



Participant Handbook

Sector
Electronics

Sub-Sector
Industrial Automation

Occupation
**Assembly And System
Integration**

Reference ID: **ELE/Q5804, Version 1.0**
NSQF Level 4



Electrician

Published by

Electronics Sector Skills Council of India (ESSCI)

155, 2nd Floor, ESC House, Okhla Industrial Area-Phase 3, New Delhi- 110020, India

Email: info@essc-india.org

Website: www.essc-india.org

Phone: +91 8447738501

All Rights Reserved ©2022

First Edition, November 2022

Copyright © 2022

Electronics Sector Skills Council of India (ESSCI)

155, 2nd Floor, ESC House, Okhla Industrial Area-Phase 3, New Delhi- 110020, India

Email: info@essc-india.org

Website: www.essc-india.org

Phone: +91 8447738501

This book is sponsored by Electronics Sector Skills Council of India (ESSCI)

Under Creative Commons Licence: CC-BY-SA

Attribution-ShareAlike: CC BY-SA



This license lets others remix, tweak, and build upon your work even for commercial purposes, as long as they credit you and license their new creation under the identical terms. This license is often compared to “copyleft” free and open source software licenses. All new works based on yours will carry the same license, so many derivatives will also allow commercial use. This is the license used by Wikipedia and is recommended for materials that would benefit from incorporating content from Wikipedia and similarly licensed projects.

Disclaimer

The information contained herein has been obtained from sources reliable to ESSCI. ESSCI disclaims all warranties to the accuracy, completeness or adequacy of such information. ESSCI shall have no liability for errors, omissions, or inadequacies, in the information contained herein, or for interpretations thereof. Every effort has been made to trace the owners of the copyright material included in the book. The publishers would be grateful for any omissions brought to their notice for acknowledgements in future editions of the book. No entity in ESSCI shall be responsible for any loss whatsoever, sustained by any person who relies on this material. The material in this publication is copyrighted. No parts of this publication may be reproduced, stored or distributed in any form or by any means either on paper or electronic media, unless authorized by the ESSCI.





Shri Narendra Modi
Prime Minister of India

“ Skilling is building a better India.
If we have to move India towards
development then Skill Development
should be our mission. ”



Certificate
COMPLIANCE TO
QUALIFICATION PACK - NATIONAL OCCUPATIONAL
STANDARDS

is hereby issued by the
Electronics Sector Skills Council of India
for
SKILLING CONTENT : PARTICIPANT HANDBOOK

Complying to National Occupational Standards of
Job Role/ Qualification Pack: ' "Electrician" ' QP No. ELE/Q5804, NSQF Level 4

Date of Issuance: November 17th 2022

Valid up to*: November 17th 2025

*Valid up to the next review date of the Qualification Pack

Authorised Signatory
Electronics Sector Skills Council of India

Acknowledgements

The need for having a standard curriculum for the Job Role based Qualification Packs under the National Skills Qualification Framework was felt necessary for achieving a uniform skill based training manual in the form of a Participant Handbook.

I would like to take the opportunity to thank everyone who contributed in developing this Handbook for the QP Electrician.

The Handbook is the result of tireless pursuit to develop an effective tool for imparting the Skill Based training in the most effective manner.

The preparation of this Handbook would not have been possible without the Industry's support. Industry feedback has been extremely encouraging from inception to conclusion and it is with their input that we have tried to bridge the skill gaps existing today in the Industry. This handbook is dedicated to the aspiring youth who desire to achieve special skills which will be a lifelong asset for their future endeavours.

About this book

This Participant Handbook is designed to enable training for the specific Qualification Pack (QP). Each National Occupational (NOS) is covered across Unit/s.

This book is designed to enable a candidate to acquire skills that are required for employment. The content of this book is completely aligned to the National Occupation Standards QP/NOS and conform to the National Skills Qualification Framework (NSQF).

The Qualification pack of Electrician, Level 4 includes the following NOS's which have all been covered across the units -

Compulsory NOS:

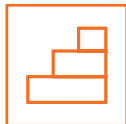
1. **ELE/N5806:** Planning, Design & Installation of electrical & electronics sub system
2. **ELE/N5805:** Testing, Commissioning, Maintenance, Fault Finding & Repair
3. **DGT/VSQ/N0102:** Employability skills
4. **ELE/N1002:** Apply health and safety practices at the workplace

Key Learning Objectives for the specific NOS mark the beginning of the Unit/s for that NOS. The symbols used in this book are described below.

Symbols Used



Key Learning
Outcomes



Steps



Exercise



Notes



Unit
Objectives

Table of Contents

S. No.	Modules and Units	Page No.
1.	Introduction to Electrician	1
	Unit 1.1 – About Electronics Industry	3
	Unit 1.2 – Basics of Electricity and Electronics	9
2.	Planning, Design and Installation (ELE/N5806)	19
	Unit 2.1 – Electrical and Electronic Circuit Diagrams	21
	Unit 2.2 – Electrical and Electronic System Components and Accessories	34
	Unit 2.3 – Tools and Measuring Instruments Required	78
	Unit 2.4 – Cable Assembly	81
	Unit 2.5 – Assembly Procedure	93
3.	Test and Commissioning (ELE/N5805)	101
	Unit 3.1 – Testing and Fault Finding	103
4.	Basic Health and Safety Practices (ELE/N1002)	125
	Unit 4.1 – Workplace Hazards	127
	Unit 4.2 – Fire Safety	139
	Unit 4.3 – First Aid	142
	Unit 4.4 – Waste Management	145



S. No.	Modules and Units	Page No.
5.	Employability Skills (60 Hours) (DGT/VSQ/N0102)	149
	Employability Skills is available at the following location: https://www.skillindiadigital.gov.in/content/list Scan the QR code below to access the eBook	
		150
6.	Annexure	151
	Lists of QR Codes used in the PH	152





1. Introduction to Electrician

Unit 1.1 – About Electronics Industry

Unit 1.2 – Basics of Electricity and Electronics



Key Learning Outcomes



At the end of this module, participants will be able to:

1. Describe about electronics industry
2. List applications of electronics industry
3. Describe trends and challenges in electronics industry
4. Describe electric circuits
5. Describe voltage, current and resistance
6. Define Ohm's law
7. Explain the difference between alternating current (AC) and direct current (DC)
8. Describe active and passive components
9. Identify colour coding in different electrical components

UNIT 1.1: About Electronics Industry

Unit Objectives



At the end of this unit, participants will be able to:

1. Describe about electronics industry
2. List applications of electronics industry
3. Describe trends and challenges in electronics industry

1.1.1 Introduction

The electronics industry is the economic 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.

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.

1.1.2 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.

- **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.

- **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.

- **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 metre for checking sugar levels, a pacemaker for dropping and increasing heartbeat count and so on.

- **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.
- **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.

1.1.3 Electronic Industry Trends and Challenges

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.

Challenges in the electronic industry

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.

Electronic Industry Trends

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.

1. **The 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.

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.

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.
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. As a result, software must meet the quality standards of the manufacturing industry.
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. As the trend of conducting online meetings and video sales calls continues, this new standard will grow even more in 2022.
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. 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.

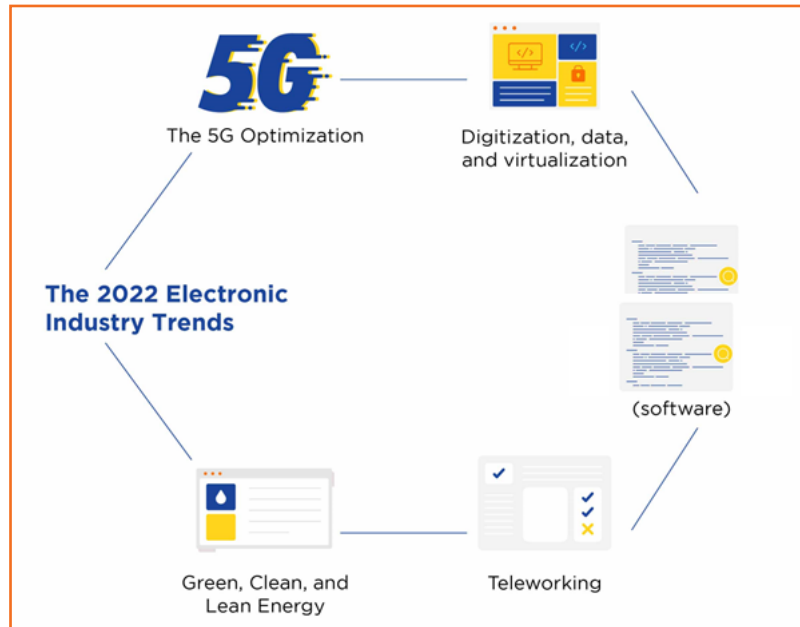


Fig 1.1.1: Trends in electronics industry

Electronics manufacturing trends for 2022

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. Startups and scaleups are developing silicon alternatives and other semiconductor materials or composites for high performance and efficiency.
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. Designing circuits with microbial components or producing devices with biodegradable and recyclable materials is seen to be the next electronics manufacturing trend.
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. 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.

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. Further, the transition to 5G-enabled devices requires flawless, innovative chips with more efficient architectures at lower costs.
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. So the designing and manufacturing sector of such systems is undergoing numerous innovations to improve performance, security, and connectivity capabilities.
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. 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, startups and scaleups are developing solutions for advanced printing technologies.
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. 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.
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. Consequently, the implementation of this electronics manufacturing trend speeds up prototyping, offers mass customization, and decentralizes parts production.

UNIT 1.2: Basics of Electricity and Electronics

Unit Objectives

At the end of this unit, participants will be able to:

1. Describe electric circuits
2. Describe voltage, current and resistance
3. Define Ohm's law
4. Explain the difference between alternating current (AC) and direct current (DC)
5. Describe active and passive components
6. Identify colour coding in different electrical components

1.2.1 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 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 1.2.1 Electric circuit constituents

An electric circuit consists of two paths/loops, as shown in the following image -

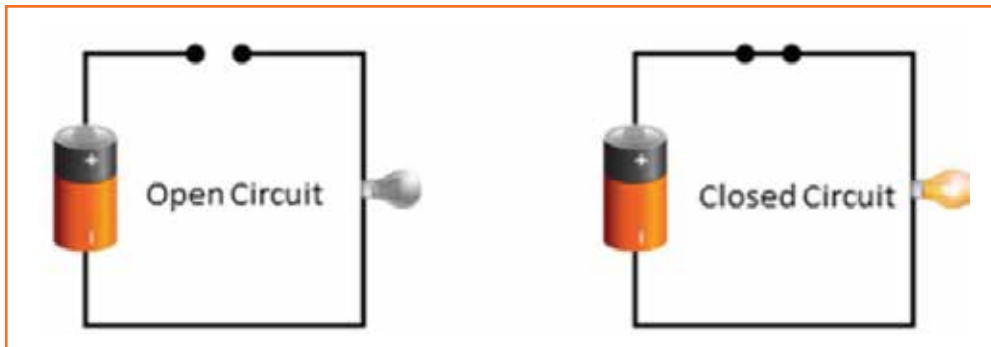


Fig 1.2.2 Closed and open path

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 image shows such an electric circuit -

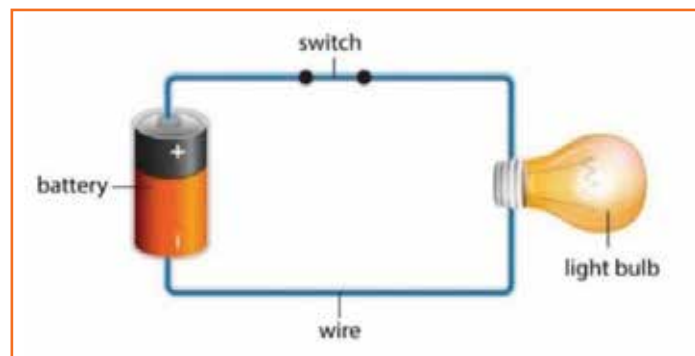


Fig 1.2.3 An electric circuit

1.2.2 Types of Electric Circuits

An electric circuit is classified into two types:

- Series circuit
- Parallel circuit

Series Circuit

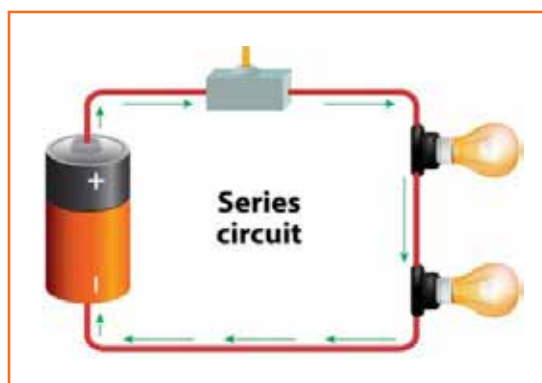


Fig 1.2.4 A series circuit

In this type of a circuit, all components are connected as a chain and the 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. Opening or breaking any point in a series circuit causes the whole circuit to stop functioning, which then needs to be replaced.

Parallel Circuit

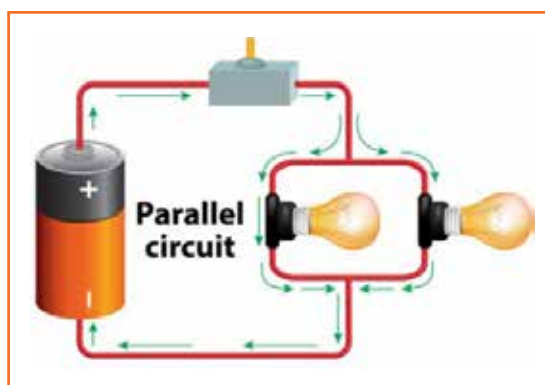


Fig 1.2.5 A parallel circuit

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. If any point of the circuit gets damaged, only that part needs to be replaced.

1.2.3 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

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.

Current

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

AC and DC Current

The following figure lists the two types of current sources that are dependent on the direction in which the electrons flow -

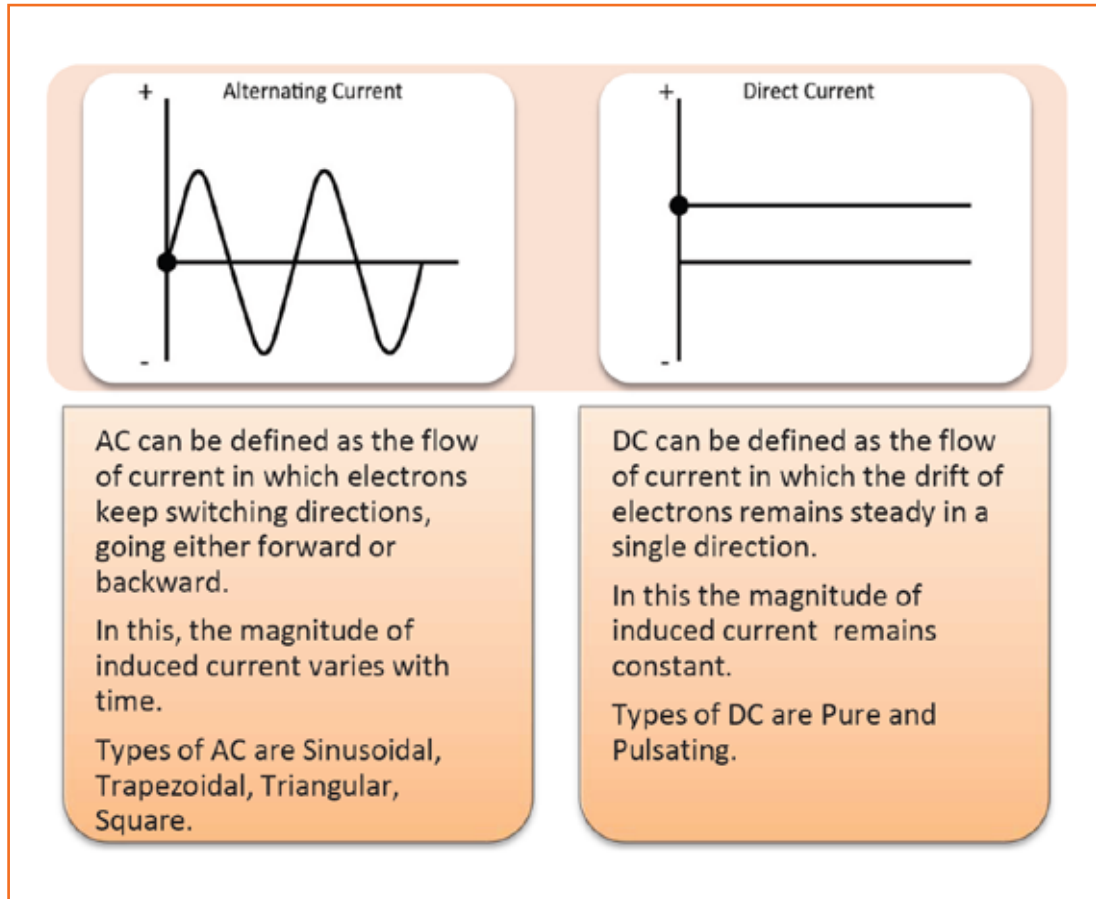


Fig 1.2.6 Difference between AC and DC current

Resistance

Resistance is an obstruction caused by a substance to the current flow. The unit of resistance is ohm and it is denoted with the symbol, Ω . According to Ohm's law, 1Ω resistance allows $1A$ of current to flow from one point to the other with a $1V$ voltage difference.

1.2.4 Ohm's Law

According to Ohm's law, the flow of current through a conducting material is directly proportional to the conductor's voltage. The mathematical equation of Ohm's law is as follows -

$$I = V/R$$

Where,

I is the current

V is the potential difference

R is the resistance

Ohm's law states that R in the preceding relation is constant and independent of the current flowing through it as shown in the following image -

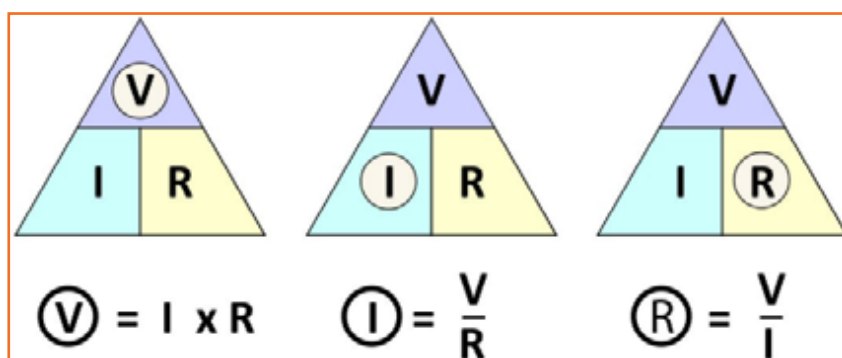


Fig 1.2.7 Ohm's law

1.2.5 Circuit Elements

A circuit consists of a number of components that may be electrical, electronic, mechanical and so on. The following figure shows various types of circuit elements or components that are used in a control panel -

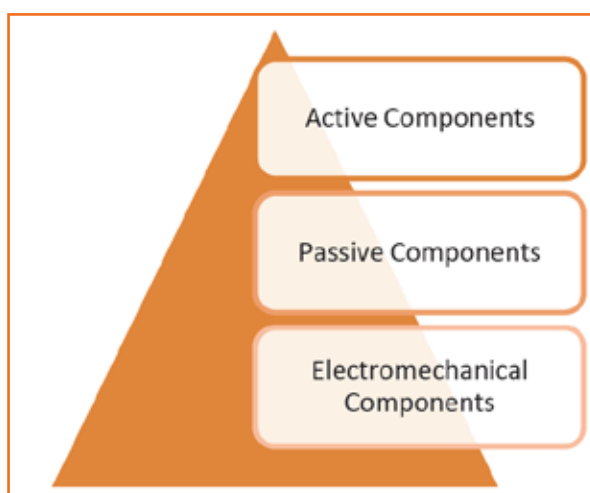


Fig 1.2.8 Circuit elements

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 following figure lists the different types of active components in a circuit -

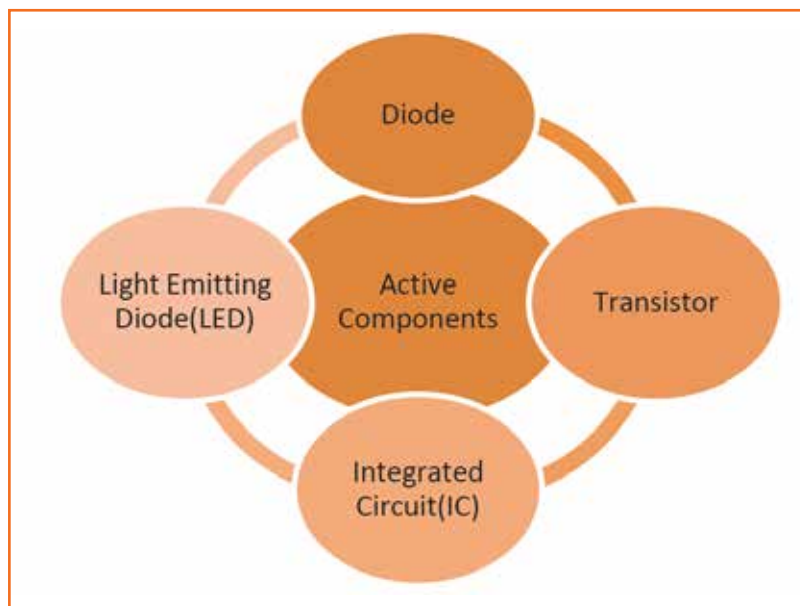


Fig 1.2.9 Active components

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 following figure lists the different types of passive components in a circuit -

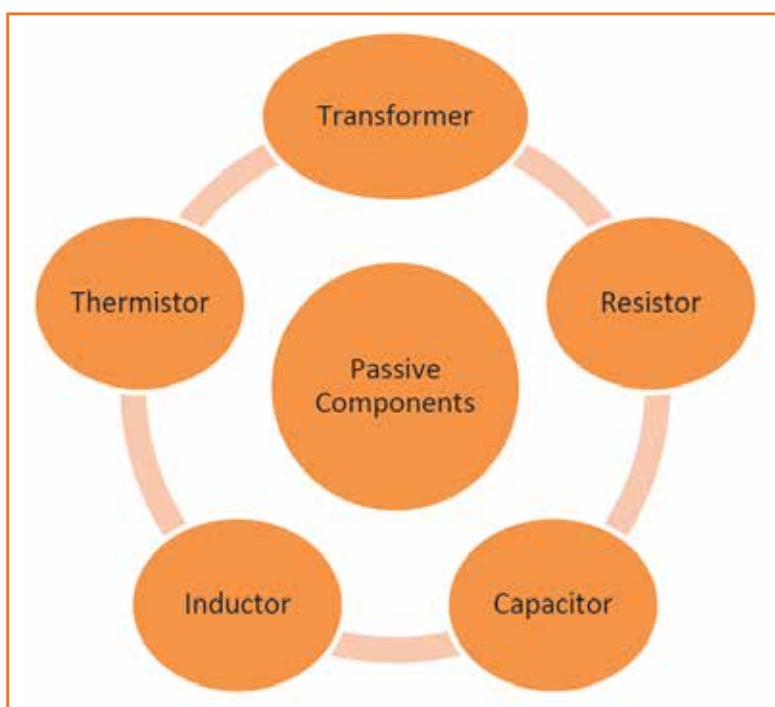


Fig 1.2.10 Passive components

Electromechanical Components

Electromechanical components convert electric energy into mechanical energy (mechanical movement) or vice versa for carrying out electric operations. The following figure lists various electromechanical components -

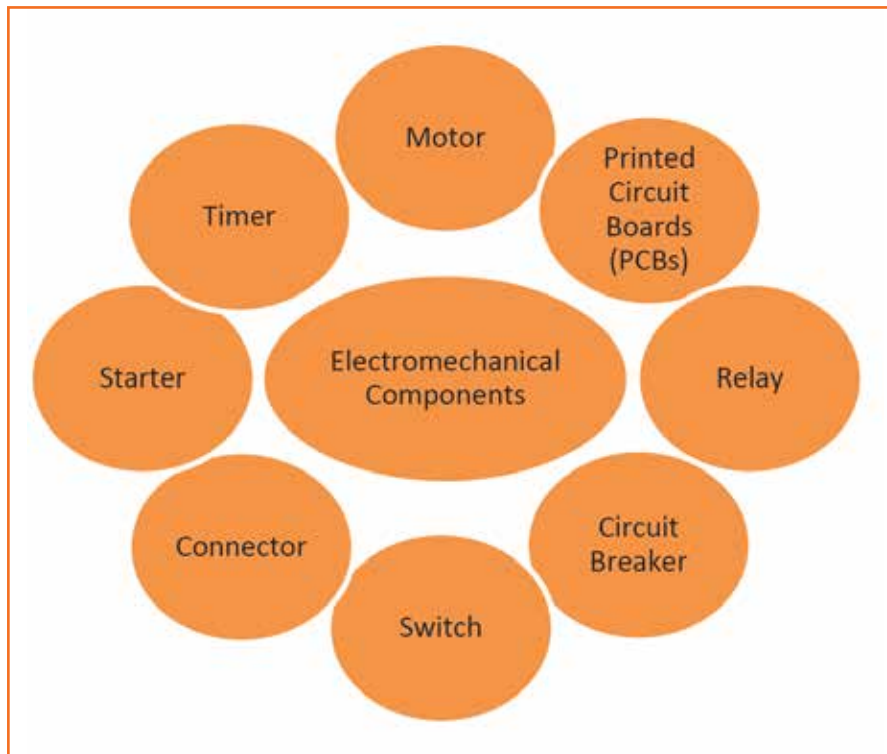


Fig 1.2.11 Electromechanical components

Exercise



1. Name this equipment



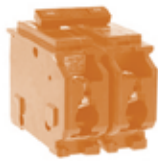
2. Electric tools should not be used in damp or wet locations.

(a) True

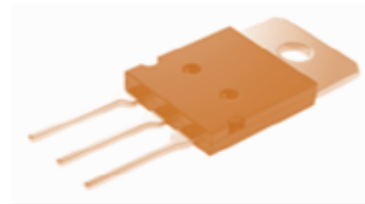
(b) False

3. Identify the different electronic components and write down their names in the boxes give below them:

1.



2.



3.



4.



5.



4. Perform categorisation of the following components as active or passive:

1. Resistor
2. Transistor
3. Capacitor
4. Diode
5. LED
6. Inductor
7. IC
8. Thermistor
9. Transformer

Scan the QR code or click on the link to watch related videos



www.youtube.com/watch?v=mc979OhitAg
Basics of electricity



www.youtube.com/watch?v=m4jzggZu-4s
Electric circuits

[illegible]



2. Planning, Design and Installation

Unit 2.1 – Electrical and Electronic Circuit Diagrams

Unit 2.2 – Electrical and Electronic System Components and Accessories

Unit 2.3 – Tools and Measuring Instruments Required

Unit 2.4 – Cable Assembly

Unit 2.5 – Assembly Procedure



Key Learning Outcomes



At the end of this module, participants will be able to:

1. Describe different types of circuit diagram
2. List various electrical and electronic component symbols
3. Discuss wiring color code
4. List various electrical and electronic system components
5. Describe functioning and use of various electrical and electronic system components
6. List various tools and measuring instruments required
7. Demonstrate use of various tools and measuring instruments required
8. Describe methods and techniques of cable assembly
9. Demonstrate procedure of cable assembly
10. Demonstrate stripping and crimping of wires
11. Demonstrate soldering process
12. Demonstrate electrical and electronic sub systems assembling procedure
13. Demonstrate assembling procedure with mechanical equipment

UNIT 2.1: Electrical and Electronic Circuit Diagrams

Unit Objectives



At the end of this unit, participants will be able to:

1. Describe different types of circuit diagram
2. List various electrical and electronic component symbols
3. Discuss wiring color code

2.1.1 Circuit Diagrams

A circuit diagram (also known as an electrical diagram, elementary diagram, or electronic schematic) is a simplified conventional graphical representation of an electrical circuit.

These electrical circuits are represented by lines to represent wires and symbols or icons to represent electrical and electronic components. It helps in better understanding the connection between different components. Electricians use different types of drawings or diagrams to represent a certain electrical system or circuit and highlight certain aspects of the system but the physical circuit and its function still remains the same.

Types of electrical drawings or diagrams

1. **Block Diagram:** A block diagram is a type of electrical drawing that represents the principal components of a complex system in the form of blocks interconnected by lines that represent their relation. It is the simplest form of electrical drawing as it only highlights the function of each component and provides the flow of process in the system.

It lacks the information about the wiring and placement of individual components. It only represents the main components of the system and ignores any small components.

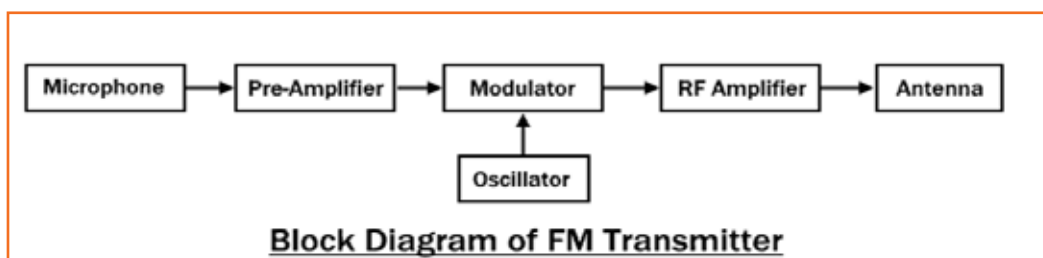


Fig 2.1.1 Block diagram

This diagram shows the process of converting an audio signal into frequency modulated signal. It is pretty simple and easy to understand. Each block process the signal and pass it to the next one.

2. **Wiring Diagram:** The wiring diagram is used for the representation of electrical components in their approximate physical location using their specific symbols and their interconnections using lines. Vertical and horizontal lines are used to represent wires and each line represents a single wire that connects between electrical components.

Wiring diagram shows a pictorial view of the components such that it resembles its electrical connection, arrangement and position in real circuit. It helps in showing the interconnections in different equipment such as electrical panel and distribution boxes etc.

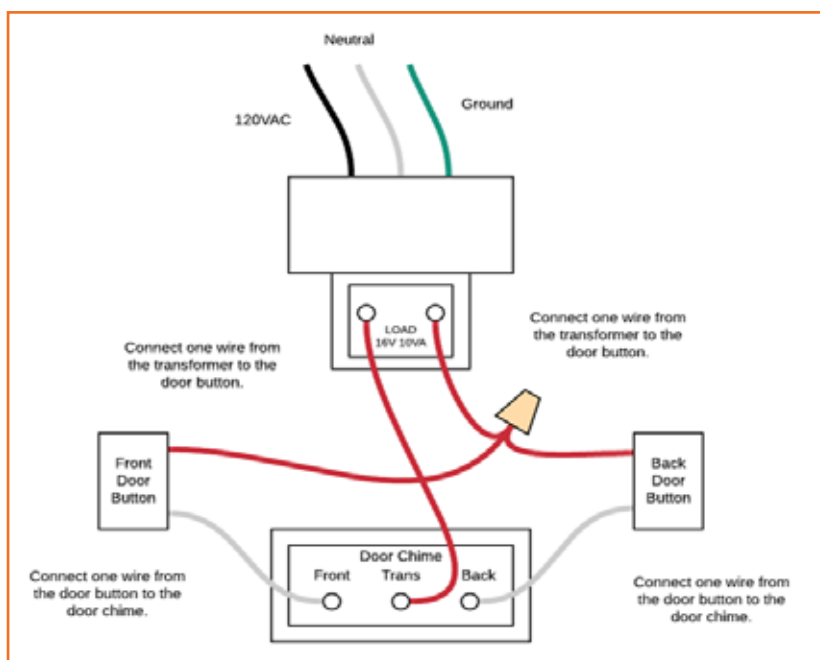


Fig 2.1.2 Wiring diagram

The following pictorial electric diagram is an example of a more detailed wiring for a front and back doorbell system. This type of drawing is still very simple, but includes enough detail that the person should be able to successfully install and wire a two doorbell system.

3. **Schematics Circuit Diagram:** The schematic diagram of an electrical circuit shows the complete electrical connections between components using their symbols and lines. A schematic diagram used for electronics uses standardized symbols and simple line drawings to represent various electronic components. The standardized symbols make it possible for any experienced electrician to read and understand any schematic diagram. Unlike wiring diagram, it does not specify the real location of the components.

It helps in showing the series and parallel connection between the components and the exact terminal connection between them. It is the most common type of electrical drawing and are mostly used in implementing electrical circuits by technician.

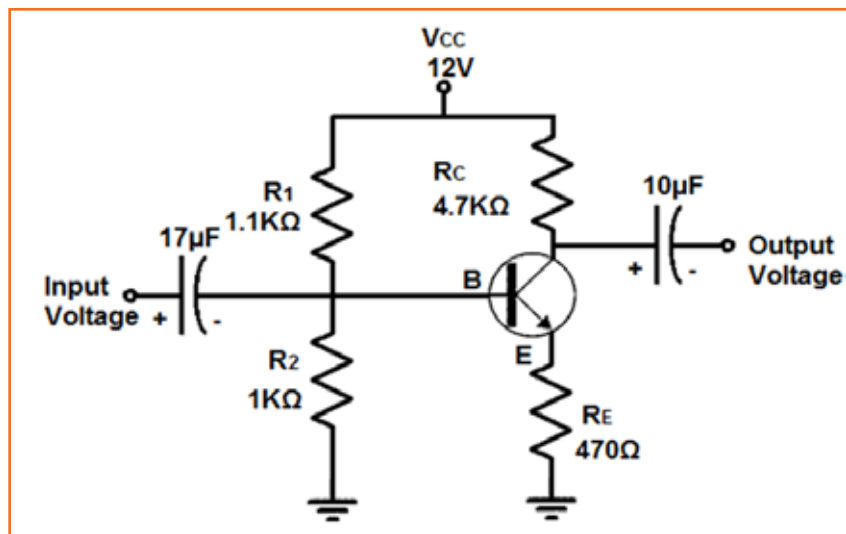


Fig 2.1.3 Schematic circuit diagram

This is a schematic diagram of a voltage amplifier. It uses various symbols to represent the electrical components and the lines to represent the electrical connection between their terminals.

4. **Single Line Diagram or One-line Diagram:** Single Line diagram (SLD) or one-line diagram is the representation of an electrical circuit using a single line. As the name suggests, a single line is used to denote the multiple power lines such as in 3 phase system.

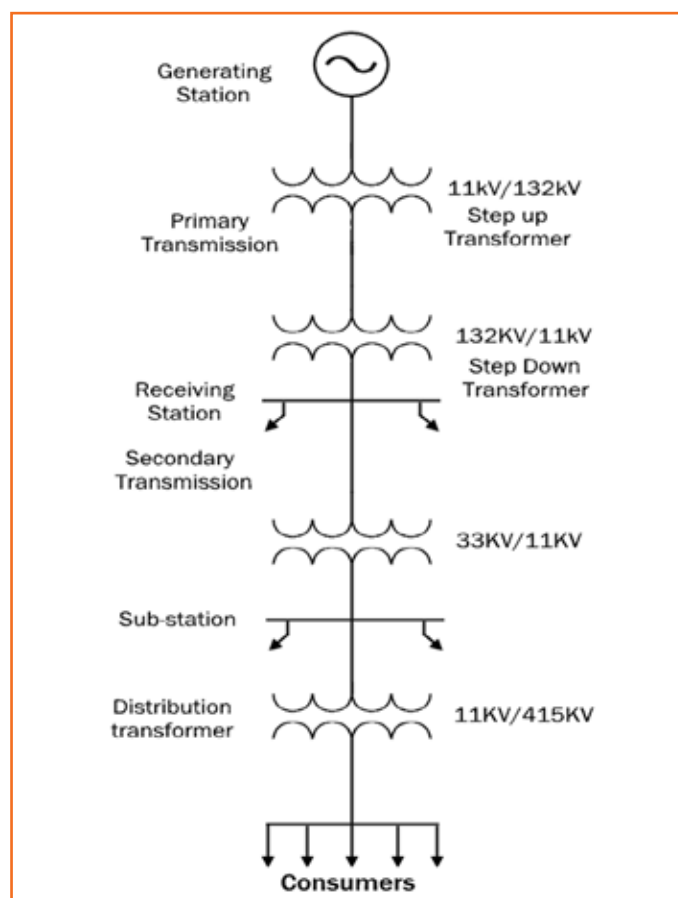


Fig 2.1.4 Single line diagram

Single line diagram does not show the electrical connections of the component but it may show the size and ratings of the components being used.

5. **Pictorial Diagram:** The pictorial diagram does not necessarily represent the actual circuit. In fact it shows the visual appearance of the circuit in real time. it cannot be used to understand or troubleshoot the actual circuit and for this reason alone, it is not commonly used. For someone with less knowledge of electrical, it is impossible to understand how the circuit works.

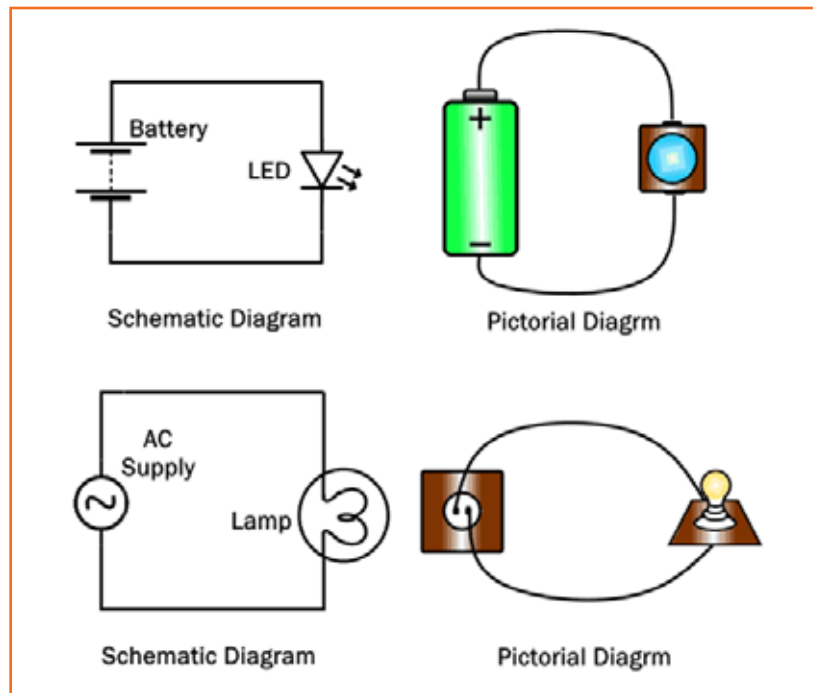


Fig 2.1.5 Pictorial diagram

As you can see, the pictorial diagram does not provide enough information regarding the electrical connection of the components.

2.1.2 Reading Wiring Diagram

By understanding how to read a wiring diagram will help to save individual harm or injury to the object on which you are working whether you are working with a vehicle, light fixture or appliance.

1. **Find the wiring diagram:** With appliances and other objects, the wiring diagrams are often given.
2. **Check your voltage (V):** Check voltage requirements of the equipment as described in the wiring diagram.
3. **Learn the symbols:** Understanding the symbols in wiring diagram meaning will help you discover dissimilar electronic components and wiring networks with the mechanical equipment. Symbols

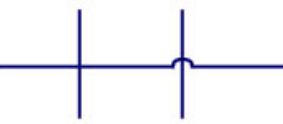
usually look like the part they showing.

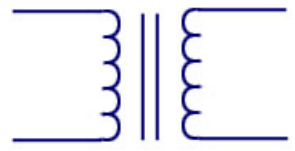
4. **Know the color code:** Representation of different components can be done by different colors of wires. For the testing of dissimilar components within the system become simple. To express you what every color means there should be a key or legend on the wiring diagram. For all electrical items there will be a specific color for a home electrical system are same.

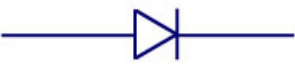
- White wires are neutral and they take power back to the service panel.
- The ground wires are green or bare wires. In the case of neutral wires fail these carry power back to the service panel.
- For the representation of hot wires, colors like Black, red, blue are used. These are the ones that carry power to the object with which you are working.
- If you are not confirming what the dissimilar colors mean then use a voltage tester.

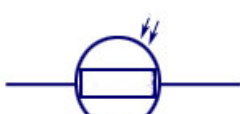
2.1.3 Component Symbols

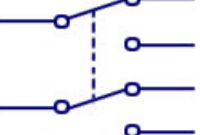
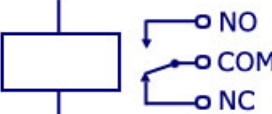
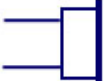
Take a look at the symbols for electrical and electronic components.

Electrical and Electronic Component	Symbol	Description
Wires		
Wire		Used to interface one segment to another.
Wires Joined		One gadget might be associated with another through wires. This is spoken to by drawing "blobs" on the point where they are shorted.
Un-joined Wires		At the point when circuits are drawn a few wires may not touch others. This must be appeared by crossing over them or by drawing them without blobs. In any case, connecting is usually rehearsed as there won't emerge any perplexity.
Power Supplies		
Cell		Used to provide a provision to a circuit.
Battery		A battery has more than a cell and is utilized for a similar reason. The littler terminal is negative and the bigger one is positive. Shortened as "B".

Electrical and Electronic Component	Symbol	Description
DC Supply		Utilized as a DC power supply, that is, the current will dependably stream one way.
AC Supply		Utilized as AC power supply, that is, the current will continue exchanging directions.
Fuse		Utilized as a part of circuits where a likelihood of extreme current streams. The fuse will break the circuit if exorbitant current streams and spares alternate gadgets from harm.
Transformer		Utilized as an ac power supply. Comprises of two loops, the primary and secondary that are connected together through an iron center. There is no manual association between the two coils. The guideline of common inductance is utilized to get power. Truncated as 'T'.
Earth/Ground		Utilized as a part of electronic circuits to speak to the 0 volts of the power supply. It can likewise be characterized as the real earth, when it is connected in radio circuits and power circuits.
Resistor		
Resistor		A resistor is utilized to confine the measure of current course through a gadget. Denoted as 'R'.
Rheostat		A rheostat is utilized to control the current stream with two contacts. Pertinent in controlling light brightness, capacitor charge rate, and so on.
Potentiometer		A potentiometer is utilized to control the voltage stream and has three contacts. Have applications in changing a mechanical edge change to an electrical parameter. Curtailed as 'POT'.
Capacitor		
Capacitor		Capacitor is a gadget that is utilized to accumulate electrical energy. It comprises of two metals plates that are isolated by a dielectric. It is relevant as a filter, that is, to restrict DC signals and permit AC signals. Denoted with letter 'C'.

Electrical and Electronic Component	Symbol	Description
Capacitor – Polarized		Capacitor can be utilized as a part of a clock circuit by including a resistor.
Variable Capacitor		Used to shift the capacitance by turning the handle. A sort of variable capacitor is the trimmer capacitor that is little in estimate. The documentations are all the same.
Diode		
Diode		A diode is utilized to enable electric current to stream in just a single heading. Shortened as 'D'.
Light Emitting Diode (LED)		LED is utilized to discharge light when a current is gone through the gadget. It is curtailed as LED.
Zener Diode		After a breakdown voltage, the gadget enables current to stream in the turnaround course also. It is contracted as 'Z'.
Photo Diode		Photodiode fills in as a photo detector and changes over light into its comparing voltage or current.
Transistor		
NPN Transistor		This is a transistor with a layer of P-doped semiconductor settled amid two layers of N-doped semiconductors that go about as the emitter and collector. Abridged as 'Q'.
PNP Transistor		This is a transistor with a layer of N-doped semiconductor settled between two layers of P-doped semiconductors that go about as the emitter and collector. Contracted as 'Q'.
Phototransistor		The working of a phototransistor is like that of a bipolar transistor with a distinction that it changes over light into its corresponding current.
Field Effect Transistor		A FET has three terminals: Gate, Source and Drain. FET has an electric field which controls the conductivity of a channel in a semiconductor substance.

Electrical and Electronic Component	Symbol	Description
N-Channel Junction FET		The Junction Field Effect Transistor (JFET) is the least difficult kind of FET with applications in Switching and voltage variable resistor. In an N-channel JFET an N-sort silicon bar has two littler bits of P-sort silicon material diffused on each sides of its center part, shaping P-N junctions.
P-Channel Junction FET		P-channel JFET is comparable in development to N-channel JFET with the exception of that P-sort semiconductor base is sandwiched between two N-sort junctions. For this situation dominant part carriers are gaps.
Meters		
Voltmeter		Voltmeter is utilized to gauge the voltage at one point in the circuit.
Ammeter		An Ammeter is utilized to gauge the current that goes through the circuit at a specific point
Galvanometer		A galvanometer is utilized to quantify little currents in the request of 1 milli ampere or less.
Ohmmeter		Resistance of the circuit is estimated utilizing an Ohmmeter.
Oscilloscope		An oscilloscope is utilized to quantify the voltage and era of signs alongside their shape display.
Sensors		
Light Dependent Resistor (LDR)		It is shortened as LDR. LDR is used to change over light into its corresponding resistance. Rather than straightforwardly measuring the light, it detects the warmth substance and changes it onto resistance.

Electrical and Electronic Component	Symbol	Description
Thermistor		Rather than straightforwardly measuring the light, a thermistor detects the warmth substance and changes it into resistance. Shortened as "TH".
Switches		
Push Switch		This is a common switch that passes current just upon pushing.
Singe Pole Single Throw Switch		Otherwise called the ON/OFF switch. This switch permits the stream of current just when it is continued. Abridged as SPST.
Single Pole Double Throw Switch		Otherwise called the 2-way switch. It can be likewise called as an ON/OFF/ON switch as it has an OFF position in the inside. The switch causes the stream of current in two ways, contingent upon its position. It can be condensed as SPDT.
Double Pole Single Throw Switch		Abridged as DPST. Can likewise be called as a double ON-OFF switch. This is utilized to disengage between the live and unbiased associations in the primary electrical line.
Double Pole Double Throw Switch		Contracted as DPDT. The switch utilizes a focal OFF position and is connected as switching switch for engines.
Relay		Relay is used to protect the circuit from overcurrent.
Audio and Radio Devices		
Microphone		This gadget is utilized for changing over sound to its relating electrical energy. Contracted as 'MIC'.
Earphone		Does the turnaround procedure of amplifier and changes electrical energy into sound.

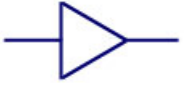
Electrical and Electronic Component	Symbol	Description
Loudspeaker		Does likewise operation as a headphone, however changes over an increased variant of the electrical energy into its subsequent sound.
Piezo-Transducer		It is a transducer that changes electrical energy into sound.
Amplifier		Used to open up a signal. It is primarily used to speak to an entire circuit instead of only one part.
Output Devices		
Lighting Lamp		This is utilized to give light to the yield.
Indicator Lamp		Used to change over electrical energy into light. The best case is the notice light on a car dashboard.
Heater		This transducer is utilized to change electrical vitality into warm.
Inductor		Inductor is utilized to create an attractive field when a specific current is gone through a loop of wire. Shortened as 'L'.
Motor		This gadget is utilized to change over electrical energy into mechanical energy. Can be utilized as a generator too. Curtailed as 'M'.
Bell		Utilized to deliver a sound as the output, as indicated by the electrical energy created as the data.
Buzzer		It is used to produce an output sound corresponding to the electrical energy in the input.

Table 2.1.1 Electrical and electronic components symbol

Electrical and Electronic Units Symbol

Take a look at the symbols for electrical and electronic units.

Unit	Symbol
Ampere (amp)	A
Volt	V
Ohm	Ω
Watt	W
Volt-Ampere-Reactive	VAR
Volt-Ampere	VA
Farad	F
Henry	H
Kilowatt-hour	kWh
Electron-volt	eV
Ohm-meter	$\Omega \cdot m$
Volts per meter	V/m
Volt-meter	V·m
Tesla	T
Hertz	Hz
Seconds	s
Meter / Metre	m
Square-meter	m ²
Decibel	dB
Parts per million	ppm

Table 2.1.2 Electrical and electronic units symbol

2.1.4 Electrical Wiring Color Code

Standard color coding is used that supports organize each wire role in the circuit.

RGB mode i.e. Red- Green- Black of wire is used in India. There are different functions of these RGB wire -

- **Red:** Red wire signifies the phase in electric circuit. It is the live wire which cannot be connected to another red wire or black wire.
- **Black:** The neutral wire in electric circuit is defined by black wires. Inside an electric panel the neutral wires are joined to neutral bus bar. A bus bar is a conductive metal bar that entices the electric current for supply purpose. This can be joined to black wire only and no other color wire will connect with black wire.
- **Green:** For grounding/ earthing in electric circuit a green wire is used. This wire should be joined to green wire only (no other wire). For lights and fan purposes the grounding wires are not in use and for socket purpose green wires are chiefly used.

Type of Wire	Colour
Neutral	Black
Earth	Green or Green and Yellow
Phase	Red or Yellow or Blue

Table 2.1.3 Wiring color code

	Single Phase	Three Phase
Phase Conductor (Line)	 Red or  Yellow or  Blue	 Line 1 Red  Line 2 Yellow  Line 3 Blue
Neutral Conductor	 Black	
Protective Conductor (Earth)	 Green-and-Yellow	

Fig 2.1.6 Wiring color code

Scan the QR code or click on the link to watch related videos



<https://www.youtube.com/watch?v=pBiGez-SIXE>

Electronic component symbols

UNIT 2.2: Electrical and Electronic System Components and Accessories

Unit Objectives



At the end of this unit, participants will be able to:

1. List various electrical and electronic system components
2. Describe functioning and use of various electrical and electronic system components

2.2.1 Switch

A switch is a segment which regulates the unclosed and close-ness of an electric circuit. Current flow in a circuit regulates by a switch. Switches are basic segments in any circuit which needs worker's client cooperation or command.

A switch can just exist in one of two states: open or shut. In the off situation, a switch resembles an open gap in the circuit. This, as a result, resembles an open circuit, keeping current from streaming.

In the on situation, a switch demonstrations simply like a bit of flawlessly leading wire. This shuts the circuit, turning the framework **"on"** and enabling current to stream unobstructed through the whole framework.

Characteristics of switch

1. **Actuation Method:** with a specific end goal to change starting with one situation then onto the next, a switch must be incited. That is, some kind of physical activity must be performed to "flip" the switch's situation. The activation strategy for a switch is one of its all the more characterizing attributes.

Switch activation can originate from pushing, sliding, shaking, pivoting, tossing, pulling, key-turning, heating, magnetizing, kicking, snapping, licking,... any physical cooperation which can make the mechanical linkages inside the switch come into, or leave out of, contact.

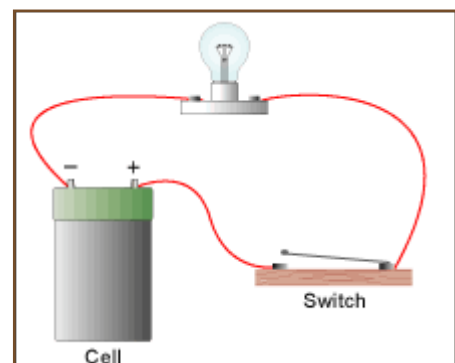


Fig 2.2.1 Simple circuit



Fig 2.2.2 Switches

2. **Momentary vs. Maintained:** All switches can be categorized as one of two unmistakable classes: momentary or maintained.

Maintained switches –like the light switches on your divider – remain in one condition until impelled into another one, and afterward stay in that condition until followed up on at the end of the day. These switches may likewise be called toggle or ON/OFF switches.

Momentary switches just stay dynamic insofar as they're impelled. In the event that they're not being activated, they stay in their "off" condition.

3. **Mounting Style:** As with most parts, the end style of a switch dependably boils down to either surface mount (SMD) or through-hole (PTH).

SMD switches are littler in respect to the PTH partners. They sit flat, on top of a PCB. SMD switches as a rule require a delicate touch, they're not worked to support as much exchanging power as a through-hole switch.



Fig 2.2.3 Mounting style switches

Panel mount switches – intended to sit outside a enclosure in area – are a mainstream mounting style also. It's difficult to flip a switch when it's covered up inside an enclosure.

4. **Poles and Throws:** A switch should have no less than two terminals, first helps the current to (conceivably) enter, second helps to (possibly) turned out.

The quantity of poles on a switch characterizes what number of independent circuits the switch can regulate. So a switch with one pole, may just impact solo circuit. Four-pole switch can independently regulate four unique circuits.

A switch's throw check characterizes what number of positions each of the switch's posts can be associated with. For instance, each circuit (pole) in the switch can be associated with one of two terminals if a switch has two throws.

Knowing what number of poles and throws a switch has got, it could be particularly characterized:

- **SPST:** A solitary pole, single-throws (SPST) switch is more or less straightforward. It has one output and one input.



Fig 2.2.4 SPST switch

The switch will either be shut or totally detached. SPSTs are ideal for on-off switching.

- **SPDT:** Another basic switch-sort is the SPDT. SPDTs has got three terminals: one basic pin and two pins which struggle to link with the normal. SPDTs are awesome for choosing between two power sources, swapping inputs, or whatever it is you do with two circuits attempting to go one place.

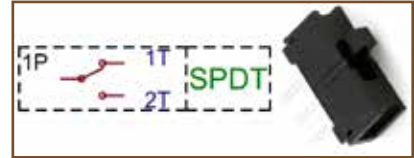


Fig 2.2.5 SPDT switch

- **DPDT:** Adding another pole to the SPDT makes a double-pole, double-throw (DPDT) switch. Essentially two SPDT switches, which regulates two different circuits, however are constantly exchanged together by a solo actuator.



Fig 2.2.6 DPDT switch

DPDTs ought to have six terminals.

Sorts of switches:

1. **Push-button:** Push-button switches are the exemplary flitting switch. Normally these switches have a truly pleasant, “clicky” input when you squeeze them. They come in a wide range of assortments: huge, little, brilliant, illuminated (when a LED shines up through the catch). They may be ended as through-hole, surface-mount, or even panel mount.



Fig 2.2.7 Push button switch

2. **Button Matrices:** Large varieties of flashing buttons, similar to your console or considerably littler groupings like a keypad, for the most part organize the greater part of their switches into a major network. Each catch on the pad is appointed a line and segment .



Fig 2.2.8 Button matrice

3. **Slide Switch:** Need a really basic, no-frills ON/OFF or selector switch. Slide switches might be for you! These switches have a tiny little nub which protrudes from the switch, and it slides across the body into one of two (or more) positions. You’ll usually find slide switches in SPDT or DPDT configurations.



Fig 2.2.9 Slide switch

4. **Toggle Switch:** Toggle switches have a long lever, which moves in a shaking movement. As they move to another position, toggle switches make a truly fulfilling “snap”. toggle switches are regularly SPST (two terminals) or SPDT (three terminals).



Fig 2.2.10 Toggle switch

Switch Applications

1. **On/Off Control:** Amongst the majority apparent of switch applications is straightforward on and off control. An on/off switch can be actualized by basically putting a SPST switch in arrangement with an electrical power-line. Typically the on/off switch will be kept up, similar to a flip or slide switch, however temporary on/off switches can have their function.

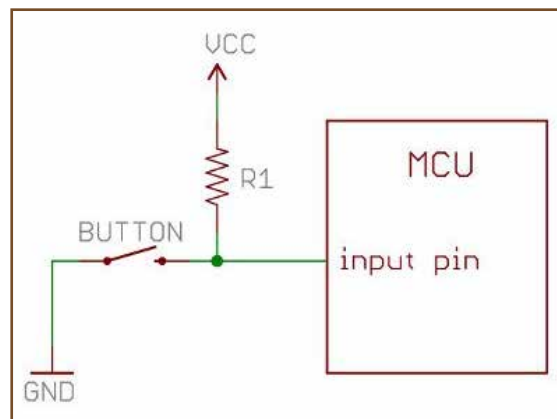


Fig 2.2.11 Switch application

2. **User Input:** user input is the most typical applications for switches. When the switch is open at particular point, the MCU pin connects through resistor at 5V. When switch is closed at the particular point, the GND is specifically connected through pin. The resistor in that circuit is a pull up resistor, essential to inclination the input high, and keep a short to ground when the switch is closed.

2.2.2 Limit Switch

A limit switch is a switch worked by the movement of a machine part or existence of a thing.

They are utilized for controlling equipment as a major aspect of a control framework, as a wellbeing

interlocks, or to tally protests passing a point. limit switch is an electromechanical gadget that comprises of an actuator mechanically connected to an arrangement of contacts. At the point when a question comes into contact with the actuator, the gadget works the contacts to represent the moment of truth an electrical association.



Fig 2.2.12 Limit switch

Limit switches are utilized as a part of an assortment of utilizations and conditions in view of their toughness, simplicity of establishment, and unwavering quality of operation. They can decide the existence or nonexistence, passing, situating, and end of journey of an thing Regular limit switches are manufacturing control segments produced with an assortment of administrator sorts, including lever, roller plunger, and whisker sort. Limit switches might be straightforwardly mechanically worked by the movement of the working lever.

2.2.3 Socket

To get the electricity for table lamp, press iron, radio, transistor and TV etc. electrical point socket is used. Socket is available in two forms-

- Surface type
- Flush type

It has both type of arrangements, two pin and three pin. Two pin sockets has one pin for phase and the other one for neutral, but the 3 pin has one more bigger pin for earthings, known as earthing pin. For light-fan circuits



Fig 2.2.13 Socket

socket 5A 250V grade and for domestic power circuits 5A/15A is used and 6 pin is also now common in use. Sockets are usually switch controlled.

Specification of Sockets

It includes-

- | | |
|---------------------------------|--------------------|
| (i) Electrical current capacity | (ii) Voltage grade |
| (iii) Number of Pins | (iv) Forms |
| (v) Base | (vi) Shape |

(vii) Color

(viii) Manufacturer

For Example-

- (i) 5A, 250V, two-pin Bakelite base, rounded, surface format, black colored switch, surface format socket, KEY make, IS certified.
- (ii) 5A, 250V three-pin, porcelain base, rectangular, white colored, flash format socket, Anchor make, IS certified

2.2.4 Plug

Plug is devise for pairing utilities like table lamp, iron press, radio, TV etc. with electrical source to get the electricity. They are of two types-

1. **Two Pin Plugs:** This plug contains two pins to form the contact with phase wire and neutral wire of socket. As per socket two 5A, 250V and 15A, 250V grades are available. On one pin - phase and on other pin - neutral wire is attached and they provide connection for equipment when socket is attached to it.
2. **Three Pin Plugs:** Apart from two pins for phase and neutral, there is provision of third thick pin for earthing in this type of plug, and that is why it is known as three pin plug. It is mounted on a three pin socket. Same as socket it comes with 5A 250V and 15A 250V grade. It is used as per socket. It not only provides electricity to equipments but also secures from electrical shocks, due to the fact that the metal cover of the equipment gets earthed.



Fig 2.2.14 Two pin plug



Fig 2.2.15 Three pin plug

2.2.5 Circuit Breaker

This is a equipment designed to safeguard the electrical system of a house or building. Electrical systems are subject to sudden overloads of electrical flow. These sudden electrical surges can damage electrical

equipment and appliances. Even more dangerous, these overloads can cause fires in the house.

This is where circuit breakers come in. Circuit breakers immediately block or stop a surge of power before any damage is caused. When there is a power surge, the circuit trips. The problem in the circuit can be easily traced and resolved. Once the circuit is repaired, the circuit breaker is switched on again and it continues to operate as usual.



Fig 2.2.16 Circuit breaker

Miniature Circuit Breaker

Miniature circuit breaker (MCB) have more or less replaced main switch fuse breakers.

MCBs are available for 230/415 V and 50 Hz single and triple phase circuits. They are also available with a neutral wiring system in 16/32/40/50/63 A electric line bearing capacity.

They are used as:

- Single Polar (SP) units
- Single Polar Neutral (SPN) or Double Polar (DP) units
- Triple Polar (TP) units
- Triple Polar Neutral (TPN) or Four Polar (FP) units



Fig 2.2.17 MCB

Specification of Miniature Circuit Breaker

Certain details must be mentioned when describing a miniature circuit breaker. These details are:

- Electrical current capacity (16A, 32A, 40A, 50A, 63A etc)
- Voltage grade (230V/415V etc)
- Format (SP, SPN, DP, TP, TPN etc)
- Name of manufacturer/I.S. certification

2.2.6 Fuse

It's a piece of wire of little resistance and it helps like sacrificial equipment to give safety during current over loading or a short circuit. The fuse element is a metal stripe or cable, mount connecting a pair off of electrical terminal. The fuse element is typically covered with a non-combustible cover.

Functions of a fuse

A fuse wire is a material with a very low melting point so that when excessive current flows through the circuit the wires gets heated and melts. This results in breakage of circuit and the flow of current is stopped.

It can avoid fire and added harm while fire mishaps occur due to short circuit or current overloads. Such accidents include loose cables coming

in contact with the circuit, cable in connection box contact a grounded terminal, a nail drive throughout insecure cabling or broken insulation.



Fig 2.2.18 Fuse

2.2.7 Electric Relay

Electric relay is a switch which detects a strange state of electrical circuit and shuts its contacts down. These in turn close and finish the electrical switch trip loop circuit thus makes the electrical switch stumbled for disengaging the flawed part of the electrical circuit from rest of the circuit. Relays relays can keep away from equipment harm by recognizing electrical irregularities, including overcurrent, undercurrent, overburdens and turn around current.



Fig 2.2.19 Relay

Working of relay

At the point when power moves through the primary circuit

1. It initiates the electromagnet (brown), creating a magnetic field (blue) that pulls in a contact (red) and trigger the second circuit.
2. When the power is turned off, a spring pulls the contact back to its unique position, turning the second circuit off once more.

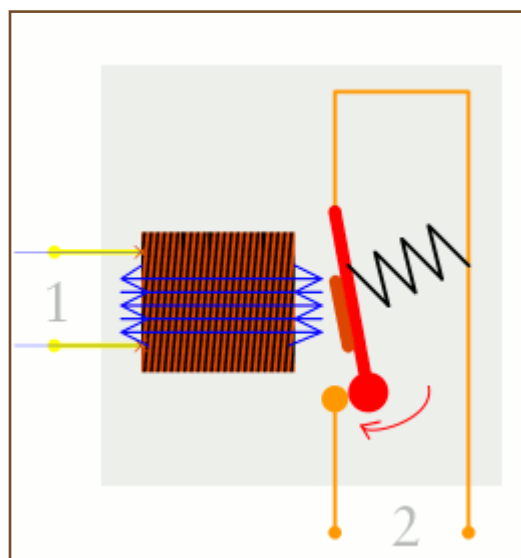


Fig 2.2.20 Working of relay

Types of relays

These are either solid-state relays or electro-mechanical.

- In **electro-mechanical relays** (EMR), magnetic drive are use to open or shut the contacts.
- With **solid-state relays** (SSR), shutting is absolutely electronic and contacts are not required.

The relay has several advantages such as:

- Reducing the voltage drop caused by very long circuits (circuits controlled from the instrument panel).
- Reducing the intensity of the current in passenger compartment switches and wiring harnesses (the control current of a relay is 0.2 A).
- Reducing the section of wires in the system control circuit.

4.2.8 Sensors

Sensors are advanced gadgets which are habitually utilize to recognize and react to optical or electrical signs. It changes over the physical parameter (for instance: circulatory strain, temperature, stickiness, speed, and so forth.) into an indication that can be electrically measured. How about we clarify the case of temperature. The glass of mercury thermometer extends and gets the fluid to change over the deliberate temperature that is perused through a watcher on the adjusted tube of glass.

In our everyday life we much of the time utilize diverse sorts of sensors in a few applications, for example, IR sensor used for Television remotes, Passive Infrared sensor utilized to programmed shopping centers entryway/door entry opening system and LDR sensor utilized for lighting outside areas or road framework lighting , etc.

Selection criteria of a Sensor

Elements which must be considered wisely when we choose a sensor are mentioned below:

1. Precision
2. **Environmental condition:** generally has restrictions for humidity and temprature
3. **Range:** Measurement end points of sensor
4. **Calibration:** Basic for most by far of the measuring gadgets as the readings gets changed with

time

5. **Resolution:** Smallest augmentation recognized through sensor
6. Costing
7. **Repeatability:** The perusing that changes is again and again measured under a same circumstance



Fig 2.2.21 Different type of sensors

Classification of sensors

The sensors are characterized into the following criteria:

1. Primary Input amount
2. Transduction standards (Using physical and chemical effects)
3. Material and Technology
4. Property
5. Application

Different types of sensors with their applications

Normal uses of different sorts of sensors, for instance, use of Speed sensor for synchronizing the speed of various engines, Temperature sensor application for industrial temperature control, utilization of the PIR sensor for customized gateway opening structure, Ultrasonic sensor application for distance estimation, etc., are discussed underneath:

1. **Speed Sensor:** used for distinguishing pace of a thing or vehicle is called as Speed sensor. There are various sorts of sensors to distinguish the speed, for instance, Wheel speed sensors, speedometers, LIDAR, ground speed



Fig 2.2.22 Speed sensors

radar, pitometer logs, doppler radar, speed pointers, pitot tubes and so forth.

2. **Temperature Sensor:** A device which gives temperature estimation as an electrical sign is called as Temperature sensor. This electrical sign will be as electrical voltage and is relating to the temperature estimation.

There are several types of sensors used for measuring temperature i.e. Contact type and non-contact type temperature sensors.



Fig 2.2.23 Temperature sensors

These are further divided into mechanical temperature sensors like Thermometer and Bimetal and electrical temperature sensors like Resistance thermometer, Thermocouple, Silicon band gap temperature sensor and Thermistor.

3. **PIR Sensor:** An electronic sensor used for measuring the infrared light radiation delivered from objects in its field of view is called as a PIR sensor or Pyroelectric sensor. Every thing that has a temperature above pre-eminent zero, discharge heat radiations which are transmitting at infrared wavelengths and unnoticeable to the human eye. These can be recognized by remarkable electronic devices like PIR movement identifiers.



Fig 2.2.24 PIR sensor

Programmed door opening system is a typical use of PIR sensors which is customized for closing and opening operations of door.

4. **Ultrasonic Sensor:** The rule of ultrasonic sensor resembles sonar or radar in which interpretation of echoes from radio or sound waves to evaluate the properties by creating the high-frequency sound waves (around 40kHz). The transducer used for changing over energy into ultrasound or sound waves with ranges above human hearing degree is known as a ultrasonic transducer.



Fig 2.2.25 Ultrasonic sensor

The distance measurement at out of reach areas is for constant use of ultrasonic sensors. The circuit comprises of a microcontroller, LCD display and ultrasonic module.

2.2.9 Choke Coil

A choke coil is a part utilized as a part of electrical circuits to enable DC current to course through while restricting AC current from passing. These coils are utilized as a part of various electrical gadgets. At the point when utilized as a major aspect of a radio's hardware, it can be categorized as one of two frequency classes: audio or radio. Those utilized as a part of circuits with higher frequencies use diverse center materials than those utilized as a part of lower frequency circuits.



Fig 2.2.26 Choke coil

The choke coil works since it goes about as an inductor. At the point when the current going through changes, as AC currents do, it commonly makes a magnetic field in the loop that conflicts with that current. This property, known as inductance, restricts the greater part of the AC current from going through. Thus, currents that don't change, for example, DC currents, can proceed through while those that do are hindered by the extremely attractive field they made.

At the center of this part is a material used to create its magnetic field. Coils used to channel higher frequencies may utilize an air-core or a ferrite core, while bring down frequency coils may utilize an iron core. The material in the core decides the quality of the magnetic field and the inductance rate of the coil. While picking the best sort to use in a circuit, the engineer will take a gander at the voltage, the DC resistance of the coil, and the level of inductance. These components figure out which loop will most productively go through the right streams while hindering the undesirable ones.

2.2.10 Panel Meters

Galvanometer

A **galvanometer** is an electromechanical instrument for perceiving and deciding electric current. The most generally perceived usage of galvanometers was as basic measuring instruments, called ammeters, used to evaluate the immediate current (stream of electric charge) through an electric circuit.

In galvanometer, when direct current (DC) travels by coil, then it makes an magnetic field. This field

exhibits against the ceaseless magnet. The coil turns, pushing against the spring, and moves the pointer. The hand centers at a scale exhibiting the electric current. Vigilant diagram of the pole pieces ensures that the magnetic field is uniform, for the exact deviation of the pointer is relative to the current.

Most present day utilizations are in positioning and control frameworks. They are utilized as a part of a few sorts of printing machines, military applications, space systems, laser-based standardized bar-code scanner and imaging applications



Fig 2.2.27 Galvanometer

Voltmeter

A voltmeter is an instrument utilized for measuring electrical potential distinction between two focuses in an electric circuit. Voltmeters are made in an extensive variety of styles. Instruments forever mounted in a board are utilized to screen generators or other fixed apparatus. Convenient instruments, normally prepared to likewise quantify current and resistance as a multimeter, are standard test instruments utilized as a part of electrical and electronics work.

Voltmeters working on the electrostatic guideline utilize the shared repugnance between two charged plates to avoid a pointer connected to a spring. Meters of this sort draw negligible current yet are delicate to voltages over around 100 volts and work with either alternating or direct current.



Fig 2.2.28 Voltmeter

A digital voltmeter (DVM) measures an obscure input voltage by changing over the voltage to a computerized value and afterward shows the voltage in numeric figure.

2.2.11 Rectifiers

A rectifier lets electrical current flow in only one direction and is mainly used for power supply operation. Rectifier diodes can handle higher current flow than regular diodes and are generally used in order to change alternating current into direct current.

A rectifier can take the shape of several different physical forms such as solid-state diodes, vacuum tube diodes, mercury arc valves, silicon-controlled rectifiers and various other silicon-based semiconductor switches.

Rectifiers are used in various devices, including:

- DC power supplies
- Radio signals or detectors
- Generating current opposes basic power
- As existence of flame is identified by flame rectification
- Power transmission systems of high-voltage DC
- Several family machines utilize power rectifiers to make control, similar to scratch notebooks or tablets, computer game frameworks and TVs.

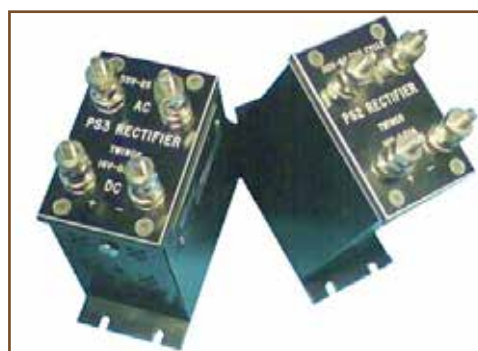


Fig 2.2.29 Rectifier

Rectifier has distinctive waveforms and can contain more than one diode in particular arrangements, for example:

- **Half Wave:** Either the negative or positive portion of the AC wave is passed in half-wave rectification of a single-phase supply, while the rest is blocked. Since just a single portion of information waveform achieves the yield, mean voltage is lesser. Half-wave rectification requires a solitary diode in a solitary stage supply, or three out of a three-phase supply.

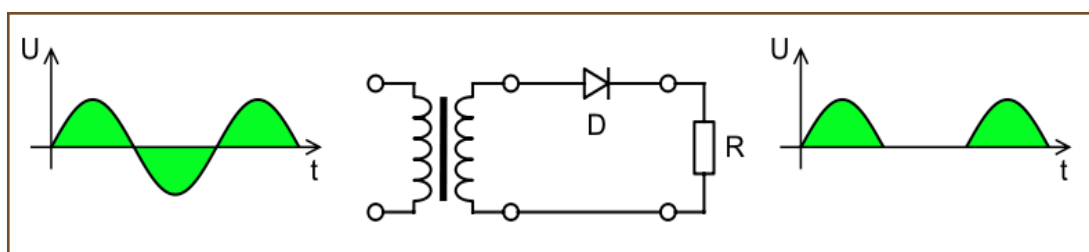


Fig 2.2.30 Half-wave rectifier

- **Full Wave:** A full-wave rectifier changes over the whole of the info waveform to one of relentless extremity (positive or negative) at its yield. Full-wave rectification changes over the two polarities

of the input waveform to throbbing DC, and yields a higher typical yield voltage. Two diodes and an inside tapped transformer, or four diodes in a bridge arrangement and any AC source (checking a transformer without focus tap), are required.

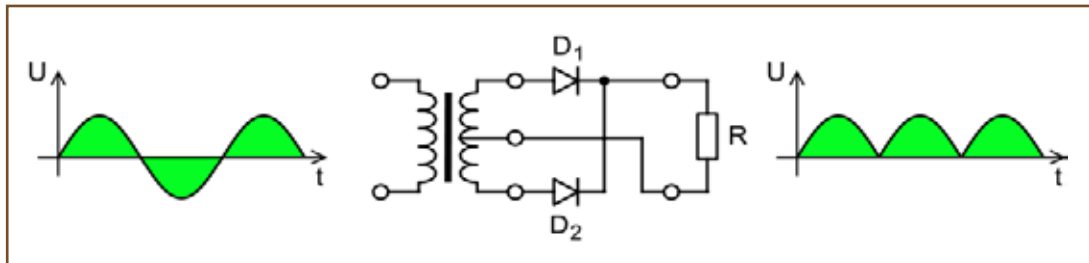


Fig 2.2.31 Full-wave rectifier

- **Single-Phase AC:** If the transformer is center tapped then two diodes can shape a full-wave rectifier. Four diodes arranged in a bridge are required if there is no inside tap.
- **Three-Phase AC:** Three sets of diodes are generally used

2.2.12 Battery

A battery is a device which converts chemical energy into electrical energy. Batteries can be found in various sizes. A battery might be as little as a shirt button or might be so large can cover an entire room. With this variety of sizes, the battery is utilized anywhere from little wrist watches to a vast ship.

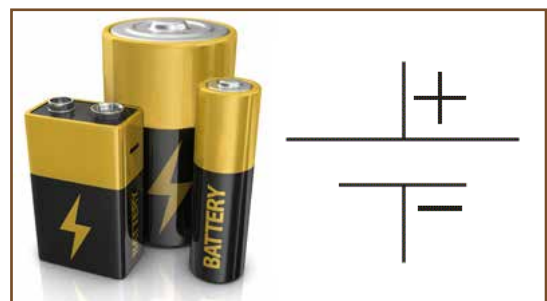


Fig 2.2.32 Battery and its symbol

In battery symbol, the long line is the positive terminal of the cells and small line is the negative terminal of the cells associated in the battery.

How batteries work?

There are three areas in batteries, an anode (-), a cathode (+), and the electrolyte. The cathode and anode (the positive and negative sides at either end of a standard battery) are trapped to an electrical circuit..

The chemical responses in the battery causes a development of electrons at the anode. This outcomes in

an electrical distinction between the anode and the cathode. The electrons need to revamp themselves to dispose of this discrepancy. Be that as it may, they do this in a particular manner. Electrons repulse one another and attempt to go to a place with less electrons.

In a battery, the principle place to go is to the cathode. Regardless, the electrolyte shields the electrons from going straight from the anode to the cathode inside the battery. Right when the circuit is closed (a wire relates the cathode and the anode) the electrons will have the ability to get to

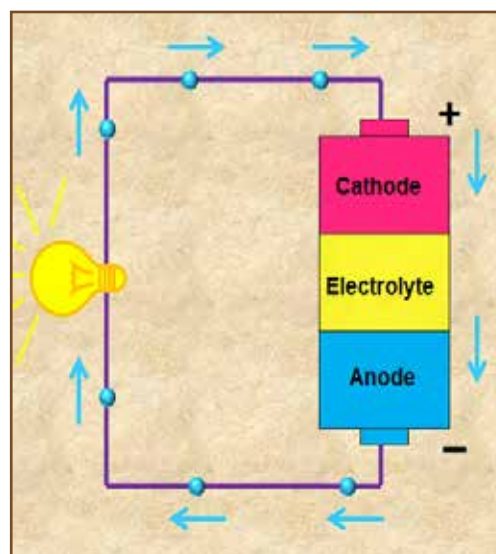


Fig 2.2.33 Working of battery

the cathode. In the photograph over, the electrons encounter the wire, lighting the bulb in transit. This is one strategy for delineating how electrical potential makes electrons course through the circuit.

In any case, these electrochemical systems adjust the chemicals in anode and cathode to make them quit giving electrons. So there is a limited measure of vitality available in a battery.

When you restore a battery, you adjust the course of the stream of electrons using another power source, for example, sunlight based boards/solar panels. The electrochemical procedures occur backward, and the anode and cathode are reestablished to their unique state and can again give full power.

Batteries are classified into primary and secondary forms:

- **Primary batteries** irreversibly change chemical energy to electrical energy. Right when the supply of reactants is drained, energy can't be instantly restored to the battery.
- **Secondary batteries** can be energized; that is, they can have their synthetic reactions pivoted by giving electrical energy source to the cell, generally restoring back to their starting organization.

2.2.13 Power Supplies

A power supply is an electronic device that arrangements electric energy to an electrical load. The fundamental limit of a power supply is to change more than one sort of electrical energy to another and, subsequently, control supplies are as a less than dependable rule implied as electric power converters. Some power supplies are different, stay single devices, while others are joined with greater devices nearby their loads. All power supplies have a power input, which gets energy from the energy source, and a power yield that passes on energy to the load.

A DC Power Supply Unit (typically called a PSU) getting power from the AC mains (line) supply plays out different endeavors:

1. It changes (by and large diminishes) the level of supply to an esteem appropriate for conveying the load circuit.
2. It creates a DC supply out of the mains (or line) supply AC sine wave.
3. It shields any AC from appearing at the supply yield.
4. It will ensure that the yield voltage is kept at a consistent level, independent of changes in:
 - a) The AC supply voltage at the supply input.
 - b) The Load current drawn from the supply yield.
 - c) Temperature.

The fundamental building blocks of a directed dc control supply are as per the following:

1. Step down transformer
2. Rectifier
3. DC filter
4. Regulator

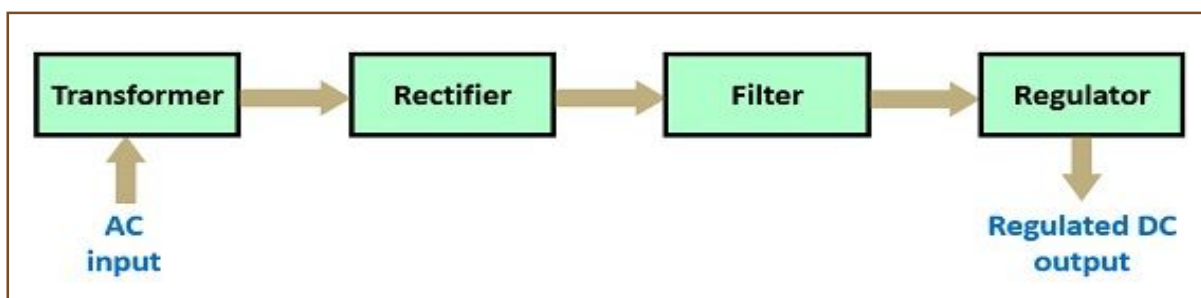


Fig 2.2.34 Power supply block diagram

Operation of regulated power supply

1. **Step down transformer:** A phase down transformer will wander down the voltage from the ac mains to the important voltage level. The turn's extent of the transformer is so adjusted, for instance, to get the required voltage esteem. The yield of the transformer is given as a commitment to the rectifier circuit.
2. **Rectification:** Rectifier is an electronic circuit involving diodes which finishes the amendment/correction methodology. Correction is the route toward changing over a substituting voltage or current into comparing direct (DC) sum. The contribution to a rectifier is AC however its yield is unidirectional throbbing DC. Regularly a full wave rectifier or a bridge rectifier is used to correct both the half cycles of the ac supply (full wave rectfication).
3. **DC filtration:** The amended voltage from the rectifier is a throbbing DC voltage containing great measure of ripple substance, along these filter is used. Various sorts of filters are used, for instance, Choke input filters, π type filter, capacitor filters , LC filters.
4. **Regulation:** This is the last piece in a managed DC control supply. The yield voltage or current will change or shift when there is change in the commitment from ac mains or due to advance in stack current at the yield of the directed power supply or in view of various factors like change in temperature. This issue can be wiped out by using a regulator. A regulator will keep up the yield enduring despite when changes at the information or some different changes happen. Transistor arrangement controller, Fixed and variable IC controller or a zener diode worked in the zener region can be used depending upon their applications.

Power supply applications

- Computer power supply
- Electric Vehicle power supply
- Welding power supply
- Aircraft power supply
- AC adapter

2.2.14 Switch Mode Power Supply

Switch-mode control supply is the electronic power supply facilitated with the switching regulator for changing over the electrical power capably beginning with one shape then onto the following casing with favored characteristic. It is used to get directed DC yield voltage from unregulated AC or DC input voltage.

Switch mode power supply

Like other power supplies, switch-mode control supply is a puzzled circuit that arrangements control from a source to loads.

Not in any manner like a direct power supply, the pass transistor of a trading mode supply incessantly switches between low-dissipation, all out and full-off states, and puts beside no time in the high dissipation transition, which limits wasting of energy.

Most of electronic DC loads are given from standard power

sources. Shockingly, standard source voltages may not be equivalent to the levels required by chip, motors, LEDs, or different burdens, especially when the source voltage is not controlled. Battery-filled devices are prime instances of the issue: the ordinary voltage of a standard Li+ cell or NiMH stack is either too high/low or drops too far in the midst of discharge to be used as a piece of standard applications.

Advantages and disadvantages

- The principle preferred standpoint of the exchanging power supply is more noteworthy effectiveness than linear regulators in light of the fact that the switching transistor disperses little power when going about as a switch.
- Other preferences incorporate littler size and lighter weight from the end of overwhelming line-frequency transformers, and similar heat produced. Standby power misfortune is frequently a great deal not as much as transformers.
- Disadvantages incorporate more prominent multifaceted nature, the era of high-adequacy, high-frequency energy that the low-pass filter must restrict to maintain a strategic distance from electromagnetic interference(EMI), a ripple voltage at the switching frequency and the harmonic frequencies thereof.
- Very minimal effort SMPSS may couple electrical switching clamor back onto the mains control



Fig 2.2.35 SMPS

line, causing impedance with A/V hardware associated with a similar stage. Non-power-factor-amended SMPSs additionally cause harmonic mutilation.

2.2.15 Resistor

The first and most normal electronic segment is the resistor. There is for all intents and purposes no working circuit I am aware of that and doesn't utilize them, and few viable circuits can be assembled utilizing nothing else. There are three primary parameters for resistors, yet just two of them are regularly required, particularly for strong state electronics.



Fig 2.2.36 Resistor

- **Resistance** - the estimation of resistance, estimated in Ohms. This is the essential parameter, and decides the present stream for any connected voltage.
- **Power** - The measure of power the resistor can deal carefully. Expansive resistors (physically) for the most part have a higher power rating than little ones, and this is constantly determined by the manufacturer. Abundance power will make the resistor overheat and bomb, regularly in a stunning way.
- **Voltage** - Rarely indicated, however this is the most extreme voltage that may show up over a resistor. It has nothing to do with power rating, which might be surpassed at evaluated voltage. It is a measure of the most extreme voltage that may show up over any estimation of resistance for this style with no breakdown.

The resistance value is indicated in ohms, the standard representation is "R" or Ω .

Representation of  resistor is

The tolerance of resistors is mostly 1%, 2%, 5% and 10%.

Functions of resistor

The primary capacity of resistors in a circuit is to control the stream of current to different segments. Take a LED (light) for instance. In the event that an excessive amount of current courses through a LED it is annihilated. So a resistor is utilized to confine the current.

At the point when a current moves through a resistor energy is squandered and the resistor warms up. The more noteworthy the resistance the more burning it gets. The battery needs to do work to drive the electrons through the resistor and this work winds up as warmth energy in the resistor.

The rule by which resistors work can likewise be connected to warming components in irons, toasters, heaters, electric stoves and hair dryers, which disperse voltage as heat. Variable resistors may work as sensors, switches or voltage dividers.

2.2.16 Capacitor

Capacitors are parts that can store electrical pressure (Voltage) for drawn out stretches of time. At the point when a capacitor has a distinction in voltage (Electrical Pressure) between its two leads it is supposed to be charged. A capacitor is charged by driving a one way(DC) current to move through it for a brief time frame. It can be released by letting an inverse direction current flow out of the capacitor.



Fig 2.2.37 Capacitor

Capacitors are appraised in Farads, and the standard image is “C” or ‘F’, contingent on the specific situation. The unit of estimation for capacitance is Farad however this unit is much too huge for viable work. It is typically measured in microfarads (uF) or picofarads (pF).

Sign of capacitor is 

The tolerance of the majority capacitors is commonly 10%, however by and by it is normally superior to that. Close tolerance kinds (e.g. 1%) are accessible; however they are generally quite costly.

Polarity of capacitors

- The negative side has got shorter terminal.
- The negative terminal side of the capacitor has as trip.
- The board is set apart for positive or negative.

Functions of capacitor

Functions of capacitor in electronic circuits are as follows:

- Storing electrical energy.

- Avoid stepping over the electric circuit which are using coil like power supply, adapter, lamps etc.

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

2.2.17 Inductor

An inductor is most generally a coil, yet in actuality, still a straight bit of wire has inductance. Winding it into a coil basically focus the magnetic field, and expands the inductance impressively for a given length of wire. In spite of the fact that there are some extremely regular inductive segments, they are not frequently utilized as a part of sound. Small inductors are some of the time utilized as a part of the yield of power amplifiers to counteract precariousness with capacitive loads.



Fig 2.2.38 Inductor

An inductor can be viewed as the inverse of a capacitor. It passes DC with little resistance, however turns out to be a greater amount of an impediment to the signal as frequency increments.

There are various diverse images for inductors, and three of them are demonstrated as follows. To some degree unreasonably maybe, I utilize the “standard” image more often than not, since this is what is bolstered best by my schematic drawing package.

Inductance is measured in Henrys (H) and has the image ‘L’. The average range is from a couple of smaller scale Henrys up to at least 10h. In spite of the fact that inductors are accessible as segments, there are barely any traditions as to values or markings.

Sign of inductor is 

Inductance Materials

The most widely recognized winding material is copper, and this might be bolstered on a plastic bobbin. Iron or ferrite cores might be toroidal (molded like a ring), or can be in the customary EI (ee-eye) design.

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 inductor increments as the frequency of signal increments. At the point when consolidated with a capacitor, whose impedance diminishes as the frequency of signal increments, a notched filter can be made that lone 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 frequency from a combined signal. They are also used in electronic oscillators to produce sinusoidal signs.
- Transformer is formed by coupling flux using inductors of different number of turns and is used in power transmission systems
- Inductors restrict exchanging currents /fault currents. This is why they are used in electrical transmission systems and are alluded as reactors

2.2.18 Diode

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



Fig 2.2.39 Diode and its symbol

- A Device which allows the current to flow in one direction and restricts the current in other direction is called diode. It has two leads
- A diode is formed by combining n-type and p-type silicon. 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 p-side's voltage is higher than that of n-side. The arrowhead in figure points in the direction of conventional current flow.

Functions of diode

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

Diode Applications: Diodes are utilized as a part of building AC to DC Power Supply, rectifier, Diode Gates, Diode Clamp, Limiter.

2.2.19 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

Electronic sign of LED is 

Advantages of LED's

- Very low voltage and current is adequate to drive the LED.
- Voltage ranges from 1 to 2 volts.
- Current ranges from 5 to 20 milliamperes.
- Total power yield will be under 150 milliwatts.

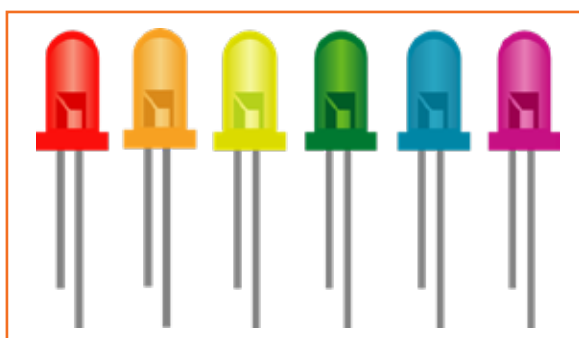


Fig 2.2.40 Light emitted diode (LED)

- The reaction time is less – just around 10 nanoseconds.
- The device does not require any warming and warm up time.
- Miniature in dimension and henceforth light weight.
- Have a rough structure and thus can withstand stun and vibrations.
- An LED has a life expectancy of over 20 years.

Disadvantages

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

Function of LED

Four important functions are:

- LEDs are used in signaling systems like traffic signals road direction 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

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 humans and are used in remote controls. They can be used in optical disconnection of higher voltage framework from low voltage circuits

2.2.20 Transistors

A transistor is a three-terminal gadget in which a voltage connected to one of the terminals (called the base) can control current that streams over the other two terminals (called the collector and the emitter). The transistor is a standout amongst the most vital gadgets in electronics

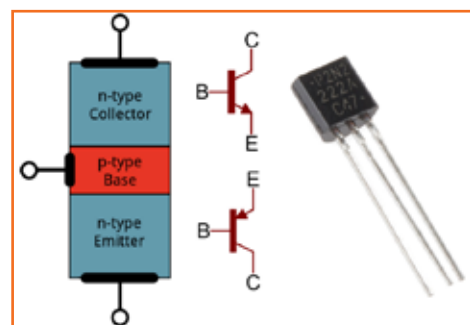


Fig 2.2.41 Transistor

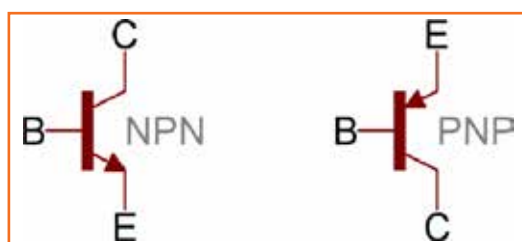


Fig 2.2.42 Type of transistor

In figure shown there are three legs. B is base, C is collector and E is emitter

Outward arrow on emitter side is indication of NPN transistor and inward arrow on emitter side is indication of PNP transistor.

Operation Modes

They can operate in four modes, which are

- **Saturation** – In which current flows from collector to emitter like in a short circuit
- **Cut-off** – It acts like an open circuit by preventing current from collector to emitter
- **Active** – In this case collector current (collector to emitter) is proportional to base current

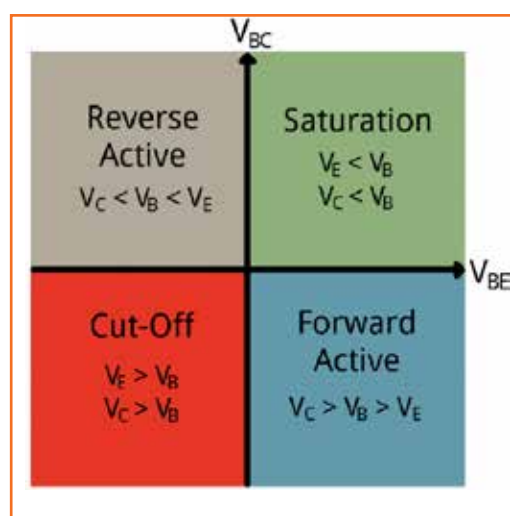


Fig 2.2.43 Diode operation modes

- **Reverse-Active** – A backward current proportional to base current (flowing into base) flows from emitter to collector

The transistor's mode can be changed by changing voltages from base to emitter (V_{BE}) and from base to collector (V_{BC})

Functions of a transistor

A transistor is a semiconductor with a strong and non-moving part to pass a charge. It can increase and switch electrical power and electronic signals.

Applications of transistor

The transistor as an amplifier

1. As the base current decides the much larger collector current in active mode the transistor is used to amplify the signals by supplying small signals like microphone output at the base
2. Sound waves that are encouraged into the microphone make the diaphragm in the microphone

to vibrate.

3. The electrical yield of the microphone changes as per the sound waves.
4. As an outcome, the base current is differing as a result of the little rotating voltage delivered by the microphone
5. A little change in the base current causes an extensive change in the collector current.
6. The changing authority current streams into the loudspeaker. There, it is changed into the sound waves relating to the original sound waves.
7. The frequencies of both waves are proportionate however the plentifulness of the sound wave from the loudspeaker is higher than the sound waves bolstered into the microphone.

The transistor as switch

1. In a transistor, no current can stream in the collector circuit unless a current streams in the base circuit. This property enables a transistor to be utilized as switch.
2. The transistor can be switched on or off by altering the base.
3. There are a couple of sorts of exchanging circuits worked by transistors.
 - (a) Light-Operated Switch
 - (b) Heat-operated switch

2.2.21 Integrated Circuit (IC)

An arrangement of electronic circuits on one little plate of semiconductor material, regularly silicon is called an integrated circuit or monolithic integrated circuit. This can be made substantially littler than a discrete circuit produced using independent electronic parts.

An integrated circuit (IC), some of the time called a chip or microchip, is a semiconductor wafer on which thousands or a great many modest resistors, capacitors, and transistors are manufactured. An IC can work as an intensifier, oscillator, clock, counter, PC memory, or microprocessor.

The capacity of an incorporated circuit (IC) is to be a solitary segment that can perform abnormal state



Fig 2.2.44 Integrated Circuit

errands, for example, amplification, signal processing, or even advanced computerized calculations as on account of microprocessors. Barely any electronic circuits don't utilize an IC or a chip or microchip. Besides, the capacity of a coordinated circuit incorporates miniaturization, cost lessening, and execution improvement among others.

2.2.22 PCB (Printed Circuit Board)

A printed circuit board (PCB) is a flat plate or base of insulating materials that contains a pattern of conducting material and components. PCB provides mechanically support and electrically connect electronic components using conductive pathways, tracks usually etched from copper sheets laminated onto a non-conductive substrate. Components are fixed in position by drilling holes through the board, locating the components and then soldering them in place.

Different kinds of PCBs available are:

1. Double / Single Sided
2. Flexi
3. High Layer Count Multilayer
4. Controlled Impedance
5. Microwave and RF
6. Aluminum backed PCBs

Single sided PCB:

Single-sided PCB are usually a single layer of copper on a rigid base material.

This type of PCB can be used for both through hole and SMD components

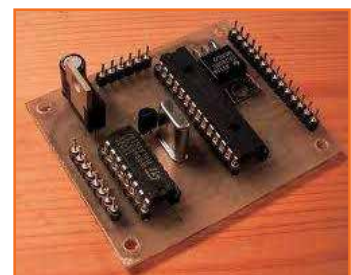


Fig 2.2.45 Single sided PCB

Double sided PCBs:

It consist of two copper layer on a base material, the two copper layers are not connected. This type of PCB can also be used for both through hole and SMD components. Usually they are connected through vias.

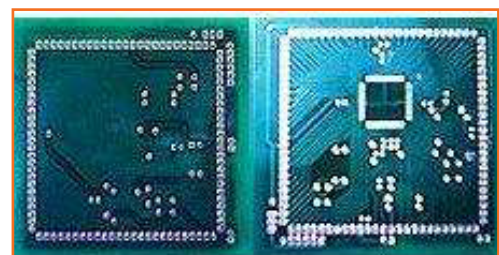


Fig 2.2.46 Double sided PCBs

Flexible PCBs:

Flexible PCB's are being used where flexibility matters in a large number of different applications

Advantages of flexible PCBs are as follows

1. Solving interconnecting problems
2. Reduction of weight
3. Reduction of space and reduced assembly costs.

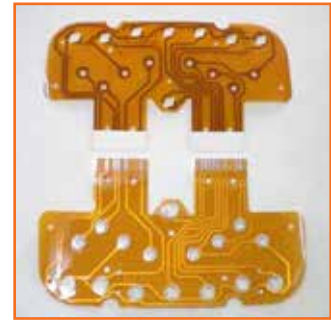


Fig 2.2.47 Flexible PCBs

Applications include:

- Dynamic flexing applications like in slide mobile phones etc.
- Flexing or stress over a period of time at elevated temperatures.

Multi-layer PCB:

In multi-layer PCBs we would be having multi traces on a substrate or a clad. The multilayer PCB is also very useful in high-speed circuit. The multi-layer PCB can provide more space for the conductor pattern and power.

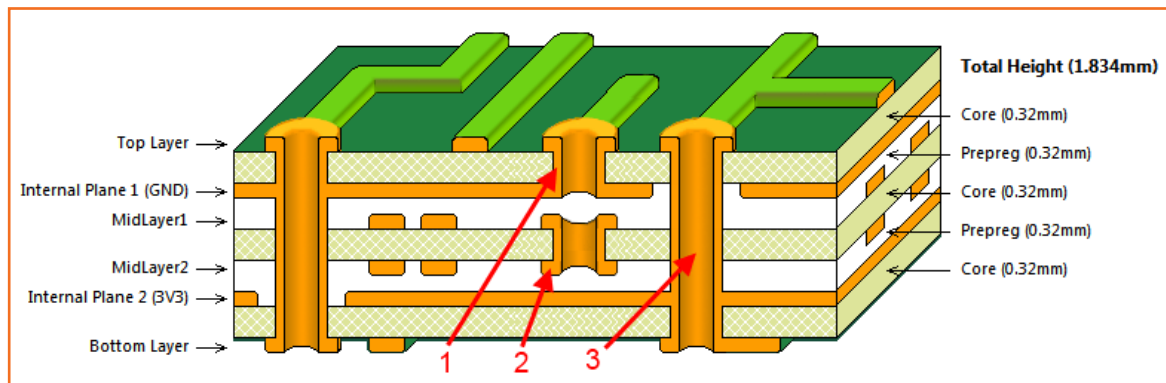


Fig 2.2.48 Multi-layer PCBs

Controlled Impedance printed circuit boards

These are used across a broad range of applications to help ensure high signal integrity. PCB traces need to be considered not as simple connections but as transmission lines.

The impedance of a PCB trace is controlled by its configuration



Fig 2.2.49 Controlled Impedance printed circuit boards

- Dimensions (trace width and thickness and height of the board material)
- Dielectric constant of the board material

Aluminium Backed PCBs

Aluminium backed PCB's are now being used in place of traditional PCBs for high power LED applications. This is due to rapidly changing developments in LED technology, with brighter more powerful LED's coming on to the market all most daily. This raised a problem to designers and PCB manufactures with larger amounts of heat being generated by the components to overcome this problem they developed aluminium backed PCBs.

Aluminium backed PCB with the use of thermally conductive pre-preg between the copper and the aluminium the thermal performance is 8–10 times better than a normal PCB.

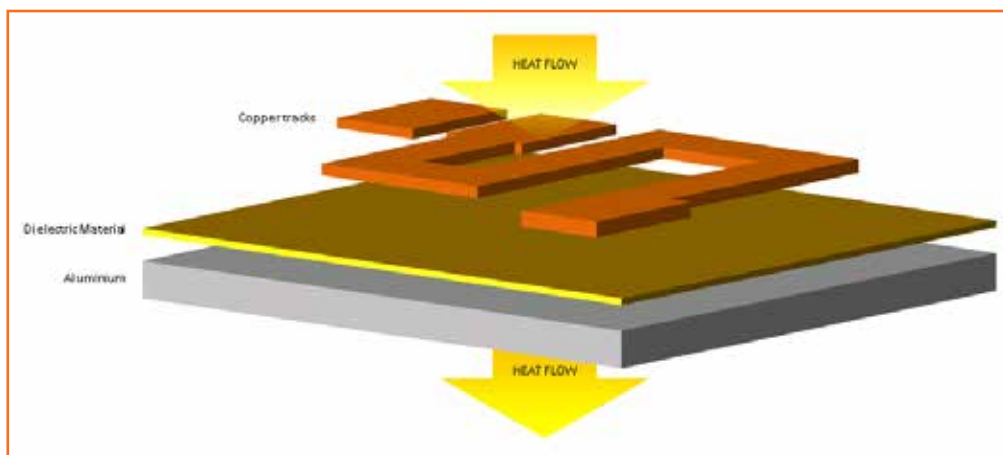


Fig 2.2.50 General composition of an Aluminium single Sided PCB (SMI)

RF and microwave PCBs

Usually RF and microwave PCB need to be designed where Dielectric Loss, Resistive Loss and Skin Effect are parameters, these Can be High at Frequencies Above 500 MHz. To prevent this we need to go for microwave PCBs.

2.2.23 Wires

Electrical wire is the medium through which electricity is carried to and through each individual home that uses electrical power. It is made of a metal that easily conducts electricity, usually copper, in a plastic sheath called an insulator. A wire is a single, usually cylindrical, flexible strand or rod of metal. Wires are used to bear mechanical loads or electricity.

Forms of wire

- **Solid wire:** Solid wire consists of one piece of metal wire. Solid wire is useful for wiring breadboards. Solid wire is cheaper to manufacture than stranded wire and is used where there is little need for flexibility in the wire
- **Stranded wire:** Stranded wire is composed of a number of small wires bundled or wrapped together to form a larger conductor. Stranded wire is more flexible than solid wire of the same total cross-sectional area. Stranded wire tends to be a better conductor than solid wire because the individual wires collectively comprise a greater surface area.
- **Braided wire:** A braided wire is composed of a number of small strands of wire braided together. Similar to stranded wires, braided wires are better conductors than solid wires. Braided wires do not break easily when flexed. Braided wires are often suitable as an electromagnetic shield in noise-reduction cables.



Fig 2.2.51 Solid wire



Fig 2.2.52 Stranded wire



Fig 2.2.53 Braided wire

Number of strands: The more individual wire strands in a wire bundle, the more flexible, kink-resistant, break-resistant, and stronger the wire becomes. However, more strands increase manufacturing complexity and cost.

2.2.24 Cables

An electrical cable is made of two or more wires running side by side and bonded, twisted, or braided together to form a single assembly, the ends of which can be connected to two devices, enabling the transfer of electrical signals from one device to the other. Cables

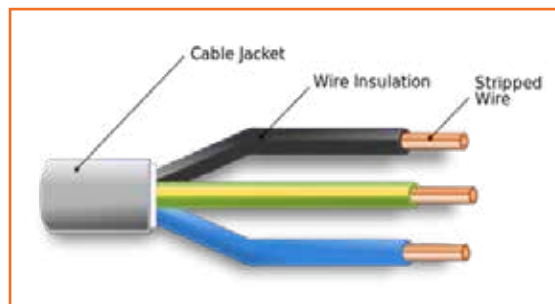


Fig 2.2.54 Parts of a cable

are used extensively in electronic devices for power and signal circuits. Electrical cables are extensively used in building wiring for lighting, power and control circuits permanently installed in buildings.

Electrical cable is an assembly consisting of one or more conductors with their own insulations and optional screens, individual covering(s), assembly protection and protective covering(s). Electrical cables may be made more flexible by stranding the wires. Power cables use stranded copper or aluminum conductors, although small power cables may use solid conductors.

The various parts of underground cables are as under

- a. Cores or conductors
- b. Insulation
- c. Metallic sheath
- d. Bedding
- e. Armoring
- f. Serving

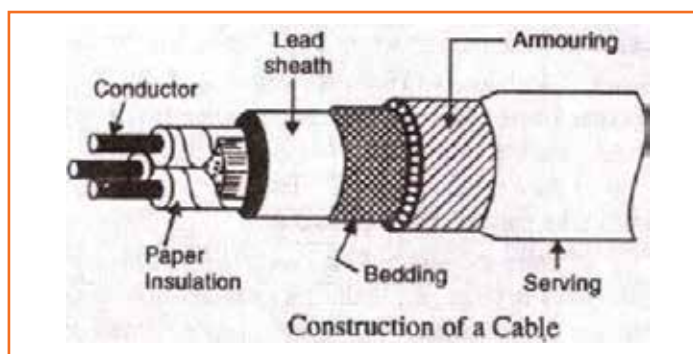


Fig 2.2.55 Parts of a cable

Classification of cables

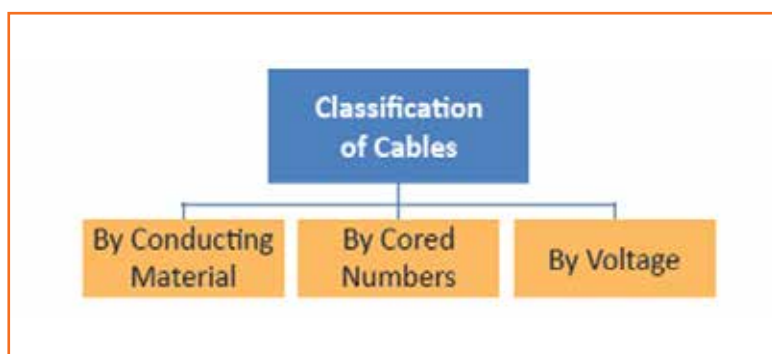


Fig 2.2.56 Classification of cables

By conducting material:

Based on conducting material, cables can be of two types:



Fig 2.2.57 Copper conductor cables



Fig 2.2.58 Aluminium conductor cables

By cored numbers:

Based on cored numbers, cables can be of six types:

- Single core cables
- Double core cables
- Double core with earthing wire cables
- Triple core cables
- Three and a half core cables
- Four core cable

By voltage:

Based on voltage, cables can be of two types:

- 250@440 V grade
- 650@1100 V grade

Types of Electrical Cables – For applications like transmission to expensive industrial utilization 15 types of cables are available today. Mostly used cables are:

- **Non-Metallic Sheathed Cable:** Used in underground or outside utilization and are having a plastic jacket covering two or four wire with an uncovered ground cable. on metallic building wire cable is the other name for this type cable.



Fig 2.2.59 Non metallic sheathed cable

- **Underground Feeder Cable:** They are used in open air wiring and for ground applications. Same as in non metal type wires are combined and fixed inside a flexible material .They can be used in gardens ,open air lights, water pumps etc because of water protection and are available in different wire sizes.



Fig 2.2.60 Underground feeder cable

- **Metallic Sheathed Cable:** Important devices /mains power can be provided with this type of cable. They have PVC outer sheath covers a PVC bedding contains three copper wires with plain strands. The purposes of wires are to carry current, neutral connection and establish wire. The wire insulation is made of cross-connected polyethylene. Another name of this cable is heavy clad or BX cable. For open air and high stress equipment steel wire sheathed cable is used.

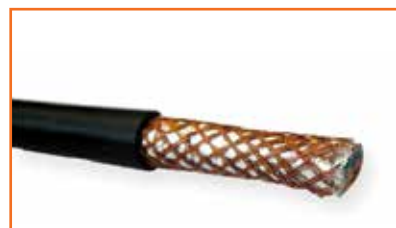


Fig 2.2.61 Metallic sheathed cable

- **Multi-Conductor Cable:** With an external protection they consist of multiple cores/wires and because of well insulation can be used in homes, audio cable, etc.



Fig 2.2.62 Multi conductor cable

- **Coaxial Cable:** Used in TV and interfacing video signal transmission system .They have an external sheath over a conductor shield which is covering a protection layer of conductor running axially.



Fig 2.2.63 Co-axial cable

- **Unshielded Twisted Pair Cable:** They contain pairs of wire that are twisted together. Signal transmission and video applications are possible using this type cable since the wires aren't protected. They are also used in telephones, surveillance camera and information systems. To use in in wall installation cables with strong copper cores are preferred because of flexibility.

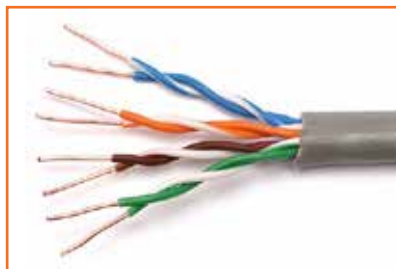


Fig 2.2.64 Unshielded twisted pair cable

- **Ribbon Cable:** They have conducting wires attached together to form a flat surface like a ribbon and are useful in low voltage devices like in PC to connect Processor and its peripherals etc.
- **Direct-Buried Cable:** Because of its large metal center with many layers of metal strip sheathing, thick rubber covers, presence of shock absorbent gel, water proof wrapped thread fortified tape they are used as coaxial fiber optic cables types that are buried underground without any additional protection. Transmission or correspondence applications can use this cable due to high temperature resistance, dampness and other environmental components.
- **Twin-Lead Cable:** They are used in TV/radio to connect antenna to receiver and comprise of two conductor wire inside an insulated covering.
- **Paired Cable:** DC or low recurrent AC appliances use this type cable with two independently insulated conductors,



Fig 2.2.65 Ribbon cable



Fig 2.2.66 Direct buried cable



Fig 2.2.67 Twin-lead cable



Fig 2.2.68 Paired cable

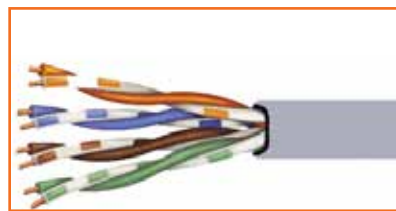


Fig 2.2.69 Twisted pair cable

- **Twisted Pair:** They contain paired wires that are twisted together

Cable Color Code – Active, neutral and earth conductors are decided by cable insulation colour coding and are different in different nation/area like district. Green/yellow, light blue/red or black can't be the color of active conductors.

Cable Size – The conductor cross sectional area /gauge is called cable size. It is mentioned like 10,12 etc. Cable size labeled 10/3 means 3 wires of size 10 .G is used to indicate ground wire.

Cables must be used instead of wires since they give more protection from accidents like shortage, fire etc.

2.2.25 Fiber Optic Cables

An optical fiber cable is a cable containing one or more optical fibers that are used to carry light. The optical fiber elements are typically individually coated with plastic layers and contained in a protective tube suitable for the environment where the cable will be deployed.

A fiber optic cable comprises of a heap of glass strings, each of which is equipped for transmitting messages regulated onto light waves.

Advantages of fiber optic cables are

- More data transfer capability than conventional cables
- Normally there will be less obstructions to fiber optic cable than copper cables.
- They are not heavy and big like copper cables .So easy to handle them.
- Fiber optic cables can carry digital data , which makes them a suitable part of latest communication systems



Fig 2.2.70 Fiber optical cable

Disadvantages are the joining of fiber optic cable is difficult, more subtle and costly than copper cable

Types of fiber-optic cables

There are different ways of transferring signal through fiber optic cables, which are known as modes and are explained below

1. **Single mode fiber** – In this straight travelling occurs for signal without touching edges and is available as large wrapped package. Their diameter is five to ten micron. 100 km is the signal transfer capability of single mode fiber and used as Digital TV cable, Internet cables, and phone cables.
2. **Multi mode fiber** – In this type light rays can travel in different ways by continuously getting reflected by the edge of fiber as in figure and their fibers are 10 times better than single mode type, at the end of the day, in numerous diverse mode. Multi-mode cable can send data generally for short distances and are utilized (in addition to other things) to connect PC networks together.

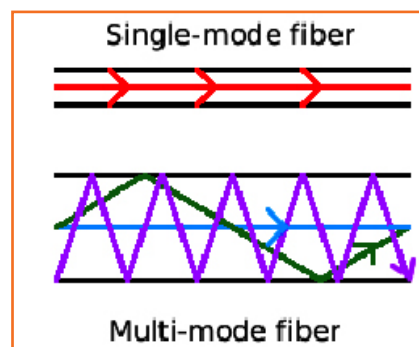


Fig 2.2.71 Fiber optical modes

Glass/plastic are used to construct the optical fiber, because of extraordinary attribute and discover utilization as a part of altogether different applications. Short distance communication use plastic type

and short/medium multimode and long single mode (media communication) use glass fiber.

Color coding

Color code, utilized as a part of fiber optics, looks like that of copper. The significant distinction is 12-Color succession as restrict to 10-Color for copper. The series of color is the same, with expansion of two Color i.e. Rose (11th) and Aqua (12th)

Fiber color codes in free tube cables, this color code will be utilized for tubes and in addition to fibers inside the tubes and subgroups.

For cables that comprise of more than 12 strands, the color code rehashes itself. Each gathering of 12 strands is related to some different means, for example:

- Multiple buffer tubes each with 12 or less strands either numbered or colored after a similar color code, e.g., first tube is blue, second is orange, and so on.
- 24 strands bunches with the color code rehashing with some disparity, e.g., the first gathering of 12 strands are solid colors and the second gathering are solid colors with a stripe or some other distinguishing mark.

TUBE (OR FIBER) NUMBER	COLOR
1	Blue
2	Orange
3	Green
4	Brown
5	Slate
6	White
7	Red
8	Black
9	Yellow
10	Violet
11	Pink (Rose)
12	Aqua

Fig 2.2.72 Fiber optic modes color codes

Fiber optic cable jacket and connector color

Color Coding of Premise Fiber Cable		
Fibre Type/Class	Diameter	Jacket Color
Multimode 1a	50/125	Orange
Multimode 1a	62.5/125	Slate
Multimode 1a	85/125	Blue
Multimode 1a	100/140	Green
Multimode IVa	All	Yellow
Multimode IVb	All	Red

Table 2.2.1 Fiber optic cable jacket and connector color

For open aerial and burial kind cable, the jacket color is typically black polyethelene for both multimode and single-mode cables to avoid UV radiation harm.

For indoor cables, the external most fiber cable jacket might be of any color however the true business standard is:

- Multimode fibers as Orange
- Single-mode fibers as Yellow

This is additionally by and large valid for fiber optic patch cords.

2.2.26 Connectors

An electrical connector is an electro-mechanical gadget used to join electrical terminations and make an electrical circuit. Electrical connectors comprise of plugs (male-ended) and jacks (female-ended). The connection might be transitory, concerning compact equipment, require a device for gathering and evacuation, or fill in as a changeless electrical joint between two wires or gadgets.

Electrical connectors are described by their pinout and physical development, size, contact resistance, insulation between pins, roughness and imperviousness to vibration, imperviousness to entry of water or different contaminants, imperviousness to pressure, reliability, lifetime, and simplicity of connecting and disconnecting



Fig 2.2.73 USB Connectors

. It is normally alluring for a connector to be anything but difficult to recognize visually, fast to gather, require just straightforward tooling, and be cheap.

Commonly used connectors

1. **USB Connectors:** Host and peripheral are the two types of USB connectors. In USB, there is a contrast between the cable connectors and devices. **Molded strain relief** – To reduce the damage of electrical connection USB cables are having flexible over-trim at connector.

USB-A connector- They are a marginal male connector which we can find in USB cable ends of keyboard, mouse etc and also at the end of USB drive which are peripheral devices of PC

USB-B Connector- It is solid and cumbersome than USB A connector and used in peripherals where greatest unwavering connection is required and space is not limited. Both panel and board mounted types are available.

Audio Connectors

Another well-known connector bunch is those utilized for varying audio-visual applications. Even if they cannot be considered in same family lets view them as similar elements

2. **Phone type connectors:** The connector that is found at the end of ear phones with size 1/8 inch (3.5mm), 1/4 inch (6.35 mm), 2.5 mm. Mostly used types are 1/4 inch size that we can find in electric guitars/amplifier tip sleeve jack. To additionally incorporate an amplifier for hands-free communications some phones uses 2.5mm TRRS (tip ring sleeve) jack for associating with earphones.



Fig 2.2.74 Audio Connector

3. **RCA Connectors:** RCA RCA connectors are normally found on gadgets. Using female jacks we can expand their length/ transform them and are used in component video cable, composite video cable and also as stereo audio cable. These



Fig 2.2.75 RCA Connector

types of connectors are generally found on cables.

Power Connectors

While numerous connectors convey control notwithstanding information, a few connectors are utilized particularly to give power connections with gadgets and they vary from device to device in size and shape. The basic ones are

4. **Barrel Connectors:** Ordinarily present in minimal effort customer gadgets which can be connected to divider control by means of cumbersome AC wall connectors.

In spite of the fact that there are numerous techniques for appending the attachment to the end of the wire, this type is used in wire terminations.



Fig 2.2.76 Barrel Connector

Barrel connectors give just two associations, every now and again alluded to as “joint” or “tip” and “sleeve”

5. **“Molex” Connectors:** Molex connectors can handle high power and are used to supply power to PC peripherals like hard disc, CD drive, mother board and also to supply power to 3D printing machine, CNC machine etc from PC power supply .



Fig 2.2.77 Molex Connector

These have male/female pins inside plastic shell connected at the end of link. Frequent attachment and detachment is possible with these type connectors which require them to be of good quality and are very tight and squeeze fit type.

6. **IEC Connector:** In desktop PC power supply cables we can find this connector and are used for AC input only. In most global area local wall plugs are suitable to connect to IEC PC to wall cables.



Fig 2.2.78 IEC Connector

7. **Pin Header Connectors:** Pin header connectors include a few unique methods for attachment. They are either parallel or vertical to the PCB and have a series of pins either in one or multiple rows on connector which is

firmly connected to a PCB. They are available in a variety types. The connectors are either attached with individual wires by crimping connector or with ribbon cable. Ribbon cables can be connected by using such male and female connectors. The cables are generally having a female connector which can be connected to male connector.



Fig 2.2.79 Pin header Connector



Fig 2.2.80 (A) Six-position crimp-type cable (B) Insulation displacement connectors (IDC)

Temporary connectors

8. **Screw Terminals:** Sometimes, it might be alluring to have the capacity to associate uncovered, un-terminated circuit wire. To connect miscellaneous interfacing devices this connectors are useful.

The issue of connection of little wire can be solved with this connector. They can without much of a stretch be reached out at a similar pitch by basically interfacing at least two smaller sections together and thus they can be said to be modular.



Fig 2.2.81 Screw terminal

9. **Banana Connector:** They are extremely straightforward connectors called banana jack and used in test devices like multimeter, power supply etc. hardware (multimeter, power supplies). Banana plugs crimped sprung metal plugs are used to connect to this type of connector. They are as often as possible accessible in a stackable design and can be effortlessly attached with a wire. They are equipped for conveying a few amps of current and are reasonable.



Fig 2.2.82 Banana Connector

10. Alligator Clip: Alligator clips are useful for test associations with posts or exposed wires. They have a tendency to be cumbersome, effortlessly make shorts to adjacent uncovered wire, and weak holding capacity. For trouble shooting and temporary connection they are used.



Fig 2.2.83 Alligator clips

11. Ring and spade terminals: The connectors appeared in picture are known as ring terminals and spade terminals.

Electrical contact is made by the level surface of the ring or spade, while mechanically they are joined by passing a screw or fastener through them. The spade terminal frame figure encourages attachments since the screw or fastener can be left mostly screwed as the spade terminal is evacuated or connected.



Fig 2.2.84 Ring and spade terminals

2.2.27 Fasteners

A fastener is an equipment gadget that mechanically joins or appends at least two objects together.

Mechanical fasteners for electrical products come in three classifications:

1. One manages with threaded inserts for plastic. These hold plastic cases to metal boards or to other plastic parts.
2. Other nibbles into metal sheets, for example, panels and chassis. Since the primary employment of these fasteners is to hold parts together, they depend essentially on mechanical properties.
3. But a third sort of fastener depends likewise on its oxidation resistance and electrical properties, for example, fasteners and nuts that interface strong bus bars or tightens to wires in terminal strips.

Threaded inserts for plastics: Threaded inserts for plastics appears in three styles. Ultrasonic tools put in one type, other cast straight in the plastic, and the third press fits into an already present hole. Ultrasonic tools create high-frequency vibrations that warmth the plastic-to-insert interface and soften the plastic.

The plastic streams into the insert's knurled serrations, barbs, and undercuts, and afterward re-sets holding the embed set up. Ultrasonic establishment gives higher torsional and pullout powers than cool press-fit techniques.

Ultrasonic inserts for plastics are additionally characterized into three sorts. One fits narrow holes for fast and precise arrangement. Another fits straight-walled holes, where a unique lead-in helps position. The third is a symmetrical insert which introduces in either a straight or tapered hole and needs no unique introduction.

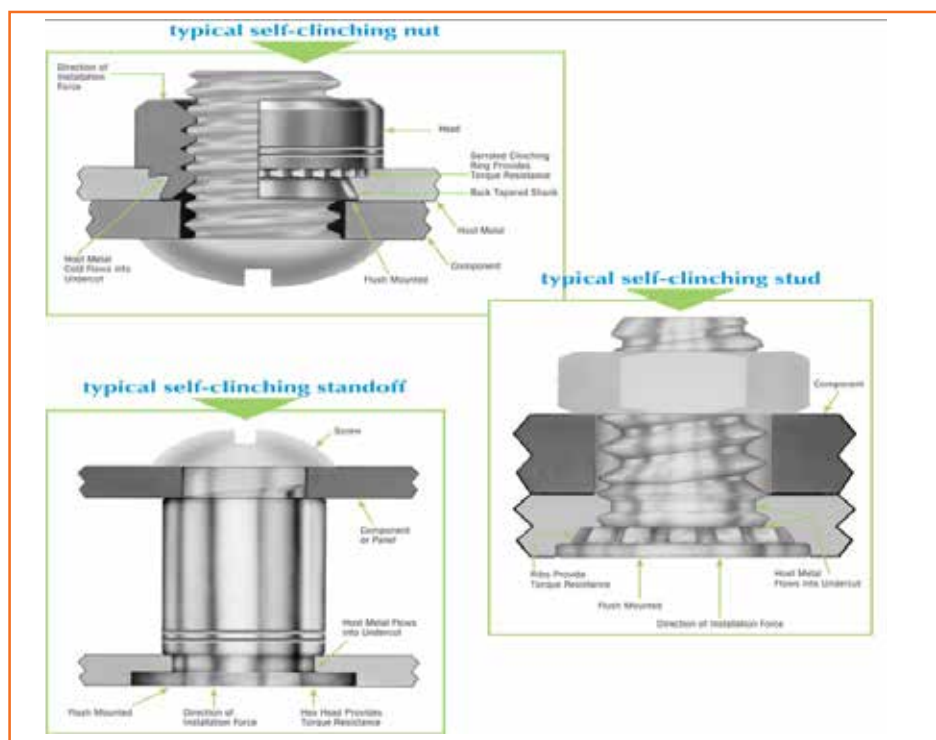


Fig 2.2.85 Self clinching threaded fasteners

Self-clinching fasteners are likewise broadly utilized for electronics items. They are normally strung and press into flexible metal or circuit sheets. The circuit-board material uproots around the mounting gap, and the metal icy streams into a space around the fastener's shank. A knurl, rib, or hex head keeps the fasteners from turning in place.



Fig 2.2.86 Self clinching fasteners

Self-securing clasp require less space and less assembly sequence than conventional fasteners, for example, anchor nuts. They join sheet metal and different thin materials where different fasteners could

haul out or hand over place under torque. Self-clinching fasteners are reusable, and they hold more tightly than sheet-metal screws.

Electrical fasteners normally utilize nonferrous parts to anticipate electrolytic decay and rust. Electrolytic corrosion grows involving copper channels and steel combinations in sticky climates, and rust brings down electrical conductivity and can pluck screws. Subsequently, top notch clamping parts are generally made of brass while screws are high-tensile copper alloys.



Fig 2.2.87 Electrical fasteners

Scan the QR code or click on the link to watch related videos



www.youtube.com/watch?v=vZ1m_kOxEvo

Electronic components

UNIT 2.3: Tools and Measuring Instruments Required

Unit Objectives

At the end of this unit, participants will be able to:

1. List different tools and measuring instruments required during work
2. Demonstrate use of tools and measuring instruments required during work

2.3.1 Tools and Measuring Instruments Required

Tool	Use	Image
Screwdrivers	Screw driver is a tool used for driving in or removing a screw. To use a screwdriver: • Choose the correct size and tip of the screw driver, so that it fit into fastener's head easily. • If required make a starter hole by drill or pressing the tip into object. • Insert tip of screwdriver into the screw head and turn its handle clockwise direction, then apply pressure over the handle so that tip can inserted into the handle properly. • Continue turning the screwdriver firmly and check that that screw is in straight position while inserting in the material.	
Pliers • Combination • Slip joint • Side cutters • Long nose	Pliers are used for gripping, twisting and cutting wires. To use pliers: • Determine the type of pliers required. • Make any adjustments if required for slip joint • Adjust locking pliers before using. • Press the handles of plier and close its jaws for holding the object. • To turn the object, rotate the tool as required. • Keep the fingers away from the jaws for safety.	

Tool	Use	Image
Hammers • Ball peen hammer • Engineers hammer • Soft faced • Rubber mallet • Dead blow • Brass • Leather	Hammers are used to drive nails, fit parts, forge metal, and break apart objects. To use a hammer: • Select the weight of the hammer appropriate to the fastener to be struck. • Make tight grip at the hammer handle lower half, then swing the hammer slowly and hit the fastener head squarely. • Do not strike your hand by the hammer head or handle. • Wave the hammer with extra power to strike the fastener head. • Continue the process of striking the fastener head to drive it into the material.	
Testing Lamps	A testing lamp is used to diagnose an troubleshoot an electrical problem.	
Ampere Meter	It is used to measure electrical current in an appliance. To use it break the circuit and attach the instrument to allow the electrical current to flow through the meter for measuring.	
Volt Meter	Volt meter is used to measure AC or DC voltages of electrical components. Voltmeter is used to measure the voltage available in the circuit.	

Tool	Use	Image
Megger - Manual Megger - Electronic Megger	This device is used to measure electrical leakage in wire. It is used for checking the electrical insulation level of electrical machines and devices like motor, generator winding, etc.	
Wire wrapping tool	It is a process to build electronic circuit boards. Electronic components riding on an insulating board are connected by insulated wire run with the connections made around a component lead or socket pin.	
Crimping Tool	It is assembling 2 pieces of metal or other ductile material by distorting one or both of them to grip the other. The bend or irregularity is called the crimp.	
Static Safe Tweezers	These well-made tweezers are a cheap solution to your soldering requirement and perfect for picking or placing small electronic components on SMD and through hole in PCBs. The non-metallic/non-static material creates these tweezers appropriate for use with voltage sensitive devices and decreased the risk of scratching or damaging components.	
Wire Stripper	To strip the electrical insulation from electric wires a wire stripper hand-held device used.	

Table 2.3.1 Tools and measuring instruments

UNIT 2.4: Cable Assembly

Unit Objectives

At the end of this unit, participants will be able to:

1. Describe methods and techniques of cable assembly
2. Demonstrate procedure of cable assembly
3. Demonstrate stripping and crimping of wires
4. Demonstrate soldering process

2.4.1 Cable Assembly

In cable assembly, a group of wires or cables are clipped together into a single unit. Cable assembly is a get together of wires or cables which transmit signals or electrical power. The cables are bound mutually by straps, cable binding, cable ties, electrical tape, sleeves, channel, or a mix thereof.



Fig 2.4.1 Cable assembly

Binding the cables and wires and into a cable bridle, secures the wires from antagonistic impacts of scraped areas, vibrations and dampness. Binding the wires into a non-flexing pack, use of space is advanced and the danger of a short circuit is diminished. Binding the wires into a heat shrink sleeve also lowers the risk of electrical fires. Geometric and electrical necessities are factor through which cable assembly are designed. Wiring figure present the directions in support of the assembly making and assembly.

1. Firstly, cut the wires into required extent taken after by a marking procedure (both manually or preset) for recognition use.
2. Then, the wires are uncovered to expose their metal centers and gathered jointly via whichever additional terminals or connectors housings essential.
3. Then the bundle is fixed together to a structure panel or assembly installation.
4. The completed mass is then fixed by whichever defensive sleeves, conductor or expelled yarn.

This whole procedure can normally finished with hand as a result of the complicated preparing requisite next to different phases of manufacturing,

- directing the wires via sleeves,
- taping through fabric tape, specifically on branch outs starting from wire strands,
- crimping terminals against wires,
- Add one sleeve with another furthermore
- Binding the strands through tape, clips or cable ties.

2.4.1.1 Tools and Equipment Require for Cable Assembly



Fig 2.4.2 Tools and equipments require

2.4.2 Wire Stripping

Stripping a wire is the process of removing the insulator from the end of a wire, usually done to connect that wire to other wires or electrical parts. It requires a wire stripper.

The initial process is toward stripping the wire. This is the means by which a programmed wire stripper

operates. The worker places the wire all the way through the right molded hole and press the handle. The apparatus grasps the wire and after that drag the end off. Strip the wire thus there is quite sufficient to fit into the crimp zone of the terminal.

Procedure for stripping a wire stripper:

1. Recognize the gage of the wire (more often than not imprinted as an afterthought).
2. Coordinate the gage amid the proper hole on the wire stripper. The hole would be checked.
3. Then the wire stripper handles need to be open. "Seat" the wire on one side of the hole.
4. Gradually push the handles jointly in anticipation of the point that they can go no more distant.
5. Extremely essential: softly turn the wire inside the hole (or the wire stripper around the wire either is less complicated). The worker doesn't need to rotate far-off: only a quarter hands over one bearing and back.
6. Drag off the "cut" end of the wire casing.
7. Once the wire is stripped, there will be about 1/4" (0.5 cm) of bare metal wire exposed.



Fig 2.4.3 Stripping of wire

2.4.3 Inserting Heat Shrink

On the off chance that the wire is comprised of numerous littler strands turned together, tenderly move the strands so they are for the most part deceiving structure a smooth cylinder. On the off chance that the wire is a strong conduit wire, this won't be important.

Placing heat shrink: To utilize heat shrink tubing to protect the graft, removed a bit of tubing about twice the length of the zone of the join. Slide it on to the finish of both of the wires. Drive it up the wire off the

beaten path of the graft with the goal that it is not rashly warmed by the joining operation.

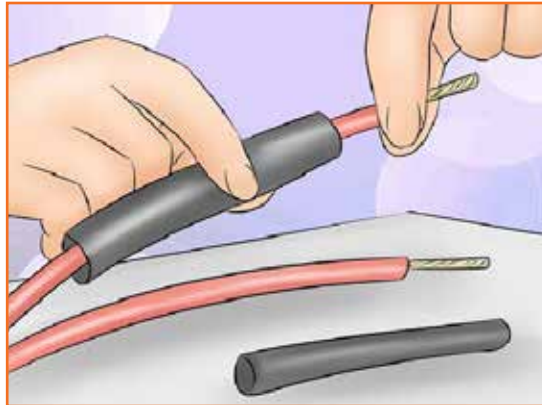


Fig 2.4.4 Heat shrink

2.4.4 Crimping

Crimping is a way of making electrical connections that doesn't require solder. It protects wires exposed ends and can be used to connect wires to each other or to other electrical parts. It requires a wire crimper.

Procedure for crimping:

1. First select a properly sized crimp connector. Place the connector into the crimper.
2. Place the stripped wire end inside the cylindrical plastic end of the crimp connector. The wire insulation should butt up against the inside of the crimp connector, and no exposed wires should stick out.
3. Take the crimpers and place the blunt part of the crimpers over the place you want to crimp. (For the first crimp, you probably want to make the crimp near the connector head, but make sure you get both the connector and the wire). Then, compress the crimper tightly. This will take a lot of hand strength.



Fig 2.4.5 Crimping tool



Fig 2.4.6 Crimping wire



Fig 2.4.7 Crimping wire

4. Once you have crimped the wire a first time, crimp the wire a second time at 90° (a quarter turn) to the first crimp, and farther from the connector head.



Fig 2.4.8 Crimped wire



5. Now, slide the heat shrink over the crimp and heat it by using heat gun until it closes tight.
6. This is not generally fundamental, except rather if you're wiring association will be liable to dampness or over the top motion and shaking, and then a smart thought is to tape the link.



Fig 2.4.9 Taping wire

Electrical tape utilizes rubbing to hold itself, so it should be twisted firmly around the electrical connection.

2.4.5 Soldering

Fastening is a procedure in which at least two metal things are consolidated by liquefying and after that streaming filler metal into the joint—the filler metal having a generally low softening point.

Soldering is utilized to shape a lasting association between electronic segments.

The metal to be patched is soldered with a welding iron and after that solder is softened into the connection.

- Just the solder liquefies, not the components that are being soldered.
- Solder is metallic “paste” that holds the parts together and shapes an association that enables electrical current to stream.



Fig 2.4.10 Soldering process

The vast majority of the solder metals are the composite of

tin and lead. These alloys display an extensive variety of liquefying point so extraordinary sort of soldering metal can be utilized for assortment of utilizations. Proportion of lead is kept at minimum because of its harmful properties. Tin turns out to be chemically dynamic at welding temperature and encourages the wetting activity required for making the joint. Copper, silver and antimony are likewise utilized as a part of soldering metal according to the quality prerequisites of the joint.

A solder is chosen on the premise of its softening point. On the off chance that metals to be joined have higher softening point weld of higher dissolving point is for the most part chosen. Patch of high softening point gives better quality of the joint.

Soldering Methods

1. **Hand Soldering:** Hand Soldering is done physically utilizing solder iron. Little joints are made by along these lines in brief term period around in one second.
2. **Wave Soldering:** Wave soldering is a method which permits different lead wires to be soldered to a PCB as it disregards an influx of liquid bind. In this procedure a PCB on which electronic parts have been put with their lead wires stretching out through the gaps in the board, is stacked onto a conveyor for transport through the wave soldering gear. The conveyor bolsters the PCB on its sides, so its underside is presented to the preparing steps, which comprises of the accompanying:
 - a) Flux is used with the help of foaming, spraying, brushing
 - b) Wave soldering is utilized pump liquid solder from a liquid bath on to the base of board to build soldering associations between lead wire and metal circuit on the board.
3. **Re-flow Soldering:** This procedure is additionally broadly utilized as a part of hardware to gather surface mount segments to print circuit sheets. In this procedure patch glue comprising of weld powders in a flux cover is connected to spots on the board where electrical contacts are to be made between surface mount segments and the copper circuit.

The parts are put on the glue spots, and the board is warmed to soften the weld, framing mechanical and electrical bonds between the segment leads and the copper on the circuit board.

2.4.5.1 Materials and Equipment for Soldering

The accompanying materials and types of tools are required for soldering:



Fig 2.4.11 Soldering equipments

- **A soldering iron**
 - o A soldering iron is utilized to heat up the attachments to be soldered.
 - o For electronic circuits, you need to utilize a 25-to 40-watt (W) soldering iron.
 - o Higher wattage soldering irons are not really sultrier; they are quite recently ready to warm bigger parts. A 40-W soldering iron makes joints quicker than a 25-W soldering iron does.
 - o A soldering iron can be acquired at tool shops and at most expansive retail establishments.
- **Solder**
 - o Solder has a lower softening point than the metals that are being associated do. The solder liquefies when it is warmed by the soldering iron, yet the metals being joined won't soften.
 - o The rosin center goes about as a flux. It counteracts oxidation of the metals that are being associated, and improves the capacity of the solder to "wet" the surfaces that are being joined.
 - o Solder that is utilized to join copper pipes has a corrosive center, which is suitable for pipes, however will erode electronic associations. Utilize solder that has a rosin center.
 - o For most gadgets work, a solder with a width of 0.75 millimeters (mm) to 1.0 mm is ideal. Thicker solder may make soldering little joints troublesome and furthermore builds the odds of making solder connects between copper cushions that are not intended to be associated.

- o An alloy of 60/40 (60% tin, 40% lead) is utilized for most hardware work, however sans lead solders are accessible too.
- **Stand on which to hold the hot soldering iron**
 - o There are assortments of stands accessible. It is vital to dependably keep the hot iron in its stand when not being used.
- **Sponge**
 - o The damp sponge is utilized to make the tip of the iron clean.
- **Solder braid**
 - o This is utilized to expel solder.
 - o To utilize the braid, put it over the solder to be expelled and warm it from above with the iron. The solder will stream into the braid.
 - o Solder braid is utilized to separate an electronic part that is soldered onto a board.
 - o It is likewise used to lessen the measure of solder on an association.
- **Prototype board**
 - o A prototype board is utilized to gather the circuit.
 - o Prototype boards have copper tracks or pads for associating segments.
- **Steel wool or fine sandpaper**
 - o This is utilized to clean associations preceding soldering.
 - o Solder won't stream over a messy connection.
- **Crocodile clips**
 - o These can be utilized as heat sinks, if necessary.

2.4.5.2 Soldering Process

Preparing the Soldering Iron: Tinning the Tip

1. **Prepare the parts for soldering.** Select the right segment by checking it's sort and value deliberately. For resistors, their color code needs to be confirmed. Bend leads accurately, if essential, being mindful so as not to surpass the bend specifications, and clinch leads be suitable for the board.
2. Position the soldering iron in its rest and connect it to it.
3. Hang around till the time soldering iron warms up.
4. Dampen the sponge.
5. Dab the tip of the iron with the help of clammy sponge. This will make the tip clean.
6. Melt a small amount of solder on the tip of the iron.
 - o This is called tinning and it will enable the warmth to spill out of the iron's tip to the joint.
 - o The solder should stream onto the tip, creating a brilliant glossy surface.
 - o If the solder won't stream onto the tip, clean it by wiping it with the help of wet wipe.
 - o When tinned, clean overabundance solder off on the wet wipe.
 - o You don't have to tin the tip prior to each joint, yet you should re-tin it on the off chance that it has gone dull when the welding iron has not been utilized for a couple of minutes.
 - o Check the manufacturer's directions identified with tinning the tip.
7. The tip of the welding iron ought to be glossy silver shading. On the off chance that it is dark and pitted, supplant it with another one.



Fig 2.4.12 Tip tinning

2.4.5.3 Soldering of Two Wires

Begin with tinning the two wires. It is valuable to have something to grip one wire for you. Position the tip of the iron on the wire and allow it warm for a moment or three. At that point include some solder until the point when the wire is doused with solder. On the off chance that it is a thick wire, you should turn up the warmth on your iron (if conceivable) to make the wire warm up speedier. Rehash the tinning procedure on the other wire.

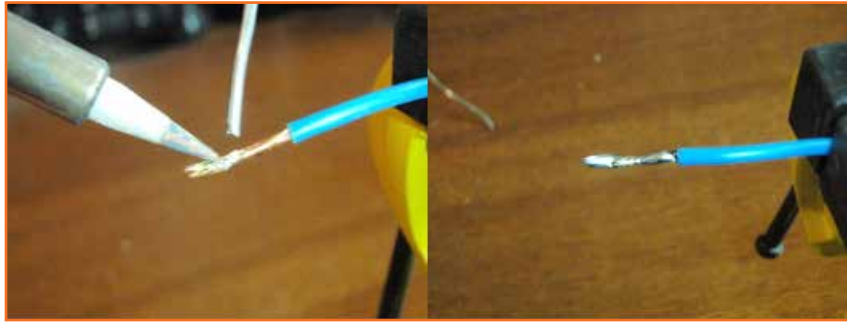


Fig 2.4.13 Soldering of two wires

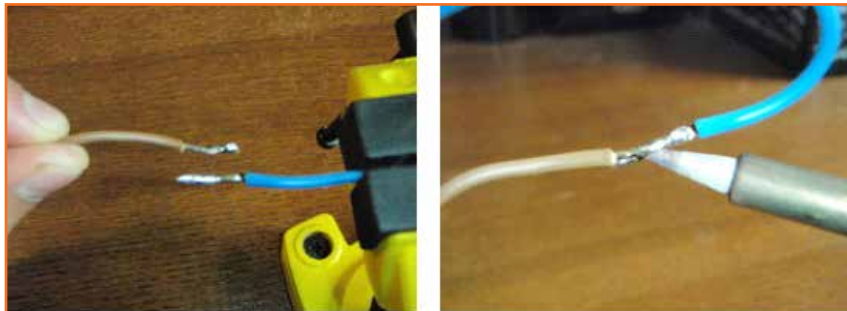


Fig 2.4.14 Soldering of two wires

At this moment put the two tinned wires together keep still while warming them with the soldering iron so the tin on each of the wires liquefy jointly.

2.4.5.4 Safety Precautions and Tips During Soldering

1. **Caution:** A soldering iron temperature goes somewhere near to 400°C , that can lead to you getting burned up or can initiate a fire, that is why utilize it with extra caution.
2. Unplug the iron when it is not being used.
3. Keep the power line far from spots where it can be stumbled over.
4. Take incredible care to abstain from touching the top of the soldering iron on an electrical cable. On the off chance that a power line is touched by a hot iron, there is a genuine danger of burns and electric stun.
5. Always restore the soldering iron to its stand when it is not being utilized.
6. Never put the soldering iron down on your work seat, notwithstanding for a minute!
7. Work out of an all around ventilated part.
8. The smoke that will frame as you liquefy solder is generally from the flux and can be very bothering.

Always keep your head aside, not over the work to avoid intake of smoke by breathing.

9. Solder contains lead, which is a harmful metal. Wash your hands subsequent to utilizing solder.

Tips

Solid operation of a circuit with soldered associations relies upon great soldering techniques. Here are a few tips for effective soldering

1. Plan preceding you begin to solder. Distinguish every one of the parts that you will be utilizing.
2. It is useful to connect each part to a bit of paper and compose what it is and its value for instance, resistor #1: 100 ohms).
3. Some parts, for example, LED's, must be set the right path around with a specific end goal to work.
4. Below points are recommended order for the setting up of various components:
 - o Capacitors, less than 1 micro farad
 - o Large capacitors, 1 micro farad or greater
 - o Diodes, note the orientation.
 - o LED's, note the orientation.
 - o Transistors, note the orientation.
 - o Solid wire associations linking parts on the board
 - o Solid wire is genuinely unbending, so it will remain fixed at one place once joined.
 - o Stranded wire to components that are joined by wire to the circuit
 - o Stranded wire has got more elasticity than solid wire.
 - o Join them with the appropriate way.
 - o Leave IC's in their antistatic bundling till the point that you require them, at that point ground your hands by touching a metal water pipe or window outline before touching the IC's.
 - o Carefully embed IC's in their holders. Ensure every one of the pins are aligned with the attachment and afterward push down tightly with your thumb.

2.4.6 Securing Wire

Cable ties

A cable tie or tie-wrap, also known as a hose tie, or zip tie is a type of fastener, for holding items together, primarily electric cables or wires. Because of their low cost and ease of use, tie-wraps are ubiquitous, finding use in a wide range of other applications. Stainless steel versions, either naked or coated with a rugged plastic, cater for exterior applications and hazardous environments.



Fig 2.4.15 Cable ties

The common tie-wrap, normally made of nylon, has a flexible tape section with teeth that engage with a pawl in the head to form a ratchet so that as the free end of the tape section is pulled the tie-wrap tightens and does not come undone. Some ties include a tab that can be depressed to release the ratchet so that the tie can be loosened or removed, and possibly reused.

P-clips

- Preformed P clips will clamp wires or wire bundles of 16 to 50 mm diameter.
- P-clips offer good resistance to ageing, corrosion and ozone and UV radiation and have good dielectric properties.
- Ideal for use with electrical equipment and for interior/ exterior installation work.



Fig 2.4.16 P clips

Scan the QR code or click on the link to watch related videos



<https://www.youtube.com/watch?v=lpkkfK937mU>

Soldering

UNIT 2.5: Assembling Procedure

Unit Objectives

At the end of this unit, participants will be able to:

1. Demonstrate electrical and electronic sub systems assembling procedure
2. Demonstrate assembling procedure with mechanical equipment

2.5.1 Assembly and Wiring of Distribution Panel

An arrangement which is used for distribution of electrical energy to various circuits, in which exit points for circuits are made by fixing fuse units of different circuits for various circuits and it has a wooden or metal cover which is of sun mica sometimes.

Now there are distribution board arrangements available in the market which are placed in covered metal and hold different number of circuits. These units are known distribution box.

These distribution boxes are available in single phased and triples phase forms both. The neutral wire link is available

in the distribution box with neutral wire requirements. Some companies are making some distribution boxes where main switches are also fixed.



Fig 2.5.1 Distribution panel

LT Panel and HT Panel

Getting power from transformer or generator and distributes the same to various electronic devices and distribution boards by LT Panel, which is an electrical distribution board. For external and internal use in industries such panels are used, therefore, they are somewhat rough to withstand dissimilar climatic circumstances. To work with low electricity consumption, LT panels are created and that creates them cost effective.

HT panel is used for high tension cables this is only the basic difference between HT Panel and LT Panel.

Special description of distribution board-

Following details are to be mentioned while providing special details about distribution boxes-

- Number of lines (3 lines, 6 lines etc.)
- Per line electric current capacity(15 A/line, 60 A/line)
- Voltage grade (250 V, 500 V etc.)
- Number of poles (DP, TP etc.)
- If it has metal cover then its detail (I.C.) is given.

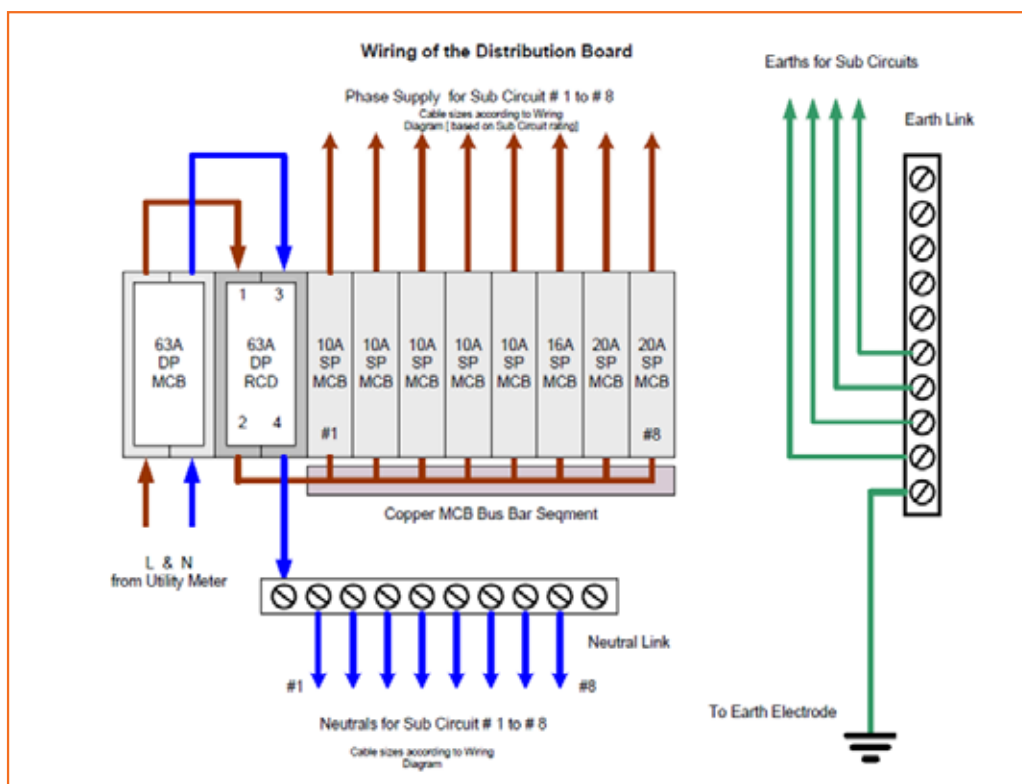


Fig 2.5.2 Distribution box assembly

Components of control relay

- Enclosure
- MCB
- Relay
- Earth leakage circuit breaker
- Cables
- Bus bars
- Contactor

Assembly of components on distribution box

Take a look at the steps for the assembly of the components on the distribution box:

1. Wear the personal protective equipment before starting. Switch off the main input supply.
2. Mark the area for fixing the MCB on the distribution box.
3. Use a drill machine, drill holes in the marked locations.
4. Use a suitable screwdriver; fix the MCB box on the wooden board by tightening the screws.
5. Fix the isolator in the MCB box. Press the lock available on the isolator switch and lock it with the MCB box.
6. Take the MCB switches mounting panel and mark the locations on the wooden board.
7. Use a drilling machine, drill holes in the marked locations.
8. Fix the panel on the wooden board, using a screw driver.
9. After fixing the panel, fix all the MCB switches on it. Press the lock available on the MCB switches and lock it with the panel.
10. Similarly mark the area for the three bus bars.
11. Fix the bus bars to the distribution board with the help of screws.
12. Take the wire connector for connecting the MCB neutral wire output. Fix the wire connector on the MCB switch. Press the lock available on the wire connector and lock it with the panel.

The assembly of components in the distribution box is now complete. The box is now ready for wiring.

Wiring of the Distribution Box

Take a look at the steps for wiring of the distribution box:

1. Connect the output terminals of the isolator cut-out switch to the input terminals of the distribution box through the MCB.
 - Connect the phase wires in the R, Y and B phase output terminals of the isolator cut-out switch.
 - Connect the phase output of the cut-off switch to the respective inputs on the pole switch.
 - Take the black neutral wire from the energy meter neutral output and connect it with the input neutral terminal on the TPN switch.
 - Connect the earthing wire of the input supply main to the earthing terminal in the MCB.
 - This is how the input mains supply connects with the distribution board.
2. Connect the output terminals of the pole switch to the bus bar of the respective phase.

- Connect the wires in the phase and neutral output terminals of the pole switch.
- Connect the other end of all the phase wires to their respective phase bus bars.
- To connect it, take a 25 sq mm wirelax and connect it at the stripped ends of all the phase wires using a plier.
- Take the phase wire and connect it to the input terminal of the phase bus bar by tightening it with the nut and screw.
- Take the neutral wire from the output of the pole switch and insert it into the input of the wire connector.

3. Connect the all phase bus bars with their respective MCB switches.

- Connect the red wire on the phase bus bar output terminal.
- Connect the other ends of all the phase wires with their respective MCB switches.
- For the phase use 2 MCB switches, one of 16 amps and one of 32 amps.
- Insert the wire from the output of the phase bus bar to the input of the phase 16 amp switch.
- Connect the 32 amp phase MCB switch with the R phase bus bar. For this, interconnect the 16 amp switch with the 32 amp switch by taking a cut piece of phase wire.

4. Check all the connections to ensure that there are no loose connections.

- To check, gently tug the wires.

There are numerous other mechanical parts for assembly of electronic hardware. A large portion of them fall into the classification of exchanging or connecting circuits. Just the spacer falls into an alternate classification, called mounting.

- The switch is utilized to divert current or voltage starting with one circuit then onto the next.
- The wire nut is utilized to hold two contorted wires together and insulate them (keep them from being stripped and uncovered) in the meantime.

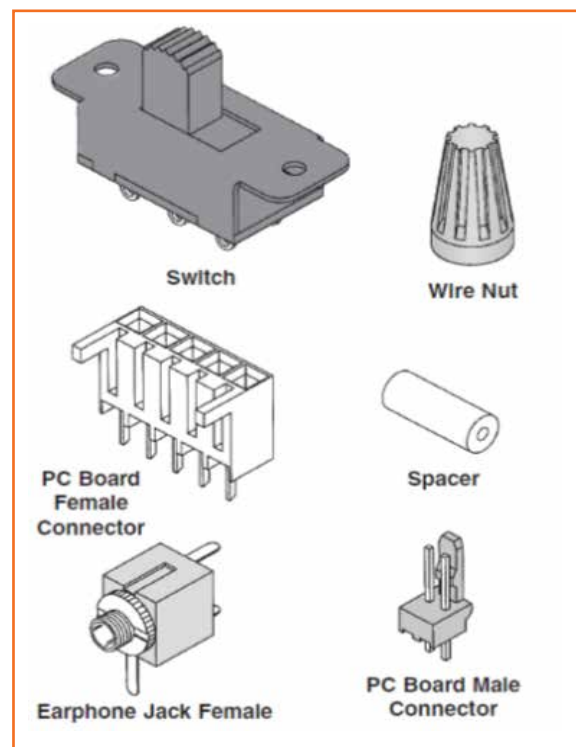


Fig 2.5.3 Mechanical parts for assembly

- The PC board male and female connectors are utilized to append wires from controls or different circuits to the PCB.
- The spacer holds the PCB far from the case to keep leads from shorting to the case.

2.5.2 Assembling with Mechanical Equipment

Manufacturers are using lot of other mechanical parts for creating electrical equipment. These come into the group of connecting circuits or switching.

- Redirect of voltage or current from one circuit to another is done by the switch.
- To grip two twisted wires collected and protect them (save them from being basic and exposed) at the similar time a wire nut is used.
- To save leads from shorting to the case the spacer grip the printed circuit board away from the case.

Mounting on mechanical equipment

For mounting distribution panels there are different methods. The using of machine screws and spacers is the simplest method. The requirement for a lock washer and nut can remove by the self-threading screw but can create metal fragments that must be eliminate to save shorts from occurring.

Use proper fasteners and tools as discussed in previous unit for assembling the PCB board with the mechanical equipment.

Connect the cable terminals into their proper connectors fitted in the mechanical equipment.



Fig 2.5.4 Assembling with mechanical equipment

Exercise



1. Identify the resistance of resistor

- (a) 47 k Ω with a tolerance of $\pm 10\%$
- (b) 47 k Ω with a tolerance of $\pm 5\%$
- (c) 6.2 Ω with a tolerance of $\pm 10\%$
- (d) 6.2 Ω with a tolerance of $\pm 5\%$



2. The image to the right is of a

- | | |
|---------------|--------------|
| (a) Capacitor | (b) Diode |
| (c) Inductor | (d) Resistor |



3. As a capacitor is being charged, current flowing into the capacitor will

- | | |
|---------------------|-----------------|
| (a) increase | (b) decrease |
| (c) remain the same | (d) cannot tell |

4. What is a varistor?

- (a) a voltage-dependent resistor
- (b) a voltage-dependent diode
- (c) a current-dependent resistor
- (d) a current-dependent diode

5. A pn junction allows current flow when

- (a) the p-type material is more positive than the n-type material
- (b) the n-type material is more positive than the p-type material
- (c) both the n-type and p-type materials have the same potential
- (d) there is no potential on the n-type or p-type materials

6. The electrical energy consumed by a coil is stored in the form of

- (a) an electrical field
- (b) a force field
- (c) an electrostatic field
- (d) a magnetic field

7. Out of the following which is an insulating material
- | | |
|------------|-----------|
| (a) copper | (b) gold |
| (c) silver | (d) paper |
8. If electrical wires are overheated due to high electric current they can cause
- | | |
|------------------|--------------|
| (a) Fires | (b) burns |
| (c) both a and b | (d) freezing |
9. Why is the single core cables not provided with armouring?
- | |
|---|
| (a) Avoids excessive loss in the armour |
| (b) Make the cable more flexible |
| (c) Make the cable non hygroscopic |
| (d) None of the above |
10. How many cores are used in a cable for the transmission of voltages upto 66 kV?
- | | |
|-----------------|----------------------|
| (a) Single core | (b) Two core |
| (c) Three core | (d) All of the above |
11. Embedded processors can be categorized as ordinary microprocessors and
- | | |
|----------------------|----------------------|
| (a) Macrocontrollers | (b) Macroprocessor |
| (c) Both 1 and 2 | (d) Microcontrollers |

Scan the QR code or click on the link to watch related videos



www.youtube.com/watch?v=NWSWm5d3f90

Distribution panel wiring diagram

[illegible]



3. Test and Commissioning

Unit 3.1 – Testing and Fault Finding



Key Learning Outcomes



At the end of this module, participants will be able to:

1. Describe different testing techniques for fault identification
2. Demonstrate testing techniques for fault identification
3. Demonstrate troubleshooting and repairing of electrical system faults
4. Demonstrate troubleshooting of PCB faults

UNIT 3.1: Testing and Fault Finding

Unit Objectives



At the end of this unit, participants will be able to:

1. Describe different testing techniques for fault identification
2. Demonstrate testing techniques for fault identification
3. Demonstrate troubleshooting and repairing of electrical system faults
4. Demonstrate troubleshooting of PCB faults

3.1.1 Testing of Completed Electrical Installation

All new completed electrical installation should be tested before connection to the supply, to ensure that the installation is technically sound and free from any possible short circuits, etc. the main reasons, to test a new electrical installation or house wiring before it is switched on to the mains are as follows:

- To know the cause of failure of a particular circuit or circuits or equipment and to locate the exact position of break down.
- To ensure that it is free from faults and is as per electricity rules.
- These tests will receive the attention of the owner before any possible undue damage occurs.

The electrical testing is divided into 2 parts:

1. **Visual inspection** to guarantee that the installation complies with the safety requirements (presence of an earth electrode, protective devices, etc.) and does not show any visible evidence of damage.
2. **Measurements:** There are 4 main measurements required:
 - I. Earth
 - II. Insulation
 - III. Continuity
 - IV. Tests of protective devices

3.1.2 Visual Inspection

This is very important as approximately 90% of faults can be found by visual inspection alone. This part of the testing process may involve:

- Smelling the electrics
- Pulling on leads – checking for anything loose or uneven
- Tapping the appliance – checking for sparks or reactions
- Shaking the appliance – same as above
- Checking general safety and quality

If there are any major issues or faults, they can usually be identified through this first stage of testing.

3.1.3 Insulation Resistance Test

Insulation resistance is defined as the resistance to current leakage through and over the surface of the insulation material surrounding a conductor. It is measured in Ohm's and its value represents a very important factor to electricians working within the electrical industry.

Insulation starts to age as soon as it's made. As it ages, its insulating performance deteriorates. Any harsh installation environments, especially those with temperature extremes and/or chemical contamination, accelerates this process. Stresses due to different factors like:

- **Electrical stresses:** Mainly linked to overvoltage and undervoltage.
- **Mechanical stresses:** Frequent start-up and shutdown sequences can cause mechanical stresses.
- Balancing problems on rotating machinery and any direct stress to the cables and the installations in general.
- **Chemical stresses:** The proximity of chemicals, oils, corrosive vapours and dust, in general, affects the insulation performance of the materials.
- **Stresses linked to temperature variations:** When combined with the mechanical stresses caused by the start-up and shutdown sequences, expansion and contraction stresses affect the properties of the insulating materials. Operation at extreme temperatures also leads to aging of the materials.

- Environmental contamination causes aging acceleration of insulation.

This wear and tear can reduce the electrical resistivity of the insulating materials, thus increasing leakage currents that lead to incidents which may be serious in terms of both safety (people and property) and the costs of production stoppages. Thus it's important to identify this deterioration quickly so that corrective steps can be taken. In addition to the measurements carried out on new and reconditioned equipment during commissioning, regular insulation testing on installations and equipment helps to avoid such incidents through preventive maintenance. These tests detect ageing and premature deterioration of the insulating properties before they reach a level likely to cause the incidents described above.

Wire and cable manufacturers use the insulation resistance test to track their insulation manufacturing processes, and spot developing problems before process variables drift outside of allowed limit.

Insulation resistance (IR) test detects insulation failure, determine the quality of insulation, and track insulation manufacturing processes.

How Insulation Resistance is Measured?

Insulation resistance measurement is done using an IR tester. This is a portable tool that is more or less an ohmmeter with a built-in generator that's used to produce a high DC voltage. The voltage usually measures at least 500V, and causes a current to flow around the surface of the insulation. This gives a reading of the IR in ohms.

Insulation resistance measurement is based on Ohm's Law, ($R=V/I$). By injecting a known DC voltage lower than the voltage for dielectric testing and then measuring the current flowing, it is very simple to determine the value of the resistance. In principle, the value of the insulation resistance is very high but not infinite, so by measuring the low current flowing, the megohmmeter indicates the insulation resistance value, providing a result in kW, MW, GW and also TW (on some models). This resistance characterizes the quality of the insulation between two conductors and gives a good indication of the risks of leakage currents flowing.

Well, if you are looking at a high number of IR, you have some good insulation. If it is relatively low, on the other hand, the insulation is poor.

However, this is not everything – a variety of factors can affect the IR, including temperature and humidity. You will have to do a number of tests over time to make sure the IR value stays more or less the same.

Value of insulation resistance is often expressed in Giga-ohms [$G\Omega$].

Good Insulation is when megger reading increases first then remain constant. Bad Insulation is when megger reading increases first and then decreases.

There is one advantages of the IR test is its non-dangerous nature. DC voltages don't cause destructive and additionally combined consequences for insulation materials and gave the voltage is underneath the breakdown voltage of the insulation, does not worsen the insulation. IR test voltages are all well inside the protected test voltage for most (if not all) protection materials.

Test procedure

To lead a protection resistance test, play out the system recorded beneath:

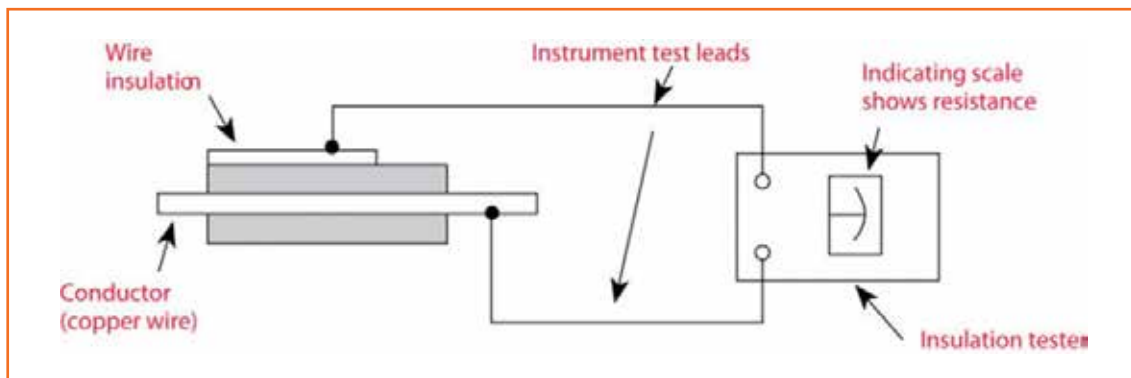


Fig 3.1.1 Insulation test

1. Check the insulation tester by shorting its test leads. It should indicate zero resistance. On the off chance that test leads are kept open, it should demonstrate interminable resistance.
2. The segment to be examined is isolated from power supply
3. All electrical /light gadgets are disconnected from the circuit to be examined.
4. Depending upon the rating of the system select the correct working voltage for directing the examination
5. Make sure that the area to be tried is only involved in the test and no other areas are connected with test.
6. Make sure there are no stray parallel spillage ways.
7. Pointer file or some other pre-change requirement of instrument to be checked.
8. To have great quality insulation conduct the test promptly
9. Make sure that the capacitors are discharged by shortening leads before beginning of the test and

also after the test. Otherwise, false reading may be produced during test.

10. The energy that may have been put away in the links amid the test have to be removed, before touching link closes after examination. This happens very much in long keeps running of bigger links because of their capacitance.
11. Low perusing ohmmeters are to be used for checking progression of an earthling framework which has to be zero checked before each test and adjusted on normal interims.
12. Earth-resistance analyzers (Uncommon type) must be utilized to test the earth electrode resistance (resistance between the electrode and the general mass of earth).

3.1.4 Continuity Test

Checking of an electronic circuit's continuity by setting a little voltage and checking of current stream is called continuity test. A progression test is performed by setting a little voltage (wired in arrangement with a LED or commotion creating segment, for example, a piezoelectric speaker) over the picked way. In case of breakage in circuit, excess resistance, damaged parts etc speaker will not work indicating an open circuit

Devices that can be utilized to conduct progression tests includes millimeters to measure current and concentrated coherence analyzers which are less expensive, more essential gadgets, by and large with a basic light that glow up when current flows

Procedure for testing the continuity



1. Turn the dial to Continuity Test mode (). It will probably impart a spot on the dial to at least one capacities, normally resistance (Ω). With the test tests isolated, the multimeter's show may indicate OL and Ω .
2. If needed, press the progression key.
3. First embed the black test lead into the COM jack.
4. Then embed the red lead into the V Ω jack. Whenever completed, expel the leads backward request: red initially, then black.



Fig 3.1.2 Continuity test

5. With the circuit de-energized, connect the test leads across the component being tested. The position of the test leads is arbitrary. Note that the component may need to be isolated from other components in the circuit.
6. The digital multimeter (DMM) beeps if a total way (continuity) is distinguished. In the event that the circuit is open (the turn is in the OFF position), the DMM won't beep
7. When completed, kill the multimeter to save battery life.

To identify a short out situation a congruity test is especially valuable; it is a consequence of cross-connecting of wires among two unique circuits

Following reasons define an interconnection between circuits is probably going:

- Wrong removal of wires
- Output of insulation failure
- Wrong association at field intersection box

3.1.5 Polarity Test

In a low voltage installation, this test is performed to verify that all single pole switches have been connected to phase wire throughout the installation.

It is very necessary to place all switches on phase so that when a switch is made OFF, the connected appliance is quite dead.

If the switch is connected to the neutral wire, then the connected appliance will get phase even if the switch is in OFF position and remain alive.

There is absolutely no difference in the functioning of the switch in either case, but from the safety point of view to avoid shock, etc. the phase should always be given through the switch and neutral direct to the point.

The simple method of conducting the polarity test is by using a test lamp.

Before performing this test, the position of the main switch, fuses, switches, etc. should be as under:

- main switch in ON position,
- all switches in OFF position,

- all lamps and other appliances should be removed.

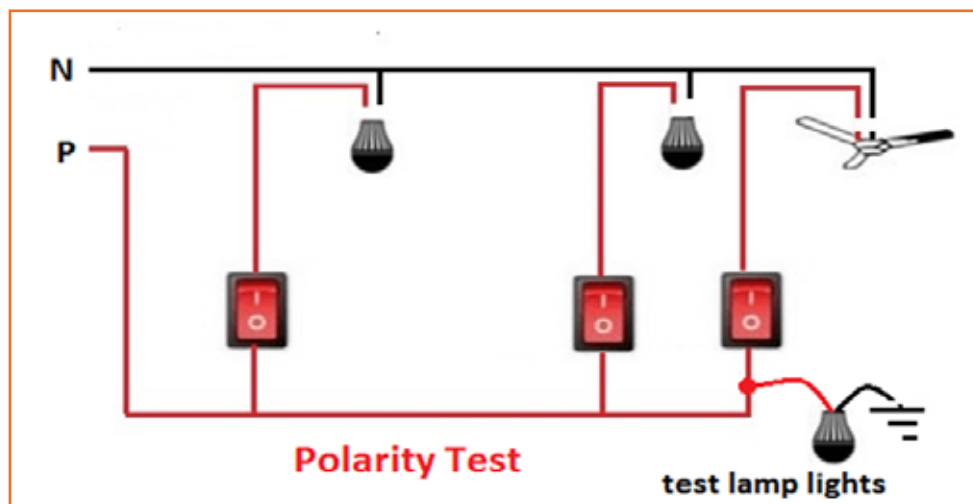


Fig 3.1.3 Polarity test

One end of the test lamp is connected to earth wire and the other end to the incoming terminal of the switch.

If the lamp lights, it indicates that the switch is connected to phase wire, otherwise to neutral wire.

3.1.6 Earth Resistance Test

To guarantee safety on residential or industrial electrical installations, one of the basic rules is that there must be an earth electrode.

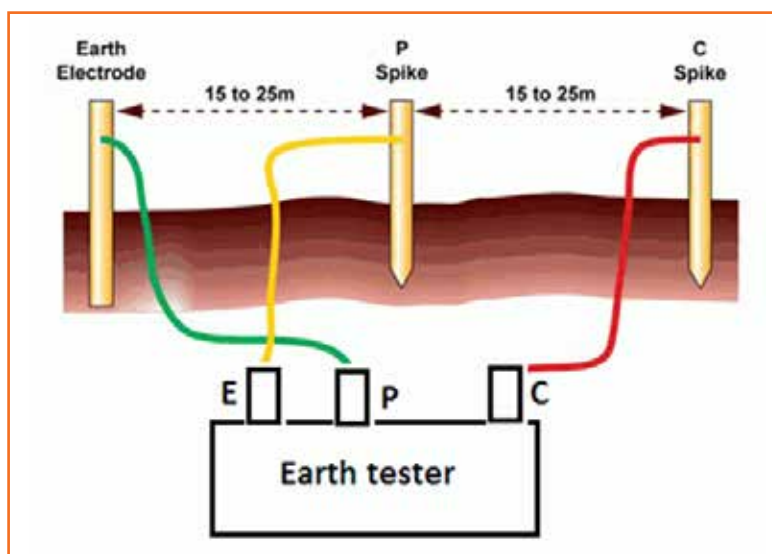


Fig 3.1.4 Earth resistance test

If there is no earth electrode, it may endanger people's lives and damage electrical installations and property.

The Resistance of the earth can be measured with the help of megger earth tester or earth megger.

The earth megger is essentially a direct reading ohmmeter and it has a hand driven generator which supplies the testing current. The ohmmeter essentially consists of two coils (current coil and pressure coil) mounted at a fixed angle to each other on a common axis.

It has four terminals P1, C1, P2 and C2. Its terminals P1 and C1 are short-circuited. This junction makes a common point. Hence it has got three terminals E (common point), P (P1) and C (C1) outside.

To measure the earth resistance with a megger earth tester, the earth electrode under test is connected to its E terminal and P and C terminals are connected to auxiliary electrodes through a connecting lead of negligible resistance.

When the handle of the megger earth tester is rotated at a uniform speed, it directly indicates the earth resistance on the dial or calibrated scale. Set of readings are obtained by burying the electrode P at various positions.

Firstly, it can be buried between earth electrode and current electrode C. Secondly, it should be hurried 15 meters away from the earth electrode on the opposite side of current electrode C. Then it should be buried 15 meters away from the current electrode C. The mean of the three readings gives the resistance between the earth electrode and soil.

The resistance between earth electrode (i.e. plate or pipe etc.) and the soil does not remain constant due to variable moisture conditions. To have good and effective earthing, the earthing system should be tested from time to time and moisture contents in the nearby soil should be increased by adding water.

The earth resistance should be less than 1 ohm for power stations. And for the sub-stations, it should be less than 5 ohms. It should be noted be that the earth resistance should be as small as possible for two reasons:

- In the case of a fault, when the metal frame comes in contact with the live wire or phase wire, a current will flow through the earth connection, which causes a potential difference between the metal frame and earth. This potential difference should be very low because it will act across a person who touches the metal frame in such a faulty condition.

- A low resistance to earth will cause high current to flow when the fault occurs. The high current will cause the fuse to melt in a very short time, thus disconnecting the faulty apparatus from the lines thus ensuring safety.

Significance of Earthing and Earth Resistance

The provision of earthing for an electrical installation is very significant due to the following reasons:

- All the parts of electrical equipment, like the casing of machines, the casing of circuit breakers, tanks of transformers must be connected to an earth electrode. It is done to protect the various parts of the installation as well as the persons working against damage in case the insulation of a system fails at any point.
- By connecting these parts to an earthed electrode, a continuous low resistance path is available for leakage currents to flow to earth. This current operates the protective devices and thus the faulty circuit is isolated if a fault occurs.
- The earth electrode ensures that in the event of over-voltage on the system due to lightning discharges or other system faults, those parts of equipment which are normally dead, do not attain dangerously high potentials.
- In a three-phase circuit the neutral of the system is earthed in order to stabilize the potential of the circuit with respect to earth.

An earth electrode will only be effective so long it has a low resistance to the earth and carry large currents without deteriorating.

Since the amount of current which an earth electrode will carry is difficult to measure, the resistance value of earth resistance is taken as sufficiently reliable indication of its effectiveness. The resistance of the earth electrode should be low to give good protection and it must be measured.

The main factors on which the resistance of any earthing system depends are:

- Shape and material of earth electrode or electrodes used.
- Depth in the soil at which the electrodes are buried.
- The specific resistance of soil and in the neighbourhood of electrodes.

3.1.7 Testing of Protection Devices

Fuses / Circuit-breakers

To check the specifications of the protective devices such as fuses or circuit-breakers, a fault loop impedance measurement is carried out to calculate the corresponding short-circuit current. A visual inspection can then be used to check that the sizing is correct.

3.1.8 Short Circuit Test

A short circuit (in some cases abbreviated as to short or s/c) is an electrical circuit that enables a current to go along an unintended way with no or low electrical impedance. The electrical inverse of a short circuit is an “open circuit”, which is a boundless resistance between two nodes. It is normal to misuse “short circuit” to portray any electrical glitch, paying little mind to the real issue

A short circuit is an unusual association between two nodes of an electric circuit expected to be at various voltages. These outcomes in an extreme electric current restricted just by the Thévenin proportional resistance of whatever remains of the system and conceivably causes circuit damage, overheating, fire or blast. Albeit more often than not the consequence of a blame, there are situations where shortcircuits are caused purposefully, for instance, with the end goal of voltage-detecting crowbar circuit defenders.

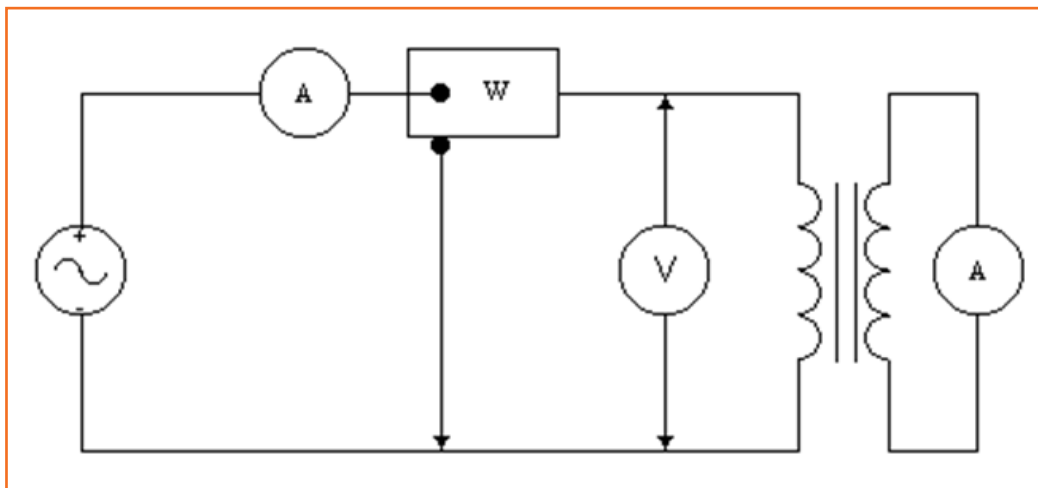


Fig 3.1.5 Short circuit test

In circuit examination, a short out is an association between two nodes that constrains them to be at a similar voltage. In a perfect short circuit, this implies there is no resistance and no voltage drop over

the short. In real circuits, the outcome is an association with no resistance. In such a case, the current is restricted by whatever is left of the circuit.

Procedures to direct short out test

1. Direct test is needed among neutral conductors and dynamic conductor, neutral conductors of each particular circuit and the dynamic conductor of a similar circuit at the mains supply appropriation to uncover any interconnection error.
2. In advance performing of tests, execute the accompanying strides:
3. Neutral connection should be disconnected from circuit
4. Protection of circuit is very important
5. All switches or contactors should be closed.
6. Verify every immediate interconnection with the low-go ohmmeter.
7. A short out condition will be raised if resistance appeared in the ohmmeter is low.
8. Load can be identified with associated load only, if the load is associated with an active phase and is neutral from various circuits.
9. If these means are executed preceding the beginning of the assessment, at that point verify the resistance among the neutral and the dynamic conductors.
10. To verify insulation resistance of links, carry insulation resistance with megger or analyzer, particularly if insulation failure is happening.
11. If the wiring or gadget terminal has an insulation issue it shows resistance less than 1 M ω .

To recognize every electrical circuit and it's dynamic and insulation conveyor, compute load resistance with the ohmmeter and as needs be, distinguish every dynamic and neutral transmitter.

3.1.9 Troubleshooting of Electrical Installation

Electrical troubleshooting is the process of analyzing the behavior or operation of a faulty electrical circuit to determine what is wrong with the electrical circuit. Troubleshooting then involves identifying the defective electrical component(s) and repairing the circuit. Sometimes electrical problems are easily diagnosed and the problem component easily visible. Other times the symptoms as well as the faulty

component can be difficult to diagnose. A defective plug with visual signs of burning should be easy to spot, whereas an intermittent problem caused by a high resistance connection can be much more difficult to find.

Use this seven-step process when presented with a complex problem:

- Gather the information
- Understand the malfunction
- Identify which parameters need to be evaluated
- Identify the source of the problem
- Correct/repair the component
- Verify the repair
- Document the repair

Common electrical problems and its solutions

1. Loose Outlets

Over time, the contacts in a receptacle or outlet wear down, making it easier for a plug or cord to slip out. This isn't only a nuisance; it's also quite dangerous. A loose contact can lead to arcing, or electricity "jumping" from one point to another. Arcing is a significant fire hazard, as the arc can ignite dust, wood, or other in-wall debris.

Solution: Replace the receptacle.

2. Ungrounded Outlets

Older homes are more likely to have ungrounded receptacles, or receptacles with two openings instead of three. This is a problem because excess electrical current has no safe place to travel. It also prevents from plugging in devices with three-prong plugs.

Solution: Replace the receptacle with grounded ones.

3. Over-Lamping

Over-lamping is when a light fixture is fitted with a bulb with a higher wattage than the fixture is meant to handle. This is a greater danger than many people realize. A hot bulb can damage the fixture's socket and adjacent wiring. This can lead to arcing, which in turn can cause a fire.

Solution: Check all light fixtures to ensure the bulbs are at or below the wattage limits. If the limit isn't

marked, use a 60-watt bulb or under to be safe.

4. Absence of GFCIs

A ground fault circuit interrupter (GFCI) outlet is a modern receptacle that can detect minor changes in an outlet's electrical current. This means it can shut down power in the case of human contact or exposure to water. In simple terms, GFCIs are safer than conventional outlets.

Solution: Install GFCI

5. Coverless Junction Boxes

Junction boxes are often locations where high-voltage electrical wiring is spliced together. Though these splices should be secured with plastic clips and perhaps electrical tape, there is still the danger of electrocution.

Solution: Cover the junction boxes and screw them tightly

6. Faulty Switches

On/off and dimmable switches can fail for a number of reasons. It could be loose wiring, arcing, or wear and tear on the plastic pieces. In any case, it's best to fix the switch to avoid a potentially dangerous situation.

Solution: Replace switches

7. Over-Wired Panels

Over-wiring is when a panel is wired to more circuits than it's meant to manage. This can lead to problems with your circuit breaker or, in older homes, electrical fuse box problems.

Solution: Fix an over-wired panel by adding a subpanel.

8. Loose Wire Connections at Switches and Outlets

The most common problem is when screw terminal connections at wall switches and outlets become loose. Because these fixtures get the most use within an electrical system, these are the places to look first if you suspect wire connection problems.

Loose wire connections at a switch, outlet, or light fixture are often signaled by a buzzing or crackling sound or by a light fixture that flickers.

Solution: To address this problem, it involves first turning off the power to the suspected wall switch, light fixture, or outlet. With the power shut off, remove the cover plate and use a flashlight to carefully

examine the screw terminals inside where the wires are connected. If you find any that are loose, carefully tighten the screw terminals down onto the wires.

9. Wire Connections Made With Electrical Tape

A classic wire connection error is when wires are joined together with electrical tape rather than a wire nut or other sanctioned connector.

Solution: To fix the problem, first, turn off the power to the circuit. Then, remove the electrical tape from the wires and clean them. Make sure there is the proper amount of exposed wire showing (for most connectors, this means about 3/4 inch), then join the wires together with a wire nut or other approved connector (there are now push-in connectors that some pros like to use).

If the wire ends are damaged, you can cut off the ends of the wires and strip off about 3/4 inch of insulation to make a proper wire nut connection.

10. Two or More Wires Under One Screw Terminal

Another common wire connection problem is when you find two or more wires held under a single screw terminal on a switch or outlet.

Solution: To fix this problem first shut off the power. Then, the two offending wires are removed from their screw terminal. Cut a 6-inch pigtail wire of the same color as the two wires (use a green pigtail if you are joining two bare copper grounding wires). Strip 3/4 inch of insulation from each end of the pigtail, then join one end to the two wires you just disconnected, using a wire connector (wire nut). Now, attach the free end of the pigtail wire to the screw terminal that once held the two wires.

You have essentially created a bridge, or pathway, that connects both wires to the desired screw terminal on the outlet or switch.

11. Exposed Wires

It is quite common, especially with amateur electrical work, to see a screw terminal connection or wire nut connection where it has too much (or too little) exposed copper wire showing at the wires.

Solution: With wire nut connections, all of the bare copper wire should be hidden under the plastic cap, with no exposed wire showing at the bottom of the wire nut.

To fix the problem, turn off the power to the device, then disconnect the wires and either clip off the excess wire or strip off additional insulation so the proper amount of wire is exposed. Then, reconnect

the wires to their screw terminal or wire nut. Tug lightly on the wires to make sure they are securely connected.

12. Loose Connections on Circuit Breaker Terminals

A less common problem is when the hot wires on circuit breakers in the main service panel are not tightly connected to the breaker. When this happens, you may notice lights flickering or service problems on fixtures all along the circuit. When making connections to circuit breakers, be sure to strip the proper amount of wire insulation from the wire and make sure that only the bare wire is placed under the terminal slot before tightening. Insulation under the connection slot is a code violation.

Solution: To address this problem, turn off the breaker then unclip it from the hot bus bar in the main service panel. Check the hot wire connected to the breaker to make sure that the screw is tight and that there is no insulation under the terminal and no excess bare copper wire exposed. With repair complete, snap the breaker back into place on the hot bus bar and turn the breaker back on.

13. Faulty Neutral Wire Connections at Circuit Breaker Panels

Another less common problem is when the white circuit wire is not correctly mounted to the neutral bus bar in the main service panel. Symptoms here will be similar to those with a faulty hot wire.

Solution: To fix this problem, check that neutral wire is sufficiently stripped and correctly attached to the neutral bus bar.

3.1.10 Troubleshooting of PCB by Bench Test Instruments

1. Multimeter

For testing a circuit by multimeter, you need following basic tools -

- Analog/Digital multimeter
- Soldering gun
- Desoldering station
- Magnifying glass

Steps for using multimeter for checking a circuit board

i. **Plugging:** First observe the polarity and then probe in the multimeter. Every multimeter device comes with two types of probes, namely red and black. While the red one is the positive probe, the black one is the jack at the end of the probe wire.



Fig 3.1.6: Multimeter

ii. **Testing:** Select the multimeter function first to check a circuit board. Multimeters are modeled in such a way that they can measure both voltage and resistance. In case you have to test the power or voltage, turn the function knob or select the AC or DC voltage. The circuit board and the overall voltage will then be displayed on the device.

iii. **Checking:** Circuit boards are made up of many components in general and are placed inside an electrical device. Thus, to know if all parts are working in sync with each other, first unplug the device and the housing. Then switch it on and make sure that you do not touch any of the wirings.



Fig 3.1.7: Circuit Checking

iv. **Measure Voltage and Resistance:** The next thing to do using a multimeter is to check for voltage and resistance. For this step to work out smoothly, you need to do a basic test first. To test circuit board properly, touch the multimeter probes to the test points present on the board.



Fig 3.1.8: Measure Voltage & Resistance

Make sure while playing out this step you have your hands on the plastic portion of the probes. You can then go on to check either the voltage or resistance. When measuring the resistors' resistance, connect one probe to the end of each resistor.

v. **Check The Final Result:** Multimeters are used for checking the working functionality of the circuit board. Thus, to check and see if all the components are working properly repeats the step 1 to 4 for every component present on the board.

Checking the circuit board

- If the components look fine, power up the circuit board. Measure the voltage of the power rails with the multimeter. Both the input and output of the voltage regulator need to show the expected values.

- Check the fuse if the input voltage measured at the voltage regulator is 0V. If the fuse is replaced and immediately breaks after power-up, it means other components are shorted and draining a huge amount of current.
- A voltage of 0V, or below VCC, at the output often means that the regulator or a component along the voltage rail has a short circuit. If that's the case, the damaged component will heat up quickly.
- If there aren't signs of overheated components then look for broken traces. A broken trace could result in the voltage being detected at some points of the trace but not in others. Use your multimeter to narrow down where the discontinuity is.

Troubleshooting a PCB is very important nowadays. It is because, with the rising demand for electrical appliances, the supply for circuit boards has also increased. Thus, a minor distraction in the board can make it non-functional or damage the components. This can be easily traced with the help of a multimeter.

2. Oscilloscope

The oscilloscope is a particularly useful item of test equipment that can be used for testing and fault-finding a variety of electronic circuits from logic circuits through analogue circuits to radio circuits. By knowing the basics of using an oscilloscope it is possible to fault find circuits more effectively and more swiftly as well as gaining a better understanding of how they the circuits work.

The main purpose of an oscilloscope is to graph an electrical signal as it varies over time. Most scopes produce a two-dimensional graph with time on the x-axis and voltage on the y-axis.

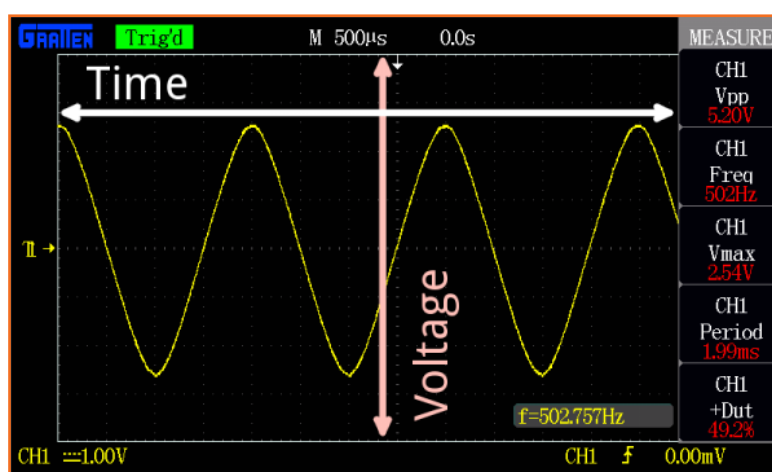


Fig 3.1.9: Oscilloscope WAVEFORMS

An example of an oscilloscope display. A signal (the yellow sine wave in this case) is graphed on a

horizontal time axis and a vertical voltage axis.

Controls surrounding the scope's screen allow you to adjust the scale of the graph, both vertically and horizontally - allowing you to zoom in and out on a signal. There are also controls to set the trigger on the scope, which helps focus and stabilize the display.

What Can Oscilloscope Measure

Many oscilloscopes have measurement tools, which help to quickly quantify frequency, amplitude, and other waveform characteristics. In general a oscilloscope can measure both time-based and voltage-based characteristics -

- **Timing characteristics:**

- ❑ **Frequency and period:** Frequency is defined as the number of times per second a waveform repeats. And the period is the reciprocal of that (number of seconds each repeating waveform takes). The maximum frequency a scope can measure varies, but it's often in the 100's of MHz (1E6 Hz) range.
- ❑ **Duty cycle:** The percentage of a period that a wave is either positive or negative (there are both positive and negative duty cycles). The duty cycle is a ratio that tells you how long a signal is «on» versus how long it's «off» each period.
- ❑ **Rise and fall time:** Signals can't instantaneously go from 0V to 5V, they have to smoothly rise. The duration of a wave going from a low point to a high point is called the rise time, and fall time measures the opposite. These characteristics are important when considering how fast a circuit can respond to signals.

- **Voltage characteristics:**

- ❑ **Amplitude:** Amplitude is a measure of the magnitude of a signal. There are a variety of amplitude measurements including peak-to-peak amplitude, which measures the absolute difference between a high and low voltage point of a signal. Peak amplitude, on the other hand, only measures how high or low a signal is past 0V.
- ❑ **Maximum and minimum voltages:** The scope can tell you exactly how high and low the voltage of your signal gets.
- ❑ **Mean and average voltages:** Oscilloscopes can calculate the average or mean of your signal, and it can also tell you the average of your signal's minimum and maximum voltage.

Steps in using an oscilloscope

- i. **Turn power on:** This may appear obvious but is the first step. Usually the switch will be labelled «**Power**» or «**Line**». Once the power is on, it is normal for a power indicator or line indicator light to come on. This shows that power has been applied.
- ii. **Wait for oscilloscope display to appear:** Although many oscilloscopes these days have semiconductor based displays, many of the older ones still use cathode ray tubes (crt), and these take a short while to warm up before the display appears. Even modern semiconductor ones often need time for their electronics to “**boot-up**”. It is therefore often necessary to wait a minute or so before the oscilloscope can be used.
- iii. **Find the trace:** Once the oscilloscope is ready it is necessary to find the trace. Often it will be visible, but before any other waveforms can be seen, this is the first stage. Typically the trigger can be set to the centre and the hold-off turned fully counter-clockwise. Also set the horizontal and vertical position controls to the centre, if they are not already there. Usually the trace will become visible. If not the «**beamfinder**” button can be pressed and this will locate the trace.
- iv. **Set the gain control:** The next stage is to set the horizontal gain control. This should be set so that the expected trace will nearly fill the vertical screen. If the waveform is expected to be 8 volts peak to peak, and the calibrated section of the screen is 10 centimetres high, then set the gain so that it is 1 volt / centimetre. This way the waveform will occupy 8 centimetres, almost filling the screen.
- v. **Set the timebase speed:** It is also necessary to set the timebase speed on the oscilloscope. The actual setting will depend on what needs to be seen. Typically if a waveform has a period of 10 ms and the screen has a width of 12 centimetres, then a timebase speed of 1 ms per centimetre or division would be chosen.
- vi. **Apply the signal:** With the controls set approximately correctly the signal can be applied and an image should be seen.
- vii. **Adjust the trigger:** At this stage it is necessary to adjust the trigger level and whether it triggers on the positive or negative going edge. The trigger level control will be able to control where on the waveform the timebase is triggered and hence the trace starts on the waveform. The choice of whether it triggers on the positive or negative going edge may also be important. These should be adjusted to give the required image.
- viii. **Adjust the controls for the best image:** With a stable waveform in place, the vertical gain and

timebase controls can be re-adjusted to give the required image.

Steps for checking PCB by oscilloscope

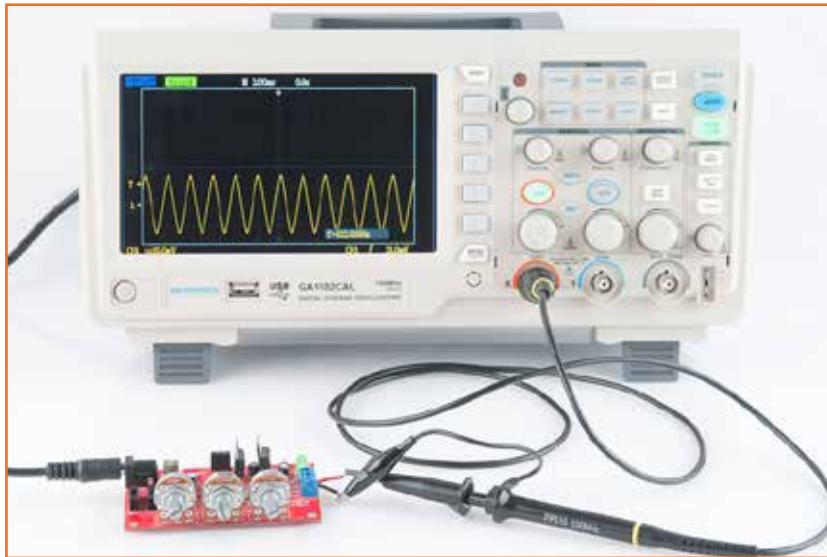


Fig 3.1.10: Checking PCB by oscilloscope

Step 1: Set the constant current and voltage to minimum

Before turning the power supply on, make sure that you twist every button value to zero. Now connect the GND pole of the power supply to the ground of your PCB and turn the power supply on.



Fig 3.1.11: Checking PCB by oscilloscope

Step 2: Carefully rise the voltage

Now connect both poles of the power supply to your PCB. Smoothly rise the voltage until it reaches the required voltage level. Some kind of indicator can be helpful on your printed circuit board, for example a built in LED showing if the board is working.



Fig 3.1.12: Checking PCB by oscilloscope

Step 3: Check the waveform of the signal with an oscilloscope

If everything went as expected you should do the final measurements with an oscilloscope. This can be useful for measuring signals. It can measure voltage in real time between two points. For example if you connect the oscilloscope on a blinking LED, you should see a PWM signal. If the signal is HIGH the LED is turned on or if the signal is LOW the LED is turned off.

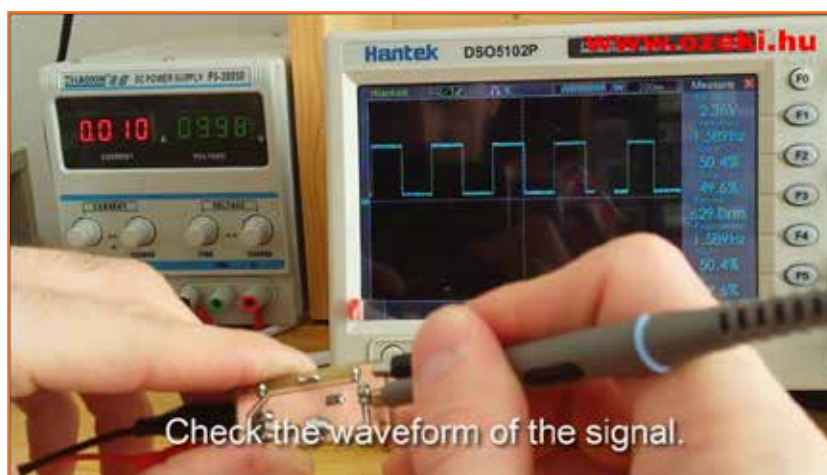


Fig 3.1.13: Checking PCB by oscilloscope

Exercise



1. How do fixed resistors usually fail?
 - (a) by increasing their value
 - (b) slowly over time
 - (c) by becoming an open circuit
 - (d) by increasing their value and becoming an open circuit
2. Which insulating material is used for low voltage cables?
 - (a) Impregnated paper
 - (b) Rubber
 - (c) Silk and cotton
 - (d) Vulcanised Indian rubber
3. In case of Short Circuit, _____ Current will flow in the circuit.
 - (a) Zero
 - (b) Very Low
 - (c) Normal
 - (d) Infinite
4. Which among these tests are to be conducted on wiring installations?
 - (a) Testing of polarity of non linked single pole switches
 - (b) Testing of earth continuity path
 - (c) Testing of earth resistance
 - (d) All of these
5. Generally grounding is provided
 - (a) only for the safety of the equipment
 - (b) only for the safety of operating personnel
 - (c) both (a) and (b)
 - (d) none of the above

Scan the QR code or click on the link to watch related videos



www.youtube.com/watch?v=o8NOK1JJbgw
PCB inspection methods and defects



4. Basic Health and Safety Practices

Unit 4.1 - Workplace Hazards

Unit 4.2 – Fire Safety

Unit 4.3 – First Aid

Unit 4.4 – Waste Management



Key Learning Outcomes



At the end of this module, the participant will be able to:

1. Discuss job-site hazards, risks and accidents
2. Explain the organizational safety procedures for maintaining electrical safety, handling tools and hazardous materials
3. Describe how to interpret warning signs while accessing sensitive work areas
4. Explain the importance of good housekeeping
5. Describe the importance of maintaining appropriate postures while lifting heavy objects
6. List the types of fire and fire extinguishers
7. Describe the concept of waste management and methods of disposing of hazardous waste
8. List the common sources of pollution and ways to minimize them
9. Elaborate on electronic waste disposal procedures
10. Explain how to administer appropriate first aid to victims in case of bleeding, burns, choking, electric shock, poisoning and also administer first aid to victims in case of a heart attack or cardiac arrest due to electric shock

Unit 4.1: Workplace Hazards

Unit Objectives



At the end of this unit, participants will be able to:

1. Discuss job-site hazards, risks and accidents
2. Explain the organizational safety procedures for maintaining electrical safety, handling tools and hazardous materials
3. Describe how to interpret warning signs while accessing sensitive work areas
4. Explain the importance of good housekeeping
5. Describe the importance of maintaining appropriate postures while lifting heavy objects
6. Explain safe handling of tools and Personal Protective Equipment to be used.

4.1.1 Workplace Safety

Workplace safety is important to be established for creating a safe and secure working for the workers. The workplace has to be administered as per the rules of the Occupational Safety and Health Administration (OSHA). It refers to monitoring the working environment and all hazardous factors that impact employees' safety, health, and well-being. It is important to provide a safe working environment to the employees to increase their productivity, wellness, skills, etc.

The benefits of workplace safety are:

- Employee retention increases if they are provided with a safe working environment.
- Failure to follow OSHA's laws and guidelines can result in significant legal and financial consequences.
- A safe environment enables employees to stay invested in their work and increases productivity.
- Employer branding and company reputation can both benefit from a safe working environment.

4.1.2 Workplace Hazards

A workplace is a situation that has the potential to cause harm or injury to the workers and damage the tools or property of the workplace. Hazards exist in every workplace and can come from a variety of

sources. Finding and removing them is an important component of making a safe workplace.

Common Workplace Hazards

The common workplace hazards are:

- **Biological:** The threats caused by biological agents like viruses, bacteria, animals, plants, insects and also humans, are known as biological hazards.
- **Chemical:** Chemical hazard is the hazard of inhaling various chemicals, liquids and solvents. Skin irritation, respiratory system irritation, blindness, corrosion, and explosions are all possible health and physical consequences of these dangers.
- **Mechanical:** Mechanical Hazards comprise the injuries that can be caused by the moving parts of machinery, plant or equipment.
- **Psychological:** Psychological hazards are occupational hazards caused by stress, harassment, and violence.
- **Physical:** The threats that can cause physical damage to people is called physical hazard. These include unsafe conditions that can cause injury, illness and death.
- **Ergonomic:** Ergonomic Hazards are the hazards of the workplace caused due to awkward posture, forceful motion, stationary position, direct pressure, vibration, extreme temperature, noise, work stress, etc.

Workplace Hazards Analysis

A workplace hazard analysis is a method of identifying risks before they occur by focusing on occupational tasks. It focuses on the worker's relationship with the task, the tools, and the work environment. After identifying the hazards of the workplace, organisations shall try to eliminate or minimize them to an acceptable level of risk.

Control Measures of Workplace Hazards

Control measures are actions that can be taken to reduce the risk of being exposed to the hazard. Elimination, Substitution, Engineering Controls, Administrative Controls, and Personal Protective Equipment are the five general categories of control measures.

- **Elimination:** The most successful control technique is to eliminate a specific hazard or hazardous work procedure or prevent it from entering the workplace.
- **Substitution:** Substitution is the process of replacing something harmful with something less

hazardous. While substituting the hazard may not eliminate all of the risks associated with the process or activity, it will reduce the overall harm or health impacts.

- **Engineering Controls:** Engineered controls protect workers by eliminating hazardous situations or creating a barrier between the worker and the hazard, or removing the hazard from the person.
- **Administrative Controls:** To reduce exposure to hazards, administrative controls limit the length of time spent working on a hazardous task that might be used in combination with other measures of control.
- **Personal Protective Equipment:** Personal protective equipment protects users from health and safety hazards at work. It includes items like safety helmets, gloves, eye protection, etc.

4.1.3 Workplace Warning Signs

A Hazard sign is defined as ‘information or instruction about health and safety at work on a signboard, an illuminated sign or sound signal, a verbal communication or hand signal.’

There are four different types of safety signs:

1. **Prohibition Signs:** A “prohibition sign” is a safety sign that prohibits behaviour that is likely to endanger one’s health or safety. The colour red is necessary for these health and safety signs. Only what or who is forbidden should be displayed on a restriction sign.



Fig 4.1.1: Prohibition Warning Signs

2. **Mandatory Signs:** Mandatory signs give clear directions that must be followed. The icons are white circles that have been reversed out of a blue circle. On a white background, the text is black.



Fig 4.1.2: Mandatory Signs

3. **Warning Signs:** Warning signs are the safety information communication signs. They are shown as a 'yellow colour triangle'.



Fig 4.1.3: Mandatory Signs

4. **Emergency Signs:** The location or routes to emergency facilities are indicated by emergency signs. These signs have a green backdrop with a white emblem or writing. These signs convey basic information and frequently refer to housekeeping, company procedures, or logistics.

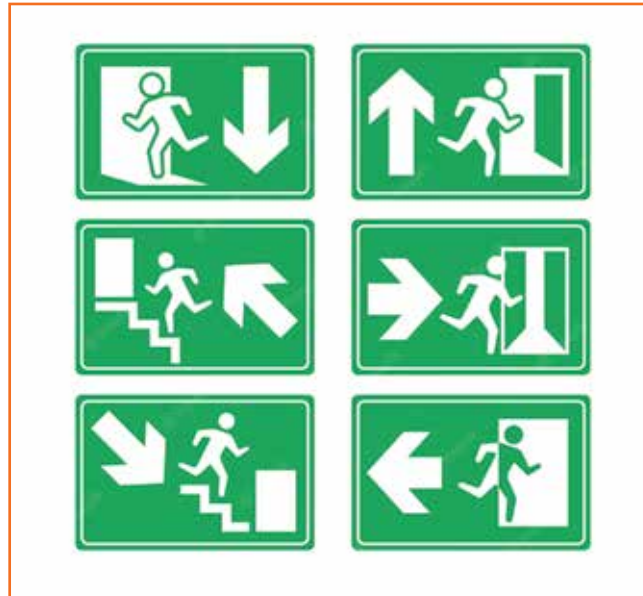


Fig 4.1.4: Emergency Signs

4.1.4 Cleanliness in the Workplace

Workplace cleanliness maintenance creates a healthy, efficient and productive environment for the employees. Cleanliness at the workplace is hindered by some elements like cluttered desks, leftover food, waste paper, etc. A tidy workplace is said to improve employee professionalism and enthusiasm while also encouraging a healthy working environment.

Benefits of cleanliness in the workplace:

1. **Productivity:** Cleanliness in the workplace can bring a sense of belonging to the employees, also motivating and boosting the morale of the employees. This results in increasing their productivity.
2. **Employee Well-being:** Employee well-being can be improved by providing a clean work environment. Employees use fewer sick days in a workplace where litter and waste are properly disposed of, and surfaces are cleaned regularly, resulting in increased overall productivity.
3. **Positive Impression:** Cleanliness and orderliness in the workplace provide a positive impression on both employees and visitors.
4. **Cost saving:** By maintaining acceptable levels of cleanliness in the workplace, businesses can save

money on cleaning bills and renovations, which may become necessary if the premises are not properly kept.

Reasons for cleaning the workplace

- Cleaning of dry floors, mostly to prevent workplace slips and falls.
- Disinfectants stop bacteria in their tracks, preventing the spread of infections and illness.
- Proper air filtration decreases hazardous substance exposures such as dust and fumes.
- Light fixture cleaning improves lighting efficiency.
- Using environmentally friendly cleaning chemicals that are safer for both personnel and the environment.
- Work environments are kept clean by properly disposing of garbage and recyclable items.

4.1.5 Lifting and Handling of Heavy Loads

Musculoskeletal Injuries (MSIs), such as sprains and strains, can occur while lifting, handling, or carrying objects at work. When bending, twisting, uncomfortable postures and lifting heavy objects are involved, the risk of injury increases. Ergonomic controls can help to lower the risk of injury and potentially prevent it.

Types of injuries caused while lifting heavy objects:

- Cuts and abrasions are caused by rough surfaces.
- Crushing of feet or hands.
- Strain to muscles and joints

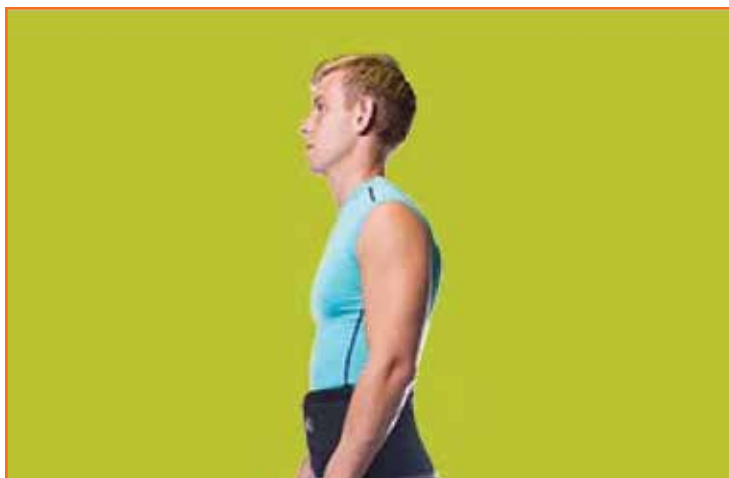


Fig 4.1.5: Lifting loads technique

Preparing to lift

A load that appears light enough to bear at first will grow increasingly heavier as one carries it further.

The person carrying the weight should be able to see over or around it at all times.

The amount of weight a person can lift, depends on their age, physique, and health.

It also depends on whether or not the person is used to lifting and moving hefty objects.

Common causes of back injuries

The most common causes of back injuries are -

1. **Inadequate training:** The individual raising the load receives no sufficient training or guidance.
2. **Lack of awareness of technique:** The most common cause of back pain is incorrect twisting and posture, which causes back strain.
3. **Load size:** The load size to consider before lifting. If the burden is too much for one's capacity or handling, their back may be strained and damaged.
4. **Physical strength:** Depending on their muscle power, various persons have varied physical strengths. One must be aware of their limitations.
5. **Teamwork:** The operation of a workplace is all about working together. When opposed to a single person lifting a load, two people can lift it more easily and without difficulty. If one of two people isn't lifting it properly, the other or both of them will suffer back injuries as a result of the extra strain.

Techniques for lifting heavy objects

Technique	Demonstration
1. Ensure one has a wide base of support before lifting the heavy object. Ensure one's feet are shoulder-width apart, and one foot is slightly ahead of the other at all times. This will help one maintain a good balance during the lifting of heavy objects. This is known as the Karate Stance.	

2. Squat down as near to the object as possible when one is ready to lift it, bending at the hips and knees with the buttocks out. If the object is really heavy, one may wish to place one leg on the floor and the other bent at a straight angle in front of them.



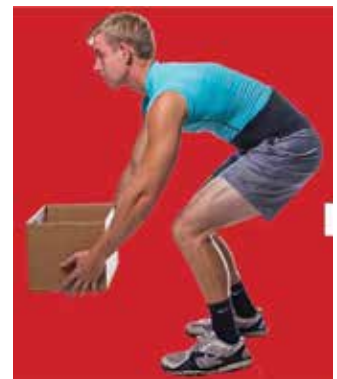
3. Maintain proper posture as one begins to lift upward. To do so, one should keep their back straight, chest out, and shoulders back while gazing straight ahead.



4. By straightening one's hips and knees, slowly elevate the thing (not the back). As one rises, they should extend their legs and exhale. Lift the heavy object without twisting the body or bending forward.



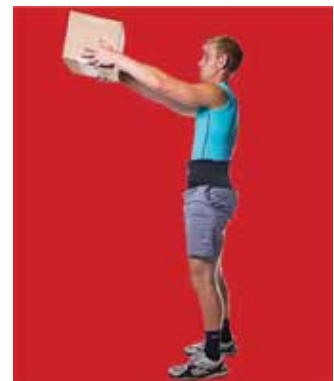
5. Do not lift bending forward.



6. Hold the load close to the body.



7. Never lift heavy objects above the shoulder



8. Use the feet (not the body) to change direction, taking slow, small steps.



9. Set down the heavy object carefully, squatting with the knees and hips only.



Table 4.1.1. Techniques for lifting heavy objects

4.1.6 Safe Handling of Tools

Workers should be trained on how to use tools safely. When tools are misplaced or handled incorrectly by workers, they can be dangerous. The following are some suggestions from the National Safety Council for safe tool handling when they are not in use -

- Never carry tools up or down a ladder in a way that makes it difficult to grip them. Instead of being carried by the worker, tools should be lifted up and down using a bucket or strong bag.
- Tools should never be tossed but should be properly passed from one employee to the next. Pointed tools should be passed with the handles facing the receiver or in their carrier.
- When turning and moving around the workplace, workers carrying large tools or equipment on their shoulders should pay particular attention to clearances.
- Pointed tools such as chisels and screwdrivers should never be kept in a worker's pocket. They can be carried in a toolbox, pointing down in a tool belt or pocket tool bag, or in hand with the tip always held away from the body.
- Tools should always be stored while not in use. People below are put in danger when tools are left sitting around on an elevated structure, such as a scaffold. In situations when there is a lot of vibration, this risk increases.

4.1.7 Personal Protective Equipment

Personal protective equipment, or "PPE," is equipment worn to reduce exposure to risks that might result in significant occupational injuries or illnesses. Chemical, radiological, physical, electrical, mechanical, and other job dangers may cause these injuries and diseases.

PPE used for protection from the following injuries are:

Injury Protection	Protection	PPE
Head Injury Protection	Falling or flying objects, stationary objects, or contact with electrical wires can cause impact, penetration, and electrical injuries. Hard hats can protect one's head from these injuries. A common electrician's hard hat is shown in the figure below. This hard hat is made of non conductive plastic and comes with a set of safety goggles.	

Injury Protection	Protection	PPE
Foot and Leg Injury Protection	In addition to foot protection and safety shoes, leggings (e.g., leather) can guard against risks such as falling or rolling objects, sharp objects, wet and slippery surfaces, molten metals, hot surfaces, and electrical hazards.	
Eye and Face Injury Protection	Spectacles, goggles, special helmets or shields, and spectacles with side shields can protect against the hazards of flying fragments, large chips, hot sparks, radiation, and splashes from molten metals. They also offer protection from particles, sand, dirt, mists, dust, and glare.	
Protection against Hearing Loss	Hearing protection can be obtained by wearing earplugs or earmuffs. High noise levels can result in permanent hearing loss or damage, as well as physical and mental stress. Self-forming earplugs composed of foam, waxed cotton, or fibreglass wool usually fit well. Workers should be fitted for moulded or prefabricated earplugs by a specialist.	
Hand Injury Protection	Hand protection will aid workers who are exposed to dangerous substances by skin absorption, serious wounds, or thermal burns. Gloves are a frequent protective clothing item. When working on electrified circuits, electricians frequently use leather gloves with rubber inserts. When stripping cable with a sharp blade, Kevlar gloves are used to prevent cuts.	

Injury Protection	Protection	PPE
Whole Body Protection	Workers must protect their entire bodies from risks such as heat and radiation. Rubber, leather, synthetics, and plastic are among the materials used in whole-body PPE, in addition to fire-retardant wool and cotton. Maintenance staff who operate with high-power sources such as transformer installations and motor-control centres are frequently obliged to wear fire-resistant clothes.	

Table 4.1.2. Personal protective equipment

Unit 4.2: Fire Safety

Unit Objectives



At the end of this unit, participants will be able to:

1. List the types of fire and fire extinguishers

4.2.1 Fire Safety

Fire safety is a set of actions aimed at reducing the amount of damage caused by fire. Fire safety procedures include both those that are used to prevent an uncontrolled fire from starting and those that are used to minimise the spread and impact of a fire after it has started. Developing and implementing fire safety measures in the workplace is not only mandated by law but is also essential for the protection of everyone who may be present in the building during a fire emergency.

The basic fire safety responsibilities are:

- To identify risks on the premises, a fire risk assessment must be carried out.
- Ascertain that fire safety measures are properly installed.
- Prepare for unexpected events.
- Fire safety instructions and training should be provided to the employees.

4.2.2 Respond to a Workplace Fire

- Workplace fire drills should be conducted on a regular basis.
- If one has a manual alarm, they should raise it.
- Close the doors and leave the fire-stricken area as soon as possible. Ensure that the evacuation is quick and painless.
- Turn off dangerous machines and don't stop to get personal items.
- Assemble at a central location. Ascertain that the assembly point is easily accessible to the employees.
- If one's clothing catches fire, one shouldn't rush about it. They should stop and descend on the ground and roll to smother the flames if their clothes catch fire.

4.2.3. Fire Extinguisher

Fire extinguishers are portable devices used to put out small flames or minimise their damage until fire-fighters arrive. These are maintained on hand in locations such as fire stations, buildings, workplaces, public transit, and so on. The types and quantity of extinguishers that are legally necessary for a given region are determined by the applicable safety standards.

Types of fire extinguishers are:

There are five main types of fire extinguishers -

1. **Water:** Water fire extinguishers are one of the most common commercial and residential fire extinguishers on the market. They're meant to be used on class-A flames.



2. **Powder:** The L2 powder fire extinguisher is the most commonly recommended fire extinguisher in the Class D Specialist Powder category, and is designed to put out burning lithium metal fires.



3. **Foam:** Foam extinguishers are identified by a cream rectangle with the word "foam" printed on it. They're mostly water-based, but they also contain a foaming component that provides a quick knock-down and blanketing effect on flames. It suffocates the flames and seals the vapours, preventing re-ignition.



4. **Carbon Dioxide (CO₂):** Class B and electrical fires are extinguished with carbon dioxide extinguishers, which suffocate the flames by removing oxygen from the air. They are particularly beneficial for workplaces and workshops where electrical fires may occur since, unlike conventional extinguishers, they do not leave any toxins behind and hence minimise equipment damage.



5. **Wet Chemical:** Wet chemical extinguishers are designed to put out fires that are classified as class F. They are successful because they can put out extremely high-temperature fires, such as those caused by cooking oils and fats.



Table 4.2.1 Fire Extinguishers

Scan the QR code or click on the link to watch related videos



www.youtube.com/watch?v=DaYwcH1GMEg
Workplace emergency procedures

Unit 4.3: First Aid

Unit Objectives



At the end of this unit, participants will be able to:

1. Explain how to administer appropriate first aid to victims in case of bleeding, burns, choking, electric shock, poisoning
2. Explain how to administer first aid to victims in case of a heart attack or cardiac arrest due to electric shock.

4.3.1 First Aid

First aid is the treatment or care given to someone who has sustained an injury or disease until more advanced care can be obtained or the person recovers.

The aim of first aid is to:

- Preserve life
- Prevent the worsening of a sickness or injury
- If at all possible, relieve pain
- Encourage recovery
- Keep the unconscious safe.

First aid can help to lessen the severity of an injury or disease, and in some situations, it can even save a person's life.

4.3.2 Need for First Aid at the Workplace

In the workplace, first aid refers to providing immediate care and life support to persons who have been injured or become unwell at work.

Many times, first aid can help to lessen the severity of an accident or disease.

It can also help an injured or sick person relax. In life-or-death situations, prompt and appropriate first aid can make all the difference.

4.3.3 Treating Minor Cuts and Scrapes

Steps to keep cuts clean and prevent infections and scars:

- **Wash Hands:** Wash hands first with soap and water to avoid introducing bacteria into the cut and causing an infection. One should use the hand sanitiser if one is on the go.
- **Stop the bleeding:** Using a gauze pad or a clean towel, apply pressure to the wound. For a few minutes, keep the pressure on.
- **Clean Wounds:** Once the bleeding has stopped, clean the wound by rinsing it under cool running water or using a saline wound wash. Use soap and a moist washcloth to clean the area around the wound. Soap should not be used on the cut since it may irritate the skin. Also, avoid using hydrogen peroxide or iodine, as these may aggravate the wound.
- **Remove Dirt:** Remove any dirt or debris from the area. Pick out any dirt, gravel, glass, or other material in the cut with a pair of tweezers cleaned with alcohol.

4.3.4 Heart Attack

When the blood flow carrying oxygen to the heart is blocked, a heart attack occurs. The heart muscle runs out of oxygen and starts to die.

Symptoms of a heart attack can vary from person to person. They may be mild or severe. Women, older adults, and people with diabetes are more likely to have subtle or unusual symptoms.

Symptoms in adults may include:

- Changes in mental status, especially in older adults.
- Chest pain that feels like pressure, squeezing, or fullness. The pain is most often in the centre of the chest. It may also be felt in the jaw, shoulder, arms, back, and stomach. It can last for more than a few minutes or come and go.
- Cold sweat.
- Light-headedness.
- Nausea (more common in women).
- Indigestion.
- Vomiting.
- Numbness, aching or tingling in the arm (usually the left arm, but the right arm may be affected alone, or along with the left).

- Shortness of breath.
- Weakness or fatigue, especially in older adults and in women.

First Aid for Heart Attack If one thinks someone is experiencing a heart attack, they should:

- Have the person sit down, rest, and try to keep calm.
- Loosen any tight clothing.
- Ask if the person takes any chest pain medicine, such as nitro-glycerine for a known heart condition, and help them take it.
- If the pain does not go away promptly with rest or within 3 minutes of taking nitro-glycerine, call for emergency medical help.
- If the person is unconscious and unresponsive, call 911 or the local emergency number, then begin CPR.
- If an infant or child is unconscious and unresponsive, perform 1 minute of CPR, then call 911 or the local emergency number.

Scan the QR code or click on the link to watch related videos



www.youtube.com/watch?v=BumbKHqXJo0

First-aid practices

Unit 4.4: Waste Management

Unit Objectives



At the end of this unit, participants will be able to:

1. Describe the concept of waste management and methods of disposing of hazardous waste.
2. List the common sources of pollution and ways to minimize them.
3. Elaborate on electronic waste disposal procedures.

4.4.1 Waste Management and Methods of Waste Disposal

The collection, disposal, monitoring, and processing of waste materials is known as waste management. These wastes affect living beings' health and the environment. For reducing their effects, they have to be managed properly. The waste is usually in solid, liquid or gaseous form.

The importance of waste management is:

Waste management is important because it decreases waste's impact on the environment, health, and other factors. It can also assist in the reuse or recycling of resources like paper, cans, and glass. The disposal of solid, liquid, gaseous, or dangerous substances is the example of waste management.

When it comes to trash management, there are numerous factors to consider, including waste disposal, recycling, waste avoidance and reduction, and garbage transportation. Treatment of solid and liquid wastes is part of the waste management process. It also provides a number of recycling options for goods that aren't classified as garbage during the process.

4.4.2 Methods of Waste Management

Non-biodegradable and toxic wastes, such as radioactive remains, can cause irreversible damage to the environment and human health if they are not properly disposed of. Waste disposal has long been a source of worry, with population increase and industrialisation being the primary causes. Here are a few garbage disposal options.

1. **Landfills:** The most common way of trash disposal today is to throw daily waste/garbage into landfills. This garbage disposal method relies on burying the material in the ground.
2. **Recycling:** Recycling is the process of transforming waste items into new products in order to reduce energy consumption and the use of fresh raw materials. Recycling reduces energy

consumption, landfill volume, air and water pollution, greenhouse gas emissions, and the preservation of natural resources for future use.

3. **Composting:** Composting is a simple and natural bio-degradation process that converts organic wastes, such as plant remnants, garden garbage, and kitchen waste, into nutrient-rich food for plants.
4. **Incineration:** Incineration is the process of combusting garbage. The waste material is cooked to extremely high temperatures and turned into materials such as heat, gas, steam, and ash using this technology.

4.4.3 Recyclable, Non-Recyclable and Hazardous Waste

1. **Recyclable Waste:** The waste which can be reused or recycled further is known as recyclable waste.
2. **Non-recyclable Waste:** The waste which cannot be reused or recycled is known as non-recyclable waste. Polythene bags are a great example of non-recyclable waste.
3. **Hazardous Waste:** The waste which can create serious harm to the people and the environment is known as hazardous waste.

4.4.4 Sources of Pollution

Pollution is defined as the harm caused by the presence of a material or substances in places where they would not normally be found or at levels greater than normal. Polluting substances might be in the form of a solid, a liquid, or a gas.

- **Point source of pollution:** Pollution from a point source enters a water body at a precise location and can usually be identified. Effluent discharges from sewage treatment plants and industrial sites, power plants, landfill sites, fish farms, and oil leakage via a pipeline from industrial sites are all potential point sources of contamination. Point source pollution is often easy to prevent since it is feasible to identify where it originates, and once identified, individuals responsible for the pollution can take rapid corrective action or invest in longer-term treatment and control facilities.
- **Diffuse source of pollution:** As a result of land-use activities such as urban development, amenity, farming, and forestry, diffuse pollution occurs when pollutants are widely used and diffused over a large region. These activities could have occurred recently or in the past. It might be difficult to pinpoint specific sources of pollution and, as a result, take rapid action to prevent it because

prevention often necessitates significant changes in land use and management methods.

Pollution Prevention

Pollution prevention entails acting at the source of pollutants to prevent or minimise their production. It saves natural resources, like water, by using materials and energy more efficiently.

Pollution prevention includes any practice that:

- Reduces the amount of any hazardous substance, pollutant, or contaminant entering any waste stream or otherwise released into the environment (including fugitive emissions) prior to recycling, treatment, or disposal;
- Reduces the hazards to public health and the environment associated with the release of such substances, pollutants, or contaminants (these practices are known as “source reduction”);
- Improved efficiency in the use of raw materials, energy, water, or other resources, or Conservation is a method of safeguarding natural resources.
- Improvements in housekeeping, maintenance, training, or inventory management; equipment or technology adjustments; process or method modifications; product reformulation or redesign; raw material substitution; or improvements in housekeeping, maintenance, training, or inventory control.

4.4.5 Electronic Waste

Lead, cadmium, beryllium, mercury, and brominated flame retardants are found in every piece of electronic waste. When gadgets and devices are disposed of illegally, these hazardous compounds are more likely to contaminate the earth, pollute the air, and leak into water bodies.

When e-waste is dumped in a landfill, it tends to leach trace metals as water runs through it. The contaminated landfill water then reaches natural groundwater with elevated toxic levels, which can be dangerous if it reaches any drinking water bodies. Despite having an environmentally benign approach, recycling generally results in international shipment and dumping of the gadgets in pits.

Some eco-friendly ways of disposing of e-waste are:

- Giving back the e-waste to the electronic companies and drop-off points
- Following guidelines issued by the government
- Selling or donating the outdated technology-based equipment
- Giving e-waste to a certified e-waste recycler

Scan the QR code or click on the link to watch related videos



www.youtube.com/watch?v=K6ppCC3lboU

Waste management



5. Employability Skills (60 Hours)



Scan the QR code or click on the link to watch related videos



<https://www.skillindiadigital.gov.in/content/list>
Employability skills (60 hours)



6. Annexure

Lists of QR Codes used in the PH



ANNEXURE - QR Codes

S.No.	Chapter No.	Unit No.	Topic Name	Page No.	QR code(s)	URL
1	Chapter 1: Introduction to Electrician	Unit 1.2 – Basics of Electricity and Electronics	Basics of electricity	17		https://www.youtube.com/watch?v=m-c979OhitAg
2		Unit 1.2 – Basics of Electricity and Electronics	Electric cir- cuits	17		https://www.youtube.com/watch?v=m-4jzgqZu-4s
3	Chapter 2: Planning, Design and Installation	Unit 2.1 – Electrical and Electronic Cir- cuit Diagrams	Electronic component symbols	33		https://www.youtube.com/watch?v=p-BiGez-SIXE
4		Unit 2.2 – Electrical and Electronic System Com- ponents and Accessories	Electronic components	77		https://www.youtube.com/watch?v=vZ1m_kOxEvo
5		Unit 2.4 – Cable Assem- bly	Soldering	92		https://www.youtube.com/watch?v=lpkkfK-937mU
6		Unit 2.5 – Assembly Procedure	Distribution panel wiring diagram	99		https://www.youtube.com/watch?v=NWS-Wm5d3f90

S.No.	Chapter No.	Unit No.	Topic Name	Page No.	QR code(s)	URL
7	Chapter 3: Test and Commissioning	Unit 3.1 – Testing and Fault Finding	PCB inspection methods and defects	124		https://www.youtube.com/watch?v=5WuS-CHKaz8o
8	Chapter 4: Basic Health and Safety Practices	Unit 4.2 – Fire Safety	Workplace emergency procedures	141		https://www.youtube.com/watch?v=DaYwcH-1GMEg
9		Unit 4.3 – First Aid	First-aid practices	144		https://www.youtube.com/watch?v=Bumb-KHqXJo0
10			Waste Management	148		https://www.youtube.com/watch?v=K6ppC-C3lboU
11	Employability skills (60 hours)	Employability skills (60 hours)	Employability skills (60 hours)	150		https://www.skill-india.digital.gov.in/content/list

Notes



Lined area for taking notes, consisting of 25 horizontal lines.





Skill India

कौशल भारत - कुशल भारत



सत्यमेव जयते
GOVERNMENT OF INDIA
MINISTRY OF SKILL DEVELOPMENT
& ENTREPRENEURSHIP



N.S.D.C.
National
Skill Development
Corporation
Transforming the skill landscape



Skilling India in Electronics

Address: Electronics Sector Skills Council of India

155, 2nd Floor, ESC House Okhla Industrial Area-Phase 3, New Delhi- 110020

Email: info@essc-india.org

Web: www.essc-india.org

Phone: +91-84477-38-501

Price: ₹