen. This procedure is shown in Figure 4.12.

Fig. 4.12: Measurements of AC Voltage

Measurement of DC Voltage

Set the Selector Switch – Turn the selector switch to the DC voltage (V-) setting. This is usually denoted by a "V-" or "VDC" symbol.

Select the Range – Choose the appropriate voltage range on the multimeter. Start with a higher range and then adjust as needed.

Connect the Probes – Connect the red probe to the positive (+) terminal and the black probe to the negative (-) terminal. If measuring across a component, connect the probes to the two points in the circuit.

Take the Reading – Place the probes at the points in the circuit where you want to measure DC voltage. The multi meter will display the DC voltage in volts on the screen. Connection for this measurement is shown in Figure 4.13.

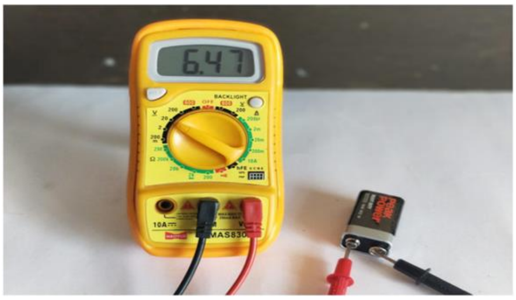


Fig. 4.13: Measurements of DC Voltage

Measurement of Current

Setting the Selector Switch – Turn the selector switch to the current (A) setting.

Connecting the Probes – For measuring current, the multi meter must be inserted into the circuit. Break the circuit and connect the multimeter in series with the load.

Reading the Display – The multi meter will display the current value in amperes. The connection can be done as shown below in Figure 4.14.

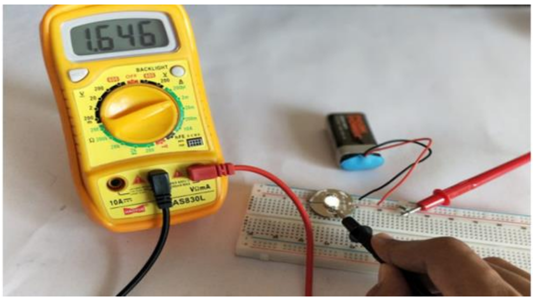


Fig. 4.14: Measurements of Current

Measurement of Resistance

Setting the Selector Switch – Turn the selector switch to the resistance (Ω) setting.

Connecting the Probes – Connect the probes to the two ends of the resistor or component being measured.

Reading the Display – The multi meter will display the resistance value in ohms. It can be performed as shown in following Figure 4.15.

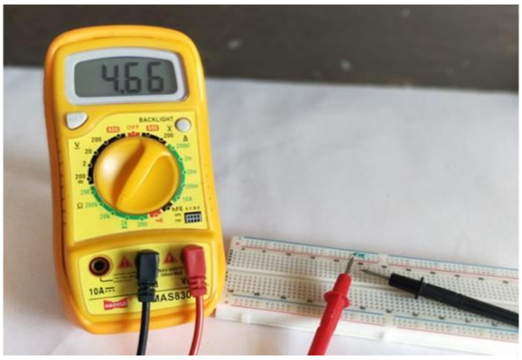


Fig. 4.15: Measurements of resistance

Continuity Test using Multimeter

Setting the Selector Switch – Turn the selector switch to the continuity setting (often represented by a symbol that looks like sound waves).

Connecting the Probes – Touch the probes to the two points in the circuit being tested.

Reading the Display – The multi meter will produce a beep if there is continuity, indicating a low resistance path. The position of knob and wires for continuity testing is as shown in Figure 4.16.

Fig. 4.16: Continuity Test using Multimeter

4.4 Safety practices to use Tools, Equipment and Measuring instrument

Safety practices are paramount for technicians working with tools, equipment, and measuring instruments. Adhering to proper safety procedures helps prevent accidents, ensures the well-being of the technician, and promotes a secure working environment. Here's a detailed guide on safety practices for technicians:

4.4.1 General Safety Practices

Personal Protective Equipment (PPE)

Always wear the appropriate PPE for the task at hand. This may include safety glasses, gloves, hearing protection, and, if necessary, a helmet or other specialized equipment. The images of PPE kit are given in Figure 4.17.

Fig. 4.17: Personal Protective Equipment (PPE)

Tool Inspection

Before using any tool or equipment, inspect it for damage, wear, or defects. Do not use tools that are damaged, as they can pose a safety risk.

Proper Tool Use

Use each tool for its intended purpose, following manufacturer guidelines and safety recommendations. Improper tool use can lead to accidents and damage to the equipment.

Secure Work Area

Keep the work area clean and organized. Remove clutter to prevent tripping hazards and ensure easy access to tools and equipment.

Training and Certification

Ensure that technicians are adequately trained and certified to use specific tools and equipment. Ongoing training is essential to stay updated on safety protocols and industry best practices.

4.4.2 Electrical Safety

De-Energize Before Maintenance

When working on electrical systems, always de-energize circuits before performing maintenance or repairs. Use appropriate lockout/tagout procedures.

Use Insulated Tools

When working with live electrical components, use insulated tools to reduce the risk of electrical shock. Ensure tools have proper insulation and are in good condition.

Grounding

Ensure that equipment requiring grounding is properly connected to a grounding source. This helps prevent electrical hazards.

Voltage and Current Measurement

When measuring voltage or current, use the correct range on the measuring instrument. Ensure the instrument is rated for the expected values and follow proper measurement procedures.

4.4.3 Mechanical and Hand Tool Safety

Wear Safety Gloves

Use appropriate safety gloves when handling sharp or rough materials. Gloves provide protection against cuts, abrasions, and other hand injuries.

Eye Protection

Wear safety glasses or goggles to protect the eyes from flying debris, dust, or chemical splashes. Use a face shield when needed.

Proper Lifting Techniques

When lifting heavy objects, use proper lifting techniques to prevent back injuries. Lift with the legs, not the back, and seek assistance for heavy loads.

Fire Safety

Fire Extinguishers: Know the location of fire extinguishers in the work area. Understand how to use them and participate in fire safety drills.

Flammable Materials

Store flammable materials properly, away from heat sources. Follow safety protocols for handling and disposing of flammable substances.

4.4.4 Emergency Preparedness

First Aid

Have a well-equipped first aid kit accessible in the work area. Ensure that all technicians are trained in basic first aid procedures.

Emergency Procedures

Establish and communicate emergency procedures, including evacuation plans, in case of accidents, fires, or other emergencies.

By prioritizing these safety practices, technicians can create a work environment that minimizes risks, protects individuals, and promotes efficient and secure operations. Regular safety training and a commitment to best practices contribute to a culture of safety in the workplace.

Summary

The "Tools, Equipment and Measuring Instruments'' chapter explores crucial hand tools like cutters, scissors, and screwdrivers, emphasizing precision and safety. It introduces measuring instruments for electrical systems, including phase testers and watt meters. The guide covers multimeter usage for AC/DC voltage, current, resistance, and continuity tests. Key safety practices include PPE use, proper tool inspection, and emergency preparedness.

Check Your Progress

A. Multiple Choice questions

1. What is the primary consideration when using hand tools? (a) Productivity (b) Accuracy (c) Multipurpose use (d) Work output
2. What is the purpose of wire strippers among hand tools? (a) Cutting wires (b) Removing insulation (c) Gripping materials (d) Bending materials
3. Which hand tool is essential for turning screws and bolts? (a) Cutter (b) Scissors (c) Screwdriver (d) Combination pliers
4. What is the main use of a phase tester in measuring instruments? (a) Measure resistance (b) Determine voltage presence (c) Measure power consumption (d) Assess energy consumption
5. When measuring AC voltage with a multimeter, what is the first step? (a) Connect the probes (b) Set the selector switch to AC voltage (c) Select the appropriate voltage range (d) Take the reading
6. What is the purpose of a clamp meter in electrical testing? (a) Measure AC current (b) Measure DC voltage (c) Measure resistance (d) Measure power consumption
7. In general safety practices, what does PPE stand for? (a) Professional Protection Equipment (b) Personal Protective Equipment (c) Proper Procedure Enforcement (d) Protective Productive Environment
8. Why is it essential to de-energize circuits before electrical maintenance? (a) To save energy (b) To prevent accidents (c) To increase productivity (d) To reduce resistance
9. What is the recommended practice for lifting heavy objects? (a) Lift with the back (b) Use improper techniques (c) Seek assistance (d) Avoid safety gloves
10. What should technicians do during emergency procedures? (a) Continue working (b) Ignore evacuation plans (c) Use tools without PPE (d) Follow evacuation plans

B. Fill in the blanks

1. When using hand tools, ________ are more crucial than productivity.
2. Combination pliers are versatile hand tools that combine features of both ___.
3. A device or mechanism used to determine the _________of the quantity under measurement is classified as a Measuring Instrument.
4. A ________measures electrical power consumption in watts, helping users monitor and control energy usage.
5. A multi-meter is a versatile instrument that combines multiple measurement functions, including _________.
6. A clamp meter is an electrical test instrument that combines a current sensor and a________.
7. Choose the appropriate voltage range on the multimeter. Start with a _____and then adjust as needed.
8. When working on electrical systems, always _______ circuits before performing maintenance or repairs.

9. When working with live electrical components, use______ to reduce the risk of electrical shock.
10. When lifting heavy objects, use ________ to prevent back injuries.

C. State whether True or False

1. Before using any tool or equipment, it is essential to inspect them for damage, wear, or defects, and damaged tools should not be used to prevent safety risks.
2. The selector switch on a multi-meter must be set to the appropriate mode for measuring AC or DC voltage, current, or resistance.
3. When measuring AC voltage using a multimeter, the appropriate voltage range should be chosen, starting with a higher range and adjusting as needed.
4. Proper grounding of equipment requiring grounding is essential to prevent electrical hazards in the workplace.
5. Ongoing training and certification are necessary for technicians to stay updated on safety protocols and industry best practices.
6. Phase testers are used to determine the presence or absence of electrical voltage in a circuit,
7. A watt meter is valuable for assessing the power consumption of electrical appliances and optimizing energy efficiency.
8. Earth testers are used to measure the total electrical energy consumed over time.
9. The clamp meter is ideal for safely measuring AC current in live electrical circuits without the need for direct contact.
10. When measurement is performed using a multimeter, the appropriate range should be chosen, starting with a lower range and adjusting as needed.

D. Answer the following questions in short

1. Explain the importance of accuracy and proper use when using hand tools. Give an example.
2. Describe the use of an earth tester and its significance in maintaining electrical safety.
3. How does a clamp meter measure current in live electrical circuits, and in what situations is it particularly useful?
4. Provide step-by-step instructions for measuring DC voltage using a multimeter.
5. Why is it essential to wear safety gloves when handling sharp or rough materials, and what type of protection do gloves offer?
6. Explain the purpose of a watt meter and how it aids in monitoring and controlling energy usage.
7. What is the role of continuity test in electrical measurements using a multimeter?
8. Discuss the importance of personal protective equipment (PPE) in ensuring safety when working with tools and equipment.
9. How does a combination plier differ from other hand tools, and what tasks is it commonly used for?
10. Why is it necessary to de-energize circuits before performing maintenance on electrical systems, and what safety measures should be followed?

Module 2	Installation and Repairing of LED Lights

Module Overview

This Module provides a comprehensive overview of different types of light sources, with a focus on LED lights. It gives exposure to the fascinating world of Light Emitting Diodes (LEDs), examining their principles of operation, advantages, applications, and the underlying technology that powers these energy-efficient light sources. Understanding LEDs is crucial in the context of modern lighting systems and electronic displays.

The session covers the components of an LED luminary assembly, LED drivers, tools used in luminaire assembly, heat sinks, thermal interface materials, and the installation process for various LED products such as MR-16/Spot Light, LED Bulb, LED Tube Light, LED Down Light, LED Round Panel Light, and LED Street Light.

The detailed breakdown of LED luminary components, tools, and assembly steps is particularly valuable for individuals involved in the installation and repair of LED lights. The inclusion of information about LED drivers, their types, selection criteria, and the tools used in luminaire assembly adds depth to the understanding of the topic.

The second part of the module covers troubleshooting and repairing of LED lights. Troubleshooting is a systematic approach to locate the cause of a fault in an electronic circuit or system. A Field Technician should have the knowledge and skill to repair all kinds of appliances. Technicians should be able to diagnose and troubleshoot the problem. They should carry out repairs according to the requirements of that particular appliance. It is very important for a technician to correctly identify the fault in the home appliances. Wrong identification of fault will lead to waste of time and money and it can also cause damage to the equipment. It covers common LED failure modes, secondary optics failure modes, thermal management system failure, and LED driver failure. The chapter concludes with a step-by-step guide for diagnosing and repairing faults in LED lights, emphasizing the importance of productivity and quality standards.

Overall, the content is well-organized and informative, providing a thorough guide for individuals involved in the installation, repair, and maintenance of LED lights. The inclusion of visuals, such as figures and images, enhances the understanding of the concepts presented in the sessions.

Learning Outcomes

After completing this module, you will be able to:

- Understand the fundamental principles of LED lights, including their structure, functionality, energy efficiency, and common applications.
- Demonstrate the correct procedures for installing LED lights, including wiring, mounting, and ensuring safety compliance during the process.
- Identify common issues with LED lights and apply effective troubleshooting and repair techniques to restore functionality and performance.

Module Structure
Session 1. Basics of LED Light
Session 2. Installation of LED Light
Session 3. Troubleshooting and Repairing of LED

Session 1. Basics of LED Light

Light is a form of energy that allows us to see the world around us. It comes in different colors, like those in a rainbow, because it travels in waves with varying lengths called wavelengths. The part of light that we can see is called visible light, which includes all the colors we know. But there are also other types of light that we can't see, like ultraviolet and infrared. Ultraviolet light can give us sunburns, while infrared light makes things feel warm, like when we stand near a fire. Understanding light helps us make sense of our surroundings and how things work in the world.

Lighting plays a pivotal role in our daily lives, influencing our moods, productivity, and overall well-being. As technology advances, the range of available light sources has expanded, offering diverse options in terms of energy efficiency, colour temperatures, and applications. This overview explores various types of light sources, each with its unique characteristics and advantages.

From traditional incandescent bulbs to cutting-edge LED technology, the evolution of lighting reflects our ongoing quest for illumination that is not only functional but also environmentally conscious.

Understanding the distinctions between these light sources enables individuals to make informed choices based on their specific needs, contributing to a more efficient, sustainable, and visually appealing lighting landscape.

1.1 Different types of light sources

Different types of light sources that used frequently are as follows:

- ✓ LED Lights (Light Emitting Diodes)
- ✓ Incandescent Bulb
- ✓ CFL (Compact Fluorescent Lamp)
- ✓ Halogen Light

These light sources as shown in Figure 1.1.

Fig. 1.1: Different types of light sources

A brief description of these light sources are as follows:

1. LED Lights (Light Emitting Diodes)

LED lights use semiconductor diodes to produce light when an electrical current is applied. They are energy-efficient, durable, and come in various colours.

Advantages

1. Energy efficiency: LEDs consume less energy and have a longer lifespan.
2. Durability: LEDs are solid-state lights, making them more robust and resistant to shock and vibrations.
3. Versatility: Available in various colours and shapes, suitable for diverse applications.
4. Instantaneous illumination: LEDs light up instantly without a warm-up period.

2. Incandescent Bulb

Incandescent bulbs produce light by heating a wire filament until it becomes white-hot and emits visible light. They are less energy-efficient compared to newer technologies.

Advantages

- Simplicity: Incandescent bulbs are simple in design and produce a warm, familiar light.
- Inexpensive: More affordable than some other types of bulbs.

3. CFL (Compact Fluorescent Lamp)

CFLs use a different method than incandescent bulbs to produce light. They contain a small amount of mercury vapor that emits ultraviolet light when energized, which then stimulates a phosphor coating to produce visible light.

Advantages

- Energy efficiency: CFLs are more energy-efficient than incandescent bulbs.
- Long lifespan: CFLs have a longer lifespan compared to incandescent bulbs.
- Brightness: CFLs produce more light output per watt than incandescent bulbs.

4. Halogen Light

Halogen lights are a type of incandescent lamp that uses a tungsten filament, like traditional incandescent bulbs, but contains halogen gas that allows for higher efficiency and longer life.

Advantages

1. Brightness: Halogen lights produce a bright, white light similar to natural daylight.
2. Longer lifespan: Halogen bulbs generally have a longer lifespan than traditional incandescent bulbs.
3. Dimmable: Halogen bulbs can be easily dimmed.

These various types of lights cater to different needs and preferences, offering a range of energy efficiency, colour temperatures, and lifespans. Choosing the right type of light source depends on factors such as the intended use, energy efficiency goals, and personal preferences. LED lights, in particular, have gained popularity for their energy efficiency and versatility in various applications.

Activity 1

Practical Activity 1.1. To familiarize students with different types of light sources and their advantages.

Materials Needed

Images of LED lights, incandescent bulbs, CFLs, and halogen lights (Fig. 1.1)

Descriptions of each light source

Procedure

Step 1. Show images of LED lights, incandescent bulbs, CFLs, and halogen lights to the students.

Step 2. Discuss the advantages of each type based on the provided descriptions.

Step 3. Engage students in a class discussion about which light source might be suitable for different scenarios (e.g., energy efficiency, brightness).

1.2 Introduction of LED Lights

LED lights have transformed the lighting industry with their energy efficiency, durability, and versatility. Unlike traditional bulbs, LEDs use semiconductor technology to produce light, resulting in lower energy consumption and longer life spans. They provide instant illumination, resist impact and vibration, emit minimal heat, and offer vibrant colors without filters. With these benefits, LEDs have become the go to choose for various applications, from homes to commercial and industrial settings, driving energy conservation and sustainable lighting solutions. As shown in different types of LED lights Figure 1.2.

Fig. 1.2: Different types of LED lights

1.3 Advantages of LED technology

LED’s have high economic benefits due to consumption of less energy, long life and better service intervals. LEDs are reliable even in adverse environmental conditions. LED lighting offers numerous advantages over traditional lighting technologies across various parameters as follows:

1.3.1 Low Energy Consumption

LED lights are significantly more energy-efficient than traditional lighting options. They consume up to 80-90% less energy than incandescent bulbs and around 50% less energy than fluorescent lights, resulting in lower electricity bills and reduced carbon emissions.

1.3.2 Low Cost

While the upfront cost of LED lights may be higher than traditional bulbs, they offer long-term cost savings due to their energy efficiency and longer lifespan. LED lights can last up to 25 times longer than traditional bulbs, reducing the frequency of replacements and overall maintenance costs.

1.3.3 High Level of Efficiency

LEDs are highly efficient in converting electrical energy into light, resulting in less wasted energy and more effective illumination.

1.3.4 Long Life

LED lights have a much longer lifespan compared to traditional bulbs, lasting up to 25 times longer. This reduces the frequency of replacements and associated maintenance costs.

1.3.5 Small Dimensions

LED fixtures are compact and lightweight, making them versatile and suitable for a wide range of applications, including tight spaces and architectural lighting designs.

1.3.6 High Resistance to Switching Cycles

LEDs are resilient to frequent switching on and off, making them ideal for applications where frequent switching is required, such as motion sensors and automotive lighting.

1.3.7 Immediate Light Output

LEDs provide instant illumination when switched on, eliminating the need for warm-up time and ensuring immediate visibility.

1.3.8 Wide Range of Operating Temperature

LEDs can operate efficiently across a wide range of temperatures, from extremely cold to hot environments, making them suitable for outdoor and industrial applications.

1.3.9 High Resistance to Impact and Vibration

LEDs are durable and robust, withstanding shocks and vibrations better than traditional bulbs, reducing the risk of damage and premature failure.

1.3.10 No UV or IR Radiation

LEDs emit minimal ultraviolet (UV) and infrared (IR) radiation, making them safer for use in sensitive environments and reducing the risk of UV-related health issues.

1.3.11 High Colour Saturation

LEDs offer vibrant and saturated colors without the need for additional filters, enhancing the visual appeal of illuminated spaces and objects.

1.3.12 No Mercury

Unlike fluorescent lamps, LEDs do not contain mercury, making them environmentally friendly and easier to dispose of at the end of their lifespan.

1.3.13 Low Maintenance and Repair

LED lights require minimal maintenance compared to traditional lighting options. Their durable design and long lifespan mean they rarely need to be replaced, reducing the need for frequent maintenance interventions. This is particularly advantageous in hard-to-reach or large-scale lighting installations.

LED lights are generally not repairable in the same way as traditional bulbs. However, they are less prone to failure and damage due to their solid-state design. In case of a malfunction, individual LED components can sometimes be replaced or repaired, although this may not always be practical or cost-effective.

1.4 Construction of LED

LED diodes are the essential components in LED lights, emitting light when an electrical current pass through them. They offer higher energy efficiency, longer lifespan, and instant illumination compared to traditional lighting sources. Used in various applications, from residential to commercial and automotive lighting, LED diodes have revolutionized the lighting industry with their efficiency and versatility.

The construction of LED is very simple because it is designed through the deposition of three semiconductor material layers over a substrate. These three layers are arranged one by one where the top region is a P-type region, the middle region is active and finally, the bottom region is N-type. The three regions of semiconductor material can be observed in the construction. In the construction, the P-type region includes the holes; the N-type region includes elections whereas the active region includes both holes and electrons.

When the voltage is not applied to the LED, then there is no flow of electrons and holes so they are stable. Once the voltage is applied then the LED will be forward biased, so the electrons in the N-region and holes from the P-region will move to the active region. This region is also known as the depletion region. Because the charge carriers like holes include a positive charge whereas electrons have a negative charge so the light can be generated through the recombination of polarity charges. The construction and structure of LED is shown in the following Figure 1.3.

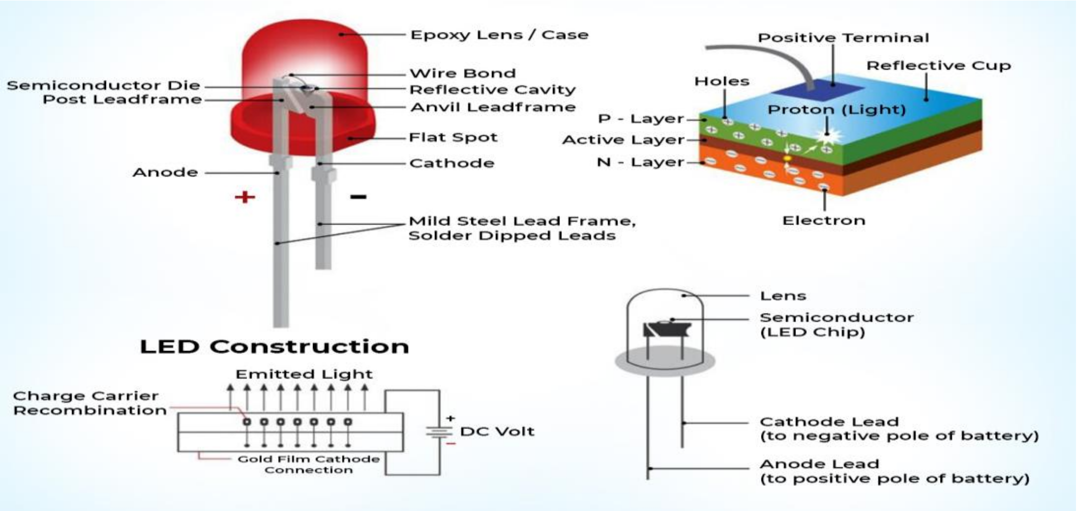


Fig. 1.3: Construction of LED

1.5 Working of LED

LEDs work on the principle of Electroluminescence. In LED chips, on application of certain voltage, electromagnetic radiation in the form of light is given out.

When the diode is forward biased, then the electrons & holes are moving fast across the junction and they are combined constantly, removing one another out. Soon after the electrons are moving from the n-type to the p-type silicon, it combines with the holes, then it disappears. Hence it makes the complete atom & more stable and it gives the little burst of energy in the form of a tiny packet or photon of light. The Figure 1.4 shows the working of LED.

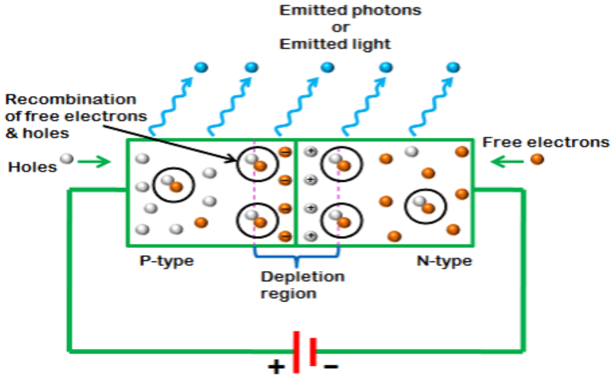


Fig. 1.4: Working of LED

The figure shows that the N-type silicon includes the electrons which are indicated by the brown circles. The P-type silicon contains holes, they are indicated by the white circles. The power supply across the p-n junction makes the diode forward biased and pushing the electrons from n-type to p-type. Pushing the holes in the opposite direction. Electrons and holes at the junction are combined. The photons are given off as the electrons and holes are recombined.

1.6 Types of LED

LED can be classified as follows:

1.6.1 Based on colour emission

Depending on the kind of semiconductor material used, the LED emits light in a specific colour like red, green, yellow, or blue. LEDs in every colour and with a high level of brightness can be created using two different materials. Blue LEDs also emit white light by using a yellowish fluorescent layer or by creating a mix of red, green, and blue LEDs (RGB). The latter method is used for giving a decorative effect to lighting. There are different types of LEDs, some of them are mentioned in *Table 1.1.*

Table 1.1 Colours emission by different types of LED material

S.N.	***LED Material***	***Colour Emitted***
1.	Gallium Arsenide (GaAs)	infra-red
2.	Gallium Arsenide Phosphide (GaAsP)	red to infra-red, orange
3.	Aluminium Gallium Arsenide Phosphide (AlGaAsP)	high-brightness red, orange-red, orange, and yellow
4.	Gallium Phosphide (GaP)	red, yellow and green
1.	Aluminium Gallium Phosphide (AlGaP)	green
6.	Gallium Nitride (GaN)	green, emerald green
7.	Gallium Indium Nitride (GaInN)	near-ultraviolet, bluish-green and blue
8.	Silicon Carbide (SiC)	blue as a substrate
9.	Zinc Selenide (ZnSe)	blue
10.	Aluminium Gallium Nitride (AlGaN)	ultraviolet

1.6.2 Based on Power Consumption

There are basically three types of LED’s.

1. Indicator Type or Low Power LED’s, also called PTH LED
2. Illuminator Type LED or Power LEDs also called SMD LED

3. Chip on Board (COB) LED

Indicator type – These LEDs are generally available in 5 mm size, but also come in 3 mm and 8 mm sizes. They typically possess two "legs" and a narrow beam spread of 150 to 300. These LEDs have low power and function on currents from 20 mA to 100 mA. The heat produced is dissipated within the LEDs.

Illuminator type – These LEDs were first available in the market as effective packages of 1W and operated at 350 mA. Later, 3W and 5W high power LEDs were manufactured. These LEDs are soldered on a PCB directly. They provide a path which is thermally conductive for extracting heat and benefit from much better heat extraction. High power LEDs are available in various shapes and sizes.

Chip on board (COB) – These LEDs are utilized for closely packed high-power LED modules. COB technology is used to place the LED chips directly onto the PCB. The beam spread can be narrow or wide angle.

1.7 Factors Affecting Life of LED

LEDs can have an operating life of more than 50,000 hours. As compared to other light sources, LEDs seldom fail and are generally service free. The exception is the luminous flux whose life slightly decreases over the operating period. The following are the factors that can affect the entire LED module.

1. Temperature
2. Mechanical influence
3. Current
4. Radiation and Light
5. Dampness
6. Chemical influences

1.7.1 Temperature

Heat is produced with production of light. This applies to an individual LED as well as the entire LED module and impacts both the LED's life cycle and luminous flux. To disperse the heat, installation techniques or appropriate heat sinks should be applied. An LED's life and performance will improve with decreasing operating temperature.

1.7.2 Mechanical influence

An LED can be affected by mechanical forces in different stages. This may occur during the production, assembly, or handling of the LED. The use of specific materials that develop these forces during significant temperature fluctuations may also be the cause of it. These pressures may shorten an LED's lifespan or even cause damage to it.

1.7.3 Current

An LED module needs to be operated within a certain current range. Even within the range, less energy will be released and less heat will be produced the lower the current. As a result, the current directly affects how long an LED will operate.

1.7.4 Radiation and Light

The aging process of an LED's components, which are affected by the light the chip emits, is significantly influenced by the housing design. Some housing designs have a built-in reflector that ages more quickly after a few hundred hours of operation because of the chip's high brightness and light intensity.

1.7.5 Dampness

An LED is robust and insensitive on its own. It is unbreakable and insensitive to vibrations. But a lot of the sensitive metal parts, connections, and electronic components inside are susceptible to corrosion from moisture, which could lead to the module failing. An appropriate selection of materials shields the LED from corrosion. It is imperative to protect the LED modules from moisture if a long operating life is to be achieved.

1.7.6. Chemical influences

Chemical influences can have varying influences on an LED, depending on the location of the application. Hence, while setting up an LED lighting system, the environmental conditions must be kept in mind.

The following conditions of the environment have a negative effect on the operating life of an LED:

1. If the atmosphere is corrosive (the air has high sulphur dioxide content)
2. If the climate is coastal with medium salt content
3. If there is a chemical industry nearby
4. If it is in a swimming pool with medium chloride content

1.8 Basic Parameters of LED

1.8.1 Colour Rendering Index (CRI)

To determine how well the light sources, render an object's colour, one can use the Colour Rendering Index (CRI). The CRI is rated on a range of 0 to 100. Its performance is evaluated by comparing the light source rendering colour to a reference light source. An incandescent light bulb with a CRI of 100 is used as the standard light source. The LED's capacity to render colours accurately will improve with a higher CRI. As a result, CRI is a crucial metric for assessing light quality. But only when light sources have the same colour temperature (CCT) can their CRI values be compared. The following Figure 1.5 shows CRI of different light source.

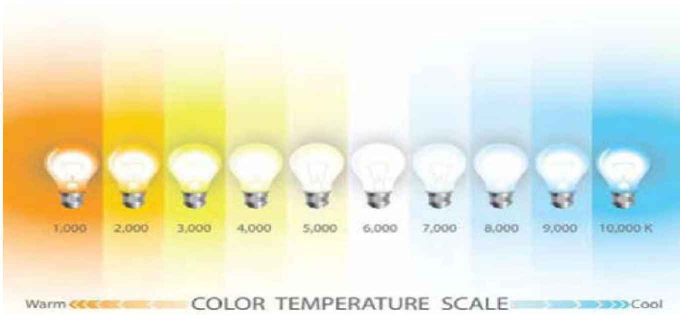


Fig. 1.5: Colour Rendering Index

LED products with CRI greater than 80 are considered best for indoor application. Products with a CRI less than 80 are suitable for outdoor application.

1.8.2 Correlated Colour Temperature (CCT)

The colour characteristics of light warm (yellowish) or cool (bluish) can be described by determining its colour temperature. It is measured in degrees of Kelvin (°K). This phenomenon is shown below in Figure 1.6.

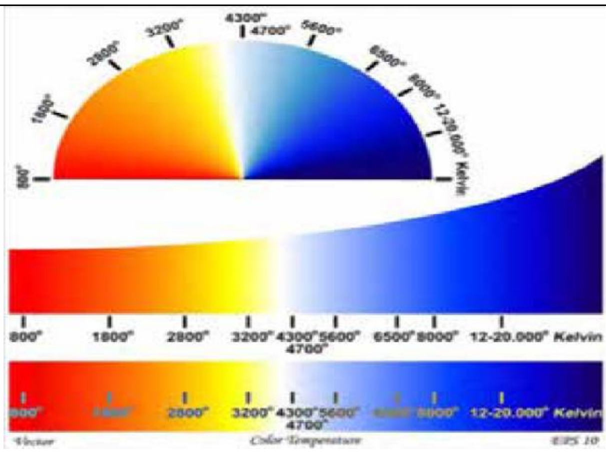


Fig. 1.6: Colour Temperature

In the case of an LED light, there are primarily three types of white colours: warm white, natural white and cool white. The colours below 3000°K will seem yellow or orange, while those at 4000°K will appear almost neutral. When the colour temperature falls, the light seems warmer, and as it rises, it is cooler. Generally, most LED lights make CCT from 2700°K–6700°K. It is shown in the following Figure 1.7. The exceptions are a few special applications, such as decorative lights, aquarium lights or glow lighting.

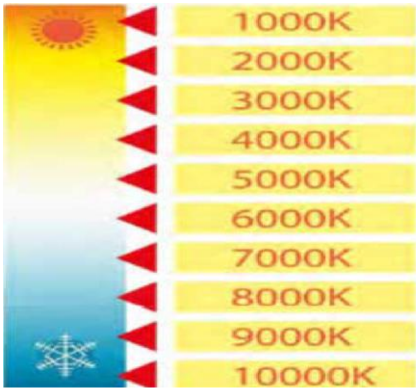


Fig. 1.7: CCT

Different colour temperature LED lighting for different places are as follows:

Public applications – People mostly use warm white LEDs of 2800–3500°K to promote relaxation.

Hotel LED lighting – Hotel lobbies go for cool white LEDs of 5500–6500°K, while rooms generally have warm white lights of 2700–3200°K.

Office lighting – Offices usually have natural white LEDs of 4000–5000°K to cool white with CCT of 5500-6500°K to enhance concentration.

Warehouse lighting – Warehouses mostly use natural white light of 4000–5000°K or cool white light of 5500–6500°K.

Shopping mall LED lighting – Malls generally go for warm white lights with CCT OF 2700–3200°K. Within the mall, different areas use different lighting—natural white with 4000–5000°K and cool white with 5000–6500°K.

1.9 LED Power Sources

The difference between powering a LED and other electronics product lies in the source of power since a constant current source is required by an LED while most others need a constant voltage source. Hence, a dedicated power supply requires to be implemented to power the LEDs in a circuit.

The power supply must be able to provide a high voltage known as the forward voltage (V_f) that is enough to illuminate the LED and must also provide controlled constant current known as forward current (I_f) as shown in the Figure 1.8. Current above the value of If may damage the LED and the light output depends on the forward current.

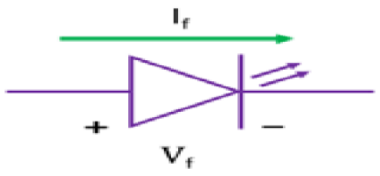


Fig. 1.8: Powered LED

The easiest method of supplying power to an LED is to utilize a DC constant voltage source that is already giving power to the other electronics within the circuit. Current can be typically regulated using a series resistor. This method proves to be cost-effective and useful, especially if other components already have power. It is shown in Figure 1.9.

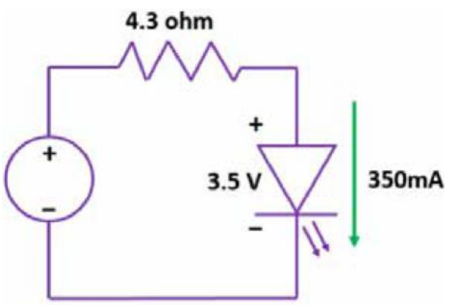


Fig. 1.9: Working of LED drivers

Indicator LEDs are generally powered by this method. For lighting applications, there are some drawbacks of this method and one of them is inefficiency. There is loss of power across the resistor in the form of heat.

For example, if a 10V source is used to provide power to an LED with a V_f of 1.5V and an I_f of 450 mA, it results in a 1V drop across the resistor. This will lead to power wastage,

$P = VI$

$P = (1V)\ (0.45A) = 0.450W$

This indicates that powering a single LED wastes 450 mW. The inability to control the current is yet another disadvantage of this approach. Different LEDs have different $V_f$values, which can also affect the voltage drop across the resistor. As a result, both the light output and the current may differ amongst the different LEDs. These disadvantages are accentuated when more than one LED is being powered. The LEDs would need to be powered in parallel if there is a 10V supply. Power would be distributed among numerous resistors, and each LED may produce a different amount of light. Therefore, setting up a constant current power supply would be more appropriate than utilizing a current limiting resistor with a constant voltage source. A switching mode power supply (SMPS) is the most efficient power supply out of all the simple linear constant current supplies.

This can be explained with the help of the following example:

There is power loss in the linear supply due to voltage conversion. If a linear regulator is being utilized for the conversion of 12V to 3.5V and the load is 350 mA, the total power consumed can be given as:

P (total) = (12V) (0.350A) = 1.2W

The power utilized by the LED is: PLED = (3.5V) (0.35A) = 1.23W

The power wasted in the regulator is: PLINEAR = P (total) – PLED = 2.98W

Most SMPs are around 90 percent efficient. In the above example, the power consumption is:

$P(total) = (V_{out})\ (I_{out})/90\%$

P (total) = (3.5V) (0.35A)/ (0.90) = 1.36W

P_{LED} = (3.5V) (0.35) = 1.23W

P_{SMPS} = P (total) – P_{LED} = 0.13W

Thus, if a switching regulator is being used, 0.13W is lost in power conversion. On the other hand, 2.98W is lost if a linear regulator is being used.

According to power consumption the LEDs can be categorised as follows:

LEDs used as indicators – These use low power and are used to light a small indicator such as the one on a laptop that shines when the hard drive is on. The I_f requirements are generally 10 mA to 20 mA.

LEDs used for lighting –These require a higher power requirement than the indicator ones. Ineffective techniques for powering LEDs lead to significant power losses that have negative effects. LEDs are preferred over other materials in order to optimize lighting system efficiency. LEDs can need hundreds of milliampere-hours (usually 350 mA) to produce the same amount of light as they can.

The light output is measured in Candelas. It is the power of a light source that is emitted in a particular direction. The other unit is Lumen. It is the amount of light that is produced from a source of 1 Candela in a solid angle of 1 steradian (SI unit of solid angle).

The LED applications specify high luminous intensity and therefore, the supply of power should be efficient, and output current must be controlled with accuracy.

1.10 LED Circuit Connections

1.10.1 Parallel Connection

It is very important to figure out whether to power the LEDs in applications having multiple LEDs in series or in parallel. The available supply voltage is often too low that it cannot meet the V_f of multiple LEDs. It may seem that powering the LEDs in parallel configuration would be the preferred method. A few disadvantages of parallel configuration of the LEDs include:

1. There is a variation of light output from one LED to the other. The variation of forward voltage from LED to LED results in varying If, which causes the light output to vary. Because of the negative temperature coefficient, the hotter the LED gets, the more current it uses and thus gets even hotter. However, grouping of the LEDs, considering the light output characteristics, is performed by the manufacturers of LEDs.

2. The LEDs may be damaged if there is failure in opening an LED. More current could also flow to the other LEDs, which could possibly burn them out. If there is a short, too little current would flow to the other LEDs. Faults would have to be monitored and the available current would have to be adjusted to other LEDs. Additional circuitry would be required to operate under these circumstances.

3. The required amount of current increases with each LED. If multiple LEDs are powered in parallel, it could affect the power supply design. If N is the number of LEDs, it needs N* amount of current output. This implies that the inductor, catch diode and MOSFET need to be rated at a greater current. This would make them more expensive and larger in size.

1.10.2 Series Connection

If multiple LEDs are powered in series, these issues are eliminated, but some other problems come up. In series, the total $V_f$of the LEDs is cumulative. For example, if a series of five LEDs with a V_f max of 4V has to be turned on, the power supply voltage would require an output voltage of 20V. Instead of needing a larger maximum current rating, the output capacitors would need a larger voltage rating. The increase in the size and expense of a capacitor with a voltage rating of 6V versus 50V is less as compared to a 500mA inductor versus a 5A inductor.

For example, for lower current, the difference in the size of the inductor could be 5 mm^2 in comparison with 12 mm^2 for higher current. The package size of a high voltage rated capacitor and a low voltage rated one could be the same. The other drawback in series configuration is that if one LED fails, all other LEDs connected in the series are turned off. If the LEDs are secured with appropriate mechanical design for being protected and a thermal design for preventing it from being overheated, they have a greater lifespan. The advantage of LEDs connected in series is that each of them receives the same current which results in the same output light of each LED.

1.11 Thermal Management of LEDs

1.11.1 Heat transfer procedure in a LED Luminary

For better performance of LEDs, it is required to keep the junction temperature low. Heat is transferred by three means:

- Conduction
- Convection
- Radiation

The encapsulation of LEDs is typically made up of transparent resin, a poor thermal conductor. The electrical energy that was not converted into light, generated heat and is conducted via the back of the chip. The conduction of heat to outside ambience takes a long path:

Junction -> Solder point -> Board -> The heat sink -> Atmosphere

The junction's temperature will drop and the ambient temperature will also drop if the thermal impedance is low. Hence, to maximize the range of ambient temperature for a given power dissipation, the thermal resistance within the heat conduction path must be minimized. The LED's manufacturer affects the thermal resistance values. It varies, for instance, from 2.6°C/W to 18°C/W. Depending on the kind of material, the thermal resistance of the thermal interface material—typically thermal grease, solder, and pressure-sensitive adhesive—also varies. Mounted on the MCPCB are power LEDs, which are subsequently connected to a heat sink. Important parameters in the package design are:

• Flatness of the surface and contact area

• Quality of each component

• Applied mounting pressure

• The type of interface material and its thickness

1.11.2 Passive Thermal Design

Heat Sink

Heat sinks are considered for passive thermal designs for ensuring efficient thermal management of high-power LED application. The heat sinks play as medium for the travelling of heat from a LED source to outside. Power can be dissipated by the heat sinks in three ways:

1. Conduction – It is the mechanism of heat transfer from one solid to another

2. Convection – It is the mechanism of heat transfer from a solid to a moving fluid (air, for most LED application)

3. Radiation – It is the mechanism of heat transfer through thermal radiation from two bodies having different surface temperatures.

Material – The heat sink material's (typically aluminum, though copper is also used) thermal conductivity has an impact on the effectiveness of dissipation through conduction. Thermoplastics are one of the new heats sink materials that could be utilized in applications where less heat dissipation is required. Although natural graphite solutions, which make up the heat sink, have higher production costs than copper, they provide superior thermal transfer. Heat pipes can be utilized in conjunction with copper or aluminum heat sinks to lower the spreading resistance.

Shape – Heat sinks should have a large surface area as the heat transfer takes place at the surface. For this, the size of the heat sink can be increased or many fine fins can be used.

Surface Finish – Thermal radiation of heat sinks depends on its surface finish. For example, a painted surface offers emissivity greater than the unpainted one. About one-third of the heat in flat-plate heat sinks is dissipated by radiation. A perfectly flat surface area allows reducing the thermal resistance between the LED source and the heat sink by using a thinner layer of thermal compound. Anodizing the surface of a heat sink also helps in decreasing the thermal resistance.

Method of Mounting – Heat-sink mountings using screws and springs provide better performance than thermal conductive glue, clips or sticky tape. Adhesive is used to attach LED to board, and board to the heat sinks. Thermal performance can be optimized by using a thermal conductive adhesive.

Heat Pipes and Vapour Chambers

They are passive devices used in LED thermal management, and offer effective thermal conductivity in the range of 10,000 to 100,000 W/mK. The benefits are as follow:

1. They transfer heat to a heat sink that is in a remote location offering minimum drop in temperature.

2. A natural convection heat sink can be iso thermalized, by reducing size and increasing the efficiency. For example, adding five heat pipes may reduce the mass of the heat sink from 1.4 kg to 2.9 kg, which is by 34%.

3. They directly transform the high heat flux under an LED to a lower one efficiently that can easily be removed.

1.12 LED Configurations

Constant Current LED Driver

Colour and brightness of an LED can be controlled using a constant current driver. It continuously maintains the level of current through the LED, regardless of the operating conditions and the external factors, such as power supply drift and variations in V_f. There is an internal feedback network which keeps track of the flow of current in a string of LEDs and regulates the output in order to maintain the desired level of current. The driver offers a flexible power solution for a wide range of LED products. The same current driver may be used for the super-bright LEDs that require forward voltage in the range of 3 V to 3.5 V.

LED lighting applications generally utilize many LEDs operating in the range of 1W to 3W together. Multiple LEDs can be connected either in parallel or in series. Both configurations have advantages regarding:

1. Efficiency
2. Brightness matching
3. LED failure immunity

Series String Configuration

The total string voltage is a function of the number of LEDs in the string, and the forward voltage (V_f) of each LED. If 30 LEDs with a V_f of 1.5VDC are used, the total string voltage would be 135VDC. One constant current driver provides power to the LEDs and hence, in this configuration all LEDs receive the same current. This configuration is depicted in Figure 1.10.

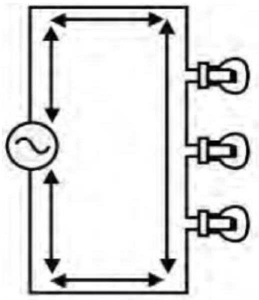


Fig. 1.10: Series Connection

Advantages

The advantages of connecting the devices in series are as follows.

1. The configuration is simple, consisting of only a single circuit.
2. Since each LED gets the same amount of current, there is no current imbalance.
3. Since there is no resistor to limit the current, the efficiency of this configuration is high.

If an LED fails to work then the remaining LEDs continue to operate normally and the string voltage will decrease by the V_f of the failed LED and consequently the power consumption will also decrease. The overall brightness of the string will dim by only one LED.

Disadvantages

The disadvantages of connecting the devices in series is that the configuration poses a safety risk as the output voltage may become high if large numbers of LEDs are used.

For instance, to calculate the maximum number of LEDs that can be safely connected in a series configuration, to a constant current LED driver use the maximum output voltage of the driver divided by the forward voltage of each LED. If $V_{out\ max}$ = 40VDC, and the $V_{forward}$ = 3.5V, then the maximum number of LEDs is 40/3.5=11.43. A total of 11 LEDs can be connected in series with the constant current LED driver. To select the required output current of the driver, refer to the specification sheet for the LED used for the optimal current and then select an LED driver with the same optimum.

Parallel String Configuration

In addition to lowering the maximum string voltage, joining LED strings in parallel increases fault immunity. Examine the following illustration, in which a lamp is lit by ten LEDs. Two parallel strings of five LEDs each could be used to arrange the LEDs. When compared to a series connection of the same, the total setup's string voltage drops by a factor. The number of strings of bulbs arranged parallel to one another equals this factor. Depending on how well each string's limiting resistor matches the others, there is a division of current among the strings. The parallel configuration of LED's is shown below in Figure 1.11.

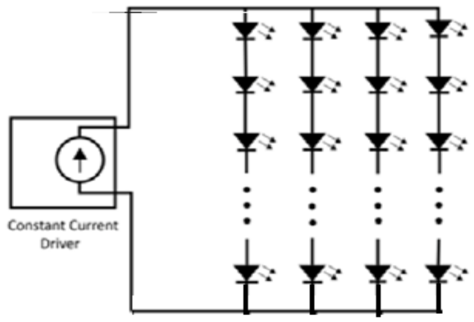


Fig. 1.11: Parallel Connection

There could be significant imbalances in the current of the different strings as a result of variations in the V_f of the LEDs. To balance the current in each string, a resistor is typically used.

Advantages

1. A parallel configuration needs only a single driver.
2. The combined output voltage is comparably low.
3. An approximate equal sharing of current can be obtained amidst the various LED strings by selecting the resistance value properly.

Disadvantages

1. This configuration improves current sharing, but at the expense of increased power consumption and decreased system efficiency.
2. The other LEDs experience more stress when one of them fails short because they have to manage a higher current handling capacity. This could cause more LEDs in the string to fail. Since the driver's current rating determines the total current, the LEDs in the remaining strings will get dimmer.
3. If an LED in that string fails to open, the rest of the LEDs in that string will also stop working. Depending on the number of strings, the current in the remaining

strings will increase. The effect of the open failed LED can be reduced by connecting a by-pass circuit in parallel with each LED This measure will short out the failed LED.

Matrix Configuration

Another option of configuration known as a matrix is hybrid of the series and parallel connection. The matrix configuration tries to eradicate a few of the issues linked with parallel configuration by including more connections between the LEDs. Both matrix and parallel configuration have similar topology with the difference in there being a connection between each of the strings in the matrix configuration. The first LED of each string has a parallel connection with the first LEDs of all the rest of the strings. Here successive LEDs are in parallel with their neighbouring LEDs. Thus, the LEDs are organised in a matrix of rows and columns.

Advantages

1. A single output driver is required in this configuration. The output voltage as compared to a parallel configuration is relatively low.
2. Usually, this configuration possesses greater fault-tolerance.
3. The efficiency is more as current sharing resistors are generally not utilized.

Disadvantages

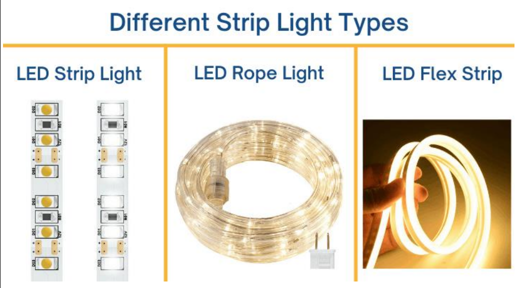
1. Current imbalances are a problem. Including resistors to help in current sharing is the simple solution as in the case of a parallel configuration.
2. Unequal current sharing results in irregular light and thermal distribution.
3. In a situation where an LED fails short, the rest of the LEDs of the same row will also stop functioning. The LEDs of the other rows will function normally except that the lamps will become less bright.
4. In a situation where an LED fails open, the rest of the LEDs of the same row will have to face higher current. This raises the chance of another LED of that row also failing. The rest of the LEDs will function normally.

The effect of the open failed LED can be reduced by connecting a by-pass circuit in parallel with each LED. This measure will short out the failed LED.

1.12 Types of LED lights

There are different types of LED lights: LED Strip Lights, LED Tube, Colour LED as shown in following table 1.2.

Table 1.2: Types of LED lights

Type	Image
LED Strip Lights – LED strip lights, also known as LED tape lights or ribbon lights, are flexible circuits embedded with small LED chips. They offer versatile lighting solutions for various applications, including accent lighting, task lighting, and decorative purposes. LED strip lights are easy to install, energy-efficient, and come in a range of colors and brightness levels to suit different needs and preferences.	

LED Tube – LED tube lights are modern, energy-efficient replacements for traditional fluorescent tubes. They offer long lifespans, low maintenance, and superior durability, making them ideal for a variety of lighting needs in commercial, industrial, and residential settings.	
Colour LED - Colored LED lights provide vibrant illumination for decorative, mood, and accent lighting. With energy efficiency and long lifespans, they're favoured for both indoor and outdoor applications, enhancing ambiance and visual displays.	

1.13 Comparison of various types of lights

Comparison of General specifications of various light sources are given in table 1.3.

Table 1.3: Specifications of various types of lights

LAMP SOURCE COMPARISON	***LED***	***Halogen Bulb (Main Voltage)***	***Compact Fluo Lamp (Magnetic Ballast)***	***T8 Fluo Lamp (Magnetic Ballast)***	***High intensity Discharge Lamp (Magnetic Ballast)***
Efficacy (lm/W)	> 100 lm/W	20 lm/W	75 lm/W	80 lm/Wt	90-120 lm/W
Vibration resistance	Yes	No	No	No	No
Full brightness with instant start (Lamp start up)	Immediate	Immediate	Flicker Start	Flicker Start	15 min Warm Up
Average Service Lifespan (hrs)	50000 hrs	1000 hrs	6000 hrs	6000 hrs	10000 hrs

1.14 Energy ratings (BEE) and consumption of various lights

BEE, (Bureau of Energy Efficiency Ratings) under its labelling program for LED lights, considers 'Lumens per watt' and other safety requirements like photo-biological safety as main parameters to rate the bulbs on a five-star scale for energy efficiency. More number of stars translates to higher efficiency of the LED bulb. It is shown in Table 1.4 (a) & 1.4 (b) and Figure 1.12.

Table 1.4 (a): Energy ratings (BEE) and consumption of various lights

Bulb Type	**Energy consumed**				**Rated Life**
	450 Lumens	**800 Lumens**	**1100 Lumens**	**1600 Lumens**	
Incandescent	40w	60w	75w	100w	1 Year
Halogen	29w	43w	53w	72w	1-3 Years
CFL	11w	13w	20w	23w	6-10 Years
LED	9w	12w	17w	20w	15-20 Years

Table 1.4 (b): Energy ratings (BEE) and consumption of various lights

SN	Type of bulb	Energy consumption
1	Conventional incandescent bulbs	100%
2	Improved incandescent bulbs (class C of the energy label, halogen lamp with xenon gas filling)	70-80%
3	Improved incandescent bulbs (class B of the energy label, halogen lamp with inftared coating)	50-60%
4	Compact fluorescent lamps (CFLs)	20-30%
5	Light-emitting diodes (LEDs)	<20%

Figure 1.12: Energy ratings (BEE) and consumption of various lights

Summary

The "Basic Concepts of LED" chapter introduces semiconductor LEDs, emphasizing their energy efficiency and extended lifespan. It covers working principles, factors impacting longevity, and essential parameters like CRI and CCT. The chapter explores LED types, factors influencing lifespan, and thermal management. It concludes with a brief overview of LED light types, specifications, and energy ratings.

Check Your Progress

A. Multiple Choice questions

1. What is the main advantage of LED technology? (a) Lower cost (b) Higher energy consumption (c) Longer lifespan and energy efficiency (d) Slower switching speed
2. LEDs work based on which principle (a) Thermoluminescence (b) Electromagnetic induction (c) Electroluminescence (d) Photoelectric effect
3. What are the three types of LEDs? (a) Primary, Secondary, Tertiary (b) Indicator, Illuminator, COB (c) Red, Green, Blue (d) Low Power, Medium Power, High Power
4. What factors can affect the lifespan of LEDs? (a) Temperature, Mechanical forces, Current, Radiation (b) Voltage, Humidity, Chemical influences, Light intensity (c) Colour Rendering Index, Colour Temperature, Power Consumption (d) Heat Sink, Housing Design, PCB

5. What does CRI stand for, and what does it measure? (a) Colour Rendering Index, measures power consumption (b) Constant Resistance Indicator, measures resistance in LEDs (c) Coolness Rating Index, measures temperature (d) Continuous Reflectance Indicator, measures reflectance of LEDs
6. How is the Colour Temperature (CCT) of LED lights described in the chapter? (a) In degrees Fahrenheit (b) In Kelvins (°K) (c) In Lumens (d) In Watts
7. What is the primary function of a heat sink in LED thermal management? (a) Increase LED brightness (b) Decrease LED lifespan (c) Efficiently dissipate heat (d) Change LED colour
8. Which LED configuration offers higher fault tolerance, Series or Parallel? (a) Series (b) Parallel (c) Both have equal fault tolerance (d) Matrix Configuration
9. What is the purpose of a bypass circuit in LED matrix configuration? (a) Increase current flow (b) Short out a failed LED (c) Change LED colour (d) Improve energy efficiency
10. What is the significance of the Colour Rendering Index (CRI) in LED lighting? (a) Measures LED lifespan (b) Indicates LED brightness (c) Assesses how well LEDs render colors (d) Determines LED switching speed

B. Fill in the blanks

1. An LED is a _______ electronic light-emitting component.
2. LED's have high economic benefits due to consumption of less energy, long life and ______.
3. In LED chips, on application of certain voltage, ____ in the form of light is given out.
4. An LED comprises _______layers of semi-conducting material.
5. Photons are released as a result of ________.
6. Depending on the kind of semiconductor material used, the LED emits light in a specific colour like ________.
7. The LED's capacity to render colours accurately will ____ with a higher CRI.
8. LED products with CRI _______are considered best for indoor application.
9. In the case of an LED light, there are primarily three types of white colours: ____.
10. Heat sinks are considered for _____ ensuring efficient thermal management of high-power LED applications.

C. State whether True or False

1. LEDs are a type of incandescent light source, known for their high energy consumption and short lifespan.
2. In the matrix configuration of LED circuits, the LEDs are organized in rows and columns, aiming to eliminate issues associated with parallel connections.
3. LED luminaries with passive thermal solutions, such as heat sinks, are effective in dissipating heat and minimizing the impact of high operating temperatures on LED performance.
4. LEDs used for lighting applications require a constant voltage source, unlike other electronics products that need a constant current source.
5. The Color Rendering Index (CRI) is a crucial metric for assessing light quality, and LEDs with a CRI greater than 80 are considered best for outdoor applications.

6. Chemical influences, such as exposure to a corrosive atmosphere or medium chloride content, can negatively impact the operating life of LEDs.
7. In the series connection of LEDs, if one LED fails, it may lead to the failure of the entire string, but the overall brightness of the string will decrease by only one LED.
8. The matrix configuration of LED circuits provides fault tolerance and efficiency advantages, but current imbalances can be addressed by adding resistors for better current sharing.
9. Correlated color temperature (CCT) is used to describe the warmth or coolness of light, and different CCTs are suitable for various applications, such as warm white for relaxation and cool white for concentration.
10. The advantages of LED technology include low power consumption, long life, and immediate light output when switched on.

D. Answer the following questions in short

1. What is the working principle of LEDs, and role of Electroluminescence?
2. Name three advantages of LED technology over traditional lighting sources.
3. Explain the factors influencing the life of an LED module.
4. Describe the importance of Color Rendering Index (CRI) in assessing light quality. What CRI is considered best for indoor applications?
5. How does Correlated Color Temperature (CCT) define the characteristics of LED light, and what are the typical applications for warm white and cool white LEDs?
6. Differentiate between the series and parallel connection of LEDs in terms of advantages and disadvantages.
7. What are the key components of passive thermal design for LEDs, and how do heat sinks contribute to efficient thermal management?
8. Discuss the advantages and disadvantages of the constant current LED driver in controlling LED color and brightness.
9. Explain the matrix configuration of LED connections and its advantages in fault tolerance.
10. List the types of LED lights with examples for each.

Session 2: Installation of LED lights

Installation of LED lights and other lighting fixtures involves planning the layout, selecting appropriate fixtures based on efficiency and aesthetics, securely mounting them, connecting wiring according to safety standards, and testing the system for proper functionality. This process ensures optimal illumination, energy efficiency, and safety in the illuminated space.

2.1 LED Luminaire

LED Luminaire is a complete lighting unit consisting of light emitting diode (LED)-based light emitting elements and a matched driver together with parts to distribute light, to position and protect the light emitting elements, and to connect the unit to a branch circuit.

An LED Luminaire has the following major components/ parts:

1. An LED Light Engine
2. An LED Driver
3. An LED Heat Sink
4. An LED Luminaire Diffuser / Lens
5. Mechanical Housing
6. Thermal Compounds/ Thermal Tapes/ Thermal Pads
7. Connecting Wires

1. LED Light Engine

It is the source of light of a luminaire. A light engine is simply a PC board mounted with LEDs. The following are some examples of LED light engines/modules:

a) COB based light engine module

In COB (chip on board) lighting, single LED chips are placed directly on a circuit board (or substrate) which has thermal properties to disperse heat. Heat dissipation is a very important aspect of LED lighting since it can have a major impact on the life expectancy of the luminary. COB LEDs offer many advantages over the standard options. COB LEDs are basically multiple LED chips (typically nine or more) bonded directly to a substrate by the manufacturer to form a single module. The following Figure 2.1 shows the image of COB based light engine module.

Fig. 2.1: COB based light engine module

b) Flexible based light engine module

A flexible-based light engine module is a lighting system designed on a flexible substrate, such as a flexible printed circuit board. It incorporates LEDs, driver circuits, and other components, providing versatility for applications on curved surfaces. Its customizable design, thin profile, and integration with smart features make it suitable for diverse uses, including architectural and automotive lighting. The module's flexibility simplifies installation and allows for innovative designs, contributing to its appeal in modern lighting systems. This type is shown in Figure 2.2.

Fig. 2.2: Flexible based light engine module

c) LED based light engine module

An LED-based luminaire employs an LED module mounted to a housing. The LED module is advantageously configured to transmit heat generated by the LEDs across and/or through the module and to the housing for dispersal to the environment. LED modules can be configured with conductive or non-conductive cores, and may be configured to evacuate heat from one or both faces of the LED module. Further, multiple heat paths can be defined from components on an LED module to the housing and to the environment. It is shown below in Figure 2.3.

Fig. 2.3: LED based light engine module

2. LED Drivers

An LED driver is the source of power for LEDs. Whenever you are building LED luminaires, you will always need a driver or possibly even multiple drivers. There are different types of LED drivers, as there are different types of LEDs.

LED drivers can be categorized into:

1. Constant Current (CC) LED Driver – Constant current drivers always feed relatively constant current. Voltage range may vary. Many times, the output voltage range is related to the physical dimensions of the driver. This restriction may set some selection challenges, if the luminaries are compact and there is limited space for the driver. One of the important functions of a constant current driver is the capability to maintain constant current. The characteristics of a constant current LED driver are:

Efficiency – It indicates what part of the input power can actually be used by the driver to power the LED.

Power factor – The power factor indicates how much load the driver puts on the electrical network. The maximum value of power factor can be 1.

2. Constant Voltage (CV) LED Driver – A constant voltage driver keeps the voltage constant. The feeding current varies according to the load. The higher the load is, the bigger the current is. Constant voltage drivers are usually used in applications where all LED components are in series. These with high powers can be used as electrical energy suppliers for many smaller power constant current drivers. In larger lighting systems, they are storages that feed stable current into the LED loads they have. In some cases, constant voltage drivers are the only suitable solution, such as when replacing halogen lamps. Replacements require 12V or 24V voltage. If used in a parallel mode, electrical load variation can result in brightness variation due to current variation.

An LED driver is usually an AC/DC converter. In other words, it converts AC voltage from the main 220V, 230V or 240V power supply to DC supply, suitable for the LED component.

Selection criteria of an LED Driver

Forward current requirement of LED

We should find the forward current your LED needs, from the datasheet. If your LED needs a current of 350mA, you should try to find a driver with 350mA output current.

Power Consumption of the LED

The power consumption of the LED can also be found from the datasheet or at least it can be calculated with the data in the datasheet. The power consumption can be calculated by multiplying the typical driving current value with the typical forward voltage value. Both are present in the LED data sheet. Sometimes you can even find the power consumption directly from the datasheet. If you are using multiple LED components, you have to find a driver that can feed all the LED components.

Driver Voltage

Take a look at the datasheet and check the voltage of the LED. If you have multiple LEDs, you should add the voltages together. Then, you should find a driver with a voltage range that your LEDs fit into.

Dimming

A need for dimming is mainly dependent on the specification of your luminaire. If you do not need dimming, a normal on/off driver is enough for you. If you need dimming, there are many different types available.

Physical Dimensions

You should also consider whether there are some limitations for the physical dimensions of the driver. These will obviously have an impact on your driver selection. You will generally find the physical dimensions of the driver from its datasheet.

Surrounding Environment

If it is designed for indoor use, then probably not need to think about IP-classification much. If the luminaire is used in a room with a lot of dust or moisture, this has to be taken into account. IP20 class drivers can be used in indoor lighting applications but hardly stand harsh conditions in outdoor lighting, unless the luminaire itself is waterproof, thus protecting the driver. When a luminaire is designed for outdoor use, then you should check that the driver has a good IP-class. Usually IP67 drivers are heavier in weight, the driver electronics are moulded with plastic (such as potted) and the electrical throughputs of the wires, both on the primary voltage and the secondary voltage side, are sealed with the required protection against moisture.

By using these criteria suitable LED driver can be found for the application.

3.Heat Sink

Heat sink of a thermal system allows conduction of heat away from various sensitive components. It looks as shown in Figure 2.4.

Fig. 2.4: Heat Sink

4. An LED Luminaire Diffuser / Lens

An LED luminaire diffuser/lens is an optical component used in lighting fixtures. It modifies the output beam of LED lamps, ensuring the light meets specific photometric specifications. These components can include diffusers, lenses, or a combination of both. The choice of diffuser or lens affects factors like light distribution, intensity, and glare control in LED luminaires, contributing to the overall performance and visual comfort of the lighting system.

4. Mechanical housing

The mechanical housing in LED luminaire design refers to the physical structure or casing that encloses and protects the internal components of an LED lighting fixture. It serves several purposes, including providing structural support, heat dissipation, and protection against environmental factors. The design of the mechanical housing is crucial for ensuring the longevity and performance of the LED luminaire. Factors such as material selection, heat management, and ease of installation are taken into account to optimize the overall functionality and reliability of the LED luminaire.

2. Thermal Interface Materials

The types of thermal interface materials used for LED products are shown below in Figure 2.5.

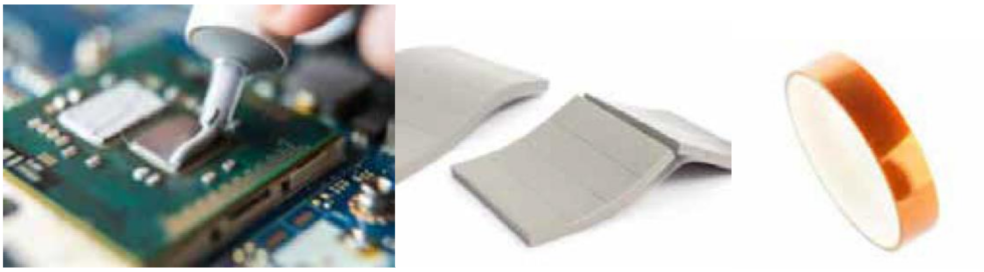


Fig. 2.5: (a) Thermal Grease (b) Thermal Pads (c) Thermal Tapes

7. Connecting Wires

Connecting wires are used to connect different parts of a unit with each other.

Activity 1

Practical Activity 2.1. Exploring LED Luminaire Components

Materials Needed

Diagrams of LED Luminaire components (LED Light Engine, LED Driver, Heat Sink, Luminaire Diffuser/Lens, Mechanical Housing, Thermal Compounds, Connecting Wires)

Procedure

Step 1. Present the diagrams and explain each component's role in an LED Luminaire.

Step 2. Divide students into groups and provide each group with the diagrams.

Step 3. Ask each group to discuss and present the function of one specific component to the class.

Step 4. Encourage questions and discussions to ensure understanding.

2.3 Installation of LED Product Assembly

2.3.1 Steps in installation

In the installation of LED products there are basically three steps:

1. Base assembly – In a base assembly, the driver is placed into the enclosure. There are various options available in a base assembly such as shrinking the driver by a PVC tube and inserting the driver inside the cavity.

2. Assembly of heat sink – In heat sink assembly, the LED module is placed onto the heat sink either by using a thermal tape or a heat sink compound, according to our requirement.

3. Joining of base assembly and heat sink assembly – Joining the base assembly with the heat sink assembly means connecting the LED driver to the LED module by a manual solder or a connector.

2.3.2 Tools Used in the installation of LED product assembly

The installation of LED products typically requires a few essential tools for efficient assembly. These tools may include screwdrivers, pliers, wire cutters/strippers, wire connectors, voltage testers, and possibly a drill for mounting fixtures. Additionally, specialized tools such as soldering irons and heat guns may be necessary for more intricate installations or customizations. Having the right tools on hand ensures a smooth and precise assembly process, facilitating the proper installation of LED products for optimal performance and longevity. Commonly used tools in the installation of LED product assembly are illustrated in the following table 2.1.

Table 2.1: Tool Used in Installation of LED product assembly

Name of the tool	***Image***
Automatic Screw Driver – An electric screwdriver, also called a cordless or power screwdriver, is a handheld, battery-powered tool that drives screws into various materials Cordless screwdrivers help you drive screws faster and won't tire out your arm like a traditional screwdriver.	
Manual Screw Driver – Manual screwdrivers are manually operated and require strength and skill to use effectively. It features a handle and a shaft of varying lengths with tips shaped to fit snugly into the head of the screw.	
Wire Cutter/Stripper – A wire stripper is a small hand-held tool that is used to remove the insulation from electric wires.	
Nose pliers – Nose pliers are used for gripping and twisting of wires.	

Allen Key Set – Hex keys, commonly known as Allen keys/wrenches are a very simple hand tool of the general spanner and socket family, used for tightening and loosening hexagonal bolts and other compatible fasteners.	
Spanner Set – The spanner is a hand-held tool used to provide grip and tighten or loosen fasteners. It gives a mechanical advantage in applying torque to turn objects. The tool is used in turning rotary fasteners like nuts and bolts.	
Multimeter - A multimeter is a device used to measure multiple parameters of an electric circuit like voltage, current, and resistance. The device is made up of a digital or analog meter, batteries, resistors, and other circuitry, which ensure the measurement of several electrical quantities with very high accuracy and speed.	

2.3.3 General Instructions for Installation of LED products

Turn off Power – Before starting the installation, ensure that the power to the lighting circuit is turned off at the breaker or fuse box.

Choose Location – Select the desired location for the MR-16/Spot Light Assembly. Consider the lighting requirements and ensure the mounting surface is suitable.

Mark Mounting Holes – Hold the assembly against the mounting surface and mark the positions for the mounting holes. Use a pencil or marker for clear markings.

Drill Holes – With the marked positions, drill holes into the mounting surface. Use an appropriate drill bit size for the type of surface (wood, drywall, etc.) and insert any wall anchors if needed.

Secure Mounting Bracket – If the assembly includes a mounting bracket, secure it to the mounting surface using screws. Ensure it is level and tightly fastened.

Connect Wiring – Connect the wiring from the MR-16/Spot Light Assembly to the electrical supply. Follow the manufacturer's instructions and local electrical codes.

Attach Assembly – Place the MR-16/Spot Light Assembly onto the mounting bracket or housing. Secure it in place using the provided screws or fasteners.

Adjust Direction – If the assembly allows for directional adjustments, aim the light in the desired direction. Some assemblies come with swivels or adjustable brackets for flexibility.

Secure Bulb – If not pre-installed, insert the MR-16 bulb into the socket. Ensure it is securely in place, following any guidelines provided by the manufacturer.

Test Operation – Turn on the power and test the operation of the Light Assembly. Confirm that the light is functioning correctly and adjust the direction if necessary.

Final Checks – Double-check all connections, ensure the assembly is securely mounted, and inspect for any issues. Make any necessary adjustments.

2.4 Installation of MR-16/Spot Light Assembly

MR16 light fixtures are commonly used in residential and commercial settings for directional lighting. The "M R" of "MR16" stands for multifaceted reflector, which is what controls the direction and spread of light cast from a MR16 lamp.There are two base types for MR16 light bulbs, the GU10 (twist) and the two-pin GU4.3 (push to fit). The GU4.3 bases commonly operate using 12 volts, while the GU10 operates off 120 volts.

MR16 Assembly Parts

Different parts of MR16 assembly are shown below in Figure 2.6 and 2.7.

Fig. 2.6: MR16 Assembly Part

Driver PCBA

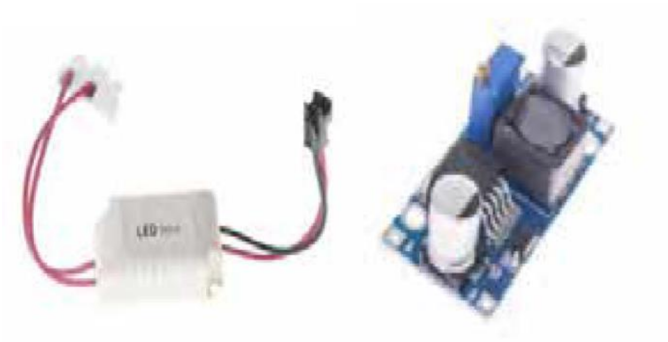
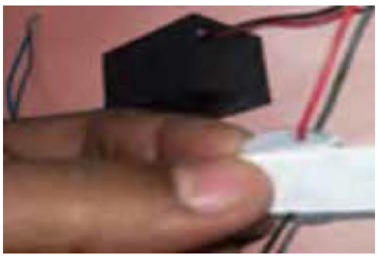


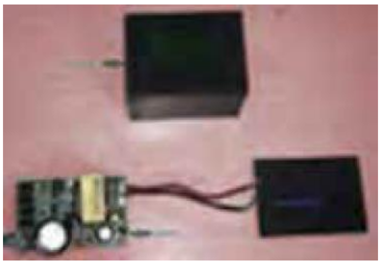
Fig. 2.7: Driver PCBA

Product Assembly Installation

Step by step installation steps are discussed below in table 2.1.

Table 2.2: Installation of MR-16/Spot Light Assembly

Steps	***Image***
Place double sided adhesive thermal tape on the bottom side of the light engine printed circuit board assembly (PCBA) and ensure that there are no wrinkles while pasting the tape.	

Place the taped light engine PCBA on the aluminium profile. Ensure that there are no dust or foreign particles on the profile surface.	
Press the PCBA gently to get proper bonding between the light engine PCBA & the aluminium profile. Ensure that there are no gaps in between.	
Take the required driver PCBA and place it into the plastic enclosure. Ensure that there are no damages to the input and output end wires of the driver.	
Later, place the lens on the mechanical.	
Fit the LENS placed with the spring ring	
Then, draw the wires of the spotlight out of the plastic.	

Connect the spotlight output wires to the input wires by soldering.	

After performing these steps, apply 220V AC and observe that the LED should be lit and the required wattage should be achieved. Keep the spot light in ON position for minimum 4 hrs for burn-in test. Power-up and ensure that there is correct wattage and intensity.

2.5 Installation of LED Bulb Assembly

2.5.1 Parts of LED bulb

Different parts of an LED lamp are described as follows:

A) LED Module

This consists of LED chips. These are the semiconductor devices that emit light when an electric current pass through them. LED chips are typically made of gallium nitride (GaN) or similar materials, and they determine the brightness, color, and energy efficiency of the bulb.

B) Heat Sink

LED bulbs generate heat during operation, and a heat sink is essential for dissipating this heat to prevent overheating and prolong the lifespan of the bulb. Heat sinks are usually made of aluminum or other materials with high thermal conductivity.

C) Driver Circuit

The LED driver integrated circuit (IC) regulates the electrical current and voltage supplied to the LED module, ensuring stable operation and preventing damage from fluctuations in power supply. It converts alternating current (AC) from the mains power source to direct current (DC) suitable for powering the LEDs. Additionally, the driver IC may incorporate features such as dimming control and power factor correction to optimize energy efficiency and lighting control.

D) Capacitor

Capacitors are crucial components in LED bulbs, contributing to power factor correction, filtering electrical noise, and stabilizing voltage fluctuations. They store and release electrical energy as needed, improving the efficiency and reliability of the bulb's operation. Capacitors in LED bulbs are carefully selected to withstand high temperatures and voltage stresses, ensuring long-term performance and safety.

E) Base and socket

The base and socket of an LED bulb provide mechanical support and electrical connections to the light fixture. The base incorporates electrical contacts that make reliable connections with the fixture's socket, enabling power transmission to the LED module and driver IC. Robust construction and proper insulation of the base and socket are essential for safety and durability in LED bulb applications.

F) Lampshade

In LED bulbs, the lampshade, or diffuser, softens and distributes the light emitted by the LEDs, improving aesthetics and reducing glare. It comes in various shapes and materials, such as glass or plastic, and provides protection for the internal components while enhancing the bulb's overall performance and user experience.

All these parts of an LED lamp are shown in Figure 2.8 given below.

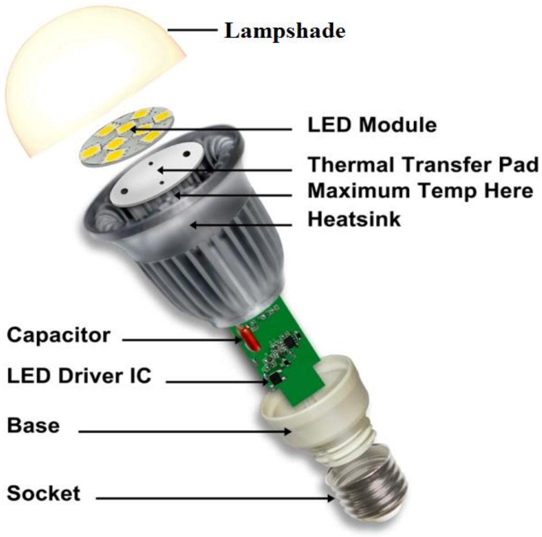


Fig. 2.8: LED Lamp

2.5.2 Installation of LED Bulb Assembly

Material required for making LED bulb (7W COB Bulb) are as follows:

1) LED Driver circuit (Pcb board)
2) LED Board (with LED mount)
3) Aluminum Heat sink plate
4) Plastic Housing
5) Metal cap

Step 1. Assemble all the components as per the requirement.

Step 2. Check all the LEDs in the driver circuit as shown in Figure 2.9.

Fig. 2.9: Check all the LEDs

Step 3. Mount the LED board on aluminum heatsink: For the LED bulb, its board size aluminum heat sink will be available only with the board. To paste the LED board on it, heat sink compound has to buy from the market and first put the compound on the heat sink and then place LED board up and paste. Aluminum heat sink is shown in Figure 2.10.

Fig. 2.10: Aluminum heat sink

Step 4. Mount the LED driver in Housing: Fix the LED driver PCB by putting it inside the housing, keep in mind that PCB does not move. To fix, it can stick with the hot gun by applying glue as shown in Figure 2.11.

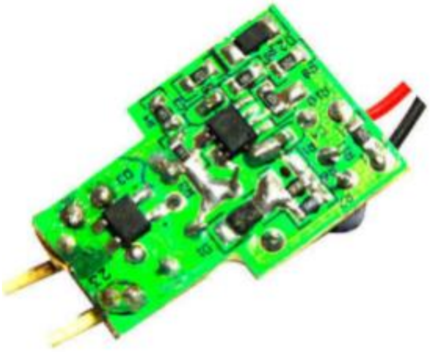


Fig. 2.11: LED driver in Housing

Step 5. Add the input wire to the metal cup of the Driver circuit: Now remove both the wires of the LED driver's input mains 220V from the metal cup holes and solder them well, be careful that the solder is not dry as shown in following Figure 2.12.

Fig. 2.12: Metal cup with wires connected

Step 2. Crimp metal cup with housing: Now join the metal cup with the housing, press the crimping machine, so that the two will be well connected together. Just remember, that both should be properly fixed and not shaken.

Step 7. Solder LED board with driver PCB: Now, start soldering by connecting both pins of the driver PCB output to the LED board as shown in Figure 2.13.

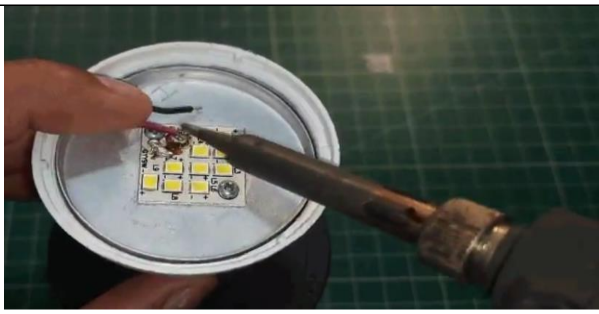


Fig. 2.13: soldering of components

Step 8. Mount the LED board above the housing: In the housing, there are some locking systems for fixing the LED board, so that the board should be well trapped and does not move.

Step 9. Fit the plastic cup above the housing: Now put the plastic cup that comes with the bulb and close the bulb with it. Now you can test your bulb by putting it on the board of the mains supply, if the bulb is burning well then you are successful.

Step 10. Mount the PCB board in the LED Housing with all the wires. The complete connections are shown in Figure 2.14.

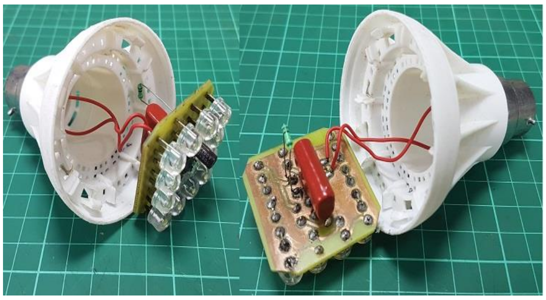


Fig. 2.14: LED bulb connections

Step11. Now join both the parts of the bulb. Connect it to the power supply and check it working. It must glow as shown in Figure 2.15.

Fig. 2.15: LED bulb working

2.6 Electromagnetic Interference (EMI)/Electromagnetic Compatibility (EMC) Driver PCB Assembly:

1. Place all the components required for an EMI/EMC board manually and solder them
2. Cut-off the leads, if extended
3. Solder input and output wires
4. Clean the boards.

Product Assembly Instructions

1. Place the EMI/EMC driver assembly inside the fireproof plastic holder.

2. Draw out the input and output wires from the plastic holder and fix the EMI/EMC PCB to the plastic holder by tightening the screws.

3. Apply thermal paste on the back side of the COB module. Spread the thermal paste homogeneously as shown in Figure 2.16.

Fig. 2.16: Apply the thermal paste on the back side of the COB

4. Place the COB module on the aluminium surface of the heat sink. Ensure, there are no dust or foreign particles on the aluminium surface.

5. Then, solder the output wires of the EMI assembly to the AC points on the COB module.

6. After soldering on the COB module, fix the COB module on the heat sink by tightening the screws.

7. Solder the input wire of the EMI assembly to the base B22/or E27 depending upon the type of bulb required. If a pin-type bulb is required, use a B22 base and if a screw-type bulb is required, use an E27 base. After soldering the AC input wire, crimp the base to the heat sink.

8. Later, place the PC diffuser on the heat sink and lock it.

Product Testing

Driver PCBA Testing:

1. Apply 200Vac to 260Vac, 50Hz to the Input wires for testing.

2. Observe that LED lumens are according to those mentioned in the datasheet.

3. Power Factor is >0.95 and the Efficiency>80%.

4. Keep the COB light bulb in the ON position for 4 hrs-BURN-IN TEST.

5. Lastly, after testing is done and the product is given as PASS, pack the bulb in the required packing.

Activity 2

Practical Activity 2.2. Demonstrate the installation steps of an LED bulb assembly.

Materials Required

LED bulb components (COB module, Driver PCB, Heat Sink, Diffuser, Connecting Wires)

Tools (Screwdriver, Wire Cutter/Stripper, Multimeter)

Procedure

Step 1. Divide students into pairs or small groups.

Step 2. Provide each group with LED bulb components and tools.

Step 3. Guide students through the installation steps mentioned in Section 2.4.

Step 4. Ask each group to demonstrate the installation process to the class.

Step 4. Discuss any challenges faced and solutions found during the activity.

2.6 Installation of LED Tube Light Assembly

Follow the given process for the assembly of a 4 feet LED tube light:

Step 1. For a length of 4 feet, two light engines with jumper wire have to be soldered as shown in Figure 2.17.

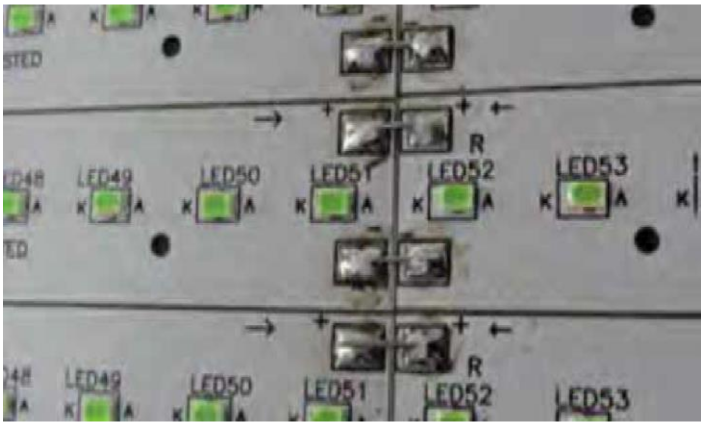


Fig. 2.17: Soldered two light Engines with jumper wire

Step 2. For a custom-designed heat sink, apply thermal compound over the heat sink surface for heat transfer prior to fitting the light engine PCBA in the aluminum heat sink.

Step 3. Place the light engine PCB after applying the thermal compound on the aluminum heat sink.

Step 4. Ensure that there are no gaps between the profile and the PCBA.

4. Place the tube light driver into the oven with the sleeve for protection as shown in Figure 2.18.

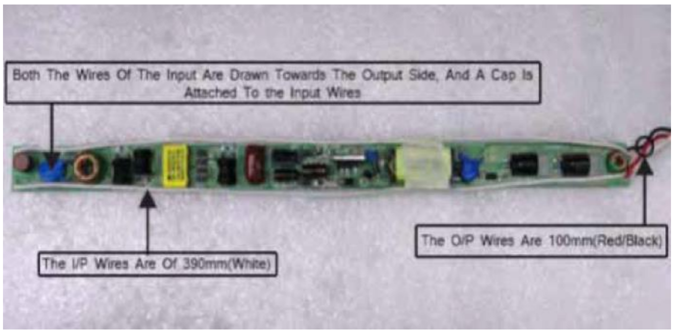


Fig. 2.18: Driver Unit

Step 5. Take the tested driver and insert it into the sleeve as shown below in Figure 2.19. Pass the sleeved driver through the reflow oven at conveyor speed 0.70 m/min, for heat shrinking of the heat sink sleeve at a reflow temperature of 110 degrees C.

Fig. 2.19: Sleeve driver

Step 6. Place the sleeved driver inside the aluminum extrusion, and solder the input wires to the end caps and the output wires to the light engine input points. The wire colours: input-White, output- Red (+) / Black (-) The input points of the light engine are connected to the output of the driver, while the input points on the other side of the light engine are shorted. It will look like as shown in Figure 2.20.

Fig. 2.20: LED Tube

Step 7. Mount the end caps over the LED tube light profile as shown above and tighten it with screws on tested and passed lights as shown in the following Figure 2.21.

Fig. 2.21: Mounted LED Tube

Step 8. Apply the required voltages and current and ensure that all LEDs must be lit with the same intensity.

Step 9. Solder the input wires on the end caps and the output wires on the light engine PCBA. Ensure that no solder splashes and balls remain during manual soldering.

Step 10. Apply 90-265Vac and ensure that all LEDs must be lit and the required wattage is achieved.

Step 11. Insert the required printed PC covers onto the aluminum profile; ensure that there are no scratches and the lamination sheets must be on the cover.

Step 12. Keep the tube light in the ON position at least for 4 hours on the Burn-In Test aging line.

Step 13. Tested and passed lights must be screwed with end caps.

Step 14. Power up and ensure the correct wattage and intensity.

Step 15. Pack the light in their covers as shown in Figure 2.22.

Fig. 2.22: Thermocol box used for packing a set of 5 LED tube lights

Activity 3

Practical Activity 2.3. To simulate the assembly of a 4 feet LED tube light.

Materials Required

Components for LED tube light assembly

Tools used in the installation (Automatic Screw Driver, Manual Screwdriver, Wire Cutter/Stripper)

Procedure

Step 1. Demonstrate the assembly process using a mock setup.

Step 2. Divide students into small groups.

Step 3. Provide each group with the necessary components.

Step 4. Ask students to follow the steps outlined in Section 2.6 to assemble the LED tube light.

Step 5. Encourage students to troubleshoot and solve any assembly issues.

2.7 Installation of LED Down Light Assembly

2.7.1 Downlight assembly parts

Different parts of LED downlight like the light engine, diffuser, heat sink are shown in Figure 2.23.

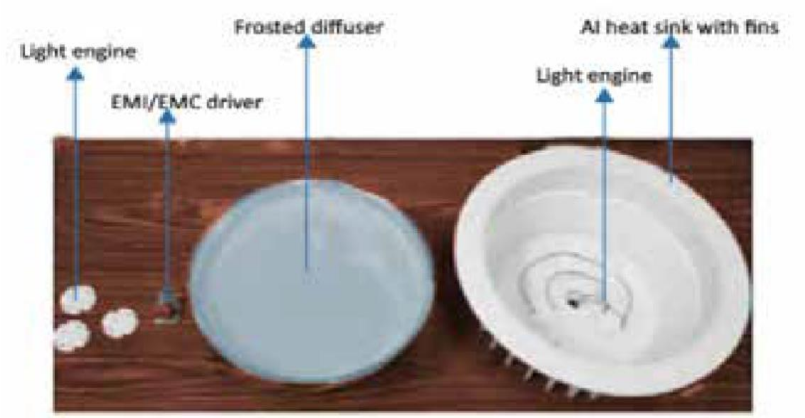


Fig. 2.23: Down Light Assembly parts

Product assembly instructions

Step 1. Ensure that there is correct PCB usage per production order, which means the size and number of the LEDs board.

Step 2. Clean the surface at the bottom of the COB with IPA (Isopropyl alcohol), and then place the thermal adhesive tape.

Step 3. Place the COB on the aluminum profile. Ensure that no dust or foreign particles are there on the profile surface. Press it against the aluminum heat sink for proper contact.

Step 4. Place these light engines in an orientation of 120 degrees (if 3 COBs are used for 18W), and 90 degrees with each other (if 4 COBs are used for 24W).

Step 5. After placing the light engines, connect the COB with the output wires of the EMI/EMC PCB.

Step 6. Ensure that there is no continuity between the input wires.

Step 7. Apply 220Vac, 50Hz to the Input wires.

Step 8. Observe. The LEDs must be illuminated with the same intensity.

Step 9. Measure the PF and the efficiency. The PF must be >0.9 and the efficiency must be >80%. When P1 represents input power and P2 represents output power

Efficiency (η) = P_2/P_1

Step 10. Solder the AC supply points with wires.

Step 11. While soldering does not place more than the required solder on the pads otherwise the wires may get disconnected or the pads may come out.

Step 12. Solder the EMI/EMC PCB with the output wires of the COB.

Step 13. Later place the reflector and the frosted cover over the heat sink.

Step 14. Lock the product with screws.

Step 15. Apply 220VAC, 50Hz, and check whether the COBs shave the correct illumination. Figure 2.24 shows a 18W downlight at 220V AC.

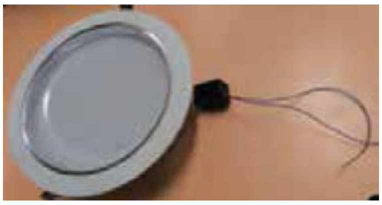


Fig. 2.24: Down Light

Step 16. Keep the COB light in ON for a minimum of 4 hrs.

Step 17. Ensure there is correct wattage and intensity.

Step 18. Pack the light.

Step 19. Keep the color of wires as follows:

Input = Red (Both line and neutral)

Output = Red (Line), Black (Neutral)

2.8 Installation of LED Street Light Assembly

Product assembly instructions

Step 1. Before starting the LED street light assembly, complete the heat sink assembly. The Heat Sink Assembly Insulation Sheet is shown below in Figure 2.25.

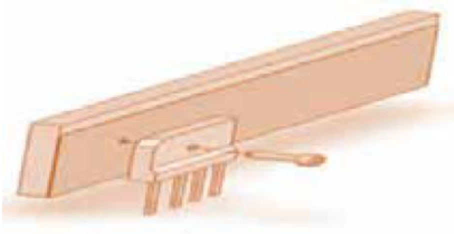


Fig. 2.25: Heat Sink Assembly Insulation Sheet

Note: This heat sink is made of Aluminium (Al) and covered with thermal tape. It is used to mount on a metal–oxide semiconductor field-effect transistor (MOSFET) for heat management. The MOSFET after being mounted is screw fitted. Also, ensure there is no air bubble in between the insulation sheet and the heat sink.

Step 2. The driver PCB is placed properly inside the PSU cover and its screw is tightened with the help of washers. It is shown in Figure 2.26.

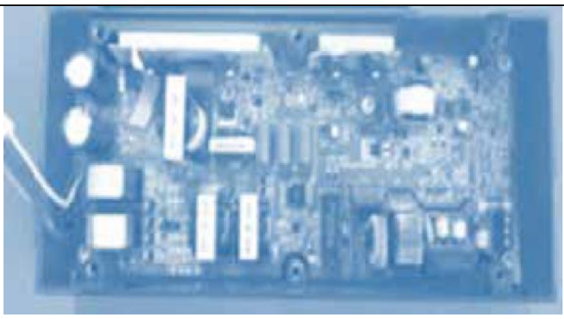


Fig. 2.26: PCB

Step 3. The thermal tape is used for heat management through LEDs. It is made in such a way that it has two window openings to fit the lens and the light engine PCBs.

i. It is placed below the metal sheet.

ii. Later, the wires are drawn through the holes and the connectors. LEDs are placed, and rapid repair (RR) powder is added to fill the holes.

iii. The gasket is used for air-tight fittings.

iv. For 60W we will use a 24 LED light engine.

v. This is used for a 100W, 48 LED light engine.

The flexible arm is later screwed to the street light fixture to enable it to move to an angle.

• Every assembled PSU must power up on resistive loads at least for 8 hrs.

• Ensure that the wire color combination and polarity are according to the given table.

• The same polarity has to be followed in a light engine while connecting with a wire.

2.9 Installation of LED Round Panel Light Assembly

6-inch round panel light parts are shown in the following Figure 2.27.

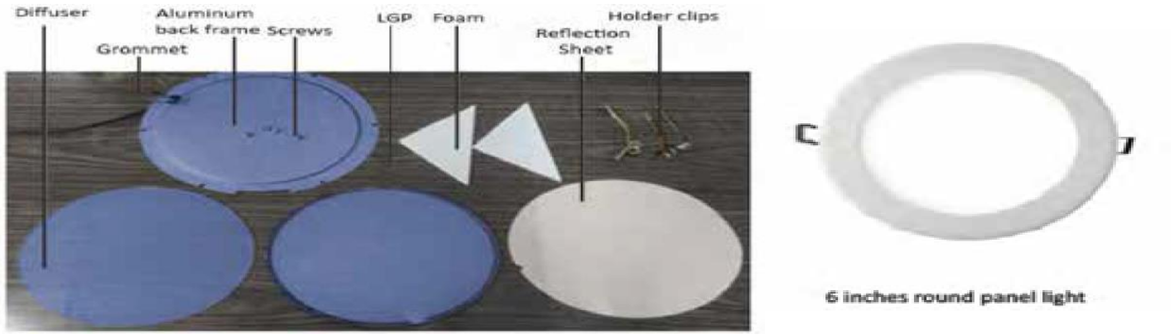


Fig 2.27: Round Panel light parts

Product Assembly Instructions

1. Clean the aluminum die cast and the LED light engine with IPA.
2. Take the LED strip and paste the double-sided thermal tape behind it.
3. Paste the thermal tape around the die-cast.
4. Draw out the wires.
5. Now place the diffuser.
6. Place the LGP over the diffuser.
7. Then, place the reflection sheet.
8. Place the foam sheet before covering it with the aluminum back plate.

9. Finally, place the screws and tighten up, drawing the output wires out of the hole in the aluminum back panel.

10. A grommet is placed on the aluminum back plate to keep the wires stiff as shown below in Figure 2.28.

Fig. 2.28: grommet in round panel light

11. A connector is placed in the output wires.

2.10 Installation of 1x1 and 2x2 Square Panel Light

Product Assembly

A panel light has many parts included as follows:

- Extrusion/Die Cast
- Diffuser
- Light Guide Plate
- Reflection Sheet
- Foam Sheet
- Aluminum Back Plate
- Thermal Tape, Reflection Tape

Product Assembly Instructions

1. For 2x2 and 1x1 panel light, use a 599 mmx599mm and 299 mmx299mm aluminium frame.

2. Use two light engines at opposite sides in a 2x2 and 1x1 Panel light.

3. The output wires (Red, Black) are soldered onto the light engine polarities.

4. Clean the light engine and the Al extrusion with IPA to remove the dust particles and to place the thermal tape properly without any gap.

5. Then, for 2x2 panel light, the thermal tape of 570mm length and 8mm width is used beneath the light engine and for1x1 panel light, 282mmx8mm thermal tape is used.

6. The frame with a light engine is ready.

7. Place the diffuser inside the frame and the LGP on top of it.

8. Then, place the reflection sheet on top of the LGP and cover from all sides using an aluminium reflection tape to avoid any light dissipation or losses.

9. Lastly, place the foam sheet to provide stability to the mechanicals of the panel light.

10. Finally, place the aluminium back plate.

It is shown below in Figure 2.29.

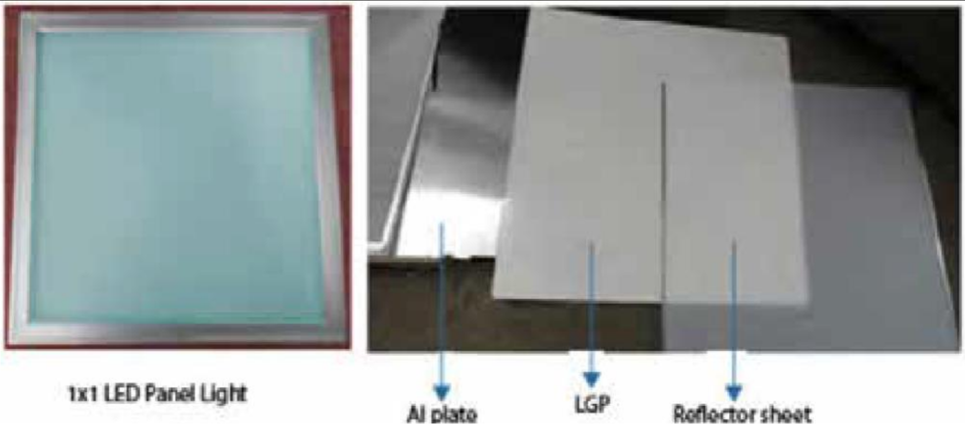


Fig. 2.29: 1x1 and 2x2 Square Panel Light

2x2 Panel Light Assembly Steps

1. The four aluminum extrusions are taken and cleaned with IPA.
2. The extrusions are placed together to form a frame.
3. Then, the LED strips are pasted behind them with the thermal tape
4. The diffuser is placed initially on the thermal tape over the frame.
5. Then, the LGP is placed over the diffuser.
6. The LGP has a reflection sheet below it.
7. Lastly, the foam sheet covered by an aluminium sheet and screwed tight.
8. The reflector sheet has an aluminium reflection tape pasted on the two sides to cover the light coming out from the LED strip to prevent losses.
9. Grooves are made in the extrusion and the reflection sheet to provide for holding of clips and to fasten them with screws.

It is depicted in Figure 2.30.

Fig. 2.30: 2x2 Panel Light Assembly

10. A grommet is provided to draw out the output wires through the aluminium back panel.

2.11 LED Product Testing

2.11.1 Driver PCBA + Light Engine Testing

1. Connect the driver output with the light engine.
2. Place the driver into its enclosure and draw out its input and output wires. Ensure that there is no continuity between the input wires.
3. Connect the light engine at the output wires.
4. Apply 220Vac, 50Hz to the input wires; take extreme care against electric shock. Observe that all LEDs must be illuminated with the same intensity.
5. Measure the PF and the efficiency. PF must be > 80 % and the efficiency must be >$\eta = P_2/P_1$ P_1= Input Power and P_2= Output Power

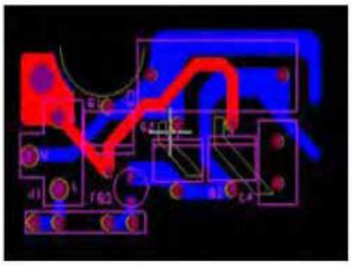
6. Power up the driver and ensure that it is working.
7. Check that there is no damage to the driver and its input and output wires are not shorted or torn out while closing in the enclosure.

2.11.2 Burn in Test for LED Luminaire

Burn-in is the process of exercising the components of a system before they are placed in service. The purpose is to detect the components that may fail due to the initial, high-failure rate of the reliability of the component. A longer and more stressful burn-in period ensures that the system is free from further early failures after the process is complete.

One of the efficient and reliable ways is to do a burn-in test of the product on an aging line with a conveyor having different voltage zones and a high temperature zone, as shown in figure 2.31.

Burn-in Test



	WIRE COLOR
Phase/Live (L)	Red
Neutral (N)	White
Earth (E)	Green with yellow tracer

Fig. 2.31: Burn It Test Output

2.11.3 Inspection of the Completed Assembly – After the burn-in test, the next step is visual inspection. In visual inspection, check for the following:

• Assembly faults

• Soldering faults

• Wire colour incompatibility Finally, place the aluminium back plate.

2.11.4 IP (Ingress Protection) Rating

The Ingress Protection Marking referred to as IP Code, is also known as International Protection Marking. It falls under IEC standard 60529, published by the International Electromechanical Commission (IEC), and defines the ratings and categorization of the degree of protection provided against the following:

• accidental contact by electrical enclosures and mechanical casings

• intrusion by hands and fingers

• water

• dust

The rating is denoted as IP (characteristic numerals). For example, an electrical socket rated IP22. The first and second digits denote protection against solid particles and liquid ingress respectively.

The digits indicate the conformity of the component with some specified conditions. The numerals are replaced with 'X' such as IPX7 when there is no protection rating available about any one of the criteria. The level of protection against solid particles is listed in the following table 2.2.

Table 2.3: The level of protection against solid particles

Level	Object size protected against	Effective against
0	-	No protection provided against contact and entrance of objects
1	> 50 mm	Protection provided against any large surface of the body part (back of the hand). No protection is provided against intentional contact with the body.
2	> 12.5 mm	Protection is provided against fingers or objects of the same type.
3	> 2.5 mm	Protection provided against thick wires and tools.
4	> 1 mm	Protection against crews, wire, and so on
5	Dust protected	Complete protection provided against dust contact. It can be said to be dust proof. Entry of dust is not totally prevented; however, it is restricted to a tolerable level that it does not limit the operation.
6	Dust tight	Provides complete protection from dust (it is considered to be tightly packed to allow dust.)

Activity 4

Practical Activity 2.4. To understand the importance of inspection and testing in LED product assembly

Materials Required

Completed LED products, Inspection checklist, Testing equipment (Multimeter)

Procedure

Step 1. Explain the significance of inspection and testing in ensuring product quality.

Step 2. Provide an inspection checklist to each student.

Step 3. Ask students to inspect a completed LED product for assembly faults, soldering faults, and wire color incompatibility.

Step 4. Demonstrate how to use a multimeter for basic testing of LED products.

Step 4. Encourage students to test the products and discuss their findings.

Summary

This chapter introduces various light sources, focusing on the efficiency and versatility of LED lights. It covers LED luminary assembly components, including the crucial role of LED drivers. The chapter provides concise step-by-step assembly instructions for various LED products, emphasizing testing, burn-in procedures, and considerations for IP ratings.

CHECK YOUR PROGRESS

A. Multiple Choice Questions

1. What is the primary advantage of LED lights? (a) Affordability (b) Simplicity (c) Energy efficiency (d) Instantaneous illumination
2. Which component is responsible for providing power to LEDs in a luminaire assembly? (a) Heat sink (b) Light engine (c) LED driver (d) Luminaire diffuser
3. What are the criteria for selecting an LED driver? (a) Colour temperature and brightness (b) Forward current requirement and dimming capability (c) Physical dimensions and surrounding environment (d) All of the above
4. What tools are commonly used in the assembly of LED luminaires? (a) Screwdriver and wire cutter (b) Hammer and nails (c) Tape measure and pliers (d) Paintbrush and roller
5. What is the purpose of the burn-in test in LED luminaire assembly? (a) To assess colour accuracy (b) To check for assembly faults (c) To detect early component failures (d) To measure energy efficiency
6. What does IP stand for in the context of LED luminaire assembly? (a) Intelligent Panel (b) Ingress Protection (c) Illumination Power (d) Integrated Performance
7. What does an IP rating of "IPX4" indicate? (a) Protection against thick wires (b) Dust tight (c) Complete protection from dust (d) Protection against water splashes from any direction
8. What is the function of a thermal interface material in LED products? (a) To control colour temperature (b) To facilitate dimming (c) To conduct heat away from sensitive components (d) To enhance brightness
9. Which type of light source uses a tungsten filament and halogen gas for higher efficiency and longer life? (a) LED Lights (b) Incandescent Bulbs (c) CFL (Compact Fluorescent Lamp) (d) Halogen Light
10. What is the primary role of an LED luminary diffuser or lens? (a) To house the LED light engine (b) To distribute light evenly (c) To provide power to the LED (d) To dissipate heat

B. Fill in the Blanks

1. For efficient LED Bulb Assembly, it is essential to apply __________ on the backside of the COB module before placing it on the aluminum surface of the heat sink.
2. In the assembly of 1x1 and 2x2 Square Panel Light, grooves are made in the extrusion and the reflection sheet to provide for holding __________ and to fasten them with screws.
3. During LED Product Testing, it's crucial to connect the driver output with the __________ to ensure proper functionality and illumination.
4. The IP Code, denoting Ingress Protection, indicates the level of protection against solid particles and liquid ingress, where the first digit refers to protection against _________.
5. In LED Round Panel Light assembly, the use of a grommet in the aluminum back plate is designed to keep the __________ of the wires stiff.
6. When selecting an LED driver based on the forward current requirement of LED, it's crucial to find a driver with __________ output current matching the LED's specifications.

7. During LED Street Light assembly, the thermal tape is placed below the metal sheet with window openings to fit the lens and the __________ PCBs.
8. The burn-in test is essential for detecting potential early failures and ensuring that the LED luminaire is free from further __________ after the process is complete.
9. In LED Down Light assembly, the __________ orientation of light engines plays a role in achieving the desired illumination for different wattages.
10. The selection criteria of an LED driver include factors such as forward current requirement, power consumption, __________, and surrounding environment.

C. State whether True or False

1. LED lights, using semiconductor diodes, produce light when an electrical current is applied.
2. Incandescent bulbs are considered energy-efficient and have a longer lifespan compared to newer technologies like LEDs.
3. CFLs (Compact Fluorescent Lamps) use mercury vapor to emit ultraviolet light, which then stimulates a phosphor coating to produce visible light.
4. Halogen lights, a type of incandescent lamp, produce a warm, familiar light similar to traditional incandescent bulbs.
5. The LED Luminary Assembly includes major components such as an LED Light Engine, an LED Driver, and a Mechanical Housing.
6. Constant Voltage (CV) LED Drivers keep the voltage constant, and their feeding current varies according to the load.
7. The installation of LED products involves three steps: Base assembly, Assembly of heat sink, and Joining of base assembly and heat sink assembly.
8. The Burn-in Test for LED luminaires is a process to detect potential early failures and ensure the system is free from further issues after completion.
9. The Ingress Protection Marking, known as IP Code, provides information about protection against accidental contact by electrical enclosures but does not consider protection against dust.
10. For LED Down Light assembly, the orientation of light engines at 120 degrees is crucial for 18W, while at 90 degrees, for 24W.

D. Answer the following questions in short

1. Explain the key advantages of LED lights over traditional incandescent bulbs.
2. Describe the function of an LED driver in the LED Luminary Assembly.
3. Briefly outline the tools commonly used in an LED luminary assembly.
4. What is the role of a heat sink in the thermal system of LED luminaires?
5. Explain the importance of the Burn-in Test in LED luminaire production.
6. Describe the purpose and significance of the Ingress Protection Marking (IP Code) in LED products.
7. How does a Compact Fluorescent Lamp (CFL) produce light, and what are its advantages over incandescent bulbs?
8. Explain the purpose of thermal interface materials in LED products and list three types commonly used.
9. Describe the key steps involved in the installation of LED Tube Lights.
10. In LED Street Light Assembly, why is the insulation sheet used in the heat sink assembly, and what role does it play?

Session 3: Troubleshooting and Repairing of LED

Troubleshooting and repairing LEDs involves identifying and addressing common issues to ensure optimal performance. If an LED is not lighting up, first check the power source and connections to ensure they are secure. If the LED still does not work, it may be a faulty LED or a wiring issue. In such cases, replacing the LED or repairing the wiring connections can often resolve the problem. Additionally, using a multimeter to test the voltage and continuity can help pinpoint the source of the issue. Proper troubleshooting techniques and careful examination of the LED and its surrounding components are discussed here that are essential for effective repairing.

3.1 Analysis of faults in LED Lights

1. Hot Environment – Depending on temperature and time, LED light output decreases exponentially. The LED light will deteriorate more quickly in an environment with higher temperatures, which will shorten its lifespan. Thus, thermal control is essential to guarantee an extended lifespan for LEDs.

2. Incorrect LED Driver – Incandescent lighting can be run on either AC or DC power, but LEDs need to be powered by a DC source. LED drivers or power supplies can be used to drive LEDs when connected to an AC power source. An LED fails due to overdrive caused by high voltage or current from the driver or power supply.

3. Incorrect Polarity – Since LEDs are diodes, they must be connected by their polarity. Therefore, the supply's positive and negative terminals are connected to the anode (positive terminal) and cathode (negative terminal), respectively. Reversely connecting LED terminals can result in a catastrophic failure that prevents light from emanating and causes an open circuit.

3.2 LED Luminaire Failure Analysis

90% of the luminaire failures are due to something other than the LED. Analysis due to different causes are shown in Figure 3.1.

Fig. 3.1 Failure Analysis

LED Luminaire Failure Types:

1. LED Failure Modes
2. Secondary Optics Failure Modes
3. Thermal Management System Failure
4. LED Driver Failure

1. LED Failure Modes

Different LED failure modes are listed as follows:

Packaging Related Failure

Epoxy degradation – Heat causes certain plastic package material components to turn yellow. It results in a loss of efficiency because it partially absorbs the wavelengths that are affected.

Thermal stress – Upon reaching the glass transition temperature, the epoxy resin package begins to rapidly expand. The semiconductor and the bonded contacts are subjected to mechanical stresses as a result of the expansion, which weakens and even tears off the bonded contacts. Extremely low temperatures may also cause the packaging to crack.

Degeneration of differentiated phosphor – The light colour produced by white LEDs varies because age and heat cause different phosphors in the LEDs to degrade at different rates. For instance, the organic phosphor formulation used in pink and purple LEDs may deteriorate after a few hours of use and result in a significant change in the colour of the light.

Metal and Semiconductor Related Failure

A common mechanism for degradation of the location of radiative recombination (known as active region) is nucleation and growth of dislocations. This is caused due to the presence of a defect in the crystal and the rate is accelerated by high current density, heat, and the light emitted from the LED. Elements such as aluminium gallium arsenide are more vulnerable to it. Metal atoms are moved to the active region from the electrodes as a result of metal diffusion, which happens due to high voltage or currents at elevated temperatures.

Stress-related

Thermal runaway – This is caused by loss of thermal conductivity due to the presence of non-homogeneities in the substrate. In this case, damage caused by heat results in more heat generation. The most common voids are the ones that are caused by incomplete soldering.

Electrostatic discharge: It may cause:

1. a permanent shift of the parameters of the semiconductor junction
2. immediate failure
3. latent damage that leads to enhanced rate of degradation.

2. Secondary Optics Failure Modes

Secondary optics ensure that the output beam of the LED lamp meets the photometric specifications by modifying it.

Secondary optics in LED may be any of the following:

1. Diffuser
2. Lens
3. Specular or diffuse reflector
4. Lens and reflector combination; for example, total internal reflection lens or TIR

Diffusing types are depicted in following Figure 3.2.

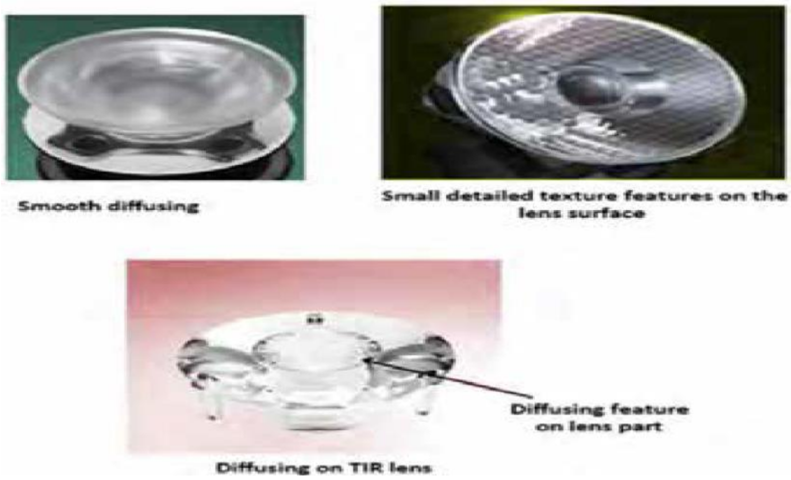


Fig. 3.2: Diffusing types

The secondary optic, in the case of outdoor applications, is exposed to ionizing radiation emitted from the sun.

3.Thermal Management System Failure

These include the following:

a) Heat sink failure
b) Thermally conductive adhesives wear
c) Thermally conductive gap filling materials degradation
d) Thermal tape wear
e) Thermal grease dry up

4. Driver Failure

Most of the high-power LED drivers, especially using power greater than 15W, use electrolytic capacitors. There can be two cases. The capacitors can be placed either on the input AC stage for allowing noise filtering or on the driver's output DC stage. In a driver circuit, the electrolytic capacitors are weak elements and fail frequently at high temperatures. Other prominent components that can fail:

a) Isolated
b) Input- fuse/ MOV
c) Output- transistor/ transformer/ IC

3.2 Steps for Diagnosing and repairing Faults in LED

a) Finding and repairing component level faults
b) Connection/soldering faults

LED Fault

1. Connect the LED light that is not functioning with the AC source.

2. If the light does not switch on, look for loose or de-soldered wires and connections.

3. Solder the wire and check for any loose connections so that the light can be operational again.

Light Engine Fault

1. Disassemble the parts of the LED light, if there are no faults in the connections.

2. Ensure that the light engine as well as the DC supply complies with the voltage/current requirements of the LED product.

3. If the LED light engine is found to be faulty, replace it.

LED Driver Fault

1. Check the driver with an AC supply or a multimeter to measure the voltage and the current output, in case the LED light engine is functioning properly.

2. Measure the output voltage and the current of each section of the supply unit to identify the faulty section.

3. Check every component of the section that either shows no output or has output voltage less than the desired one, by using a multimeter.

4. Repair /replace the damaged component, primarily the electrolytic capacitors.

5. Check the output voltage/current again with the multimeter and reassemble, if the repaired driver is found okay.

Components of a Typical LED Driver

An LED driver circuit with different components like a diode, capacitor, regulator, etc. are shown below in Figure 3.3.

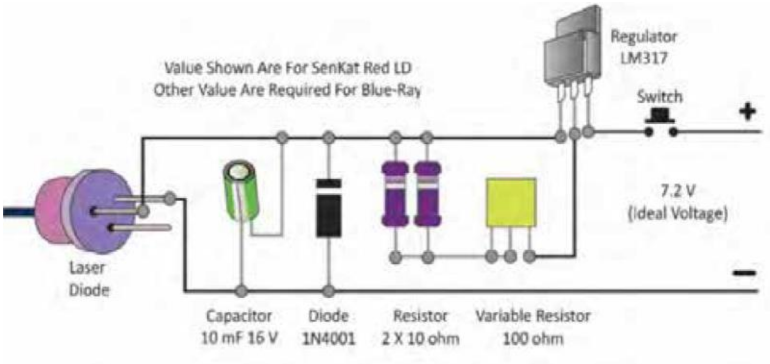


Fig. 3.3: Components of a Typical LED Driver

LED Strip Level Fault

1. Connect the LED light that is not functional with the AC supply.

2. Look for the damaged or non-functional LED strips or LEDs from the LED strips array in the light.

3. Replace the damaged LED strips by removing the glass shell.

4. Connect the LED array with the AC source and check it.

5. Replace the glass shell if all the LED strips are working.

3.3 Achieving Productivity and Quality Standard

1. Identify the root cause for the non-functionality of an LED light correctly and repair it effectively as soon as possible.
2. Document the steps of fault diagnosis and process of repairing as per standard operating procedures (SOP).
3. Effectively communicate with the colleagues and the supervisor about the fault diagnosing and the repairing method.
4. Report faults found in the LED lights.

Activity 1

Practical Activity 3.1. Understanding LED Failure

Material needed

LED bulbs of different power

Procedure

Temperature Impact Experiment

Steps 1. Place LED bulbs in different temperature environments.

Steps 2. Measure and record changes in light output over time.

LED Polarity Testing

Steps 1. Students connect LEDs with incorrect polarity.

Steps 2. Observe the effects and discuss findings.

Activity 2

Practical Activity 3.2. Diagnosing and Repairing Faults in LED

LED Fault Diagnosis:

Procedure

Step 1. Set up malfunctioning LED lights.

Students diagnose faults:

Check for loose connections and soldering issues.

Repair and document the process.

Step 2. Light Engine Examination

Disassemble LED lights with no connection issues.

Verify compliance with voltage/current requirements.

Replace faulty light engines.

Step 3. LED Driver Testing

Students use multimeters to test LED drivers.

Identify and replace damaged components (especially electrolytic capacitors).

Steps 4. LED Strip Replacement

Connect faulty LED strips to an AC supply.

Identify and replace non-functional LED strips.

Test the repaired LED array.

Summary

This chapter explores LED failure modes, emphasizing factors like hot environments, incorrect drivers, and polarity issues. Luminaire failures, excluding LEDs, are dissected, covering optics, thermal, and driver issues. The guide details steps for diagnosing and repairing LED, light engine, and driver faults, promoting adherence to standard operating procedures for enhanced productivity and quality.

CHECK YOUR PROGRESS

A. Multiple Choice Questions

1. What can cause LED deterioration in a hot environment? (a) Decreased voltage (b) Increased light output (c) Exponential decrease in light output (d) Improved lifespan
2. Why do LEDs need a DC power source? (a) They operate on both AC and DC (b) AC damages LEDs (c) DC enhances LED lifespan (d) LEDs are diodes, requiring DC
3. What is a common cause of LED luminaire failures? (a) LED issues (b) Secondary optics failure (c) Driver failure (d) Factors other than LEDs
4. Which is NOT a LED failure mode? (a) Thermal runaway (b) Packaging-related failure (c) Electrostatic discharge (d) Optical diffuser failure
5. What are examples of secondary optics in LEDs? (a) Lens and reflector combination (b) Heat sink and thermally conductive adhesives (c) Electrolytic capacitors (d) Thermal tape and thermal grease
6. In LED driver failures, what components are prone to frequent issues? (a) Resistors (b) Capacitors (c) Transistors (d) Inductors
7. What is a recommended step when diagnosing LED strip level faults? (a) Disassemble the light engine (b) Check the driver with a multimeter (c) Replace the glass shell (d) Connect to the AC supply and look for damaged LED strips
8. Why is documenting fault diagnosis and repair steps important? (a) Enhances LED lifespan (b) Maintains standard operating procedures (c) Causes rapid degradation (d) Improves luminaire performance
9. What role does thermal control play in extending LED lifespan? (a) Reduces light output (b) Increases temperature (c) Guarantees extended lifespan (d) Causes catastrophic failure
10. Which component in LED luminaire is exposed to ionizing radiation in outdoor applications? (a) LED driver (b) Secondary optics (c) Thermal management system (d) Light engine
11. What is a consequence of reverse connection of LED terminals? (a) Increased light output (b) Catastrophic failure (c) Enhanced LED lifespan (d) Improved colour rendition
12. What failure mode is NOT related to packaging in LEDs? (a) Epoxy degradation (b) Thermal stress (c) Metal diffusion (d) Electrostatic discharge
13. What can cause secondary optics failure in LEDs? (a) Exposure to ionizing radiation (b) Thermal runaway (c) Loss of thermal conductivity (d) Diffuser degradation
14. Why do high-power LED drivers often use electrolytic capacitors? (a) Improve color rendition (b) Enhance thermal conductivity (c) Resist high temperatures (d) Filter noise in the input AC stage
15. What is a recommended step for achieving productivity and quality standards in LED repair? (a) Avoid communication with colleagues (b) Neglect documentation of fault diagnosis (c) Repair faults slowly (d) Identify root causes and follow SOPs

B. Fill in the Blanks

1. LED lights exposed to __________ temperatures may experience a decrease in light output, necessitating thermal control for extended lifespan.

2. LEDs must be powered by a __________ source, and failure can occur if the LED driver supplies excessive __________ or __________.
3. Incorrect polarity in LED connections can lead to __________ failure, resulting in a loss of light and an open circuit.
4. __________ of differentiated phosphor can cause a change in the colour of light emitted by white LEDs due to __________ and __________.
5. The nucleation and growth of dislocations in the crystal can cause degradation in the location of __________ in LEDs, particularly in materials like __________.
6. Secondary optics in LEDs, such as __________ and __________, may be exposed to ionizing radiation in outdoor applications.
7. Common thermal management system failures include __________, __________ wear, and __________ degradation.
8. High-power LED drivers often use __________ capacitors, which can fail frequently at high temperatures.
9. During LED strip level fault diagnosis, if damaged LED strips are found, they should be __________, and the LED array should be checked after __________.
10. To achieve productivity and quality standards in LED repair, it's crucial to identify the __________ of faults, document __________, and effectively communicate with __________.

C. State whether True or False

1. LED light output decreases linearly over time in hot environments.
2. LEDs can be powered by either AC or DC sources without any issues.
3. Reversely connecting LED terminals does not lead to catastrophic failure.
4. The colour change in white LEDs is primarily caused by age, not heat.
5. Dislocations in the crystal, leading to the degradation of radiative recombination, are accelerated by low current density.
6. Secondary optics, such as lenses and reflectors, are not exposed to ionizing radiation in outdoor LED applications.
7. Thermal runaway is caused by an increase in thermal conductivity due to non-homogeneities in the substrate.
8. Electrolytic capacitors in high-power LED drivers are robust and do not frequently fail at high temperatures.
9. During LED strip level fault diagnosis, damaged LED strips should be replaced before checking the LED array.
10. Effective communication with colleagues and supervisors is not essential in achieving productivity and quality standards in LED repair.

D. Answer the following questions in short

1. Explain the impact of a hot environment on LED light output.
2. Why do LEDs require a DC power source, and how can an incorrect LED driver lead to LED failure?
3. What are the consequences of reversing the polarity when connecting LED terminals?
4. Describe the factors contributing to the degradation of white LEDs and the resulting colour change.
5. Explain the role of dislocations in the crystal and how they accelerate the degradation of LED components.
6. What are the common failure modes associated with secondary optics in LED luminaires?

7. List and briefly explain the types of failures in the thermal management system of LED lights.
8. Why are electrolytic capacitors in high-power LED drivers prone to failure, especially at high temperatures?
9. During LED strip level fault diagnosis, what steps should be taken if damaged LED strips are identified?
10. What are the key actions to achieve productivity and quality standards in LED repair, according to the chapter?

Module 3 — Occupational Health and Safety Standards

Module Overview

In today's dynamic work environment, prioritizing the well-being of employees and safeguarding the environment is of utmost importance. The unit covers a comprehensive approach to workplace safety and environmental sustainability. It covers a range of critical topics, from precautionary measures and first aid techniques to fire safety, evacuation procedures, and safe working practices. This knowledge equips individuals with the skills needed to identify and address potential hazards, respond effectively to emergencies, and establish a secure work environment.

Furthermore, the module delves into the organization's commitment to eco-friendly practices. It addresses waste management, including handling E-Waste and proper segregation of recyclable and non-recyclable materials. Understanding waste disposal methods and the sources of pollution is crucial for maintaining a clean and sustainable work environment. Additionally, the module emphasizes the integration of green practices into various job roles, contributing to a more environmentally conscious workplace. By adopting these principles, organizations can foster a culture of safety, health, and environmental responsibility, creating a better working environment for all stakeholders.

Learning Outcomes

After completing this module, you will be able to:

- Recognize and apply essential workplace health and safety protocols to ensure a safe working environment and prevent accidents.
- Understand the principles of waste management and implement green practices to minimize environmental impact in the workplace.

Module Structure

Session 1: Workplace Health and Safety Practices

Session 2: Waste Management and Green Practices

Session 1: Workplace Health and Safety Practices

Employees have a right to a secure workplace. Because of this, the businesses set and follow the law and ensure a safe working environment. The highest requirements for worker safety and conditions are outlined in a workplace health and safety policy. Ensuring that the workplace complies with the highest safety regulations is the obligation of all organizations. When beginning a business, some things to consider are:

1. Use furniture and equipment with ergonomic designs to avoid bending and twisting.
2. Provide mechanical support to avoid having to lift or move heavy objects.
3. Stock up on safety equipment for risky jobs.
4. Make sure the emergency exits are present and in a handy location.
5. Create health codes and ensure adherence to them.
6. Adhere to the regular safety protocol.

1.1 Precautions to be taken while at work

Every employee has a responsibility to adhere to the organization's safety procedures. Every employee needs to develop the following habits:

- Notify the supervisor of any unsafe conditions right away.
- Identify and report any safety risks that could cause trips, falls, or slips.
- Notify the supervisor of any accidents or injuries.
- Put on the appropriate safety gear when necessary.
- Acquire the knowledge necessary to operate the safety-related equipment properly.
- Recognize and refrain from doing anything that can put other people in danger.
- Constantly be aware
- Inform the staff of the location of the fire extinguishers and the first/emergency exits on the floor.

1.2 First Aid Techniques

Injuries, Pain, illness, are all a part of life. This may occur in any case. Every person is vulnerable to disease and accidents at any time and in any location. In the event that any of these occur, prompt medical attention or treatment is required to lessen pain, discomfort, and condition progression. "First Aid" refers to the initial medical care provided before seeking professional medical assistance. First aid is the temporary care provided to an accident or sudden illness victim in the interim until "Medical Aid" arrives. First aid refers to giving victims of accidents or illnesses the necessary medical attention and life support in the beginning. First Aid, however, has its limitations and is not a substitute for professional medical treatment. A patient's life can be saved when a first aider provides appropriate, prompt assistance. Accidents and illnesses can occur anywhere: at home, at work, or in public. Regardless of the safety precautions we take, illness is a possibility for everyone occasionally. Some common injuries and their rescue techniques are described in the next section.

1. Direct pressure must be applied to the cut or wound with a clean cloth, tissue, or piece of gauze, until bleeding stops.
2. If blood soaks through the material, it is highly recommended not to remove it.

3. More cloth or gauze must be put on top of it, and pressure must be continued.
4. If the wound is on the arm or leg, the limb must be raised above the heart to help slow the bleeding.
5. Hands must be washed again after giving first aid and before cleaning and dressing the wound.
6. A tourniquet must not be applied unless the bleeding is severe and not stopped with direct pressure.

Clean cut or wound

1. The wound must be cleaned with soap and lukewarm water.
2. To prevent irritation and burning sensation, the soap solution must be rinsed out of the wound.
3. Hydrogen peroxide or iodine must not be used to clean or treat the wound since they are corrosive and can damage live tissues. It is shown in Figure 1.1.

Fig. 1.1: Clean cut or wound

Protect the wound

- Antiseptic cream or solution must be applied to the wound to reduce the risk of infection.
- Then the wound must be gently covered with a sterile bandage.
- Till the wound heals, the bandage must be changed (dressed) daily to keep the wound clean and dry. It is depicted in Figure 1.2 and 1.3.

Fig. 1.2: Apply antiseptic

Fig.1.3: Protect the wound

Call the Emergency Helpline if

1. The bleeding is severe and deep
2. You suspect Internal Bleeding
3. Abdominal or Chest wound exists
4. Bleeding continues even after 10 minutes of firm and steady pressure

For Burns

Immediately put the burnt area under cold water for a minimum of 10 minutes as shown in Figure 1.4.

Fig. 1.4: Put Burnt Area under Water

If the burned area is covered, take clean scissors, cut, and remove the fabric covering the area

- In case clothing is stuck to the burned area, leave it as it is Before sterile dressing application, remove jewellery (if any).
- It is better to leave the burned area open Do not apply any medication or ointment Breaking a blister – it is an absolute no-no!

For Broken Bones and Fractures

1. Protruding bone must be left alone

- If a bone has broken through the skin, it must not be pushed back into place.
- The area must be covered with a clean bandage and immediate medical attention must be sought.

2. Bleeding must be stopped

- Steady and direct pressure must be applied with a clean piece of cloth for 15 minutes and the wound must be elevated.
- If a blood soaks through, one must apply another cloth over the first and seek immediate medical attention.

3. Swelling must be controlled

- The RICE (Rest, Ice, Compression and Elevation) therapy must be applied to control and reduce swelling.
- Rest the injured part by having the person stay off of it.
- Ice must be applied on the area with the help of an ice pack or by wrapping the ice in a clean cloth. Ice must not be directly placed against the skin.

For Heart Attack/Stroke

- Think FAST. Face: is there weakness on one side of the face?
- Arms: can they raise both arms?
- Speech: is their speech easily understood?
- Time: to call Emergency helpline
- Immediately call medical/ambulance helpline or get someone else to do it. It is shown in Figure 1.5 Anatomy of Hear Attack.

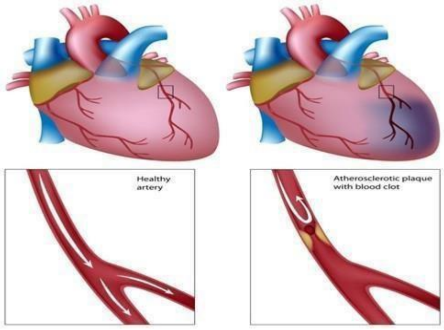


Fig 1.5: Anatomy of Heart Attack

For Head Injury

- Ask the victim to rest and apply a cold compress to the injury (e.g. ice bag)
- If the victim becomes drowsy or vomits, call Medical helpline.

Chemical hazards

It is caused by toxic materials, which are poisonous. And being poisonous in nature, they can either be fatal or cause serious damages in case the preventive actions are not taken on time. Now, the exposure to chemicals can be in 3 forms.

They can be

1. Inhaled (entering the body through nose)
2. Directly in contact with skin
3. Ingested (consumed)

The symptoms, in this case, will be:

1. Seizures
2. Partial or complete loss of responsiveness
3. Burning sensation
4. Stomach Cramping with bouts of excruciating pain
5. Nausea
6. Vomiting (and in times with blood-stains). It is shown in Figure 1.6.

Fig 1.6: Chemical hazards

Now, where there is a problem, their solutions come side by side. In such situations, the person giving first aid requires to be calm and take certain preventative actions.

Some of the essential actions are:

1. Using insulated equipment
2. Wearing protective clothing, goggles, masks, shoes and gloves
3. Ensuring the place has enough ample ventilation

Remedial action

- The foremost thing that one should do is to provide immediate first aid.
- However, it is to be remembered that the victim should not be given any kind of fluid (water, milk) until doctors from the Poison control unit give a green signal.
- Aside from this, there are a few things a person can perform to the victim of toxic material exposure.
- Remove the victim from the toxic zone or vicinity
- Call for an ambulance
- Remove contaminated clothing
- Splash water in the eyes
- If ingested, do not try to make the victim puke (vomit)
- Wash their mouth with water
- In case the victim's breathing has stopped, give CPR (Cardiopulmonary resuscitation) as shown in Figure 1.7.

Fig 1.7: CPR

1. In case of burning due to toxic material, apply burn gel or water gel on that area.
2. Avoid any cream based or oil-based lotion or ointment

Even though giving first aid is the right thing to do in the first place, it is also important to report the incident to their supervisor.

Steps of using breathing apparatus

It is shown below in table 1.1.

Table 1.1: Steps of using breathing apparatus

Procedure	**Illustration**
Check the parts of the breathing apparatus thoroughly	
Check the bypass knob (red). Close it if you see it open. After this, press the reset button (area above bypass nob – black)	

Inspect the face mask to see that it is undamaged	
Lift the cylinder ensuring that on the top the cylinder valve should be present. The back plate of the cylinder should face the wearer. Wear the breathing apparatus on the shoulder like a bag pack and by the neck strap, hang the face mask.	
After wearing the breathing apparatus, tighten shoulder straps and fasten the waist belt.	
The cylinder valve should be opened slowly to inspect the pressure gauge.	
Make sure that 80% of the cylinder is full.	
Wear the mask slowly by resting your chin in the resting cusp and pull the head strap slowly over your head. Pull the head straps for a snug but comfortable fit.	
Breath in and normally to see if you can breathe normally or not.	
Now insert a finger side wise of the face mask for easy outward airflow.	

Slowly close the cylinder valve without leaving the knob. Be steady for 10 minutes and hold your breath or extremely slow to listen to any wheezing sound. Also, check the pressure gauge for any dip in the pressure.	
Normally Breathe to vent system. Listen for a whistle alarm while observing the pressure gauge at 55 bar (+/-5 bar)	

Briefing and Guidance for Fire Fighters

There are basically three methods with the help of which people can be rescued from a building engulfed in a blazing fire. To ensure on-site reception, here are two of the important steps that we will discuss now. These come under the best safe lifting and carrying practices.

Conventional Technique: This is a good method if there is an open area close by. The first rescuers will make the victim sit, reach under their armpits and finally, grab their wrist. The other rescuer will cross the ankle (victim), pull up that person’s legs on his shoulder. Finally, on the count of 3, both will lift the person up and move out as shown in Figure 1.8.

Fig. 1.8: Fast Strap

Fast Strap: In case the victim is completely incapable of moving out of the fire zone. The rescuers should follow this method. One of the rescuers will place their knee between the victim's shoulder and head. Pin the loop of webbing to the ground with the help of the knee. This acts as an anchor. With the non- dominant hand hold the other end of the webbing and make a loop. With steady hands, pull the victim’s hand in from the loop, tie it securely and finally clip the webbing loops as shown in Figure 1.9.

Fig. 1.9: Fast Strap

Essentials for Smooth Evacuation: The following are essential to have a smooth evacuation during an outbreak:

1. Clear passageways to all escape routes
2. Signage indicating escape routes should be clearly marked
3. Enough exits and routes should be present to allow a large number of people to be evacuated quickly
4. Emergency doors that open easily
5. Emergency lighting where needed
6. Training for all employees to know and use the escape routes
7. A safe meeting point or assembly area for staff
8. Instructions on not using the Elevator during a fire

Special Evacuation Requirements for Especially Abled Persons

The Visually Impaired

1. Announce the type of emergency
2. Offer your arm for help

With Impaired Hearing

Turn lights on/off to gain the person's attention, or indicate directions with gestures, or write a note with evacuation directions

People with Prosthetic Limbs, Crutches, Canes, Walkers

1. Evacuate these individuals as injured persons.
2. Assist and accompany the evacuation site if possible.
3. Use a sturdy chair, or a wheeled one, to move the person to an enclosed stairwell Notify emergency crew of their location

1.3 Importance of Fire Safety Drills

Any public or commercial building should have fire drills to practice what to do in the event of a fire. In addition, all employees of a company are required to work as per the Fire Safety Order of 2005, which is a legal requirement. Here's how to maximize your fire training experience. Fire drills are essential for a number of reasons. Firstly, they provide an opportunity to rehearse evacuation procedures to ensure that all personnel are familiar with them. Because everyone will know what to do in a real-life emergency, there won't be as much panic because the staff will leave the building swiftly. Fire drills are also useful for evaluating the effectiveness of escape routes.

It is also possible to verify that emergency exits are operational and alarm systems are functioning correctly during fire drills. In general, fire drills improve safety by preparing you for the best possible outcome in the event of a real fire. Two fire drills should ideally occur each year, though this can vary depending on the workplace and after reviewing the risk assessment of the company. If any employees work shifts, appropriate arrangements should be made to guarantee that every employee participates in a fire drill annually and receives training on how to handle emergency situations.

There are justifications for and against informing the public in advance of fire drills. Some claim that keeping employees in the dark adds a sense of surprise and makes them approach drills with greater sincerity. In a real fire, on the other hand, this could also have the opposite effect, as people might assume it's merely a drill after hearing the alarm. The advantage of informing all employees ahead of time about fire drills is that, at first, they won't become alarmed, preventing any injuries that might result from a hasty departure from the building. In addition, in the event that the alarm goes off without any prior notice, everyone will know it's a drill and react appropriately. In public places such as shopping centres, it is prudent to make members of the public alert when a drill is about to happen. The symbol for this alert is shown below in Figure 1.10.

Fig. 1.10: drill alert

1.4 Importance of safe working practices

There are millions of bacteria and viruses in the environment in which we live. Additionally, these microorganisms may use our bodies as a breeding ground. They proliferate, spread, and give rise to numerous illnesses that can occasionally be lethal to people. Each year, these microorganisms that cause disease claim the lives of over 17 million people. We can all experience amazing changes with a few easy tricks and small adjustments to our basic personal hygiene routines. If we practice good hygiene every day, we can avoid getting these diseases.

1.5 Importance of Social Distancing

Preventing communicable diseases

All these above practices will help us to prevent communicable diseases. These diseases are highly infectious and contagious and spread through air, urine, faces, saliva, skin (through touch) and using the same towels and utensils.

Social Distancing and isolation, Self-Quarantine

Ever since the spread of the pandemic covid-19, several health organisations have been insisting on following social distancing and isolation. Communicable diseases mainly spread through coming close to the infected individual and through physical touch. If a person is infected with diseases like normal flu or cold and spreads it to others, the symptoms may remain with the infected person for a day or two. The virus may be destroyed by taking an antibiotic. But in severe cases like coronavirus the infection is severe and can prove fatal to the affected people. To prevent the spread of the virus, the entire world adopted lock down, ***social distancing*** and compulsory face masks. And the infected person has to be in ***self isolation*** and ***quarantine*** till the time the symptoms are over. This was the advisory from the World Health Organisation, and the entire world followed it to prevent the rapid spread of the virus. The same can be applicable to all types of communicable diseases that are spread mainly through air and touch.

Anybody who is infected with a contagious disease needs to practice isolation in order to prevent the spread of the germs to their near and dear ones. This became very popular and was strictly adhered to during the covid-19 pandemic. People who were confirmed to have COVID-19, **isolation** was mandatory. Isolation is a health care term that means keeping people who are infected with a contagious illness away from those who are not infected. Isolation can take place at home or at a hospital or care facility. Special personal protective equipment will be used to care for these patients in health care settings. They are attended by well trained nurses and specialized doctors. And these people have to be in the PPE kits all through their presence in the hospital.

Fig.1.11: Complete PPE Kit

Health professionals and physicians who treat patients with highly contagious diseases and who are segregated to stop the spread wear the personal protective equipment (PPE) kits It is shown in Figure 1.11. When their shift is over, they have to take it off. They have to wear it whenever they come in contact with the patient. The face mask and goggles can be reused as long as they are properly sanitized, but the majority of PPE components are meant to be used only once. PPE kits must be disposed of carefully because they may contain contaminants that are stuck to them and, if improperly disposed of, could infect a healthy person. The risk of contracting the illness may be higher for healthcare professionals.

1.6 Safe Workplace Practices

Every company has the provision of a first aid box. As you have already read about the types of injuries that technicians can receive in their field of work, it is imperative for the companies to have appropriate first aid accessories. It shown in Figure 1.12. The basic first aid supplies and accessories that a first aid box should have are:

Fig. 1.12: First aid box contents

1.7 Methods of Reporting Safety Hazards

Every organization, from every industry, has a standard reporting protocol, comprising the details of people in the reporting hierarchy as well as the guidelines to be followed to report emergencies. However, the structure of this reporting hierarchy varies between organizations, but the basic purpose behind the reporting procedure remains the same.

The general highlights of the Organizational Reporting Protocol, commonly known as the 6Cs, are:

1. Communicate First – The first source of information during an emergency is the preferred source. Crises situations are time-bound and hence it is important to communicate promptly.

2. Communicate Rightly – Distortion of information due to panic must be avoided. Proper, accurate information must be provided to concerned authorities and this can save lives.

Communicate Credibly – Integrity and truthfulness must never be forgotten during emergencies.

Communicate empathetically – One must wear the shoes of the victims while communicating emergencies.

Communicate to instigate appropriate action – Communicating to the right authorities helps in taking the necessary action.

Communicate to promote respect – Communicating with the victims with respect helps in earning their trust and thus eases the disaster management process.

It is shown in Figure 1.13 hazard matrix. Hazards and potential risks / threats can be identified and then reported to supervisors or other authorized persons in the following ways:

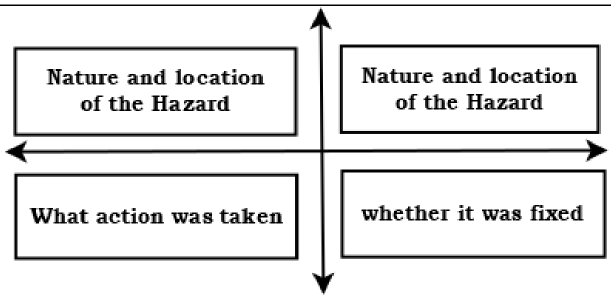


Fig. 1.13: Describing hazard matrix

Part A: To be completed by the Worker Details Required:

1. Name of Worker
2. Designation
3. Date of filling up the form
4. Time of incident / accident
5. Supervisor / Manager Name
6. Work Location / Address
7. Description of the hazard / what happened (Includes area, task, equipment, tools and people involved)
8. Possible solutions to prevent recurrence (Suggestions)

Part B: To be completed by the Supervisor / Manager Details Required:

Results of Investigation (Comment on if the hazard is severe enough to cause an injury and mention the causes of the incident / accident)

Part C: To be completed by the Supervisor / Manager Details Required:

Actions taken / Measures adopted (Identify and devise actions to prevent further injury, illness and casualty).

The reporting format is shown in following table 1.2.

Table 1.2: list of actions taken

Action	***Responsibility***	***Completion Date***

Any job role and any occupation in this world have some hazards, in varying severity, associated with it. These are called Occupational Hazards. Occupational Hazard can be defined as "a risk accepted as a consequence of a particular occupation". According to the Collins English Dictionary, it is defined as "something unpleasant that one may suffer or experience as a result of doing his or her job". Occupational Hazards report form is shown in the *Table 1.3*.

Table 1.3: Hazards Report Form

Hazard Report Form	
Name:	Date:
Location:	
Tool/Equipment: Description of the hazards:	

Suggested corrective action:	
Signature:	
Supervisors remarks	
Corrective action taken:	
Signature of Supervisors	Date:

Activities

Practical Activity 1.1. Workplace Safety Inspection to familiarize with potential hazards and safety measures in a workplace.

Step 1. Choose a workplace setting (e.g., office, workshop, construction site).

Step 2. Walk through the chosen setting and identify potential hazards (e.g., tripping hazards, unsafe equipment).

Step 3. Document the identified hazards along with suggested preventive measures.

Step 4. Discuss findings with colleagues or supervisors.

Practical Activity 1.2. Practice first aid techniques for common injuries.

Step 1. Select a specific injury scenario (e.g., cut, burn, broken bone).

Step 2. Simulate the scenario using props or role-play with a partner.

Step 3. Apply appropriate first aid techniques based on the provided guidelines.

Step 4. Evaluate the effectiveness of the applied first aid.

Practical Activity 1.3. Practice reporting safety hazards using a standardized reporting form.

Step 1. Review the provided Hazard Report Form given in the chapter.

Step 2. Choose a hypothetical workplace scenario with a safety hazard.

Step 3. Complete the Hazard Report Form (Parts A, B, and C) based on the chosen scenario.

Step 4. Discuss the identified hazard and proposed preventive measures with a peer or supervisor.

Practical Activity 1.4. Analyze different types of hazards and assess their associated risks.

Step 1. Review the list of hazards given in the chapter.

Step 2. Select a specific hazard (e.g., chemical exposure, ergonomic strain).

Step 3. Conduct a risk assessment for the chosen hazard, considering severity and likelihood.

Step 4. Propose appropriate preventive measures for the identified hazard.

Summary

This chapter emphasizes the critical importance of workplace safety and compliance with legal regulations. It covers key elements of a comprehensive health and safety policy, including practical measures like ergonomic equipment and emergency preparedness. The chapter also provides guidance on employee precautions and first aid techniques for various situations. Additionally, it highlights the significance of fire drills and personal hygiene practices in preventing the spread of communicable diseases.

CHECK YOUR PROGRESS

A. Multiple choice questions

1. What is the primary emphasis of the chapter on "Workplace Health and Safety Practices"? (a) Employee benefits (b) Legal obligations and safety compliance (c) Business profitability (d) Workplace aesthetics
2. Which of the following is NOT mentioned as a practical consideration for businesses in ensuring workplace safety? (a) Use of ergonomic furniture and equipment (b) Providing mechanical support for heavy objects (c) Stocking up on safety equipment for risky jobs (d) Maximizing office aesthetics
3. According to the chapter, what should employees do in case of unsafe conditions at the workplace? (a) Ignore them and continue working (b) Notify the supervisor right away (c) Wait until the end of the day to report them (d) Document them for personal reference
4. What is the purpose of a workplace health and safety policy? (a) To set the highest standards for worker safety and conditions (b) To maximize business profits (c) To control employee behavior (d) To ensure compliance with taxation regulations
5. What is the significance of fire drills, according to the chapter? (a) To evaluate the effectiveness of escape routes (b) To test the fire alarm system (c) To improve workplace aesthetics (d) To assess employee performance
6. In the context of preventing the spread of communicable diseases, what is the role of personal hygiene practices, as mentioned in the chapter? (a) They have no impact on disease prevention (b) They play a crucial role in preventing diseases (c) They are only relevant during flu seasons (d) They are primarily for cosmetic purposes
7. According to the chapter, what is the primary purpose of reporting safety hazards? (a) To assign blame for incidents (b) To document incidents for legal purposes (c) To prevent future occurrences and ensure safety (d) To increase insurance premiums
8. What is the primary purpose of providing mechanical support to employees for lifting heavy objects? (a) To encourage regular exercise (b) To minimize the risk of injuries from lifting (c) To improve workplace aesthetics (d) To reduce the need for physical exertion
9. What is the recommended action if blood soaks through the material used to apply direct pressure on a wound? (a) Remove the material immediately (b) Add more material and continue applying pressure (c) Leave the material in place and add more on top (d) Wash the wound with soap and water
10. What does the RICE therapy stand for in the context of injuries? (a) Rest, Ice, Compression, Elevation (b) Run, Inhale, Cover, Exhale (c) Roll, Inflate, Check, elevate (d) Reduce, Instruct, Cover, Evaluate

B. Fill in the blanks

1. Use furniture and equipment with ergonomic designs to avoid ____________ and twisting.
2. Make sure the ____________ exits are present and in a handy location.
3. In case of a clean cut or wound, direct pressure must be applied until ____________ stops.
4. Antiseptic cream or solution must be applied to the wound to reduce the risk of ____________.
5. In case the victim's breathing has stopped, give ____________
6. Clear passageways to all escape routes, signage indicating escape routes, and enough exits are essential for a smooth ____________.
7. According to the chapter, personal hygiene practices play a crucial role in preventing ____________ diseases.
8. The purpose of a hazard report form is to identify and report safety hazards for ____________ action.
9. Using ____________ equipment is recommended to prevent accidents and injuries at work.
10. The acronym FAST stands for Face, Arms, Speech, ____________ in the context of stroke assessment.

C. State true or False for the following

1. Hydrogen peroxide or iodine should be used to clean and treat wounds, as they help in preventing infection.
2. In case of a broken bone protruding through the skin, it is recommended to push the bone back into place.
3. Using insulated equipment, wearing protective clothing, and ensuring ample ventilation are important preventive actions for chemical hazards.
4. Personal protective equipment (PPE) kits should be disposed of carefully to prevent potential contamination.
5. Social distancing and isolation are important practices for preventing the spread of communicable diseases, especially during a pandemic.
6. Reporting safety hazards is essential for preventing future incidents and ensuring workplace safety.
7. Occupational hazards refer to risks accepted as a consequence of a particular occupation.
8. Providing clear passageways, signage, and sufficient exits are not essential for a smooth evacuation during an emergency.
9. The purpose of a hazard report form is to assign blame for incidents and accidents in the workplace.
10. In the context of first aid, a tourniquet should be applied immediately to stop any bleeding, regardless of its severity.

D. Short Answer Type Questions

1. What are some of the considerations mentioned for businesses when it comes to ensuring workplace safety?

2. How to protect a clean cut or wound?
3. What are the three forms of exposure in case of chemical hazards?
4. What are some essential actions mentioned for providing first aid in case of exposure to toxic materials?
5. Why are fire drills considered important in a workplace or public setting?
6. What are the benefits of informing employees in advance about fire drills, according to the chapter?
7. Why is it important to practice social distancing and isolation during a pandemic or outbreak of a contagious disease?
8. What is the purpose of a hazard report form, and how does it contribute to workplace safety?
9. What are occupational hazards, and why is it important for individuals to be aware of them?
10. Why is it essential to have clear passageways, signage, and sufficient exits for a smooth evacuation during an emergency?

Session 2: Waste Management and Green Practices

2.1 Waste Management

2.1.1 E-Waste

Electrical and electronic products are all around us. We can't imagine a world without these gadgets. Our life is indispensable without electricity and electronic devices. Growth in the IT and communication sectors has increased the usage of electronic equipment immensely. Frequent change on the technological features of electronic products is forcing consumers to discard their old electronic products very quickly, which, in turn, adds to e-waste to the solid waste pool. What this translates to is mountainous masses of electrical and electronic waste which has a high potential to pollute the environment. This growing menace of e-waste calls for a greater focus on recycling e-waste and better e-waste management.

E-waste means electrical and electronic equipment, whole or in part discarded as waste by the consumer or bulk consumer as well as rejects from manufacturing, refurbishment, and repair processes. E-waste usually is made up of usable and non-usable material. Some of the waste if left unattended will be destructive to the environment. E-waste is made up of hazardous substances like lead, mercury, toxic material, and gases.

There are many companies these days who are engaged in the collection, handling, and disposal of this e-waste in a safer and more secure place to protect the environment.

The amount of e-wastes comprising computers and computer parts, electronic devices, mobile phones, entertainment electronics, refrigerators, microwaves, TV, fridges, and industrial electronics that are obsolete or that have become unserviceable is growing. All these electronic devices contain plastics, ceramics, glass, and metals such as copper, lead, beryllium, cadmium, and mercury and all these metals are harmful to humans, animals, and the earth. Improper disposal only leads to poisoning the Earth and water and therefore all life forms. Our effort is meant to preserve the environment and prevent pollution by proper handling of e-waste. While it will take a lot of effort to educate people to dispose of such wastes in the right way, we are doing our part by providing a channel to collect e-wastes and dispose of them in a sustainably safe manner. We convert waste to usable resources. The electronic industry is not only the world's largest industry but also a fast-growing manufacturing industry. It has been instrumental in the socio-economic and technological growth of the developing society of India.

At the same time, it poses a major threat in the form of e-waste or electronics waste which is causing harmful effects on the whole nation. e-waste is creating a new challenge to the already suffering Solid waste management, which is already a critical task in India.

Electronic goods/gadgets are classified under three major heads:

1. White goods: Household appliances,
2. Brown goods: TVs, camcorders, cameras etc.,
3. Grey goods: Computers, printers, fax machines, scanners etc. The complete process is carried out as per the government guidelines.

2.1.2 E-waste Management Process

1. Collection of e-waste from all the electronic stores, manufacturing companies, etc.
2. Transport of e-waste to the disposal units
3. Segregation of e-waste at the disposal unit
4. Manual dismantling of e-waste to segregate components into various types such as metal, plastics and ceramics
5. Convert into raw material (recycle and reuse)
6. Supply recovered raw material to processors and electrical/electronic industries
7. Dispatch hazardous e-waste for safe disposal
8. Waste management is carried out to ensure that all types of waste and garbage are collected, transported, and disposed of properly. It also includes recycling waste so that it can be used again.
9. The basic waste management hierarchy is shown below in Figure 2.1.

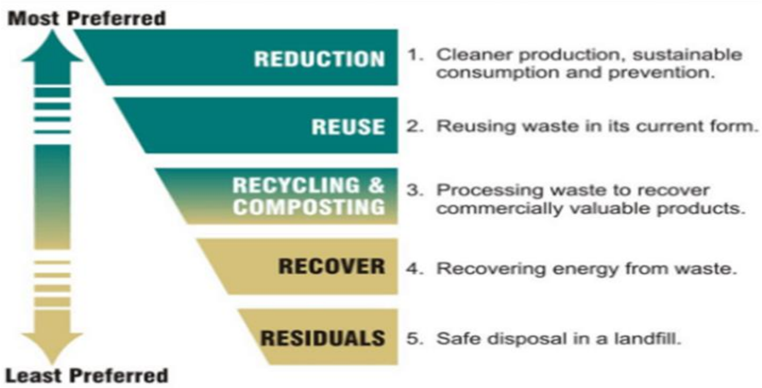


Fig. 2.1: e-waste Management Process

2.2 Recyclable and Non-Recyclable waste

Recyclable waste is renewable or can be reused. This means that the waste product is converted into new products or raw materials, like paper, corrugated cardboard (OCC), glass, plastic containers and bags, hard plastic, metal, wood products, e-waste, textile, etc. Recycling not only conserves important areas in our landfills but also assists decrease greenhouse gas emissions. Contrary to this,

Non-recyclable waste cannot be recycled and cause a major threat to the environment. The following items cannot be recycled: Shredded paper, aerosol cans, paper coffee cups, milk and juice cans, used baby diapers, and bottle caps.

Recycling is one of the best ways to have a favorable influence on the world where we live. Recycling will greatly help us to save both the environment and humans from pollution. If we take immediate action, we can control this, as the quantity of waste we are accumulating is increasing all the time.

2.3 Color codes of waste collecting bins

India's urban population of 429 million citizens produce a whopping 62 million tons of garbage every year. Out of this, 4.6 million tons is plastic waste, 0.17 million tons is biomedical waste, 7.90 million tons is hazardous waste and 15 lakh tons is e-waste.

According to an estimate, 40% of municipal waste in the city is 'wet' waste, which can easily be composted and used as manure. Nearly 30% of the municipal waste comprises plastic and metal, which can be sent to an authorized dealer for recycling, and about 20% of it is e-waste, from which precious metals can be taken apart and recycled. However, out of the total municipal waste collected, 94% is dumped on land and only 5% is composted. To gather the garbage two colour bin systems were suggested. Green bin for wet waste and blue for dry waste. However, there is a drawback in that system. People go through the sanitary napkins and children's diapers along with wet waste causing contamination of things. Hence the government has come up with three colored garbage collection bins.

1. Green Bin – The green colored bin is used to dump biodegradable waste. This bin could be used to dispose of wet/organic material including cooked food/leftover food, vegetable/fruit peels, egg shell, rotten eggs, chicken/fish bones, tea bags/coffee grinds, coconut shells and garden waste including fallen leaves/twigs or the puja flowers/garlands will all go into the green bin.

2. Blue bin – The blue colored bin is used for segregating dry or recyclable left over. This category includes waste like plastic covers, bottles, boxes, cups, toffee wrappers, soap or chocolate wrapper and paper waste including magazines, newspapers, tetra packs, cardboard cartons, pizza boxes or paper cups/plates will have to be thrown into the white bin. Metallic items like tins/cans foil paper and containers and even the dry waste including cosmetics, hair, rubber/thermocol (polystyrene), old mops/dusters/sponges.

3.Black bin – Black bin, make up for the third category, which is used for domestic hazardous waste like sanitary napkins, diapers, blades, bandages, CFL, tube light, printer cartridges, broken thermometer, batteries, button cells, expired medicine etc. These three colored bins are shown in Figure 2.2.

Fig. 2.2: Tri Colored Bins

2.4 Waste disposal methods

***Incineration* –** Combusting waste in a controlled manner to minimize incombustible matter like waste gas and ash.

***Waste Compaction* –** Waste materials are compacted in blocks and are further sent way for recycling.

***Landfill* –** Waste that can't be recycled or reused can be thinly spread out in the low-lying areas of the city.

***Composting* –** Decay of organic material over time by microorganisms.

***Biogas Generation* –** With the help of fungi, bacteria, and microbes, biodegradable waste is converted to biogas in bio-degradation plants.

***Vermicomposting* –** Transforming the organic waste into nutrient-rich manure by degradation through worms.

2.5 Sources of Waste

Construction waste– waste coming from construction or demolition of buildings.

***Commercial waste* –** Waste from commercial enterprises.

***Household waste* –** Garbage from households is either organic or inorganic.

Medical or clinical waste-wastes from the medical facilities- like used needles and syringes, surgical wastes, blood, wound dressing.

***Agricultural waste* –** Waste generated by agricultural activities that include empty pesticide containers, old silage packages, obsolete medicines, used tires, extra milk, cocoa pods, wheat husks, chemical fertilizers, etc.

***Industrial waste* –** The waste from manufacturing and processing industries like cement plants, chemical plants, textile, and power plants

Electronic waste-The defective, non-working electronic appliances are referred to as electronic waste. These are also called e-waste. Some e-waste (such as televisions) contains lead, mercury, and cadmium, which are harmful to humans and the environment.

***Mining waste* –** Chemical gases emitted in mine blasting pollutes the environment. And the mining activity greatly alters the environment and nature.

***Chemical waste* –** Wste from the chemical substance is called chemical waste.

***Radioactive waste* –** Radioactive waste includes nuclear reactors, extraction of radioactive materials, and atomic explosions.

2.6 Sources of Pollution

All the waste above mentioned also adds to environmental pollution. The contaminants that cause detrimental change to the environment are called pollution. It is one of the most serious problems faced by humanity and other life forms on our planet. The earth's physical and biological components have been affected to such an extent that normal environmental processes could not be carried out properly.

2.7 Types of Pollution

Pollution Type	***Detail/Pollutants involved***
Air pollution	Solid particles and gases mixed in the air cause air pollution. Pollutants: emissions from the car, factories emitting chemical, dust, and pollen.
Water pollution	Water gets polluted when toxic substances enter water bodies such as lakes, rivers, oceans, and so on. They get dissolved in it and cause it to be unfit for consumption. Pollutants that contaminate the water are discharges of untreated sewage, and chemical contaminants, release of waste and contaminants into the surface.
Soil pollution	It is the presence of toxic chemicals (pollutants or contaminants) in soil, in high enough concentrations to pose a risk to human health and/or the ecosystem Sources of soil pollution include metals, inorganic ions, and salts (e.g. phosphates, carbonates, sulfates, nitrates)
Noise pollution	Noise pollution happens when the sound coming from planes, industry or other sources reaches harmful levels Underwater noise pollution coming from ships has been shown to upset whales' navigation systems and kill other species that depend on the natural underwater world
Light pollution	Light pollution is the excess amount of light in the night sky. Light pollution, also called photo pollution, is almost always found in urban areas. Light pollution can disrupt ecosystems by confusing the distinction between night and day.

2.8 Organization's focus on the Greening of Jobs

2.8.1 ESG

1. The ESG is the short form of environmental, social, and governance. ESG guidelines are used to evaluate businesses on how well they control emissions, governance, human rights, and other factors of their business.
2. Several companies audit these companies for ESG compliance. They will let the companies know how well the ESG policies are implemented in their company hat let companies know how well their ESG policy is working.
3. Every business enterprise is deeply intertwined with Environmental, Social, and Governance (ESG) issues. ESG has been looked at seriously by the corporate, government establishments and stakeholders.

4. ESG is important as it creates high value, drives long-term returns, and global stakeholders are paying attention to the topic.
5. ESG is said to have created high value, and focuses on long-term returns, and stakeholders are focusing more on this concept.

2.8.2 Factors of ESG

Several factors are used to determine how well a business is doing in maintaining its ESG policies. For creating the ESG Policy, thorough knowledge of these factors is critical.

The factors are divided into three categories; environmental, social, and governance. Knowing about these factors come a long way in designing the effective ESG policy.

Environmental

Environmental factors relate to a business's impact on the environment. Examples include:

1. Usage of renewable energy
2. Effective waste management
3. Policies for protecting and preserving the environment

Social

Social factors relate to the people of the organization. How they are treated in the organization is what it focuses on. The major entities are the stakeholders, employees, and customers. Examples include:

1. Diversity and inclusion
2. Proper work conditions and labour standards
3. Relationships with the community

Governance

Governance factors relate to the company policies for effectively running it. They include:

1. Tax strategies
2. Structure of the company
3. Relationship with stakeholders
4. Payments to the employees and CEO

Every factor is important and matters a lot to the overall rating of the company in ESG compliance. Ignoring one aspect in favour of another can affect the rating and in turn the reputation of the company.

The companies make a clear communication about these policies to all the employees, and to the public, they should mention what their various activities are that will protect the environment, people, and the governing factors.

Activities

Practical Activity 1. Raise awareness about proper e-waste disposal.

Step 1. Workshops: Educate employees on e-waste dangers and recycling benefits.

Step 2. Posters: Display informative posters on e-waste in the workplace.

Step 3. Collection Drive: Set up collection points for old electronic devices.

Step 4. Partner with Recyclers: Collaborate with certified e-waste recycling companies.

Step 5. Progress Tracking: Keep records and share e-waste collection progress.

Practical Activity 2. Educate employees on waste segregation.

Step 1. Educational Materials: Provide pamphlets on recyclable waste.

Step 2. Game: Have employees categorize waste into recyclable and non-recyclable.

Step 3. Discussion: Discuss the importance of waste segregation.

Step 4. Proper Bins: Label bins for recyclable and non-recyclable waste.

Practical Activity 3. Familiarize employees with the tricolored bin system.

Step 1. Information Session: Explain green, blue, and black bins.

Step 2. Interactive Quiz: Test knowledge of bin usage.

Step 3. Bin Labeling: Ensure bins are labeled correctly.

Step 4. Role Play: Demonstrate proper waste disposal.

Summary

The chapter focuses on green practices in organizations. It highlights e-waste management, introduces a tri-colored bin system for waste collection, and explains various disposal methods. It identifies sources of waste and discusses types of pollution. The chapter emphasizes the adoption of ESG guidelines for environmental, social, and governance considerations. Overall, it underscores the importance of sustainable practices for both organizations and the environment.

CHECK YOUR PROGRESS

A. Multiple Choice Questions

1. What is e-waste? (a) Waste from construction activities (b) Electrical and electronic equipment discarded as waste (c) Biodegradable waste (d) Hazardous waste from medical facilities
2. What are the three major categories of electronic goods? (a) Red goods, blue goods, green goods (b) White goods, brown goods, grey goods (c) Recyclable goods, non-recyclable goods, hazardous goods (d) Electronic, electrical, and industrial goods
3. What is the purpose of the tricolored bin system in waste collection? (a) To create a visual appeal for waste bins (b) To confuse people about waste segregation (c) To improve the segregation of different types of waste (d) To reduce the number of waste bins needed
4. What is one of the methods mentioned for waste disposal? (a) Exporting waste to other countries (b) Throwing waste in rivers and lakes (c) Incineration to minimize waste gas and ash (d) Leaving waste in open areas for natural decomposition
5. What does ESG stand for in the context of organizations? (a) Environmental, Social, and Governance (b) Energy, Sustainability, and Growth (c) Efficiency, Safety, and Governance (d) Ecology, Standards, and Growth
6. Which factor is NOT part of the ESG framework for evaluating businesses? (a) Environmental (b) Social (c) Governmental (d) Governance

7. What is the significance of ESG compliance for businesses? (a) It has no impact on the business's reputation (b) It creates high value and drives long-term returns (c) It only matters to government agencies (d) It is only relevant for large corporations
8. What are some examples of environmental factors in ESG evaluation? (a) Diversity and inclusion (b) Effective waste management (c) Proper work conditions (d) Relationships with the community
9. Why is proper waste management important for the environment? (a) It creates more job opportunities (b) It conserves important areas in landfills and reduces greenhouse gas emissions (c) It increases pollution levels (d) It has no significant impact on the environment
10. What percentage of municipal waste in India is categorized as 'wet' waste? (a) 40% (b) 30% (c) 20% (d) 10%

B. Fill in the blanks

1. The tricolored bin system in waste collection includes green bin for biodegradable waste, blue bin for dry or recyclable waste, and black bin for domestic ____________ waste.
2. Ignoring one aspect of ESG compliance in favour of another can affect the company's ____________ and reputation.
3. Effective waste management is an example of an ____________ factor in ESG evaluation.
4. Recyclable waste can be converted into new products or raw material, while non-recyclable waste cannot be ____________.
5. India's urban population of 429 million citizens produces a __________of garbage every year.
6. E-waste contains hazardous substances like lead, mercury, and ____________.
7. Light pollution is the __________ in the night sky.
8. The blue colored bin is used for _____________.
9. Waste management is carried out to ensure that all types of waste and garbage are collected, transported, and _________.
10. The contaminants that cause detrimental change to the environment are called ___.

C. State true or False for the following

1. Recycling helps conserve space in landfills and reduces greenhouse gas emissions.
2. The black bin is used for disposing of biodegradable waste.
3. Composting is a method of waste disposal that involves the decay of organic material over time by microorganisms.
4. ESG factors include environmental, social, and geological considerations.
5. ESG compliance is important for creating high value and driving long-term returns.
6. Social factors in ESG focus on how people within the organization are treated.
7. Governance factors in ESG pertain to how a company is effectively run, including tax strategies and stakeholder relationships.
8. Soil pollution is caused by the presence of toxic chemicals in soil at low concentrations.
9. Non-recyclable waste can be converted into new products or raw materials.

10. Landfills are used for waste that cannot be recycled or reused.

D. Short Answer Type Questions

1. What is e-waste, and why is it a growing concern for the environment?
2. Explain the process of e-waste management.
3. What is the purpose of using tri colored bins for waste collection?
4. Name three types of recyclable waste and explain why recycling is important.
5. Describe the factors used to evaluate a business's ESG compliance.
6. What is the impact of soil pollution on human health and ecosystems?
7. How does composting contribute to waste management?
8. What are the sources of electronic waste mentioned in the chapter?
9. What are the different methods of waste disposal mentioned in the chapter?
10. Why is it important to properly segregate waste into recyclable and non-recyclable categories?

Glossary

Appliance: A machine or device designed to perform specific household tasks, such as washing, cooking, or heating.
Circuit: A complete path that allows electricity to flow, consisting of a power source, conductors, and a load (the appliance).
Troubleshooting: The process of identifying and resolving issues or malfunctions in appliances and electrical systems.
Voltage: The measure of electric potential difference between two points in a circuit, expressed in volts (V); it drives the flow of current.
Current: The flow of electric charge in a circuit, measured in amperes (A), indicating how much electricity is flowing through a conductor.
Wattage: A measure of electrical power consumption, indicating how much energy an appliance uses, expressed in watts (W).
Fuse: A safety device that protects electrical circuits from overloads by melting and breaking the circuit when excessive current flows.
Thermostat: A device that regulates temperature by controlling heating or cooling systems, maintaining a set temperature range.
Insulation: Material used to prevent the loss of heat or the passage of electricity, ensuring safety and energy efficiency in appliances.
Maintenance: Regular actions taken to keep appliances in good working order, including cleaning, inspections, and repairs.
Short Circuit: An abnormal connection in an electrical circuit that allows current to flow along an unintended path, potentially causing damage or fires.
Grounding: A safety measure that involves connecting electrical systems to the earth, preventing electric shocks and equipment damage.
Energy Efficiency: The ability of an appliance to use less energy to perform the same task, often measured by energy ratings.
Capacitor: An electronic component that stores electrical energy temporarily and releases it when needed, commonly used in motors and power supplies.
Multimeter: A versatile instrument used to measure voltage, current, and resistance in electrical circuits, essential for troubleshooting.

Answer

Module 1: Fundamentals of Electrical and Electronics

Session 1: Roles and Responsibilities of Junior Field Technician

A. Multiple Choice Questions

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

B. Fill in the Blanks

1. electronic devices 2. circuit boards 3. 4.8% 4. troubleshooting 5. non- commercial use 6. revenue and productivity 7. high output and ultralow latency 8. 40% more 9. manufacturing process 10. type of equipment

C. State whether True or False

1. (F) 2. (T) 3. (F) 4. (T) 5. (T) 6. (F) 7. (F) 8. (F) 9. (T) 10. (F)

Session 2: Basics of Electrical Circuits

A. Multiple Choice Questions

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

B. Fill in the blanks

1. electrical components 2. entire path 3. the same 4. units of volts 5. electric charge 6. direct current (DC) 7. power 8. source of energy 9. Ohm's law 10. flow of current

C. State whether True or False

1. (F) 2. (T) 3. (T) 4. (F) 5. (T) 6. (F) 7. (F) 8. (F) 9. (T) 10. (T)

Session 3: Basics of Electronics Circuits

A. Multiple Choice Questions

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

B. Fill in the blanks

1. Ohm 2. Passive two-terminal devices 3. resistance value 4. regulate current flow 5. Insulator 6. electric current 7. restricts it in the other 8. Light 9. switch electronic signals 10. silicon

C. State whether True or False

1. (F) 2. (F) 3. (T) 4. (T) 5. (T) 6. (F) 7. (F) 8. (F) 9. (F) 10. (T)

Session 4: Tools, Equipment and Measuring Instruments

A. Multiple Choice Questions

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

B. Fill in the blanks

1. accuracy and proper use 2. cutting pliers and gripping pliers 3. present value of the quantity 4. watt meter 5. voltage, current, and resistance 6. a simple digital multimeter 7. higher range 8. de-energize 9. insulated tools 10. proper lifting techniques

C. State whether True or False

1. (T) 2. (T) 3. (T) 4. (T) 5. (T) 6. (T) 7. (T) 8. (F) 9. (T) 10. (T)

Module 2: Installation and Repairing of LED Light

Session 1: Basics of LED Light

A. Multiple Choice Questions

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

B. Fill in the blanks

1. electrical current 2. tungsten filament 3. electromagnetic radiation 4. Three 5. Photons are released as a result of 6. red, green, yellow, or blue 7. improve 8. greater than 80 9. warm white, natural white and cool white 10. passive thermal designs

C. State whether True or False

1. (F) 2. (T) 3. (T) 4. (F) 5. (F) 6. (T) 7. (T) 8. (T) 9. (T) 10. (T)

Session 2: Installation of LED Light

A. Multiple Choice Questions

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

B. Fill in the Blanks

1. thermal paste 2. of clips 3. light engine 4. solid particles 5. voltage fluctuations 6. LED module 7. Aluminium 8. early failures 9. softens and distributes the light 10. Dimming.

C. State whether True or False

1. (T) 2. (F) 3. (T) 4. (T) 5. (T) 6. (F) 7. (T) 8. (T) 9. (F) 10. (T)

Session 3: Troubleshooting and Repairing of LED

A. Multiple Choice Questions

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

B. Fill in the Blanks

1. identifying and addressing 2. Higher 3. high voltage or current 4. Reversely 5. white LEDs 6. outdoor applications 7. Heat sink failure 8. Electrolytic 9. non-functional 10. fault diagnosing

C. State whether True or False

1. (F) 2. (F) 3. (F) 4. (F) 5. (T) 6. (F) 7. (F) 8. (F) 9. (T) 10. (F)

Module 3: Occupational Health and Safety Standards

Session 1: Workplace Health and Safety Practices

A. Multiple Choice Questions

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

B. Fill in the blanks

1. bending 2. Emergency 3. Bleeding 4. Infection 5. CPR 6. Evacuation 7. Communicable 8. Preventive 9. Insulated 10. Time

C. State true or False for the following

1. (T) 2. (F) 3. (T) 4. (T) 5. (T) 6. (T) 7. (T) 8. (F) 9. (F) 10. (F)

Session 2: Waste Management and Green Practices

A. Multiple Choice Questions

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

B. Fill in the blanks

1. hazardous 2. the rating 3. Environmental 4. cannot be converted 5. 62 million tonnes 6. Cadmium 7. excess amount of light 8. segregating dry or recyclable left over 9. disposed of properly 10. pollution

C. State true or False for the following

1. (T) 2. (F) 3. (T) 4. (F) 5. (T) 6. (T) 7. (T) 8. (F) 9. (F) 10. (T)