WIREMAN

NSQF LEVEL - 4

2nd Year

TRADE THEORY

SECTOR: POWER

(As per revised syllabus July 2022 - 1200 hrs)

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Directorate General of Training

DIRECTORATE GENERAL OF TRAINING
MINISTRY OF SKILL DEVELOPMENT & ENTREPRENEURSHIP
GOVERNMENT OF INDIA

NATIONAL INSTRUCTIONAL MEDIA INSTITUTE, CHENNAI

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FOREWORD

The Government of India has set an ambitious target of imparting skills to 30 crores people, one out of every four Indians, by 2020 to help them secure jobs as part of the National Skills Development Policy. Industrial Training Institutes (ITIs) play a vital role in this process especially in terms of providing skilled manpower. Keeping this in mind, and for providing the current industry relevant skill training to Trainees, ITI syllabus has been recently updated with the help of Mentor Councils comprising various stakeholder's viz. Industries, Entrepreneurs, Academicians and representatives from ITIs.

The National Instructional Media Institute (NIMI), Chennai has now come up with instructional material to suit the revised curriculum for **Wireman 2nd Year Trade Theory NSQF Level - 4 (Revised 2022) in Power Sector.** The NSQF Level - 4 (Revised 2022) Trade Practical will help the trainees to get an international equivalency standard where their skill proficiency and competency will be duly recognized across the globe and this will also increase the scope of recognition of prior learning. NSQF Level - 4 (Revised 2022) trainees will also get the opportunities to promote life long learning and skill development. I have no doubt that with NSQF Level - 4 (Revised 2022) the trainers and trainees of ITIs, and all stakeholders will derive maximum benefits from these IMPs and that NIMI's effort will go a long way in improving the quality of Vocational training in the country.

The Director General, Executive Director & Staff of NIMI and members of Media Development Committee deserve appreciation for their contribution in bringing out this publication.

Jai Hind

ATUL KUMAR TIWARI, *I.A.S*
Secretary
Ministry of Skill Development & Entrepreneurship,
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New Delhi - 110 001

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PREFACE

The National Instructional Media Institute (NIMI) was established in 1986 at Chennai by then Directorate General of Employment and Training (D.G.E & T), Ministry of Labour and Employment, (now under Ministry of Skill Development and Entrepreneurship) Government of India, with technical assistance from the Govt. of the Federal Republic of Germany. The prime objective of this institute is to develop and provide instructional materials for various trades as per the prescribed syllabi (NSQF LEVEL - 4) under the Craftsman and Apprenticeship Training Schemes.

The instructional materials are created keeping in mind, the main objective of Vocational Training under NCVT/NAC in India, which is to help an individual to master skills to do a job. The instructional materials are generated in the form of Instructional Media Packages (IMPs). An IMP consists of Theory book, Practical book, Test and Assignment book, Instructor Guide, Audio Visual Aid (Wall charts and Transparencies) and other support materials.

The trade practical book consists of series of exercises to be completed by the trainees in the workshop. These exercises are designed to ensure that all the skills in the prescribed syllabus are covered. The trade theory book provides related theoretical knowledge required to enable the trainee to do a job. The test and assignments will enable the instructor to give assignments for the evaluation of the performance of a trainee. The wall charts and transparencies are unique, as they not only help the instructor to effectively present a topic but also help him to assess the trainee's understanding. The instructor guide enables the instructor to plan his schedule of instruction, plan the raw material requirements, day to day lessons and demonstrations.

In order to perform the skills in a productive manner instructional videos are embedded in QR code of the exercise in this instructional material so as to integrate the skill learning with the procedural practical steps given in the exercise. The instructional videos will improve the quality of standard on practical training and will motivate the trainees to focus and perform the skill seamlessly.

IMPs also deals with the complex skills required to be developed for effective team work. Necessary care has also been taken to include important skill areas of allied trades as prescribed in the syllabus.

The availability of a complete Instructional Media Package in an institute helps both the trainer and management to impart effective training.

The IMPs are the outcome of collective efforts of the staff members of NIMI and the members of the Media Development Committees specially drawn from Public and Private sector industries, various training institutes under the Directorate General of Training (DGT), Government and Private ITIs.

NIMI would like to take this opportunity to convey sincere thanks to the Directors of Employment & Training of various State Governments, Training Departments of Industries both in the Public and Private sectors, Officers of DGT and DGT field institutes, proof readers, individual media developers and coordinators, but for whose active support NIMI would not have been able to bring out this materials.

Chennai - 600 032 **EXECUTIVE DIRECTOR**

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NIMI records its appreciation for the Data Entry, CAD, DTP operators for their excellent and devoted services in the process of development of this Instructional Material.

NIMI also acknowledges with thanks the invaluable efforts rendered by all other NIMI staff who have contributed towards the development of this Instructional Material.

NIMI is also grateful to everyone who has directly or indirectly helped in developing this Instructional Material.

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INTRODUCTION

TRADE PRACTICAL

The trade practical manual is intended to be used in workshop. It consists of a series of practical exercises to be completed by the trainees during the course of the **Wireman** Trade supplemented and supported by instructions/ informations to assist in performing the exercises. These exercises are designed to ensure that all the skills in compliance with NSQF LEVEL - 4 (Revised 2022)

The manual is divided into Ten modules

Module 1	-	Commercial Wiring
Module 2	-	Industrial Wiring
Module 3	-	Illumination
Module 4	-	CFL & LED Lamps & DC Regulated Power Supply
Module 5	-	Solar Power Plant
Module 6	-	Cable Joints
Module 7	-	Electric vehicle
Module 8	-	Domestic Appliances
Module 9	-	Basic Electrical Wiring and Winding
Module 10	-	Wiring Installation

The skill training in the shop floor is planned through a series of practical exercises centered around some practical project. However, there are few instances where the individual exercise does not form a part of project.

While developing the practical manual a sincere effort was made to prepare each exercise which will be easy to understand and carry out even by below average trainee. However the development team accept that there is a scope for further improvement. NIMI, looks forward to the suggestions from the experienced training faculty for improving the manual.

TRADE THEORY

The manual of trade theory consists of theoretical information for the course of the **Wireman 2nd Year NSQF Level - 4 (Revised 2022)** in **Power** Trade. The contents are sequenced according to the practical exercise contained in the manual on Trade practical. Attempt has been made to relate the theoretical aspects with the skill covered in each exercise to the extent possible. This co-relation is maintained to help the trainees to develop the perceptional capabilities for performing the skills.

The Trade theory has to be taught and learnt along with the corresponding exercise contained in the manual on trade practical. The indicating about the corresponding practical exercise are given in every sheet of this manual.

It will be preferable to teach/learn the trade theory connected to each exercise atleast one class before performing the related skills in the shop floor. The trade theory is to be treated as an integrated part of each exercise.

The material is not the purpose of self learning and should be considered as supplementary to class room instruction.

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LEARNING / ASSESSABLE OUTCOME

On completion of this book you shall be able to

S.No.	Learning Outcome	Ref. Ex.No.
1	**Plan, draw, install and test different types of Commercial wiring including advanced systems. Install temporary electrical wiring at construction site. (Mapped NOS: PSS/N1707)**	**2.1.109 - 2.1.118**
2	**Plan, draw, estimate material/ cost, install and test different types of industrial wiring system as per IE rules. Layout cables for various purposes including cable management. (Mapped NOS: PSS/N1707)**	**2.2.119 - 2.2.133**
3	**Plan, install and test illumination system including domestic, commercial and industrial requirements. Connect, program and operate PAR light on DMX controller (Stage light control). (NOS: PSS/N1707)**	**2.3.134 - 2.3.141**
4	**Assemble simple electronic circuits, repair CFL, LED lamps and DC regulated power supply. (Mapped NOS: PSS/N6002)**	**2.4.142 - 2.4.149**
5	**Assist in Installation and commissioning of small solar plant, solar pumps and construct Solar DC appliances. (Mapped NOS: PSS/N6003)**	**2.5.150 - 2.5.157**
6	**Plan, prepare and carry out jointing of LT/HT underground cables with due care and safety. (Mapped NOS: PSS/N2512)**	**2.6.158 - 2.6.164**
7	**Install Electric Vehicle charging stations and carry out preventive/ breakdown maintenance.**	**2.7.165 - 2.7.167**
8	**Install and repair domestic appliances viz., electric kettle, food processor, fan, washing machine, geyser, water pump etc. including repair of electrical faults in refrigerator, window and split AC. (Mapped NOS: PSS/N6003, PSS/N4402, PSS/N1711)**	**2.8.168 - 2.8.177**
9	**Perform winding of small transformers and motors viz., ceiling fan, table fan, mixer/grinder, submersible pump, etc. (Mapped NOS: PSS/N4402)**	**2.9.178 - 2.9.184**
10	**Carry out Estimation & costing for different wiring systems and ready to adopt structured / smart wiring concept for automation and IoT applications.**	**2.10.185-2.10.188**

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SYLLABUS FOR WIREMAN

Duration	Reference Learning Outcome	Professional Skills (Trade Practical) with Indicative hours	Professional Knowledge (Trade Theory)
Professional Skill 115 Hrs; Professional Knowledge 30 Hrs	Plan, draw, install and test different types of Commercial wiring including advanced systems. Install temporary electrical wiring at construction site. (Mapped NOS: PSS/N1707)	109.Practice wiring for communication circuits and computer networks using UTP, STP, Co-axial and optical fibre cables. (11 hrs) 110.Wire-up lighting system for control using motion detector. (12 hrs) 111.Wire-up panel board for control of lights and fans from wireless remote. (12 hrs) 112.Demonstrate wiring and components of fire alarm system, interior siren, control & signalling using visual aids. (12 hrs) 113.Practice installation of 1 ϕ & 3 ϕ online/ offline UPS wiring and test. (12 hrs) 114.Install and wire up CCTV camera. (08 hrs) 115.Install inverter and carry out wiring. (12 hrs) 116.Demonstrate wiring plan, lighting fixtures, receptacles and sensors for bathing area. (12 hrs) 117.Demonstrate multi- storeyed building wiring. (12 hrs) 118.Install temporary LV electrical panels and lighting arrangements for construction site. (12 hrs)	**Commercial Wiring:** Wiring in commercial building- their special precautions as per I.E. rules. Different types of wiring - Power, control, Communication and entertainment wiring. Wiring circuits planning, Cabling in healthcare facilities; importance of grounding, shielding and routing in accordance with life safety codes to minimize interference with medical equipment. GFCI (Ground-fault circuit interrupter) receptacles. (30 hrs)
Professional Skill 110 Hrs; Professional Knowledge 28 Hrs	Plan, draw, estimate material/ cost, install and test different types of industrial wiring system as per IE rules. Layout cables for various purposes including cable management. (Mapped NOS: PSS/N1707)	119.Identify accessories and tools required for industrial wiring. Demonstrate various switchboards, switchgears, industrial control panels and accessories. (06 hrs) 120.Demonstrate cable tray, raceways, auxiliary gutter, cable bus assembly, trench for passing of cables. (06 hrs) 121.Determine minimum ampacity and size of conductors for continuous and non-continuous loads. (06 hrs) 122.Practice installing cables in conduit as per IE rules. (06 hrs) 123.Practice cutting, threading and bending of metallic conduit. (08 hrs)	**Industrial Wiring:** Adverse conditions likely to affect the installation. Degree of mechanical and electrical protection necessary. Peak-Non-peak Loads in Office Buildings Lighting Design; lighting power density, Estimation of load, cable size, bill of material and cost. Inspection and testing of wiring installations. Special wiring circuit e.g. hospital, godown, tunnel and workshop, etc. Danger notice as per IE rules **Cable Management:** Types of cables, their use, Various cable glands

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		124.Identify different bus bars, practice joining and installation including overhead bus bar system as per IE rules. (10 hrs) 125.Prepare bill of material, plan and practice wiring of an institute and workshop as per IE rules. (16 hrs) 126.Demonstrate Hospital, Tunnel and Godown wiring using visual aids. (06 hrs) 127.Practice testing / fault detection of industrial wiring installations and repair. (14 hrs) 128. Practice laying of cables in raceways and trenches. (05 hrs) 129. Demonstrate various cable glands. Practice cable entry on a switch cabinet wall. (05 hrs) 130.Practice passing of cables through cable entry plate for standard cables without connectors, up to IP 68 rated protection. (05 hrs) 131.Practice split cable entry for multiple pre-terminated cables, up to IP 65 rated protection. (05 hrs) 132.Demonstrate bonding and grounding of raceways, cable assembly and panels. (04 hrs) 133.Demonstrate use of earth rods. Test underground cables for faults and remove the fault. (08 hrs)	Introduction to IP ratings (Ingress protection) and IP Codes format. Importance of Bonding and grounding, various types. Testing of cables, locating faults, open circuit, short circuit and leakage in cables.(28 hrs)
Professional Skill 60 Hrs; Professional Knowledge 20 Hrs	Plan, install and test illumination system including domestic, commercial and industrial requirements. Connect, program and operate PAR light on DMX controller (Stage light control). (NOS: PSS/N1707)	134.Group different wattage of lamps in series for specified voltage. (03 Hrs) 135.Practice on low voltage track system, mains voltage track system and LED battery powered lighting. (07 hrs) 136.Prepare decorative lamp circuit to produce rotating/ running light effect. (08 Hrs) 137.Install different display spotlights and LED downlights. (08 Hrs) 138.Demonstrate kitchen under- cabinet lighting, shelf lighting, closet lighting and cove lighting. (05 hrs) 139.Practice installation of various lamps e.g. fluorescent tube, HP mercury vapour, LP mercury vapour, HP sodium vapour, LP sodium vapour, metal halide, LED lights, pendant lighting. (15 hrs) 140.Assemble, program and Practice on DMX controller for operation of PAR lights. (10 hrs) 141. Visual demonstration of LED video wall panel installation, hardware & software setup. (04 hrs)	**Illumination & Stage Light Control:** Laws of Illuminations. Types of illumination system. Illumination factors, intensity of light. Type of lamps, advantages/ disadvantages and their applications. Calculations of lumens and efficiency. Spotlights, downlights, Strip lights Various reflectors; PAR (Parabolic aluminized reflector), MR (Multi-faceted reflector) LED video wall panel applications. (20 hrs)

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Professional Skill 65 Hrs; Professional Knowledge 20 Hrs	Assemble simple electronic circuits, repair CFL, LED lamps and DC regulated power supply. (Mapped NOS: PSS/N6002)	142.Determine the value of resistance by colour code and identify types. (05 hrs) 143.Determine V-I characteristics of semiconductor diode. (05 hrs) 144.Identify circuit components and their terminals viz, diode, transistor, capacitors, regulator. (06 hrs) 145.Construct half wave, full wave and bridge rectifiers. (15 hrs) 146.Practice soldering on basic electrical and electronic circuits. (06 hrs) 147.Troubleshoot defects in simple power supplies. (05 hrs) 148.Identify different components and circuits of CFL & LED lamps. (08 hrs) 149.Check faulty section/ components of LED & CFL and practice for repairing. (15 hrs)	**CFL/LED Lamps & DC regulated power supply;** Resistors; colour code, types and characteristics. Diode; P-N junction, classification, specifications, biasing and characteristics. Rectifier circuit; half wave, full wave, bridge rectifiers and filters. Active and passive components. Functioning of components used in CFL and LED circuits. CFL and LED lamp's circuit. Safety and disposal procedure (20 hrs)
Professional Skill 80 Hrs; Professional Knowledge 20 Hrs	Assist in Installation and commissioning of small solar plant, solar pumps and construct Solar DC appliances. (Mapped NOS: PSS/N6003)	150.Construct a solar lantern using Solar PV panel (15W), Charge controller (6V, 5A), output control circuit for variable illumination, Rechargeable battery (6V, 7Ah) and DC LED lamp (5W). (15 hrs) 151.Construct a Solar Day lighting using manual charge controller (12V, 10A), Solar battery (12V, 100Ah), Solar panel (75 W) and 4X LED light (12V DC, 5W). (10 hrs) 152.Construct a Solar Street light using dusk to dawn charge controller (12V, 10 A), Solar battery (12V, 100 Ah), Solar panel (75 W) and 4X LED light (12V DC, 5W). (10 hrs) 153.Construct a Solar water pump using a DC pump (24 V), Solar Panel (250 W), Charge controller (24 V, 10 A). (12 hrs) 154.Connect a Solar panel (10W), Solar charge controller (12V, 10A), Solar battery (12V, 100 Ah) and a normal inverter and convert to a solar inverter. (10 hrs) 155.Prepare bill of material for a 1 KW solar PV installation. (10 hrs) 156.Demonstrate through audio visual aids; automatic manufacturing of solar panels, installation of solar street light, solar fertilizer sprayer, solar water pump and solar traffic light. (09 hrs) 157.Demonstrate synchronization between Solar Panel & AC grid supply using visual aids. (04 hrs)	**Solar Power Plant:** Solar energy fundamentals. Study of Sun path (east to west, North to south and south to north movement). Study of daily and seasonal changes of sunlight. Angle of inclination of radiant light and its relation with latitude and longitude of different locations on Earth. Solar DC domestic application: Making of solar lantern. Solar Day lighting. Solar Garden Lights. Safety in DC system. Quality standards List out the inventory list of equipments. Solar DC industrial application: Solar street light. Solar home lighting system. Solar Security system. Solar DC water pump. Differentiate AC and DC solar pumps and their PV requirements for various HP capacities. Solar PV e-learning software. (20 hrs)

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Professional Skill 85 Hrs; Professional Knowledge 20 Hrs	Plan, prepare and carry out jointing of LT/HT underground cables with due care and safety. (Mapped NOS: PSS/N2512)	158.Identify different parts of various underground cables. (05 hrs) 159.Practice preparation of cables for termination and joining. (12 hrs) 160.Demonstrate termination kits and practice on terminations of LT/HT cables. (15 hrs) 161.Practice discharging procedure of underground cables. (08 hrs) 162.Make straight joint of different types of underground cable. (25 hrs) 163.Demonstrate jointing of XLPE cables using audio- visual aids. (12 hrs) 164.Demonstrate various tests on underground cables. (08 hrs)	**Underground cable joints:** Need of cables, advantages and disadvantages, various types viz., PVC, XLPE, PILC, oil filled, etc. Cable insulation & voltage grades. Joints and terminations; pre- moulded, heat shrinkable, extrusion molded joints Slip on, cold shrink terminations. Types of connectors used in the cable, current path. Methods of conductor connection, contact resistance. Galvanic corrosion and use of bimetals. Connectivity for cable screen and armour, mechanical protection Kits for joints and terminations. Cable termination to equipment Standards and testing; type, routine, field test, Stress control (20 hrs)
Professional Skill 20 Hrs; Professional Knowledge 05 Hrs	Install Electric Vehicle charging stations and carry out preventive/ breakdown maintenance.	165.Demonstrate different charger specifications. (04hrs) 166.Perform installation of EV charging Station for Public places. (08 hrs) 167.Perform installation of Home EV charging stations. (08 hrs)	EV scenario in India and EV Charging basic theory. EV Charging safety requirements. (05 hrs)
Professional Skill 135 Hrs; Professional Knowledge 40 Hrs	Install and repair domestic appliances viz., electric kettle, food processor, fan, washing machine, geyser, water pump etc. including repair of electrical faults in refrigerator, window and split AC. (Mapped NOS: PSS/N6003, PSS/ N4402, PSS/ N1711)	168.Service and repair of bell/ buzzer. (06 hrs) 169.Service and repair of electric iron, electric kettle, cooking range and geyser. (15 hrs) 170.Service and repair of induction heater. (06 hrs) 171.Service and repair of mixer/grinder and food processor. (20 hrs) 172.Service and repair of fan, blower, cooler, etc. (15 hrs) 173.Service and repair of semi- automatic washing machine. Demonstrate components of fully automatic top & front load washing machine using visual aids. (15 hrs) 174.Service and repair of refrigerator. (15 hrs) 175.Demonstrate installation and repair of pump set and submersible pump. (15 hrs) 176.Carry out repair of electrical circuit of window and split AC. (20 hrs) 177.Demonstrate installation and maintenance of split AC using visual aids. (08 hrs)	**Domestic appliances:** Working principles and circuits of common domestic electrical appliances; Bell, buzzer, electric iron, kettle, cooking range, geyser, induction heater, mixer, grinder, juicer, food processor, fan, pump set, washing machine, refrigerator and air conditioner etc. Concept of Neutral and Earth. (40 hrs)
Professional Skill 130 Hrs;	Perform winding of small transformers and motors viz., ceiling fan, table fan, mixer/grinder,	178.Practice winding of single- phase transformer. (12 hrs) 179.Practice on ceiling fan and table fan motor winding. (12 hrs)	**Winding:** Concentric/ distributed, single/ double layer winding and related terms. Troubleshooting of single-phase

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Professional Knowledge 35 Hrs	submersible pump etc. (Mapped NOS: PSS/N4402)	180.Carry out maintenance, service and repair of single- phase AC motors viz., mixer/grinder, table fan pumps etc. (25 hrs) 181.Practice on single/double layer and concentric winding for AC motors and testing. (30 hrs) 182.Carry out maintenance and servicing of universal motor. (12 hrs) 183.Carry out winding of submersible pump. (15 hrs) 184.Practice winding of small 3-ϕ AC motor. (24 hrs)	AC induction motors and universal motor. (35 hrs)
Professional Skill 40 Hrs; Professional Knowledge 10 Hrs	Carry out Estimation & costing for different wiring systems and ready to adopt structured / smart wiring concept for automation and IoT applications.	185.Perform estimation and costing for different types/scheme of wiring for labour, materials and accessories as per layout. (25 hrs) 186.Demonstrate structured wiring/ smart wiring for home & office automation through visual aids. (05 hrs) 187.Visual demonstration of IoT based home automation/ control of electrical appliances through smartphone. (05 hrs) 188.Demonstrate software available for electrical wiring and circuits. (05 hrs)	Concept and Principles of estimation and costing. Different wiring layouts and Bill of material; domestic, commercial, and industrial wiring. Smart wiring concept Procedure for taking wireman permit and competency certificate. (10 hrs)

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Wiring in commercial building their special precautions as per IE Rules

Objectives: At the end of this lesson you shall be able to
- **explain commercial building wiring**
- **state useful electrical safety precautions tips for commercial building.**

Commercial building: Commercial buildings require more power than residential homes. They have much more complex electrical systems at play.

Most commercial buildings have offices filled to the birth with equipment, appliances and electronics. These devices are often used at exactly the same time (during official work hours). This includes desktop computers, monitors, laptops, printers, scanners, air-conditioning units and coffeemakers. To safely accommodate this massive amount of energy consuming activity, most have specific electrical needs that need to be addressed.

Offer lighting: Lighting is one of the most important electrical features you will come across during a commercial construction or renovation. Lighting softens the look of any commercial property, giving it a more welcoming vibe. If your commercial property does not have enough windows or adequate natural light, then you may need to install more lighting fixtures to boost work productivity. People tend to work well under the correct lighting conditions.

Wiring and cabling: Electrical installation and wiring is hardcore work, it is not something you can achieve on your own. The installation of electrical wiring and cabling in an office setting requires planning, manpower, the right tools and materials. Because of strict safely regulations, such electrical tasks should only be carried out by a professional electrician.

Commercial wiring ensures you have an ample source of electricity for every device. Every worker has an electrical socket for his or her electronics and so do common areas such as kitchens and receiving areas where employees can find a spare electrical outlet. Proper wiring and cabling in a commercial area guarantees everyone's workplace safety.

Wiring server rooms: Decades ago, server rooms were reserved for large government and educational institutions. Today, you can count on every office having a dedicated and temp-controlled server room with a back-up generator. Server rooms are the main data centers which houses confidential information, sales statistics, company research and personal data. They are the life blood of businesses.

Creating a proper server room environment demands an expert electrician keen on protecting these tech assets through a well-thought-out electrical design process. This includes appropriate power surge protection and ample back-up power supply that can keep computers going while off a power grid. A skilled electrician will cover all bases and prevent the possibility of data loss in the event of a power spike.

Every commercial building depends on electricity. Since these buildings are loaded with equipment, appliances and various other electronics the consumption of electricity tends to be extremely high, but it is not the consumption that worries us the most, it's the safety.

Any electrical irregularities in commercial buildings can pose the risk of accidents like fires in seconds.

Therefore, safety is the top priority when it comes to commercial buildings, especially due to the fact that they employ countless workers. To make sure these buildings stay safe, here are some useful electrical safety tips.

Here are a few recommended precautions guidelines for electrical safety.

1 **Appliances must be in perfect condition:** Most commercial buildings consist of offices which are filled with appliances and electronics like microwaves, air conditioning, refrigerators, computers and so on. The more appliances, the bigger the risk of something going wrong.

With that in mind, in order to avoid any potential electrical hazards, you should regularly inspect all appliances and identify any faulty electrical wiring, cords, switches and plugs and replace them. If some appliances aren't in regular use switch them off.

2 **Careful placement of electrical cords:** Electrical cords connect the power supply and the appliances, so these cords need extra care when treated, in most cases, electrical cords are the main cause of numerous accidents. The best thing to do is, avoiding positioning them anywhere where they will be exposed.

Instead, try to place them around the walls to reduce any chance of accidents. Also, if there are any cords placed outdoors, they need to be property weather protected.

3 **Special attention to lighting:** Light bulbs can do more damage than most damage than most people are aware off. Therefore, they require special attention. Depending on the lighting systems your commercial building uses, you should regularly check and inspect them, as faulty lighting can lead to electrocution and other dangers. If you need to replace light bulbs, switch off the lighting first.

4 **Equipment use and maintenance:** Employees working in commercial buildings need to use electricity on a daily basis. This is why they need to learn how to

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correctly utilize and maintain their electrical equipment, as well as what to do in case of an emergency. This can greatly reduce the risk of an electrical fire.

A few additional steps to making commercial buildings safe are:

- All electrical plugs and cords require regular inspection and proper maintenance done by qualified personnel.
- Electrical equipment such as computers and so on should be regularly serviced by professionals.
- All employees should be introduced to how to properly unplug electrical equipment.
- If there's any need for using extension cords, it should be temporary.
- Stapling or nailing extension cords is not an option.

Follow these commercial building electrical safety tips and you'll be safe from harm! For help ensuring you have the most secure electrical systems, reach out to MSC Electrical today!

1 Keep an eye on damaged outlets

Wall outlets, otherwise known as receptacles, are also susceptible to normal wear and tear, especially if a commercial space utilizes several electrical appliances to operate. Your receptacles have neutral, hot and ground connections.

When these wear out, the metal contact points lose their grip onto the cords. As a result, this causes the wall outlets to build up heat. If this is left unmonitored, this may lead to blowups and fires. Here are some signs that you need to replace your wall outlets.

- Cracked wall outlets
- Discolored outlets
- Plugs falling out
- Sparks or buzzing sound
- Burning smell

2 Replace frayed cords from commercial appliances

Worn or frayed cords are also fire-starters. When a cable is frayed, the protective layer exposes the stripped wires which hold the electrical current.

These wires may run not and can cause extreme heating. When the coils heat up, it can ignite other highly combustible materials like curtains, rugs, carpets, paper, or even floors. Check your cords from time to time and replace them if necessary.

3 Avoid extension cords as much as possible

Extension cords can be the go-to for most establishments. However, using extension cords quite often may lead to fires or electric shocks. An extension cord may not be able to handle excess current, especially if it's fully loaded.

Extension cords plugged to another extension cords are also a no-no. If possible, call your electrician to install as many wall outlets than using a few extension cords.

4 Install designated circuit breakers

Commercial appliances vary in watt usage. The types of appliances will depend on the kind of establishment. However, the most commonly used commercial appliance is a floor-mounted air conditioner. Floor standing air conditioners usually consume about 6,000 watts. On the other hand, desktops consume around 250 watts and an average CFL bulb consumes about 15 watts.

Since these appliances and fixtures have varying electricity consumption, they run on different amp levels in circuits. These circuits are connected to a circuit breaker box. The circuit may not be able to handle too much current from all of the appliances at the same time.

The extra current causes the insulation to melt and start a fire. However, the circuit breaker stops the flow of excess current by "tripping" which in turn, prevents further accidents. That said, it's essential to install designated circuit breakers to handle different groups of appliances and fixtures.

5 Turn off appliances and unplug cords when not in use

To prevent an overcurrent that can run overnight, turn off appliances and fixtures which aren't in use. Better yet, unplug cords from office equipment or commercial appliances, if the space is empty. It may seem like a tedious task but adhering to electrical safety tips for your commercial buildings and office spaces will ensure everyone's safety.

Types of wiring

Objectives: At the end of this lesson you shall be able to
- **explain different types of wiring**
- **explain application of each wiring.**

Types of wiring

1 Power wiring: Power wiring refers to the wiring used to distribute electrical power throughout a building. This includes wiring for circuits that power lights, outlets, motors, and other electrical loads. Power wiring is typically done with larger gauge wires, such as copper conductors, to handle the higher currents and voltages involved.

2 Control wiring: Control Wiring refers to the wiring used control electrical devices or systems, such as motors, HVAC systems, and lighting systems. Control wiring is typically low voltage and is used to transmit signals between devices, such as switches, relays, and programmable controllers. Control wiring is often done with smaller gauge wires, such as twisted pair wires, to minimize signal interference.

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3 Communication wiring: Communication wiring refers to the wiring used to transmit data signals between devices or systems, such as computer networks, phone systems, and security systems. Communication wiring can include copper or fiber optic cables, depending on the data transmission speed and distance required. Communication wiring may also require specialized connectors and termination equipment to ensure proper signal transmission and reception.

4 Entertainment wiring: Entertainment wiring refers to the wiring used for audio, video and other multimedia systems, such as home theaters, sound systems, and gaming systems. Entertainment wiring may include speaker wires, HDMI cables, coaxial cables, and other specialized cables and connectors. Entertainment wiring is typically low voltage and may require specialized termination equipment to ensure optimal signal quality.

Applications for each type of wiring

1 Power wiring

- Lighting circuits in commercial and residential buildings
- Outlets for appliances and other electrical devices.
- Wiring for motors and other heavy machinery in industrial settings
- Distribution panels and circuit breakers

2 Control wiring

- HVAC system in commercial and residential buildings
- Motor control system in industrial settings
- Lighting control system in commercial and residential buildings
- Programmable controllers for manufacturing and automation systems

3 Communication wiring

- Computer networks in offices and homes
- Telephone systems in offices and homes
- Security systems, such as access control and video surveillance
- Audio and video distribution systems in commercial and residential buildings

4 Entertainment wiring

- Home theater systems in residential buildings.
- Sound systems in commercial buildings, such as restaurants and concert halls
- Gaming systems in homes and arcades Video distribution systems in commercial and residential buildings

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Lighting system for control using motion detector

Objectives: At the end of this lesson you shall be able to
- **explain lighting system for control using motion detector.**

A lighting system that is controlled using motion detectors is an efficient and convenient “solution for both residential and commercial spaces. It not only saves energy by turning off “lights when they are not needed but also provides convenience by automatically turning “them on when motion is detected in the area.

The lighting system consists of several components, including the motion detectors, light fixtures, and a control unit. The motion detectors are installed in the area where lighting control is required. These detectors use infrared sensors to detect motion and trigger the lighting system to turn on. The light fixtures, which are connected to the control unit, are then powered on, illuminating the area where motion is detected.

The control unit is responsible for controlling the entire lighting system. It receives signals from the motion detectors and uses them to switch the lights on or off. It can also be programmed to adjust the lighting level based on the amount of ambient light in the area.

One of the main advantages of a motion-controlled lighting system is its energy-saving capability. When motion is not detected, the lights turn off automatically, saving energy and reducing electricity bills. This feature is particularly beneficial in areas where lighting is required intermittently, such as corridors, storage rooms, and parking lots.

Another benefit of a motion-controlled lighting system is its convenience. Users do not need to manually turn the lights on or off, which can be especially helpful in spaces where hands-free operation is required, such as restrooms and kitchens.

However, it's worth noting that motion-controlled lighting systems require proper installation and calibration to function effectively. The motion detectors must be placed in a location that allows them to detect motion in the intended area, while minimizing false triggers. In addition, the control unit must be programmed correctly to ensure that the lights turn on and off at the appropriate times.

A motion-controlled lighting system is an efficient and convenient solution for controlling lighting in a variety of spaces. It can save energy and provide hands-free operation, making it a popular choice for both residential and commercial applications. However, proper installation and calibration are essential to ensure that the system functions effectively.

Motion-controlled lighting systems are also beneficial for security purposes. In areas where security is a concern, such as warehouses, motion detectors can detect unauthorized entry, triggering the lighting system to turn on and alerting security personnel to potential intruders.

Another advantage of motion-controlled lighting systems is that they can be integrated with other smart home or building automation systems. For instance, the lighting system can be programmed to turn on the air conditioning or heating system when motion is detected, ensuring that the space is comfortable and energy-efficient.

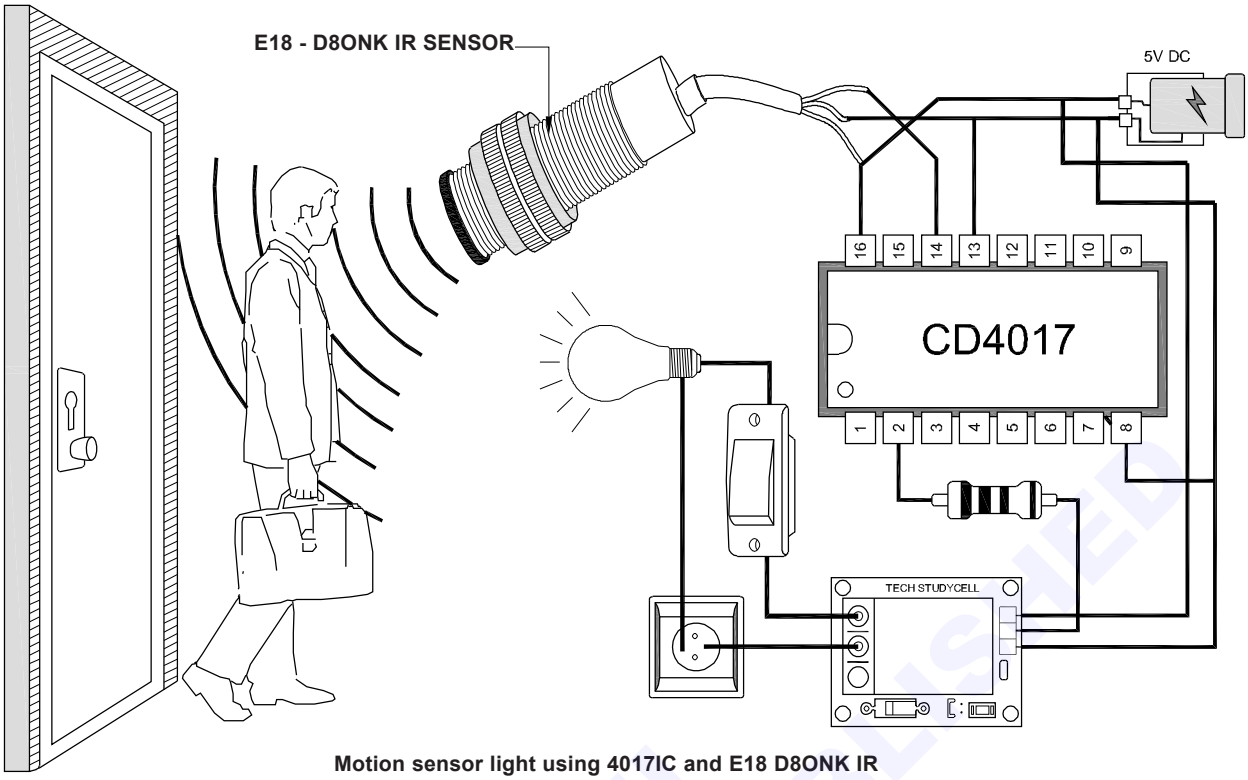
Moreover, motion-controlled lighting systems are a cost-effective solution that can be easily retrofitted into existing buildings. They do not require extensive wiring or complex installations, making them an ideal choice for renovation projects or buildings with limited access.

It is also worth mentioning that motion-controlled lighting systems can contribute to creating a more sustainable environment. By reducing energy consumption and greenhouse gas emissions, these systems can help businesses and homeowners to meet their sustainability goals and reduce their carbon footprint.

Finally, motion-controlled lighting systems offer a degree of flexibility and customization, allowing users to adjust the lighting level, motion detection sensitivity, and other settings to suit their needs. This feature makes it possible to create a lighting system that meets specific requirements and preferences, providing a personalized lighting experience.

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Fig 1



Motion sensor light using 4017IC and E18 D8ONK IR

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Wireless remote control for light and fans

Objectives: At the end of this lesson you shall be able to
- **explain wireless remote control for light and fans.**

Wireless remote control systems have revolutionized the way we interact with our electronic devices, providing convenience, efficiency, and comfort. We will explore the benefits and features of wireless remote controls specifically designed for lights and fans. We will discuss how these devices offer enhanced control, flexibility, and energy efficiency, transforming our living spaces into smart and connected environments.

Convenience and Enhanced control

Wireless remote controls for lights and fans offer unparalleled convenience and control. With a simple press of a button, users can effortlessly adjust the intensity of their lights or control the speed and direction of their ceiling fans from anywhere within the range. This eliminates the need for physically reaching out to switches or pulling chains, making it ideal for individuals with mobility issues or limited accessibility. Moreover, the wireless nature of these remote controls allows users to operate multiple devices simultaneously, providing centralized control and eliminating the hassle of managing individual switches.

Flexibility and customization

Wireless remote controls empower users with unparalleled flexibility and customization options. Advanced models feature programmable settings that enable users to create personalized lighting and fan profiles to suit their preferences. This allows for easy adjustment of brightness levels, color temperatures, and fan speeds, creating the desired ambiance and airflow in any given space. Furthermore, these devices often include scheduling features that allow users to automate lighting and fan operations, ensuring energy efficiency and convenience. For instance, users can program lights to turn on and off at specific times or adjust fan speeds automatically based on room temperature.

Energy Efficiency

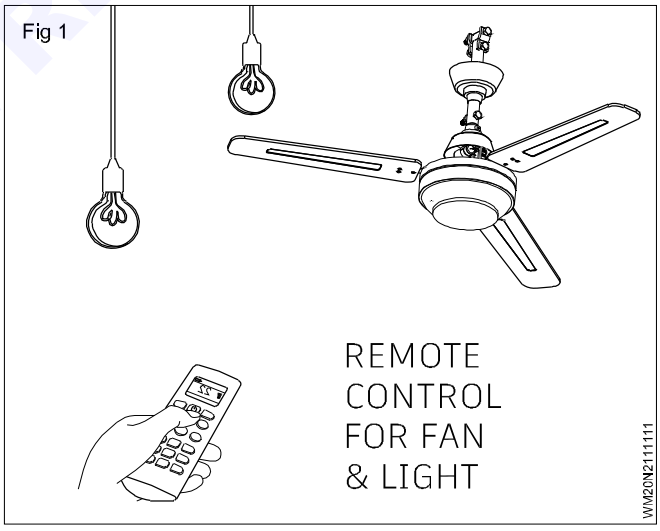
Wireless remote controls play a crucial role in promoting energy efficiency in lighting and ventilation systems. By providing precise control over individual lights and fans, users can optimize energy consumption and reduce wastage. For example, with dimming capabilities, users can lower the intensity of lights to create a cozy atmosphere while conserving energy. Similarly, adjustable fan speeds enable users to match the airflow to their comfort level, “avoiding unnecessary energy consumption. Furthermore, scheduling features allow users to automatically turn off lights and fans when not needed, reducing energy usage during idle periods.

Integration with smart home systems

Wireless remote controls for lights and fans are often compatible with smart home systems, enabling seamless integration and expanding functionality.

Wireless remote controls for lights and fans have revolutionized the way we interact with our home environments. With their convenience, enhanced control, flexibility, and energy “efficiency features, these devices offer numerous benefits to users. They provide effortless control over lighting and ventilation systems, allowing users to create personalized “environments and optimize energy consumption.

Fig 1



Wiring circuits planning

Objectives: At the end of this lesson you shall be able to
- **explain wiring circuits planning.**

Planning electrical installation involves several steps that are critical to ensuring the safety and functionality of the system.

1 Considerations for planning electrical wiring installations

- Type of supply, occupancy, envisaged load & earthing arrangement available.

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- Atmospheric condition which are likely to affect the connections.
- Presence of inflammable or explosive dust vapour or gas.
- Degree of electrical & mechanical protection necessary.
- Importance of continuity of service including the possible need for standby supply
- Probability for modification of future expansion
- Operation & maintenance cost
- Relative cost of various alternative methods
- Safety aspects
- Need for radio & telecommunication interference suppression
- Energy conservation

While planning an installation, consideration should be taken of the anticipated increase in the use of electricity for lighting general purpose socket-outlet kitchen heating, etc.

Supply of electricity

- the supply to houses & other small buildings is done by an underground/overhead ring circuit from local substations. Supplies to factories and other large buildings or complexes are taken from the 11 kV main supply.
- Larger buildings and developments will require their own transformer.
- For easy identification, each phase cable has colour coded plastic. Insulation of red, yellow, blue. The neutral is colour coded black.

3 Distribution of main supply

- A circuit breaker or load break switch fuse on each live conductor of the supply mains at the point of entry.
- The wiring throughout the installation shall be such that there is no switch or fuse unit in the earthed neutral of condutor.
- The neutral shall also be distinctly marked and an indication of a permanent nature shall be provided to identify the earthed neutral conductor.
- The main switch shall be easily accessible and situated near the termination of service line.

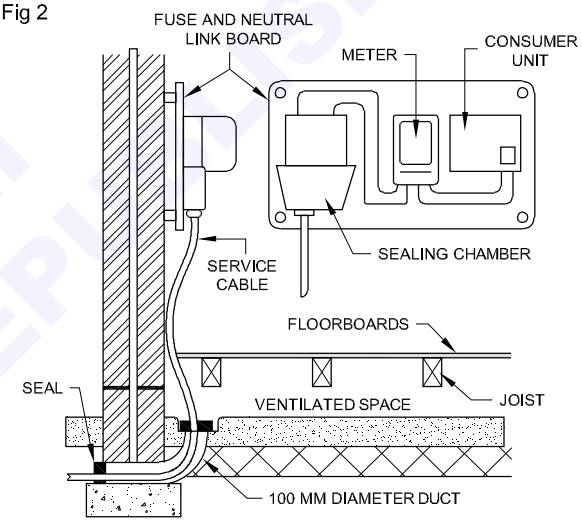
4 Energy meters

- Energy meters shall be installed in residential buildings at such a place which is readily accessible to the owner of the building and the authority.
- These should be installed at a height where it is convenient to note the meter reading. It should preferably not be installed below 1m from the ground.
- The energy meters should either be provided with a protecting covering enclosing it completely except the glass window through which the readings are noted or should be mounted inside a completely enclosed panel provided with hinged or sliding doors with arrangement for locking.
- In multi-storeyed buildings, meter shall be installed with tapping point for meters of the rising main (bus trucking) on individual floor.

5 Main switches and switchboard

- The location of the main board should be such that it is easily accessible for fireman and other personnel to quickly disconnect the supply in case of emergencies. If the room is locked for security, means of emergency access by schemes such as break glass cupboard shall be incorporated main switch board shall be installed in rooms or cupboards so as to safeguard against operation by unauthorized personnel.

Fig 2

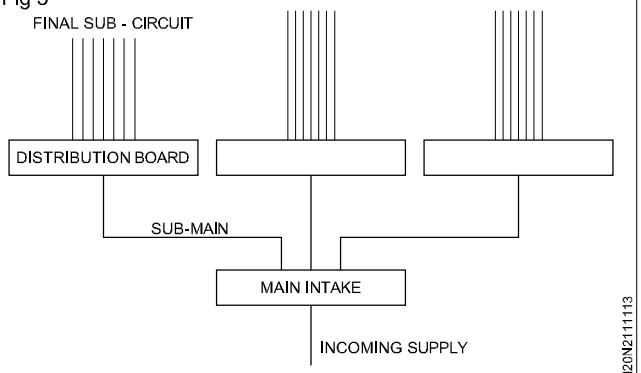


UNDERGROUNG SERVICE ENTRY

- All main switches shall be either of metal-clad enclosed pattern or of any insulated enclosed pattern which shall be fixed at close proximity to the point of entry of supply. Every switch shall have an environments protection level rating (IP) so that its operation is satisfactory in the environment of the installation. (Woodwork shall not be used for the construction or mounting of switches and switch boards installed in a building.)
- Switch boards shall be placed only in dry situations and in ventilated rooms and they shall not be placed in the vicinity of storage batteries or exposed to chemical fumes. In damp situation or where in flammable or explosive dust, vapour or gas is likely to be present, the switchboard shall be totally enclosed and shall have adequate degree of protection.

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Fig 3



6 Distribution boards

- A distribution board comprises of one or more protective devices against over current and ensuring the distribution of electrical energy to the circuits.
- The distribution boards shall be located as near as possible to the centre of the load they are intended to control.
- Distribution board shall provide plenty of wiring space.

7 Branch distribution boards

- Branch distribution boards shall be provided, along with earth leakage protective device (ELCB) (incoming) with a fuse or a miniature circuit breaker or both of adequate rating/setting chosen on the live conductor of each sub-circuit and the earthed neutral conductor shall be connected to a common link and be capable of being disconnected individually for testing purpose.
- At lease one spare circuit of the same capacity shall be provided on each branch distribution board.

Cabling in health care facilities

Objectives: At the end of this lesson you shall be able to
- **explain cabling in healthcare facilities.**

Cabling in health care facilities plays a critical role in ensuring the efficient and reliable transmission of information, data, and communication throughout the entire infrastructure. In a healthcare setting, where patient care and safety are of paramount importance, a robust cabling system is essential to support various critical applications and technologies.

Firstly, structured cabling forms the backbone of communication within healthcare facilities. It provides a standardized and organized approach to cabling, incorporating copper and fiber optic cables to support voice, data, and video transmissions. This infrastructure supports various systems such as electronic health records (EHRs), telemedicine, medical imaging, and communication between medical staff. Reliable and high-speed connections are crucial for quick access to patient data and seamless collaboration among healthcare professionals.

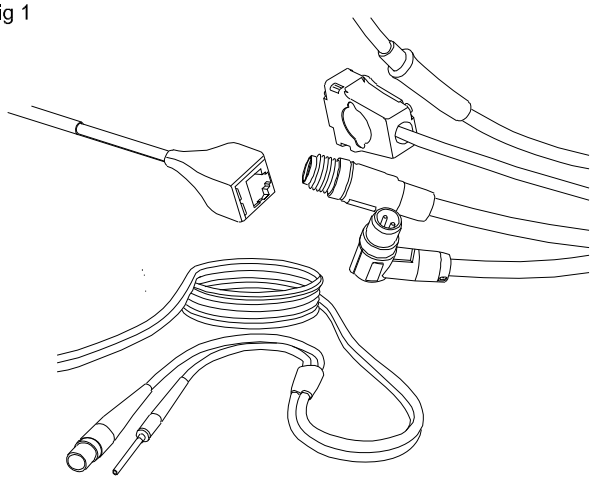
Secondly, patient monitoring and medical devices heavily rely on cabling systems. Cables connect various medical equipment, such as heart monitors, infusion pumps, and ventilators, to centralized monitoring stations and data servers. A stable cabling network is vital to ensure real-time and accurate data transfer, allowing medical personnel to respond promptly to critical situations and make informed decisions.

Furthermore, healthcare facilities need to adhere to stringent regulations and standards related to patient data security and privacy, such as the Health Insurance Portability and Accountability Act (HIPAA). Properly designed and implemented cabling systems help maintain data integrity and confidentiality, reducing the risk of unauthorized access to sensitive patient information.

In addition to clinical aspects, cabling is also crucial for enhancing the patient experience. Many modern healthcare facilities incorporate multimedia and entertainment systems to improve patient comfort during their stay. Whether it's interactive patient portals, bedside entertainment units, or communication systems for patient-nurse interaction, reliable cabling is essential for seamless functioning and user satisfaction.

In conclusion, cabling is the lifeline of health care facilities, supporting critical applications, patient care, and data security. A well-designed and properly installed cabling infrastructure ensures seamless communication, efficient medical device connectivity, and compliance with privacy regulations, ultimately contributing to improved patient outcomes and overall operational efficiency within healthcare settings.

Fig 1



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Grounding, shielding and routing

Objectives: At the end of this lesson you shall be able to
- **explain importance of grounding**
- **explain importance of shielding**
- **explain importance of routing.**

Grounding

Grounding or Earthing is a process of connecting electrical systems, appliances and metal enclosure to ground. Here, ground refers to the physical connection to Earth which acts as a reference point and also a return path for current.

The main purpose of grounding is to provide a low resistance path for electricity to flow. We can implement the connection to ground with the help of a grounding electrode. This way, we can keep all the non-current-carrying conductors such as metal frame/housing of a computer, washer, drier, electric drill etc. at zero V potential.

A typical grounding system consists of two parts. In the first part, all the individual branch circuits consist of a wire (ground wire) that we connect to the metal frame of outlet boxes, appliances, tools, etc. All the ground wires from individual branch circuits reach the main circuit breaker panel and connect to the ground bus.

The second part of the grounding system consists of a large copper wire (known as grounding electrode conductor) that is connected to a ground rod buried in earth.

Importance of grounding

Let us understand the importance of grounding with the help of a small example. Assume there is a large electrical appliance such as a washing machine and the live wire touches the metal body of the machine due to an accident. If the appliance is properly grounded i.e., the metal frame of the machine is connected to the grounding bus at the main circuit breaker panel, then the following happens.

The current from the live wire will pass through the metal body of the machine. As we connected the equipment grounding conductor, the current flows through this conductor to the main service panel instead of the neutral wire. As a result, the circuit breaker if that circuit will trip.

If it were an ungrounded system, the current from the metal body will pass through a human body who makes contact with the machine. The human body will provide an easy path for the current to flow through ground. It will lead to a severe electric shock.

Another case is buildup of static voltage due to lightning strikes. During a lightning strike, the electromagnetic pulse from the lightning will induce a voltage into the metal body of the appliance such as the washing machine.

As we connected the metal body to the grounding conductor, it will take this surge voltage to the main circuit breaker panel and then transfers it to the grounding electrode.

Importance of shielding

Cable assemblies are used in different variety of industrial uses, which can show electrical noise. Electrical noise can point to Electromagnetic Interference (EMI) in cable assemblies. When a cable assembly obtains or produces electromagnetic interference, it can make less signal amount and loss of data. It can also interrupt the purpose of electronic equipment and other factors about it. Therefore, it is essential to utilized special shielding to protect those cable assemblies from EMI.

Shielding for Protecting Cable Assemblies from EMI

Cable shielding is utilized to solve the problem of EMI in cable assemblies. A cable shield encloses in a cable to give prefect protection. The shielding affect EMI in two ways.

- The first way is by speculate the electromagnetic energy.
- The second way is by gathering noise, and grounding it.

While some energy will go across the shielding, but it will be so highly decreased that it won't have any effect on the assembly.

Types of shields Used in cable assemblies

Different kinds of shields are used in cable assemblies built on the application they will be used in. Normally utilized shields in cable assemblies are:

Foil sheaths: Foil shields consist of a thin layer of aluminum or copper bonded to a carrier such as a Polypropylene or polyester film. A foil sheath supply 100% coverage to the cable or elements. The foil shield comprises of a drain wire for ending and grounding the EMI.

Metal braids: A braid shield is manufacture as a woven mesh on the cable core. It is created from bare or tinned copper wires. For important applications, stainless steel or silver plated copper braid creation is also utilized. Metallic braids offer better termination and less DC resistance than foil sheaths, which cause them prefect for low frequency interference.

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Routing

Routing is the process of selecting a path for traffic in a network or between or across multiple networks. Broadly, routing is performed in many types of networks, including circuit-switched networks, such as the public switched telephone network (PSTN), and computer networks, such as the Internet.

In packet switching networks, routing is the higher-level decision making that directs network packets from their source toward their destination through intermediate network nodes by specific packet forwarding mechanisms. Packet forwarding is the transit of network packets from one network interface to another. Intermediate nodes are typically network hardware devices such as routers, gateways, firewalls, or switches. General-purpose computers also forward packets and perform routing, although they have no specially optimized hardware for the task.

The routing process usually directs forwarding on the basis of routing tables. Routing tables maintain a record of the routes to various network destinations. Routing tables may be specified by an administrator, learned by observing network traffic or built with the assistance of routing protocols.

Routing, in a narrower sense of the term, often refers to IP routing and is contrasted with bridging. IP routing assumes that network addresses are structured and that similar addresses imply proximity within the network. Structured addresses allow a single routing table entry to represent the route to a group of devices. In large networks, structured addressing (routing, in the narrow sense) outperforms unstructured addressing (bridging). Routing has become the dominant form of addressing on the Internet. Bridging is still widely used within local area networks.

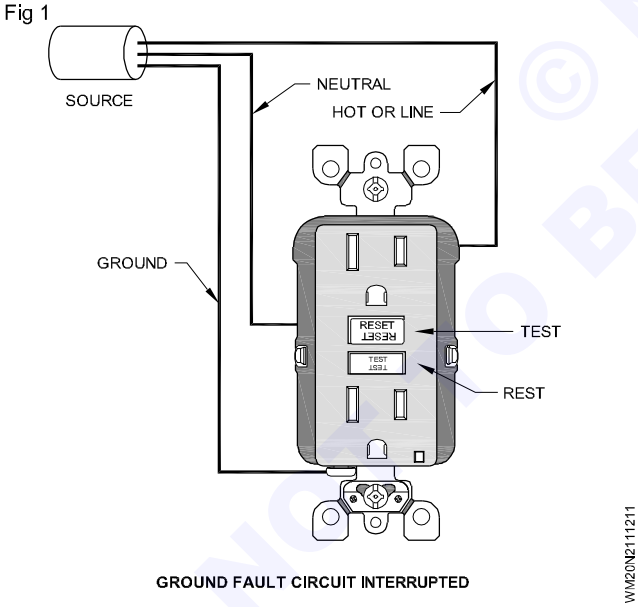
Ground fault circuit interrupter

Objectives: At the end of this lesson you shall be able to
- **explain working principle of GFCI.**

A GFCI (Ground Fault Circuit Interrupter) is an automatic device that offers personal protection against lethal electrical shock or electrocution.

It is a special electrical receptacle or outlet that can stop electrical power within milliseconds as a safety precaution.

Fig 1



GROUND FAULT CIRCUIT INTERRUPTED

It trips electrical circuits whenever it detects ground faults or leakage currents. So when a person's body starts to receive a shock, the GFCI senses this and cuts off the power before he or she can get injured.

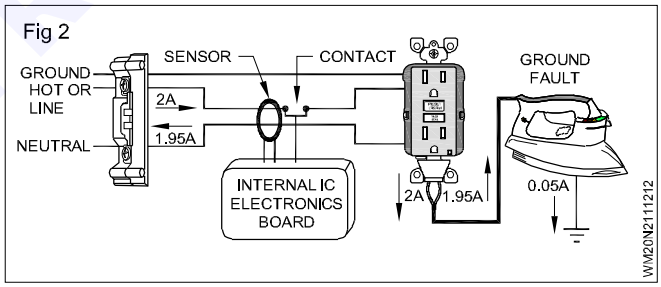
In general, GFCIs are installed wherever there is the potential for contact between a person and an electrical appliance in or near moisture, water, or water pipes.

One needs to ensure that GFCIs are installed in his or her kitchen, bathrooms, workshop, basement, garage, swimming pools, hot tubs, outdoor outlets and fixtures, and any other areas where water and electricity are likely to come in contact.

GFCIs are especially useful for cord-connected appliances and equipment used outdoors or near water.

How GFCI works?

Fig 2



Usually a normal electrical outlet has two small round holes and a large round hole just above them. The "left hole" corresponds to "neutral and "right hole" is called "phase". The third, large round hole is the "ground".

Normally, electricity flows from phase to neutral in the outlet. The GFCI works by measuring the current leaving the phase side of the power source and comparing it to the current returning to the neutral side.

If they are not equal, this means that some of the current is flowing along an unintended path possibly through water or through a person.

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The GFCI detects imbalance in the current flowing from phase to neutral, imbalance in the current flowing from phase to neutral and quickly cuts off electricity, thus reducing the risk of electrical shock.

The sensor inside a GFCI detects the difference between the current flowing to the appliance and the current flowing from the appliance.

If the electricity flowing into the circuit differs by as small as 4 or 5 milliamps from that returning, a GFCI quickly turns off all power by tripping a relay within it within a few hundredths of a second, much before the user hardly feels the shock.

When the problem is corrected, GFCI's can later be reset to restore power to the affected circuit.

If the problem still exists and GFCI continues to "sense" the difference in the amount of electricity flowing into the circuit to that flowing out, it will not reset.

The GFCI outlet

It is like a standard electrical outlet and protects any appliance plugged into it. The GFCI outlet can also be wired to protect other outlets that are connected to it.

Fire alarm systems

Objectives: At the end of this lesson you shall be able to
- **explain fire alarm system.**

Fire alarm systems are an essential component of any building's safety infrastructure. Their primary function is to detect and alert occupants of the presence of a fire, allowing them to evacuate the premises promptly and safely. Fire alarm systems utilize a range of advanced technologies, such as smoke detectors, heat detectors, alarms, and notification devices, to provide early warning and mitigate the risks associated with fire incidents. This lesson explores the various components, types, working principles, and benefits of fire alarm systems, highlighting their crucial role in enhancing safety and protecting lives.

Components of a Fire Alarm System

Control Panel: The control panel serves as the brain of the fire alarm system, receiving signals from detectors and initiating appropriate actions.

Detectors

Smoke Detectors: These detectors sense the presence of smoke particles and trigger an alarm when the smoke concentration exceeds a specific threshold.

Heat Detectors: Heat detectors respond to rapid increases in temperature and are particularly useful in areas where smoke detectors may not be suitable.

Flame Detectors: Flame detectors detect the presence of flames by analyzing the unique infrared or ultraviolet light patterns emitted by fires.

Alarms and Notification Devices

Audible Alarms: These devices produce loud sounds or sirens to alert occupants about a fire.

Visual Alarms: Visual alarms use bright strobe lights or flashing beacons to notify individuals, especially those with hearing impairments.

Textual/Graphic Displays: Advanced fire alarm systems may incorporate text or graphic displays to provide specific information about the fire incident and evacuation procedures.

Communication Devices

Telephone Interfaces: These interfaces allow the fire alarm system to automatically dial emergency services, notifying them about the fire incident.

Public Address Systems: Integrated public address systems can deliver pre-recorded or live evacuation announcements, guiding occupants to safety.

Power Supply and Backup: Fire alarm systems are equipped with reliable power sources, often backed up by batteries or generators, to ensure continuous operation during power outages.

Conventional Fire Alarm Systems: Conventional systems divide the protected area into zones, where each zone connects multiple detectors and alarms to a single circuit. When a detector within a zone is triggered, the alarm panel indicates the specific zone but does not provide precise information about the location of the fire.

Working Principles

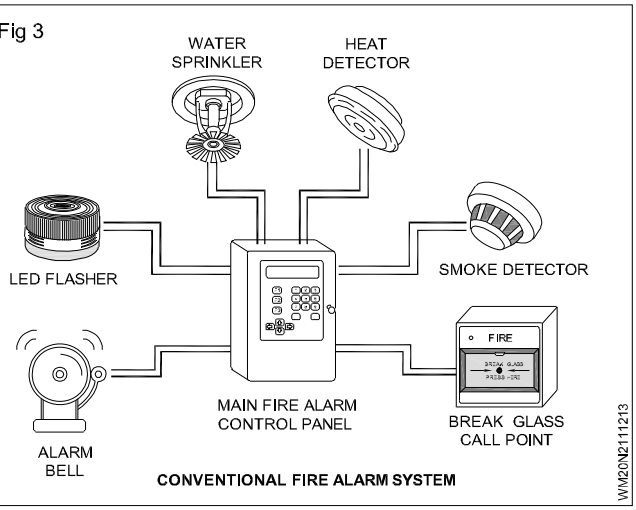
Fire alarm systems operate based on either the conventional or addressable principle. In conventional systems, detectors are connected in parallel to a common circuit, while addressable systems use individual wiring for each device. When a detector senses smoke, heat, or flames, it sends a signal to the control panel. The control panel then activates the appropriate alarms and notification devices to alert occupants and initiate evacuation procedures.

Benefits of Fire Alarm Systems

Early Fire Detection: Fire alarm systems provide early detection, allowing occupants to evacuate before the fire spreads, reducing the risk of injuries and fatalities.

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Fig 3



CONVENTIONAL FIRE ALARM SYSTEM

Interior siren

Objectives: At the end of this lesson you shall be able to
- **explain interior siren.**

An interior siren is a security device designed to emit loud, attention-grabbing sounds within the enclosed space of a building or vehicle. It serves as an audible warning system to deter potential intruders, alert occupants of an emergency, or provide a notification for various events. The following explanation will delve into the features, functions, and benefits of interior sirens.

Interior sirens are typically installed in strategic locations throughout a building or vehicle, such as hallways, entryways, or near control panels. They are compact in size and can be discreetly mounted on walls or ceilings. The primary purpose of an interior siren is to create a high-decibel sound that captures attention and causes discomfort, ensuring that people within the vicinity are alerted to potential dangers.

One of the key features of an interior siren is its sound output. It is designed to produce a loud, piercing noise that is difficult to ignore. The sound is usually in the range of 90 to 120 decibels, which is comparable to the volume of a chainsaw or a live rock concert. This level of intensity is deliberately chosen to startle and disorient potential intruders, as well as to grab the attention of nearby individuals, prompting them to take immediate action.

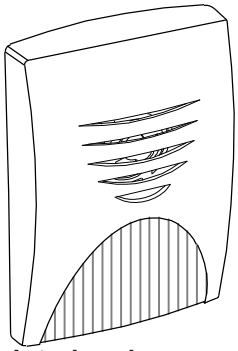
Interior sirens are often integrated into larger security systems, which may include motion sensors, door/window sensors, and control panels. When a security breach is detected, the sirens can be activated automatically or manually. In automatic mode, the system triggers the siren upon sensing unauthorized entry, movement, or other pre-set conditions. In manual mode, the siren can be activated by authorized individuals, such as security personnel or occupants, in emergency situations.

In residential environments, interior sirens can be connected to home security systems. In addition to deterring intruders, they can provide valuable peace of mind for homeowners by alerting them to potential dangers and facilitating a rapid response. For example, if a break-in occurs while the occupants are away, the siren can attract the attention of neighbors or passersby, increasing the chances of someone reporting the incident to the authorities.

Another benefit of interior sirens is their versatility. They can be customized to emit different types of sounds or tones, allowing for specific signaling based on the situation. For instance, a continuous, steady siren might indicate a security breach, while a pulsating or intermittent tone may signify a different event, such as a power failure or a system malfunction. These variations in sound patterns can help people quickly identify and respond to the specific situation at hand.

An interior siren is a powerful security device that plays a crucial role in alerting occupants to potential threats or emergencies.

Fig 1



Interior siren

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Control and signaling

Objectives: At the end of this lesson you shall be able to
- **explain control and signaling.**

Control and signaling are essential components in various systems and industries, enabling the effective management, coordination, and communication between different elements within a system. Whether in industrial automation, telecommunications, transportation, or any other domain, control and signaling play pivotal roles in ensuring efficient operations, safety, and reliable information exchange. In this essay, we will delve into the significance and functions of control and signaling, exploring their applications, principles, and key technologies.

Control, in its broadest sense, refers to the regulation and management of processes, devices, or systems to achieve desired outcomes.

Signaling, on the other hand, refers to the exchange of information or messages between different components or entities within a system. It serves as a means of communication, coordination, and synchronization. Signaling mechanisms can be found in a wide range of applications, including telecommunications, transportation, and computer networks. They enable the transmission of data, commands, or status information, allowing different elements to cooperate and interact effectively.

In the field of telecommunications, signaling is crucial for establishing and managing communication links.

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Installation of single phase and three phase on line and off line ups

Objectives: At the end of this lesson you shall be able to
- **explain installation of Single Phase and Three Phase On-line and Off-line UPS.**

Uninterruptible Power Supply (UPS) systems are crucial for providing backup power during electrical outages and fluctuations. They ensure continuous power supply to critical equipment, preventing data loss, damage, and downtime. In this article, we will discuss the installation process of single-phase and three-phase on-line and off-line UPS systems.

Single-Phase On-line UPS Installation

Site Selection: Choose a well-ventilated area with sufficient space near the load to install the UPS. Ensure it is away from direct sunlight, moisture, dust, and corrosive substances.

Electrical Wiring: Connect the UPS input power cord to a single-phase power outlet. Ensure the voltage and frequency of the power outlet match the UPS specifications. Use an appropriate circuit breaker to protect the UPS and load.

Load Connection: Connect the load to the UPS output power sockets. Check the load power requirements and ensure it does not exceed the UPS capacity. Use proper electrical connectors and ensure tight connections.

Battery Connection: Connect the UPS battery to the designated battery terminals. Follow the manufacturer's instructions for proper battery connection, ensuring correct polarity.

Grounding: Connect the UPS grounding wire to an appropriate grounding point. Ensure proper grounding to prevent electrical shocks and improve system stability.

Communication Interfaces: If required, connect communication interfaces, such as USB or Ethernet, to enable remote monitoring and management of the UPS.

Single-Phase Off-line UPS Installation

Site Selection: Choose a suitable location following the same guidelines mentioned earlier for on-line UPS installation.

Electrical Wiring: Connect the UPS input power cord to a single-phase power outlet. Verify that the voltage and frequency match the UPS specifications. Use an appropriate circuit breaker for protection.

Load Connection: Connect the load to the UPS output power sockets. Check the load's power requirements and ensure it does not exceed the UPS capacity. Use proper electrical connectors and ensure tight connections.

Battery Connection: Connect the UPS battery to the designated battery terminals, following the manufacturer's instructions for proper connection.

Grounding: Connect the UPS grounding wire to an appropriate grounding point for safety and stability.

Communication Interfaces: Some off-line UPS systems may include communication interfaces for remote monitoring and management. If available, follow the manufacturer's instructions to connect these interfaces.

Three-Phase On-line UPS Installation

Site Selection: Choose a well-ventilated area with sufficient space near the load. Ensure it is away from direct sunlight, moisture, dust, and corrosive substances.

Electrical Wiring: For a three-phase UPS, connect each phase to the respective power source. Verify the voltage and frequency match the UPS specifications. Install appropriate circuit breakers for protection.

Load Connection: Connect the load to the UPS output terminals, ensuring proper phase connections. Consider balancing the load across all three phases for efficient operation.

Battery Connection: Connect the UPS battery to the designated battery terminals as instructed by the manufacturer.

Grounding: Connect the UPS grounding wire to an appropriate grounding point, adhering to safety guidelines and local regulations.

Communication Interfaces: Connect communication interfaces, if available, for remote monitoring and management of the UPS system.

Conclusion

Installing a UPS system properly is crucial to ensure reliable backup power supply. Whether it's a single-phase or three-phase on-line or off-line UPS, following the manufacturer's guidelines and local electrical codes is essential. Pay attention to site selection, electrical wiring, load and battery connections, grounding, and optional communication interfaces.

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CCTV camera

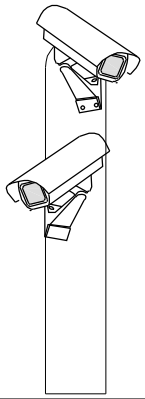
Objectives: At the end of this lesson you shall be able to
- **explain CCTV camera.**

CCTV stands for closed-circuit television. The broadcasts from CCTVs are transmitted to a limited number of monitors as opposed to regular television broadcasts which are open to the public. A CCTV system helps up security by giving real-time footage to monitors. The footage can be recorded and played back as and when needed.

What is a closed-circuit security camera? (Fig 1)

A closed-circuit television system consists of not just the cameras but also includes the wiring, video footage storage, monitors, access control, and general system management. CCTV cameras can help secure your business and personal spaces through round-the-clock surveillance. Many cameras today have motion sensors as well. This helps detect any irregular movements around the premises under monitoring.

Fig 1



What is a CCTV system?

A CCTV system, also known as video surveillance, utilizes video cameras and transmits the video to a limited number of monitors. CCTVs may employ point to point (P2P) or point to multipoint (P2MP), or mesh wired or wireless links. The main components of a CCTV system, are three. These are the camera, monitor and video management software. The installed system may vary depending on the type of system being utilized. The surveillance coverage depends on the number of cameras being used and the size of the area being covered.

Cameras: When you are thinking of installing cameras, there are generally two options to choose from. These are analog cameras and Internet Protocol (IP). With advancements in technology, people are preferring IP cameras because of their high compatibility with other surveillance applications.

Types of CCTV systems

There are two basic types of CCTV systems, Network Video Recorders (NVR) and Digital Video Recorder (DVR). DVR systems are more popular among consumers due to their cost-efficiency factor. However, NVR systems are a better option when it comes to compatibility and better integration with IP cameras. It is recommended to have a combination of an NVR system and IP cameras to enhance the transmission's resolution and acquire a flexible wireless system.

CCTV monitoring

CCTV monitoring works by picking up a sequence of images which are then transmitted as a signal to a recording device and a display device. This comes as video footage on a screen or monitor. CCTV cameras need a power supply through a power box or adapter for working. IP cameras are powered through PoE technology by using special cables. There is a battery-operated and solar-powered option available as well.

CCTV surveillance cameras

Surveillance cameras differ from ordinary cameras. They come in different types depending on their functionality and purpose. Some of these are dome cameras, bullet cameras, and day-night cameras.

Advantages

Installing a CCTV system help us

- **Crime management**

CCTV cameras can help deter crimes and enable law enforcement to identify criminals. Businesses can use CCTV cameras to monitor on-site and in-house activities. Employees can be monitored and held accountable in the event of any mishaps.

- **Disaster management**

CCTV cameras can help prevent disasters by identifying problem areas beforehand. Emergency services can effectively track and monitor disaster-stricken areas. Video surveillance can help teams to reach places that could potentially be dangerous for them.

- **Neighborhood monitoring**

Neighborhoods and communities can install CCTV cameras to monitor traffic conditions and identify events or people that may seem suspicious. CCTV cameras can also be used to gather data regarding the community as well.

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Installation of inverter in domestic wiring

Objectives: At the end of this lesson you shall be able to
- **enumerate the important points to be kept in your mind to select the inverter to be installed**
- **state how to select the place to install the inverter and battery**
- **explain how to install the inverter with battery and load, and check for its performance.**

Important points to be considered before installing an inverter

Many time when a new inverter is not giving proper service, the fault is due to improper installation only, not in inverter.

Another most important point is when connecting an inverter to the line is, the total load connected to the inverter should not exceed 80% of capacity of inverter.

Before providing points to connect the loads to the inverter, the total connected load must be considered.

If over load occur, then the overload protection will 'cut OFF' the output and reduce the load then the reset key must be pressed, and if the inverter is not provided with overload protection, it may get damaged at the time of over load than the capacity of the inverter.

Selection of place for installation of inverter

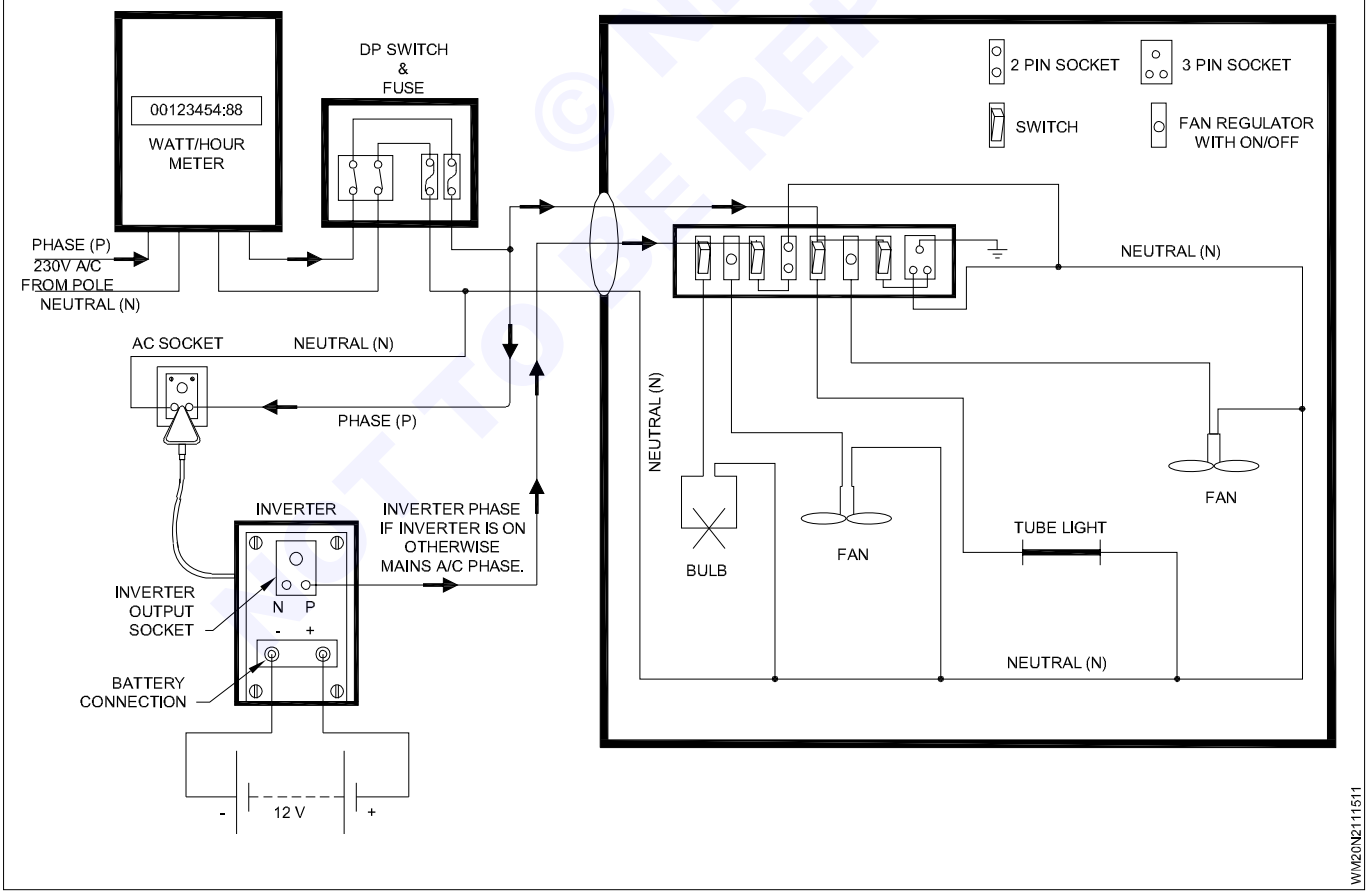
To connect inverter to the supply line, suitable place for the inverter is to be located. That place must be nearer to the service energy meter and ICDP switch and provide a 3 pin output socket from the mains supply line for the inverter and connect the inverter to the socket as in (Fig 1).

Installation of inverter

Collect the suitable inverter with sealed free maintenance battery to be installed, and check for their proper function

Place the inverter's battery to a suitable place near the inverter and connect the battery to the inverter. (Fig 1)

Fig 1



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Keep the battery as close as possible to the inverter, so that the wire connecting the battery terminals to the inverter can be small and current loss is reduced. Make sure the battery is fully charged before installation.

The positive terminals of battery (red wire) is connected to the place provided for the positive terminal on the inverter and the negative terminal of the battery (blue or black wire), which is to be connected to the place provided for the negative terminal on the inverter.

When connecting battery terminals to the inverter, use special auto wires do not use common mains wiring with wires such as '3/20' and 7/20 etc.Connecting battery using these wires will not provide proper connection between the battery and the inverter.

After connecting the battery, put some grease (or) vase-line on the battery terminals, which reducing the terminal corrosion.

All the connection is completed take the output from the inverters output socket and use it to power the load. Use 1/18 copper wire to the output of the load. Do not use 3/20, 3/22 or 7/20 wires, commonly used in house wiring.

The output is taken from the phase out 'pin of inverter' output socket, and is provided to the ON/OFF switches on the wall pause. (Fig 1)

The neutral line is common for both the inverter output and the mains A/C line. So, only one wire for the phase line can be drawn from the inverter output socket to the switches.

In Fig 1, one bulb, one fan and a 2 pin output socket are connected to the inverter output and the other devices in the room. (ie) the tube light, fan (2) and a 3 pin output socket are directly connected to the mains A/C line.

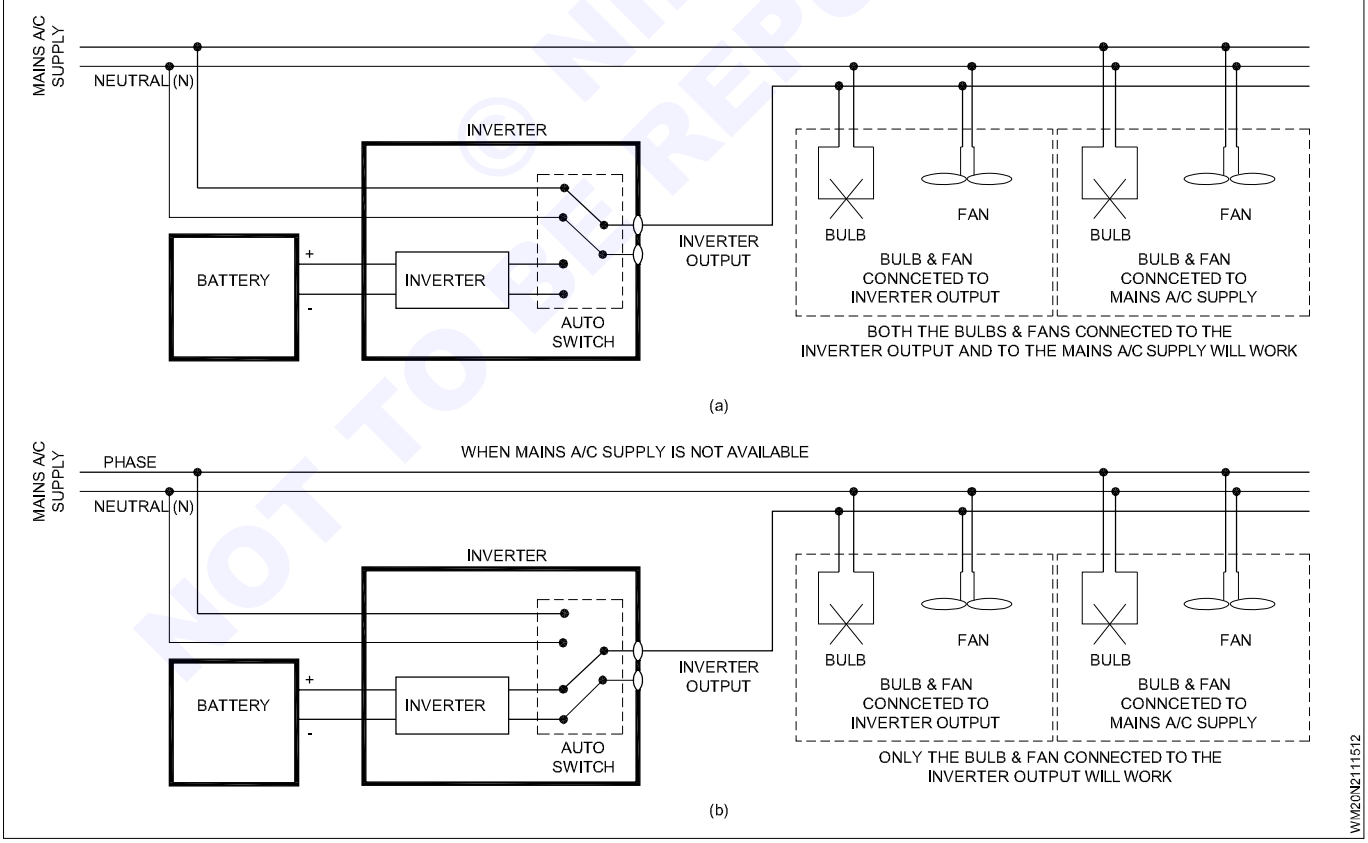
In the two pin socket, should not be connected with heavy load during power 'OFF' only small load like mosquito repelled can be connected.

As in (Fig 1) the load connected to the inverter will get the mains A.C supply. If the mains supply is 'On' at the same time, other devices will also work on the main supply, because they are connected directly to the mains A.C supply.

But at the time of power shut down, the devices directly are connected to the mains A.C will stop functioning and the devices, which are connected to the inverter output will keep on working on the inverter output.

Later, if the mains A.C supply returns, the inverter will once again connect the load, which are connected to its output to the main supply. This process is shown in Fig 2.

Fig 2



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Wiring plan lighting fixtures receptacles and sensors for bathing area

Objectives: At the end of this lesson you shall be able to
- **explain wiring plan lighting fixtures receptacles and sensors for bathing area.**

Designing a comprehensive wiring plan for a bathing area involves careful consideration of lighting fixtures, receptacles, and sensors. In this plan, we will discuss the placement and wiring of these components to ensure safety, functionality, and aesthetics. Please note that while this plan provides a general overview, it is crucial to consult with a licensed electrician and adhere to local electrical codes and regulations.

Lighting Fixtures

Lighting in the bathing area plays a vital role in both functionality and ambiance. Consider a combination of general lighting, task lighting, and accent lighting to create a well-lit and visually appealing space. Here are some key points to consider:

a **General Lighting:** Install ceiling-mounted fixtures or recessed downlights to provide overall illumination. Ensure even distribution of light to minimize shadows.

b **Task Lighting:** Task lighting is essential for specific activities such as grooming and applying makeup. Consider adjustable fixtures to cater to individual preferences.

c **Accent Lighting:** Accent lighting adds a decorative touch and highlights specific features in the bathing area.

d **Dimmers and Controls:** Incorporate dimmer switches to allow for adjusting light intensity according to the desired mood and task requirements. Consider installing a central lighting control system or smart home automation for convenient control of multiple lighting zones.

Receptacles

Bathing areas require receptacles to power various electrical devices such as hairdryers, electric shavers, and other personal grooming appliances. Follow these guidelines when planning receptacle placement:

a **GFCI Protection:** All receptacles in the bathing area must be Ground Fault Circuit Interrupter (GFCI) protected to ensure electrical safety. This protection is crucial due to the proximity of water sources.

b **Near Sinks and Vanity Areas:** Install GFCI-protected receptacles within 3 feet of any sink or vanity area. These receptacles should be at least 6 feet away from a bathtub or shower space to prevent water contact.

c **Additional Receptacles:** Consider the placement of additional GFCI-protected receptacles throughout the bathing area, ensuring they are within a reasonable distance for convenient use. Include receptacles near toilet areas and other functional spaces as needed.

Sensors and Controls

Integrating sensors and controls in the bathing area adds convenience and energy efficiency. Here are some examples of sensors and controls you might consider:

a **Occupancy Sensors:** Install occupancy sensors to automatically turn on lights when someone enters the room and turn them off after a period of inactivity. This is especially useful for reducing energy consumption in guest bathrooms or public spaces.

b **Motion Sensors:** Motion sensors can be used to activate specific lighting zones, such as vanity lights or accent lighting near mirrors, when someone approaches. This feature enhances both functionality and energy efficiency.

c **Exhaust Fan Controls:** Consider connecting the exhaust fan to a humidity sensor or timer. This ensures that the fan operates automatically when the humidity levels rise during showering, preventing moisture buildup and potential mold issues.

d **Lighting Controls:** Implement centralized lighting controls or smart home automation systems that allow for preset lighting scenes, scheduling, and remote control of lights and other devices in the bathing area.

Remember to consult with a licensed electrician to ensure compliance with local electrical codes and regulations.

Fig 1



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Multi storied building wiring

Objectives: At the end of this lesson you shall be able to
- **explain multi storied building wiring.**

Multi storied buildings are common in urban areas, and they require complex electrical wiring systems to ensure that all residents have access to reliable and safe electricity. The wiring of a multi storied building is a critical aspect of the construction process, and it must be done by qualified electricians to ensure that it is up to code and meets all safety requirements.

The first step in wiring a multi storied building is to determine the electrical load requirements. This involves calculating the total amount of electricity needed to power all the appliances, lighting, and other electrical devices in the building. The load calculation takes into account the number of units, the square footage of each unit, and the types of appliances and devices that will be used.

Once the load calculation is complete, the electrician will design the wiring system. This involves determining the number and location of electrical panels, the size and type of wiring, and the location of outlets and switches. The wiring must be designed to meet the building code requirements for electrical safety and to ensure that it can handle the expected load.

The wiring system for a multi storied building typically consists of three main components: the service entrance, the distribution system, and the branch circuits. The service entrance is the point where the electrical power enters the building from the utility company's grid. The distribution system is the network of wires and devices that carry the electricity from the service entrance to the various floors and units of the building. The branch circuits are the individual circuits that power specific devices, such as outlets and light fixtures.

One of the key challenges of wiring a multi storied building is ensuring that the wiring is “. properly grounded. Grounding is a safety feature that prevents electrical shocks and reduces the risk of fires. The electrician must install grounding rods and connect them to the main electrical panel to ensure that the building is properly grounded.

Another important aspect of multi storied building electrical wiring is the use of circuit breakers and fuses. Circuit breakers and fuses are safety devices that protect the wiring and devices from overloading and overheating. If a circuit becomes overloaded, the circuit breaker or fuse will trip, cutting off the electricity to that circuit and preventing damage to the wiring and devices.

The wiring system for a multi storied building must also include emergency power systems. Emergency power systems provide backup power in the event of a power outage or other emergency. These systems may include generators or battery backup systems, and they must be designed ô••„ovide enough power to run critical systems such as elevators, fire alarms, and emergency lighting.

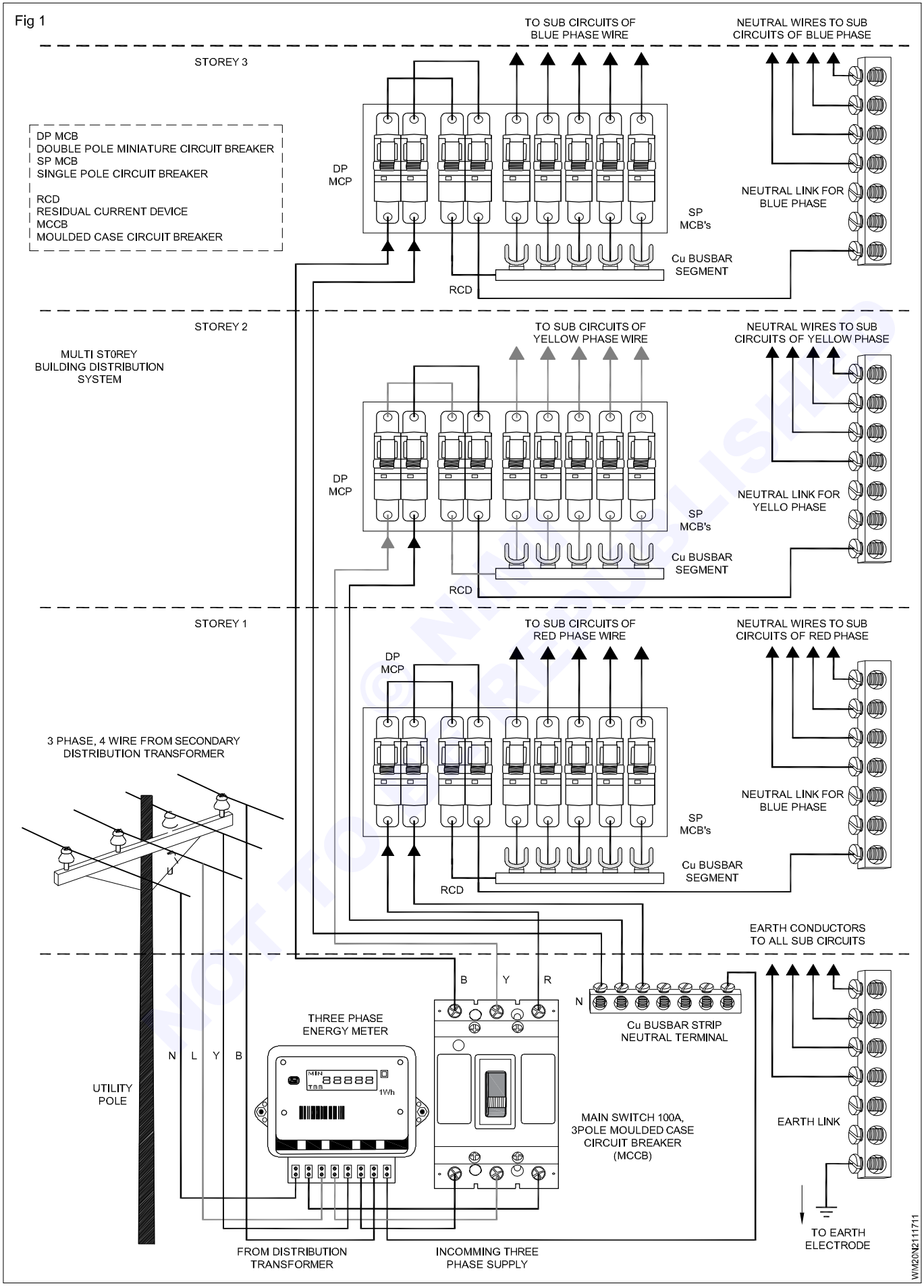
In addition to the wiring itself, the electrician must also install various electrical devices such as outlets, switches, and light fixtures. These devices must be installed according to building code requirements to ensure safety and reliability.

Finally, the electrician must test the wiring system to ensure that it is functioning properly and meets all safety requirements. This includes testing the grounding system, the circuit breakers and fuses, and the emergency power systems. The electrician may also use specialized testing equipment to check the quality of the wiring and to detect any potential problems.

Wiring a multi storied building is a complex and challenging task that requires careful planning, design, and installation. It is important to work with qualified and experienced electricians who understand the requirements of building codes and safety regulations. By following best practices and ensuring that the wiring system is properly designed, installed, and tested, it is possible to create a safe and reliable electrical system that can serve the needs of residents in a multi storied building for years to come.

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Three phase electrical wiring installation in a multi storied building



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Temporary low voltage electrical panels and lighting arrangements for construction site

Objectives: At the end of this lesson you shall be able to
- **explain temporary low voltage electrical panels and lighting arrangements for construction sites.**

Construction sites require a reliable and efficient electrical infrastructure to power various tools, machinery, and lighting systems. Temporary low voltage electrical panels and lighting arrangements play a crucial role in ensuring a safe and productive work environment. In this article, we will explore the importance of these components and discuss their key features and considerations.

Temporary Low Voltage Electrical Panels

Temporary low voltage electrical panels are essential for distributing power throughout a construction site. These panels act as centralized hubs, connecting the main power source to different areas and equipment. Here are some key points to consider when setting up temporary low voltage electrical panels:

a **Capacity:** Determine the power requirements of the site, including both essential tools and auxiliary systems. This assessment will help you select the appropriate panel size and capacity.

b **Safety Measures:** Install residual current devices (RCDs) or ground fault circuit interrupters (GFCIs) to protect workers from electrical shocks. These devices detect imbalances in the electrical circuit and immediately cut off the power supply.

c **Location:** Place the temporary electrical panels in a dry, well-ventilated area away from potential hazards such as flammable materials or heavy machinery. Ensure easy access for maintenance and repairs.

d **Cable Management:** Implement proper cable management techniques to prevent tripping hazards and cable damage. Use cable trays, conduits, or protective covers to organize and secure the wiring.

Lighting Arrangements

Adequate lighting is vital for ensuring worker safety, preventing accidents, and maintaining productivity on construction sites. Consider the following factors when planning lighting arrangements:

a **Illumination Levels:** Determine the required illumination levels for different areas based on the tasks performed. Brighter lighting may be necessary for intricate work, while general areas might need moderate illumination.

b **Energy Efficiency**: Opt for energy-efficient lighting options, such as LED (Light Emitting Diode) fixtures. LEDs consume less power, have a longer lifespan, and provide better quality lighting compared to traditional options.

c **Lighting Zones:** Divide the construction site into different lighting zones, such as task lighting, general area lighting, and safety lighting. This zoning helps in providing targeted illumination and minimizing energy wastage.

d **Emergency Lighting:** Install emergency lighting systems to ensure safe evacuation in case of power outages or emergencies. Emergency lighting should have backup power sources like batteries or generators.

e **Motion Sensors:** Incorporate motion sensors in lighting arrangements to automatically switch lights on and off based on occupancy. This feature helps conserve energy by preventing lights from operating in unoccupied areas.

f **Temporary Lighting Solutions:** For areas under construction or temporary structures, portable lighting options like floodlights or temporary light towers can provide flexibility and ease of installation.

g **Lighting Maintenance:** Regularly inspect lighting fixtures, replace faulty bulbs, and clean the lenses to maintain optimal illumination levels. Promptly address any lighting issues reported by workers to ensure a safe working environment.

Temporary low voltage electrical panels and lighting arrangements are critical components for construction sites. Proper planning, installation, and maintenance of these systems contribute to a safe and efficient working environment. Consider factors such as capacity, safety measures, location, illumination levels, energy efficiency, and emergency lighting to design an effective electrical infrastructure for your construction site.

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Industrial wiring

Objectives: At the end of this lesson you shall be able to
- **explain industrial wiring.**

Different types of electrical installations are required for different places. For example

1 Commercial installation

2 Industrial installation

3 Residential installation

Industrial electrical installation

Industrial electrical installation is related to the installation of industrial electrical machineries, electrical panels, industrial electrical safety, power supply systems, proper power distribution for different categories (production, utility, building), etc. It is related to production or manufacturing plant, stations, etc.

Industrial electrical installation is more complicated than others as there are so may restrictions and safety measures provided by the government. Here, so many different types of panels are installed because an industry or manufacturing company has so many machines and devices. For example, MCC (Motor Control Center) panel connect all the motor of that company. PCC (Power Control Centre) panel distribute power to the different section. So industrial electrical installation involves so many complex wirings, automation systems, safety features, etc.

Comparison between industrial, commercial and residential installations

Comparison Elements	**Industrial Electrical Installation**	**Commercial Electrical Installation**	**Residential Electrical Installation**
Location	Manufacturing Plants, factories industrial sectors, stations	Shopping Malls, Hospitals, warehouses	Homes, offices, clubs, etc.
Voltage	Above 440V three-phase	440V three-phase	230V single phase
Wires and cables	It requires a huge amount of wires and cables	It requires more wires and cables than a residential installation	It requires fewer wires and cables
Materials	High-grade materials	Medium	Low
Electrical Protection	Extra ordinary protection required	Moderate protection	Low protection
Insulation	Higher-level insulation	Moderate	Low
Installation cost	High	Moderate	Low

Adverse conditions likely to affect the installation

It is important to maintain a safe working environment in a place where electrical installations are carried out. The rated current value of the protection device must provide for the best possible over current protection of an installation. Let us discuss at same common causes for unsafe electrical installations.

Working wire size: The wrong size of wire can quickly cause it to overheat and possibly start a fire. So it is extremely important to have the right size wiring for your installation.

Un protected wiring: Wiring can get damaged it is left uncovered or exposed to harsh weather or tampering.

- Exposed electrical parts
- Improper grounding
- Improperly installed equipment
- Improperly use of electrical equipment

Presence of unauthorized personnel: There is a risk of electrical accidents if the installations are carried under unauthorized personnel.

Inadequate training: If a competent person is performing the installation there is great chance of reducing risk for workers. Ensure that you hire only the licensed electricians to installation and repairs. They always follow the electrical safety rules and construction safety.

Quality of materials: If the installations are temporary there is a chance that the contractors and workers don't checking the durability and safety at installing products. So that before installation carefully checked all the products.

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We should follow wiring installation codes and regulations which are intended to protect human life electrical machines and property from electrical shock and fire hazards. They are usually based on a model code such as IEE.

Degree of mechanical protection and electrical protection

Mechanical protection: Mechanical protection is essential in the wiring of industrial installations to prevent damage to the cables and ensure the safety of workers. The following are some of the necessary mechanical protection measures.

Conduit: Conduits are pipes or tubes used to protect cables from physical damage, moisture, and chemical exposure. Conduits can be made of various materials such as PVC, steel, or aluminium.

Cable trays: cable trays are support systems used to hold and protect cables in industrial installations. They are made of metal or plastic and provide a safe and secure pathway for cables.

Cable glands: Cable glands are used to provide a seal around cables as they enter or exit enclosures. They protect against moisture and dust, prevent cable pullout, and provide strain relief.

Electrical protection: Electrical protection is essential to ensure the safety of personnel and equipment in industrial installations. The following are some of the necessary electrical protection measures.

Circuit Breaker: Circuit breakers are used to protect electrical circuits from overcurrent and short circuit faults. They trip the circuit when the current exceeds the rating, prevent damage to the equipment and reducing the risk of fire.

Fuses: Fuses are used to protect electrical circuits from overcurrent and short-circuit faults. They melt when the current exceeds the rating, interrupting the circuit and protecting the equipment.

Ground fault circuit interrupter (GFCI): GFCIs are used to protect personnel from electrical shock. They are the difference in current between the ground and neutral wires and trip the circuit when a ground fault occurs.

Surge protectors: Surge protectors are used to protect equipment from voltage surges caused by lighting. They limit the voltage to a safe level, preventing damage to the equipment.

Peak loads and non peak loads in office buildings

Objectives: At the end of this lesson you shall be able to
- **explain peak loads and non-peak loads in office buildings.**

Peak loads and non-peak loads in office buildings play a significant role in energy management and efficiency. Understanding these load patterns can help building managers optimize their energy usage, reduce costs, and minimize environmental impact. In this article, we will explore what peak loads and non-peak loads are and discuss their implications for office buildings.

Peak loads refer to the periods of the day when energy consumption is at its highest in a building. These typically occur during business hours when occupants are actively using various electrical devices and systems such as lighting, heating, ventilation, and air conditioning (HVAC), computers, printers, and other office equipment. During peak load times, the demand for electricity is often greater than the building's baseline energy consumption, resulting in a spike in power usage.

On the other hand, non-peak loads refer to the periods of lower energy demand when fewer occupants are present in the building or when the building is not fully operational. Non-peak loads occur during evenings, weekends, and holidays when office buildings may have reduced occupancy or even be completely vacant. During these times, energy consumption is significantly lower compared to peak load periods.

Understanding the distinction between peak loads and non-peak loads is crucial for effective energy management in office buildings. Here are a few reasons why:

Cost savings: Electricity demand during peak load times often incurs higher utility rates due to peak demand charges. By actively managing and reducing peak loads, building managers can lower their energy bills. This can be achieved through strategies like load shifting, which involves scheduling energy-intensive activities during non-peak hours or implementing demand response programs to temporarily reduce energy usage during peak periods.

Equipment sizing: Peak loads help determine the capacity requirements for building systems and equipment. HVAC systems, for example, need to be sized appropriately to handle the maximum cooling or heating demands during peak load periods. Accurate sizing can prevent oversizing or under sizing of equipment, leading to energy inefficiencies or inadequate comfort levels.

Energy efficiency: Analyzing peak loads provides insights into areas where energy efficiency measures can be implemented. By identifying energy-intensive equipment or inefficient operational practices contributing to high peak loads, building managers can target these areas for improvement. Upgrading to energy-efficient devices, optimizing HVAC settings, or implementing smart building technologies can help reduce peak loads and overall energy consumption.

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Grid stability: Excessive peak loads can strain the power grid, potentially leading to power outages or blackouts. By managing and minimizing peak loads, office buildings contribute to the overall stability and reliability of the electricity grid. This is particularly important as renewable energy sources like solar and wind become more prevalent, as they can be intermittent and require grid support during high-demand periods.

Environmental impact: Peak load reduction strategies not only benefit the building occupants and managers but also have a positive environmental impact. By decreasing peak loads and overall energy consumption, office buildings can reduce their carbon footprint and contribute to sustainability goals. This aligns with global efforts to mitigate climate change and transition to cleaner energy sources.

In conclusion, peak loads and non-peak loads are crucial concepts in energy management for office buildings. Understanding and effectively managing these load patterns can lead to significant cost savings, improved energy efficiency, enhanced grid stability, and reduced environmental impact.

Lighting Design

Objectives: At the end of this lesson you shall be able to
- **explain lighting design: enhancing spaces with illumination.**

Lighting design plays a crucial role in shaping the ambiance and functionality of various spaces. Whether it's an architectural masterpiece, a theatrical production, or an interior design project, lighting has the power to transform and elevate the experience. It goes beyond mere illumination, becoming an art form that requires skill, creativity, and technical expertise.

In architectural lighting design, the objective is to enhance the aesthetic appeal of a structure while ensuring practicality and safety. Lighting designers consider the architectural features, the purpose of the space, and the desired mood or atmosphere. They carefully select fixtures, determine placement, and choose appropriate lighting techniques to highlight architectural details, create focal points, and provide adequate visibility.

Theatrical lighting design is an integral part of live performances, enabling directors and designers to shape narratives, set moods, and guide the audience's attention. Through the strategic use of spotlights, color filters, gobos, and dynamic lighting effects, lighting designers can create illusions, establish different time periods or locations, and evoke specific emotions.

In interior lighting design, the focus shifts to creating comfortable and functional spaces. Lighting designers collaborate with interior designers to understand the purpose of each area and the users' needs. They consider factors such as task lighting for work areas, ambient lighting for relaxation, and accent lighting for visual interest.

Advancements in lighting technology have revolutionized the field of lighting design. LED (Light Emitting Diode) lighting, for instance, has gained popularity due to its energy efficiency, longevity, and versatility. LED fixtures can be programmed to change colors, intensity, and direction, enabling lighting designers to create dynamic lighting displays and interactive experiences. Furthermore, smart lighting systems allow for remote control, automated scheduling, and integration with other building systems, offering enhanced flexibility and energy savings.

Lighting design also plays a significant role in outdoor spaces. Landscape lighting can transform gardens, parks, and public areas into enchanting nighttime scenes. By accentuating trees, pathways, and architectural elements, lighting designers can create a sense of drama, enhance safety, and invite people to explore the outdoor environment even after the sun sets. Additionally, façade lighting can bring buildings to life, turning them into landmarks and symbols of identity for cities.

In conclusion, lighting design is a multidimensional discipline that combines art, science, and technology to shape spaces and create experiences.

Lighting power density

Objectives: At the end of this lesson you shall be able to
- **explain lighting power density.**

Light power density refers to the amount of power or energy carried by light per unit area. It is a crucial parameter in various fields such as optics, photonics, and lighting technology. Light power density plays a significant role in determining the brightness, intensity, and efficiency of light sources. In this discussion, we will explore the concept of light power density, its importance, and its applications.

Light power density, also known as irradiance, is measured in watts per square meter (W/m²). It represents the total power of light incident on a surface area. The power density of light depends on several factors, including the intensity of the light source, the distance between the source and the surface, and the angle of incidence. Mathematically, light power density can be calculated by dividing the power of the light source by the area over which it is distributed.

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Light power density is a fundamental parameter in lighting design. It is used to determine the appropriate light levels for different applications. For example, in architectural lighting, power density is crucial for creating well-lit spaces that are visually appealing and comfortable for occupants. In industrial settings, proper light power density ensures safe working conditions and enhances productivity. Understanding light power density is also essential in designing efficient solar panels, as it helps determine the amount of light energy that can be converted into electricity.

Advancements in lighting technology have led to the development of high-power light sources with increased power density. Light-emitting diodes (LEDs) have revolutionized the lighting industry by providing energy-efficient and long-lasting lighting solutions. LEDs can achieve high power density while consuming minimal energy, making them ideal for various applications, including general lighting, displays, and automotive lighting.

In conclusion, light power density is a critical parameter that influences the brightness, intensity, and efficiency of light sources. It plays a significant role in lighting design, and various scientific applications.

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Estimation of load, cable size, bill of material and cost

Objectives: At the end of this lesson you shall be able to
- **state the points to be considered before taking up domestic wiring**
- **calculate the load(s) and select the number of sub(branch) circuits**
- **estimate the load in a circuit**
- **select proper cable size for branch main circuits and the supply system**
- **estimate and list out the accessories for given wiring installation.**

Points to be considered before taking up domestic wiring

The following points shall be noted particularly in respect of domestic dwellings.

Before starting the wiring installation, information should be exchanged between the owner of the building or architect and the local supply authority in respect of tariffs applicable, types of apparatus that may be connected under each tariff, requirement of space for installing meters, switches, service lines etc. and for the total load requirement of lights, fans and power.

While planning an installation, consideration should be given to the anticipated increase in the use of electricity for lighting, general purpose socket-outlet, kitchen, heating etc. Otherwise, the householder may be tempted to carry out extension of the installation himself or to rely upon the use of multi plug adaptors and long flexible cords, both of which are against the electric supply rules. Fundamentally safe installation may be rendered dangerous, if extended in this way.

Hence the National Electricity Code suggests the following schedule.

Number of points in branch circuits: The recommended yardstick for dwelling units for determining the number of points is given in Table 1.

Table 1

Number of points for dwelling units

Sl.No.	Description	Area of the main dwelling unit (m^2)				
		35	45	55	85	140
1	Light points	7	8	10	12	17
2	Ceiling fans (See NOTE below.)	2-2	3-2	4-3	5-4	7-5
3	5 A socket outlets	2	3	4	5	7
4	15 A socket outlets	–	1	2	3	4
5	Call bell (buzzer)	–	–	1	1	1

NOTE: **The figures in the table against Sl.No.2 indicate the recommended number of points and the number of fans. Example: For the main dwelling unit of 55m^2, 4 points with 3 fans are recommended.**

Number of socket outlets

The recommended schedule of socket outlets for the various sub-units of a domestic dwelling are given in Table 2.

Table 2

Description	Number of socket outlets	
	6A	16A
Bedroom	2 to 3	1
Living room	2 to 3	2

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Kitchen	1	2
Dining room	2	1
Garage	1	1
For refrigerator	–	1
For air-conditioner	–	1 (for each)
Verandah	1 per 10 m^2	1
Bathroom	1	1

Note that the BIS has changed the ampere specification of socket and plugs as 6 amps and 16 amps, whereas the earlier BIS references is for 5 amps and 15 amps. Further the manufacturers are yet to change their product specification from 5 A/15 A to 6 A/16 A. Hence the trainees are advised to use the new reference with due care for old reference also.

Electrical installation in a new building should normally begin immediately on the completion of the main structural building work. For conduit wiring system, the work should start before finishing work like plastering has begun. For surface wiring system, however, work should begin before final finishing work like white washing, painting etc.

Sub(branch) circuits

Stated below are some of the important points from the above information sheet.

Sub-circuits may be divided into two groups

a Light and fan sub-circuits.

b Power sub-circuit.

Separate distribution boards shall be provided for light and power.

Each circuit shall be provided with a fuse in the phase wire and the neutral conductor shall be connected to a common link with disconnecting arrangement for testing.

The load on the light and fan sub- circuits should be restricted to 800 watts or ten points considering each light, fan and 6 amps sockets as points.

A minimum of two lighting sub-circuits shall be provided in each house so that in case of fault in one sub-circuit, the whole house is not plunged in total darkness.

The load on power circuits should be restricted to 3000 watts having not more than two socket outlets.

Estimation of load requirements

Electrical installation in domestic dwellings is basically designed to cater to light and fan loads and for electrical appliances and gadgets. In estimating the current to be carried by any branch circuit, unless the actual values are known, these shall be calculated based on the following recommended ratings.

Item	Recommended rating (in watts)
CFL	18
Ceiling fans	60
Table fans	60
6 A, 3-pin socket-outlet points	100
LED tubes	
Length 600 mm	25
1200 mm	50
1500 mm	90
Power socket outlets (16 A)	1000

Example

Estimate the cost of material for wiring PVC channel for an office room having 2 lamps 1 fan one 6A socket outlet.

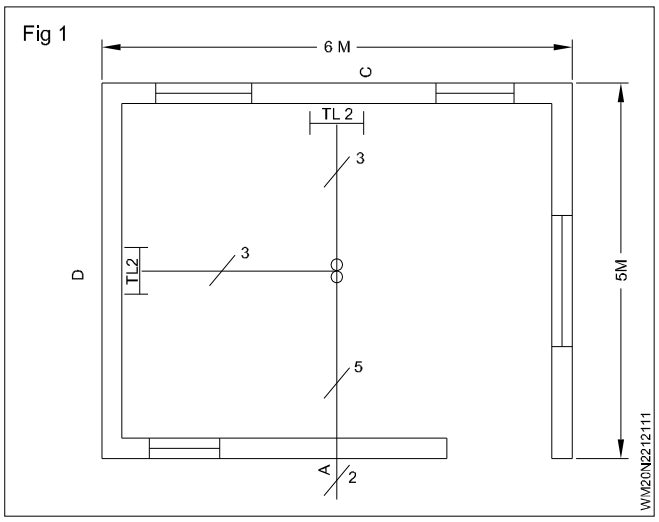
To estimate the cost of material the electrician has to follow these steps:

Type of wiring to be decided- PVC channel (casing and capping - given).

Position of the electrical points/Loads has to be decided as per the requirement.

Layout of the office has to be prepared (Fig 1).

Fig 1



Total load to be calculated, In the given example

i Lamp 2nos x 60 W = 120 W

ii Fan1no x 60 W = 60 W

iii 6A socket 1 no = 100 W

280 W

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circuit/connection diagram for the room has to be developed.

Based on the layout and circuit diagram calculate the length of PVC channel required.

1) Length of PVC channel in Roof = 5 +3 = 8m

2) Vertical drops = 0.5 +0.5 +2.0 = 3.0m

Total = 8+ 3.0 = 11.0 m

3) Add 10% tolerance = 1.1 m

12.1 m

7 Calculate the length of wire and size of wire based on layout, circuit diagram and load. In the given example, the total load is 260W the current taken by the total load are

$$I = \frac{P}{V \times \cos\theta} = \frac{280}{240 \times 0.8} = 1.45$$

Hence PVC copper flexible 1sqmm wire is enough to this circuit/room. However, since this wiring come in the category of commercial wiring, for safe-side, we can choose 1.5sq mm PVC insulated copper flexible wire.

Assume vertical drop is 0.5 m for tube lights and 2m for switch board then the length of wire required is

From A to B and vertical drop	= (2.5 +2)m x 5	= 22.5 m
From B to C and vertical drop	= (2.5 +0.5) m x 3	= 9m
From B to D vertical drop	= (3 +0.5)m x 3	=10.5m
total length	= 22.5 + 9 +10.5	= 42m
add 10% tolerance	= 42 + 4.2	= 46 m

The maximum number of wire runs in a PVC channel is 5 hence 19 mm x 10mm PVC channel may be used.

List of electrical accessories required with complete specification has to be prepared. Also calculate the cost of materials as per the present market rate.

Sl No	Accessories	Length	unit price	price
1	PVC channel 19 mm x10mm	12m		
2	1.5 sq mm PVC insulated copper flexible 650V	46 m		
3	Flush type SPT switch 6 A 250 V	4 No		
4	Flush type socket 6 A 250V	1No		
5	Wooden switch board 250mm x 150mm	1No		
6	LED Tube light - 32W	2No		
7	Ceiling fan 250V, 1200 mm sweep	1 No		
8	electrical fan regulator 250V , 60W	1No		
9	Wood screws 15 x 4mm, 25 x 5mm, 30 x6mm	25 Nos each		
10	PVC insulation tape 19mm width 9m length	1No		
11	Ceiling rose 3 plate 250 V , 6 A	3No		
Total	Cost of the material required			

In the same way trainees can be instructed to calculate the cost of materials required to wire up the following wiring in the PVC conduit.

1) godown wiring

2) Corridor wiring

3) hostel wiring

4) Tunnel wiring

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Inspection and testing of wiring installations

- **explain the necessity of installing correct rating fuses in a circuit taking into consideration the connected load and the circuit cable capacity**
- **explain the type of test to be carried out in wiring installations and their necessity**
- **explain the procedure of conducting the following tests**
  - **polarity**
  - **continuity test**
  - **effectiveness of earth connection**
  - **insulation test between conductors and earth**
  - **insulation test between conductors.**

Necessity of correct rating fuse in a circuit: The prime use of a fuse in a circuit is to protect the circuit from excess current. The reasons for excess current in a circuit may be overload, earth fault or short circuit. In such cases of excess current over the normal, the fuse melts and opens the circuit.

The fuse rating is normally decided by the load or by the capacity of the circuit cable whichever has a lower rating. If the load requires 10 amps and the cable capacity is only 5 amps, then the fuse should be restricted to 5 amps only. On the other hand, such a situation is practically impossible as the fuse will blow soon after the load is switched on. On the contrary if a 10 amps fuse is placed in the circuit, the under-rated cables will get overheated and cause fire hazards.

But in a circuit, there is a possibility that the circuit cables may be of higher capacity but the connected load may be less than the cable capacity. In such cases it is advisable to use the fuse of the load rating. In the event of earth fault or short circuit, the fuse will blow and open the circuit eliminating chances for shock or fire hazards in the equipment.

Hence it is of utmost necessity to place the correct capacity fuse in the circuit. As rewirable fuses cannot be readily identified, in case of doubts, it is better to replace the correct fuse wires taken from well marked stock.

General requirement of inspection and tests (Ref: B.I.S.732-(Part III) 1982.)

Before a completed installation or an addition to the existing installation is put into service, inspection and testing shall be carried out in accordance with the Indian Electricity Rules, 1956. In the event of defects being found, these shall be rectified as soon as practicable, and the installation re-tested.

Periodic inspection and testing shall be carried out in order to maintain the installation in a sound condition after putting it into service.

Where an addition is to be made to the fixed wiring of an existing installation, the latter shall be examined for compliance with the recommendations of this code.

The individual equipment and materials which form part of the installation shall generally conform to the relevant Indian Standard Specification, wherever applicable. If there are no relevant Indian Standard Specification for any items, these shall be approved by the appropriate authority.

Inspection of the installation: On completion of the wiring, a general inspection shall be carried out by competent personnel in order to verify that the provisions of this code and those of the Indian Electricity Rules, 1956 have been complied with. This, among other things, shall include checking whether all equipment, fittings, accessories, wires/cables, used in the installation are of adequate rating and quality to meet the requirement of the load. The layout and finish shall be examined for neatness that would facilitate easy identification of circuits of the system, adequacy of clearances, soundness of termination with respect to tightness, contact pressure and contact area. A complete check shall also be made of all the protective devices, with respect to their ratings, range of settings and co-ordination between the various protective devices.

Items to be inspected in a lighting circuit

Lighting circuits: The lighting circuits shall be checked for ensuring the following.

- Wooden boxes and panels are avoided in factories for mounting the lighting boards and switch controls etc.
- Neutral links are provided in double pole switch-fuses which are used for lighting control, and no fuse is provided in the neutral.
- The plug points in the lighting circuit are all of 3-pin type, the third pin being suitably earthed.
- Tamper-proof interlocked switch sockets and plugs are used for locations easily accessible.
- Lighting wiring in the factory area is taken enclosed in conduits, and conduits are properly earthed, or alternatively, armoured cable wiring is used.
- A separate earth wire is run in the lighting installation to provide earthing for plug points, fixtures and equipment.
- Proper connectors and junction boxes are used wherever joints are to be made in conductors or when cross-over of conductors takes place.

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- Cartridge fuse units are fitted with cartridge fuses only.
- Clear and permanent identification marks are painted in all distribution boards, switchboards, sub-main boards and switches as necessary.
- The polarity having been checked, all fuses and single pole switches are connected on the phase conductor only and wiring is correctly connected to the socket-outlets.
- The spare knock-outs provided in distribution boards and switch-fuses are blocked.
- The ends of the conduits enclosing the wiring leads are provided with ebonite or other suitable bushes.
- The fittings and fixtures used for outdoor use are all of weatherproof construction, and similarly, fixtures, fittings and switchgears used in the hazardous area are of flame-proof application.
- Proper terminal connectors are used for termination of wires (conductors and earth leads) and all strands are inserted in the terminals.
- Flat-ended screws are used for fixing conductors to the accessories.
- Use of flat washers backed up by spring washers for making end connections is desirable.
- The number of wires in a conduit conforms to the provisions of Part II of BIS 732.

Testing of installation: After inspection, the following tests shall be carried out, before an installation or an addition to the existing installation is put into service. Any testing of the electrical installation shall commence after obtaining a permit to work from the engineer in-charge and after ensuring the safety provisions.

1 Continuity or open circuit test
2 Polarity test
3 Earth and ground test
4 Insulation and leakage test:
   - between conductors
   - between conductors and earth.

Continuity or open circuit test: This test is carried out to check the continuity of cables in the individual sub-circuits. Before conducting this test, the main and all the distribution circuit fuses should be removed.

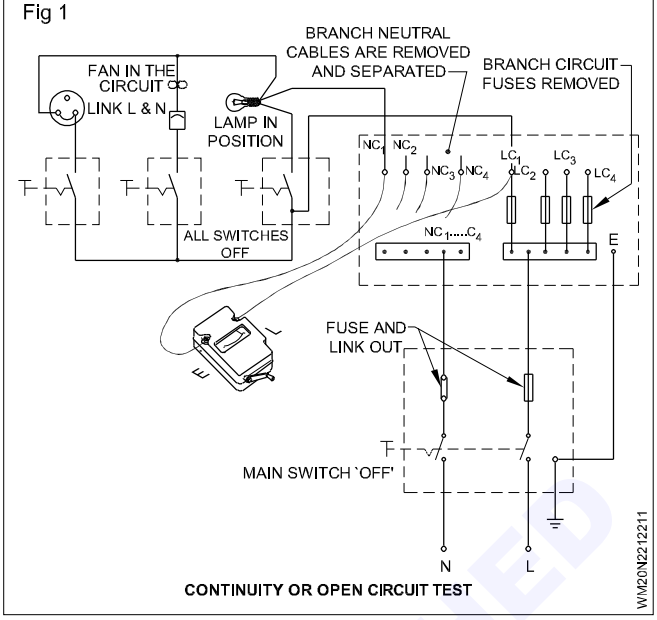
The phase and the neutral of the individual circuits should be identified from the distribution board and segregated.

Place all bulbs in position, connect fans to respective ceiling roses, regulators and switches, short all socket outlets by linking the phase and neutral.

Connect the Megger terminals E and L to the individual circuit phase and neutral as shown in Fig 1 and rotate the Megger.

By switching the switches ON and OFF one by one, the Megger should show zero reading and infinity alternatively. The two-way switches may have to be operated alternatively to ensure the correct test results.

Fig 1



CONTINUITY OR OPEN CIRCUIT TEST

If the Megger shows no continuity in the `ON' condition of the switch, then the particular circuit is deemed to be open. On the other hand, if the Megger shows continuity in both the `ON' and `OFF' positions of the switch, this indicates short in the particular circuit.

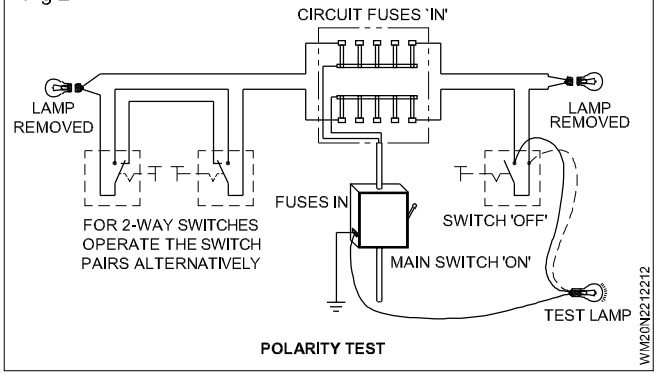
Remember to remove all the shorting links at socket points and to connect the phase to the fuse, and neutral to the link, before switching `ON' the supply.

Polarity test: This test is conducted to check whether switches are connected in phase/live cable or not.

For conducting this test, the lamps are removed from the lamp-holders, the fan regulators are kept in the `OFF' position and the fuses inserted in the main and distribution boards.

Remove the switch covers and switch `ON' the supply. Connect one end of the test lamp to the earth continuity conductor and the other end of the test lamp to the switch terminals alternatively, as shown in Fig 2.

Fig 2



POLARITY TEST

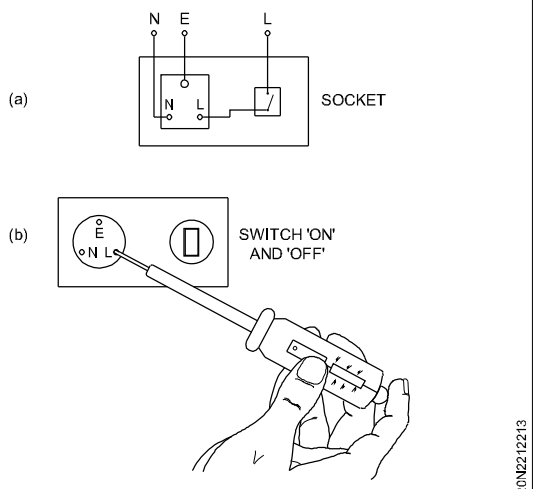
Lighting of the test lamp indicates that the phase or live cable is controlled by the switch.

A further polarity test should be done on the sockets to verify whether

- The phase wire is connected to the right side hole of the socket as shown in Fig 3a.

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Fig 3



POLARITY TEST ON SOCKETS

- The switch controls the phase wire. For this test, a neon tester could be inserted in the right side hole of the socket as shown in Fig 3b and the control switch is switched `ON'. Lighting of the neon tester when the switch is `ON' and no light when the switch is `OFF' indicate correct polarity. This test is a must, in all old or new wiring installations as a safety measure.

Testing the effectiveness of earth connection: For checking the efficiency of earthing, the following tests are done.

– Testing the continuity of earth continuity conductor (ECC) and measuring its resistance.

– Its value should not be higher than 1 ohm.

– The earth resistance of the electrode shall be measured.

Insulation tests in wiring installation (BIS 732 (Part II) - 1982): The following tests shall be done:

a The insulation resistance shall be measured by applying the test between the earth and the whole system of the conductor or any section thereof, with all the fuses in place and all the switches closed, and except in earthed concentric wiring, all lamps in position or both poles of installation, otherwise electrically connected together, a DC voltage of not less than twice the working voltage, provided that it does not exceed 500 volts for medium voltage circuits. Where the supply is derived from a three-wire AC or DC or poly-phase system, the neutral pole of which is connected to earth either direct or through added resistance, the working voltage shall be deemed to be that which is maintained between the outer or phase conductor and the neutral.

b The insulation resistance in megohms of an installation measured as in (a) shall not be less than 50 divided by the number of points on the circuit, provided that the whole installation need not be required to have an insulation resistance greater than one megohm.

c Control- rheostats, heating and power appliances and electric signs, may, if desired, be disconnected from the circuit during the test, but in that event the insulation resistance between the case or framework, and all the live parts of each rheostat, appliance and sign shall be not less than that specified in the relevant Indian Standard Specification, or where there is no such specification, shall be not less than half a megohm.

d The insulation resistance shall also be measured between all conductors connected to one pole or phase conductor of the supply and all the conductors connected to the middle wire or to the middle wire or to the neutral on to the other pole of the phase conductors of the supply. Such a test shall be made after removing all metallic connections between the two poles of the installation, and in these circumstances the insulation resistance between the conductors of the installation shall be not less than that specified in (b).

On completion of an electrical installation (or an extension to an installation) a certificate shall be furnished by the contractor, countersigned by the certified supervisor under whose direct supervision the installation was carried out. This certificate shall be in the prescribed form as required by the local electric supply authority.

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Special wiring circuits - Hospital, godown tunnel and workshop

Objectives: At the end of this lesson you shall be able to
- **state the difference between godown, tunnel and corridor, bank/hostel wirings**
- **draw the hospital circuits**
- **prepare the mode chart for the above circuits.**

Tunnel wiring

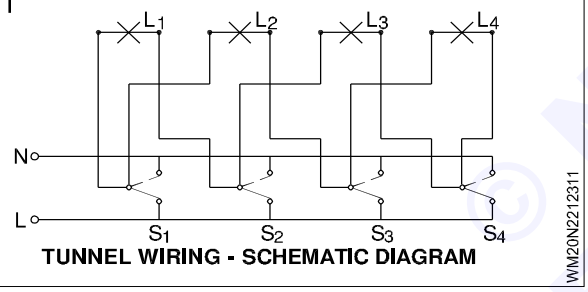
One light will not be sufficient to give enough illumination in the case of **tunnels** where darkness is more. Hence, the wiring circuit for a tunnel needs at least two lights to be 'ON' at a time while a person moves inside a tunnel and goes out.

In tunnel wiring a person walking along the tunnel can successively light behind two lamps ahead and put off a lamp behind with one switch.

All switches are two-way switches.

Caution: This circuit is not in accordance with IE rules as the phase and neutral come in the same switch. So care should be taken while connecting the wires.

Fig 1



TUNNEL WIRING - SCHEMATIC DIAGRAM

The mode of operation of the switches and the consequent lighting position are shown below.

Mode chart for tunnel wiring

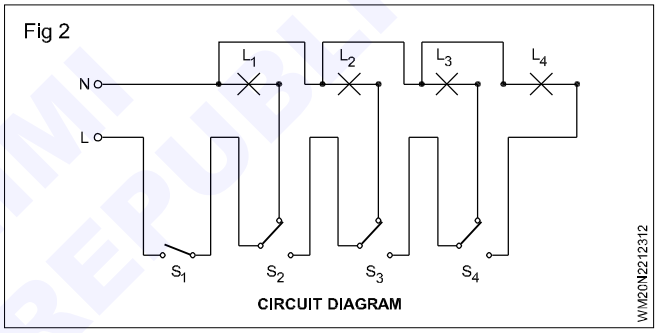
SWITCHES				LIGHTS			
S_1	S_2	S_3	S_4	L_1	L_2	L_3	L_4
✓	✗	✗	✗	✓	✓	✗	✗
✓	✓	✗	✗	✗	✓	✓	✗
✓	✓	✓	✗	✗	✗	✓	✓
✓	✓	✓	✓	✗	✗	✗	✗

MODE CHART FOR TUNNEL WIRING

Godown lighting circuit: Let us consider a godown lighting circuit (Fig 2) having four lamps L_1, L_2 , L_3 and L_4 which are to be controlled such that if one moves in a godown in either direction he can switch ON one light after the other in the forward direction while the lamp which was lighted earlier gets switched OFF. In an arrangement. S_1 is a one way switch, S_2 , S_3 and S_4 are two-way switches.

While coming back from the godown when the person switches off the light 4, then the light 3 will be on and give light for his return movement. When he leaves the godown all the lights could be switched 'off' by operating switch S_1.

Fig 2



CIRCUIT DIAGRAM

The following chart gives the mode of operation of the switches and lights. Trainees are advised to make the return mode chart.

Mode chart for godown wiring

Switches				Lights			
S_1	S_2	S_3	S_4	L_1	L_2	L_3	L_4
ON	OFF	OFF	OFF	ON	-	-	-
ON	ON	OFF	OFF	-	ON	-	-
ON	ON	ON	OFF	-	-	ON	-
ON	ON	ON	ON	-	-	-	ON

Hospital wiring

Objectives: At the end of this lesson you shall be able to
- **explain hospital wiring.**

Hospital wiring plays a crucial role in ensuring the efficient and reliable operation of healthcare facilities. The electrical systems in hospitals must be designed to meet the specific needs of medical equipment, maintain patient safety, and comply with regulatory standards.

I Design Principles for Hospital Wiring:

Load Calculation and Power Distribution: Hospitals have diverse electrical loads, including lighting, medical equipment, HVAC systems, and computer networks. Proper load calculation is essential to determine the electrical capacity required for efficient operation.

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Power distribution systems must be designed to handle the anticipated loads while providing flexibility for future expansions and changes in equipment.

Separation of Circuits: Separation of circuits is crucial in hospital wiring to prevent interference between different types of equipment. Essential systems, such as life support equipment, must be isolated from non-essential systems to ensure uninterrupted operation.

Backup Systems: Hospitals require reliable power sources to minimize downtime and ensure patient safety. Backup generators and uninterruptible power supply (UPS) systems are essential to provide backup power during electrical outages and emergencies.

II Safety Considerations in Hospital Wiring

Grounding and Isolation

Proper grounding of electrical systems in hospitals helps protect patients, staff, and sensitive equipment from electrical shock hazards. Isolation transformers are often used to reduce the risk of electrical leakage and ensure patient safety.

Surge Protection: Hospitals are susceptible to power surges caused by lightning strikes and electrical system faults. Surge protection devices (SPDs) are installed to divert excess voltage and safeguard sensitive equipment from damage.

Electrical Codes and Standards: Compliance with electrical codes and standards, such as the National Electrical Code (NEC) and healthcare-specific guidelines, is crucial for hospital wiring. These regulations cover aspects like wiring methods, equipment installation, and safety measures.

Fire Safety: Hospitals require robust fire safety measures to protect patients, staff, and valuable medical equipment. Fire-resistant wiring, proper circuit protection, and installation of fire detection and suppression systems are critical to minimize fire hazards.

III Importance of Reliable Electrical Infrastructure in Healthcare Settings:

Continuity of Care: Reliable electrical infrastructure ensures uninterrupted operation of critical medical equipment, life support systems, and electronic health records (EHR) systems, which are vital for patient care and safety.

Emergency Response: During emergencies and natural disasters, hospitals must remain operational. Reliable electrical systems enable emergency lighting, communication systems, and medical equipment, facilitating effective response and patient evacuation if necessary.

Medical Equipment Performance: Hospital wiring should provide clean and stable power to medical equipment, as fluctuations or interruptions can affect their performance, accuracy, and patient outcomes.

Workshop wiring

Objectives: At the end of this lesson you shall be able to
- **explain workshop wiring.**

Wiring is a critical aspect of any workshop setup. Whether you are setting up a woodworking shop, metalworking facility, or any other type of workshop, proper wiring is essential for safety, functionality, and efficiency. In this guide, we will discuss the key considerations and steps involved in workshop wiring, covering everything from planning and design to installation and maintenance. By following these guidelines, you can ensure a well-wired workshop that meets your electrical needs and keeps you safe.

Planning and Design

a **Assessing electrical needs:** Start by determining the electrical requirements of your workshop, including the number and type of electrical devices, tools, and equipment you plan to use. Calculate the total power consumption and consider any specific voltage requirements.

b **Outlets and circuits:** Determine the number and location of electrical outlets needed for your workshop. Distribute them strategically to ensure convenient access and avoid overloading circuits. Separate circuits may be necessary for heavy machinery and power-hungry equipment.

c **Lighting:** Adequate lighting is crucial for a safe and productive workshop. Plan the placement of lighting fixtures, considering both general illumination and task-specific lighting for workbenches or machinery areas.

d **Safety considerations:** Identify potential hazards in your workshop, such as flammable materials, moisture, or combustible dust. Ensure the electrical wiring and devices meet the required safety standards for these conditions.

Electrical Panels and Subpanels

a **Main electrical panel:** Install a main electrical panel that meets the capacity requirements of your workshop. It should accommodate all the circuits and provide circuit breakers or fuses for protection against overloads.

b **Subpanels:** Depending on the size of your workshop and electrical needs, consider installing subpanels to distribute power to specific areas or equipment. Subpanels allow for better organization and prevent long wiring runs.

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Wiring Installation

a **Materials and cables:** Select appropriate electrical wiring materials based on local building codes and regulations. Common options include non-metallic (NM) cable, armored cable (AC), and conduit systems. Use cables with sufficient gauge to handle the anticipated load.

b **Running cables:** Plan the routing of cables, ensuring they are secured properly and protected from physical damage. Keep cables away from potential hazards, such as water sources or areas prone to mechanical impact.

c **Grounding:** Establish a robust grounding system for your workshop. Grounding protects against electrical faults and ensures a safe working environment. Connect the grounding wire to the main electrical panel and all electrical devices according to the applicable codes.

d **Circuit wiring:** Install circuits for different areas of your workshop, following the appropriate wiring diagrams and local electrical codes. Clearly label circuit breakers or fuses for easy identification and maintenance.

e **Outlets and switches:** Install electrical outlets, switches, and other devices according to the design plan. Ensure proper grounding and securely fasten them to the walls or work surfaces.

Safety Measures

a **GFCI protection:** Use Ground Fault Circuit Interrupters (GFCIs) for outlets in areas exposed to moisture, such as workshops with sinks or near water sources. GFCIs provide protection against electrical shock.

b **Surge protection:** Install surge protectors or whole-house surge protection devices to safeguard your workshop's sensitive electronic equipment from power surges or lightning strikes.

c **Regular inspections:** Conduct periodic inspections of the wiring system to identify any signs of wear, damage, or potential hazards. Address any issues promptly to maintain a safe and reliable workshop environment.

Danger notice as per IE rules

Objectives: At the end of this lesson you shall be able to
- **state danger notice as per IE rules.**

Danger Notice

DANGER! KEEP OUT!

This area contains hazardous materials, equipment, or processes that may pose serious risks to health and safety. Please read and adhere to the following instructions and precautions before entering:

Personal Protective Equipment (PPE)

All personnel must wear the appropriate PPE, including safety helmets, safety glasses, gloves, and safety shoes, as indicated for the specific area or task.

PPE must be properly maintained and replaced if damaged or expired.

Restricted Access

Unauthorized personnel are strictly prohibited from entering this area.

Only authorized personnel, trained in handling the specific hazards present, may enter.

Adhere to the specified entry requirements and seek permission from the designated supervisor.

Hazardous Materials

This area contains hazardous substances, such as flammable, corrosive, or toxic materials.

Follow all handling and storage guidelines, including proper labeling and use of designated storage areas.

Report any spills, leaks, or unusual odors immediately to the designated supervisor.

Electrical Hazards

High voltage equipment and electrical panels are present in this area.

Do not touch exposed electrical components without proper authorization and training.

Report any damaged or malfunctioning electrical equipment promptly.

Machinery and Moving Parts

Be cautious of machinery in operation.

Keep a safe distance from moving parts and follow all safety procedures.

Do not attempt to operate machinery without proper training and authorization.

Confined Spaces

Follow the specified procedures for confined space entry and rescue.

Fire Safety

Fire hazards exist in this area.

Familiarize yourself with the location of fire extinguishers, emergency exits, and evacuation routes.

In case of fire, activate the nearest fire alarm and evacuate the premises immediately.

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Emergency Procedures

Understand the emergency procedures specific to this area, including evacuation plans, assembly points, and emergency contact numbers.

Report all accidents, injuries, or near-miss incidents promptly to the designated supervisor.

Safety Signage

Pay attention to all safety signs, warnings, and instructions posted in this area.

Follow the information provided to mitigate risks effectively.

Compliance

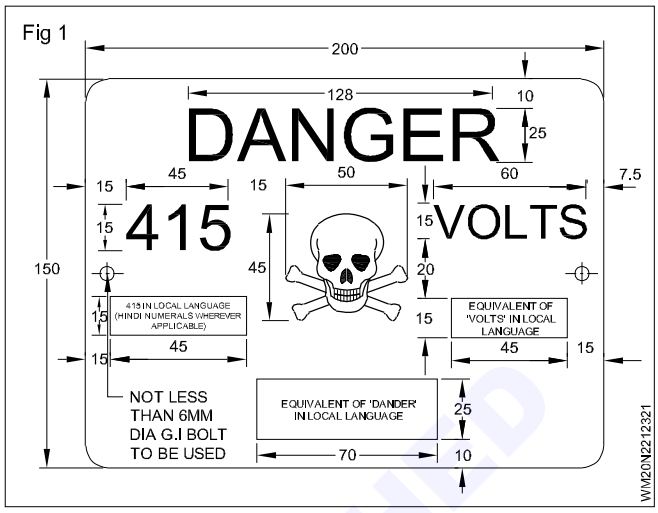
Failure to comply with these safety regulations may result in disciplinary action or removal from the premises.

Report any safety concerns or suggestions for improvement to the designated safety officer.

Remember, your safety and the safety of others are of paramount importance. By following these guidelines and using common sense, we can create a secure working environment. Together, we can prevent accidents and ensure the well-being of all personnel.

Stay safe, stay vigilant!

Fig 1



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Types of cables and their uses

Objectives: At the end of this lesson you shall be able to
- **explain type of cables and their uses.**

Cables are an essential component of modern technology and infrastructure, serving various purposes in different fields. They are designed to transmit data, signals, and power efficiency and reliably. Some common types of cables and their uses.

Ethernet cables

Ethernet cables, such as Cat5e, Cat6, and Cat7, are used for networking and data transmission in computer networks. They connect devices like computers, routers, and switches, allowing for high-speed data transfer.

Coaxial cables

Coaxial cables consist of a central conductor, insulation, shiedling, and an outer conductor. They are Commonly used for Cable Television (CATV), internet connections, and CCTV systems. Coaxial cables provide good signal quality and resistance to interference.

HDMI cables

High-Definition Multimedia Interface (HDMI) cables transmit high-definition audio and video signals between devices like televisions, monitors, DVD players, and gaming consoles. HDMI cables support both audio and video signals in a single cable.

USB cables

Universal Serial Bus (USB) cables are used for connecting peripheral devices to computers such as printers, keyboards, mice, and external storage devices. USB cable are available in various versions, including USB 2.0, USB 3.0, and USB-C, offering different data transfer speeds and power delivery capabilities.

Power cables

Power cables, such as the standard AC power cord, are used to deliver electrical power from a power source (wall outlet) to electrical devices. These cables come in different configurations based on regional standards and voltage requirements.

Fiber optic cables

Fiber optic consist of thin strands of glass or plastic called optical fibers that transmit data using light signals. They are used for long-distance, high-bandwidth data transmission, such as in telecommunication networks, internet backbones, and high-speed internet connections.

Audio cables

Audio cables, such as RCA cables, 3.5 mm auxiliary cables, and XLR cables, are used for transmitting audio signals between devices like speakers, headphones, microphones, and audio interfaces. They ensure high-quality audio transmission and are commonly used in entertainment systems and professional audio setups.

Patch cables

Patch cables, often in the form of ethernet patch cords, are short cables used to connect devices within a local area network (LAN), such as connecting a computer to a wall jack or connecting networking devices in a rack. The typically have RJ-5 connectors.

Various cable glands

Objectives: At the end of this lesson you shall be able to
- **state various Cable glands.**

Cable glands are essential components used in electrical and telecommunications installations to provide secure and reliable cable entry points into enclosures, junction boxes, or equipment. They offer protection against environmental factors such as dust, moisture, and vibration while also preventing cable damage and maintaining the integrity of the installation.

Various types of cable glands and their applications

Standard Cable Glands

Standard cable glands are the most commonly used type. They are designed to provide a secure connection for a wide range of cables. These glands typically consist of a threaded body and a compression seal or locking mechanism that ensures a tight seal around the cable, preventing the ingress of water or dust.

Armored Cable Glands

Armored cable glands, also known as cable fittings, are specifically designed for use with armored cables or cables with metallic sheaths. These glands have an additional layer of protection to secure the armored portion of the cable, providing strain relief and maintaining the integrity of the armor.

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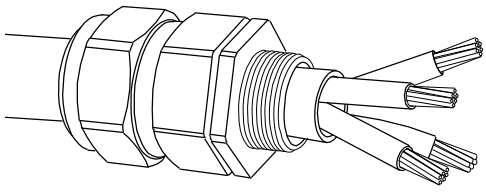
Explosion-Proof Cable Glands

Explosion-proof cable glands are used in hazardous environments where there is a risk of explosion due to the presence of flammable gases or dust. These glands are designed to prevent the propagation of explosions by providing a barrier between the hazardous area and the surrounding environment. They are constructed with flameproof materials and sealing techniques to ensure that no sparks or flames can escape or enter the enclosure.

EMC Cable Glands

Electromagnetic compatibility (EMC) cable glands are employed in applications where it is crucial to maintain proper shielding and grounding to minimize electromagnetic interference. These glands have specialized designs that provide effective grounding and shielding for cables, protecting sensitive equipment from external electromagnetic signals and preventing emissions from the cables.

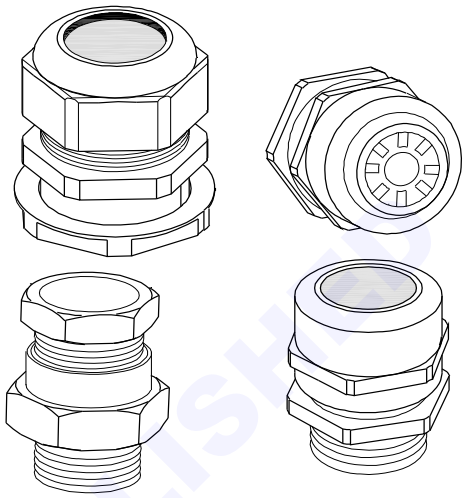
Fig 1



OUTDOOR BRASS CABLE GLAND

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Fig 2



WATER PROOF CABLE GLANDS

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Bonding & Grounding

Objectives: At the end of this lesson you shall be able to
- **explain various types of bonding and grounding.**

Bonding and grounding are essential practices in electrical systems to ensure safety and proper functioning. They involve creating a low-resistance path to allow the flow of electric current in a controlled manner, reducing the risk of electric shock, fire, and equipment damage. There are various types of bonding and grounding techniques used in different applications. This article will discuss some of the commonly employed methods.

Equipment Grounding: Equipment grounding is a fundamental type of grounding used to prevent electrical shock hazards. It involves connecting conductive parts of electrical equipment, such as appliances and machinery, to the earth or a grounding conductor. This ensures that any fault currents or leakage currents flow through the grounding path, causing protective devices to trip and disconnect the power supply.

System Grounding: System grounding refers to the intentional connection of one of the electrical system conductors, typically the neutral conductor, to the earth. There are three main types of system grounding:

a **Solid Grounding:** In solid grounding, the neutral point of the electrical system is directly connected to the earth. This type of grounding is commonly used in low-voltage distribution systems. It provides a reference point for voltage measurements and allows ground fault currents to flow, enabling protective devices to operate.

b **Resistance Grounding:** Resistance grounding involves connecting a resistor between the neutral point and the earth. This method limits the fault current magnitude, reducing potential damage and minimizing system downtime. Resistance grounding is commonly used in medium-voltage systems.

c **Reactance Grounding:** Reactance grounding utilizes inductive or capacitive reactances between the neutral point and the earth to limit fault currents. It offers similar benefits as resistance grounding but with additional advantages such as reduced voltage stress on system components. Reactance grounding is often employed in high-voltage systems.

Lightning Protection: Lightning can cause severe damage to structures and electrical systems. Lightning protection systems employ bonding and grounding techniques to provide a path of least resistance for lightning currents, diverting them safely to the ground. These systems typically involve the use of lightning rods, conductors, and grounding electrodes strategically placed on buildings or structures.

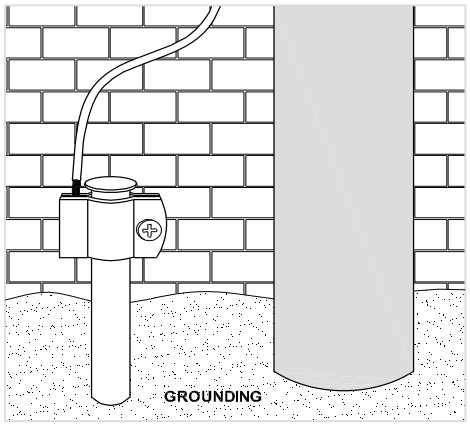
Bonding of Metallic Systems: In many applications, metallic systems such as piping, ductwork, and structural elements need to be bonded to prevent potential differences and ensure safety. Bonding these metallic systems together and connecting them to the equipment grounding system eliminates the risk of electrical shock due to potential differences and helps equalize voltages.

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Bonding in Telecommunication Systems: Telecommunication systems require bonding to minimize the effects of lightning-induced surges and electromagnetic interference. Bonding conductors are used to interconnect metallic components such as grounding electrodes, antenna masts, coaxial cables, and equipment racks to maintain equipotential bonding and protect sensitive equipment.

Bonding in Hazardous Locations: In environments where explosive gases, vapors, or dusts may be present, bonding and grounding are critical for preventing sparks that could ignite these substances. Electrical equipment and conductive components in hazardous locations need to be properly bonded to minimize the risk of explosions and comply with safety regulations.

Fig 3



Hygienic Cable Glands

Hygienic cable glands are specifically designed for applications in industries such as food processing, pharmaceuticals, and healthcare, where cleanliness and sanitary conditions are crucial.

Multi-Cable Entry Glands

Multi-cable entry glands, as the name suggests, allow the entry of multiple cables through a single gland, reducing the number of individual glands required for cable management. These glands often have a split design or multiple holes to accommodate different cable sizes or configurations, providing a neat and organized solution for cable entry points.

Fire-Resistant Cable Glands

Fire-resistant cable glands are designed to maintain the integrity of fire-rated enclosures and partitions. They are constructed with materials that can withstand high temperatures and provide a barrier against fire, preventing the spread of flames and smoke through cable penetrations.

Cable glands play a crucial role in ensuring the safety, reliability, and performance of electrical and telecommunications installations.

IP ratings and IP codes formats

Objectives: At the end of this lesson you shall be able to
- **state IP rating and IP codes formats.**

IP ratings, also known as Ingress Protection ratings, are a standard set by the International Electro technical Commission (IEC) to classify the degree of protection provided by electrical enclosures against the intrusion of solid particles and water. These ratings are represented by IP codes, which consist of two digits. The first digit indicates the level of protection against solid particles, while the second digit represents the level of protection against water.

Solid Particle Protection (First Digit)

0: No protection against contact and ingress of objects.

1: Protection against solid objects larger than 50mm in diameter.

2: Protection against solid objects larger than 12.5mm in diameter.

3: Protection against solid objects larger than 2.5mm in diameter.

4: Protection against solid objects larger than 1mm in diameter.

5: Dust-protected, limited ingress of dust allowed but must not interfere with the operation.

6: Dust-tight, no ingress of dust allowed.

Water Protection (Second Digit)

0: No protection against water.

1: Protection against vertically falling drops of water.

2: Protection against vertically falling drops of water when the enclosure is tilted up to 15 degrees.

3: Protection against spraying water at an angle up to 60 degrees from vertical.

4: Protection against splashing water from any direction.

5: Protection against low-pressure water jets from any direction.

6: Protection against high-pressure water jets from any direction.

7: Protection against temporary immersion in water up to 1 meter for 30 minutes.

8: Protection against continuous immersion in water beyond 1 meter for a specified period.

9: Protection against high-pressure, high-temperature water jets, and steam cleaning.

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These IP codes provide information about the level of protection offered by a device or enclosure, ensuring that customers can make informed decisions about the product's suitability for specific environments and applications.

For example, an IP65-rated device would be dust-tight (first digit 6) and protected against low-pressure water jets from any direction (second digit 5). This indicates that the device is well-suited for outdoor environments where it may be exposed to dust and light rain.

It's important to note that IP ratings only address protection against solid particles and water. They do not provide any information about other factors such as electrical safety, resistance to impact, or protection against chemicals or gases. Therefore, it's crucial to consider additional standards and certifications when evaluating the overall suitability of a product for a particular application.

Manufacturers often provide IP ratings and codes for their products in product specifications and datasheets, allowing customers to compare different devices and select the appropriate level of protection required for their specific use case. By understanding IP ratings and codes, consumers and professionals can make informed decisions and ensure the longevity and functionality of their electronic devices in various environments.

Types of cable faults and testing procedure

Objectives: At the end of this lesson you shall be able to
- **state IP rating and IP codes formats.**

Types of cable faults and testing procedure

The common faults which are likely to occur in cables are:

1 **Ground fault.** The insulation of the cable may breakdown causing a flow of current from the core of the cable to the lead sheath or to the earth. This is called “Ground Fault”.

2 **Short circuit fault.** If the insulation between two conductors is faulty, a current flows between them. This is called a “short circuit fault”.

Methods for locating ground and short circuit faults.

The methods used localizing the ground and short circuit faults differ from those used for localizing open circuit faults.

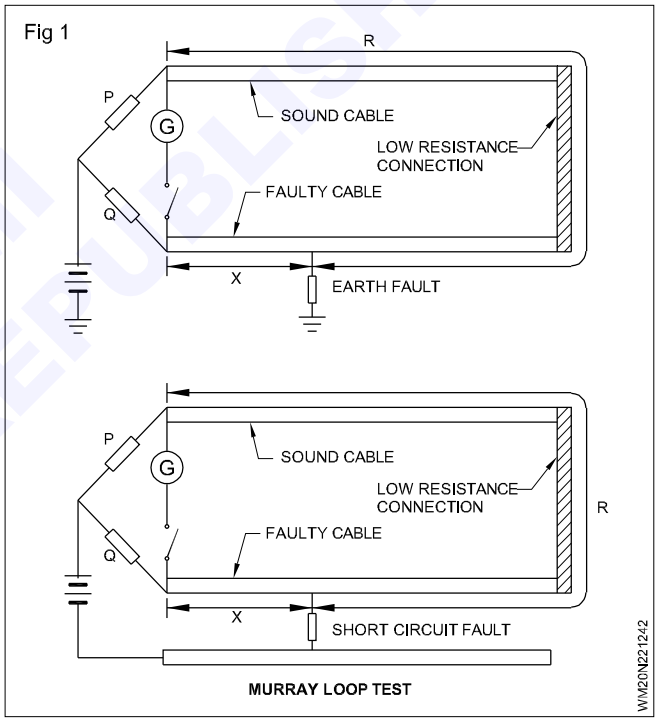
In the case of multi core cables it is advisable, first of all, to measure the insulation resistance of each core to earth and also between cores. This enables us to sort out the core that is earthed in-case of ground fault; and to sort out the cores that are shorted in case of a short circuit fault. Loop tests are used for location of ground short circuit faults. These tests can only be used if a sound cable runs along with the faulty cable or cables.

The loop tests work on the principle of a Wheatstone bridge. The advantage of these tests is that their setup is such that the resistance of fault is connected in the battery circuit and therefore does not affect the result. However, if the fault resistance is high, the sensitivity is adversely affected. In this section only two types of tests viz., Murray and Varley loop tests are being described.

Murray Loop Test. The connection for this test are shown in Fig 1a relates to the ground fault and Fig 1b relates to the short circuit fault.

In both cases, the loop circuit formed by the cable conductors is essentially a wheatstone bridge consisting of resistances P, Q, R and X. G is a galvanometer for indication of balance,

Fig 1



The resistors P, Q forming the ratio arms may be decade resistance boxes or slide wires.

Under balance conditions:

$$\frac{X}{R} = \frac{Q}{P} \text{ or } \frac{X}{R+X} = \frac{Q}{P+Q}$$

$$\therefore X = \frac{Q}{P+Q}(R+X)$$

Where (R+X) is total loop resistance formed by the sound cable and the faulty cable. When the conductors have the same cross-sectional area and the same resistivity, the resistance are proportional to lengths. If l_1 represents the length of the fault from the test end and ‘l’ is the length of each cable. Then

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$$l_1 = \frac{Q}{P+Q} \cdot 2l$$

The above relation shows that the position of the fault may be located when the length of the cable is known. Also, the fault resistance does not alter the balance condition because its resistance enter the battery circuit hence effects only the sensitivity of the bridge circuit. However, if the magnitude of the fault resistance is high, difficulty may be experienced in obtaining the balance condition on account of decrease in sensitivity and hence accurate determination of the position of the fault may not be possible.

In such a case, the resistance of the fault may be reduced by applying a high direct or alternating voltage, in consistence with the insulation rating of the cable, on the line so as to carbonize the insulation at the point of the fault.

Varley loop test. In this test we can determine experimentally the total loop resistance instead of calculating it from the known lengths of the cable and its resistance per unit length. The necessary connections for the ground fault are shown in Fig 2a and for the short circuit fault in Fig 2b. The treatment of the problem, in both cases, is identical.

A single pole double throw switch A is used in this circuit. Switch K is first thrown to position 'I' and the resistance 'S' is varied and balance obtained.

Measurement of resistance

Let the value of S for balance be S. The four arms of the Wheatstone bridge are P, Q, R + X, S_1 at balance:

$$\frac{R+X}{S_1} = \frac{P}{Q}$$

This determines R + X i.e. the total loop resistance as P, Q and S_1 are known.

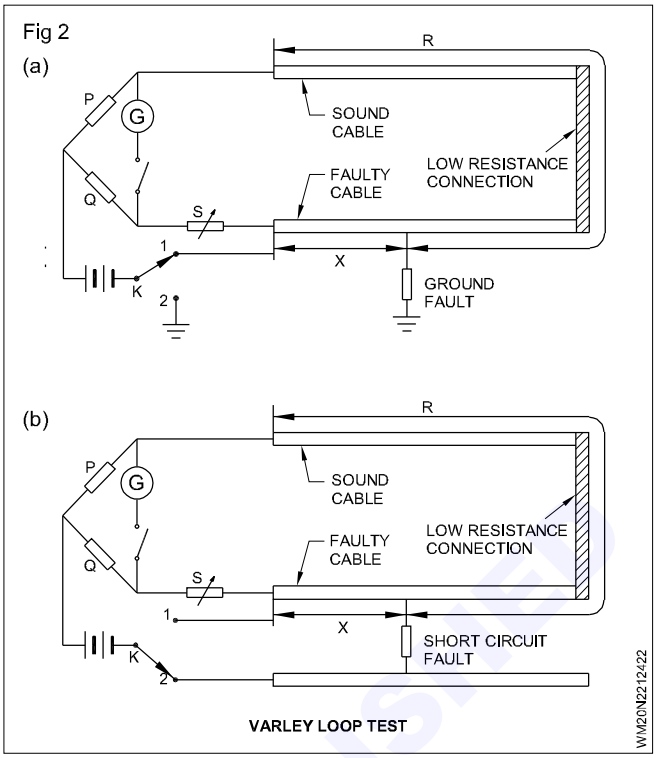
The switch K is then thrown to position '2' and the bridge is rebalanced. Let the new value of S for balance be S_2. The four arms of the bridge now are P, Q, R, X + S_2.

At balance

$$\frac{R}{X+S_2} = \frac{P}{Q}$$

$$\frac{R+X+S_2}{X+S_2} = \frac{P+Q}{Q} \text{ or } X = \frac{(R+X)Q - S_2 P}{P+Q}$$

Fig 2



VARLEY LOOP TEST

Hence, X is known from the known value of P, Q, S_2 from this equation and R+X (the total resistance of 2 cables) as determined from Eqn. knowing the value of X, the position of the fault is determined.

Now

$$\frac{X}{R+X} = \frac{l_1}{2l} \text{ or } l_1 = \frac{X}{R+X} 2l$$

Where

l_1= length of fault from the test end and

l = total length of conductor.

Equations for murray loop test and varley loop test are valid only when the cable sections are uniform throughout the loop. Corrections must be applied in case the cross-sections of faulty and sound cables are different or when the cross-section of the faulty cable is not uniform over its entire length.

Since temperature affects the value of resistance, corrections must be applied on this account if the temperatures of the two cables are different. Corrections may also have to be applied in case the cables have a large number of joints.

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Illumination terms - Laws

Objectives: At the end of this lesson you shall be able to
- **explain the nature of light**
- **state and explain different terms used in illumination**
- **state properties and advantages of good illumination**
- **state and explain laws of illumination.**

The nature of light

Light is a form of electromagnetic radiation. It is basically the same thing as the radiations used in radio, television, X-rays, gamma rays etc.

Definitions

A few principle terms in connection with illumination are defined below.

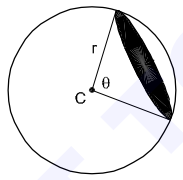
Luminous flux (F or Φ)**:** The flux of light emitted from a luminous body is the energy radiated per second in the form of light waves. The unit of luminous flux is `lumen'(lm).

Luminous intensity(I): The luminous intensity of a light source in a given direction is the luminous flux given out by the light source per unit solid angle. The angle subtended by an area r^2 on the surface of sphere of radius r, at the centre of sphere is unit solid angle. In SI, the unit of luminous intensity is the candela.

Candela: This is the amount of light emitted in a given direction by a source of one candle power. SI base unit is candela (cd). 1 candela = 0.982 international candles.

Lumen (lm)**:** It is the unit of luminous flux. This is defined as the amount of light contained in one steradian from a source of one candela at its focus. (Fig 1)

Fig 1



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If the shaded area = r^2 and a source of one candela is at the centre C, the light contained within the solid angle is one lumen.

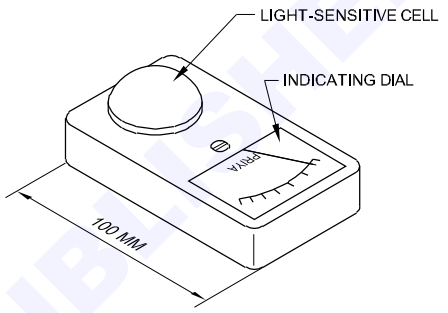
The light output of electric lamp is measured in lumens and their luminous efficiency (efficacy) is expressed in lumens per watt (lm/w).

Illuminance or Illumination (E): Illuminance of a surface is defined as the luminous flux reaching it perpendicularly per unit area. The metric unit is the lumen / m^2 or lux (lx).

Lux: This is the total output of light. Lumen per square meter ($1m/m^2$) or lux is the intensity of illumination produced in the inner surface of a hollow sphere of radius one meter by a standard candle at the centre. Sometimes this is also known as metre-candle.

Lighting engineers use a pocket-size instrument called a `light meter' to measure illuminance; and the reading in lux is read off the scale (Fig 2). This is not the same sort of instrument as a photographic exposure meter, which measures brightness, not illuminance.

Fig 2



TYPICAL POCKET-SIZE LIGHT-METER FOR MEASURING ILLUMINANCE.

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Properties of good illumination

An illumination source should, have the following properties.

i It should have sufficient light.

ii It should not strike the eyes.

iii It should not produce glareness in the eyes.

Advantages of good illumination

i It increases production in the workshop.

ii It reduces the chances of accidents.

iii It does not strain the eyes.

Laws of illumination

Inverse square law: If the internal radius of a sphere is increased from 1 metre to r metres, the surface area of it is increased from 4π to $4\pi r^2$ square metres. With a uniform point source of light of one candela at the centre, the number of lumen per square metre on the sphere of radius r metres.

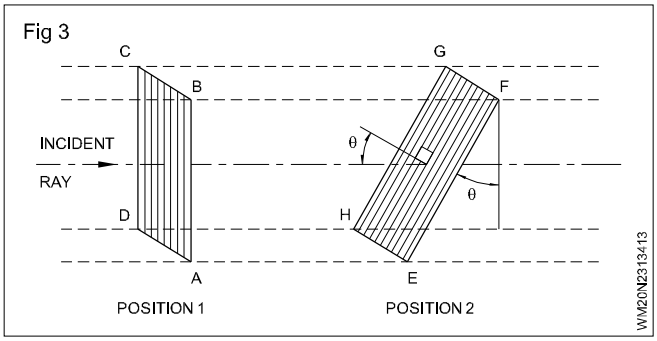
$$= \frac{4\pi}{4\pi r^2} = \frac{1}{r^2}$$

Hence the illumination of a surface is inversely proportional to the square of its distance from the source. This is called the **Inverse Square Law of Illumination.**

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Lambert's cosine law: According to this law, illumination (E) is directly proportional to the cosine of the angle made by the normal to illuminated surface with the direction of the incident flux. (Fig 3) Let Φ be the flux incident on the surface of area ABCD when in position 1. When this surface is so placed that the angle between the incident ray and the perpendicular to the surface EFGH is θ. The luminous flux falling on area EFGH is Φ.

Fig 3



Hence the illumination on the surface in position 1 is

$$E_1 = \frac{\Phi}{\text{Area ABCD}}$$

But in position 2, the illumination is

$$E_2 = \frac{\Phi}{\text{Area EFGH}}$$

(Area ABCD = AB x BC,

Area EFGH = EF x GF

$$= \frac{AB}{\cos\theta} \text{ x } BC$$

because, $\text{Cos}\theta = \frac{AB}{EF}$

Therefore, $E_2 = \frac{\Phi \text{ x } \cos\theta}{\text{Area ABCD}} = E_1 \cos\theta$

So illumination on EFGH

$$= \frac{1}{d^2} \text{ x } \cos\theta$$

where `d' is the distance of the surface from a source having a luminous intensity of one candela.

Type of illumination system

Objectives: At the end of this lesson you shall be able to
- **explain type of illumination system.**

Illumination systems are essential for providing light in various settings, ranging from residential and commercial spaces to outdoor environments and industrial applications. These systems utilize different technologies and designs to generate and distribute light efficiently and effectively. some of the common types of illumination systems and their characteristics.

Incandescent Lighting

Incandescent lighting is one of the oldest and most recognizable forms of illumination. It involves passing an electric current through a filament, usually made of tungsten, which heats up and emits light.

Fluorescent Lighting

Fluorescent lighting systems are widely used in various settings due to their energy efficiency. They work by passing an electric current through a gas-filled tube containing mercury vapor. The vapor emits ultraviolet light, which interacts with a phosphor coating inside the tube to produce visible light.

LED Lighting

LED (Light Emitting Diode) lighting has gained significant popularity in recent years due to its remarkable energy efficiency and versatility. LEDs are semiconductor devices that emit light when an electric current passes through them. They offer several advantages, including long lifespans, low power consumption, instant switching, and the ability to produce a wide range of colors. LED lighting is widely used in residential, commercial, and outdoor applications, including street lighting and automotive lighting.

Halogen Lighting

Halogen lighting is a type of incandescent lighting that uses halogen gas, such as iodine or bromine, to improve efficiency and increase the lifespan of the bulb. The halogen gas reacts with the tungsten filament, redepositing evaporated tungsten atoms back onto the filament. This recycling process allows halogen bulbs to produce brighter light and last longer than traditional incandescent bulbs. Halogen lighting finds applications in residential, commercial, and automotive lighting.

Induction Lighting

Induction lighting is a relatively newer technology that utilizes electromagnetic fields to generate light. It involves a gas-filled tube containing a coiled induction coil. The coil generates a magnetic field, which excites the gas atoms and produces light. Induction lighting offers long lifespans, high energy efficiency, and good color rendering. It is commonly used in street lighting, parking garages, and industrial applications.

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Illumination factors

Objectives: At the end of this lesson you shall be able to
- **explain illumination factors.**

Illumination factors play a crucial role in various aspects of our lives, affecting our perception, mood, productivity, and overall well-being. Here are some key factors that influence illumination:

Natural Light: The primary source of illumination is natural light from the sun.

Artificial Lighting: Artificial lighting encompasses various types, such as incandescent, fluorescent, LED, and halogen lights. The choice of artificial lighting depends on the specific requirements of the space, desired ambiance, and energy considerations.

Lighting Design: Effective lighting design considers the purpose of the space, the activities performed, and the desired aesthetic. It involves the placement and type of light fixtures, layering of light sources, and the interplay of direct and indirect lighting to create a visually appealing and functional environment.

Energy Efficiency: Energy-efficient lighting options are crucial for reducing energy consumption and minimizing environmental impact. LED lights, for example, provide high efficiency and durability while consuming less power compared to traditional lighting technologies.

Lighting Controls: Lighting controls allow users to adjust the illumination levels according to their needs and preferences. Dimmers, occupancy sensors, and daylight sensors help optimize energy usage and enhance user comfort by automatically adapting lighting levels based on occupancy and available natural light.

Illumination factors encompass a wide range of aspects that influence the quality and impact of lighting in our daily lives. Considering natural light, artificial lighting, color temperature, intensity, design, distribution, energy efficiency, controls, and applicable regulations are all crucial for creating well-lit, functional, and aesthetically pleasing spaces.

Intensity of light

Objectives: At the end of this lesson you shall be able to
- **explain intensity of light.**

The intensity of light refers to the amount of energy carried by a light wave per unit area per unit time. It plays a crucial role in various fields, including physics, optics, and photography. The concept of light intensity, its measurement, factors affecting intensity, and its significance in different applications.

Light intensity is typically measured in terms of power per unit area, commonly expressed in watts per square meter (W/m^2). It represents the rate at which energy is transmitted through a given area by a light wave. The intensity of light decreases as the distance from the source increases, following the inverse square law. According to this law, the intensity diminishes by the square of the distance from the source. This means that if you double the distance from the source, the intensity decreases to one-fourth of its original value.

Factors that influence light intensity include

Distance from the source: As mentioned above, light intensity decreases with increasing distance from the source due to the spreading of energy over a larger area.

Light source power: The power output of the light source directly affects the intensity. A higher power source emits more energy per unit time, resulting in higher light intensity.

Medium through which light travels: The medium through which light propagates can affect its intensity. When light passes through a medium like air, water, or a transparent material, it may experience absorption, scattering, or other interactions that can reduce its intensity.

Light intensity has several practical applications. Some of them include:

Photography: In photography, controlling the intensity of light is crucial for achieving proper exposure. Photographers use techniques such as adjusting aperture, shutter speed, and ISO sensitivity to regulate the intensity of light reaching the camera's sensor.

Understanding the intensity of light and its significance across different applications is essential for professionals in various fields. By manipulating and controlling light intensity, scientists, engineers, and artists can achieve desired outcomes and exploit the properties of light for their specific purposes.

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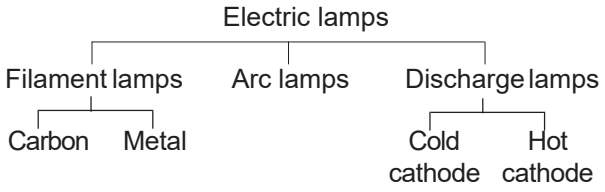
Types of lamps

Objectives : At the end of this lesson you shall be able to
- **list out the types of lamps**
- **explain the different types of lamps**
- **explain the construction and working of tungsten filament lamp.**

Types of lamps

There are many types of electric lamps now available. They differ in construction and in the principle of operation. The lamps can be grouped on the principle of operation as follows.

Filament lamps fall into a group of light producing devices called `incandescent'. They give light as a result of heating the filament to a very high temperature. The definitions of the terms are given below.



Filament lamp: A lamp in which a metal, carbon or other filament is rendered incandescent by the passage of electric current.

Vacuum lamp: A filament lamp in which the filament operates in a vacuum.

Gas-filled lamp: A filament lamp in which the filament operates in an inert gas.

Halogen lamp: A tungsten filament lamp in which the tungsten filament operates in a relatively small space filled with an inert gas and halogen of iodine or bromine.

Arc lamp: An electric lamp in which the light is emitted by an arc.

Discharge lamp: An electric lamp in which the light is obtained by a discharge of electricity between two electrodes in gas or vapour.

Carbon filament lamp: The carbon filaments made today have limited application as resistance lamps (battery charging) and radiant heat apparatus. This lamp gives a reddish light and operates at a temperature about 2000°C. Above this limit, the carbon evaporates rapidly and blackens the glass bulb or envelope. The output from a carbon filament lamp is about 3 lm/W (lumens per watt).

Tungsten filament lamp: This lamp consists essentially of a fine wire of the metal, tungsten (the filament) supported in a glass envelope and the air evacuated from the glass bulb - hence called a **vacuum lamp**.

Filaments are now constructed of tungsten due to its exceptionally high melting point. It operates at a temperature of 2300° C and has an output of about 8 lm/W.

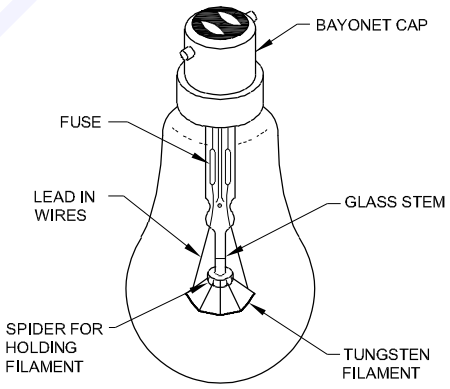
Fig 1 shows the parts of tungsten filament lamp

The two types of filaments are

- single coil filament
- coiled coil filament.

The main advantage of a coiled coil lamp is the higher light output.

Fig 1



Reflectors

Objectives: At the end of this lesson you shall be able to
- **name the various types of reflectors**
- **explain direct and indirect lighting.**

Types of reflectors: A lamp without any kind of reflector will radiate light in every direction. By placing the lamp within a reflector, you can control the light and direct it where you want it.

Dispersive type: The reflecting surface is either white enamelled or vitreous enamelled. The vitreous enamelled type is more expensive and less efficient optically but are more suitable for use in damp and corrosive atmosphere.

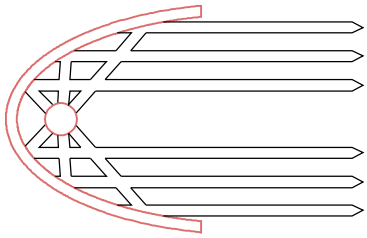
Mirror type reflector: These have highly polished surface for specular reflection. Silvered glass, Chromium plated; copper sheet anodized aluminium shades are typical example of this. This type is used in yard lighting

Parabolic and soft light reflector (Fig 1 & 2): A parabolic reflector produces a hard light and is most commonly used with tungsten lamps. A soft light reflector has shield in front of the bulb and so produces a diffused light. A spotlight enables you to vary the light beam. In each case, the light

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will be softer if the reflector surface is matted or dimpled rather than highly polished.

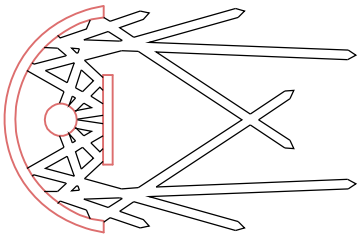
Fig 1



PARABOLIC REFLECTOR

WM20N2313431

Fig 2

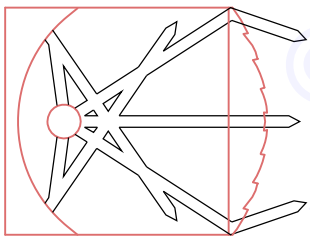


SOFTLIGHT REFLECTOR

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Spotlighting (Figs 3 & 4): Spotlighting is one way lighting, usually employed projectors with lenses but sometimes with reflectors only, and is used to give special illumination to a limited area as in theatre practice. The spotlights must be so located as to be out of the direct line of vision and produce no troublesome reflections or glare.

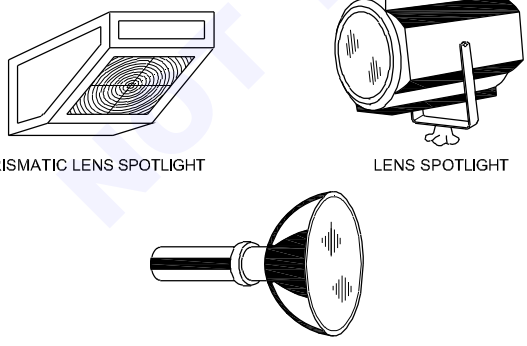
Fig 3



SPOTLIGHT

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Fig 4



PRISMATIC LENS SPOTLIGHT

LENS SPOTLIGHT

WINDOW FLOOD LIGHT

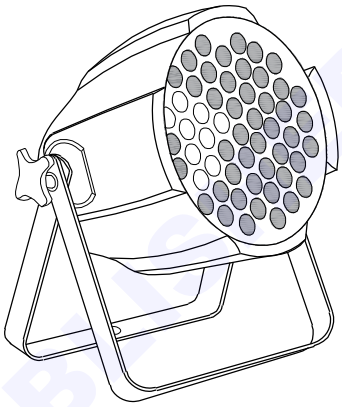
TYPE OF SPOTLIGHT FIXTURES

WM20N2313434

Parabolic Aluminized Reflector (PAR) (Fig 5) is a type of lighting fixture commonly used in various applications, including stage lighting, photography, and outdoor lighting. The PAR consists of a parabolic-shaped reflector made from aluminum-coated material, designed to efficiently collect and direct light in a focused beam.

The aluminized coating enhances the reflectivity, allowing for a higher percentage of light to be redirected, resulting in a more concentrated and intense output. These fixtures are versatile and often equipped with different lenses, enabling adjustments to the beam's angle and width. PARs are favored for their durability, efficiency, and ability to produce powerful and controlled lighting effects.

Fig 5



PARABOLIC ALUMINIZED REFLECTOR (PAR)

WM20N2313435

Multi-faceted reflector (Fig 6) is a specialized optical component with multiple mirrored surfaces designed to control and direct light efficiently. Typically used in lighting applications, these reflectors consist of numerous small facets arranged on a curved surface, strategically positioned to redirect light rays in specific directions. By precisely controlling the reflection angles, multi-faceted reflectors can enhance light output, reduce glare, and improve the overall efficiency of illumination systems. They find applications in various industries, including automotive headlights, stage lighting, projectors, and torches. The innovative design of multi-faceted reflectors plays a crucial role in achieving targeted and uniform light distribution for diverse lighting needs.

Fig 6



Multi-faceted reflector

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Different wattage lamps in series

Objectives: At the end of this lesson you shall be able to

- **state the purpose of different voltage lamps**
- **calculate and compare the hot resistance of the same voltage but of different wattage/current lamps**
- **describe the method of measuring and calculating the 'hot resistance'**
- **state the effects of different wattage lamps in series.**

Purpose: In quite a few places we use low voltage supply i.e. 6V, 12V or 24V, such as in automobile vehicles. Automobile vehicles are equipped with many lights to provide an efficient lighting system for both day and night driving conditions. The various lights require the use of different wattage and types of light lamps to provide the amount of illumination desired.

The resistances calculated above are always hot resistance. To find out the cold resistance, it is measured with the ohmmeter when the lamp is OFF and at room temperature.

Different wattage lamps in series: If the two lamps of different wattage in parallel across in A.C. circuit, it should be same voltage for proper operation. But, if they are connected in series they should have the same current ratings.

All the bulbs in house are probably connected in parallel and they will draw the current it requires, and all the lamps will glow bright.

If two lamps with unequal wattages and same voltage ratings are connected in series they will divide up the available voltage between them.

Low wattage lamp will glow bright, due to high resistance and high voltage drop. High voltage lamp will glow dim, due to low resistance and low voltage drop.

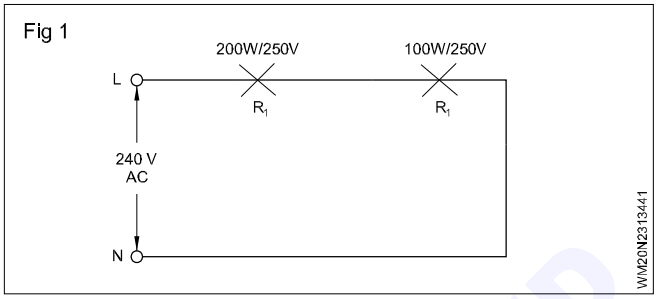
Example

In a circuit the two lamps rated as 200W/ 250V, and 100W/ 250V are connected in series, across 240 volt A.C. supply. (Fig 1)

200W (higher wattage) lamp will glow dim and

100W (low wattage) lamp will glow bright.

Fig 1



because,

The resistance of 200W/ 250V lamp,

$$R_1 = \frac{V^2}{W_1} = \frac{250 \times 250}{200} = 312.5\ \Omega$$

The resistance of 100W/250V lamp,

$$R_2 = \frac{V^2}{W_2} = \frac{250 \times 250}{100} = 625\ \Omega$$

Total resistance $R_T = 312.5 + 625 = 937.5\ \Omega$

$$\text{current } I = \frac{V}{R_T} = \frac{240}{937.5} = 0.256A$$

voltage drop in 200W lamp, $= IR_1 = 0.256 \times 312.5 = 80V$

Voltage drop in 100W lamp, $= IR_2 = 0.256 \times 625 = 160V$

Power V X I = 240 X 0.256 = 61.4 W

Hence,

The 100W lamp having high voltage drop due to high resistance it will glow bright than high wattage lamp 200W which is having low voltage drop and low resistance.

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Low voltage track system

Objectives: At the end of this lesson you shall be able to
- **state low voltage track system.**

A low voltage track system is an innovative lighting solution that provides flexibility and versatility in residential, commercial, and retail spaces. This system utilizes low voltage power to deliver safe and efficient lighting options.

The main component of a low voltage track system is the track itself, which consists of a metal rail that can be mounted on walls or ceilings. The track serves as a conduit for electrical current and allows for the attachment of various lighting fixtures.

One of the key advantages of a low voltage track system is its adaptability. The track can be easily customized to fit different layouts and lighting needs. Lighting fixtures, such as spotlights, pendant lights, or decorative fixtures, can be effortlessly attached or repositioned along the track, providing ample flexibility for design changes or updates.

Additionally, the low voltage aspect of the system ensures energy efficiency. By utilizing transformers to step down the voltage from the main power supply, the track system consumes less energy compared to traditional high voltage lighting systems. This translates into reduced energy costs and a smaller environmental footprint.

Safety is another important feature of low voltage track systems. The lower voltage levels minimize the risk of electric shock, making these systems suitable for various applications, including residential areas where safety is a priority.

In summary, a low voltage track system is a versatile, energy-efficient, and safe lighting solution. Its adaptability and ease of installation make it an attractive option for both residential and commercial spaces, providing customizable and efficient illumination."

Main voltage track system

Objectives: At the end of this lesson you shall be able to
- **state main voltage track system.**

A main voltage track system is an electrical distribution system that provides power to various devices and equipment in a building or space. It consists of a track or bus bar that runs along the ceiling or walls and carries electrical power at a high voltage level, typically 120V or 240V, depending on the region.

The main voltage track system offers several advantages over traditional wiring methods. Firstly, it provides flexibility and versatility in terms of powering and relocating electrical devices. The track system allows for easy installation and reconfiguration of power outlets, lighting fixtures, and other electrical components. This flexibility is particularly beneficial in commercial or retail spaces where layouts may change frequently.

The track system also offers a clean and aesthetic appearance as it eliminates the need for visible wires and cables. The track is typically recessed or concealed within a housing, resulting in a neat and uncluttered environment. This design feature is especially desirable in modern architectural spaces that prioritize clean lines and minimalistic aesthetics.

In addition, the main voltage track system enhances safety. Since the electrical connections are contained within the track, there is a reduced risk of accidental contact or damage compared to exposed wiring systems. Furthermore, the track system often incorporates safety features such as grounding and short-circuit protection, ensuring the protection of both the electrical system and the occupants.

Another advantage of the main voltage track system is its scalability. Additional track sections can be easily added to expand the power distribution network as needed. This scalability is advantageous in environments where electrical loads may increase over time, such as in retail stores or office spaces.

Furthermore, the track system supports various types of electrical devices and equipment. It can power lighting fixtures, outlets, audiovisual equipment, and even specialized equipment like motorized shades or track-mounted displays. This versatility makes it a popular choice for commercial, industrial, and residential applications.

In conclusion, the main voltage track system is a flexible, safe, and aesthetically pleasing electrical distribution solution. Its ability to provide power to various devices while offering easy installation and reconfiguration makes it ideal for modern spaces that require adaptability and design appeal. With its scalability and compatibility with a range of electrical equipment, the main voltage track system is a reliable choice for efficient power distribution."

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Decorative lamp circuits with drum switches

Objectives: At the end of this lesson you shall be able to
- **state the functions of a drum switch**
- **explain the designing of a lighting sequence with the drum switch.**

Drum switch

It is the usual practice to illuminate houses, workshops marriage halls, temples etc. during festivals with flash lights, flickering lights and running lights with the help of rotating drum switches.

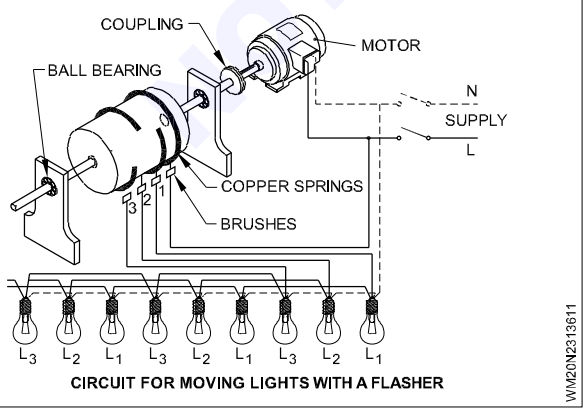
A drum switch is used for decorative lamp circuits. This switch can be used for sequential switching `on' of the decorative lamps. It is coupled with a slow speed motor so that the lamp will glow at proper intervals.

Preparation of decorative lights

The decorative effect of lights is usually obtained by means of a flasher, which consists of a wooden cylinder which rotates into the two ball bearings at the two ends. The wooden cylinder is connected to the motor through a belt or a coupling. The speed of the motor and the selection of pulley should be so made such that the wooden cylinder rotates at low r.p.m. On the wooden cylinder a copper ring is provided (to which the live wire is connected through a brush), and 3 copper segments 120° apart from each other, and each end of these segments is permanently connected to the copper ring.

As the cylinder rotates, the three segments make contact in turn with the brushes 1,2 and 3 in turn. The brush No.1 is connected to lamps L_1, the brushes No.2 and 3 are connected to lamps L_2 and L_3 respectively. Fig 1 shows the instant when the copper segment No.1 makes contact through 1/3rd of the revolution, the circuit No.1 goes off, and just at the same instant circuit No.2 becomes live and lights the lamps L_2, and after a further 1/3rd of the revolution the circuit No.3 becomes live and lights the lamps L_3. This process is repeated to make it appear that the lights move from the right to the left.

Fig 1

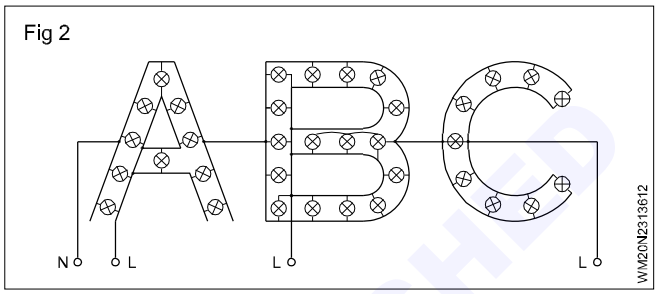


CIRCUIT FOR MOVING LIGHTS WITH A FLASHER

Waving, flickering or lightning effects can be achieved by such a system of lights.

Design of display: Draw the layout of the required display, for example ABC, on the board. (Fig 2)

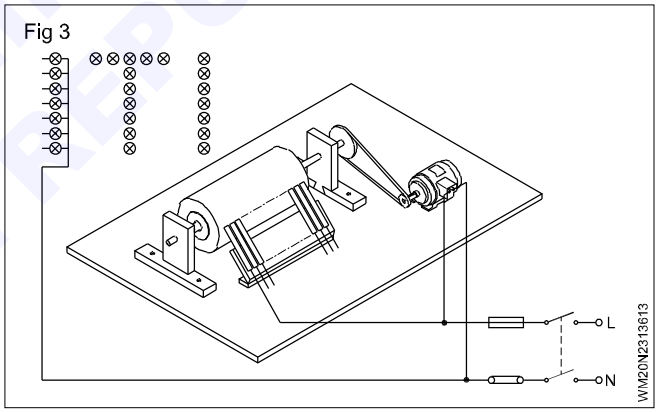
Fig 2



Mark the lamp position on the layout, connect all the lamps in parallel of letters A, B and C as shown in Fig 2, and then test the lamps for each letter by effecting supply. The neutral is run to all the lamps commonly.

Construction of a drum switch: The cylindrical drum is made of dry, soft wood, having low weight. (Fig 3)

Fig 3



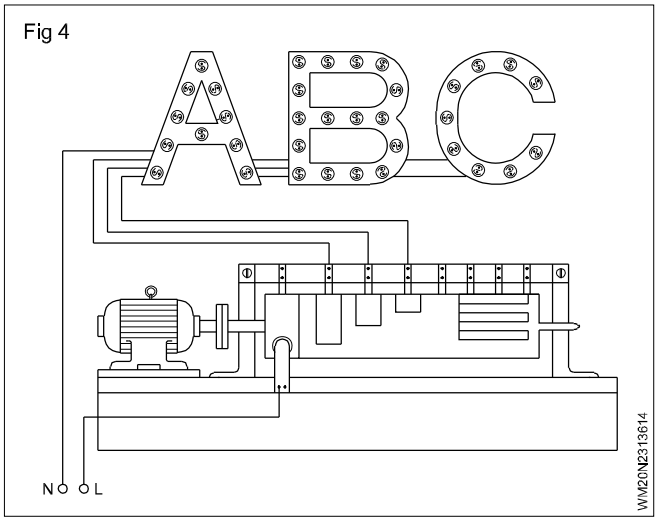
The length of the drum is determined by the number of finger-strips, and the diameter of the drum depends on the number of circuits to be incorporated. The speed of the drum must be as low as possible which is obtained by using two pulleys of different sizes to create a high ratio. (Fig 3) The drum-plates are usually made of brass/copper, and are nailed. The contact strips are fixed by screws or wire nails. (Fig 4)

The drum-plate is designed keeping in view the time required to make and break the contact in one revolution. The strip should be fixed in such a way as to establish good contact through. To avoid sparking, conductive grease should be applied over the drum-plate.

Electrical motor: A single phase, low speed motor usually the shaded pole motor with sufficient power to drive the drum, is used for this purpose.

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Fig 4



Lighting for decoration

Objectives: At the end of this lesson you shall be able to
- **state the methods used for decoration.**

Use of decoration lights

Electric light decoration for special occasions like wedding parties, festivals and fairs is a common feature nowadays. Special electric light sign circuits add much colour, fun and pleasure on the occasion. Electric signs, particularly neon signs, are extensively used in advertisements which have tremendous eye catching effects. Decoration with electric signs improves the appearance of a building and makes the place more attractive.

Two methods are mainly used for decoration.

- Signs employing miniature low voltage incandescent lights which can be switched on and off in sequence to produce the desired effect.
- Neon signs employing tubes shaped to produce designs in various colours, the colour being determined by the type of gas used in the tube.

Miniature incandescent lamps: Miniature incandescent lamps are normally available with 6V, 9V, 12V & 16V ratings with different colours which may be grouped in series or series parallel combinations for operation in available 240V supply.

For getting different messages and decoration effects the following types of flasher signs are used.

Speller type flashers are used for spelling out signs letter by letter or word by word for building up or down, plain on-off flashing, with changing colour.

Speed type flashers are used for operating spectacular signs such as lighting waving-flags, - flame, revolving wheels etc.

Script type flashers as the name implies are used when the effect of handwriting in script letters is desired.

An example of a speed type flasher for revolving is shown in Fig 1. The speed of running light/ rotating light can be adjusted. In this three-point running light (the sign flasher) there are three groups of lamps, each group switched on and off, in sequence, for running effect (Fig 2) with the help of a small induction motor which is running on eddy current principle and is connected to 240V/115V 50 Hz. Cans or drums are mounted on a shaft which is rotated by the motor.

The circumference of the cans or the drums are so cut that the brushes will make contact only during the fixed portion of the revolution, thus completing the circuit. We can make three independent circuits by the 3-point sign flashers which are switched 'ON' and 'OFF' successively.

Fig 1

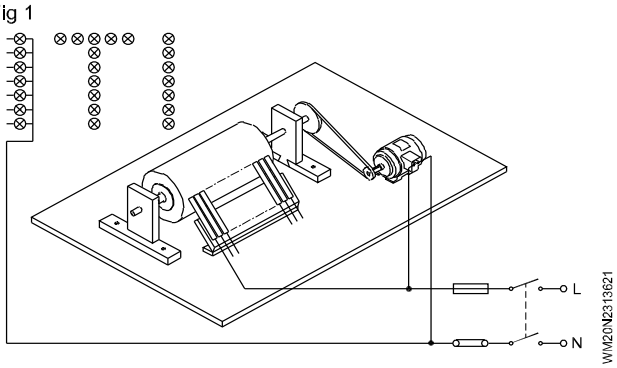
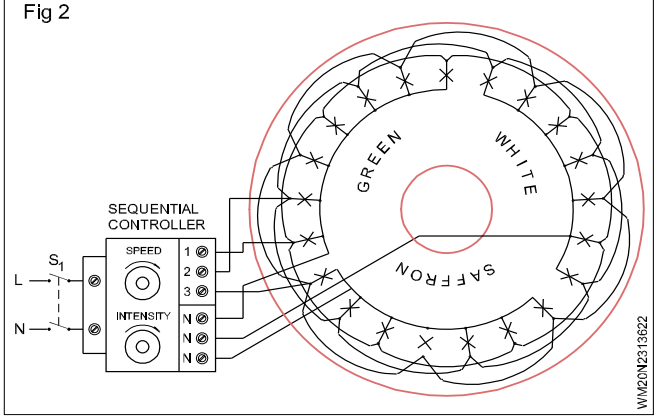


Fig 2



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Calculation of lumens efficiency

Objectives: At the end of this lesson you shall be able to
- **explain the luminous efficiency calculation.**

Luminous Efficiency Calculation

Luminous Efficiency: Luminous efficiency is a measure of how will a light source produces a visible light. It is a quantity of measurement for light source and it is defined as the ratio of luminous flux to power of the lamp in watts. It's unit is **lumen/watt** in SI unit.

$$\text{Luminous efficiency} = \frac{\text{Luminous flux in lumen}}{\text{Power in watt}}$$

This is important, it describes how much light is being given compare to the amount of electricity is used.

Purpose of calculating luminous efficiency

Typical house hold spends 30% of the electricity bill in lighting. Money can be saved by bringing the most cost efficient lighting option in home needs.

For example : A 60w light bulb usually produces 860 lumens. Calculate the luminous efficiency.

$$\text{So, efficiency} = \frac{\text{Luminous flux in lumen}}{\text{Power in watt}}$$

$$= \frac{860}{60} = 14.3 \text{ lumen/watt} .$$

This calculation can be taken for any light source as long as the data pertaining to its power and luminous flux are available. The higher efficiency lamps will save more money.

It is useful when you are shopping for light bulbs/lamps most of its box will have the bulb voltage and luminous produced. Use this calculation method to see, how the cost efficient a bulb will be for your home needs.

The luminosity function or luminous efficiency function describes the average special sensitivity of human visual perception of brightness.

By comparing LED's to compact fluorescent lamp (CFL) with 55 - 70 lumens per watt and incandescent lamp bulbs with 13 -18 lumen per watt.

The LED bulbs require much less wattage than the CFL (or) incandescent light bulbs. CFL are 4 times more efficient and 10 times longer than incandescent lamps.

The most popular energy saving bulbs available are:

- halogen incandescent bulbs
- Compact fluorescent lamps (CFLs)
- Light emitting diodes (LED)

Their initial cost is 5 to 10 times more than traditional incandescent lamps, but they save the money due to lesser energy.

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Kitchen under cabinet lighting

Objectives: At the end of this lesson you shall be able to
- **explain kitchen under cabinet lighting, shelf lighting, closet lighting and cove lighting.**

Under cabinet lighting (Fig 1&2)

Fig 1



Fig 2



Under cabinet lighting is a great way to light up your kitchen and give it a more modern look. It's also a great way to brighten up the dark corners of your kitchen.

It can also make it easier for you to cook and do other things in the kitchen.

Exactly what is meant by "Under cabinet lighting"?

Under-cabinet lighting is positioned just underneath your cabinets and illuminates the space there, making food preparation safer.

Visually, it will provide depth to the design of your kitchen, and it will highlights the colors and lines that are included in the choices of surface tile and backsplash. It provides a soft light suitable for use at night or to assist with the lighting in a home security system.

Under-cabinet lighting is a beneficial addition to any kitchen or other part of the home that is used for working, from the laundry room to the home office. It may improve both efficiency and comfort with a single, straight forward installation.

Advantages

Modifying simple components of your house, such as the lighting, for the sake of style, is always a completely valid reason to do so. When it comes time to sell your house, under-cabinet lighting is a highly popular upgrade that also increases the property's value.

Due to the layered nature of the lights, under-cabinet lighting has the potential to impart a one-of-a-kind design to your kitchen.

Shelf lighting (Fig 3)

Here we help you understand how to use shelf and joinery lights within you project and take a look different application ideas and how to position the lights. A great architectural lighting tool, shelf lighting can add an indirect softness and at the same time create a feature in the room. Think of shelves as a window in the room or even like a wall light.

Fig 3



Front lighting (Fig 4)

The simples option is to from light your shelves with a contour LED strip. This requires a simple down stand on the shelf. Sometimes you can use bare LED tape on a heat sink however using an aluminium profile with an opal cover will prevent any dotting effect and is usually the base solution. The choice depends on the detail and finishing of the shelf. This solution provides a very even light from the front suitable for most objects. The versa dot track mounted flood and spotlight is also an effective solution for front lighting in shelves and joinery. With multiple different

optics, it allows lighting to be tailored according to the display.

Fig 4

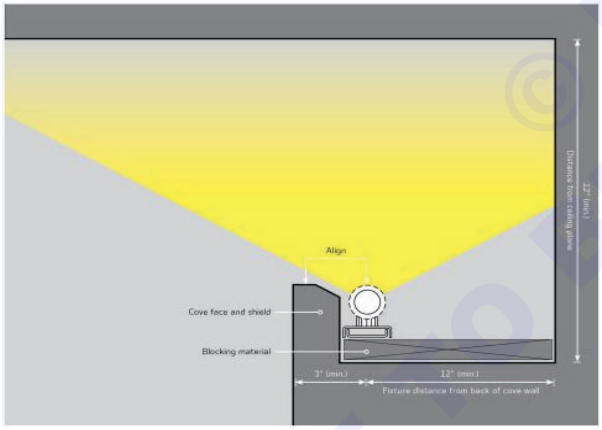


Front lighting

Cove lighting (Fig 5)

Cover lighting is one of the basic lighting techniques, a type of up lighting that directs lights to the ceiling plane from a cove on one or more sides of a room to provide overall diffuse illumination. It is also referred to as ambient luminescence. Cove lighting is typically mounted to or incorporated into a wall, but it can also be located within a ceiling coffer.

Fig 5



Cove lighting

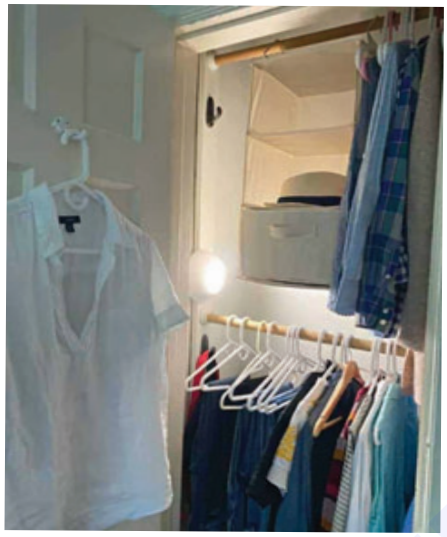
Closet lighting (Fig 6)

Take a hint from your kitchen and install a grouping of pendant lights in your closet for instant impact.

Down light (Fig 7)

Down light are versatile light fitting excellent for a multitude of uses throughout the home. They are a great way to create zones, navigate around the space and highlight your key pieces such as art. They can provide in fill light as well as task lighting for example over a kitchen island. They work well with a combination of other architectural and decorative fitting in a layered lighting schemes.

Fig 6



Closet lighting

Fig 7

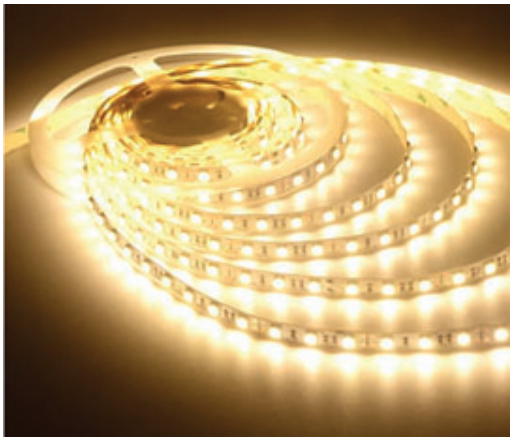


Down light

Strip lights (Fig 8)

These are called LED strip lights and are used as an illuminative decoration and as its name suggests have LEDs long its entire length. Basically it is a strip of wire with LEDs lined up on it, these LEDs are often dynamic and we can switch between multiple colours, dim the lights or have multiple colours displayer at once.

Fig 8



Strip lights

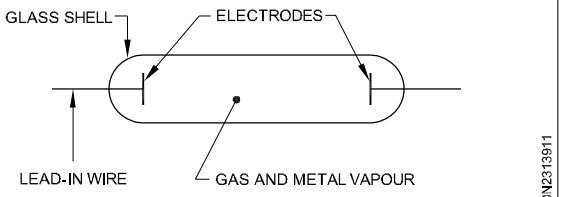
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Fluorescent lamp

Objectives : At the end of this lesson you shall be able to
- **state the principle of discharge lamps**
- **describe the construction of single tube fluorescent lamp with its components**
- **state the function of each component in the circuit.**

Principle of a discharge lamp: The basic principle of a gas-discharge lamp is explained in Fig 1. Gases are normally poor conductors, especially at atmospheric and higher pressures, but application of suitable voltage (known as ignition voltage) between two electrodes in a sealed envelope containing gas at low pressure ionises the gas, and current passes from one electrode to the other through the gas medium.

Fig 1



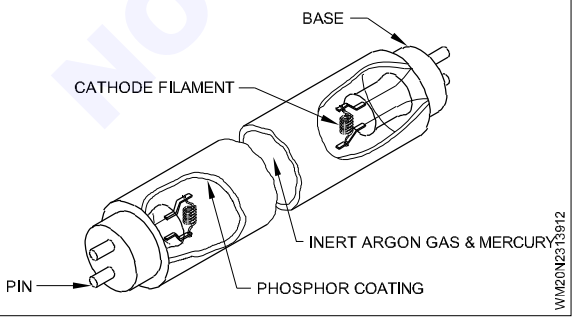
GAS-DISCHARGE LAMP

A glass shell with two electrodes apart is connected through lead in wires to the voltage source. The space within the shell is filled with low pressure vapour. When the voltage applied to the electrodes is increased to a certain value, the gas inside gets ionised and starts conducting.

The current flow through the low pressure gas is called discharge. This causes the gas/vapour to emit radiation in the ultraviolet region. The UV radiation cannot be perceived by the human eye. Certain phosphors have the property of emitting light in the visible spectrum when it is exposed to UV rays.

Construction of fluorescent tubes: A fluorescent light bulb is basically a glass tube capped by two bases. (Fig 2) These bases are fitted with pins to carry current to internal components called cathodes. Contained inside the tube are minute droplets of mercury and an inert gas.

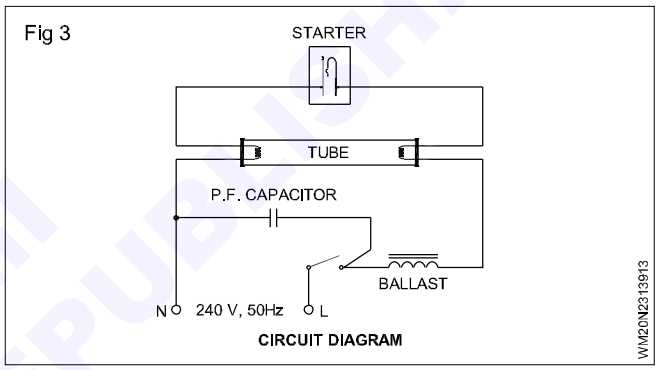
Fig 2



The inner surface of the tube is coated with a fluorescent powder or phosphor. This phosphor emits light when exposed to ultra-violet rays. Cathodes or electrodes are made up of coiled tungsten filaments coated with a mixture of barium and strontium oxides.

Circuit diagram: The method of connecting the starter, ballast and the tube's electrodes at its either end is as in (Fig 3)

Fig 3



CIRCUIT DIAGRAM

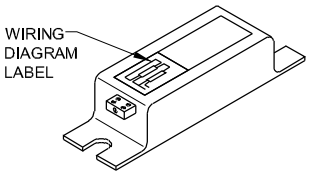
Function of the various parts in a fluorescent light circuit

Ballast (Choke)**:** The ballast is basically a coil of many turns wound on a laminated iron core (Fig 4). It steps up the supply voltage to start the fluorescent tube conducting. Once the tube is conducting, it regulates the flow of heavy current to the tube cathodes to keep them from burning out.

Starters: A starter in the fluorescent tube circuit performs two functions.

- It completes the circuit at first for preheating the electrodes.
- It opens the circuit to provide voltage kick for ignition.

Fig 4



BALLAST

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High pressure mercury vapour lamp (H.P.M.V)

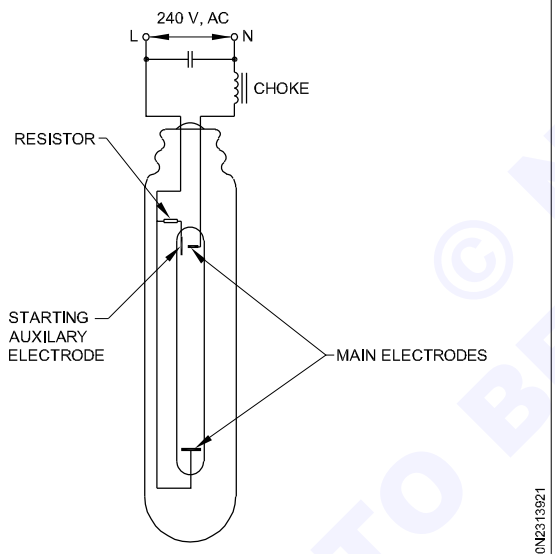
Objectives: At the end of this lesson you shall be able to
- **state the principle of discharge lamps**
- **describe the working of a `high pressure' mercury vapour lamp**
- **explain the different types of mercury vapour lamps**
- **identify the circuit elements in a mercury vapour lamp**
- **compare a sodium vapour lamp with a mercury vapour lamp.**

Discharge lamps: When an arc is struck in gas or metallic vapour, it radiates energy in characteristic wave-bonds. For example, neon gives red light, sodium yellow and mercury vapour four distinct lines in the visible, and two in the ultraviolet region of the spectrum.

All modern discharge lamps operate in a translucent enclosure. The initial discharge is usually struck in argon or neon.

The discharge occurs in an inner tube enclosed in an outer evacuated tube. (Fig 1) The inner tube of glass or quartz contains mercury and a small amount of argon to assist in the starting of the discharge. The electrodes are rich in electron-emitting materials in order to permit ease in the release of electrons.

Fig 1



MA TYPE HPMV LAMP CIRCUIT

Working of HPMV lamps

The lamp operates at high pressure. To start the discharge, an auxiliary electrode is positioned quite close to the main electrode. The auxiliary electrode is connected to the lamp terminal through a high resistor.

The high resistor limits the current. When switched on, the normal mains voltage is not sufficient to start the discharge between the main electrodes but it can start over the very short distance between the main and auxiliary electrodes.

At the beginning, the discharge current passing through the high resistance causes a potential difference to develop between the starting electrode and one of the main electrode through the argon gas. The discharge now spreads rapidly until it takes place between the main electrodes.

The argon discharge then warms up the tube and vaporises the mercury. Soon the gas content is mainly mercury vapour and the argon has less and less effect. The discharge then takes place in the mercury vapour.

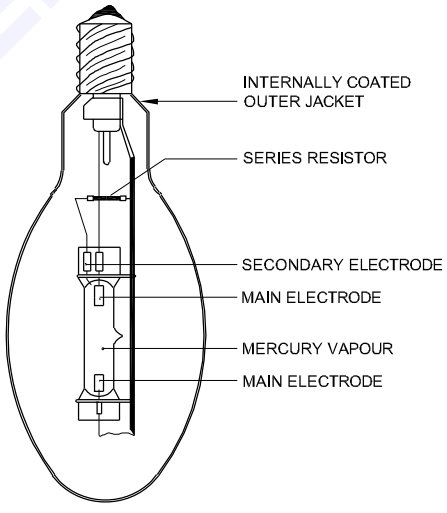
Types of HPMV lamps

Three different types of high pressure mercury vapour lamps are:

- MA type (MV lamp with auxiliary electrode)
- MAT type (MV lamp with tungsten filament)
- MB type. (MV lamp with auxiliary electrode and Bayonet cap)

MA type HPMV lamp: The discharge tube is made of borosilicate which is quite hard. The tube consisting of the main and auxiliary electrodes is sealed with an inside pressure of one and a half atmospheres. The lamp has a screw cap and is connected to the mains through the choke. (Fig 2) The lamp takes about 5 minutes to start giving full output.

Fig 2



MA TYPE HPMV LAMP

This lamp, once switched off, will not restart again until the pressure developed inside the tube falls back. It takes about 7 minutes to start again. There is no harm in keeping the switch on. The lamp should always be hung vertically, otherwise the inner tube will be damaged.

The efficiency is 45 lm/watt for 400 watts lamp.

MAT type lamp: This type of lamp is almost similar to the MA type, but the outer glass envelope, instead of being empty, consists of a tungsten filament. The tungsten filament, similar to the one in an ordinary

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lamp, is in series with the discharge tube. It acts as a ballast. This lamp requires no external choke (or ballast) and capacitor.

When the lamp is switched on, it works as a filament lamp does and its full output is given by the outer tube. At the same time, the discharge tube starts warming up, and when a particular temperature is attained, a thermal switch operates. The thermal switch cuts off a part of the filament so that the voltage across the discharge tube increases.

The light output is a mixture of light produced by a filament lamp and a discharge lamp.

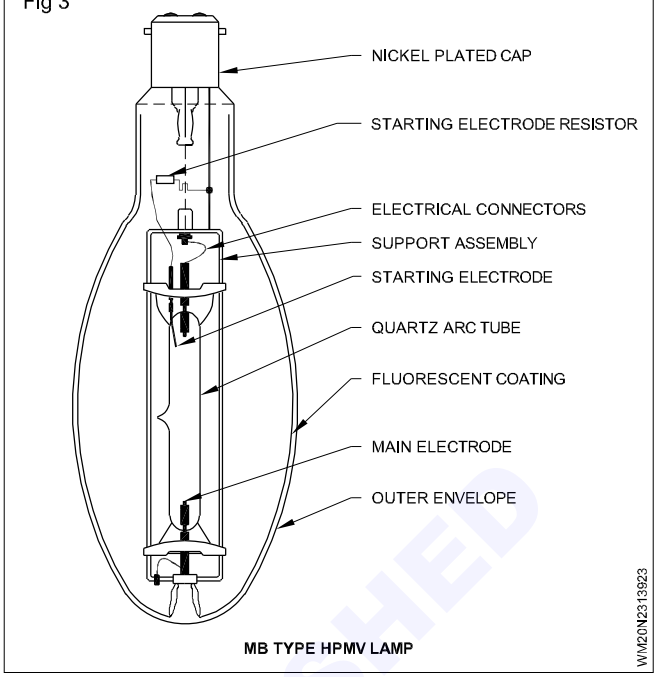
MB type lamp: This lamp operates at an extra high pressure of 5 to 10 atmospheres. The discharge tube of this type is of quartz, about 5 cm long and has three electrodes, two main and one auxiliary. This lamp has a 3-pin bayonet cap and it cannot be put into an ordinary holder as it requires a choke and capacitor. (Fig 3)

The functioning of the tube is similar to that of a MA type lamp. Since a quartz tube can withstand high temperature, it can be used in any position.

The wattages available are 80 watts 125 W, 250 W, 400 W, 700 W and 1000 watts operating in 230V/250V, 50 Hz main supply.

The efficiency is about 50 lm/W.

Fig 3



MB TYPE HPMV LAMP

Sodium vapour lamp

Objectives: At the end of this lesson you shall be able to
- **state the sodium vapour lamp and its types**
- **describe the construction of low and high pressure sodium vapour lamp**
- **state the functions of the parts in the circuit**
- **specify the standard sizes of sodium vapour lamps available**

Sodium vapour lamp and its types: Sodium vapour lamp is a cold cathode gas discharge lamp, which gives a yellow colour light. Sodium lamps are not suitable for locations where colour rendition is important, but due to their higher efficiency (110 lumens/watt), they are used for the lighting of streets, railways, storage yards etc. where human traffic is less and colour rendition unimportant. Sodium lamps are particularly suitable in fog as their yellow light can penetrate fog better.

The average life of a sodium vapour lamp is well over 6000 hours. There are two types of Sodium Vapour lamps as given below:

- low pressure SV lamp
- high pressure SV lamp.

Construction

Low pressure sodium vapour lamp: In the sodium vapour lamps efficiency decreases rapidly as the current density is increased above a certain value. Consequently, the lamp has to be operated at a low current density and this necessitates a large surface area of the tube.

This lamp possesses a brightness of 7.5 candle per sq.cm. Because of these points the length of this tube has to be very long. More over its efficiency is very sensitive to the change in tube temperature. For maximum efficiency the temperature of the lamp has to be maintained at about 220°C. So the whole tube is placed in a detachable double walled vacuum jacket.

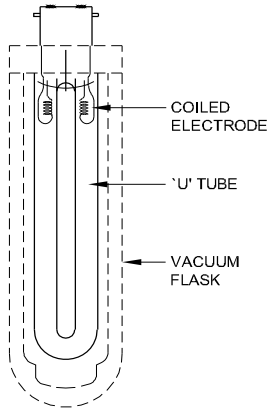
As stated above low pressure Sodium Vapour lamps require a long tube, but as there is limit to the practicable size of such a jacket of the vacuum flask type, the long lamp tube is bent to a `U' shape to suit the jacket.

The low pressure Sodium Vapour lamp possesses a `U' shaped glass tube internally coated with fluorescent powder, consisting of Sodium together with Neon and one percent of Argon, the function of the Argon being used to reduce the initializing voltage.

In a cold lamp the Sodium is in the form of solidified drops on the inner walls. The tube contains two Barium and Strontium coated, coiled Tungsten electrodes at both ends. The two ends of the electrodes are fixed to the bayonet cap. (Fig 1) Connection diagram is Fig 3.

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Fig 1

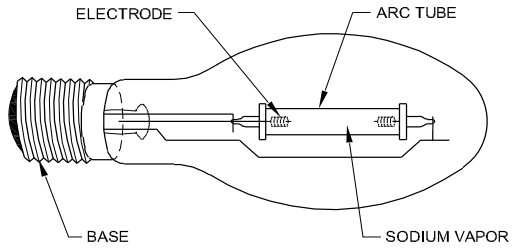


SODIUM DISCHARGE LAMP

WM20N2313931

High pressure sodium vapour lamp: A high pressure Sodium vapour lamp (Fig 2) operates at a much higher current which flows through a much shorter arc tube (discharge tube).

Fig 2



HPSV LAMP

WM20N2313932

This discharge tube is made of sintered aluminium ceramic discharge arc tube which is resistant to the hot ionised Sodium Vapour up to a temperature of about 1600^{0}C which transmits over 90% of visible radiation.

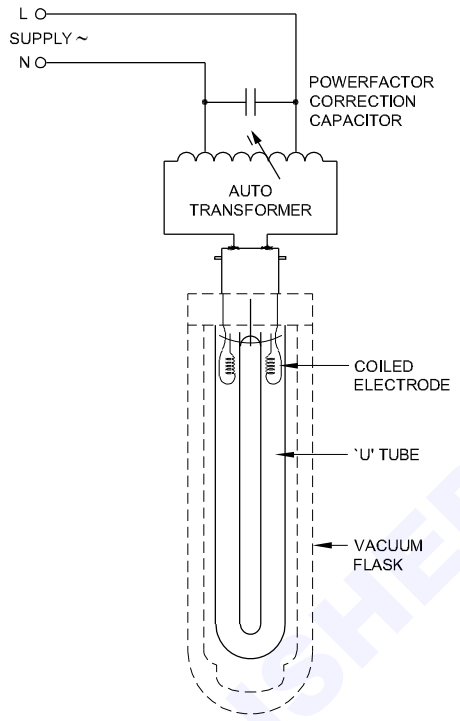
The discharge tube operates at a pressure of about half an atmosphere, and is enclosed in an evacuated hard glass envelope of elliptical shape to maintain the tube at the correct temperature. (Fig 3) The lamp gives a rich Golden light which enables colours to be easily distinguished. This discharge tube contains Sodium and Mercury, with Argon or xenon added at a low pressure for starting purposes at low pressure.

A voltage pulse of about 2.5 KV is required to initiate the discharge (Fig 4) in higher pressure Sodium Vapour lamp. This high voltage pulse is generated by high external ignitor or by built in thermal starter.

Leak transformer: The ignition voltage of sodium lamps varies from 400 to 600V. A `leak transformer' performs the dual role of providing the ignition voltage initially, and acting as a choke for limiting the current subsequently when the lamp starts conducting. The diagram of a leak transformer is shown in Fig 5.

The primary and the secondary windings are connected in series and placed around the centre limb of a 3-core yoke. Between the coils, a loose iron core is clamped in the yoke on either side, which acts as a shunt for the magnetic field.

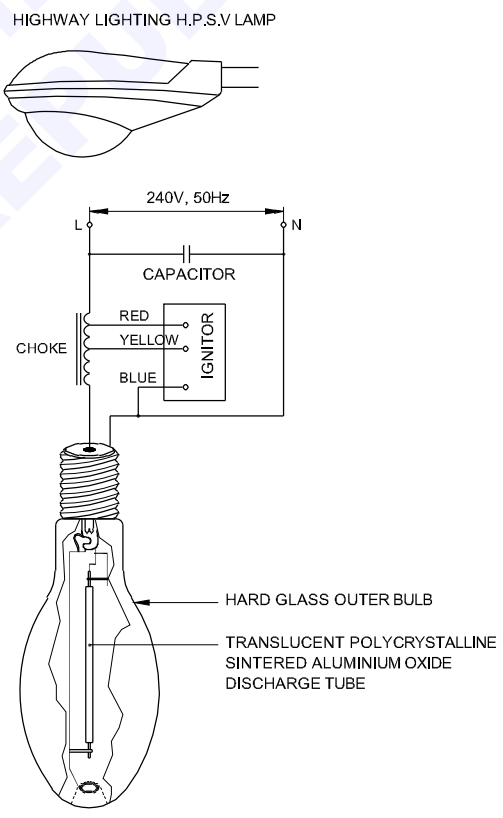
Fig 3



SODIUM DISCHARGE LAMP

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Fig 4



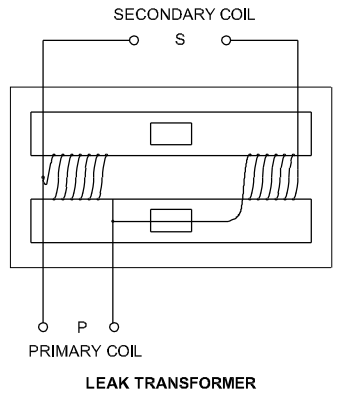
HIGH PRESSURE SODIUM VAPOUR LAMP

WM20N2313934

Under no-load conditions, the resistance of the shunt is large due to air gaps, with the result the magnetic field moves through the limbs of the yoke, and the device acts as an auto-transformer. But when the lamp ignites and consumes current, a part of the magnetic field leaks away through the shunt due to the counter-acting field of the secondary.

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Fig 5



The device now acts as a choke coil reducing the voltage across the lamp electrodes to the required value.

Function of Sodium vapour lamp

Before the lamp starts, the sodium is usually in the form of a solid deposited on the sides of the tube walls. So in the initial stage when the potential is applied to the lamp it operates as a low pressure Neon lamp with pink colour (characteristics of the neon gas); but as the lamp warms up it vaporizes the sodium, and slowly it radiates out yellow light, and after about ten minutes the lamp starts giving its full output.

Now the resistance of the lamp decreases and the current increases but the voltage drop across the high leakage transformer controls the current to safe values.

The lamp works at low voltage, and the working temperature is about 300^0C.

Operating position of sodium lamps: Sodium lamps of 45W and 60W may be operated in horizontal or any other position. The cap of the lamp should always be higher than the lamp itself, so that the Sodium does not settle behind the electrodes.

For Sodium lamps of should not exceed 20°; otherwise, the distribution of the sodium will be altered, affecting the life and performance of the lamp.

Life of sodium lamps: The average life of a sodium lamp is well over 6000 hours for three or more burning hours per switching operation. At the end of this period the light output will be less by about 15% due to ageing.

Tin-oxide sodium lamps (SOX Lamps): This lamp is an improvement over the ordinary sodium lamp the light output in its case is of the order of 150 lumens/watt.

Light Emitting Diodes (LEDs)

Objectives: At the end of this lesson you shall be able to
- **define the LED**
- **state the advantages of LEDs over-conventional bulbs**
- **explain the principle of working of LED**
- **state the popular types of LED**
- **explain the method of testing of LED**
- **calculate the resistor value to be used with LED for a given application**
- **state how to protect LEDs from high reverse voltage.**

Light emitting diodes (LED)

In recent years, the use of filament lamps/bulbs which consume quite an amount of power, has less life became absolute as indicators of electric systems. One of the most common and popular of new devices in the optical electronics is the **Light Emitting Diode** abbreviated as **LED**. These LEDs are now used as indicators in almost all electrical and electronic circuits and equipments.

The advantages of LEDs over incandescent bulbs are listed below:

1 LEDs have no filaments to heat and so require less current to glow.

2 LEDs require lower voltage level (typically 1.2 to 2.5 V) than the conventional bulbs.

3 LEDs last much longer - up to several years.

4 Because there is no filament to heat up, LEDs are always cool.

5 LEDs can be switched ON and OFF at a much faster rate compared with conventional lamps.

Principle of working of LEDs

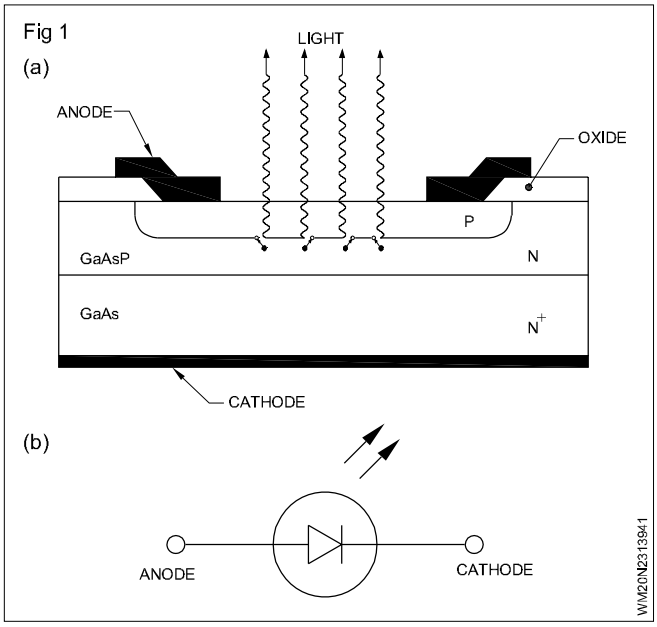
Although LED is also a type of diode, it cannot and should not be used for the purpose of rectifying AC to DC.A LED is a semiconductor device which emits visible ligt when it is property connected with the electric supply.

Recall that a general purpose diode or a rectifier diode conducts when energy is supplied to the electrons (Si=0.7V, Ge=0.3V) to cross the barrier junction. Each electron, after acquiring the supplied extra energy, crosses the junction and falls into the hole on the P side of the junction while the electron recombines with a hole, the electron gives up the extra energy by it. This extra energy is dissipated in the form of heat and light.

In general purpose diodes because the silicon material is not transparent(opaque), the light produced by the electrons does not escape to the outer environment. Hence, it is not visible. But LEDs are made using semi-transparent materials instead of silicon.

Because the material used in making LEDs is semi-transparent, some of the light produced by the electrons escapes to the surface of the diode, and, hence, is visible. (Fig 1a)

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LEDs are typically doped with gallium arsenic, gallium phosphate or gallium arseno-phosphate. Different dopes cause the LED to emit light of different colours (wave-lengths) such as red, yellow, green, amber, or even invisible infrared light.

The schematic symbol of LED Non-integrated lamps is as shown in (Fig 1b). The arrows are used to indicate that light is radiated from the device.

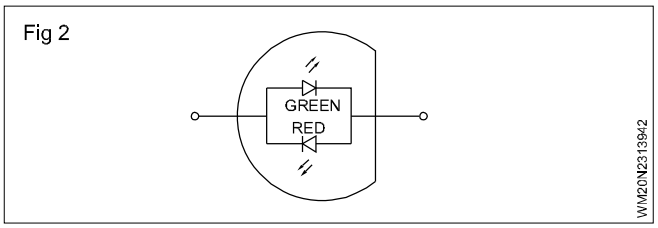
Types of LEDs

Single colour LEDs: Most of the commercially available and commonly used LEDs are single colour LEDs. These LEDs radiate one of the colours such as red, green, yellow or orange. Different coloured LEDs will have different forward voltages as given in the table below:

Colour of LED	Red	Orange	Yellow	Green
Typical Forward voltage drop	1.8V	2V	2.1V	2.2V

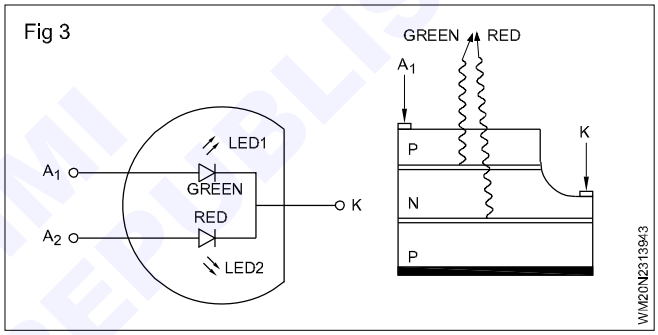
These typical forward voltage drops are at a typical LED forward current I_f = 20 mA

Two colour LEDs: These LEDs can give two colours. Actually, these are two LEDs put in a single package and connected. (Fig 2)



In a two-colour LED, two LEDs are connected in inverse parallel, so that one of the colour is emitted when the LED is biased in one direction and the other colour is emitted when the LED is biased in the other direction. These LEDs are more expensive than the single colour LEDs. These LEDs are useful to indicate +ve, –ve polarities, GO-NOGO indication, null detection etc.

Multicolour LEDs: These are special types of LEDs which can emit more than two colours. These LEDs comprises of a green and a red LED mounted in a three-pin common cathode package. (Fig 3)



Output colour	Red	Orange	Yellow	Green
LED-1 current	0	5mA	10mA	15mA
LED-2 current	15mA	3mA	2mA	0

This LED will emit green or red colour by turning ON only one LED at a time. This LED will emit orange or yellow by turning on the two LEDs with different current ratios as shown in the table given.

High pressure metal halide lamps

Objectives: At the end of this lesson you shall be able to
- **describe the working principle of metal halide lamp (M.H.L)**
- **explain the starting of M.H lamp.**

Metal halide lamps: This type of lamp is also known as an `MH' lamp. It is an HID lamp (High intensity Discharge), which means it provides most of its light from the electric arc within a small discharge tube. It is becoming increasingly popular due to its good quality white light and good efficiency. The most prominent use of the MH lamp is in stadiums and sports fields. It is also used widely for parking lots and street lighting in urban areas. Its competitors include the HPS lamp, mercury vapor lamp, LPS lamp, halogen lamps, and LEDs. MH lamps have advantages over the rest which make it more useful for certain applications.

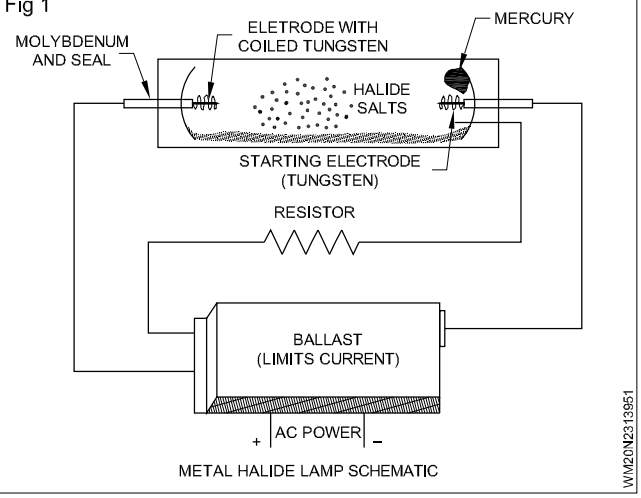
Working Principle

Fig 1 shows the schematic connection diagram of a metal Halogen lamp in to the AC supply. A resistor is connected to limit the current so as to increase the life of ballast?

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When the lamp is cold the halides and mercury are condensed on the fused quartz tube. When the lamp is turned on current passed through the starting electrode and jumps the short distance to the main electrode (Fig 1), this is aided by argon gas. The argon strikes an arc at low temperatures.

Fig 1



METAL HALIDE LAMP SCHEMATIC

After the initial small arc, the tube heats up and the mercury is vaporized. Electric arcs fight to works through the distance of a gas, but over time more molecules of the gas become ionized. This makes it even easier for more electric current to pass through, so the arc gets wider and hotter.

In the lamp as the first arc heats up, it begins to turn the solid mercury into a vapor, soon the arc is able to travel through the mercury vapor to reach the other main electrode on the opposite side of the discharge tube. There is less resistance on this path now and current stops flowing through the starting electrode, just as a river changes course to a path of least resistance, drying out the previous channel.

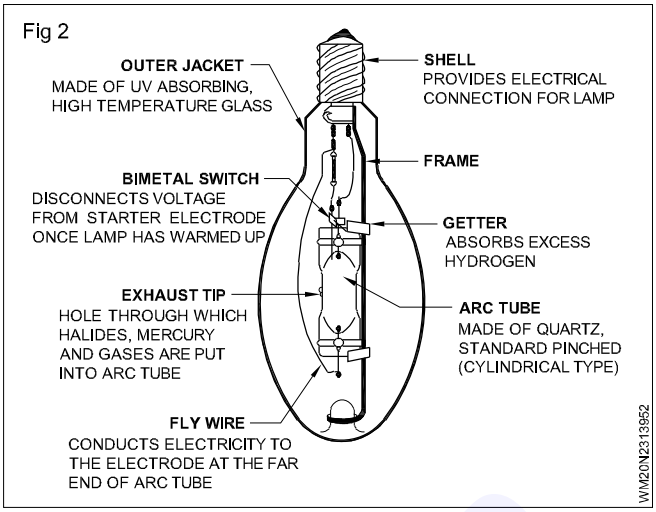
Parts of Metal Halide lamps

Fig 2 shows the inner parts and its various function of a metal halide lamp. The inner tube contains the electrodes and various metal halides, along with mercury and inert gases that make up the mix. The typical halides used are some combination of Sodium, Thallium, and Scandium and Dysprosium Iodides. These iodides control the lamp's spectral power distribution and provide color balance by combining the spectra of the various iodides used.

Light is generated by creating an arc between the two electrodes located inside the inner arc tube. The inner arc tube is typically made of quartz, and this is a very harsh environment, with high temperatures approaching 1000°C and pressure of 3 or 4 atmospheres.

To start a metal halide lamp, a high starting voltage is applied to the lamp's electrodes to ionize the gas before current can flow and start the lamp. The outer jacket is usually made of Borosilicate glass to reduce the amount of UV radiation emitted from the lamp.

Fig 2



It also provides a stable thermal environment for the arc tube and contains an inert atmosphere that keeps the arc tube's components from oxidizing at high temperatures.

Pendant lighting (Fig 3)

A pendant light, sometimes called a drop or suspender, is a one light fixture that hangs from the ceiling usually suspended by a cord, chain or metal rod. Pendant lights are often used in multiples, hung in straight line over kitchen counter tops.

Fig 3



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Assemble, program and practice on DMX controller for operation of PAR lights

Objectives : At the end of this lesson you shall be able to
- **explain DMX controller for operation of PAR lights.**

A DMX controller is an essential tool for operating PAR lights in various lighting setups, such as stage performances, concerts, theaters, or any event requiring dynamic lighting effects. This guide will walk you through the process of assembling a program and practicing the operation of PAR lights using a DMX controller. With this knowledge, you can create captivating lighting designs and enhance the ambiance of any event. (Fig 1)

Fig 1



DMX controller for operation of PAR lights

DMX Controller Setup

Before you start programming and operating PAR lights, it is crucial to set up your DMX controller correctly. Follow these steps:

a Connect the DMX controller to the lighting console or computer interface using a DMX cable.

b Ensure that the DMX addresses of the PAR lights are correctly configured and match the programming you plan to create.

c Power on the DMX controller and the PAR lights.

d Familiarize yourself with the DMX controller's user interface, including buttons, faders, and LCD screen, if applicable.

Understanding DMX Channels

DMX (Digital Multiplex) is a protocol that assigns a unique address, known as a DMX channel, to each lighting fixture or parameter. PAR lights often have multiple channels, allowing you to control various attributes independently, such as intensity, color, strobing, and movement. Refer to the PAR lights' user manual for specific channel assignments.

Programming Steps

To program your DMX controller for operating PAR lights, follow these steps:

a Select a Scene: Decide on the lighting mood or effect you want to create. For example, a "blue wash" scene.

b Patching: Assign DMX channels to the PAR lights you want to control. Ensure each light has a unique address.

c Fixture Configuration: Set the attributes of each DMX channel for each PAR light. This involves specifying values for intensity, color, movement, and other effects.

d Record the Scene: Save the programmed settings as a scene or cue on your DMX controller. This allows you to recall the scene with a single button press.

Practice and Live Operation

Once you have programmed the DMX controller, it's time to practice and operate the PAR lights. Here are some tips:

a Run through each scene and observe the lighting effects. Make adjustments as necessary.

b Experiment with different color combinations, intensities, and movements to achieve the desired ambiance.

c Coordinate lighting cues with other elements of the event, such as music or stage actions, to create a synchronized experience.

d Test transitions between scenes to ensure smooth changes in lighting.

e Familiarize yourself with manual control options on the DMX controller, allowing you to make on-the-fly adjustments during live performances.

Mastering the programming and operation of PAR lights using a DMX controller is a valuable skill for anyone involved in event production. By following the steps outlined in this guide and practicing regularly, you can create captivating lighting designs that enhance the overall experience for your audience. Remember to consult the user manuals for both the DMX controller and the PAR lights for specific instructions and features. With dedication and creativity, you can unleash the full potential of PAR lights and elevate any event's atmosphere.

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LED video wall panel applications

Objectives : At the end of this lesson you shall be able to
- **explain LED video wall panel applications.**

LED video wall panels are innovative and versatile display solutions that have revolutionized the way information is communicated and visualized in various settings. With their high-resolution screens, vibrant colors, and dynamic content capabilities, LED video wall panels have found applications across a wide range of industries, from advertising and entertainment to transportation and education. (Fig 1)

Fig 1



LED video wall panel

One of the most common applications of LED video wall panels is in the field of advertising. These panels are widely used in outdoor advertising campaigns, such as billboards and digital signage displays. The high brightness and excellent visibility of LED panels ensure that advertisements can be seen clearly even in broad daylight, capturing the attention of passersby and effectively conveying promotional messages.

In addition to outdoor advertising, LED video wall panels are also extensively used in indoor advertising applications. They can be found in shopping malls, airports, stadiums, and other public spaces, where they serve as eye-catching displays for brand promotions, product showcases, and informational content. The modular nature of LED panels allows for easy customization and flexible installation, enabling advertisers to create unique and engaging visual experiences.

Another major application of LED video wall panels is in the entertainment industry. They are commonly employed in concert venues, theaters, and arenas to create immersive visual backdrops for live performances. LED panels can be seamlessly integrated to form large-scale video walls, providing a dynamic canvas for stunning visual effects, live video feeds, and synchronized content. This enhances the overall audience experience and adds an extra dimension to the entertainment spectacle.

LED video wall panels also find utility in the field of transportation. They are frequently used in airports, train stations, and bus terminals to display real-time arrival and departure information, as well as public service announcements. The high visibility and readability of LED panels ensure that travelers can quickly and easily access essential information, facilitating smooth and efficient travel experiences.

In the education sector, LED video wall panels are increasingly being adopted to create engaging and interactive learning environments. They can be used in classrooms, lecture halls, and training centers to display educational content, multimedia presentations, and collaborative projects. The large screen size and vivid imagery of LED panels make learning materials more visually appealing and help capture students' attention, fostering better information retention and understanding.

Beyond these specific applications, LED video wall panels have also been utilized in various other contexts. They have been employed in command and control centers for real-time data visualization, in retail stores to create captivating in-store displays, and in museums and exhibitions to showcase interactive exhibits. Their versatility and adaptability make them a valuable tool for enhancing communication and delivering impactful visual experiences across diverse industries and settings.

In conclusion, LED video wall panels have become an integral part of modern visual communication strategies. Their high-resolution screens, vibrant colors, and dynamic content capabilities make them ideal for a wide range of applications. From advertising and entertainment to transportation and education, LED video wall panels continue to redefine the way information is presented and experienced, creating immersive and engaging visual environments.

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Resistor: Color code, types and characteristics

Objectives: At the end of this lesson you shall be able to
- **determine the value of resistance by using color code**
- **explain types of resistors**
- **explain characteristics of resistance.**

Resistors: These are the most common passive component used in electronic circuits. A resistor is manufactured with a specific value of ohms (resistance). The purpose of using a resistor in circuit is either to limit the current to a specific value or to provide a desired voltage drop (IR). The power rating of resistors may be from 0.1 W. to hundreds of Watts.

There are four types of resistors

1 Wire-wound resistors

2 Carbon composition resistors

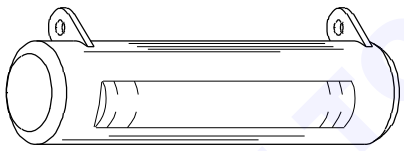
3 Metal film resistors

4 Carbon film resistors

1 Wire-wound resistors

Wire-wound resistors are manufactured by using resistance wire (nickel-chrome alloy called Nichrome) wrapped around an insulating core, such as ceramic porcelain, Bakelite pressed paper etc.Fig 1, shows this type of resistor. The bare wire used in the unit is generally enclosed in insulating material. Wire wound resistors are used for high current application. They are available in wattage ratings from one watt to 100 watts or more. The resistance can be less than 1 ohm and go up to several thousand ohms. They are also used where accurate resistance values are required.

Fig 1



WIRE-WOUND FIXED RESISTOR

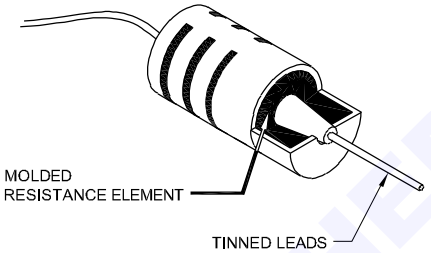
WM20N2414211

2 Carbon composition resistors

These are made of fine carbon or graphite mixed with powdered insulating material as a binder in the proportion needed for the desired resistance value. Carbon-resistance elements are fixed with metal caps with leads of tinned copper wire for soldering the connection into a circuit. Fig 2 shows the construction of carbon composition resistor.

Carbon resistor are available in values of 1 ohm to 22 megohms and of different power ratings, generally 0.1, 0.125, 0.25, 0.5 and 2 watts.

Fig 2



CARBON COMPOSITION RESISTOR

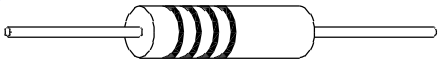
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3 Metal film resistors (Fig 3)

Metal film resistors are manufactured by two processes. Thick film resistors are pasted with metal compound and powdered glass which are spread on the ceramic base and then backed.

Thin film resistors are processed by depositing a metal vapour on a ceramic base. Metal film resistors are available from 1 ohm to 10 MΩ, upto 1W. Metal film resistors can work from 120°C to 175°C.

Fig 3



METAL FILM RESISTOR

WM20N2414213

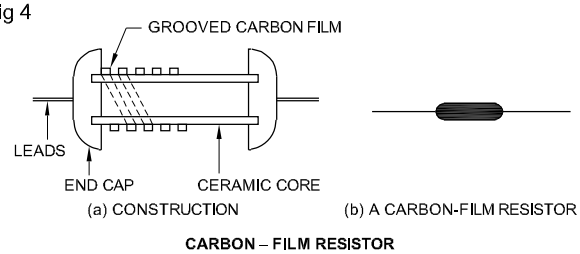
4 Carbon film resistors (Fig 4)

In this type, a thin layer of carbon film is deposited on the ceramic base/tube. A spiral groove is cut over the surface to increase the length of the foil by a specialised process.

Carbon film resistors are available from 1 ohm to few Meg ohm and up to 2W and can work from 85°C to 155°C.

All the above four types of resistors are coated with synthetic resin to protect them against mechanical damages and climatic influences, It is therefore, difficult to distinguish them from each other externally.

Fig 4



CARBON – FILM RESISTOR

WM20N2414214

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The resistors can also be classified with respect to their function as

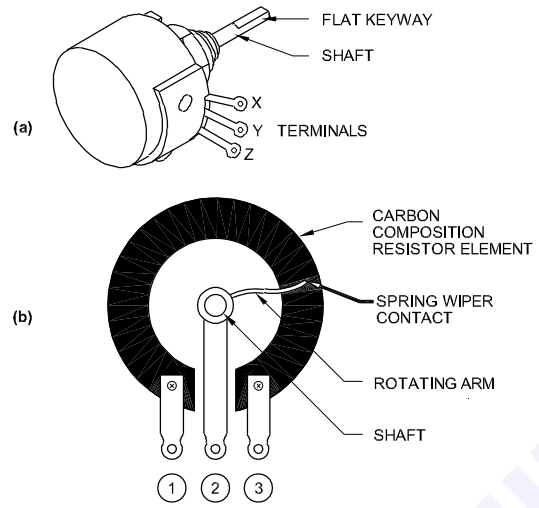
1 Fixed resistors

2 Variable resistors

Fixed resistors : The fixed resistors is one in which the nominal value of resistance is fixed. These resistors are provided with pair of leads. (Fig 2-4)

Variable resistors (Fig 5) : Variable resistors are those whose values can be changed. These are known as potentiometer resistors or simply as a potentiometers.

Fig 5



VARIABLE CARBON-RESISTANCE (a) EXTERNAL VIEW
(b) INTERNAL VIEW OF CIRCULAR RESISTANCE ELEMENT

Resistance depends upon temperature, voltage, light: Special resistors are also produced whose resistance varies with temperature, voltage, and light.

PTC resistors (Sensistors) : Since, different materials have different crystal structure, the rate at which resistance increases with raising temperature varies from material to material. In PTC resistor (positive temperature coefficient resistor), as the temperature increases, the resistance increases non linearly. For example, the resistance of PTC at room temperature may be of nominal value 100 Ω when the temperature rises say 10°C, it may increase to 150 Ω and with further increase of another 10°C, it may increases to 500 Ω.

NTC Resistors (Thermistors) : In case of NTC resistors (Negative temperature co-efficient resistors) as the temperature increases, the value of resistance decreases non-linearly, For example, NTC resistor, which has nominal value of resistance is 500 Ω at room temperature may decrease to 400 Ω with the rise of 10°C temperature and further decrease to 150 Ω when the temperature rises to another 10°C.

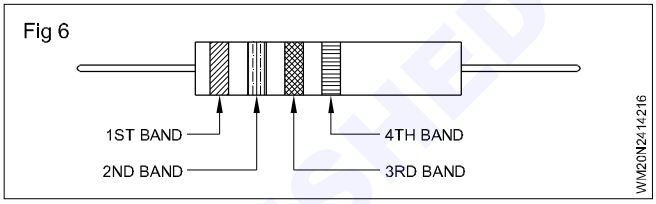
VDR (Varistors) : The VDR (Voltage dependent resistor) resistance falls non-linearly with increasing voltage. For example, a VDR, may have 100 Ω resistance at 10 V, and it may decrease to 90 Ω at rise in 5V. By further increasing the voltage to another 5V, the resistance may fall to 50 Ω. The VDRS are used in voltage stabilisation, arc quenching and over voltage protection.

Light dependent resistor (LDR): The LDRs are also known as photo- conductors. In LDRs the resistance falls with increase in intensity of illumination. The phenomena is explained as the light energy frees some electron in the materials of the resistors, which are then available as extra conducting electrons. The LDR shall have exposed surface to sense the light. These are used for light barriers in operating relays. These are also used for measuring the intensity of light.

The two significant figures and tolerances colour coded resistors have 4 bands of colours coated on the body as in Fig 6.

The first band shall be the one nearest to one end of the component resistor. The second, third and four colour bands are shown in Fig 6.

Fig 6



The first two colour bands indicate the first two digits in the numeric value of resistance. The third colour band indicates the multiplier.The first two digits are multiplied by the multiplier to obtain the actual resistance value. The forth colour band indicates the tolerance in percentage.

Example

Resistance value : If the colour band on a resistor are in the order- Red, Violet, Orange and Gold, then the value of the resistor is 27,000 ohms with +5% tolerance.

First colour	Second colour	Third colour	Fourth colour
Red	Violet	Orange	Gold
2	7	1000(10^3)	±5%

For less than ten ohms, the third band will be either golden or silver.

The colours are,

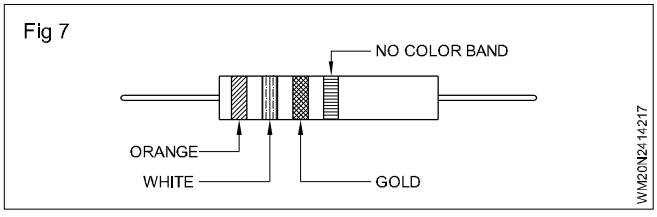
Gold -	10^{-1}	=	1/10 = 0.1
Silver -	10^{-2}	=	1/100 = 0.01

Example (Refer Fig 17)

Colour of Ist Band	Colour of 2nd Band	Colour of 3rd Band
Orange	White	Gold
3	9	1/10

thus, the value of resistor is 39/10 or 3.9 ohms. (Fig 7)

Fig 7



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Large value resistances are expressed in kilo ohms and megohms. Letter 'k' stands for kilo and M stands for mega. One kilo equals 1000 (10^3) and one mega equals 1000000 (10^6). The resistance values are expressed as

1000 ohms	=	1 k
1800 ohms	=	1k 8
100 ohms	=	0.1 k
10000 ohms	=	0.1 M
1500000 ohms	=	1 M 5.

Diode; PN Junction - semiconductor, classification, specifications biasing and characteristics

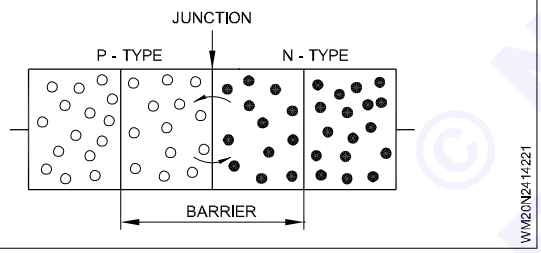
Objectives: At the end of this lesson you shall be able to

- **explain forward and reverse biasing of PN junction and semi conductor diodes and its VI characteristics**
- **state the applications specifications and classification of diodes.**

PN junction: A diode is made by combining P and N materials. The surface at which these materials meet is the PN junction.

Diffusion occurs when P and N materials are joined together. (Fig 1) some electrons in the N material, near the junction, are attracted to the holes in the P material, thus leaving holes in the N material. The diffusion of electrical charges produces a potential difference in a small area near the junction (Fig 2).As a result, the material will conduct in one direction but not in the opposite direction. For this reason, the area in which this emf exists is called a barrier.

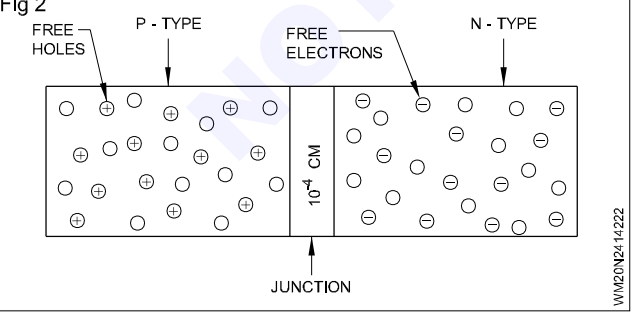
Fig 1



The internal barrier potential (V_b) : Although it is an internal contact potential that cannot be measured directly, the effect can be overcome by 0.3V for a **Ge** junction or 0.7 V for **Si**. .

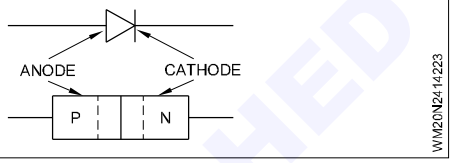
The PN junction, with the depletion zone magnified, shows the iron that has +ve and -ve charges produce the internal contact potential V_b at the barrier. (Fig 2)

Fig 2



A PN device is knows as a diode. The diode and its symbol are in Fig 3. This type of construction permits the current to flow in one direction but not in the opposite direction.

Fig 3

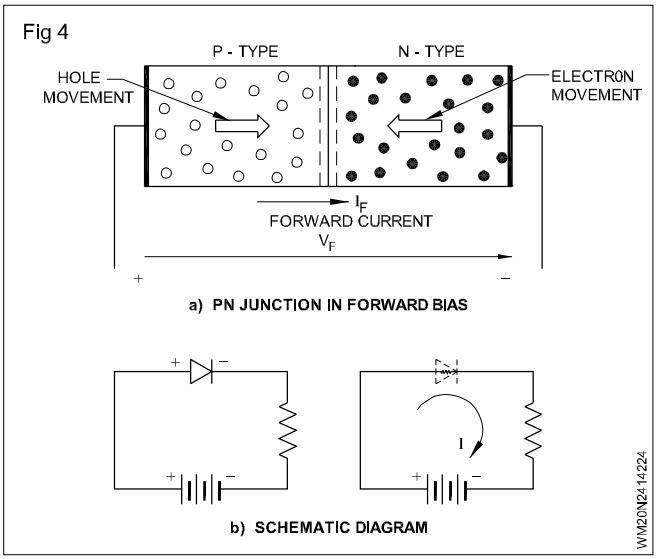


Biasing the PN junction

Forward Bias : A forward-biased PN junction is in Fig 4 The positive terminal is connected to the P-side and the negative terminal of the DC supply is connected to the N-side of the junction.

A current will flow through the diode as in the Fig 4. The positive terminal for the battery attracts electrons from P material, leaving an excess of holes. Because electrons are drifting away from the junction, the excess holes tend to accumulate near the junction. At the same instant, electrons from the negative terminal of the battery are attracted to the less negative N material of the diode. This action overcomes the barrier at the junction and allows the electrons to move into the excess holes of the P material, the result is a continuous flow of electrons in one direction. The voltage required to move the charge carries in forward bias conduction called the barrier voltage.

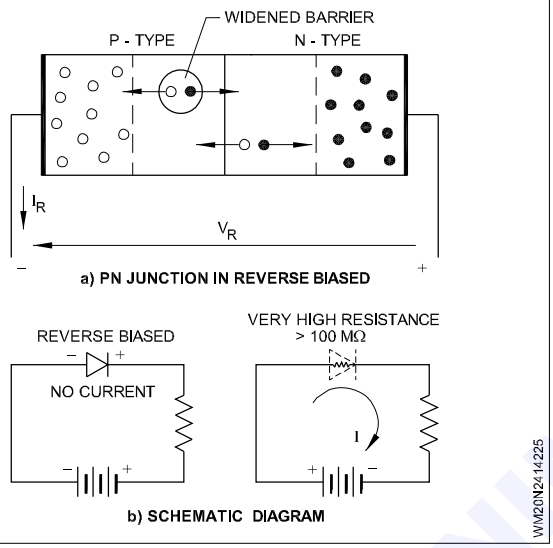
Fig 4



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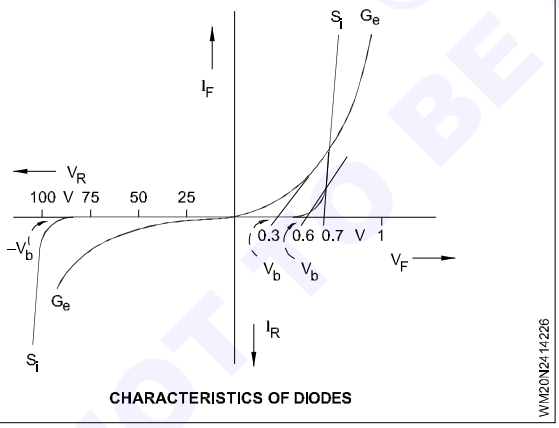
Reverse Bias: If the polarities of the DC supply are as shown in Fig 5, the PN junction is said to be reverse-biased. That is, the P side is connected to the negative and the N-side is connected to the positive terminals of the supply. Fig 5 shows the battery connection reversed (reverse bias). At the same instant, a shift in electrons in the P material causes the positive holes to appear further away from the junction near the end for the diode, which is connected to the negative terminal of the battery. This action produces a wider barrier at the PN junction through which the electrons cannot flow. (A very small current leakage may however occur).

Fig 5



V-I characteristic of PN junction : The static current voltage characteristic is in Fig 6.

Fig 6



The current in the forward direction increases rapidly upon reaching the forward voltage V_b which is known as the barrier potential or the junction potential and the barrier potential for germanium is 0.3 V and for silicon it is 0.7 V.

The behaviour of the PN junction is limited by the maximum forward current, as too much of current may destroy a diode due to the excess heat generation.

The current in the reverse direction of the junction is very small. Upon reaching —V_b in the reverse direction, the reverse current suddenly increases. —V_b in the reverse direction where the current starts increasing is called the knee potential or breakdown voltage. Normally the diode should not be operated in this region. The knee voltage depends on the type of diode which varies from 3V to 20 kV or more.

Application of diodes : Semi conductor diodes are used for various applications. Some of the major areas of application are listed below.

- Modulation and demodulation in communication receivers.
- Switching high speed digital circuits
- Low power and high power rectification
- As surge protectors in EM relay and other circuits.
- For clipping, clamping wave-forms.

Important specifications of a diodes

The material : The diode is made-of dopped semi-conductor material. This could be Silicon or Germanium or Selenium.This is important because the cut-in voltage depends upon the material the diode is made-of. For example, in Ge diodes the cut-in voltage is around 0.3V, whereas in Si diodes the cut-in voltage is around 0.7V.

Maximum safe reverse voltage : Denoted as V_R or V_r that can be applied across the diode. This is known as peak-inverse-voltage or PIV. If a higher reverse voltage than the rated PIV is applied across the diode, it will become defective permanently.

Maximum average forward current : I_f or I_F that a diode can allow to flow through it without getting damaged.

Forward voltage drop : V_F or V_f that appears across the diode when the maximum average current, I_f flows through it continuously

Maximum reverse current : I_{vr} that flows through the diode when the maximum reverse voltage, PIV is applied.

Maximum forward surge current : I_s that can flow through the diode for a defined short period of time.

The maximum junction temperature: The temperature upto which the diode junction can withstand without mal functioning or getting damaged.

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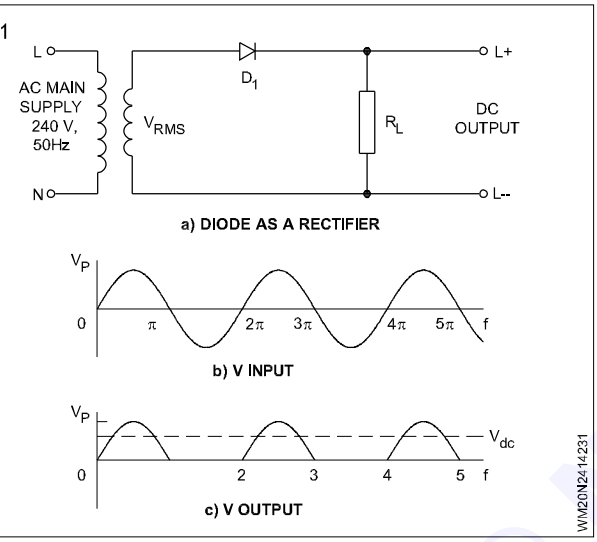
Rectifiers circuits, half wave, full wave, bridge rectifier and fillers

Objectives: At the end of this lesson you shall be able to
- **state the purpose of rectifier in power supply circuit**
- **explain the working of half-wave, full-wave and bridge rectifier circuit**
- **state the need of filter circuit to rectifier circuits**
- **state the different types filter circuit for rectifiers and their working.**

Most of the electronic equipment, both entertainment and professional, need DC voltage for operation. The power supply converts AC supply voltage into DC. Diodes are used as rectifier in a power supply circuit.

Half wave rectifier: This simplest form of AC to DC converter is by using one diode such an AC to DC converter is known as half-wave rectifier as in Fig 1.

Fig 1



A diode D_1 and a load resistance R_L in series are connected across the secondary of a step down transformer (Fig 1(a). The transformer steps down the supply voltage as needed. Further the transformer isolates the power line and reduces the risk of electrical shock. During the positive half-cycle of the input line frequency, (Fig 1b) the diode anode is made positive with respect to the cathode. The diode D_1 conducts because it is forward-biased. Current flows from the positive end of the supply through diode D_1 and R_L to the negative terminal of the input. During this period of time, a voltage is developed across R_L. The polarity of the voltage is as indicated in Fig 1C.

During the negative half cycle of AC input line frequency, the diode is reverse-biased. Practically no current flows through the diode and the load R_L and there is no voltage output.

DC output: The voltage drop across the forward biased diode is low, because the resistance of the forward-biased diode is very low. Ge diode drops 0.3V and Si diode drops 0.7V. Ignoring the small voltage drop across the diode. We can find the relationship between AC input and DC output voltage.

The AC input wave-form is shown in Fig 1b.

$V_{rms} = 0.707\ V_p$

$$V_p = \frac{V_{rms}}{0.707}$$

In Fig 1C, the DC output is shown. The diode produces only half cycle of the Ac input. The average value of this half wave is the DC output voltage.

$$V_{dc} = 0.318\ V_p$$

$$= 0.318 \times \frac{V_{rms}}{0.707}$$

$$= 0.45\ V_{rms}$$

For example if the input AC voltage is 24 volts the output DC of the half wave rectifier will be V_{dc} = 0.45 x 24= 10.8 V

The DC load current is $I_{dc} = \frac{V_{dc}}{R_L}$

Ripple frequency: From Fig 1 it is evident that the frequency of the rectified pulsating DC is same as the frequency of the input AC signal. This is true for all half-wave rectifiers.

Peak inverse voltage: Fig 1(a) shows the half-wave rectifier at the instant the secondary voltage is at its maximum negative peak.

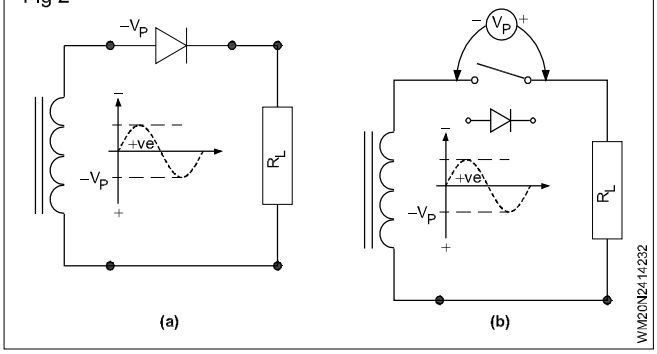
In this condition, since the diode is reverse biased, it behaves as an open switch as in Fig 2b. Since the diode is reverse biased, there is no voltage across the load R_L. Therefore, from Kirchhoff's Voltage law, all the secondary voltage appears across the diode as shown in Fig 2a. This is the maximum reverse voltage that appears across the diode in the reverse biased condition. This voltage is called the peak reverse voltage or more commonly as the peak inverse voltage (PIV). Therefore, in a half-wave rectifier the peak inverse voltage across the diode is equal to the -ve peak value of the secondary voltage $V_{s(peak)}$. Since the -ve peak voltage and +ve peak voltage in a sinusoidal wave is same in magnitude, the peak inverse voltage (PIV) across the diode in a halfwave rectifier can be taken as a $V_{s(peak)}$.

In the example considered earlier, the PIV across the diode will be,

$$V_{s(peak)} = \frac{V_{s(rms)}}{0.707} = \frac{24}{0.707} = 33.9 = 34 \text{ volts}$$

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Fig 2



To avoid break down of the diode used, the PIV appearing across the diode of the designed HW rectifier must be less than the PIV rating of the diode. For instance, in the above example to avoid break down of the diode, the PIV rating of the diode should be greater than 34 volts.

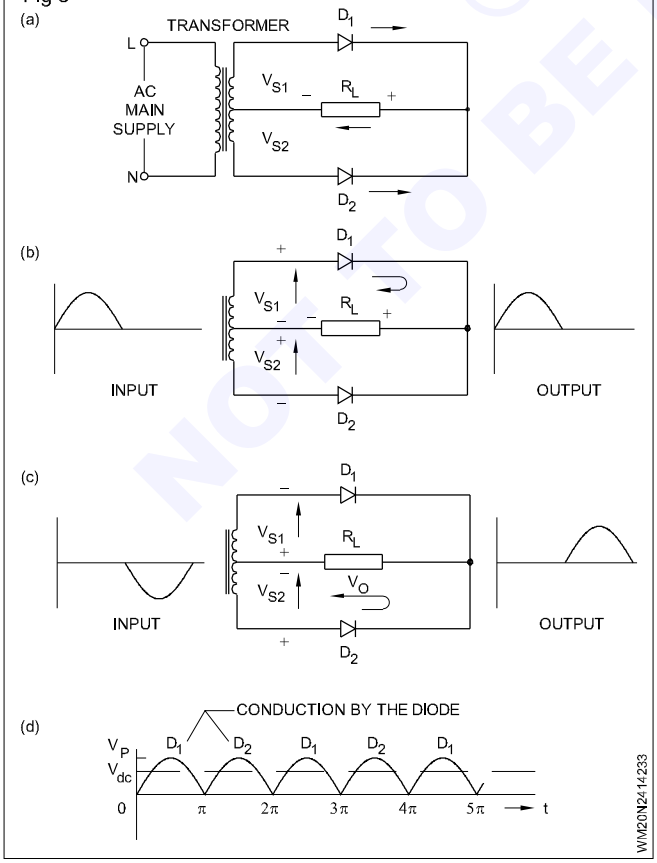
However this condition changes when a filter capacitor is used in the output DC circuit.

Full wave rectifier (FW): A full wave rectifier circuit is in Fig 3. The secondary winding of the transformer is centre-tapped. The secondary voltage is divided equally into two halves, one end of the load R_L is connected to the centre tap and the other end of R_L to the diodes.

It is seen that two half-wave rectifiers are conducting on alternate half cycles of the input Ac.

During the positive half cycle of the secondary voltage, diode D_1 is forward-biased and diode D_2 is reverse-biased. (Fig 3b) The current flows through the load resistor R_L, diode D_1 and the upper half of the secondary winding.

Fig 3



During the negative half cycle of secondary voltage, diode D_2 is forward-biased and diode D_1 is reverse-biased. Therefore, current flows through the load resistor RL diode D_2 and the lower half of the secondary winding. (Fig 3c)

The load current is in the same direction during both the half-cycles of the AC input. The output of the full-wave rectifier is shown in Fig 3d.

DC output : Since a full wave rectifier is nothing but a combination of two half-wave rectifiers, the average or DC value of a full wave rectifier is naturally twice the output of a half wave rectifier driven by the same secondary voltage.

From Fig 3 it i s evident that the average of DC value of a full wave rectified output is

$V_{dc} = 0.318\ V_{s(peak)} + 0.318\ V_{s(peak)}$

$V_{dc} = 0.636\ V_{s(peak)}$

where, $V_{s(peak)}$ is the equal peak voltage between the centre-tap and any one end A or B of the transformer secondary.

In terms of $V_{s(rms)}$ V_{dc} of full wave rectifier is given by,

$Vs_{(rms)} = 0.707\ V_{s(peak)}$

$$\text{Therefore, } V_{dc} = 0.636 = \frac{V_{s\,(rms)}}{0.707} = 0.9\ V_{s\,(rms)}$$

Example

Suppose the secondary voltage of the transformer is 24-0-24V(rms), the Dc output voltage of a full wave rectifier using this transformer will be,

For a two diode full wave rectifier

$V_{dc} = 0.9\ V_{s(rms)}$

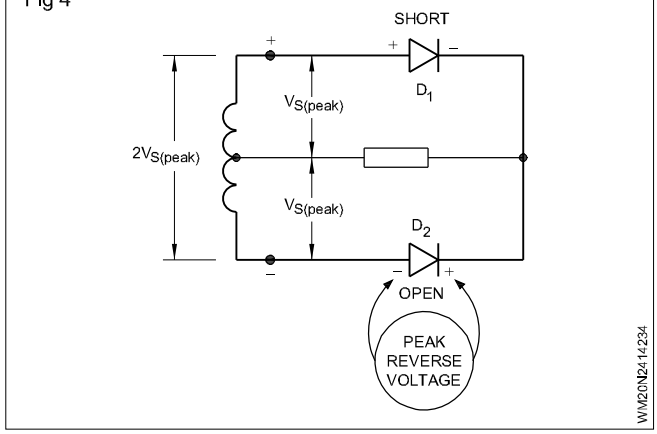
Therefore, in the given example

$V_{dc} = 0.9 \times V_{s(rms)} = 0.9 \times 24 = 21.6$ volts

Note: This increased ripple frequency has certain advantages when the pulsating DC is smoothed. This will be dealt with in further lesson.

Peak inverse voltage: Fig 4 shows the full wave rectifier at the instant the secondary voltage reaches its maximum positive value.

Fig 4



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Applying Kirchhoff's law around the outside loop, we get, $2V_{s(peak)}$ - Reverse voltage(PIV)

across D_2 + Forward voltage across D_1 = 0

Neglecting the small forward voltage across D_1 we have, $2V_{s(peak)}$ = PIV across D_2 + 0 = 0

or PIV across $D_2 = 2V_{s(peak)}$

From the above it can be seen that each diode in a full wave rectifier must have PIV rating greater than the peak value of the full secondary voltage. $2V_{s(peak)}$

In the example considered earlier, the PIV of diodes should be $2\ V_{s(peak)}$.

$$V_{s(peak)} = \frac{V_{s(rms)}}{0.707} = 2\ V_{s(peak)} = \frac{2 \times V_{s(rms)}}{0.707}$$

$$= \frac{2 \times 24}{0.707} = 68 \text{ volts (approx.)}$$

Current rating of diodes in a full wave rectifier : If the load, R_L connected in the full wave rectifier is, say 10Ω the DC current through it will be,

$$I_{dc} = \frac{V_{dc}}{10\ \Omega}$$

In the example considered above, V_{dc} = 21.6 volts

Therefore, $I_{dc} = \frac{21.6}{10} = 2.16$ amps.

Example: In a two diode full wave rectifier, with a load current requirement of 1.8 amps, what should be the current ratings of the diodes used?

Since it is a two diode full wave rectifier, the current rating of each diode should be = 1/2 the total load current.

Therefore I_f(max) of diodes should be = 1.8 amps/2 = 0.9 amps.

It is fine if a diode of 1 amp current rating is used for this rectifier circuit.

Disadvantages of TWO DIODE full wave rectifier: The full wave rectifier using two diodes and centre tap transformer has the following disadvantages

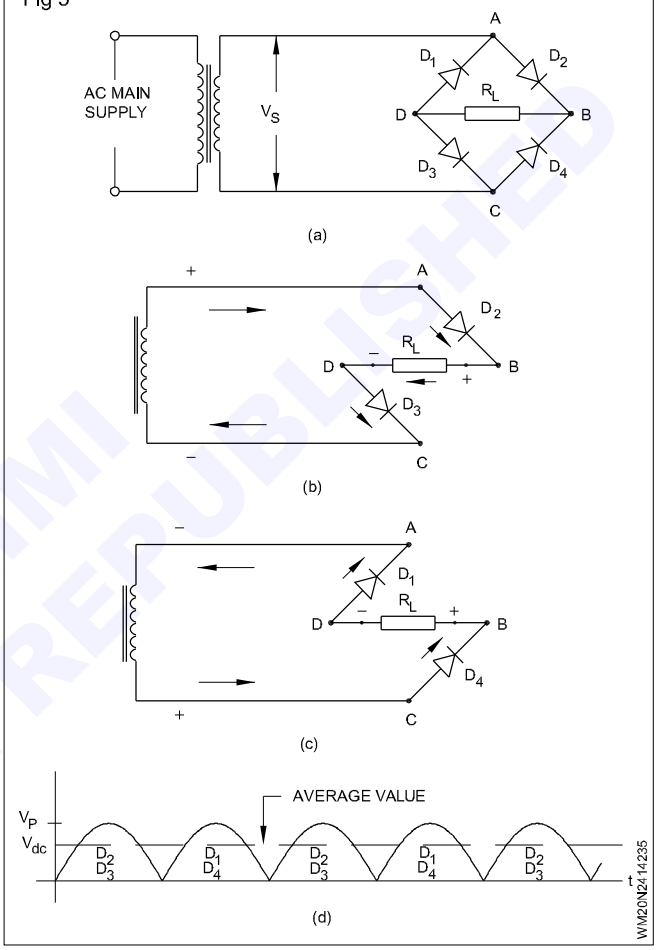
- A centre-tapped transformer that produces equal voltages on each half of the secondary winding is difficult to manufacturer and, hence, expensive.
- Centre-tapped transformers are generally bulkier than ordinary transformers, and, hence, occupy larger space.
- In a two diode full wave rectifier, only half of the secondary voltage is made use at a time although it works in both +ve and -ve half cycles.

Bridge rectifier: It is a full-wave rectifier. The circuit is in Fig 5a. In the bridge rectifier four diodes are used. There is no centre tap on the secondary of the transformer.

During the positive half of the secondary voltage, diodes D_2 and D_3 are forward-biased. Hence current flows through diode D_2 load resistance R_L and D_3 to the other end of the secondary. This is illustrated in Fig 5b. During the negative half of the secondary voltage, diodes D_1 and D_4 are conducting. The current flows through diode D_4, resistor R_L and diode D_1 to the other end of the secondary. This is illustrated in Fig 5c.

In both cases the current flows through the load resistor in the same direction. Hence, a fluctuating DC is developed across the load resistor RL. This is shown in Fig 5d.

Fig 5



DC output: Fig 6 shows the input AC and the output pulsating DC wave-form of a bridge rectifier.

This wave-form is similar to that of the full wave rectifier using a centre-tap transformer. Hence, the average DC value of the output is,

V_{dc} = 0,636 $V_{s(peak)}$

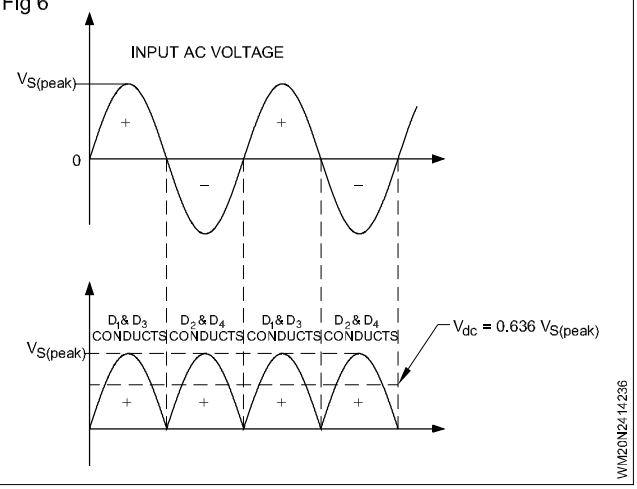
or V_{dc} = 0.9 $V_{s(rms)}$

where, Vs(rms) is the full secondary AC rms voltage.

NOTE: In a two -diode full wave rectifier $V_{s(rms)}$ refers to only half for the total secondary voltage whereas in a bridge rectifier $V_{s(rms)}$ refers to full secondary voltage.

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Fig 6



Example: In Fig 5, if the transformer secondary voltage $V_{s(rms)}$ is 24 volts, the rectified DC voltage V_{dc} across the load R_L will be,

From equation ....2, V_{dc} for a bridge rectifier is given by, $V_{dc} = 0.9\ V_{s(rms)}$

In the given example, $V_{s(rms)} = 24$ volts

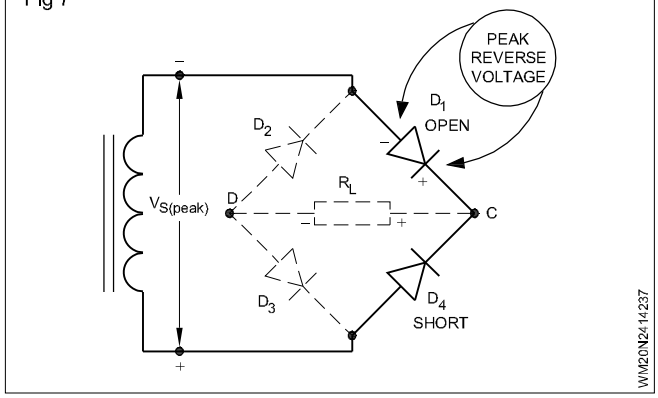
Therefore, $V_{dc} = 0.9 \times 24 = 21.6$ volts

NOTE: Using the same transformer, a two-diode full wave rectifier would have given only 10.8 volts which is half of that of bridge rectifier output.

Ripple frequency - Bridge rectifier: The pulsating DC output of a bridge is similar to the two diode full wave. Hence as in a two diode full wave rectifier, the output ripple frequency of the bridge rectifier is also twice the input AC frequency.

Peak inverse voltage - Bridge rectifier: Fig 7 shows a bridge rectifier at the instant the secondary voltage has reached its maximum value.

Fig 7



Diode D_4 is ideally short (as it is conducting) and D_1 is ideally open. summing the voltages around the outside loop and applying Kirchhoff's law,

$V_{s(peak)}$ - PIV across D_1 + 0 = 0

or PIV across $D_1 = V_{s(peak)}$

Therefore, the peak inverse voltage across D_1 is equal to the peak secondary voltage $V_{s(peak)}$

In a similar way, the peak inverse voltage across each diode will be equal to the peak secondary voltage $V_{s(peak)}$ of the transformer secondary. Hence the PIV ratings of the diodes used should be greater than $V_{s(peak)}$

Example

In Fig 7 if the transformer secondary voltage $V_{s(rms)}$ is 24 volts, find the minimum PIV of diodes used. In a bridge rectifier PIV across the diodes is same and is equal to $V_{s(peak)}$

Therefore, in the given example,

$$PIV = V_{sd(peak)} = \frac{V_{s(rms)}}{0.707} = \frac{24}{0.707} = 34 \text{ volts}$$

Filters

Objectives: At the end of this lesson you shall be able to
- **explain the filters.**

Filters in rectifier circuits are essential components used to smooth the output waveform and reduce the ripple or fluctuations in the rectified signal. Rectifiers are electronic devices that convert alternating current (AC) into direct current (DC), but the output of rectifiers often contains unwanted variations due to the pulsating nature of the AC input. These variations, known as ripple, can cause issues in various applications that require stable and smooth DC power.

There are two primary types of filters commonly used in rectifier circuits: capacitive filters and inductive filters.

Capacitive filters: Capacitors are used in parallel with the load to reduce the ripple voltage. During the positive half-cycle of the AC input, the capacitor charges and stores energy. During the negative half-cycle, the capacitor discharges and supplies current to the load. This process helps to smooth out the variations in the rectified output. The capacitor's capacitance value is chosen based on the desired level of filtering and the load requirements.

Inductive filters: Inductors, in combination with capacitors, can also be used to create more effective filtering. The inductor is connected in series with the load, and the capacitor is connected in parallel with the load. This combination forms a low-pass LC filter. The inductor opposes rapid changes in current, while the capacitor smooths out voltage variations, resulting in a better-filtered output.

Both types of filters have their advantages and limitations. Capacitive filters are generally simpler and less expensive, but they are not very effective for heavy loads or low-

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frequency applications. Inductive filters, on the other hand, can handle higher loads and lower frequencies more effectively but are bulkier and costlier.

In practical applications, bridge rectifiers are commonly used with these filters, which provide full-wave rectification and better utilization of AC input. The selection of the appropriate filter type and values depends on the specific requirements of the application, such as the amount of ripple allowed, the load current, and the operating frequency. Properly designed filters significantly improve the quality of the rectified DC output, making it suitable for a wide range of electronic devices and systems.

Active and passive components

Objectives: At the end of this lesson you shall be able to
- **explain active and passive component**
- **differentiate between active and passive components.**

Passive and active electronic components

Introduction: The Components used in electronic circuits can broadly grouped under two headings.

– passive components

– active components

Passive components: Components like resistors, capacitors, and inductors used in electronic circuit are called as passive components. These components by themselves are not capable of amplifying or processing an electrical signal. However these components are equally important in electronic circuit as that of active components, without the aid of passive components, a transistor (active components) cannot be made to amplify electrical signal.

Circuits formed with passive components obey the electrical circuits laws such as ohm's law, Kirchoff's Laws etc.,

Resistors: The components whose purpose to introduce resistance in the circuit is called as resistors. Other details of resistors are dealt in earlier lessons.

Capacitor: The components whose purpose to introduce capacitance in the circuit is called as capacitor. The unit of capacitance is 'FARAD'. Commercially capacitors are available in Microfarad (μF), Nanofarad (nF) and Picofarads (pF).

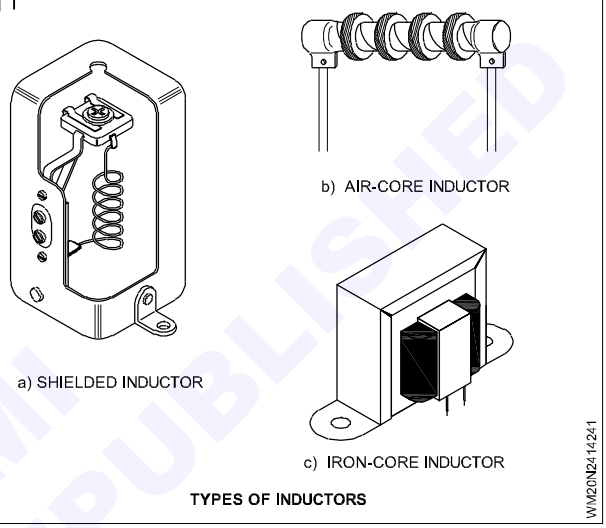
The colour coding of capacitors and resistors are same. Where as, in the case of fixed capacitors, the colour coded unit shall be in Picofarads.

Inductor: The ability of the conductor to induce voltage in itself, when the current changes in it is called as self inductance (or) simply inductance. A coil introduced in a circuit to have inductance is called as inductor. Different type of inductors are shown in Fig 1. The unit of inductance is "Henry". Commercially a coil may have inductance in Millihenry (10^{-3}H), or in Microhenry (10^{-6}H).

While specifying the inductance the following factors to be considered

- nominal value of inductance in Henry / Millihenry / Microhenry.
- tolerance in percentage (±5/10/20%)
- type of winding like single layer, double layer, multilayer and pie (p) etc.
- type of core like air core, iron core, ferrite core

Fig 1



TYPES OF INDUCTORS

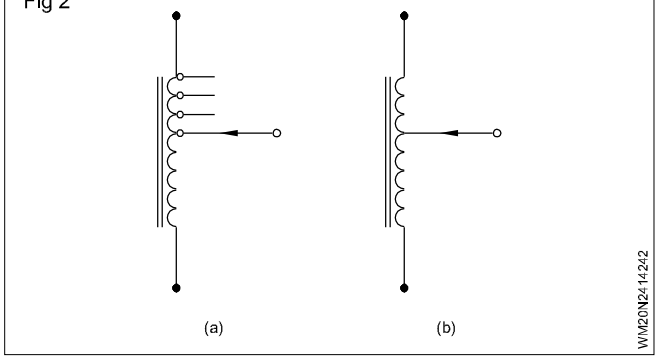
- type of application like audio frequency (AF), Radio frequency (RF) coupling coil, filter coil etc.,

In an electronic circuit some time, it is also required to vary the inductance.

The inductance of a coil can be varied by:-

- providing tapped inductive coil, as in Fig 2

Fig 2



- adjusting the core of a coil as in Fig 3.

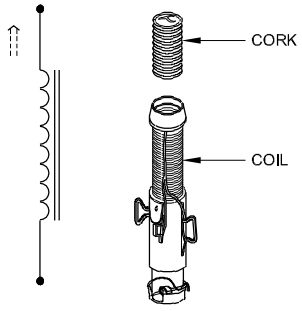
However, all inductor coils have inherent resistance due to the resistance of the winding wire in the coil. Further the maximum current that can be safely carried by an inductor depends upon the size of the winding wire used.

Active components

In electronic circuit, the components, other than passive are known as active components. Namely, transistors, diodes, SCRs Vacuum tubes etc.,

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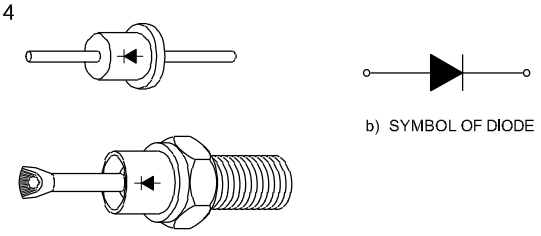
Fig 3



WM20N24114243

Active components: In electronic circuits, components other than resistors, capacitors and inductors are also used. Namely, transistors, diodes, vacuum tubes, SCRs, diacs, zener-diode (Fig 4) etc. The application of electrical circuit laws (Ohm's law etc.) in the circuit containing the above components will not give correct results. i.e. these components do not obey. Ohm's law, Kirchoff's law etc. These components are called active components.

Fig 4

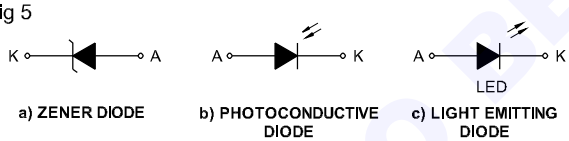


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The different active components and the method of representing them by symbols in the circuit diagram are given below (Fig 5)

The different types of diodes (Fig 5) used for specific purposes are represented by the symbols given.

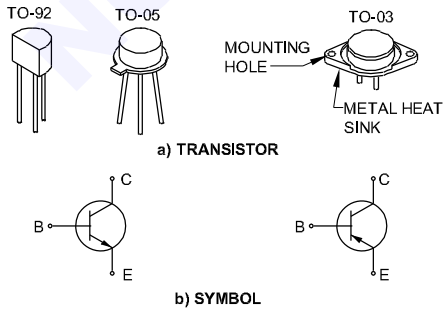
Fig 5



WM20N24114245

Transistor : Figure 6a shows the physical appearance of transistors. There are two symbols to represent a transistor. (Fig 6b). The selection of a symbol is based on either the NPN or the PNP type of transistor.

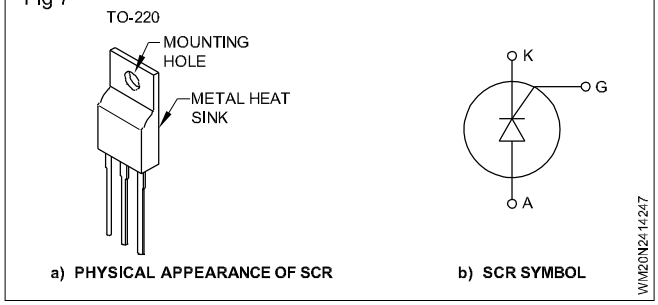
Fig 6



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SCR (Silicon controlled rectifier) : Fig 7a shows the physical appearance of one type of SCR and the symbol is shown in Fig 7b. SCRs are also called thyristors and used as switching devices.

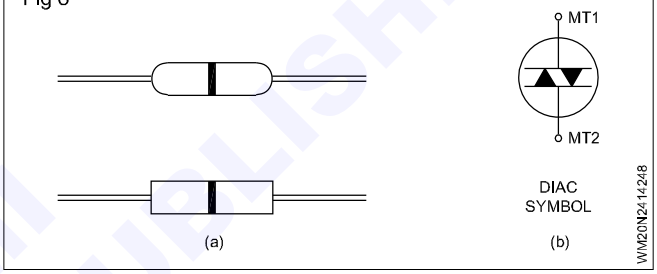
Fig 7



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Diac : A diac (Fig 8a) is a two-lead device like a diode. It is a bidirectional switching device. Its symbol is shown in Fig 8b.

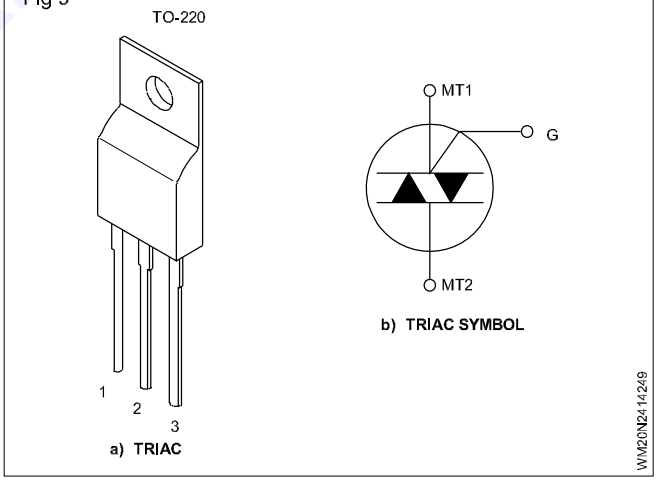
Fig 8



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Triac : A triac is also a semiconductor device with three leads like two SCRs in parallel. The triac can control the circuit in either direction. (Fig 9)

Fig 9



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Bridge rectifier or diode bridge : It is a single package of four semiconductor diodes connected in bridge circuit. The input AC and the output DC leads are marked and terminated as shown in the Fig 10.

UJT (Uni-junction transistor) : It has two doped regions with three leads and has one emitter and two bases (Fig 11).

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Fig 10

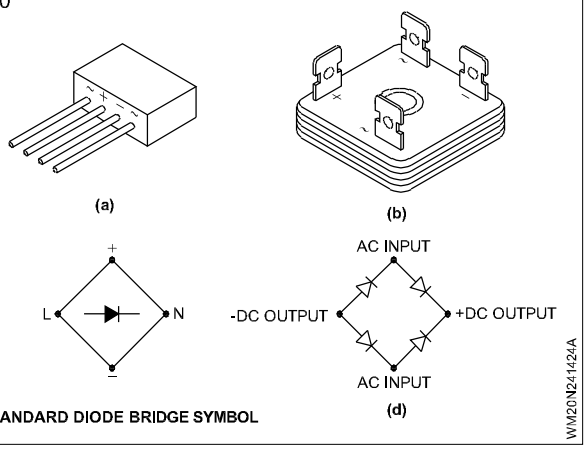
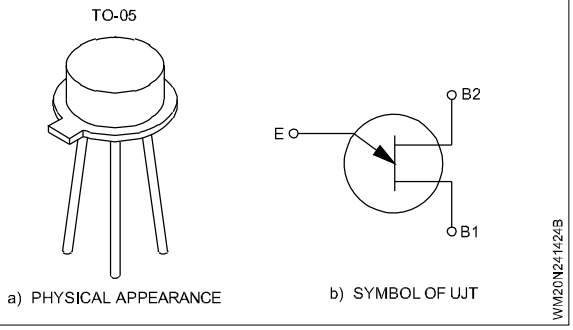


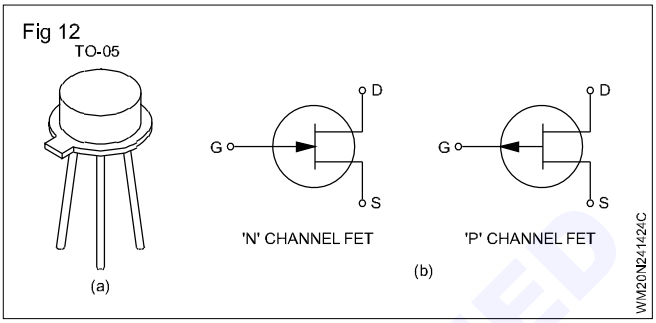
Fig 11



FET (Field effect transistor) : Fig 12a give a pictorial view of the component, and the related symbol to represent the field effect transistor is shown in Fig 12b. The selection of the symbol is based on whether the FET is a 'N' channel or a 'P' channel one.

In the active components few basic components discussed have and many more advanced components associated with modern circuits are in use.

Fig 12



Functioning of components used in CFL and LED circuits, CFL and LED lamp's circuit

Objectives: At the end of this lesson you shall be able to
- **circuit diagram of CFL & LED lamps**
- **explain circuit components of CFL & LED lamps**
- **explain the parts of CFL and LED lamps.**

Functioning and components used in CFL circuits

Compact fluorescent componetns consists of

1 Cover

2 Coil glass tube

3 Phosphor coating mercury vapour

4 Ballast cover

5 Base

Cover - Compact fluorescent bulbs sometimes have a cover to hide the glass tubes and give the bulb a more traditional shape.

Coil glass tube - Is the medium through which light producing gases and mercury travel phosphor coatings are found inside the coiled glass tube and help convert the energy to visible light mercury and other gasses inside the lamp reach and excited state and product energy.

Cathodes - direct the current through the lamp.

The ballast (Fig 1&2) - regulates the electric current and voltage into the lamp and powers the lamp ballast cover. The base- serves as a conductor of electricity.

Functioning and components used in LED circuits to explain how an LED LAMP works we must explain the four main components of and LED lamps; the LED chip, the Driver, LED chip emits lights in the bulb. Heat sink, and the optic lens.

- The driver then regulates the input current.
- The heat sink draws the heat away from the LED chip.
- The optic controls the characteristics of the light output.

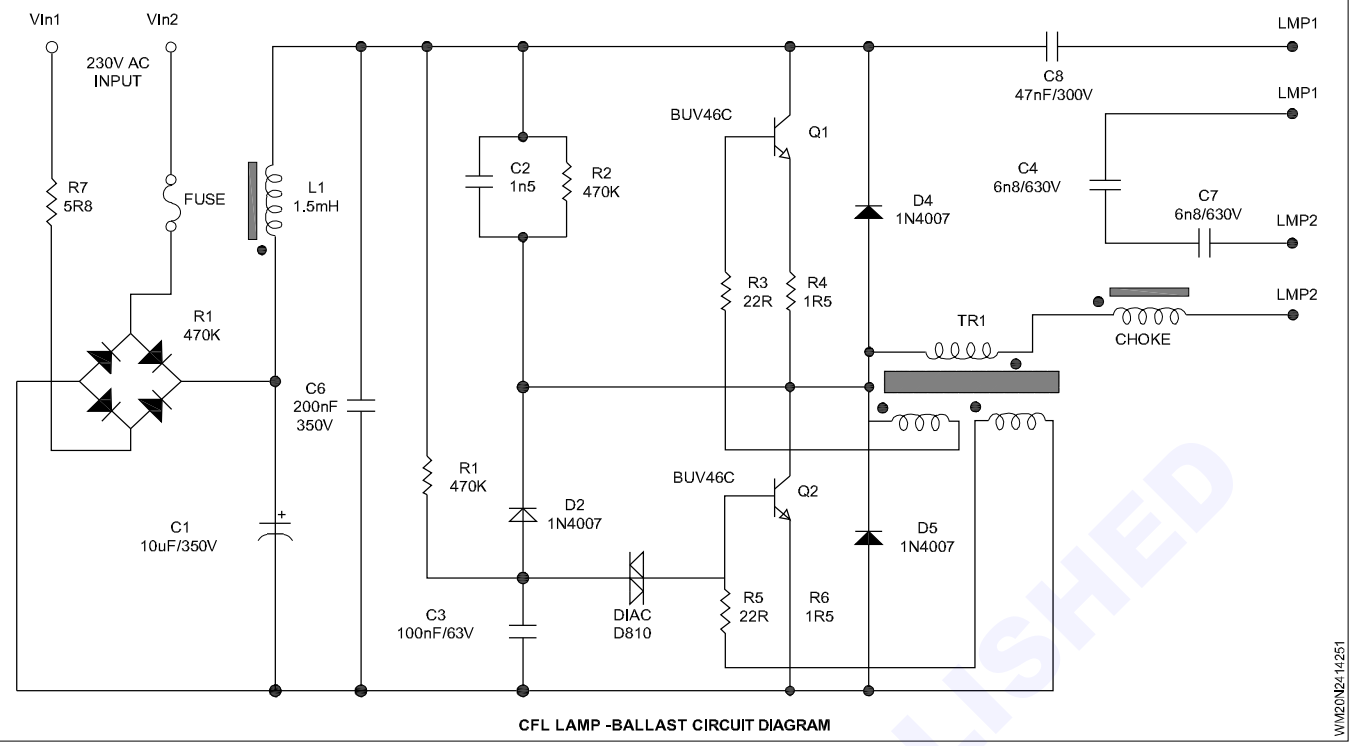
Light emitting diode (LED) is a light source that becomes illuminated by the movement of electrical current passing through a semiconductor material. A semiconductor is a substance, usually a solid chemical element or compound that can conduct electricity under some conditions making it a good medium to control an electrical current.

Solid state lighting (SSL) is lighting that uses LED's. Because it is solid state lighting, it does not require a heated filament.

A LED light is formed when bringing an P-Type (+) and a N-Type (-) semiconductors that form a PN junction. Energy is released in the form of light when the N - Type (-) electrons and the P-Type (+) positively charge holes are combined.

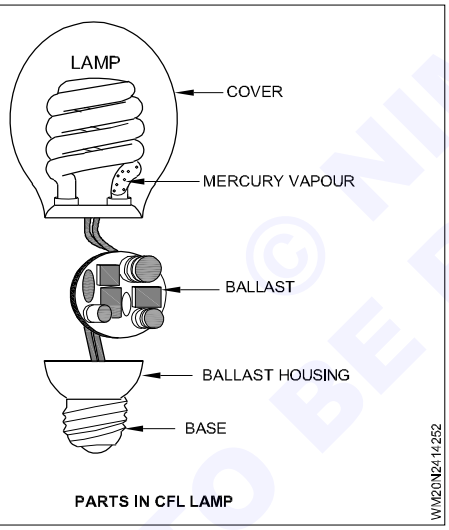
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Fig 1



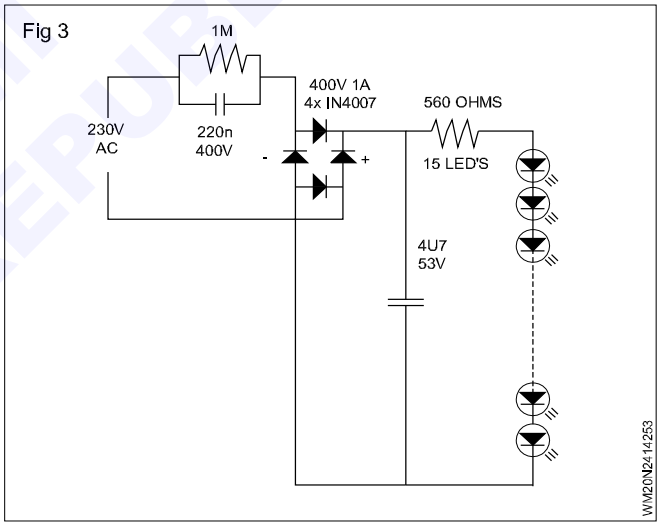
CFL LAMP -BALLAST CIRCUIT DIAGRAM

Fig 2



PARTS IN CFL LAMP

Fig 3



The driver then regulated the input current (Fig 3): An LED driver - regulates the current flowing through the LED, A regulated power supply is used to ensure that the output remains constant even if the input changes. Because of this reason led driver is a very key component the light output and greatly impacts the lamp life of the LED. Any slight variation in the current can result in unacceptable changes in light output. In LED light output is proportional to its current;

The heat sink draws the heat away from the LED chip (Fig 4): The heat sink is a key component in a good quality LED. LED's do not generate much external ambient heat but they do generate internal heat with the junction.

A heat sink is designed to maximize its surface area in contact with the cooling medium surrounding it, such as the air. Air velocity, choice of material, protrusion design and surface treatment are factors that affect the performance of a heat sink. Heat sink attachment methods and thermal interface materials also affect the die temperature of the integrated circuit. Thermal adhesive or thermal paste improve the heat sink's performance by filling air gaps between the heat sink and the heat spreader on the device. A heat sink is usually made out of aluminium or copper.

Heat must be removed from the LED chip to maintain good light output, life, and colour. The heat sink is essential to removing heat which is removed.

The optic controls the characteristics of the light output - Conductors which why they are used as mounting materials for most LED's

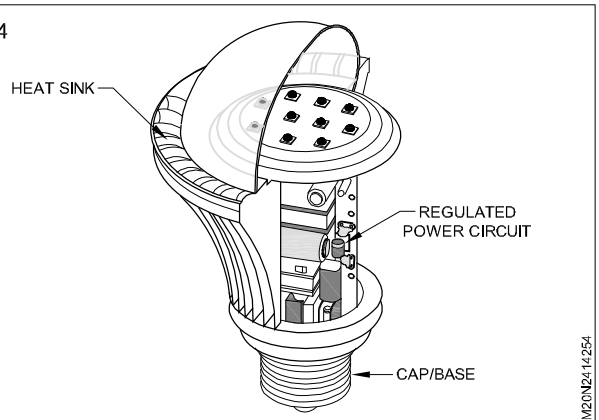
The optic is also a big component of an LED lamp which has multi level optics.

The primary optic is built directly on top of the LED chip.

The secondary optic collects and redistributed the light in the LED lamp.

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Fig 4



Safety and Disposal procedure

Objectives: At the end of this lesson you shall be able to
- **explain about electrical safety**
- **state safety working an electrical equipment**
- **state the type of waste materials**
- **list the type waste materials**
- **explain the method of disposal material.**

Safety

Always away from all conductive material. Avoid contact with entergized electrical circuits. Disconnect the power source before servicing or repainting electrical equipments

Treat all electrical devices as it they are live or energized. Don't work with exposed conductors carrying voltage. Make sure electrical equipment is properly connected to grounded, extension cords may not be used as permanent wiring and should be removed after temporary use for an activity.

Use only tools and equipment with non-conducting handles when working on electrical devices. Never use metal rulers, or wear rings or metal watch bands when working with electrical equipment. Do not forget, especially when you are showing some electrical part pointing with metallic rods.

When it is necessary to handle equipment that is plugged in, be sure hands are dry and, when possible, wear non-conductive gloves, protective clothes and shoes.

If any person comes in contact with a live electrical conductor, do not touch the equipment, or perspm. Disconnect the pwer source from the circuit breaker or pull out the plug using a leather belt. This precation reduces the life risk or accident.

Minimize the use of electrical equipment is cold rooms or other areas.

If water or a chemical is spilled onto equipment, shut off power at the main switch or circuit breaker and unplug the equipment. Never try to remove water or similar from equipment while energized.

Never touch another person's equipment or electrical control devices unless instructed to do so. Enclose all electric contact and conductors so that no one can accidentallycome into contact with them. Never handle electrical equipment when hands, feet or body are wet or when standing on a wet floor.

Be aware that interlocks on equipment disconnect the high voltage source when a cabinet door is open but power for control circuits may remain on. Deenergize open experimental circuits and equipment to be left unattended.

Do not wear loose clothing or ties near electrical equipment.

Disposal of waste material

Objectives: At the end of this lesson you shall be able to
- **state about the waste material**
- **state the types of waste material and source of waste**
- **list out the waste material in workshop**
- **explain the methods of disposal of waste material.**

Waste

Waste are unwanted or unusable materials. Waste is any substance which is discarded after primary use, or it is worthless, defective and of no use.

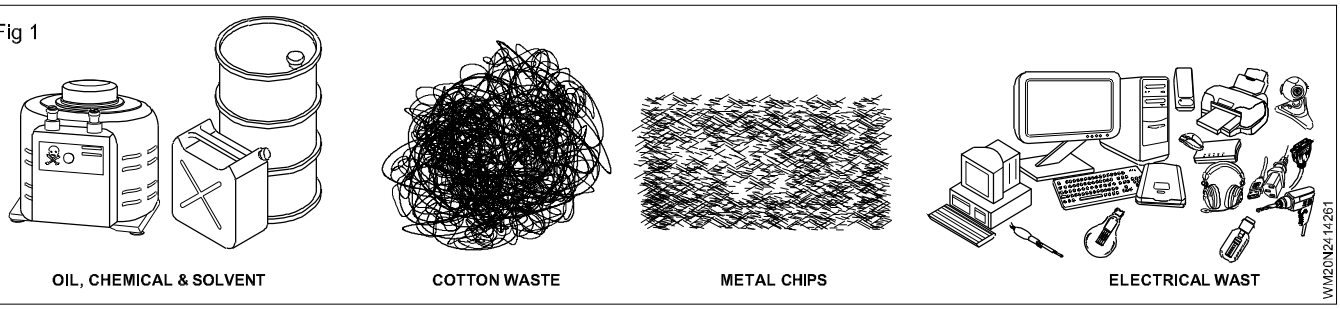
Waste is the by product of all the matter which is used in the industries.

List out the waste material in workshop (Fig 1)

- Oily waste such as lubricating oil, coolant etc.

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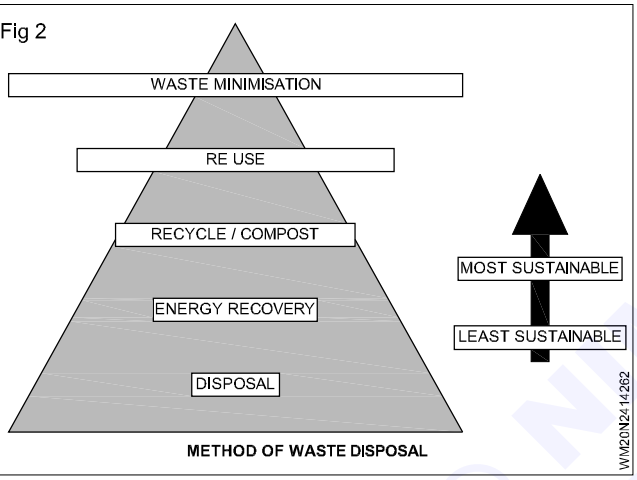
Fig 1



- Cotton waste.
- Metal chips of different materials.
- Electrical waste such as used and damaged accessories, wires, cables, pipes etc.

Methods of disposal of waste (Fig 2)

Fig 2



Disposal process : This is the final step of the waste management. From this disposal point or site the materials are selected steps as

- Recycling
- Landfill
- Waste compaction
- Animal Feed
- Composing
- Incineration
- Reuse
- Fire Wood

Recycling: Recycling is one of the most well known method of managing waste. It is not expensive and can be easily done by you. If you carry out recycling, you will save a lot of energy, resources and thereby reduce pollution.

Composting; This is a natural process that is completely free of any hazardous by-products. This process involves breaking down the material into organic compounds that can be used as manure.

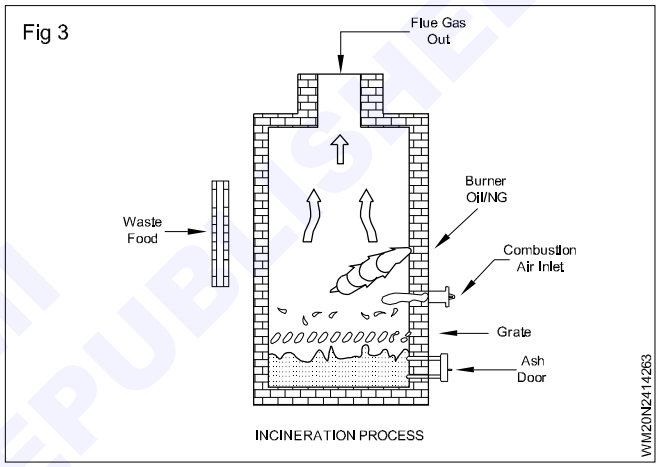
Landfill

In this process, the waste cannot be reused or recycled separated out and spread as a thin layer in some low-lying areas across the city. A layer of soil added after each layer of garbage. Once this process is complete, this area declared unfit for building construction and is only used as a playground or a park.

Incineration (Fig 3)

It is the process of controlled combustion of garbage to reduce it to incombustible matter, ash, waste gas and heat. It is treated and released into the environment (Fig 3). This reduced 90% volume of waste, sometime the heat generated used to produce electric power.

Fig 3



Waste compaction

The waste materials such as cans and plastic bottles compact into blocks and send for recycling. This process need space, thus making transportation and positioning difficult.

Reuse

The amount of waste disposal can be reduced by carefully considering the exact throwing away. Before discarding the item think for the possibility to wash and reuse them. Plastic tubs contents butter or icecream can become effective storage containers for a range of small item like nails or screws.

Fire Wood

A small amount of waste disposal can be reused when it comes to refurnishing have or replacing furniture. before discarding the furniture, cut it into more meaningful process and use as fire wood.

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Solar energy

Objectives: At the end of this lesson you shall be able to
- **explain solar energy.**

Solar energy (Fig 1)

Solar energy is a renewable and abundant source of power derived from the sun's radiation. Understanding the fundamentals of solar energy is crucial for harnessing its full potential.

Solar energy is generated through the conversion of sunlight into usable electricity or heat. This process is made possible through photovoltaic (PV) technology, which utilizes solar panels composed of semiconductor materials such as silicon. When sunlight hits the PV cells, it excites electrons, creating an electric current. This direct conversion of sunlight into electricity is known as the photovoltaic effect.

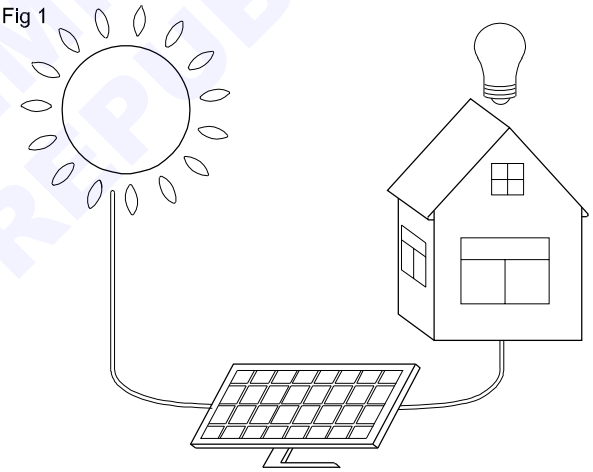
Another way to harness solar energy is through solar thermal systems. These systems use sunlight to generate heat, which can be utilized for various applications such as water heating or space heating. Solar thermal systems typically consist of collectors that absorb sunlight and transfer the heat to a working fluid, which can then be used to produce hot water or steam.

Solar energy offers numerous advantages. First and foremost, it is a clean and renewable source of power, meaning it does not produce harmful emissions or contribute to climate change. Additionally, solar energy is abundant and widely available, making it a viable option for energy production in various locations worldwide. It also reduces dependence on fossil fuels, thus enhancing energy security and reducing the risks associated with price volatility.

However, there are certain limitations to solar energy. It is an intermittent source, as it is dependent on sunlight, which varies throughout the day and is not available during nighttime or adverse weather conditions. To overcome this challenge, energy storage technologies, such as batteries, can be employed to store excess energy generated during peak sunlight hours for use during periods of low or no sunlight.

In conclusion, solar energy is a fundamental and promising form of renewable energy that harnesses the power of sunlight to generate electricity or heat. Its benefits include environmental sustainability, energy security, and reduced dependence on fossil fuels. By understanding the fundamentals of solar energy and advancing technological innovations, we can unlock its vast potential and move towards a cleaner and more sustainable energy future.

Fig 1



Sun path east to west, north to south and south to north movement

Objectives: At the end of this lesson you shall be able to
- **explain sun path east to west, north to south and south to north movement.**

The movement of the sun across the sky is a fascinating phenomenon that has been studied and observed by humans for centuries. The sun's path can be observed from various perspectives, including east to west, north to south, and south to north. We will explore the movement of the sun along these different axes and delve into the significance of these movements.

Let us begin by examining the sun's movement from east to west. This is commonly referred to as the daily motion of the sun. As the Earth rotates on its axis from west to east, it appears as if the sun is moving across the sky from east to west. This movement is responsible for the rising and setting of the sun. In the morning, the sun rises in the east, gradually climbing higher in the sky until it reaches its highest point at noon, and then descends towards the western horizon, finally setting in the west. This east-west movement of the sun is a result of the Earth's rotation and gives us our day and night cycle.

Moving on to the sun's movement from north to south, we enter the realm of the annual motion of the sun. This movement is most evident during the change of seasons. In the Northern Hemisphere, as we transition from winter to summer, the sun appears to move higher in the sky each day. This is because during the winter solstice,

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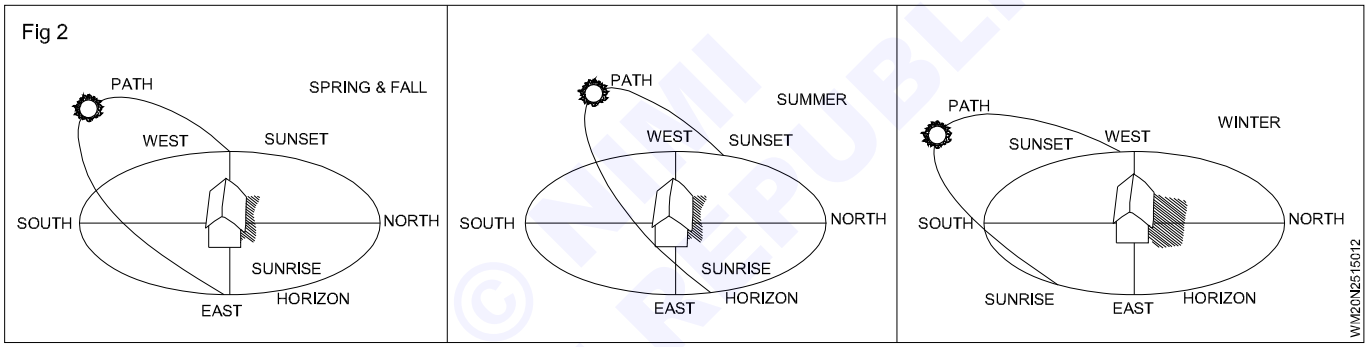
which occurs around December 21st, the North Pole is tilted away from the sun, causing the sun's rays to be spread out over a larger area and resulting in shorter days. However, as the Earth continues its orbit around the sun, the tilt of the North Pole starts to lean towards the sun, leading to longer days and higher sun angles. This process continues until the summer solstice, around June 21st, when the North Pole is tilted towards the sun, resulting in the longest day of the year in the Northern Hemisphere. Afterward, the sun's path starts to shift back towards the south, gradually lowering in the sky as we move from summer to winter.

Conversely, in the Southern Hemisphere, the sun's movement from north to south follows a reverse pattern. During the summer solstice, which occurs around December 21st in the Southern Hemisphere, the South Pole is tilted towards the sun, resulting in longer days and higher sun angles. As the Earth progresses in its orbit, the tilt of the South Pole gradually moves away from the sun, leading to shorter days and lower sun angles. This culminates in the winter solstice, around June 21st, when the South Pole is tilted away from the sun, giving rise to the shortest day of the year in the Southern Hemisphere.

Lastly, let us explore the sun's movement from south to north. This is best observed during the phenomenon known as the midnight sun, which occurs within the polar circles. In regions near the North Pole, such as parts of Scandinavia, Alaska, and Canada, during the summer months, the sun remains visible throughout the entire day and night, never setting below the horizon. Similarly, in regions near the South Pole, such as parts of Antarctica, during their summer months, the sun remains above the horizon, resulting in 24 hours of continuous daylight. This unique phenomenon is a result of the Earth's axial tilt, which causes the sun to move in a circular path around the pole. As a result, the sun appears to move from south to north during this period, creating an awe-inspiring spectacle for those lucky enough to witness it.

In conclusion, the movement of the sun from east to west, north to south, and south to north encompasses various aspects of our planet's rotation and orbit. These movements give rise to the daily and annual patterns we observe, including the rising and setting of the sun.

Fig 2



Daily and sessional changes of sunlight

Objectives: At the end of this lesson you shall be able to
- **explain daily and sessional changes of sunlight.**

The Sun, our nearest star, plays a crucial role in shaping the daily and seasonal changes of sunlight on Earth. These changes are driven by the Earth's rotation and its tilted axis, which result in variations in the angle and duration of sunlight throughout the day and year. Let's explore these changes in more detail.

On a daily basis, the amount of sunlight received by a particular location is influenced by the rotation of the Earth on its axis. As the Earth spins, different parts of the planet are exposed to the Sun's rays, resulting in the alternation between day and night. This cycle occurs every 24 hours and is responsible for the daily variation in sunlight.

The intensity and angle of sunlight also change throughout the day. At sunrise and sunset, when the Sun is near the horizon, sunlight travels through a thicker portion of the Earth's atmosphere. This causes the sunlight to scatter more, resulting in the warm hues and longer shadows characteristic of these times. As the Sun rises higher in the sky, sunlight travels through a shorter path in the atmosphere, leading to less scattering and a more direct, intense light. This is why midday sunlight appears brighter and harsher.

Seasonal changes in sunlight are primarily driven by the Earth's axial tilt. The Earth's axis is tilted at an angle of approximately 23.5 degrees relative to its orbit around the Sun. This tilt causes the angle at which sunlight strikes the Earth's surface to vary throughout the year.

During the summer solstice, which occurs around June 21st in the Northern Hemisphere and December 21st in the Southern Hemisphere, the axial tilt is such that the Sun is directly overhead at its highest point in the sky. This results in longer daylight hours and more intense sunlight. Conversely, during the winter solstice, which occurs around December 21st in the Northern Hemisphere and June 21st in the Southern Hemisphere, the Sun is at its lowest point in the sky, leading to shorter daylight hours and less intense sunlight.

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The equinoxes, which occur around March 20th and September 22nd, mark the transition between the seasons. During these times, the Earth's axis is not tilted towards or away from the Sun, resulting in equal day and night lengths across the globe. These periods signify the beginning of spring and autumn, when the intensity of sunlight is intermediate between the extremes of summer and winter.

The changing angle of sunlight also affects the distribution of sunlight across latitudes. Near the equator, the angle of sunlight remains relatively constant throughout the year, leading to fairly consistent day lengths and temperatures. In contrast, at higher latitudes, such as the poles, the angle of sunlight varies greatly between summer and winter, resulting in more pronounced seasonal differences in day length and temperature.

The daily and seasonal changes of sunlight have profound effects on the Earth's climate, weather patterns, and ecosystems. They influence the distribution of heat, drive atmospheric circulation, and play a vital role in the growth of plants and the behavior of animals.

In conclusion, the daily and seasonal changes of sunlight are a result of the Earth's rotation, axial tilt, and its orbit around the Sun. These changes manifest as variations in the angle, duration, and intensity of sunlight throughout the day and year, shaping our daily lives, seasons, and the natural world around us.

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Angle of inclination of radiant light

Objectives: At the end of this lesson you shall be able to

- **explain angle of inclination of radiant light and it's relation with latitude and longitude of different locations on earth.**

The angle of inclination of radiant light refers to the angle at which sunlight or any other form of radiant light strikes the Earth's surface. This angle is determined by the position of the Sun in the sky and varies depending on the latitude and longitude of a particular location on Earth. The angle of inclination affects various factors such as the intensity of sunlight, temperature patterns, and the length of daylight hours, ultimately influencing the climate and seasons of a region.

Latitude is the angular distance of a location from the equator, ranging from 0° at the equator to 90° at the North and South Poles. The latitude of a place has a direct relationship with the angle of inclination. As one moves away from the equator towards higher latitudes, the angle of inclination of sunlight increases during summer and decreases during winter. In the Northern Hemisphere, the summer solstice occurs around June 21st when the Sun reaches its highest position in the sky, resulting in a steeper angle of inclination and longer daylight hours. This leads to more intense sunlight and warmer temperatures. In contrast, during the winter solstice around December 21st, the Sun is at its lowest point, resulting in a shallower angle of inclination, shorter daylight hours, and less intense sunlight.

Longitude, on the other hand, does not directly affect the angle of inclination. Instead, it influences the timing of sunrise and sunset throughout the year. By convention, the prime meridian, located at 0° longitude, passes through Greenwich, London. As one moves eastward, the time at a particular location increases, while moving westward decreases the time. Therefore, the same angle of inclination will occur at different times for locations with different longitudes.

The combination of latitude and longitude determines the specific angle of inclination and the associated variations in sunlight and temperature throughout the year. For example, a location near the equator will experience relatively small seasonal changes in the angle of inclination. This leads to a relatively constant climate, with warm temperatures throughout the year.

In contrast, locations at higher latitudes, such as near the Arctic or Antarctic Circles, experience more significant variations in the angle of inclination. These areas have long, dark winters with low angles of inclination and short daylight hours, resulting in colder temperatures. Conversely, during the summer months, the angle of inclination is high, leading to longer daylight hours and warmer temperatures.

It's important to note that factors such as atmospheric conditions, altitude, and local geography can also influence the angle of inclination and its impact on the climate of a particular location. However, the primary drivers of the angle of inclination are the latitude and the position of the Earth in its orbit around the Sun.

In conclusion, the angle of inclination of radiant light is directly related to the latitude of a location, with higher latitudes experiencing greater variations in the angle throughout the year. Longitude, on the other hand, affects the timing of sunlight but does not directly influence the angle of inclination. By understanding these relationships, scientists can study and predict climate patterns and understand the seasons in different regions around the globe.

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Solar DC domestic application

Objectives: At the end of this lesson you shall be able to
- **state solar DC domestic application.**

Solar Photovoltaic System designed exclusively for DC loads include mostly domestic products such as Lantern, Home lighting, day lighting, garden lighting, mobile hand set charger etc. They are mainly for self-organized assembly and use.

The other commercial applications in DC sector are Solar DC pumps, Solar Street lights, Solar Water treatment plants, Solar Electric vehicle battery charging stations etc.

The Component List for Battery Backup DC solar System includes PV Modules, Charge Controller, Solar Batteries, Monitoring/Metering circuits, mounting structures, Hardware Wiring, Fuses/Breakers/Disconnect Switch etc.

Solar DC domestic application: Making of solar lantern. Solar Day lighting, Solar Garden Lights

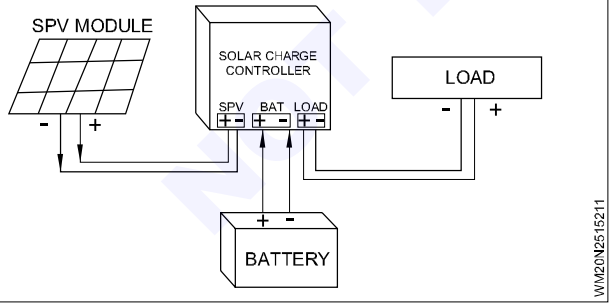
All DC products can be thought of made with Solar tag. We need solar panel, charge controller, batteries, control switches (Manual or automatic), wiring, Dc loads (in case of present topic LED lights), lamp housing, cabinets, posts and fittings.

Follow the block diagram as below:

Block diagram for DC solar product (Fig 1)

Solar Lanterns not only serves general purpose use like study lamp, room light etc, but also in other variants like the solar lamp post lights and hanging solar lights/lanterns they enhance the solar landscape design of a house or any living space.

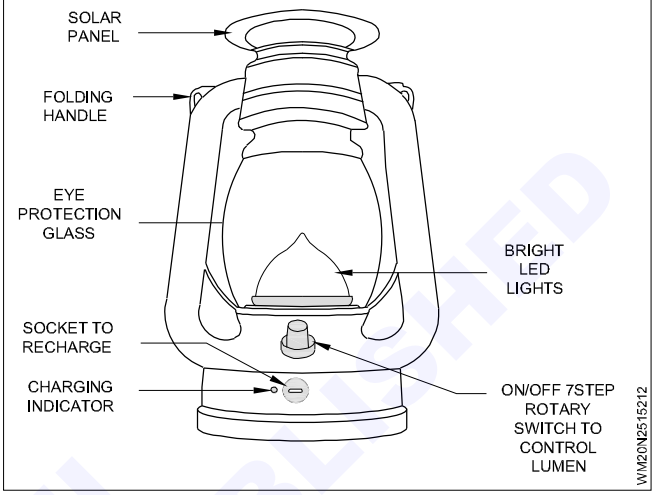
Fig 1



Solar lantern (Fig 2)

These solar power lights will add a mission theme to the solar garden or enhance the nautical style of the walkways and yards. Most of the solar lamp posts are finished with durable yet stylish materials in a variety of styles and shapes.

Fig 2



All of the post-mounted and hanging solar powered lanterns add a unique, personal touch to any space. Varieties of solar lamp posts and solar hanging lanterns of many brands with single, double and even triple styles are available for the garden, patio or walkway. This has become a way of lifestyle.

Solar powered lights add a lot of features to interior lighting or outdoor landscaping. To get the most out of the solar indoor/outdoor lights, we still need to maintain and use them properly. Outdoor solar landscape light scan last for many years of continuous operation if well cared for. Of course, choosing a high quality brand is also important.

These solar garden lights or solar lanterns work simply by using power from solar panels and one or more rechargeable batteries. Through the PV effect, the solar panels generate electricity from sunlight and thus charge the batteries during the day. When it gets dark, the energy stored in the batteries powers an LED light.

Single solar garden lamp (Fig 3&4)

Safety in DC system.

Two particular characteristics of PV generators are their DC voltage levels and the fact they cannot be shut off as long as PV modules are exposed to the sun. The short-circuit current produced by the PV module is too low to trigger the power supply's automatic disconnect. The most frequently used protective measures do not therefore apply to PV systems. However, as PV modules are installed outdoors they are exposed to the elements. And since they can be installed on roofs, critical attention should be paid to the risk of fire and the protection of fire fighters and emergency services staff.

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Fig 3

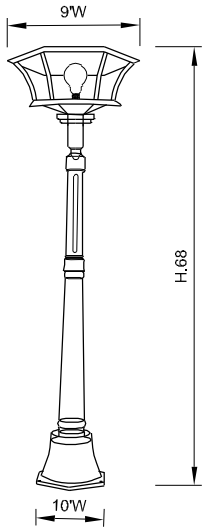


Fig 4



Solar Garden Lamp

Solar DC indication application

Solar street light

A solar street light is the raised light source from the ground mounted on the pole of metal pipe. The light sources uses Solar Photovoltaic (SPV) module as the primary source of energy. Street light stores electric energy during the day time and powers a fluorescent or LED lamp (called as luminary) during the night. It has necessary devices to store electricity such as rechargeable battery and charge controller.

The solar street light does not need to set up the transmission line or route the cable, and no any special management and control are required. It can be installed in the entire public place such as the square, the parking lot, the campus, the street or the highway etc. The street lighting is closely related to people's daily life.

A good LED Street lighting system is characterized with High efficiency, Energy-saving, Long-life, High color rendering index and Environmental protection. So it is a noticeable issue how to design a reasonable LED street light system.

Following are the basic requirements of a qualified solar LED Street Light System during design process:

- Learn general information of the meteorological conditions in the area.
- Select the cost-effective solar panel, controller, battery and a series of components.
- Adopt effective measures to protect the system.

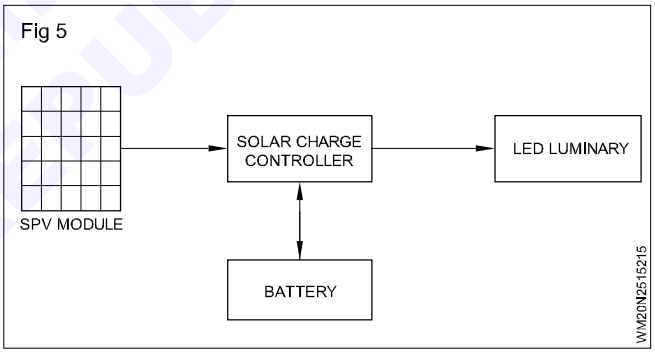
These conditions ensure to design a reasonable solution and realize the significance and value of the existence of solar LED Street Light Street.

The system consists of:

- Solar PV module
- LED lamps
- Light pole
- Control box (charger, controller, battery)

Block diagram of solar street light system (Fig 5)

Fig 5



Operation principle

The SPV Module receives solar energy and converts it into electrical energy. Converted electrical energy is stored in the battery through solar charge controller or simply, charge controller. When the light intensity reduced to about 10 lx during sun set, charge controller will turns ON the LED Light. Battery provides the energy to luminary and discharges as time passes. When sun rises the charge controller will turns off the LED Light. During night if battery voltage reduces below its critical value the charge controller will turn off the LED light to protect battery from deep discharge.

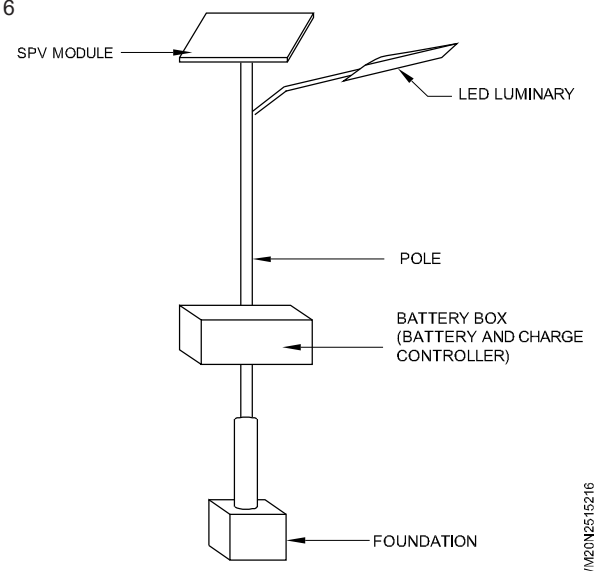
Parts of Typical Solar Street Light (Fig 6)

Solar Photovoltaic module

The solar panel converts solar energy into electricity. The solar panels used for the solar street light system is dependent on the wattage rating of the LED Luminary used. Typically, 12W LED luminary for its 12 Hours of working requires 40Wp of SPV Module.

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Fig 6



Battery: Battery will store the electricity from solar panel during the day and provide energy to the fixture during night. The life cycle of the battery is very important to the lifetime of the light and the capacity of the battery will affect the backup days of the lights.

Automatic switch and brightness control of lamp

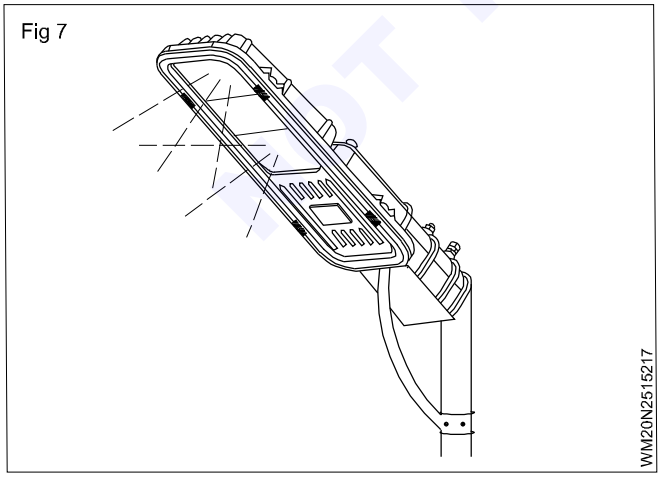
The Solar charge controller for the operation of the street light needs dusk to dawn feature i.e., turns on the luminary during sunset(dusk) and turn off during sun rise(dawn) .

Now days the adaptive brightness controlling street lights are available to optimize the battery and system size. For example, first four hours of turn on time with 100% brightness and till morning 30% brightness and during the operation if any human activity is detected in the range of 5 meters from street light it increases the brightness to 100% for 10 min and revert back to the 30% brightness.

This type of street light requires smaller battery and uses higher wattage of luminary than that of the normal one, for the same rated SPV power. And requires specially designed charge controller.

Integrated solar LED Street light (Fig 7)

Fig 7



In some cases charge controller is in-built in luminary. Only battery is kept in the box.

Note: Charge controller must present about 90cm form battery, because charge controller has temperature compensation feature to charge the battery at different battery temperature.

Installation of Solar street light system

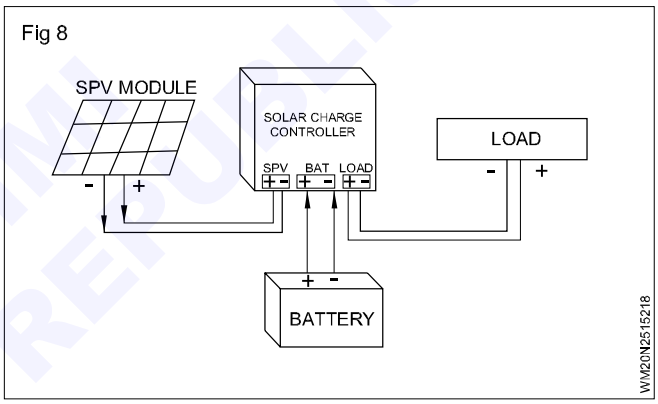
The technician shall be able to select proper place to install Solar street light system, identify different tools used in the installation process, describe the process of civil work involved in the installation of Solar street light system and describe the electrical connections involved in the installation of Solar street light system.

Electrical connection

Electrical connection of the solar street light system is connecting the different components together. The electrical connection of a solar street light system is as shown in the figure

Electric connection of the solar street light system (Fig 8)

Fig 8



Solar home lighting system

The other names used for this are small solar system, solar DC Home lighting and Solar DC Day lighting.

A small solar system is the off grid solar lighting system for the house. The light sources uses Solar Photovoltaic (SPV) module as the primary source of energy. System stores electric energy during the day time and powers a fluorescent or LED lamp and Fans during the night. It has necessary devices to store electricity such as rechargeable battery and charge controller.

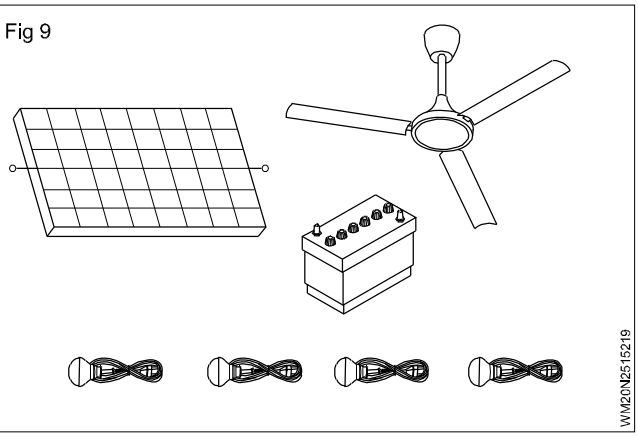
Components of Small solar system (Fig 9)

Requirements on small solar system

The small solar home system does not need to set up the transmission line or route the cable, and no any special management and control are required. It can be installed in any indoor such as house temple, farm house etc.

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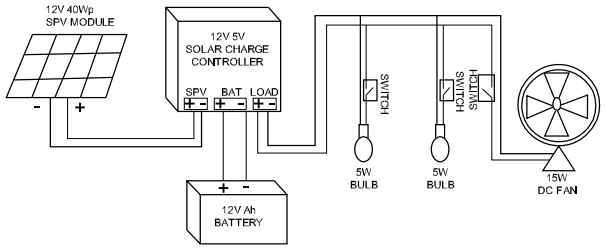
Fig 9



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Circuit diagram of typical Small home lighting system (Fig 10)

Fig 10



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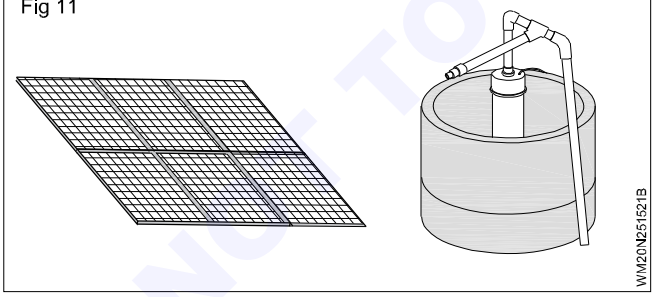
Solar water pump (AC or DC)

A solar-powered pump is a pump running on electricity generated by photovoltaicpanels.The operation of solar powered pumps is more economical mainly due to the lower operation and maintenance costs and has less environmental impact than pumps powered by an internal combustion engine (ICE).

Typical Solar pump system (Fig 11)

Devices involved are a water pump (AC or DC), solar PV array, Pump controller etc.

Fig 11



WM20N251521B

Solar pumps are useful where grid electricity is unavailable and alternative sources (in particular wind) do not provide sufficient energy.

A pump will require a certain amount of electric power to produce a certain amount of pressure and flow. By using suitable size PV array, the water pump can be operated at economical cost. Most solar pumps actually require about 20% more wattage than specified when wiring the panel directly to the pump (If this is the case, the pump manufacturer usually will state this clearly in the product specification literature). Also, having a larger panel will allow the pump to turn on earlier and later in the day and also in relatively lower light conditions. For example, a 1Hp pump requires 1KWp SPV modules.

The solar panels make up most (up to 80%) of the systems cost. The size of the PV-system is directly dependent on the size of the pump, the amount of water that is required (m^3/d) and the solar irradiance available.

Pump Controller is a small device that is installed between the panels and the pump that allows the pump to switch on during low light conditions.

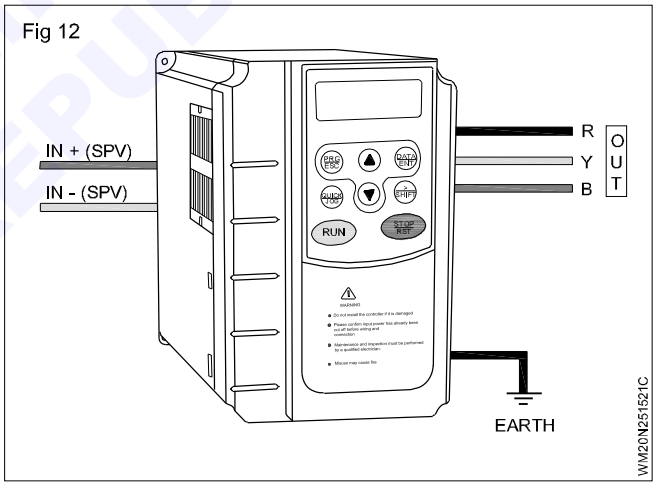
The purpose of the controller is twofold:

- It matches the output power that the pump receives with the input power available from the solar panels
- provides a low voltage protection, whereby the system is switched off, if the voltage is too low or too high for the operating voltage range of the pump.

Solar Pump controller (Fig 12)

Pump is the heart, forgiven power input; the pump produces a unique combination of flow and pressure. These pumps when maintained well last for more than 15 years on the field.

Fig 12



WM20N251521C

D.C. Motor Pump Set with Brushes or Brush Less D.C. (B.L.D.C.):

- 100 liters of water per watt peak of PV array, from a Total Dynamic Head of 10 metres (Suction head, if applicable, minimum of 7 metres) and with the shut off head being at least 12 metres.
- 50 liters of water per watt peak of PV array, from a Total Dynamic Head of 20 metres (Suction head, if applicable, up to a maximum of 7 metres) and with the shut off head being at least 25 metres.
- 35 liters of water per watt peak of PV array, from a Total Dynamic Head of 30
- metres and the shut off head being at least 45 metres.
- 21 liters of water per watt peak of PV array, from a Total Dynamic Head of 50 metres and the shut off head being at least 70 metres.

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- 14 liters of water per watt peak of PV array, from a Total Dynamic Head of 70metres and the shut off head being at least 100 metres.
- 9.5 liters of water per watt peak of PV array, from a Total Dynamic Head of 100metres and the shut off head being at least 150 metres.

Installation of solar water pump system

Place of Installation

The Solar Pump system uses the sun light as the source of energy. So the place of installation of the solar pump system shall be

- Free from shadows caused by the trees for Solar array
- Free from shadows caused by the buildings or any erected structures for array
- Free from natural water channels
- Plane area
- Near to the Bore well or the Pump

If the place does not satisfy the above requirements, then it is necessary to prepare the suitable place.

Civil work

Civil work includes the preparation of proper foundation for mounting structure. the number of SPV modules are more and all must be mounted on the same structure. So, the foundation must be strong enough to hold the weight of the SPV module and withstand wind. The civil work includes

- Preparation of the Pit for mounting structure and electrical ground point
- Preparation of the cement concrete
- Erection of the Structure

Electrical connection

The electrical connection is the process of connecting all the devices electrically together. The typical electrical circuit diagram of Solar pump system is as shown in figure below:

Maintenance of solar water pump system

Routine Maintenance

A solar electric system that is properly maintained requires very little maintenance. The routine maintenance includes SPV modules, Controller and all electrical contacts.

Module Maintenance

Cleaning of the SPV module needs careful attention as it is mounted on a single pole at a height of 6/8 feet and must be done every month as it is mounted in the field and dust accumulations can be fast.

Keeping the glass surface clean is the most important task. Dust and shade will reduce the electric output. Clean the module with water and if necessary a mild soap. Do not allow a plant or a tree to shade the panel.

Checking Connections

Inspect the junction box on the back of each panel to make sure that the wiring is tight. Make sure those wires have not been chewed by rats and that there are no insects etc, living in the junction boxes

Wiring and control

If the wiring is installed properly, there should be no wiring problems for the life of the system. However, it is useful to check the wiring of the system at least once a year, especially in places where it might be damaged by animals, tampered with or accidently.

Solar day lighting

Objectives: At the end of this lesson you shall be able to
- **state solar day lighting.**

Solar day lighting, also known as daylighting, is the practice of utilizing natural sunlight to illuminate indoor spaces during daylight hours, reducing the need for artificial lighting. It involves the strategic placement of windows, skylights, light shelves, and other architectural elements to maximize the penetration of natural light into a building.

The benefits of solar day lighting are numerous. First and foremost, it significantly reduces the dependence on electric lighting, resulting in lower energy consumption and decreased utility costs. By harnessing the sun's rays, buildings can minimize their carbon footprint and contribute to a more sustainable future.

Daylighting also offers several physiological and psychological advantages. Natural light is known to improve mood, productivity, and overall well-being. It provides a connection to the outdoors, creates a sense of spaciousness, and enhances the visual comfort of occupants. Studies have shown that exposure to natural light during the day can positively impact people's circadian rhythms, leading to better sleep patterns and overall health.

Moreover, daylighting can enhance the aesthetic appeal of a space, highlighting architectural features and providing a more visually pleasing environment. It can also reduce the reliance on artificial cooling and heating systems, as natural light brings in solar heat gain during colder months and can be effectively controlled with shading devices during warmer periods.

To maximize the benefits of solar day lighting, proper design and consideration of building orientation, window placement, glazing options, and shading strategies are crucial. Additionally, integrating lighting controls and sensors can optimize the balance between natural and artificial lighting, ensuring optimal illumination levels throughout the day.

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In conclusion, solar day lighting is an effective and sustainable approach to illuminate indoor spaces, offering numerous advantages for energy efficiency, occupant well-being, and aesthetic appeal. By harnessing the power of natural sunlight, buildings can create healthier and more environmentally friendly environments.

Solar quality standards

Objectives: At the end of this lesson you shall be able to
- **state solar quality standards.**

Solar quality standards play a crucial role in ensuring the reliability, performance, and safety of solar energy systems. These standards are developed and enforced by various organizations and regulatory bodies to provide guidelines for manufacturers, installers, and consumers in the solar industry. Here is an overview of some key solar quality standards:

International Electro technical Commission (IEC) Standards: The IEC has developed several standards related to solar photovoltaic (PV) systems. These include standards for PV modules (IEC 61215), inverters (IEC 62109), and grid integration (IEC 61727). These standards cover aspects such as design, construction, performance, and safety requirements.

National Electrical Code (NEC): The NEC, published by the National Fire Protection Association (NFPA), provides guidelines for electrical installations, including solar PV systems. It covers requirements for wiring, grounding, overcurrent protection, and system disconnects to ensure safe and code-compliant installations.

International Organization for Standardization (ISO) Standards: ISO has developed standards related to solar energy systems, including ISO 9001 (quality management systems) and ISO 14001 (environmental management systems). These standards provide a framework for organizations to establish and maintain quality and environmental management practices.

Compliance with these standards helps to ensure that solar energy systems are manufactured to rigorous quality criteria, perform reliably over their expected lifespan, and meet safety requirements. It also provides consumers with confidence in the products and promotes market growth by establishing consistent quality benchmarks.

When considering a solar energy system, it is important to check if the components and installation comply with relevant quality standards. Working with certified installers and reputable manufacturers who adhere to these standards can help ensure a high-quality and durable solar system for your needs.

List out inventory equipment required for solar system

Objectives: At the end of this lesson you shall be able to
- **explain inventory equipment required for solar system**

Inventory Equipment Required for a Solar System

Solar Panels: These are the main component of a solar system and are responsible for converting sunlight into electricity. They come in various sizes and types, such as monocrystalline, polycrystalline, and thin-film.

Mounting Structures: These are used to install the solar panels on rooftops or on the ground. Mounting structures ensure the panels are securely positioned and angled optimally to maximize sunlight absorption.

Inverters: Solar inverters convert the direct current (DC) generated by the solar panels into alternating current (AC), which is the type of electricity used in households and businesses. There are different types of inverters available, including string inverters, micro inverters, and power optimizers.

Batteries: Solar batteries are used to store excess energy generated during the day for use during periods of low or no sunlight, such as at night or during cloudy days. These batteries are typically deep-cycle batteries designed to withstand frequent charge and discharge cycles.

Charge Controllers: Charge controllers regulate the amount of electricity flowing from the solar panels to the batteries. They prevent overcharging and extend the lifespan of the batteries.

Wiring and Cables: Various types of wiring and cables are required to connect the solar panels, inverters, batteries, and charge controllers. These include solar panel cables, DC cables, and AC cables.

Disconnect Switches: Disconnect switches are installed to isolate the solar system from the grid or other power sources for maintenance or safety purposes. They provide a means to shut off the electricity flow.

Monitoring Systems: These systems allow homeowners or system operators to monitor the performance of the solar system. They provide real-time data on energy production, consumption, and system health.

Surge Protectors: Surge protectors are used to protect the solar system from voltage spikes and power surges that can damage the equipment. They help ensure the longevity and reliability of the system.

Electrical Panels: Electrical panels are used to distribute the electricity generated by the solar system throughout the building or facility. They also house circuit breakers or fuses for protection against overcurrent.

Grounding Equipment: Grounding equipment is essential for safety purposes. It ensures that any excess electricity is safely discharged into the ground, protecting people and equipment from electrical hazards.

Tools and Accessories: Various tools and accessories such as crimping tools, connectors, mounting hardware, and test equipment are required for the installation, maintenance, and troubleshooting of a solar system.

It's important to note that the specific inventory equipment required for a solar system may vary depending on the size and type of system, local regulations, and individual project requirements. Consulting with a solar installer or professional is recommended to determine the exact equipment needed for a specific solar system installation.

Solar security system

Objectives: At the end of this lesson you shall be able to
- **explain solar security system.**

Solar security system is an innovative and environmentally friendly solution designed to protect homes and businesses while harnessing the power of the sun. This advanced system incorporates solar energy to ensure round-the-clock surveillance and enhanced security measures. With its numerous benefits, it has gained popularity as a sustainable and reliable alternative to traditional security systems.

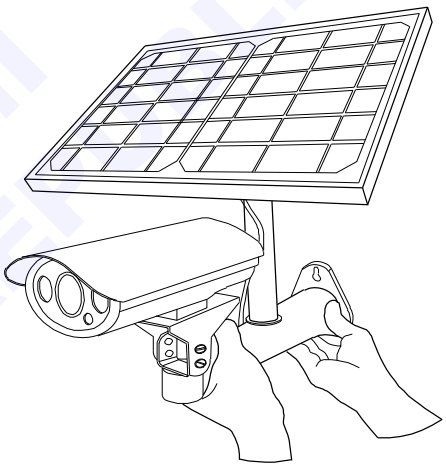
The key component of a solar security system is the solar panel array. These panels, usually installed on the roof or in an area with maximum sun exposure, capture sunlight and convert it into electricity. This renewable energy powers the entire security system, eliminating the need for grid-based electricity and reducing carbon emissions. It also ensures uninterrupted operation, even during power outages or in remote locations without access to electrical infrastructure.

Solar security systems typically feature a range of advanced components, including motion sensors, security cameras, alarms, and monitoring devices. These elements work together to detect and deter potential intruders effectively. Motion sensors activate the security cameras, which capture high-definition video footage of any suspicious activity. This footage can be accessed remotely through a mobile app or a computer, allowing homeowners or business owners to monitor their property from anywhere at any time.

Furthermore, solar security systems can be integrated with smart home technology. This allows for seamless integration with other devices, such as smart locks, door/window sensors, and lighting systems. Users can remotely control and automate these features, enhancing the overall security and convenience of their property.

One of the significant advantages of a solar security system is its cost-effectiveness. While the initial installation may require an investment, the long-term benefits outweigh the upfront expenses. Solar energy is free and abundant, significantly reducing operational costs. Additionally, solar security systems require minimal maintenance compared to conventional systems, further saving time and money.

Fig 1



SOLAR SECURITY SYSTEM

WM20N2515221

Differentiate AC and DC solar pumps and for various HP capacities

Objectives: At the end of this lesson you shall be able to
- **state the difference between AC and DC solar pumps.**

AC and DC solar pumps are two different types of pumps used in solar-powered water pumping systems. Here's a comparison of the two in terms of their working principles and applications, focusing on various horsepower (HP) capacities.

AC Solar Pumps

AC solar pumps are designed to run on alternating current (AC) power, which is the standard electrical power supplied by utility grids. They typically consist of an electric motor and a controller. The controller converts the DC power generated by solar panels into AC power to drive the motor. Here are some key points regarding AC solar pumps:

HP Capacities: AC solar pumps are available in various HP capacities, ranging from low-power applications (e.g., 0.5 HP) to higher-power applications (e.g., 10 HP or more). The specific HP capacity required depends on factors such as the desired flow rate and the total dynamic head (TDH) of the water pumping system.

Applications: AC solar pumps are commonly used for larger-scale applications, such as agricultural irrigation, water supply for residential or commercial buildings, and industrial processes. They are suitable for situations where a high flow rate or water pressure is required.

Advantages: AC solar pumps offer several advantages, including higher efficiency, longer lifespan, and better performance under variable solar conditions. They can handle large flow rates and high TDH requirements, making them suitable for demanding applications. Additionally, they can be integrated with grid power or generators for continuous operation during low sunlight periods.

DC Solar Pumps

DC solar pumps are specifically designed to run on direct current (DC) power, which is produced by solar panels without the need for an additional controller. These pumps generally consist of a brushless DC motor and a controller built into the pump itself. Consider the following points regarding DC solar pumps:

HP Capacities: DC solar pumps are available in various HP capacities, ranging from low-power applications (e.g., 0.1 HP) to moderate-power applications (e.g., 3 HP or more). The appropriate HP capacity depends on the required flow rate and TDH.

Applications: DC solar pumps are often used in smaller-scale applications, such as residential water supply, livestock watering, pond circulation, and small-scale irrigation. They are suitable for situations where a moderate flow rate or water pressure is sufficient.

Advantages: DC solar pumps offer certain advantages, including simpler installation and lower upfront costs compared to AC solar pumps. They are generally more suitable for remote locations where grid power is unavailable or unreliable. Additionally, DC pumps have the ability to start and operate at lower solar irradiation levels, enabling them to pump water even on cloudy days.

In summary, AC solar pumps are commonly used for larger-scale applications requiring high flow rates and water pressure, while DC solar pumps are suitable for smaller-scale applications with moderate flow rates and water pressure. The choice between AC and DC solar pumps depends on the specific requirements of the water pumping system, including the HP capacity needed to meet the desired flow rate and TDH.

Solar PV e-learning software

Objectives: At the end of this lesson you shall be able to
- **state Solar PV e-learning software.**

Solar PV e-learning software is a digital educational platform designed to provide comprehensive training and knowledge about solar photovoltaic (PV) systems. It offers a flexible and interactive learning experience for individuals interested in understanding the principles, installation, operation, and maintenance of solar PV technology. With the increasing global demand for renewable energy solutions, this software plays a crucial role in training a skilled workforce to meet the growing needs of the solar industry.

One of the key advantages of solar PV e-learning software is its accessibility. Learners can access the training modules from anywhere, at any time, using a computer or mobile device with an internet connection. This flexibility enables students to study at their own pace and accommodate their learning around their personal or professional commitments.

The software typically consists of a combination of multimedia elements, including video tutorials, interactive simulations, virtual labs, quizzes, and assessments. These resources help learners grasp complex concepts easily and engage with the material effectively. The interactive nature of the software encourages active participation and improves knowledge retention.

Solar PV e-learning software covers a wide range of topics, including solar energy fundamentals, PV system components, site assessment, system design, installation techniques, safety protocols, troubleshooting, and performance optimization. It provides a comprehensive understanding of the technology, allowing learners to develop the necessary skills to work in the solar industry.

Furthermore, the software often includes real-world case studies and practical examples, offering learners a hands-on learning experience. Virtual labs simulate the installation and maintenance processes, allowing learners to practice their skills in a risk-free environment. These practical exercises help bridge the gap between theoretical knowledge and practical application.

To enhance the learning experience, solar PV e-learning software may incorporate social features, such as discussion forums and peer-to-peer interaction. This fosters a sense of community among learners, encouraging knowledge sharing and collaboration.

In conclusion, solar PV e-learning software is a valuable tool for individuals seeking to gain expertise in solar PV systems. Its accessibility, interactive nature, comprehensive content, and practical exercises make it an effective learning platform. As the demand for renewable energy continues to rise, this software plays a vital role in educating and preparing a skilled workforce to contribute to the growth of the solar industry.

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Underground (UG) cables - construction - types - joints - testing

Objectives: At the end of this lesson you shall be able to
- **explain the construction of UG cables**
- **list and state the insulating materials used in cables**
- **list out and state the types of UG cables advantages and disadvantages**
- **state the types of cable joints and laying methods**
- **explain the faults and testing procedures of cables.**

Under Ground (UG) cables

"A cable so prepared that it can withstand pressure and can be installed below the ground level and normally two or more conductors are placed in an UG cable with separate insulation on each conductor"

Electric power can be transmitted (or) distributed either by over-headlines system or by underground cable system. The underground cable system has several advantage, such

Advantages

- Less chance to damage through storms or lightning.
- Low maintenance cost.
- Less chances of fault.
- Not affected by man- made problems like sabotage, strike etc.
- Voltage regulation in UG cables system is much better, because they have less inductive losses.
- Better general appearance of area compared to O.H lines.

Disadvantages

However, their major drawback / disadvantages are

- Initial cost of UG cable system is heavy.
- The cost of joints is more.
- Introduce insulation problems at high voltages compared with O.H lines.

For these reasons UG cables are employed where it is impracticable to use O.H lines like (i) thickly populated areas, where municipal authorities prohibit O.H lines for the reason of safety.

ii Around plants

iii In Substations,

iv Where maintenance conditions do not permit the use of O.H construction.

The UG cable were used many years for distribution of electric power in congested urban areas to low and medium voltages. Then with improvement and development of design, the manufactures have made it possible to use at high voltage transmission of electric power for same moderate distances.

General construction of UG cables

An underground cable essentially consists of one or more conductors covered with suitable insulation and surrounded by a protecting cover.

Necessity requirements for cables

In general, a cable must fulfill the following necessary requirements.

i The conductor used in cables should be tinned stranded copper or aluminum of high conductivity. (Strands of cable gives flexibility and carry more current).

ii The size of the conductor should be selected, so that the cable carries the desired load current without overheating and limits the voltage drop to a permissible value.

iii The cable must have proper thickness of insulation to ensure the safety and reliability for the designed voltage.

General construction of UG cables

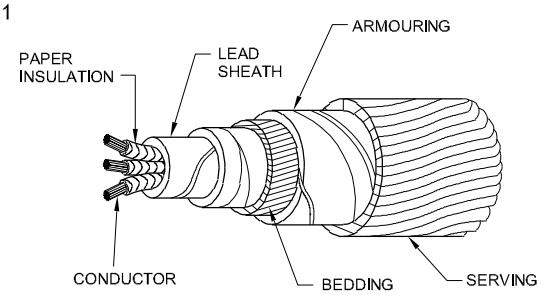
iv The cable must be provided with suitable mechanical protection so that it may withstand the rough use in laying it.

v The materials used in cables should be with complete chemical and physical stability throughout.

Construction of Cables

Fig 1 shows the general construction of a 3-core cable. The various parts are:

Fig 1



CONSTRUCTION OF CORE CABLE

i **Cores or conductors:** A cable may have one or more than one core (conductor) depending upon the type of service for which it is intended. For instance, the 3-conductor cable shown in Fig 1 is used for 3-phase

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service. The conductors are made of tinned copper or aluminium and are usually stranded in order to provide flexibility to the cable and having high conductivity.

ii **Insulation:** Each core or conductor is provided with a suitable thickness of insulation, the thickness of layer depending upon the voltage to be withstood by the cable. The commonly used materials for insulation are impregnated paper, varnished cambric or rubber mineral compound. Petrolium jelly is applied to the layers of the cambric to prevent damage.

iii **Metallic sheath:** In order to protect the cable from moisture, gases or other damaging liquids (acids or alkalies) in the soil and atmosphere, a metallic sheath of lead or aluminium is provided over the insulation as shown in Fig 1. The metallic sheath is usually a lead or lead alloy.

iv **Paper Belt:** Layer of imprignated paper tape is wound round the grouped insulated cores. The gap in the cores is filled with fibrous insulating material (jute etc.)

v **Bedding:** Over the metallic sheath is applied a layer of bedding which consists of a fibrous material like jute or hessian tape. The purpose of bedding is to protect the metallic sheath against corrosion and from mechanical injury due to armouring.

vi **Armouring:** Over the bedding, armouring is provided which consists of one or two layers of galvanized steel wire or steel tape. Its purpose is to protect the cable from mechanical injury while laying it and during the course of handling. Armouring may not be done in the case of some cables.

vii **Serving:** In order to protect armouring from atmospheric conditions, a layer of fibrous material (like jute) similar to bedding is provided over the armouring. This is known as serving.

It may not be out of place to mention here that bedding, armouring and serving are only applied to the cables for the protection of conductor insulation and to protect the metallic sheath from mechanical injury.

Types of UG cables

Further the cables are also classified according to their insulation system as under:

- PVC insulated cables (Poly vinyl chloride)
- PILC cables (Paper insulated lead covered)
- XLPE cables (Cross linked poly ethylene)
- Oil filled cables

PVC UG cable

Objectives: At the end of this lesson you shall be able to
- **explain PVC UG cable.**

PVC UG Cable Overview (Fig 1)

PVC UG cable, also known as PVC Underground cable, is a type of electrical cable commonly used for underground installations. It is designed to be buried directly in the ground, providing a safe and reliable method of transmitting electricity for various applications. Here are some key points about PVC UG cable:

Construction: PVC UG cable consists of multiple conductors made of copper or aluminum, which are insulated with a layer of polyvinyl chloride (PVC). The number of conductors can vary depending on the specific application and requirements.

Insulation: The PVC insulation on the conductors provides electrical insulation and protection against moisture, chemicals, and other environmental factors commonly found underground. It helps to prevent short circuits and ensures the longevity of the cable.

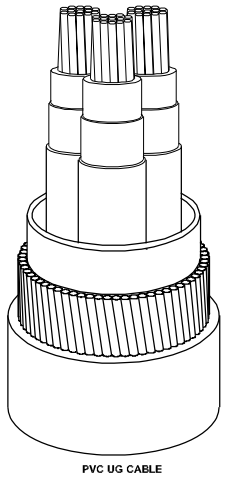
Durability: PVC UG cable is designed to withstand harsh underground conditions, including moisture, soil corrosion, and mechanical stress. The PVC outer sheath provides additional protection against abrasion and mechanical damage.

Voltage and Current Ratings: PVC UG cable is available in different voltage and current ratings to suit various applications. It is commonly used for low voltage installations, such as residential, commercial, and industrial electrical systems.

Installation: PVC UG cable is typically buried in trenches or conduits to protect it from external elements. The cable is resistant to moisture ingress, which makes it suitable for direct burial applications. However, it is important to follow local electrical codes and guidelines for proper installation practices.

Applications: PVC UG cable is widely used for various applications, including power distribution, street lighting, underground wiring for buildings, and outdoor electrical installations. It is also commonly used in agricultural, mining, and industrial settings.

Fig 1



PVC UG CABLE

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PILC under ground cable

Objectives: At the end of this lesson you shall be able to
- **explain PILC cable.**

PILC (Paper-Insulated Lead-Covered) (Fig 1) underground cable is a type of power cable that was widely used in the past for underground power transmission and distribution systems. It consists of a paper-insulated conductor covered with lead for protection against moisture, mechanical stress, and corrosion. PILC cables were commonly employed in electrical grids and urban areas, although they have been largely replaced by more modern cable technologies.

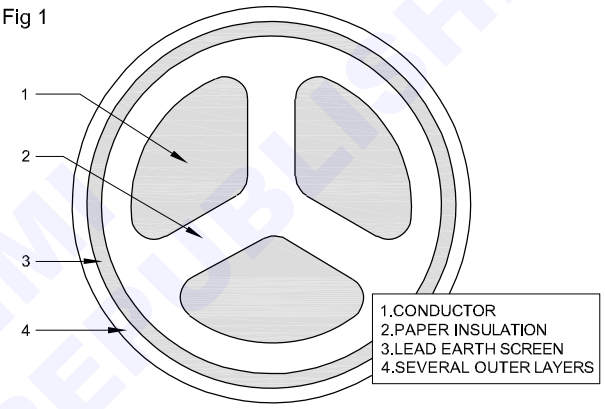
The construction of PILC cables starts with a solid copper or aluminum conductor, which is insulated with several layers of impregnated paper. The paper insulation provides electrical insulation and mechanical strength to the cable. Over the paper insulation, a lead sheath is applied to shield the cable from external environmental factors, including moisture, soil chemicals, and mechanical damage. The lead sheath also acts as a grounding conductor, providing an additional level of safety.

PILC cables were favored for their reliability and durability, with some installations lasting several decades. However, they do have certain limitations. One significant drawback is their susceptibility to degradation over time. The paper insulation can absorb moisture, leading to a reduction in the cable's dielectric strength. Moisture ingress can also cause the paper to deteriorate, resulting in a loss of electrical performance and increased risk of failure.

Additionally, PILC cables have a lower current-carrying capacity compared to newer cable designs. This limitation makes them less suitable for high-demand applications. Moreover, the lead sheath can pose challenges during installation and maintenance due to its weight and inflexibility.

PILC underground cables have played a significant role in the history of power transmission and distribution. However, their usage has declined due to their vulnerability to moisture, limited current-carrying capacity, and the availability of more advanced cable technologies. The industry has transitioned towards more reliable and efficient cable options to meet the growing demands of modern electrical systems.

Fig 1



PILC UG CABLE

XLPE under ground cable

Objectives: At the end of this lesson you shall be able to
- **explain XLPE under ground cable.**

XLPE (cross-linked polyethylene) (Fig 1) underground cables are a type of power cable widely used for transmitting electricity beneath the ground. They offer numerous advantages over traditional cables, making them a popular choice for various applications.

XLPE underground cables are constructed with a solid or stranded copper or aluminum conductor at the core, which is insulated with cross-linked polyethylene. This insulation provides exceptional electrical properties, including high voltage resistance, low dielectric loss, and excellent insulation integrity. XLPE cables have a higher current-carrying capacity compared to PVC (polyvinyl chloride) cables and are capable of operating at higher temperatures.

One of the key advantages of XLPE underground cables is their durability and resistance to environmental factors. The cross-linking process enhances the cable's resistance to moisture, chemicals, and UV radiation, making them suitable for installation in harsh underground conditions. They are also resistant to termite and rodent attacks, reducing the risk of cable damage and power outages.

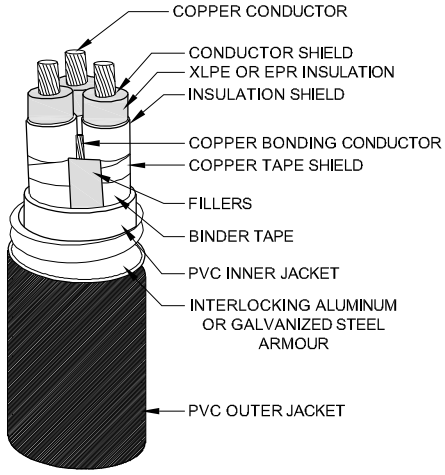
XLPE cables offer efficient power transmission with low losses, ensuring a higher level of energy efficiency compared to other cable types. This translates to reduced energy consumption and cost savings for both utilities and consumers. Additionally, their compact design allows for easier installation, saving time and labor costs.

With their high voltage ratings, XLPE underground cables are used in a wide range of applications, including power distribution networks, industrial plants, underground mining operations, and renewable energy projects. They are also commonly employed for long-distance power transmission, as they can handle high voltage levels while minimizing transmission losses.

XLPE underground cables are a reliable and efficient solution for transmitting electricity below the ground. Their excellent electrical properties, durability, resistance to environmental factors, and high current-carrying capacity make them a preferred choice for various power distribution and transmission applications."

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Fig 1



XLPE UG CABLE

Oil filled cables: In such type of cables, channels of ducts are provided in the cable for oil circulation. The oil under pressure (it is the same oil used for impregnation) is kept constantly supplied to the channel by means of external reservoirs placed at suitable distances (say 500 m) along the route of the cable.

Oil under pressure compresses the layers of paper insulation and is forced into any voids that may have formed between the layers. Due to the elimination of voids, oil-filled cables can be used for higher voltages, the range being from 66 KV upto 230 KV.

Oil-filled cables are of three types viz.

i Single-core conductor channel

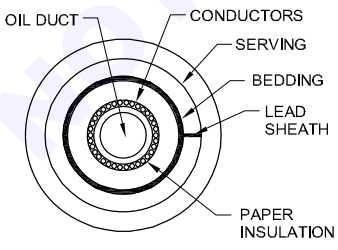
ii Single-core sheath channel and

iii Three-core filler-space channels.

i Single-core Conductor channel

Fig 2 shows the constructional details of a single-core conductor channel, oil-filled cable. The oil channel is formed at the centre by stranding the conductor wire around a hallow cylindrical steel spiral tape. The oil under pressure is supplied to the channel by means of external reservoir. As the channel is made of spiral steel tape, it allows the oil to percolate between copper strands to the wrapped insulation.

Fig 2



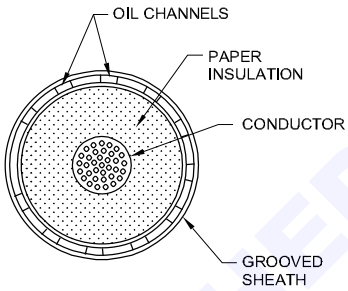
SINGLE - CORE CONDUCTOR CHANNEL OIL - FILLED CABLE

The oil pressure compresses the layers of paper insulation and prevents the possibility of void formation. The disadvantage of this type of cable is that the channel is at the middle of the cable which is at full voltage w.r.t earth, so that a very complicated system of joints is necessary.

ii Single-core sheath channel (Fig 3)

In this type of cable, the conductor is solid similar to that of solid cable and is paper insulated. However, oil ducts are provided in the metallic sheath.

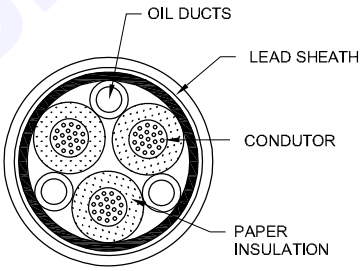
Fig 3



OIL - FILLED CABLES

In the 3-core oil-filled cable shown in Fig 4, the oil ducts are located in the filler space. These channels are composed of perforated metal-ribbon tubing and are at earth potential.

Fig 4



THREE CORE OIL FILLED CABLES

Advantages

a Formation of voids and ionization are avoided.

b Allowable temperature range and dielectric strength are increased.

c If there is leakage, the defect in the lead sheath is at once indicated and the possibility of earth faults is decreased.

Disadvantages

High initial cost and complicated system of laying.

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Cable insulation and voltage grades

Objectives: At the end of this lesson you shall be able to
- **state cable insulation and voltage grades.**

"Cable insulation is a critical component of electrical power transmission and distribution systems. It serves the purpose of providing electrical insulation and mechanical protection to the conductors within the cable, ensuring safe and reliable operation. Insulation materials are carefully selected based on their electrical and thermal properties, as well as their suitability for specific voltage levels.

Voltage grades refer to the different levels of voltage for which cables are designed and rated. These voltage grades are standardized and widely used in the power industry to ensure compatibility and interoperability between different components of the electrical infrastructure.

There are several voltage grades for cables, ranging from low voltage (LV) to high voltage (HV) and extra-high voltage (EHV) applications. The specific voltage grades can vary depending on the country and regional standards, but some commonly used voltage grades include:

Low Voltage (LV): This voltage grade typically covers voltages up to 1,000 volts (1 kV). LV cables are commonly used for residential, commercial, and light industrial applications. They are often installed in buildings for power distribution, lighting, and other electrical services.

Medium Voltage (MV): Medium voltage cables are designed for voltages between 1 kV and 35 kV. They are commonly used for power distribution in urban areas, industrial facilities, and infrastructure projects. MV cables are used for underground and overhead applications, and they are capable of carrying higher power loads over longer distances compared to LV cables.

High Voltage (HV): High voltage cables are designed for voltages above 35 kV and typically range from 66 kV to 550 kV. HV cables are used for long-distance power transmission and interconnection between different regions or countries. They are also employed in large-scale industrial applications and utility substations.

Extra-High Voltage (EHV): EHV cables are designed for extremely high voltages above 550 kV. They are used for ultra-long-distance power transmission, often over hundreds of kilometers. EHV cables are used in large power grids and are vital for connecting remote power generation sources to population centers.

The choice of insulation material for cables depends on the specific voltage grade. Common insulation materials include cross-linked polyethylene (XLPE), ethylene propylene rubber (EPR), and paper-impregnated with oil or synthetic fluid (known as oil-impregnated paper or OIP). Each material has its advantages and limitations in terms of electrical performance, thermal properties, and installation requirements.

Cable insulation is essential for ensuring safe and reliable electrical power transmission and distribution. Voltage grades define the specific voltage levels for which cables are designed and rated. The choice of insulation material depends on the voltage grade and involves a careful consideration of electrical and thermal properties. By selecting the appropriate insulation and voltage grade, we can ensure the efficient and secure operation of power systems.

Joints and termination

Objectives: At the end of this lesson you shall be able to
- **explain pre mouled, heat shrinkable, extrusion moulded joints.**

Pre-molded, heat-shrinkable, extrusion-molded joints in underground (U/G) cables provide reliable and efficient solutions for connecting and protecting cables in various applications. These joints offer numerous advantages over traditional methods, such as ease of installation, improved electrical insulation, and enhanced mechanical strength.

Pre-molded joints are specifically designed to connect two or more underground cables securely. They consist of a combination of heat-shrinkable tubing and molded components made from high-quality materials like polyethylene or polypropylene. These materials provide excellent electrical insulation, ensuring the integrity and safety of the joint.

The installation process of pre-molded joints is straightforward and time-efficient. The joints come pre-assembled with all the necessary components, including stress control tubes, insulation tubes, and outer protective sleeves. During installation, the joint is positioned over the cable ends, and heat is applied using a specialized heat gun or torch. The heat causes the tubing to shrink, creating a tight and seamless seal around the cables.

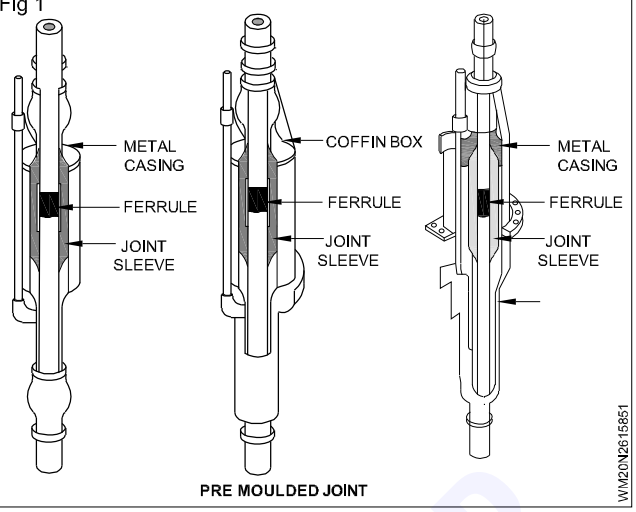
One of the primary advantages of pre-molded joints is their superior electrical insulation properties. The heat-shrinkable tubing forms a continuous barrier that prevents moisture ingress and protects the cables against environmental factors, such as dust, chemicals, and UV radiation. This insulation helps maintain optimal cable performance and minimizes the risk of short circuits or electrical failures.

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In addition to electrical insulation, pre-molded joints offer excellent mechanical strength. The molded components provide robust support to the cables, preventing any stress or strain on the joint. This structural reinforcement ensures long-term reliability, even in demanding underground conditions or when subjected to vibrations or mechanical impacts.

Overall, pre-molded, heat-shrinkable, extrusion-molded joints in U/G cables offer a reliable and efficient solution for cable connections. Their ease of installation, superior electrical insulation, and mechanical strength make them an ideal choice for both new installations and retrofitting projects. With their versatility and durability, these joints ensure the long-term performance and reliability of underground cable systems, contributing to the efficient and uninterrupted transmission of power and data.

Fig 1



PRE MOULDED JOINT

Slip-on cold shrink termination

Objectives: At the end of this lesson you shall be able to
- **explain slip on, clod shrink termination in UG cable.**

A slip-on cold shrink termination is a type of cable termination used in underground (UG) cables. It provides a reliable and efficient method for sealing and terminating cables, ensuring their performance and longevity. In this termination method, a cold shrink tube is used, which is pre-expanded and placed around the cable joint or connection. When the outer packaging is removed, the cold shrink tube shrinks and tightly fits around the cable, providing a secure seal.

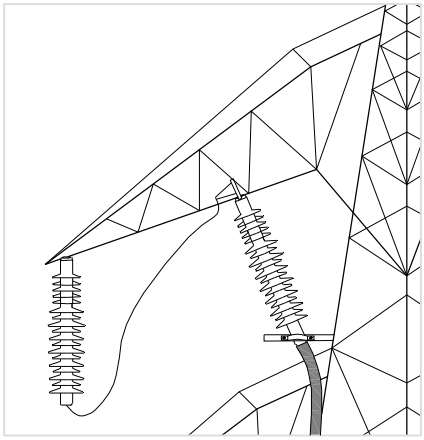
One of the primary advantages of slip-on cold shrink terminations is their ease of installation. Unlike traditional termination methods that require heat shrink techniques or the use of tools, cold shrink terminations can be easily applied by simply removing the packaging and allowing the tube to shrink onto the cable. This eliminates the need for specialized equipment or the risk of heat damage to the cable during installation.

The slip-on feature of cold shrink terminations further simplifies the installation process. The termination can be easily slipped onto the cable, even in confined spaces or areas with limited access. This makes it particularly suitable for applications where maneuverability is a challenge or where there are space constraints, such as underground cable installations.

In addition to their ease of installation, slip-on cold shrink terminations provide excellent electrical insulation and protection. The cold shrink tube is made of high-quality elastomeric materials that offer superior resistance to environmental factors like moisture, UV radiation, and chemical exposure. This ensures the long-term performance and reliability of the cable connection, even in harsh conditions.

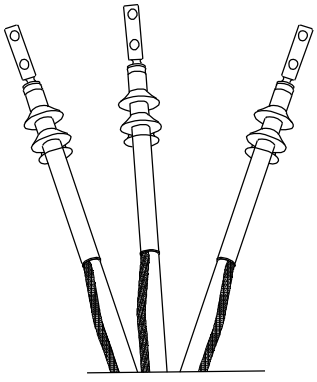
Slip-on cold shrink terminations are a reliable, efficient, and easy-to-install solution for terminating underground cables. With their simple slip-on design, excellent electrical insulation, mechanical strength, and reusability, they provide a comprehensive solution for sealing and protecting cable connections. Whether in industrial, residential, or commercial applications, slip-on cold shrink terminations offer a robust and long-lasting solution for ensuring the integrity and performance of UG cables.

Fig 1



PAT STYLE SLIP ON TERMINATION

Fig 2



15KV COLD SHRINK TERMINATON

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Type of connector used in UG cables

Objectives: At the end of this lesson you shall be able to
- **state type of connector used in UG cables.**

UG cables, also known as underground cables, are electrical power cables that are designed to be installed underground for various applications, such as power transmission and distribution. These cables are used to carry high voltage electricity from power generation stations to substations or directly to consumers. In order to connect and terminate these cables, specific types of connectors are utilized.

One commonly used type of connector for UG cables is the heat shrinkable cable connector. This connector is designed to create a secure and reliable electrical connection between two cable ends. It consists of a heat shrinkable tube made of cross-linked polyolefin material, which shrinks when heat is applied. The connector also includes a metallic core or a solderless crimping system that provides the electrical contact between the cables. Once the connector is installed, heat is applied, causing the tube to shrink and form a tight seal around the cable joint, providing insulation and protection against moisture, dirt, and other environmental factors.

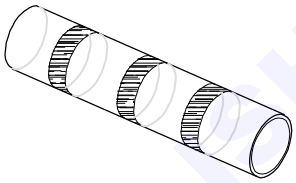
Another type of connector used in UG cables is the cold shrink cable termination. Unlike heat shrinkable connectors, cold shrink terminations do not require heat for installation. Instead, they rely on a pre-expanded silicone rubber sleeve that is stretched onto the cable joint or termination. As the sleeve is released, it contracts and tightly conforms to the cable, creating a seal and providing electrical insulation. Cold shrink terminations are known for their ease of installation and are commonly used in applications where heat sources are not readily available or when heat may pose a safety risk.

In addition to these connectors, UG cables may also use other types of connectors such as bolted connectors or compression connectors. Bolted connectors typically consist of two or more mechanical clamps that are bolted together, providing a reliable electrical connection. Compression connectors, on the other hand, use a compression-type design where the connector is crimped onto the cable using a specialized tool, ensuring a secure and low-resistance connection.

The choice of connector for UG cables depends on various factors such as the cable type, voltage rating, current carrying capacity, environmental conditions, and installation requirements. It is important to select connectors that are specifically designed and rated for underground cable applications to ensure safe and efficient electrical connections.

UG cables use a variety of connectors, including heat shrinkable connectors Fig 1, cold shrink Fig 2 terminations, bolted connectors Fig 3, and compression connectors. These connectors play a critical role in establishing reliable electrical connections in underground cable installations, providing electrical insulation, protection against environmental factors, and maintaining the overall integrity of the cable system.

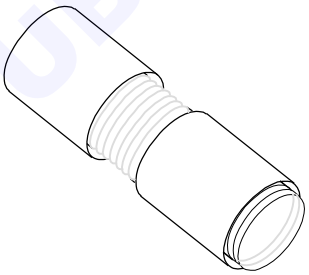
Fig 1



HEAT SHRINK CABLE CONNECTOR

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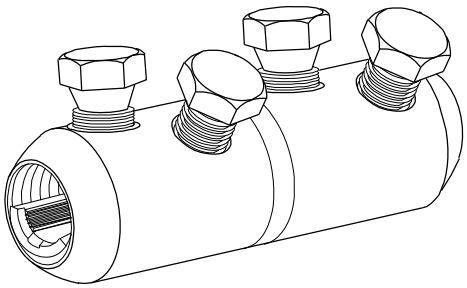
Fig 2



COLD SHRINK TUBE

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Fig 3



SHEAR BOLT CONNECTION

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UG Cable Contact Resistance

Objectives: At the end of this lesson you shall be able to
- **explain UG cable contact resistance.**

Underground (UG) cables are an integral part of electrical power distribution systems, responsible for transmitting electricity over long distances and delivering it to homes, businesses, and industries. Contact resistance refers to the resistance encountered at the points where cable connectors or terminations come into contact with the conductors.

Contact resistance in UG cables is a critical parameter as it directly affects the efficiency and reliability of the power transmission system. Ideally, the connectors should provide a low-resistance path for the current to flow smoothly without significant losses. However, in practical scenarios, contact resistance exists due to various factors.

One primary cause of contact resistance is the imperfect mating between the cable conductor and the connector. Even with carefully designed and manufactured connectors, microscopic irregularities and contaminants can create small gaps or oxide layers that impede the flow of current. These irregularities and contaminants can occur during the manufacturing process or develop over time due to environmental factors such as moisture, dust, or corrosion.

Another factor contributing to contact resistance is the type of material used for connectors and conductors. Different metals have different electrical conductivity properties, and when dissimilar metals come into contact, galvanic corrosion can occur, leading to increased resistance. Proper selection of connector materials and surface treatments can help minimize this effect.

The consequences of high contact resistance include voltage drop, power loss, and increased heat generation at the connection points. These issues can result in inefficient power transmission, reduced system capacity, and potential damage to the cables and equipment. Therefore, regular inspection, maintenance, and cleaning of UG cable connections are essential to ensure optimal performance and prevent failures.

Galvanic corrosion and use of bimetals in UG cable

Objectives: At the end of this lesson you shall be able to
- **explain galvanic corrosion and use of bimetals in UG cable.**

Galvanic corrosion is a type of corrosion that occurs when two different metals are in contact with each other in the presence of an electrolyte, such as moisture. It is an electrochemical process where one metal acts as an anode and the other as a cathode, resulting in the deterioration of the anodic metal.

In the case of underground (UG) cables, which are used for various applications such as power transmission and telecommunications, galvanic corrosion can be a significant concern. These cables are often constructed using bimetals, which are combinations of two different metals. The use of bimetals in UG cables serves multiple purposes, including enhancing conductivity, improving mechanical strength, and reducing costs.

However, when bimetals are employed in UG cables, the risk of galvanic corrosion arises. The dissimilar metals in the bimetallic construction can create a galvanic cell when exposed to moisture or other corrosive environments. The more reactive metal acts as the anode and undergoes corrosion, while the less reactive metal acts as the cathode and remains relatively unaffected.

To mitigate galvanic corrosion in UG cables, several preventive measures are implemented. One common approach is the application of protective coatings or barriers on the surfaces of the metals to prevent direct contact with the electrolyte. These coatings can include materials such as paints, polymers, or insulating tapes.

Another method to reduce galvanic corrosion is the use of sacrificial anodes. These anodes are made of a highly active metal that corrodes preferentially to the bimetal, thereby protecting the more valuable or critical components of the cable. Sacrificial anodes are strategically placed to ensure they take the brunt of the corrosion, preserving the integrity of the UG cable.

Furthermore, proper selection of compatible metals can also minimize galvanic corrosion. By choosing metals with similar electrochemical properties, the potential difference between them is reduced, minimizing the galvanic effect.

In summary, galvanic corrosion is a concern in UG cables that utilize bimetals. Protective coatings, sacrificial anodes, and careful selection of compatible metals are effective strategies to mitigate this form of corrosion and ensure the longevity and reliability of the UG cable infrastructure.

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Connectivity for cable screen and armour, mechanical protection

Objectives: At the end of this lesson you shall be able to
- **explain connectivity for cable screen and armour, mechanical protection.**

"The connectivity between the screen and armor of an underground (UG) cable is a crucial aspect of its design and installation. UG cables are used for various applications, including power transmission and telecommunications, and they require effective protection against external factors and mechanical stresses.

The screen of a UG cable serves as a protective layer that shields the core conductors from external electromagnetic interference. It is typically made of metallic materials, such as copper or aluminum, and is either applied as a metallic tape or a wire braiding around the cable core. The screen needs to be properly connected to ensure its effectiveness. This is achieved by maintaining continuous electrical contact between the screen and the metallic armor of the cable.

The armor, also known as the mechanical protection layer, is designed to provide robust physical protection to the cable against mechanical stresses, such as impacts, abrasion, and tension. It is usually made of steel wires or steel tape, wound around the cable core. The armor ensures the integrity and longevity of the cable in harsh environments, such as underground installations.

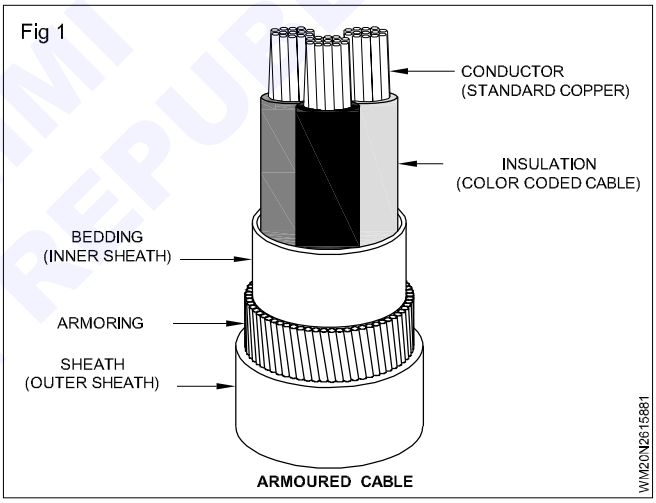
To establish connectivity between the screen and armor, various methods are employed. One common approach involves bonding the screen and armor at regular intervals along the cable's length. This is done by connecting the metallic screen and armor using metallic bonding straps or metallic clamps. These connections are typically made at cable joints, terminations, and at predetermined intervals, ensuring continuous contact between the screen and armor.

The connectivity between the screen and armor is crucial for several reasons. Firstly, it helps maintain the electrical integrity of the cable, ensuring proper shielding against external electromagnetic interference. This is particularly important in power transmission and telecommunications applications, where signal quality and reliability are paramount.

Secondly, the connectivity between the screen and armor ensures that mechanical stresses applied to the cable are effectively transferred to the armor, preventing damage to the core conductors. The bond between the screen and armor enables the cable to withstand external forces, such as bending, pulling, or crushing, without compromising its structural integrity.

In conclusion, establishing connectivity between the screen and armor of an underground cable is vital for ensuring both electrical and mechanical protection. Proper bonding or connection methods must be employed to maintain continuous contact between the metallic screen and armor, allowing the cable to effectively shield against electromagnetic interference and withstand mechanical stresses. This ensures the reliable and durable operation of UG cables in various applications.

Fig 1



Kits for joints and termination in UG cable

Objectives: At the end of this lesson you shall be able to
- **explain kits for joints and termination in UG cable.**

Underground (UG) cables are commonly used for power transmission and distribution, offering several advantages over overhead lines, such as reduced visual impact and enhanced protection against environmental factors. When it comes to joints and terminations in UG cables, specialized kits are essential for ensuring reliable connections and maintaining the integrity of the cable system. These kits typically include various components and materials designed to handle the specific requirements of UG cable installations.

Joint kits for UG cables are used to connect two cable segments together, creating a continuous electrical path. They are crucial for repairs, extensions, or when transitioning from one type of cable to another. These kits generally consist of components like cable lugs, insulation materials, mechanical connectors, and sealing compounds. The cable lugs are used to securely attach the conductors, while the insulation materials ensure electrical insulation and protect against moisture ingress. Mechanical connectors are employed to provide mechanical strength and stability to the joint, while sealing compounds prevent water penetration and safeguard the connection against corrosion.

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Termination kits are used at the ends of UG cables to provide a safe and reliable interface between the cable and the equipment it is connected to, such as transformers or switchgear. These kits generally include components such as cable terminations, stress cones, insulation materials, and sealing systems. Cable terminations ensure proper electrical connection, while stress cones distribute electrical stress and prevent electrical breakdown at the cable end. Insulation materials offer electrical insulation and protect against environmental factors, while sealing systems maintain the integrity of the termination by preventing moisture ingress and maintaining mechanical stability.

Both joint and termination kits for UG cables are designed to meet specific voltage and current ratings, as well as environmental conditions. They undergo rigorous testing to ensure their reliability and adherence to safety standards. Proper installation of these kits is crucial and should be carried out by trained personnel following manufacturer guidelines and industry best practices.

Joint and termination kits for UG cables play a vital role in ensuring reliable connections and maintaining the integrity of the cable system. These kits are carefully designed to meet the specific requirements of UG cable installations, providing electrical insulation, mechanical strength, and protection against environmental factors. Proper selection and installation of these kits are crucial for the safe and efficient operation of UG cable networks.

UG Cable termination to equipment

Objectives: At the end of this lesson you shall be able to
- **state UG cable termination to equipment.**

UG cable termination (Fig 1) refers to the process of connecting underground power cables to electrical equipment in a safe and efficient manner. It is a critical step in establishing reliable and secure electrical connections for various applications, including power distribution, industrial processes, and infrastructure projects.

When terminating an underground cable to equipment, several key considerations must be taken into account. First, the cable must be properly prepared by stripping the outer sheath and removing any insulation layers to expose the conductor cores. This is typically done using specialized cable stripping tools.

Next, the exposed conductor cores are carefully prepared for termination. This involves cleaning, trimming, and shaping the conductor ends to ensure a good electrical contact. The specific preparation requirements may vary depending on the type of cable and the termination method being used.

Once the cable cores are ready, they are connected to the appropriate terminals or connectors on the equipment. This can be achieved through various methods such as crimping, soldering, or mechanical clamping, depending on the application and the equipment manufacturer's recommendations.

It is essential to follow the manufacturer's instructions and industry standards when performing cable terminations. This ensures the integrity of the electrical connection, minimizes the risk of electrical faults or failures, and enhances the overall safety of the installation.

After the termination is complete, the connection should be carefully inspected for proper alignment, tightness, and insulation. Insulating materials, such as heat-shrink tubing or insulating tape, may be applied to protect the termination from moisture, dust, and other environmental factors.

Finally, testing procedures should be conducted to verify the integrity of the termination. This may include insulation resistance testing, continuity checks, and insulation voltage withstand tests, among others.

Fig 1



UG Cable termination to equipment

Routine Field test, stress control for UG cable

Objectives: At the end of this lesson you shall be able to
- **state routine Field test, stress control for UG cable.**

Routine field testing and stress control for underground (UG) cables are essential to ensure their proper functioning and longevity. These tests help identify any faults or weaknesses in the cables and enable preventive measures to be taken to avoid potential failures. The following are some key aspects of routine field testing and stress control for UG cables.

Insulation Resistance Test: This test measures the integrity of the cable insulation by applying a high DC voltage between the conductor and the metallic sheath or earth. A low insulation resistance reading indicates a possible insulation breakdown or moisture ingress.

High Voltage Withstand Test: This test assesses the cable's ability to withstand high voltage levels without breakdown. A higher than normal voltage is applied for a specific duration, and any insulation failure or breakdown is observed.

Cable Sheath Continuity Test: It verifies the continuity of the metallic sheath or armor of the cable. A low-resistance reading indicates a good sheath connection, while a high-resistance reading may suggest a faulty connection or damage to the sheath.

Partial Discharge Test: This test detects and measures partial discharges within the cable insulation. Partial discharges are localized electrical discharges that can lead to insulation degradation over time. Detecting and monitoring these discharges helps prevent major failures.

Temperature Rise Test: This test evaluates the cable's ability to handle current flow without excessive temperature rise. By measuring the temperature at various points along the cable, any abnormal heating or hotspots can be identified, indicating potential faults or overload conditions.

Cable Route and Stress Control: Proper cable routing and stress control techniques are essential to minimize mechanical stress on the cables. Excessive bending, pulling, or crushing can lead to insulation damage or premature failure. Cable support systems, such as trays, clamps, or conduits, are used to ensure proper alignment and support.

Cable Tension Control: Tension control is crucial during cable installation and maintenance. Improper tension can lead to mechanical stress and elongation, affecting the cable's electrical and mechanical properties. Tension monitoring devices and guidelines are followed to maintain optimal tension levels.

Cable Joint and Termination Testing: In addition to the cable itself, joints and terminations are critical points that require testing. Insulation resistance, partial discharge, and other relevant tests are conducted to ensure the integrity of these connections.

Routine field testing and stress control measures for UG cables help identify potential issues before they escalate into major failures. By conducting these tests periodically and adhering to proper stress control techniques, the reliability and lifespan of UG cables can be maximized, ensuring uninterrupted power supply and minimizing downtime.

Cable jointing methods: This process consists of the following steps.

a Exact measurement of the cable for insulation removal.

b Removal of insulation.

c Replacing of the original insulation with high grade tapes and sleeves.

d Dressing the cable ends and conductor joints through sleeves/split sleeves.

e Providing separators between cables.

f Fixing a cast iron or any other protective shell around the joint and filling the joint boxes with molten bitumen compound.

g Plumbing metallic sleeves or brass glands to the lead sheath of the cable to prevent moisture from entering the joint in case of cast iron joint boxes or tape insulation in case of cast resin kit joint boxes.

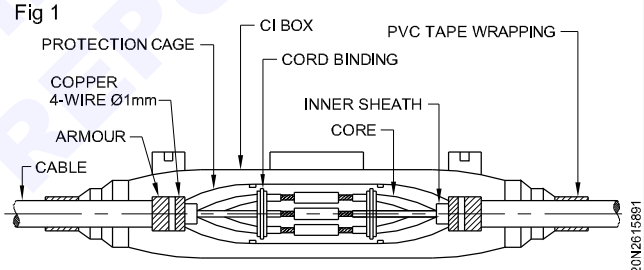
Straight through joints

The emphasis should be laid on quality and selection of proper cable, cable accessories, proper jointing techniques. The quality of joint in cable should be such that, it does not add any resistance to the circuit. The material and techniques employed in joining the cables should give adequate mechanical and electrical protection to the joint under all service conditions. The joints should further be resistant to corrosion and other chemical effects.

For PILC cable: For paper insulated lead sheathed cables, straight joints are made either by using sleeve joints or crimping joints up to voltage grade 11 KV. Above 11 KV, compound filled copper or brass sleeves, along with cast iron, fibre glass protection boxes are used.

Fig 1 shows such a joint.

Fig 1



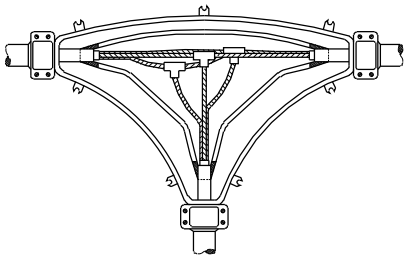
STRAIGHT THROUGH JOINTS FOR CABLES 3.3kV AND 6.6kV GRADE

The cast iron protection boxes used up to 11 KV or moulds used for 1.1 KV joints in cast resin joints should conform to the relevant Indian Standard. Above 11 KV cast resin system is not yet standardized.

Tee joint: These joints are to be restricted up to 11 KV.

These joints are made either using cast resin kits or C.I. boxes with or without sleeves for PILC cables and cast resin kits for PVC and XLPE cables. (Fig 2)

Fig 2



TEE JOINT OF 11 kV PAPER INSULATED CABLE

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EV scenario in India and EV charging

Objectives: At the end of this lesson you shall be able to

- **explain about EV scenario in India**
- **state the basic theory of EV charging batteries**
- **state the safety requirements for EV charging.**

Introduction to Electric Vehicle

In recent years, green house gas problem increases and also the gasoline fuel rate also increases days by day in India and global wide so that public also suffer financially due to this reason, automobile manufacture and new companies put their effort to convert the conventional vehicle into electric vehicle that provide reliable solution.

Electric vehicle is propelled with electric motors and draw power from on board electric source in an electric vehicle, it is more durable and mechanically simpler than gasoline vehicle. It gives more fuel efficiency that gasoline because it does not produce emission like internal combustion engine. However, automobile industry is not completely moving towards pure electric vehicle production, because there is in here problem of existing batteries technology for storing the electric energy.

However now a days increasing the usage of hybrid and electric vehicle in our country and globalise.

Electric Vehicle: This type of vehicle uses one or more electric motor for propulsion. Electric vehicle are the automobiles that are propelled by one or more electric motors using the energy stores in batteries.

India need to reduce dependency on a fossil-fuel based economy. India's crude oil imports for 2021-22 was 163.91 billion dollars approximately 13,000,00 crore rupees.

Air quality indices related to India indicate that the air in many cities of India is no longer healthy. Automobile related pollution has been one of the causes for this.

People living in some of Indian cities are being affected by noise pollution. Some of the Indian cities have the worst noise pollution levels in the world Electric Vehicles may contribute to a reduction in noise pollution levels in the cities.

Current Status of EV in India

The Indian Electric Vehicles (EV) market is at a very initial stage comprising of only 2% of the total automobile sales. 95% of the Indian EV market is dominated by 2 and 3 wheelers. The EV market in India is set to see the entry of a flurry of new players of foreign and domestic origin in the 2 and 3 wheeler segments.

In 2012 the National Electric Mobility Mission Plan (NEMMP) 2020 was established to promote hybrid and Electric Vehicles. In early 2018 the Ministry of Power launched the New National Electric Mobility Programme to focus on creating the charging infrastructure and a policy frame work to set a target of more than 30% electric vehicles by 2030.

EV Charging Basic Theory

EV charging is the process of using EV charging equipment to deliver electricity to the Car's battery AM EV charging stations taps into electrical grid to charge an EV. The technical term for EV charging stations is Electric Vehicle Supply Equipment (EVSE).

Methods of Charring an EV

Three methods of charging an EV (Electric Vehicle)

i Trickle charging method

ii AC charging method (charging from AC mains)

iii DC charging method

Types of Electric Vehicle

i Battery Electric Vehicles (BEVs)

ii Plug-in Hybrid Electric Vehicles (PHEVs)

iii Hybrid Electric Vehicles (HEVs)

Electric traction motor is used in EV. Most EVs can take in about 32 amps adding around 25 miles of Range Per Hour of charging so a 32 amp charging station is a good choice for many vehicles.

Generally electric Cars charged at home use about 7200 watts of electricity which can vary depending on the mode and home charger.

A charging station also known as a charge point or Electric Vehicle Supply Equipment (EVSE) is a piece of equipment that supplies electrical power for charging plug in electric vehicles (including electrical Cars, electrical trucks, electric buses, neighborhood electric vehicles and plug in hybrids).

Hybrid Electric Vehicles (HEVs)

Today's Hybrid Electric Vehicles (HEVs) are powered by an internal combustion engine in combination with one or more electric motors that use energy stored in batteries. HEVs combine the benefits of high fuel economy and low tailpipe emissions with the power and range of conventional vehicles. (Fig 1)

Plug-In Hybrid Electric Vehicles (PHEVs)

Plug-in Hybrid Electric Vehicles (PHEVs) use batteries to power an electric motor and another fuel, such as gasoline to power in Internal Combustion Engine (ICE). The vehicle typically runs on electric power until the battery is nearly

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depleted and then the car automatically switches over to use the internal combustion engine. (Fig 2)

Fig 1

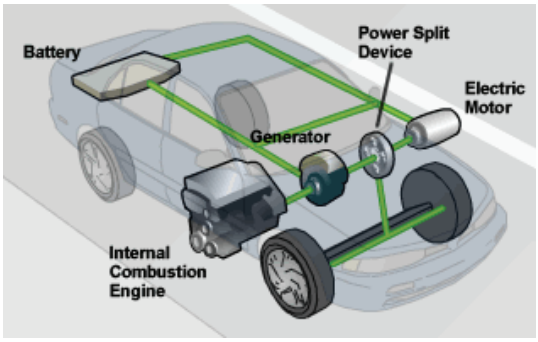
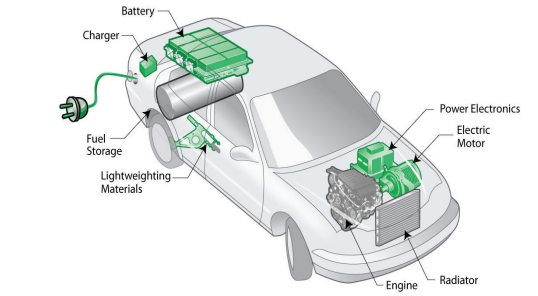


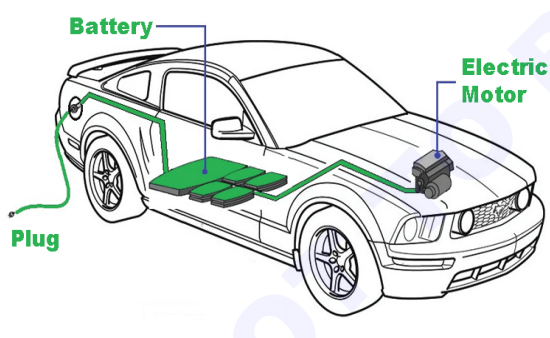
Fig 2



Battery Electric Vehicles (BEVs)

A Battery Electric Vehicles (BEVs), pure electric vehicle, only electric vehicle or all electric vehicle is a type of electric vehicle (EV) that exclusively uses chemical energy stores in rechargeable battery packs, with no secondary source of propulsion (e.g. hydrogen fuel cell, combustion engine etc) (Fig 3)

Fig 3



EV Basic Working Principle

An electric vehicle works on a basic principle of conversion of Electrical energy into mechanical energy. There is a motor used in the electric system to carry on this duty of conversion.

Main Components of EV Chargers

- Battery
- Power Conversion System
- Software

EV battery voltage is 12V for the lead acid battery any typically some where between 400-800 V for the lithium-ion battery pack. Lithium-ion battery capacity is measures in KWH (Kilo Watt Hours). The average capacity is around 40 kwh, but some Cars now have upto a 100 kwh capacity.

EV batteries are projected to last between 1,00,000 and 2,00,000 miles or about 15 to 20 years.

An electric current is a flow of charges particles. The size of an electric current is the rate of flow of charge

Quantity of Charge (Q) = Current (I) x Time (t)

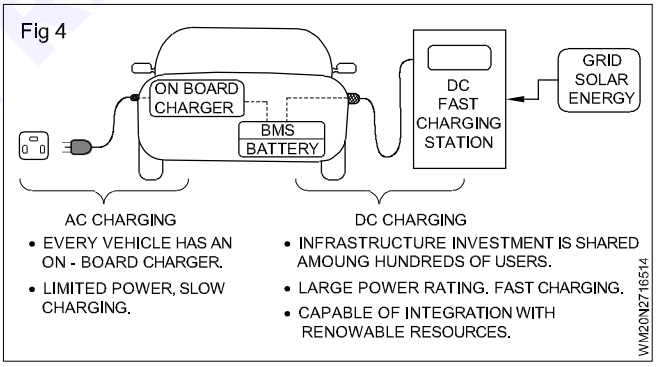
(Q) = It

In rainy season there is no issue regards to driving your EV. Plus even in the worst case there are many protective layers to a car and battery will remain safe and separate itself if at all water come in.

Working of Public charging Stations

- Electricity from the grid is delivered as Alternating Current (AC) but the EV require Direct Current (DC). A rectifier needs to sit between the grid and the battery to convert one of the other. For home and third party public charging this AC-to-DC conversion is done by EV, on-board rectifier. AC current at charge port is converted to DC for the battery by the rectifier.
- Supercharges deliver high voltage, high current DC electricity directly to the EV's battery, by passing the on-board rectifier. This allows the supercharger to push electricity into the battery as fast as the battery can take it- typically ten times faster than home charging. (Fig 4)

Fig 4



- Using induction, which is more energy efficient, the taxis can be charged as they wait in what's known as a taxi rank, or a slow-moving queue where cans line up to wait for passengers.
- The project aims to install wireless charging using induction technology. charging plates are installed in the ground where the taxi is parked and a receiver is installed in the taxi. This allows for charging up to 75 kilowatts.
- The project will be the first wireless fast-charging infrastructure for electric taxis anywhere in the world, and will also help the further development of wireless charging technology for all EV drivers.

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- Fortnum charge & Drive has long been working with the taxi industry to enable electrification of the taxi fleet.

Public charging station (Fig 5)

EV charging Safety Requirements

The global safety standards are marked as following:

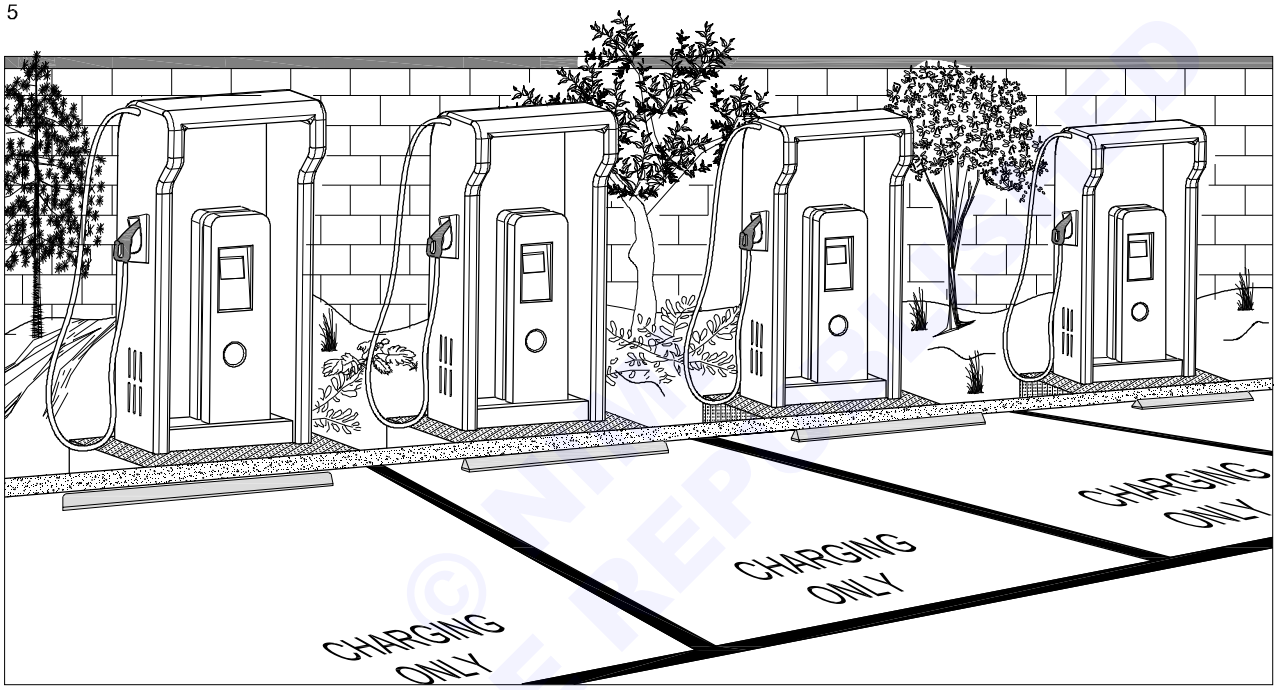
1 Unintended Vehicle Movement

- Indication to driver when vehicle is first put into "active driving possible mode".
- Signal to driver when exciting the vehicle if the vehicle is still in "active driving possible mode".
- Indication to driver of vehicle drive direction

2 Shock Protection

- Protection against direct contact
- Physical barrier/access protection
- Marking (enclosures/electrical protection barriers and colour coding of high voltage wires/cables)
- Protection against indirect contact
- Minimum isolation resistance
- Fuel cell isolation resistance monitoring
- Protection against water effects

Fig 5



3 Elimination Explosive Events

- Vibration (Component test)
- Over Charge Protection
- Over Discharge Protection
- Over Temperature Protection
- Over Current Protection

4 "Rechargeable Energy Storage System (REESS)"

- Installation Integrity/Protection
- Restricts mounting locations for impact protection.
- REESS placed/shielded from contact with road debris
- Shall remain attached and not enter the passenger compartment
- Battery placement management

Indian Safety standards of Electric Vehicles

Some Basic electric Vehicle safety requirement are as follows

- Occupant protection from electric shock
- Safety requirement for rechargeable energy storage systems
- Electrical isolation
- Battery integrity
- Best practices or guidelines for manufactures and/or emergency responders.

Advantages of Electric Vehicles

1 ECO friendly - Because electric vehicles do not utilise fuel for combustion, there are no emissions or gas exhaust.

2 Renewable Energy Source - Electric vehicles run on renewable power, whereas conventional auto- mobiles function on the combustion of fossil fuels which reduces the world's fuel stocks.

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3 Less Noise and Smoother motion - Electricity is far less expensive than fuel such as gasoline and diesel which are subject to regular price increases.

4 Low maintenance - Because electric cars have fewer moving components, wear and tear is reduced when compared to traditional auto parts.

5 Government Support - Governments thought the world have granted tax breaks to encourage people to drive electric vehicles as part of green program.

Disadvantages of Electric Vehicles

1 High Initial Cost - Electric Vehicles continue to be quite expensive and many buyers believe they are not as in expensive as traditional automobiles.

2 Charging Station Limitations- People who need to travel long distances are concerned about finding adequate charging stations in the middle as their journey which are not always accessible.

3 Recharging Takes Time - Unlike conventional automobiles which require only a few minutes to replenish their gas tanks, charging an electric vehicles takes many hours.

4 Limited Options - Currently there are not many electric car models to pick from in terms of appearances style or customized variations.

5 Less Driving Range - When compared to conventional automobiles electric vehicles have a shorter driving range.

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Electric bell and buzzer

Objectives: At the end of this lesson you shall be able to
- **define an electric bell**
- **explain the functioning of interrupter bell**
- **describe the working of buzzer and type of buzzer.**

Electric bell

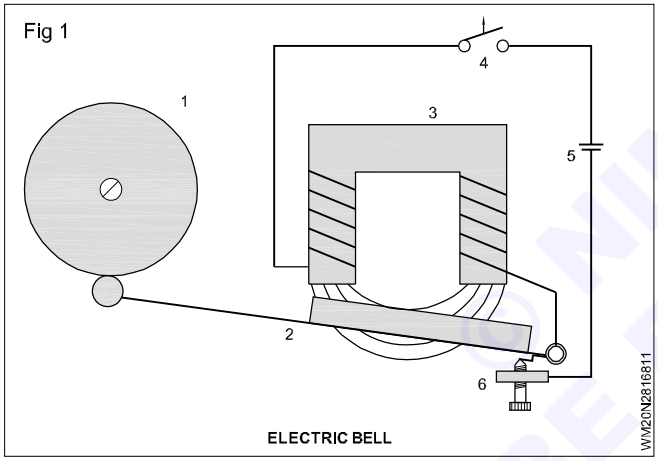
An electric bell is a mechanical bell that works of an electromagnet. When the current is passed through it, produces buzzing sound. It is used in rail road crossings, telephones, fire/burglar alarms, school bells and door bells etc, Now, they are replaced with electronic sounders.

Interrupter Bell

This interrupter bell produces continuous sound when the current is passed through it.

It consists of the following parts (Fig 1).

Fig 1



ELECTRIC BELL

- Bell (or) gang (1)
- Arm (2)
- Electromagnet (3)
- Switch (4)
- Cell (5)
- Electrical contacts (6)

Working

The bell (or) gang (1) is often in the shape of a cup or half - sphere, is struck by a spring loaded arm (2) with a metal ball on the end called a clapper, actuated by an electromagnet (3). In its rest position the clapper is held away from the bell a short distance by its arm.

When an electric current is passed through the winding of the electromagnet, when closing the switch (4) , it makes a magnetic field that attracts the iron arm of the clapper, pulling it over to give the bell a tap. This opens a pair of electrical contacts (6) attached to the clapper arm, interrupting the current to the electromagnet, and it is demagnetized, the clapper releases away from the bell.

This closes the contacts again, allowing the current to flow to the electromagnet again, so the magnet pulls the clapper over to strike the bell again. It repeats several time per second resulting in continuous ringing.

The tone of the sound generated depends on the shape and size of the bell or its natural frequency. Where several bells are installed together. By using different size and shape of gangs, different sounds can be obtained.

Electric buzzer

A buzzer or beeper is an audio signaling device, which may be mechanical, electromechanical (or) piezoelectric.

Types of buzzers

Electromechanical buzzer

The electric buzzer was invented in 1831 by "Joseph Henry'. It is mainly used for doorbell with louder tone.

Early device is based on an electromechanical system identical to an electric bell without the metal gang. Similarly, a relay may be connected to interrupt it's own actuating current causing the contacts to buzz. These unit is attached to a wall or ceiling to use it as a sounding board.

The word 'buzzer' comes from the rasping noise that electro mechanical buzzers made. Mechanical buzzer requires drivers. Joy buzzer is an example of mechanical buzzer.

Piezoelectric buzzer

A piezoelectric element may be driven by an oscillating electronic circuit (or) other audio signal source, driven with a piezoelectric audio amplifier. Sounds commonly used to indicate that a button has been pressed are a click a ring (or) a beep.

Application of buzzers

The present day applications of buzzers are

- In modern Toys and entertainment games.
- Judging panels.
- Educational purposes.
- Announciator panels.
- Game show- lock - out device.
- Microwave ovens and other house hold appliances.
- Sporting events.
- Electrical alarms.

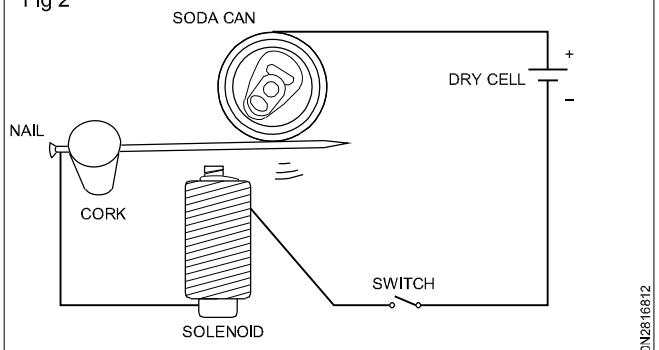
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Working of buzzer

The connection of the simple buzzer is shown in the Fig 2. When the circuit is closed, the current flows from the battery through the coil around the bolt (an electromagnet) The nail file and the soda can (Fig 2), so the solenoid is magnetized immediately. Since the nail file is magnetic, it is attracted towards the coil- when nail file and the soda can are no longer touching, the connection is disconnected and stops the current flow (Fig 3). This demagnetizes the coil causing the nail file to return back to it's original position, where it strikes the soda can to make a sound.

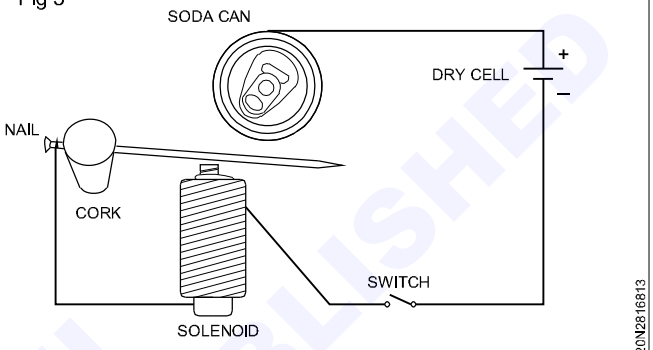
Then the circuit completes the current flow again and repeats the cycle. Each time the nail strikes back at the can, a sound is produced. Depending on the distance between the electromagnet and the nail several sound is produced.

Fig 2



BUZZER CIRCUIT IN CLOSED POSITION

Fig 3



BUZZER CIRCUIT IN OPEN POSITION

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Non - automatic electric iron

Objectives: At the end of this lesson you shall be able to
- **state the function and parts of an electric iron from the constructional diagram.**

Electric iron

An electric iron is a heating device in which the heat is concentrated on a smooth, flat, bottom surface which is applied to the fabrics to be ironed.

The electric iron will probably be the first appliance that an individual will be called upon to repair when entering the appliance servicing field. In spite of the fact that irons are quite inexpensive, many old irons are in use today.

Types of electric irons : There are three general types of electric irons:

– the non-automatic electric iron

– the automatic electric iron

– the steam iron.

The automatic iron is rapidly replacing the non-automatic iron.

Parts of an Electric Iron

The flat bottom surface is called the sole-plate.

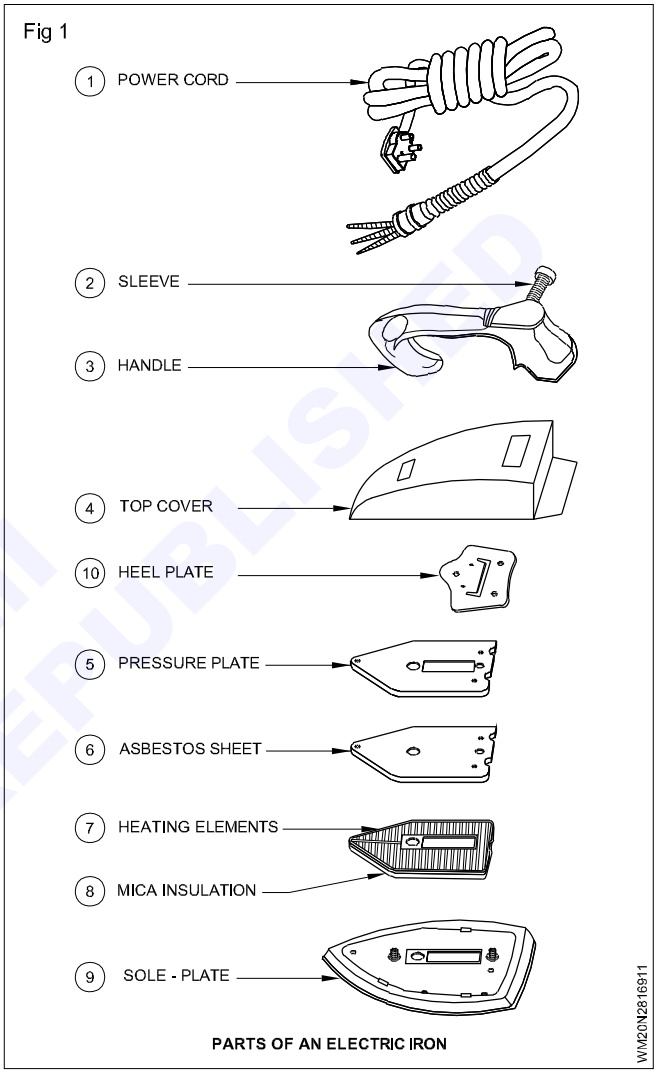
The sole-plate is heated by an element made of resistance wire or ribbon (Nichrome), placed in or on the sole-plate. Thus, the iron converts electricity into heat at the sole-plate, where it can be utilized to iron clothes.

Fig 1 shows the component parts of an ordinary electric iron. The power cord (1) delivers power from the house electrical circuit to the iron. A cord sleeve (2) reduces flexing of the electrical wires as they enter the handle (3).

The cord, cord sleeve and plug cause more iron troubles than any other part or parts of an iron. The cover (4) serves mainly a decorative purpose to hide the unsightly parts below and to keep one's hands away from the electrical terminals. It also serves to keep the heat where it belongs. A pressure plate (5) clamps the heating element (7) to the sole-plate (9) with an electric insulator (8) in between. The asbestos sheet (6) placed in between the pressure plate and the heating element provides heat insulation and reduces the heat being transferred upwardly towards the cover and the handle. The heel plate (10) allows the iron to be tilted back on its handle when the iron is not in use.

Modern irons use a permanently attached cord rather than the detachable cords which can be misplaced easily. One advantage of the permanent cord is that the wall plug is the only electric disconnecting point in the circuit.

Fig 1



PARTS OF AN ELECTRIC IRON

With detachable cords, resistive oxides may form at the iron connector. The resistive oxides formed will in course of time reduce the current input to the heating element.

The electric circuit of any iron is very simple. In many irons it is nothing more than a heating element with a cord and plug attached to connect it to an outlet.

Note that the only troubles possible in this circuit are short circuits and open circuits. Fig 2 shows the four possible parts of the circuit which may be defective. This is an electric diagram of the simple non-automatic type of iron and does not show other non-electrical parts such as the handle cover and sole-plate.

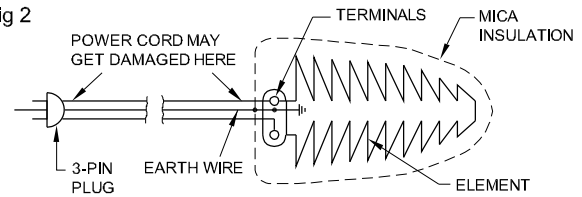
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There are six basic steps you should follow to effect an efficient, prompt repair.

– Conduct a visual examination.
– Listen to the customer's complaint.
– Conduct preliminary tests.
– Repair the iron.
– Make final tests.
– Prepare the iron for delivery.

These basic steps, while not necessarily rigid, provide a good working procedure for the repair of all types of electrical appliance.

Fig 2



CIRCUIT OF AN ELECTRIC IRON

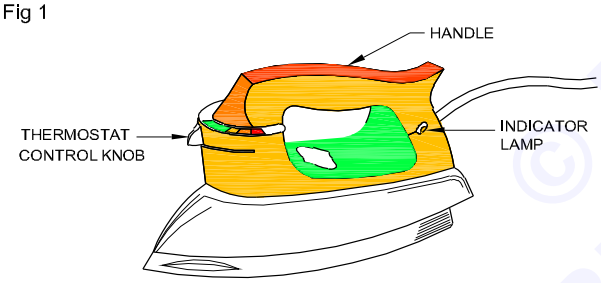
Automatic electric iron

Objectives: At the end of this lesson you shall be able to
- **state the function and parts of automatic irons**
- **describe the construction of a bimetal thermostat**
- **illustrate the working of an adjustable thermostat.**

Automatic electric iron

The difference between an automatic iron and the ordinary (non-automatic) iron is that the automatic type has a thermostatic device to regulate the temperature. The other parts are more or less the same in both the types of irons. (Fig 1)

Fig 1



AUTOMATIC ELECTRIC IRON

Automatic irons are fitted with a thermostatic switch to regulate the heat to a specific predetermined value. The thermostatic switch disconnects the supply when the predetermined value is reached and reconnects the supply when the iron cools down. A turning knob with a dial just below the handle, marked as rayon, cotton, silk, wool etc. can be operated to select the preset temperature.

They are two types of automatic electric iron, they are:

1 Dry Automatic Iron

2 Spray/Steam Automatic Iron

Thermostats

A thermostat is a switch which can be designed to close or open a circuit at predetermined temperature. One of the simplest and most dependable components in the modern heating appliances is the BIMETAL THERMOSTAT. It controls the temperature in stoves, toasters, food warmers, irons etc. It serves as a safety device to prevent overheating of the appliances.

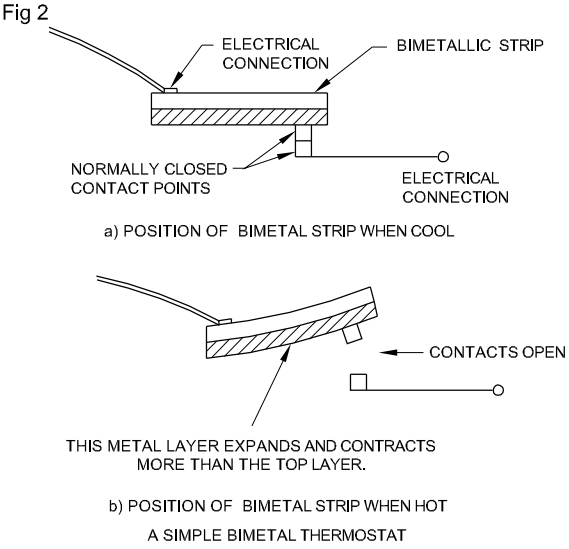
Bimetal thermostat (Fig 2)

In the thermostat there is a bimetal strip made of two strips of metal with different expansion rates welded together. The metal strip expands when heated and contracts when cooled. One metal in the bimetal strip has a high rate of expansion when heated, and the other has a low rate.

When a bimetal strip is heated, both the metals in the strip expand but the one at the bottom with a higher rate of expansion expands faster and forces the upper half to curl up or bend away from the contact point (Fig 2b). The strip curls or bends enough to break the contact, opening the circuit.

As the strip cools, it straightens and restores contact with the stationary point. The bending of the bimetal strip on heating, is towards the side that has the smaller expansion rate.

Fig 2



A SIMPLE BIMETAL THERMOSTAT

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Adjustable thermostat (Fig 3)

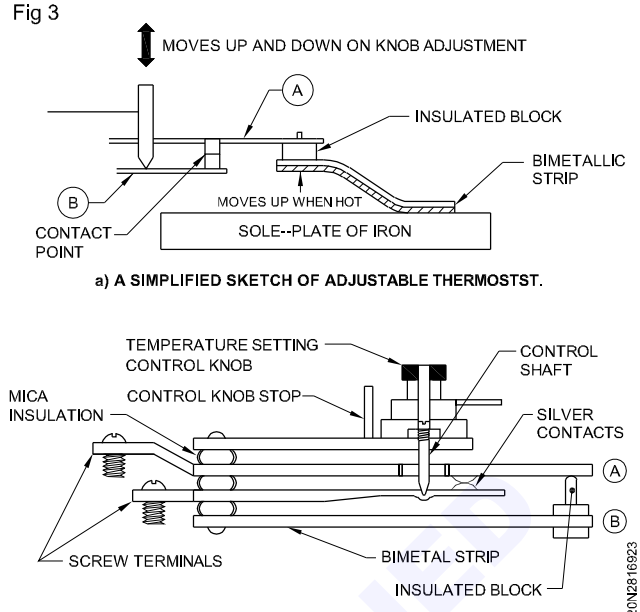
The operation of the thermostat is as follows. The strip B (Fig 3 (a) part B) along with the silver contact is designed such that it has upward tension whereas the control shaft moves the strip B either upward or downward depending upon the temperature setting.

The strip A (Fig 3(a) part A) along with its silver contact is designed such that it has downward tension. But its downward movement is restricted by the insulated block.

In the 'OFF' position of the temperature setting control knob, the strips A and B will be away from each other, keeping the silver contacts in an opened condition, thereby, keeping the heating element circuit open.

When the temperature setting control knob is set to minimum position, the control shaft moves up and allows the strip B and its silver contact to move upwards to some distance and make contact with the silver contact of the strip A.

Fig 3



a) A SIMPLIFIED SKETCH OF ADJUSTABLE THERMOSTST.

b) OPEN FRAME BIMETALLIC ADJUSTABLE THERMOSTAT.

Electric kettle

Objectives: At the end of this lesson you shall be able to
- **define electric kettle and its types**
- **list and state the parts of an electric kettle**
- **describe the method of fitting a new element.**

Electric kettle

Electrical kettle is a heating device which is used to heat the liquid (like water, milk, etc) poured in it.

There are two types of electric kettles:

– Saucepan type

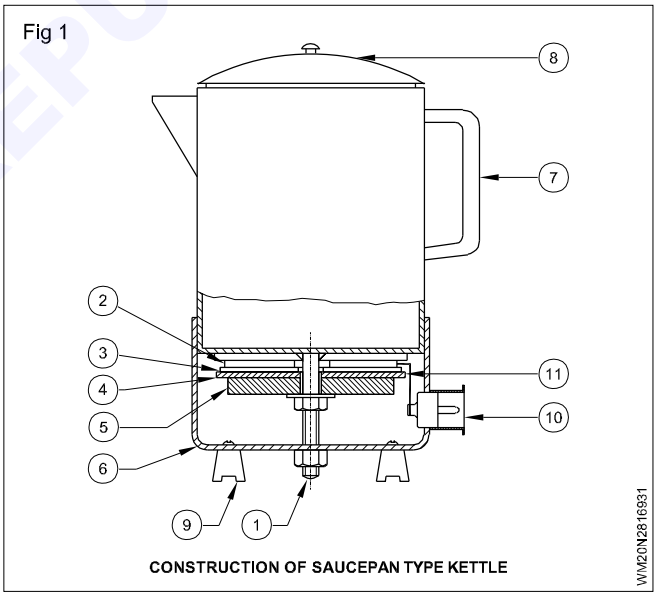
– Immersion heating type.

Saucepan type: The construction of the sauce pan type kettle is given in Fig 1. The parts are as follows.

1 Bolt, nut and washer holding bottom cover
2 Heating element
3 Asbestos sheet
4 Sole-plate
5 Pressure plate
6 Bottom cover
7 Handle
8 Top lid
9 Ebonite leg
10 Outlet socket
11 Brass strips

Bottom cover: The bottom cover is fitted to the central bolt of the body by a nut and washer. On removal of the bottom cover, ready access is made to the terminal and heating element assembly (Fig 1).

Fig 1



CONSTRUCTION OF SAUCEPAN TYPE KETTLE

Heating element: In its general construction, the heating element is made of Nichrome ribbon. The Nichrome ribbon is wound over mica. This is placed between two circular mica pieces, so that the Nichrome wire may not come in contact with any metallic part of the kettle. The two ends of the elements are connected to the outlet socket terminals of the kettle through two brass strips.

Asbestos sheet: This is placed below the element and mica insulation to serve as a heat insulator. It reduces the heat loss in the kettle in addition it gives increased insulation.

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Sole-plate: The sole plate is a cast iron plate neatly ground to have a flat surface and its main function is to keep the element in close contact with the container and to avoid deformation of the element when heated.

Pressure plate: This is made of cast iron and fitted by a nut on the middle bolt. The pressure plate holds the sole plate in position. If this pressure plate is loosely fitted, the sole plate and the element become loose. This leads to expansion and contraction of the element during working and the element will get damaged.

Method of fitting new element: Dismantle the kettle by the following steps.

– Invert the kettle and loosen the bottom cover holding nut. Take out the nut and remove the bottom cover.

– Remove the brass strip connections of the elements at the socket terminal sides.

– Remove the terminal socket by loosening the fitting screws.

– Open the nut of the pressure plate.

– Take out the pressure plate, sole-plate, asbestos sheet and then the heating element.

– Replace with a new heating element having the correct size and rating.

– Reassemble the kettle.

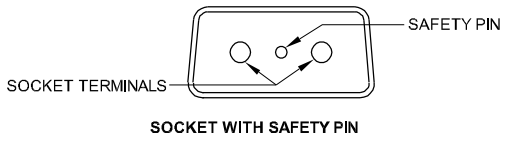
– Test the insulation resistance for any earth fault and insulation failure.

Immersion type: The heating element in this type is of tubular immersion heating design. In some kettles an ejector type safety device is incorporated in the socket terminal side.

In case the kettle is switched ON without water the safety pin (Fig 2) which is soldered against a spring which is under tension comes out and pushes the plug out. This safety pin can be placed in position by soldering. The heating element is concealed inside a hollow tube and mineral insulated (Fig 3).

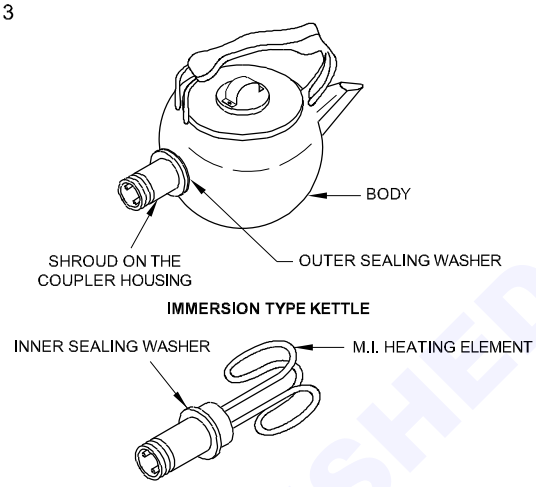
New elements can be fitted to most types of kettles without difficulty.

Fig 2



SOCKET WITH SAFETY PIN

Fig 3



IMMERSION TYPE KETTLE

KETTLE HEATING ELEMENT

Fitting a new element: A new element should be fitted in the following manner.

– Hold the element in one hand and unscrew the shroud on the coupler housing.

– Slide out the outer fibre sealing washer.

– Twist the element assembly inside the kettle and pull it out gently through the top.

– Take the old element to an electric shop to make sure that the replacement is of the exact design and wattage.

– Remove stubborn scales inside the kettle with a blunt knife without knocking the metal surface.

– Put an inner sealing washer, usually made of fibre, on the new element.

– Take care to fit new washers at the coupler housing in the correct order. Reassemble.

Cooking range

Objectives: At the end of this lesson you shall be able to
- **state the concept of neutral and earth**
- **define the cooking range**
- **explain the parts of electric range.**

Cooking range

Electric cooking range is the combination of an oven and hot plate. The electric range consist of highly efficient heating elements, it gives better cooking control, has shelf oven, fingertip controls and designs to fit almost every possible kitchen need.

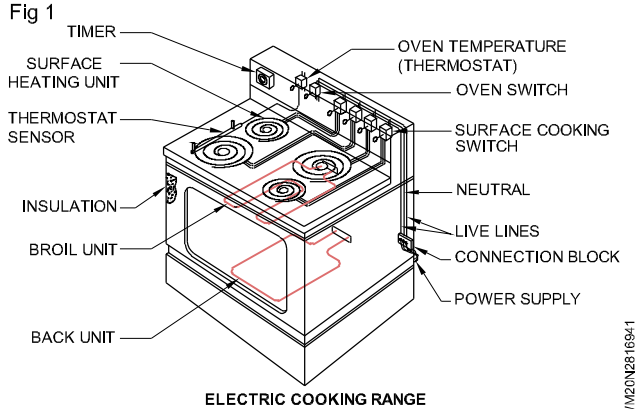
The surface heating units are set in the top of the range, the electric connections for these units are carried in the space between the top of the range (Fig 1). Oven controls are also kept in the top but in separate elevated pedestal.

The parts of a cooking range

Surface heating elements: In present day cooking range the nichrome element is encased in a metal tube with magnesium oxide insulation. This enclosed surface heating element (Fig 2) more efficient, more durable and safe to handle.

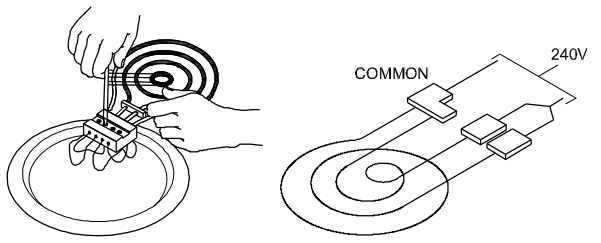
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Fig 1



ELECTRIC COOKING RANGE

Fig 2



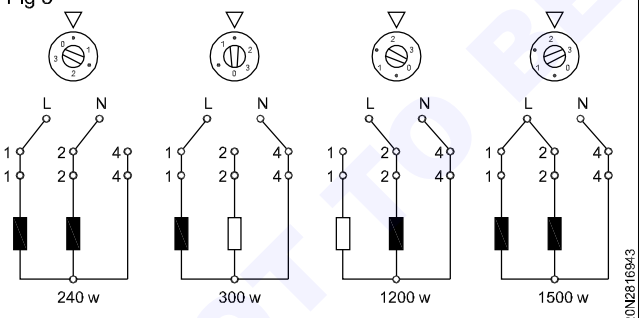
HEATING ELEMENTS

Step/Selector switches: A step switch is simply a rotary switch, which can select four or six different heats (wattages)

The step switch connected to two or three elements to 240 volts. The total circuit resistance or the voltage is changed to provide different heats.

High heat is obtained by connecting total elements in parallel. For low heat all the coils are connected in series (Figs 3).

Fig 3



STEP/SELECTOR SWITCH-4 POSITION

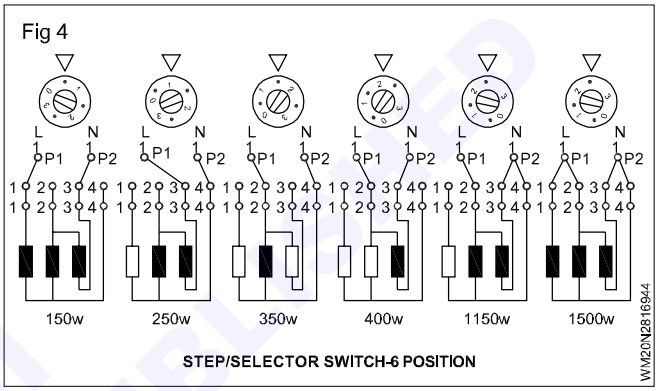
Oven unit: The oven unit consists of two heating elements, an upper element and a lower element.

The oven heat is normally controlled by thermostat and timing device.

In a oven electric circuit, the broil unit is constructed by stringing the element through the frame in two separate coils, whereas the bake unit is strung with only one coil.

Now-a-days instead of thermostat switch, the typical infinite-heat switches are used (Fig 4). This switch operates the internal heater causes the bimetal to open and close the switch that controls the range heater element. This bimetal heater is series the cooking range and must have the correct resistance for the element being controlled.

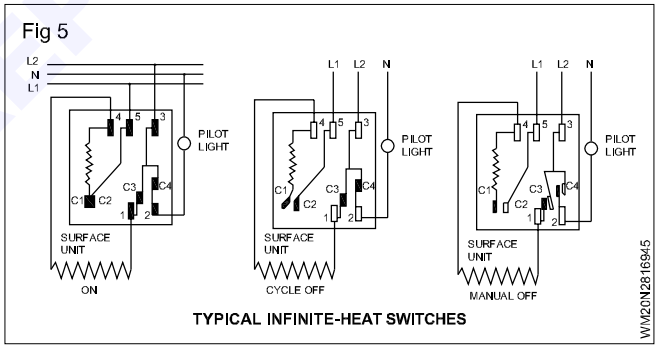
Fig 4



STEP/SELECTOR SWITCH-6 POSITION

A schematic diagram of a typical electric range is given in Fig 5.

Fig 5



TYPICAL INFINITE-HEAT SWITCHES

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Geyser

Objectives: At the end of this lesson you shall be able to
- **define the geyser**
- **list the parts of a geyser from the schematic and constructional diagrams**
- **explain the construction and operation of a geyser**
- **list the care and maintenance practices specific to the geyser.**

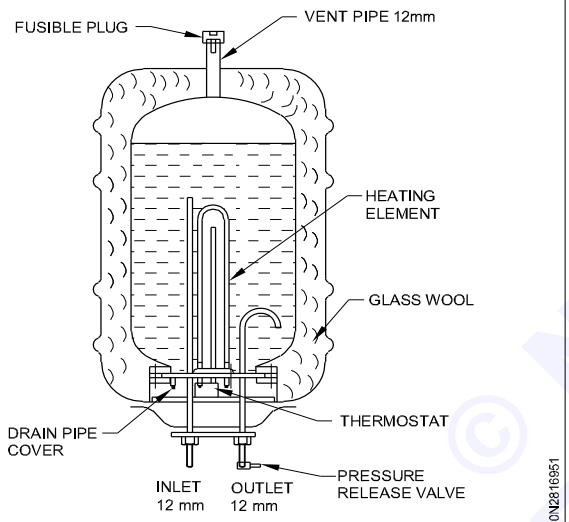
Geyser

It is an electric water heater which heats and maintains the temperature of the water stored in it.

There are several types of water heaters. The most usual one is the geyser, which is more efficient as the hot water can be directly drawn through a tap at different points.

Construction of geysers: The construction of a hot water geyser or storage water heater is simple (Fig 1).

Fig 1



CONSTRUCTION OF GEYSER

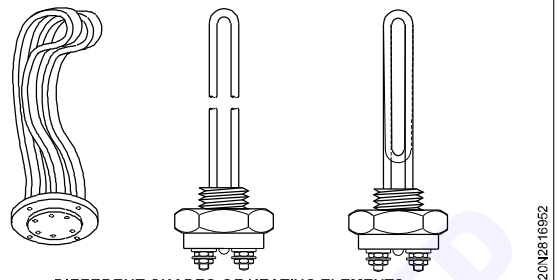
The outer casing is made of mild steel sheet. The inner tank is made of heavy gauge copper which is tinned to prevent corrosion. The space between the outer casing and the inner tank is filled with glass wool as heat insulation to avoid excess heat losses. Heating elements, thermostat, inlet and outlet pipes are fitted to the tank.

Heating elements are similar to those of immersion heaters but with different shapes to suit the tank sizes and the screw base. Fig 2 shows a few shapes of heating elements.

The rating of the heating elements depends on the capacity of the geyser. For up to 25 litres capacity, 1 KW elements are used while for 50 litres capacity 2 KW are used, for 100 litres capacity 3 KW are used.

Thermostats: Thermostats are used in water heaters to control the current to the heating elements and thereby regulate and maintain the water temperature between 32°C to 88°C.

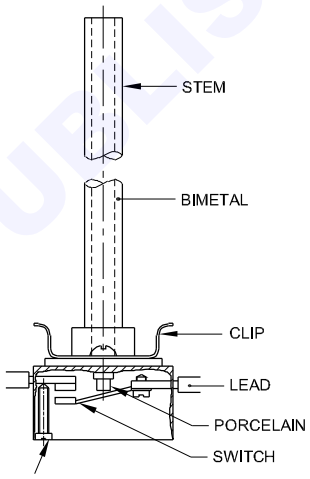
Fig 2



DIFFERENT SHAPES OF HEATING ELEMENTS

A typical thermostat used in geysers: A thermostat used in a geyser is of tube and rod bimetal type (Fig 3).

Fig 3



A TYPICAL TERMOSTAT USED IN WATER HEATER

Thermostats are available in sizes of 8 mm diameter with a length of 175 mm, 275mm or 450 mm depending on the height of the geyser. Thermostats are fixed in a tube and are connected in series with the heating element.

The outlet pipe is provided with a `U' bend inside the tank as shown in Fig 1 to prevent complete draining of water from the geyser. A pilot lamp is fitted on the outer case indicating the automatic working of the unit.

A fusible plug is fitted on the top of the unit to protect the inner tank to release the excess pressure that may be developed due to failure of the thermostat.

Working: When a geyser is fitted initially, open the inlet cock, fill the inner tank and maintain the water level. When switched `on' the heater heats the water. When the temperature of water reaches to a set value the thermostat disconnects the heater from the supply. (Fig 3) The water drawn from the outlet pipe reduces the temperature and hence the thermostat, re-connects the heater with the supply.

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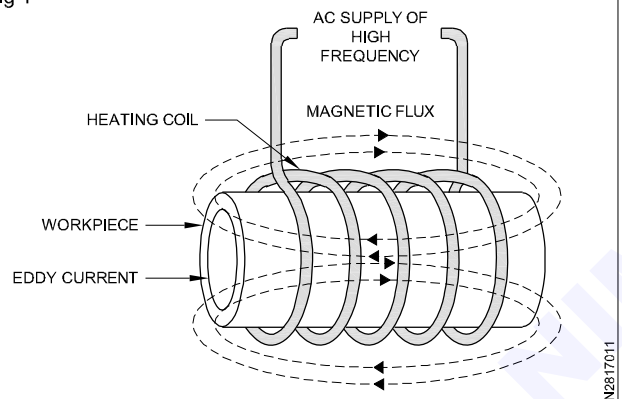
Induction heater

Objectives: At the end of this lesson you shall be able to
- **describe various parts of generation**
- **explain different types of induction heater.**

Induction heater (Fig 1)

Induction heating is a process of heating a metal or other electrically conductive material by generating an electromagnetic field around it. This is achieved by passing high-frequency alternating current (AC) through a coil, which creates a magnetic field. The magnetic field induces eddy currents in the metal, which produces heat due to resistance.

Fig 1



PRINCIPLE OF INDUCTION HEATING

Types of induction heaters

There are several types of induction heaters, including:

High frequency induction heater

A high-frequency induction heater operates at a frequency between 10 kHz and 1 MHz. This type of induction heater is commonly used for soldering. Brazing, and heat-treating applications.

Medium frequency induction heater

A medium frequency induction heater operates at a frequency between 1 kHz and 10 kHz. This type of induction heater is commonly used for forging, heartening, and melting applications.

Low frequency induction heater

A low-frequency induction heater operates at a frequency below 1 kHz. This type of induction heater is commonly used for welding, annealing, and stress relieving applications.

Applications of induction heaters

Induction heaters are used in a wide range of industrial, commercial and domestic applications.

Induction cooking (Fig 2&3)

Induction heaters are used in the food industry for cooking food quickly and efficiently. Induction cooktops are also used in homes and restaurants as a faster and more energy-efficient alternative to traditional gas or electric cooktops.

Fig 2

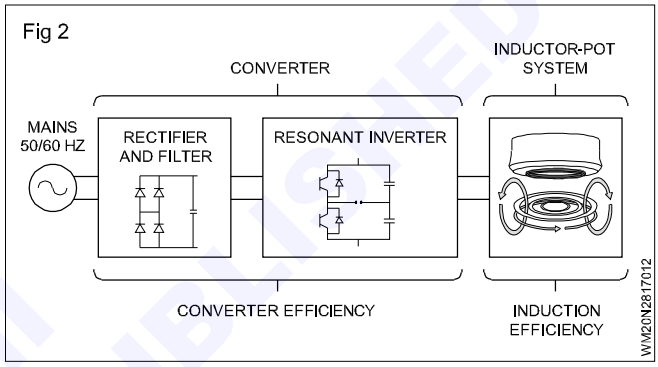
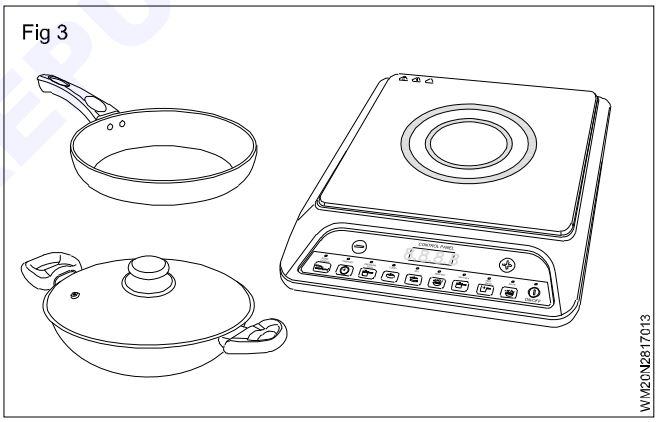


Fig 3



In conclusion, induction heaters are versatile devices used for a variety of industrial and commercial applications, from heating and melting metals to cooking food. The choice of induction heater depends on the specific application and requirements of the user.

Domestic induction heaters are electronic devices that are relatively easy to use and maintain. However, in case of any malfunction or problems, the following are some common troubleshooting types that can help:

Power supply

Check if the induction heater is receiving adequate power supply from the socket. Check the socket with a tester or plug another device to confirm that the socket is working correctly.

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Control panel

Check the control panel for any visible signs of damage, such as cracks or chips, and ensure that all buttons and switches are working correctly. If any buttons or switches are not working, try pressing them few times or clean them.

Overheating

Check for any signs of overheating, such as burning smells or unusual noise. Overheating can be caused by a dirty or damaged fan, improper ventilation, or internal component failure. Clean the fan, check the ventilation, and if these are not the cause of the overheating, consult a qualified technician.

Display

If the display is not working, check the battery and replace it if necessary. Check the wires to ensure they are properly connected.

Cookware

Ensure that the cookware used is compatible with the induction heater. Use only cookware that has a flat and smooth bottom, as uneven or curved bottom cookware can cause damage to the induction heater.

Error codes

If an error code is displayed on the induction heater, refer to the user manual to identify the problem and take the appropriate steps to resolve it.

Reset

Try resetting the induction heater by turning off the power supply and unplugging the device for a few minutes. Plug the device back in and turn it on to check if the problem has been resolved.

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Food mixer

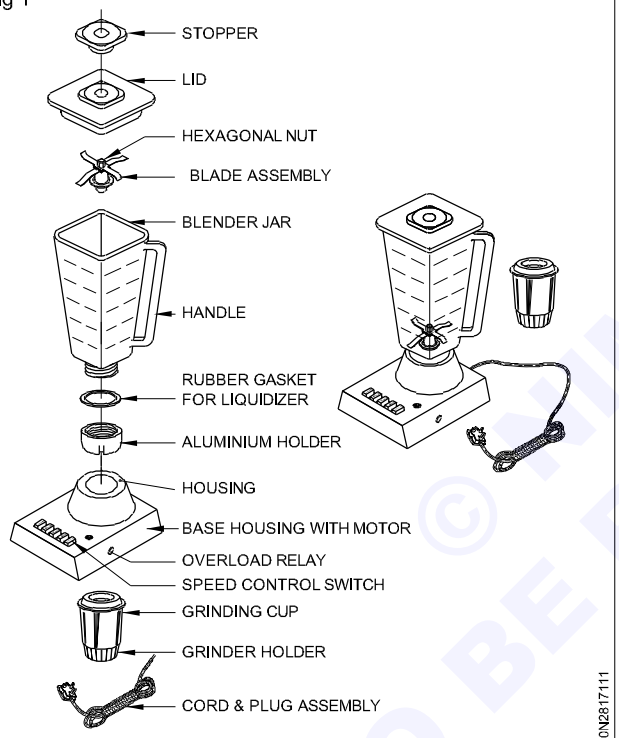
Objectives: At the end of this lesson you shall be able to
- **define the food mixer and its features**
- **state the maintenance and service procedures of mixer.**

Food mixer

It is an electric domestic appliance which is used to mix, juice, grind and blend the fruits and food grains.

A medium sized universal motor is used in it. Fig 1 shows an exploded view of a mixer.

Fig 1



EXPLODED VIEW OF A FOOD MIXER

Features of the food mixer

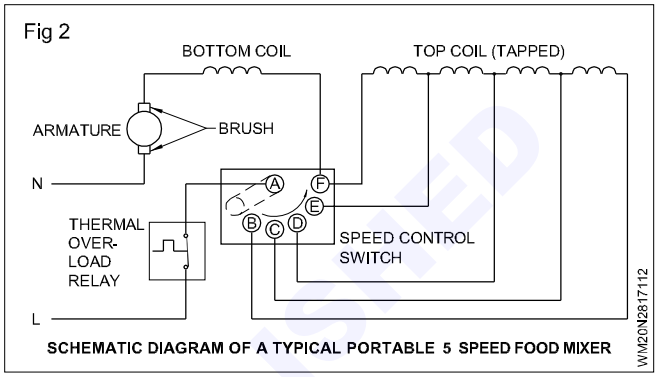
The motor housing differs widely depending on the manufacturer. Special care to be taken for vibration-free running. Safety features such as overload trip, jar mounting lock (fixing) and proper lid closing are included in the appliances.

An AC universal motor is housed in the base. The jar contains the cutting knives which is the heart of the blending action. Fig 2 shows a schematic diagram of a typical mixer.

A food mixer power rating ranges from 100 to 750 watts. The revolution of the food mixer is 3000 to 14000 revolutions per min. The desired speed is selected on the control switch.

The time rating of running the mixer varies from 1 minute to 60 minutes depending upon the type. A tapped field coil enables speed selection through a rotary or push button switch.The food mixer normally runs at 3 speeds.

Fig 2



SCHEMATIC DIAGRAM OF A TYPICAL PORTABLE 5 SPEED FOOD MIXER

Maintenance and servicing of a food mixer: The manufacturer's service manual, if available, read it a number of times and follow the instruction. First listen to the complaint from the customer and make a note of it. Visually check the mixer right from the plug to the speed selector switch connections and enter the details in the maintenance card.

Test the mixer with and without the power cord for the continuity and insulation resistance. Enter the details in the same card. The insulation resistance value for the individual part should not be less than 1 Megohm. The metal bodied mixer should have effective earth connection to the body, the power cord should be 3-core and the plug and socket should be of 3-pin/socket type with effective earth.

But double insulated (PVC body) mixers may have two core cable and 2-pin plug type. A damaged plug or power cord should be replaced. Check the brush tension and make it normal. Check the brush length; if found short by 2/3rd of its original length, replace it with the same specification brush or a brush obtained from the manufacturer of the mixer.

Check the switch for its proper function. Better to replace a faulty one with a new one having the same specification. Before opening the motor assembly, check the couplings for their proper form. Check the ply of the shaft and vertical movement to get an idea of the condition of the bearings.

Tight bearing may be due to misalignment, bend in the shaft, dried grease or lubricant, dirt, damaged commutator or due to damaged bearing. Overheating due to bearing problems will be indicated by the change of colour of the shaft near the bearing to blue colour.

Connect the supply and test for its working.

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Wet grinder

Objectives: At the end of this lesson you shall be able to
- **define the wet grinder**
- **state the different types of wet grinders**
- **explain the parts of a wet grinder.**

Wet grinder

It is a domestic electrical appliance, which is used to grind the wet grains.

Types: There are three types of wet grinders

– Conventional (regular) wet grinder.

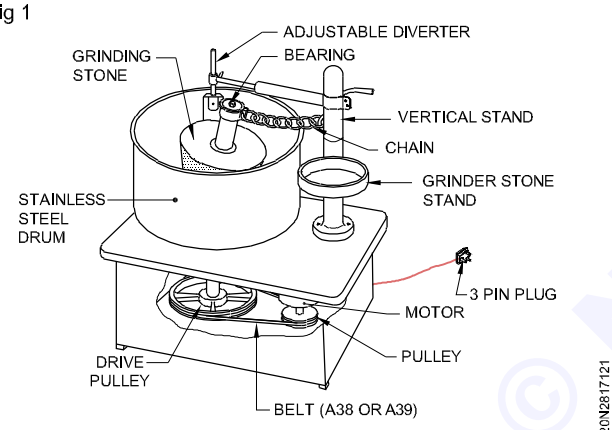
– Table top wet grinder.

– Tilting wet grinder.

Conventional (regular) wet grinder (Fig 1)

The most common wet grinder used in houses is the container rotating type wet grinder.

Fig 1



CONVENTIONAL WET GRINDER

Parts

The important parts of a wet grinder are :

– Motor

– grinding stone

– container

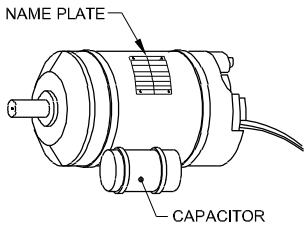
– pulley

– belt

– frame and stand

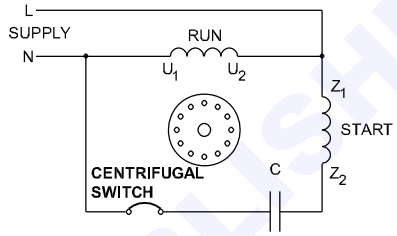
Motor: The motor used in the wet grinders is usually the capacitor start-induction motor (Fig 2 & 3). It has two windings. Both the starting and running windings are energised to start the motor, when the 70 to 80 % of the rated speed is reached, the starting winding is switched off by the centrifugal switching system. The motor then operates only on running winding.

Fig 2



GRINDER MOTOR

Fig 3

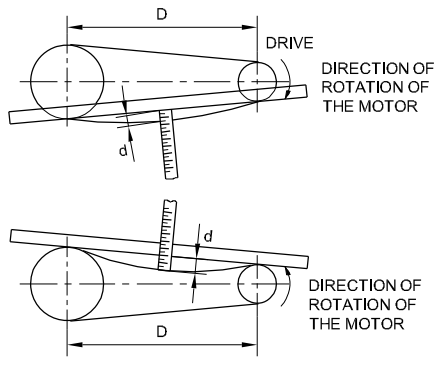


CIRCUIT DIAGRAM

Stone: The grinder stone consists of two parts of stones. One male and one female. The male part grinds the grains during rotation against conical cavity in the base (female stone). This female part is actually attached to the stainless steel container which rotates when the motor is energised. Both the stones are manufactured with hard granite which is usually whitish black in colour.

Pulley: The drum speed is lower than the motor speed, normally 500 to 600 r.p.m. The motor speed is normally 1450 r.p.m. and the speed of the drum is reduced by using a larger diameter pulley than the driven pulley, usually in the ratio of 1:3. The transmission of force between the driver pulley and the driven pulley is through a V belt of type No A 36 or A 39 (Fig 4).

Fig 4



ARRANGEMENTS OF PULLEY AND BELT

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Frame and stand: The grinding stones, motor pulleys are all housed in a rectangular frame with sunmica or stainless steel covering or plastic moulding for decoration as well as safety. A separate vertical stand is provided on one side of the grinder for holding the male grinding stone. If the MS frame is used, it is usually to be chromium plated.

Wet grinder- maintenance and servicing: In wet grinders, the trouble may be classified into two types. Electrical faults and Mechanical faults. Some mechanical faults create electrical faults too.

Some common problems and their rectifications are given in the Table 1.

Safety measures

- Make sure power is turned off before working on electrical equipment.
- Plug to be removed from the socket.

Maintenance practices: An electrical machine or appliance to be maintained according to the programme already made. Certain maintenance practices to be observed are,

– Daily maintenance

– Monthly maintenance

– Yearly maintenance

Daily maintenance: The parts are to be cleaned with cloth and the stone bearing is to be oiled. Inspect the belt tension and vibration.

Monthly maintenance: Oil and grease the main shaft of the grinder. Insulation test is to be carried out and recorded in the sheet provided.

Yearly maintenance: The electrical machine must be removed and overhauled. Insulate the winding by applying varnish. Check all the mechanical parts and rectify the defects, if any.

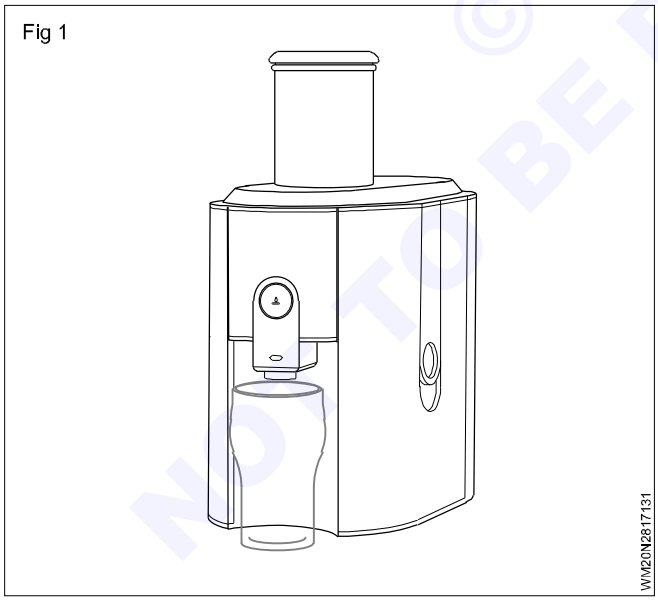
Juicer

Objectives: At the end of this lesson you shall be able to
- **explain juicer**
- **explain juicer working principle.**

A juicer, also known as a juice extractor, is a tool used to extract juice from fruits, herbs, leafy greens and other types of vegetables in a process called juicing. It crushes, grinds, and/or squeezes the juice out of the pulp.

Electric centrifugal juicer (Fig 1)

Fig 1



Some types of juicers can also function as a food processor. Most of the twin gear and horizontal masticating juicers have attachments for crushing herbs and spices, extruding pasta, noodles or bread sticks, making baby food and nut butter, grinding coffee, making nut milk, etc.

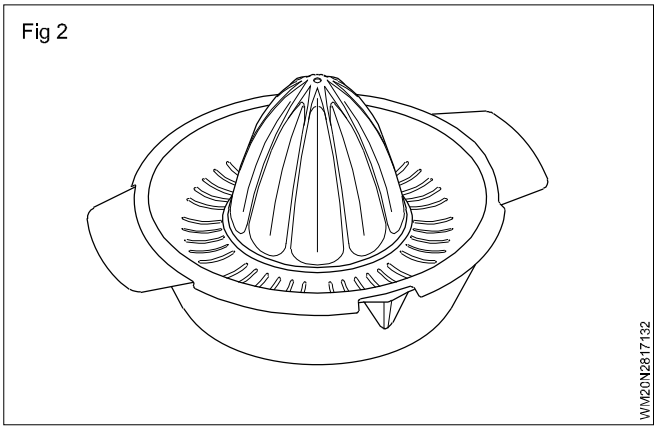
A manual-styled squeezer is used to separate citrus' juice from its pulp.

Squeezers are used for squeezing juice from citrus such as grapefruits, lemons, limes, and oranges. Juice is extracted by pressing or grinding a halved citrus along a juicer's ridged conical center and discarding the rind. Some reamers are stationary and require a user to press and turn the fruit, while others are electrical, automatically turning the ridged center when fruit is pressed upon. (Fig 2)

Centrifugal juicers

A centrifugal juicer cuts up the fruit or vegetable with a flat cutting blade. It then spins the produce at a high speed to separate the juice from the pulp.

Fig 2



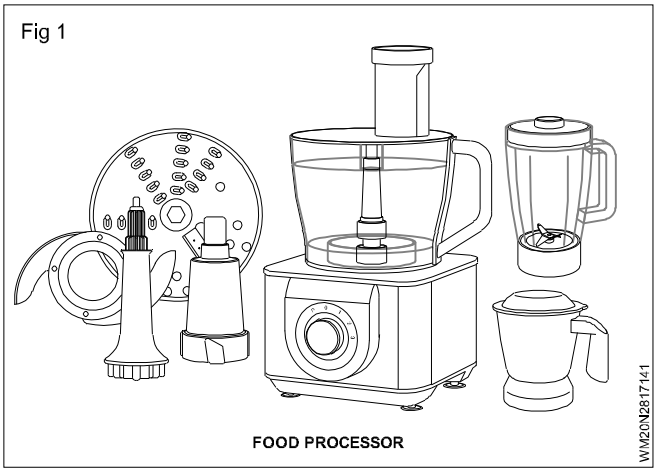
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Food Processor

Objectives: At the end of this lesson you shall be able to
- **define the food processor and its features**
- **state the maintenance and service procedures of food processor**
- **list the common problems, causes and remedies.**

Food processor

Fig 1



FOOD PROCESSOR

A food processor is a kitchen appliance that is designed to help with various food preparation tasks, such as chopping, grinding, mixing, and blending. The appliance works by using a motor to power a set of blades or disks that can be attached to the base of the food processor.

Assembly: The appliances is assembled by attaching the appropriate blades or disks to the base of the food processor.

Preparation: The food to be processed is prepared by cutting it into small, manageable pieces.

Loading: The food is then loaded into the food processor's bowl or container.

Processing: The motor is turned on, and the blades or disks rotate at high speed, processing the food according to the desired setting.

Disassembly: After processing is complete, the appliance is disassembled, and the blades or disks and removed for cleaning.

Here are some common troubleshooting tips for food processors

Motor not starting: Check if the power cord is plugged in correctly, the outlet is functioning properly, and the safety features of the appliance are properly engaged. If the motor is still not starting, it could be a sign of a faulty motor or switch.

Food processor not processing food evenly: This could be due to the blade or disk being improperly attached or worn out. Check if the blade or disk is inserted correctly and if the needs to be replaced.

Food processor vibrating excessively: This could be a sign of a faulty motor or unbalanced blade. Disassemble the appliance and check the blade and its attachment.

Food processor making unusual noises: This could be due to the blade or disk being improperly attached or worn out. Check if the blade or disk is inserted correctly and if it needs to be replaced.

Food processor leaking: This could be due to a damaged or misaligned gasket. Check the gasket for damage and replace it if necessary.

Parts of a food processor

1 **Motor:** This is the main component of the food processor that drives the blades to chop, mix food.

2 **Work bowl:** This is a container that holds the food that needs to be processed.

3 **Lid:** The lid fits over the work bowl and has a feed tube through which ingredients can be added while the processor is running.

4 **Feed tube pusher:** This is a tube located in the lid of the processor that allow ingredients to be added while the processor is in use.

5 **Dough blade:** This is a blade that is used specially for mixing and kneading dough.

6 **Shredding disc:** This is a disc that is used to shred vegetables and cheese.

7 **Slicing disc:** This is a disc that is used to slice vegetables and fruits.

8 **Pulse button:** The pulse button is a control button that allows the processor to be turned on and off in short bursts.

9 **Speed control: T**he speed control allows the user to adjust the speed of the processor depending on the taste.

10 **Motor base:** This is the bottom part of the processor that contains the motor.

11 **Locking mechanism:** This is a mechanism that locks the lid and work bowl in place when the processor is in use.

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AC ceiling fan

Objectives: At the end of this lesson you shall be able to
- **explain the construction of a ceiling fan**
- **describe the dismantling and assembling procedure for a ceiling fan**
- **state about electronic fan regulator and its advantage.**

Ceiling fan: It is a domestic electric appliance which is hanged from ceiling to circulate air for cooling purposes. The capacity of the fan is usually expressed in cubic feet per minute and is determined largely by the length, pitch and speed of the blades.

Construction: The ceiling fan consists of a:

– rotating part

– stationary part.

The rotating part (Fig 1) consists of a:

– body (rotor)

– fan blades

– bearings

– squirrel cage winding. (Rotor)

The stationary part consists of a:

– canopy

– shackle, bolt, nut and split pin

– suspension rod (down rod)

– terminal block

– capacitor

– stator winding.

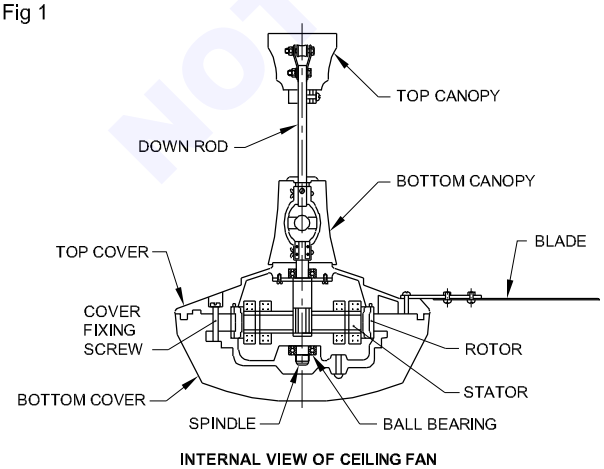
The stator winding has a:

– starting winding

– running winding.

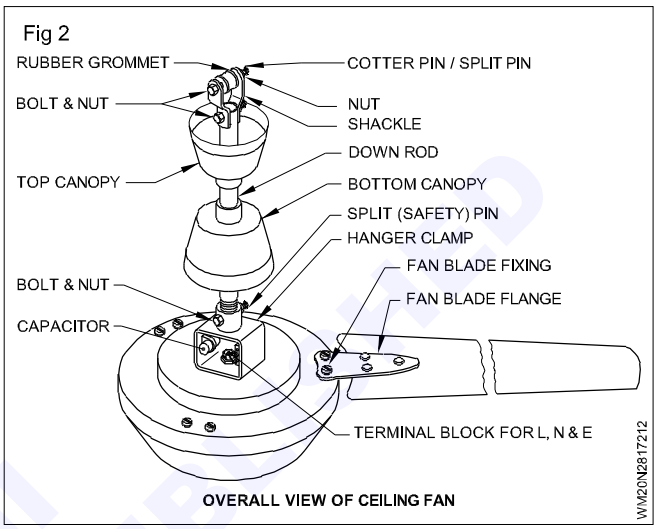
Figs 1 and 2 shows the parts of a ceiling fan.

Fig 1



INTERNAL VIEW OF CEILING FAN

Fig 2



OVERALL VIEW OF CEILING FAN

The rotor and the bottom cover are integrally die cast in high conductivity aluminium alloy which gives better accuracy and thus improves the efficiency of the cooling system.

The present day fan motor has a capacitor to give a good starting torque.

The top cover is made of aluminium die cast.

The fan blades are made from aluminium sheet. The size of the fan blades will depend on the area of the room, usage and appearance. The performance of the fan depends on the number of blades and their pitch angle, say 10 to 15°. Ceiling fans are available with three or four blades. The size of the fan is generally determined by its **sweep**. The following sweeps are available, 900 mm, 1050 mm, 1200 mm and 1400 mm.

The body (rotor) and blades rotate freely with the help of ball bearings or bush bearings which are housed on the top and bottom covers of the fan. The blade is fixed to the top cover and is fastened by clamps and bolts.

The entire unit is then hung to from the ceiling with a suitable G.I. pipe threaded on both sides and tightened with a suitable check nut, and with a split pin so as to prevent the entire unit from falling. The ceiling top clamp must be fitted to the ceiling hook with a shackle and bolt and nut.

The starting winding is connected in series with a capacitor and the running winding is connected across the supply. The two windings cause a rotating magnetic field. The capacitor used is an electrolytic, non-polarised one. The capacitor value varies according to the sweep of the fan. i.e. from 2 micro farads to 5 micro farad.

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Regulator: The speed of the fan can be varied by changing the applied voltage.

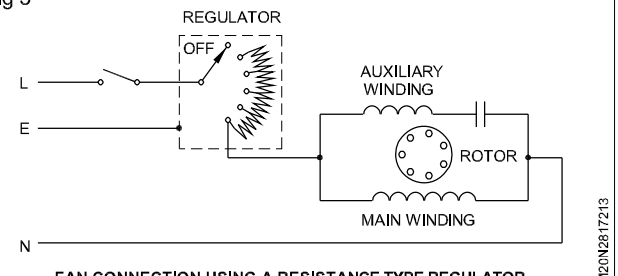
The most common method is to vary the applied voltage by

– adding series resistors to lower the voltage

– adding series inductors or tapped reactors to lower the voltage.

Fig 3 shows the schematic diagram of a fan with a resistance regulator.

Fig 3



FAN CONNECTION USING A RESISTANCE TYPE REGULATOR

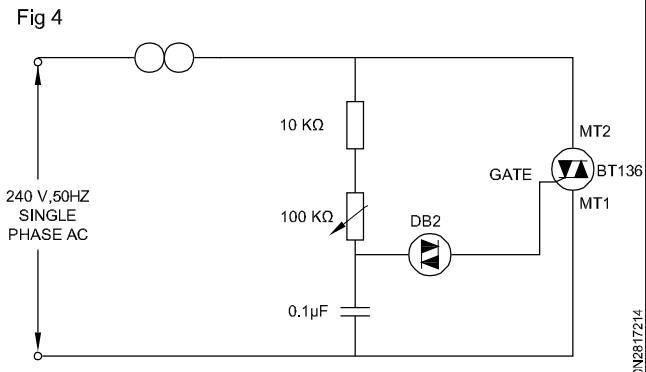
The speed control of the fan may be obtained by means of a tapped-reactor (induction coil) circuit, which is normally used in the smaller fans. Now-a-days electronic regulators are gaining more popularity. They are small in size and dissipate no heat.

Electronic fan regulators

It is an electronic controlling device which regulates / controls the speed of the fan.

The conventional type regulators which are bulky in size, use a tapped resistor to control the speed of fan, consumes considerable amount of energy. The number of speed can be achieved is only limited upto 5 different speed. But the electronic regulators overcome these problems by using electronic components. Circuits diagram of electronic regulator using triac and diac is given in Fig 4.

Fig 4



CIRCUIT DIAGRAM

Advantages of the electronic fan regulators

1 It provides a continuous and step less speed control.

2 No power loss and energy loss at all the speed.

3 Compact, small size and less weight (Fig 5).

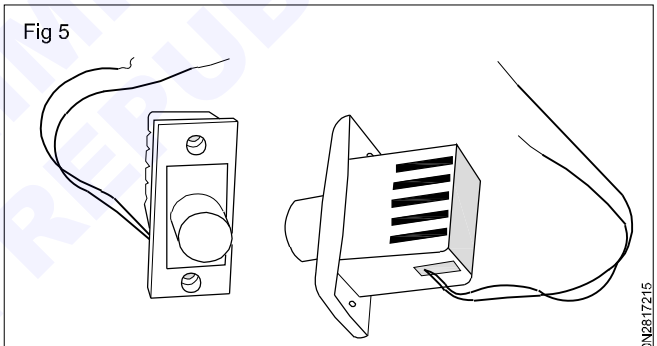
4 Simple circuit and less number of components used.

5 More efficient when compare with conventional type regulators.

6 Cost - effective.

7 Simple to operate and smooth operation.

Fig 5



ELECTRONIC FAN REGULATOR

Blowers

Objectives : At the end of this lesson you shall be able to
- **state working principle of blower**
- **describe the common faults and their remedies.**

Blowers are devices used to generate airflow for various industrial domestic and commercial applications, such as ventilation, cooling, and covering materials. It's essential to have a basic understanding of the working principle and types of blowers commonly used in the industry.

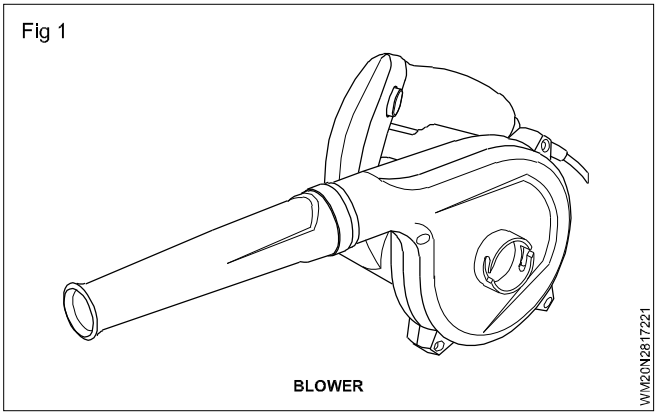
Working principle of blowers

The working principle of blowers involves converting mechanical energy into kinetic energy to generate airflow. A blower typically consists of a motor, and impeller or rotor, and a housing, the motor provides power to rotate the impeller, which creates a centrifugal force that draws air into the housing and discharges it through an outlet.

Types of blowers

1 Centrifugal blowers 2 Axial blowers

Fig 1



BLOWER

3 Regenerative blowers 4 Roots blowers

5 Screw blowers

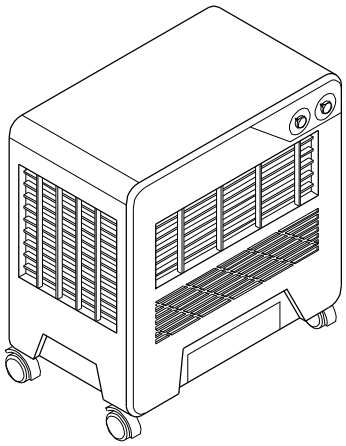
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Air coolers

Objectives : At the end of this lesson you shall be able to
- **identify the parts of air cooler**
- **types of air cooler.**

Air coolers are devices used for cooling the air in a room or a building. They work on the principle of evaporative cooling, which involves using the natural process of evaporation to cool the air. As water evaporates, it absorbs heat from the surrounding air, lowering its temperature. The cooled air is then circulated back into the room, creating a cooling effect.

Fig 1



AIR COOLER

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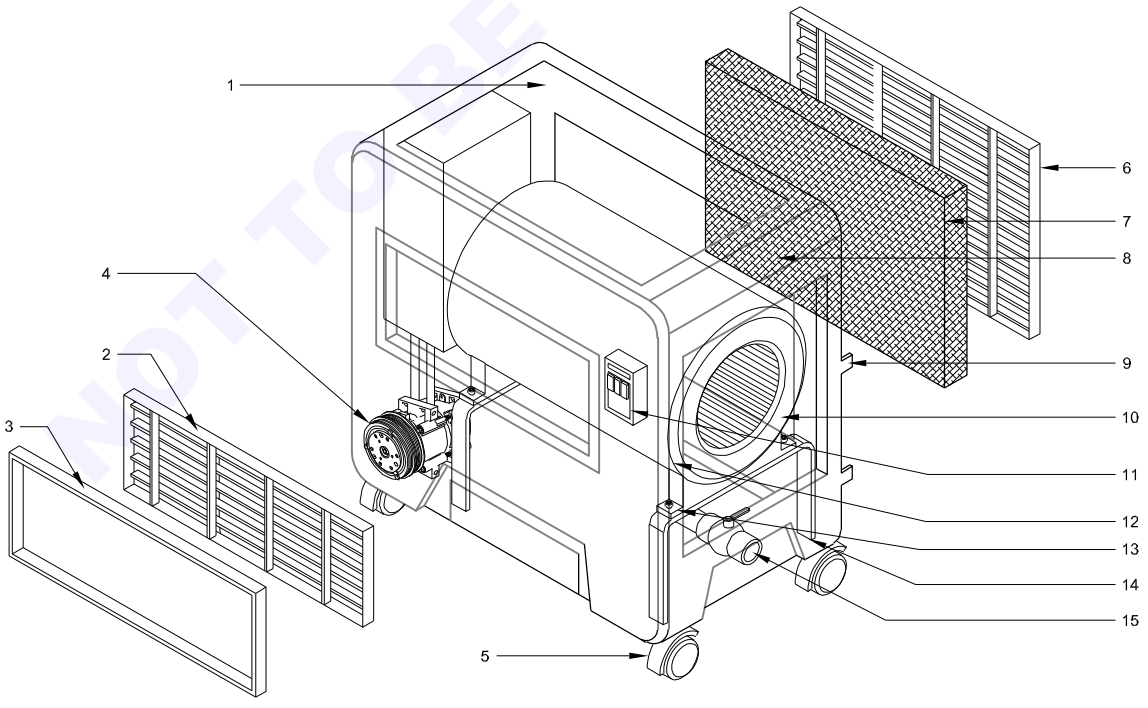
Parts of air cooler

1 Lid
2 Fan
3 Fan flange
4 Pump
5 Wheel
6 Slid panel
7 Cooling pad
8 Water distributor
9 Fixed stay
10 Volute
11 Main control box
12 Fan motor
13 Mute spacer
14 Bracket
15 Drain valve

Types of air coolers

1 Direct evaporative air coolers
2 Indirect evaporative air coolers
3 Two-stage evaporative air coolers

Fig 2



AIR COOLER

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Washing machine

Objectives: At the end of this lesson you shall be able to
- **define the washing machine**
- **state working principle of working machine**
- **state the function of mangle wringer for drying**
- **explain the function of drain pump and drive motor.**

Washing machine

It is a domestic electric appliance which is used to soak, rinse, wash, wrinkle /dry the cloth/fabrics etc.

Types of washing machines: The modern washing machines can be divided roughly into three main groups according to their function.

They are

– Ordinary

– Semi automatic

– Fully automatic.

i Ordinary type

Ordinary without timer: This machine uses the pulsator type technique in which a disc is fitted to the motor.

It has only one tub and one motor the dirty cloth is loaded in the tub, water is filled manually in the tub, detergent is added. The motor is switched on the pulsator disc moves the cloth around the tub and the time duration of washing is decided by the operator.

Ordinary with timer: Similar to the ordinary type, but added with a clock timer to select the time of wash from 1 to 15 minutes.

ii Semi-automatic type

This type has two tubs. One for washing and rinsing, the other for spin drying the cloths. The washing tub operates at lower speed whereas the spin drier tub operates at a higher speed. The machine may contain either one or two motors.

iii Fully automatic type

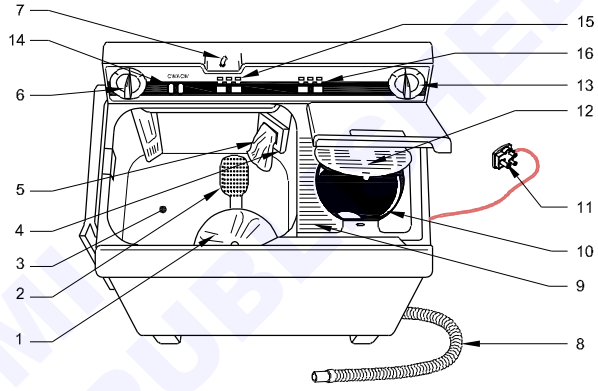
In this type, the microprocessor enables to programme the wash cycle. There will be only one tub. The machine could be programmed for wash cycle, detergent intake and water input. The machine does washing, rinsing and also dry the cloth and stops.

Further to the above types the washing machine could be further divided by the type of loading i.e. top loading and front loading. In some machines the water used for washing could be preheated with the help of an electric heater.

Semi Automatic washing machine

The parts of semi automatic washing machine is shown in Fig 1.

Fig 1



SEMI AUTOMATIC WASHING MACHINE

1 - PULSATOR	9 - SCRUBBER
2 - WATER STRAINER	10 - SPIN DRUM
3 - WASH DRUM	11 - 3-PIN PLUG
4 - WATER LEVEL SELECTOR	12 - SPIN DRUM COVER
5 - LINT FILTER	13 - SPIN TIMER
6 - WASH TIMER	14 - AGITATOR DIRECTION SWITCH
7 - WATER INLET PIPE	15 - WATER INLET-OUTLET KNOB
8 - DRAIN HOSE	16 - WATER INLET KNOB FOR SPINING

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Parts of fully automatic front load washing machine

The parts of a fully automatic front load washing machine and how they work together is given below

1 **Control Panel:** The control panel is the user interface for the washing machine. It contains buttons or a touch screen that you use to select the cycle, water temperature, and other options.

2 **Door and Seal:** A front load washing machine has a door on the front of the machine that opens to allow access to the drum. The door seal prevents water from leaking out during the wash cycle.

3 **Drum:** The drum is the inner tube of the washing machine that holds the clothes. It rotates horizontally during the wash cycle and is perforated to allow water to flow in and out.

4 **Baffles:** Baffles are curved paddles that are attached to the drum. They help to move the clothes around during the wash cycle and prevent them from bunching

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up.

5 **Dispenser:** The dispenser is a component that holds the detergent and fabric softener. It releases them at the appropriate times during the wash cycle.

6 **Pump:** The pump is responsible for moving water into and out of the washing machine. During the wash cycle, it pumps water into the drum to mix with the detergent and clothes. During the rinse and spin cycles, it pumps out the dirty water and then fills the drum with cleap water.

7 **Motor:** The motor is the power source for the washing machine. It drives the drum and the baffles, and it also powers the pump.

8 **Sensors:** Sensors are used to detect the level of water in the drum, the temperature of the water, and other factors that affect the washing process. They help the machine to automatically adjust the cycle to achieve the best results.

9 **Shock Absorbers:** Front load washing machines have shock absorbers to help stabilize the drum during the spin cycle. This helps to reduce vibration and noise.

During a typical wash cycle, the washing machine fills the drum with water and detergent, and then the drum rotates to move the clothes around. The machine senses the level of dirt and adjusts the cycle accordingly. After the wash cycle is complete, the machine drains the dirty water, fills the drum with clean water for the rinse cycle, and then spins the clothes to remove excess water. Finally, the machine drains the clean water and the cycle is complete.

Types of wash techniques

In addition to the above classification, the washing machine could be catagorised according to the wash technique used as explained below.

The pulsator wash technique (Fig 2&3)**:** This is the most common type pulsator wash technique, it has disc in concave shape used to rotate the clothes in water. Dirt is removed from the cloth by rubbing against tub wall surfaces and the disc.

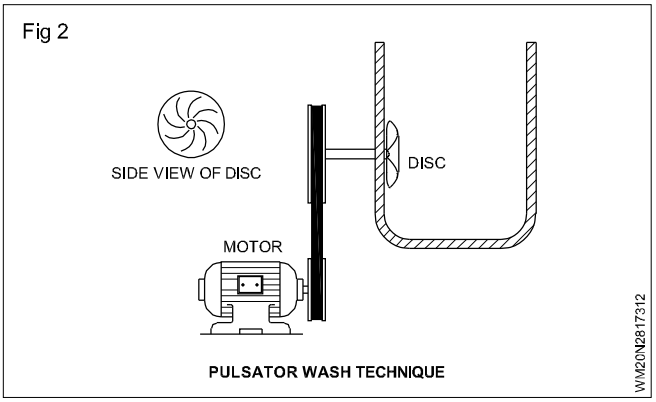
Tumbler type (Fig 4a)**:** In the tumbler type the washing is carried out by tumbling the cloths with the help of a simple drum. Here the construction is simple and cloths are tumbled around the drum by virtue of the drum itself being rotated by means of a pulley at the rear or the friction drive of the idlers.

The agitator wash technique (Fig 4b)**:** An agitator which is long and cylindrical is installed at the centre of the washing tub. The water and cloths circulate around the agitator, thereby under going a thorough cleaning process. Not suitable for delicate fabric.

The air power wash technique: This machine uses air bubble technique to wash delicate fabrics smoothly.

The chaos punch wash technique: A multifaceted method of washing, where in water is propelled upwards in the machine to prevent entanglement of garments punching, is done on clothes by forced water.

Fig 2



PULSATOR WASH TECHNIQUE

Fig 3

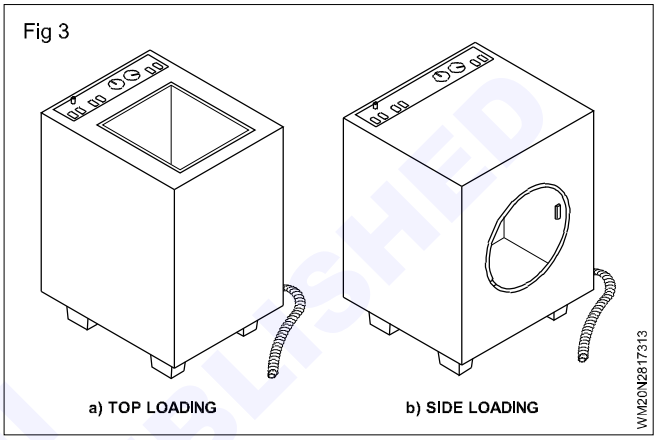
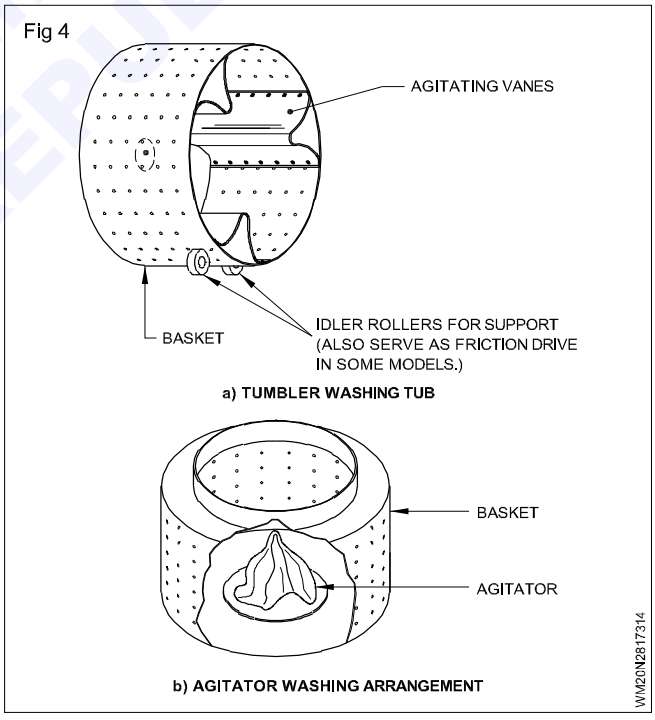


Fig 4



The neuro fuzzy logic technique: Machines use this technique uses micro processor for their programming and can make decisions about the type of washing to be used depending upon type of fabric and the extend of dirt.

The water fall technique: This is more or less similar to chaos punch technique. This machine use jets of water which are pumped from below the pulsator in to the tub. The velocity and force of water removes the dirt. Most of the washing machines could be repaired by the electrician but microprocessor controlled washing machine repair needs some more training and experience.

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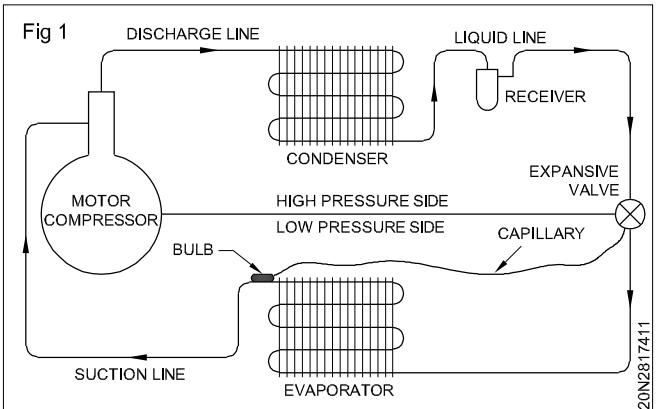
Conventional and frost free refrigerators

Objectives: At the end of this lesson you shall be able to
- **explain the functions of all the parts and controls of a Conventional type refrigerator**
- **explain the functions of all the parts and controls of Frost free refrigerator.**

Refrigeration: Refrigeration may be defined as a process of heat removal from a substance or from a space resulting in lower temperature below that of the surroundings

The refrigeration system works on vapour compression cycle shown below in (Fig 1).

Fig 1



TYPICAL COMPRESSION REFRIGERATION SYSTEM

The cycle works in four phases

– compression

– condensation

– expansion

– evaporation.

Conventional refrigeration: The important parts of the refrigerator are shown here in (Fig 2).

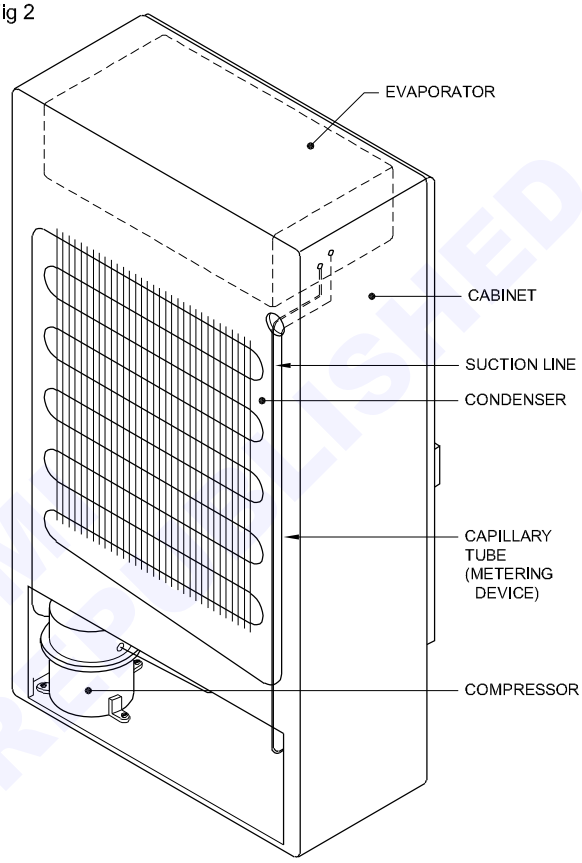
Compressor: The function of the compressor is to provide the necessary pumping action to the refrigerant. It draws cool refrigerant in through the suction line from the evaporator. It compresses it and discharge it into the condenser, where it is liquefied. The compressed gas has rise in temperature and pressure at the time of entering condenser.

Parts of a conventional refrigerator (Domestic refrigerator)

– **Condenser:** The function of the condenser is to remove the heat carried by the refrigerant and return the refrigerant to the control enabling the system to repeat the cycle.

– **Receiver:** It is the reservoir for excess liquid refrigerant not being in the system. The receiver should have sufficient capacity to hold the total amount of refrigerant in the system.

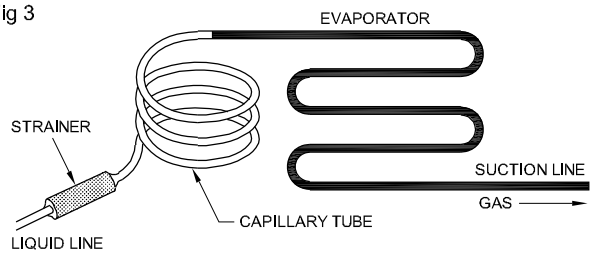
Fig 2



HOUSEHOLD REFRIGERATOR

– **Capillary tube or metering device** (Fig 3)**:** It meters out the required amount of refrigerant to pick the heat from the evaporator. It consists of a long, small diameter copper tube. As the liquid from the condenser is pushed through a small passage way, the friction between the refrigerant and the tube causes pressure drop.

Fig 3



CAPILLARY TUBE AND STRAINER

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Controls of a Conventional refrigerators and Frost free refrigerators

Capillary tube: It controls the refrigerant flow by metering out the required amount of it to pick up the heat in refrigerator and to regulate the pressure of the refrigerant by reducing the pressure of the refrigerant.

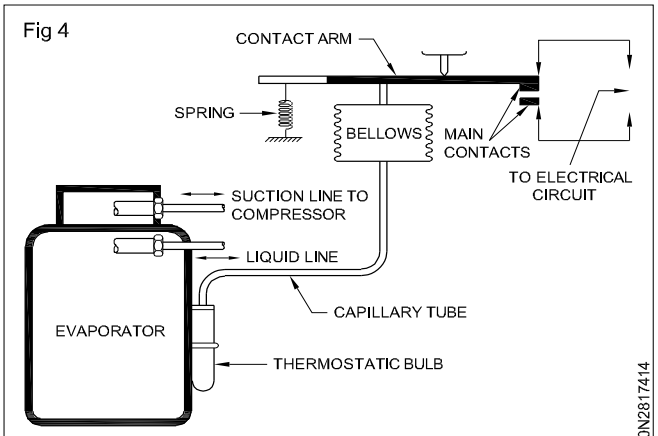
Thermostatic control: The common method of temperature control employed in house hold refrigerations units.

These are electro mechanical switches actuated by a temperature sensitive refrigerant sensor. It tells the cooling system when to run and when to shut off. The arrangement is shown in the (Fig 4). The bulb and the tube are charged with a highly volatile fluid. The gas expands and contracts in line with cabinet temperature. Corresponding pressure variations cause bellows to expand or contracts of a diaphragm to move and this movement on a temperature rise or breaks it on a temperature fall. Temperature settings can be varied by a regulating knob and thermostat operates at line voltage to run the compressor motor.

Starting relays: A protection device for the compressor. Further details can be studies in later chapters.

Suction line: The line through which refrigerant from evaporator to the compressor. This is towards the low pressure side of the system. This is made out of copper.

Fig 4

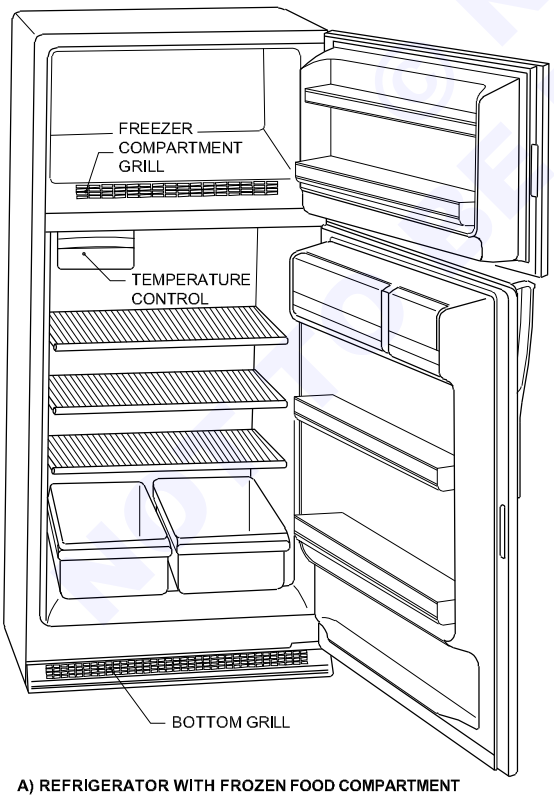


TEMPERATURE CONTROL DIAGRAM

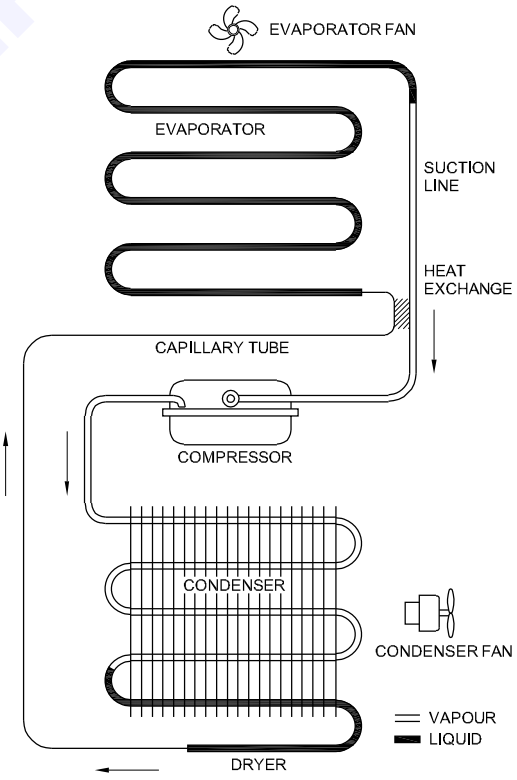
Discharge line: The line between compressor and the condenser is called discharge line, which is towards the high pressure side of the system.

Frost free refrigerator: It is a development over the Conventional refrigerator. The task of defrosting the evaporator is eliminated in this refrigerator. The evaporator is in the upper back part of the cabinet and the condenser is along the lower back part. A fan moves cold air from the evaporator in the frozen food compartment and another fan circulates room air. Through the grill at the bottom of the cabinet and over the condenser. The parts of the system is shown in Figs (5a & 5b). For functions of the parts refer to the parts of the domestic refrigerator.

Fig 5



A) REFRIGERATOR WITH FROZEN FOOD COMPARTMENT



B) FROST-FREE SCHEMATIC DIAGRAM

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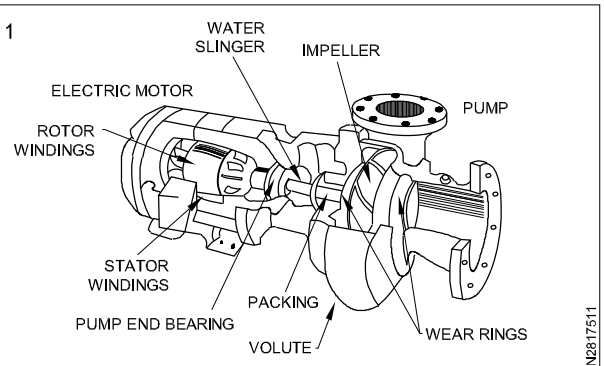
Pump set

Objectives: At the end of this lesson you shall be able to
- **explain pump set**
- **explain classification of pump set.**

Motor pump set

It is an electric motor combined with mechanical pump unit and used to lift or discharge the water from the well/ bore/sumps into a tank or canal or field or land as required. It is generally used is domestic, industries and agriculture field. (Fig 1)

Fig 1



MOTOR PUMP SET

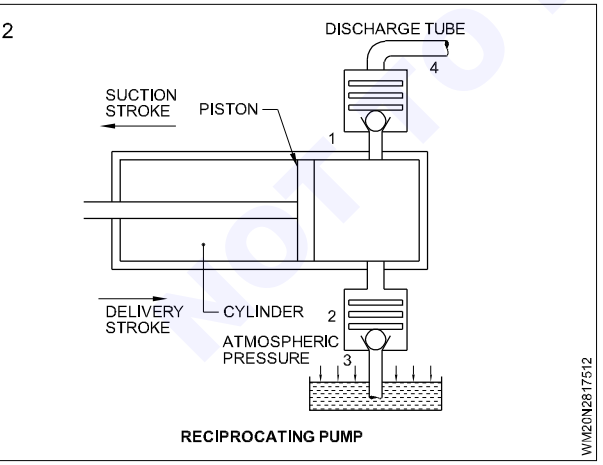
Pumps : Pumps can be classified mainly into two categories. They are

– Reciprocating pumps

– Rotary pumps.

Reciprocating pumps : In this type of pump, the main moving part has reciprocating motion only and hence the name. Fig 2 shows the main parts of a reciprocating pump.

Fig 2



RECIPROCATING PUMP

When the piston moves towards left, a partial vacuum is created inside the cylinder. The check valve 1 in Fig 1 closes due to the suction effect of the vacuum, spring action and head of water in the discharge tube 4 but valve 2 opens and allows the water to fill the cylinder through the suction pipe 3 due to atmospheric pressure outside. This stroke of the piston is called suction stroke.

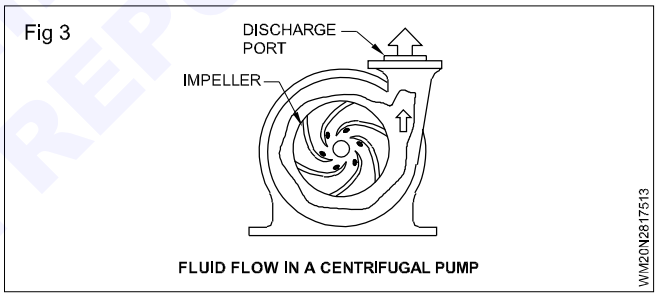
On the other hand when the piston moves towards right ie discharge or delivery stroke the liquid inside the cylinder is pushed out through check valve 1 and delivery pipe 4. During the delivery stroke valve 2 remains closed by the action of spring and the water pressure inside the cylinder.

However, as the discharge of water takes place in this type of pump only during the discharge stroke, the pump creates a pulsating flow of water and not a continuous flow. This type of pump is called a piston pump.

Rotary pumps : There are very many varieties of this pump in the market. However centrifugal pumps, jet pumps and submersible pumps are the commonly used pumps for lifting water in houses.

Centrifugal pumps : Fig 3 shows the construction and operation of a centrifugal pump.

Fig 3



FLUID FLOW IN A CENTRIFUGAL PUMP

The operation of a centrifugal pump is based on centrifugal force. As the fluid being pumped enters the inlet or central section of the pump, the rotating action of the impeller vanes forces it to the outside of the pump casing (Fig 2).

Because the fluid moves faster at the outer edge of the impeller the momentum increases. As more fluid enters the pump, more fluid momentum is built up in the casing that encloses the impeller. This momentum forces the fluid out of the pump discharge port.

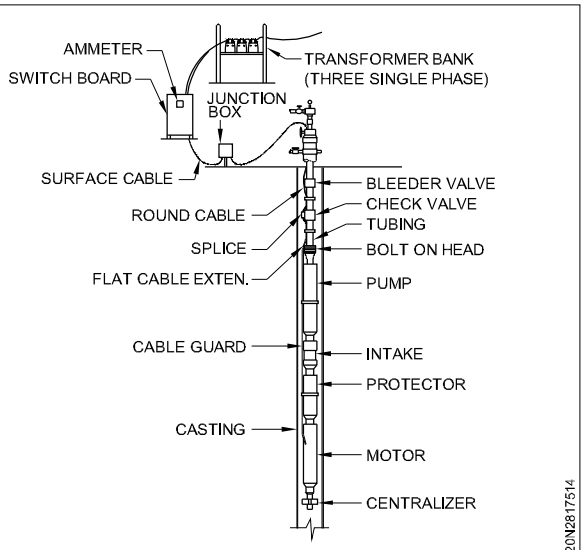
The centrifugal pumps are used where large volumes of water are to be pumped at relatively low pressure.

Submersible pumps : This pump also comes under the category of centrifugal pumps and is found in use at places where water is found in great depth.

Submersible pumps have motor and pump in an axial length are submerged in water (Fig 4). Generally such pumps are used for borewells where the volume of water to be lifted exceeds the capacity of reciprocating pumps. The motor used in such types of pumps is of 3-phase.

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Fig 4



ELECTRIC SUBMERSIBLE CENTRIFUGAL PUMP SYSTEM

The cables and motor windings have water proof sealing as they are immersed in water. Such pump sets will have following advantages.

- Diameter is smaller.
- Motor and pump are submerged in water. Hence needs no space on ground level.
- The motor and pump are entirely connected through metal pipes for delivering water.
- Efficiency is more as the motor with the pump will be to the level of water or inside the water.
- Cooling is effectively done by water only.
- Can be used for lifting water from any depth of sump or borewell as suction pipe is not used.

Disadvantages

- Erection cost and initial cost of purchasing will be high.
- In case of any defects, it is necessary to remove entire unit along with the pipe line.
- Requires skilled worker for both erection and maintenance work.

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Window air conditioner

Objectives: At the end of this lesson you shall be able to
- **explain the main components of window A/C**
- **explain the function of all the electrical components of a window air conditioner.**

Air- conditioning fundamentals

Air conditioner

Air conditioning is defined as the process of treating air so as to control simultaneously its temperature, humidity, cleanliness and distribution to meet the requirements of the conditioned space.

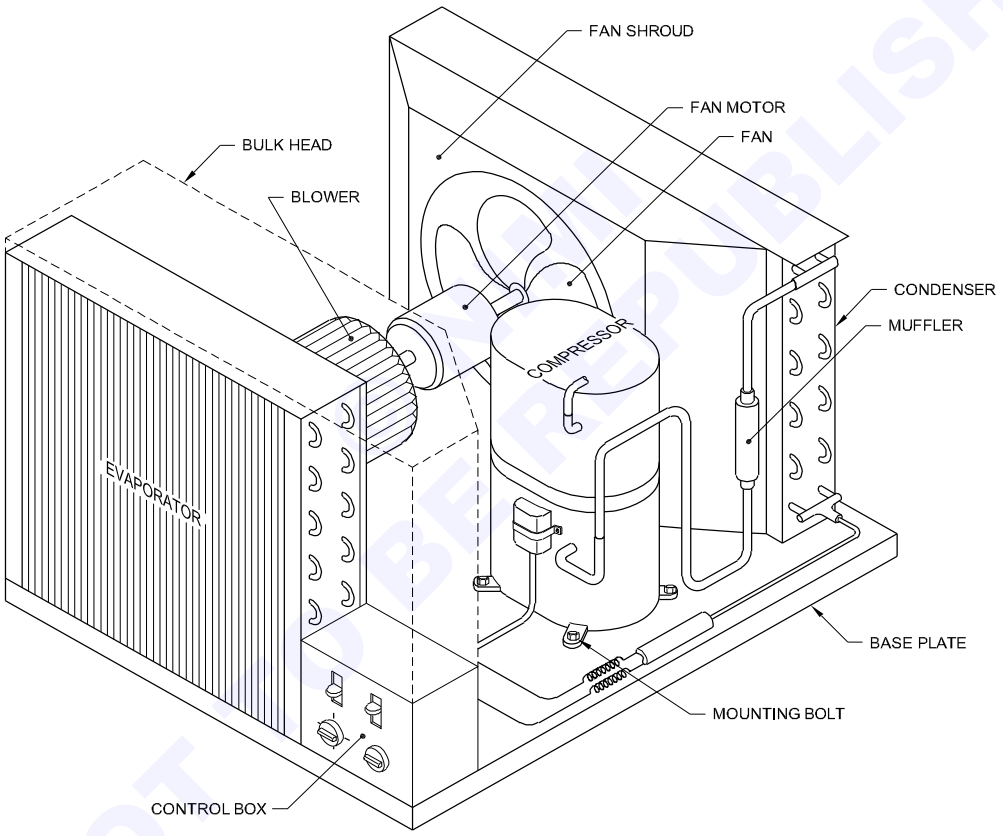
As defined the important actions involved in the operation of an air-conditioning system are:

It should be kept in mind that Air-conditioning is a use of refrigeration.

Present Air-conditioning equipment

Room Air conditioner: Room air conditioner is designed and assembled by a manufacturing company as a unit for mounting in a window through wall. It delivers conditioned air to an enclosed space without any ducts. The window AC is shown in (Fig 1&2).

Fig 1



ROOM AIR-CONDITIONERS

- Temperature control temperature control for winter heating conditions requires automatic control of the heating source as a means of maintaining desired room temperature.
- Temperature control for summer cooling conditions requires automatic control for summer cooling conditions requires automatic control of the refrigeration system to maintain the desired room temperature.

Humidity control for winter conditions usually requires automatic control addition of moisture to the heating system by humidifier.

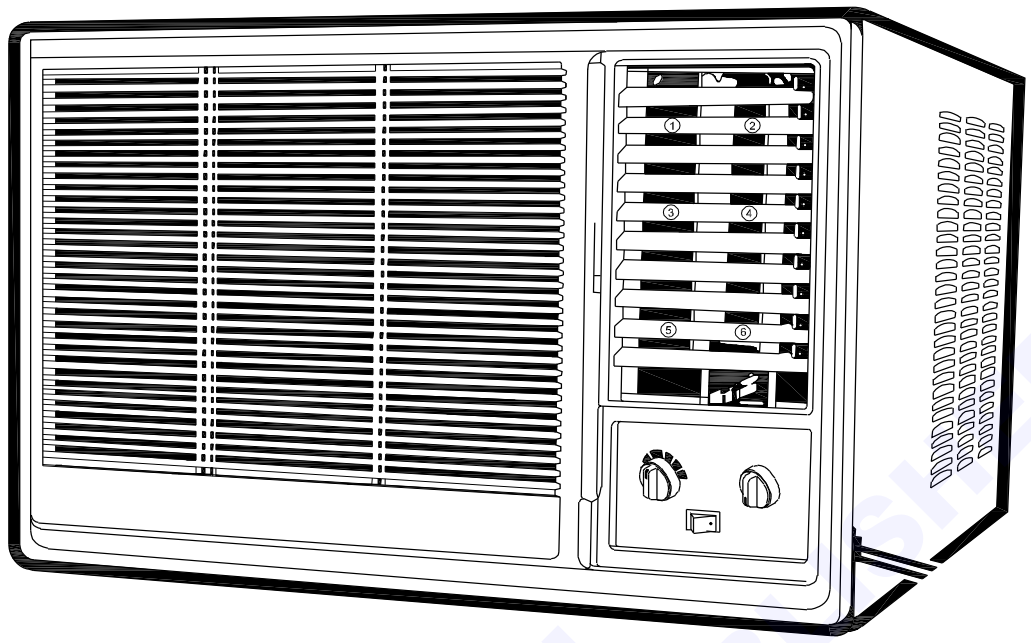
Humidity control for summer conditions requires the automatic control of dehumidifiers usually this is above at the time the air to be cooled is passed over the cold evaporator surfaces.

Air filtering is the same for both summer and winter air conditions.

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Air filtering equipment usually consists of very fine porous substances air is down through to remove contaminating particles, filters using oxide carbon and electrostatic precipitation may be added to the usual filtering mechanism to improve air cleaning. The air pollutants and methods used to remove them from the air are of different types.

Fig 2



AIR FLOW CHECK POINTS

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Main components of window A/C

Room Air conditioner: Room air conditioner is designed and assembled by a manufacturing company as a unit for mounting in a window through wall. It delivers conditioned air to an enclosed space without any ducts.

The main components of window A/c are as follows.

- Compressor
- Condenser
- Filter drier
- Capillary tube
- Evaporator

Trouble shooting

Problem	Cause/Solution
System does not restart and/or rapid cycling of the compressor.	**Cause:** The system has a built-in three minute delay to prevent short **Solution:** Wait three minutes for the protection delay to expire.
Indoor unit emits unpleasant odor when started	**Cause:** Typically, unpleasant odors are the result of mold or mildew forming on the coil surfaces or the air filter. **Solution:** Wash indoor air filter in warm water with mild cleaner. If odors persist, contact a qualified service professional to clean the coil surfaces.
You hear a “water flowing” sound	**Cause:** It is normal for the system to male “water flowing” or “gurgling” sounds from refrigerant pressures equalizing when the compressor starts and stops. **Solution:** The noises should discontinue as the refrigerant system equalizes after two or three minutes.

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A thin fog or vapour coming out of the discharge register when system is running and dehumidifies the room space.	**Cause:** It is normal for the system to emit a slight fog or water vapour when cooling extremely humid warm air. **Solution:** The fog or water vapour will disappear as the system cools
You hear a slight cracking sound when the system stops or starts.	**Cause:** It is normal for the system to male "sounds from parts expanding and contracting during system starts and stops. **Solution:** The noises will discontinue as temperature after two or three minutes.
The system will not run from running.	**Cause:** There are a number of situations that will prevent the system **Solution:** Check for the following: • Circuit breaker is "tripped" or "turned off" • Power button of controller is not turned on • Controller is in sleep mode or timer mode • Otherwise, contact a qualified service professional for assistance.
The unit is not heating or cooling adequately	**Cause:** There are a number of reasons for inadequate cooling or heating. **Solution:** Check the following • Remove obstructions blocking airflow into the room • Clean dirty or blocked air filter that is restricting airflow into the system • Seal around door or windows to prevent air infiltration into the room • Relocate or remove heat sources from the room.
Water leaking from the indoor unit into the room following:	**Cause:** While it is normal for the system to generate condensate water in cooling mode, it is designed to drain this water via condensate drain system to a safe location. **Solution:** If water is leaking into the room, it may indicate one of the • The indoor unit is not level right to left. Level indoor unit • The condensate drain pipe is restricted or plugged. All restrictions must be removed to allow continuous drainage by gravity. • If problem persists, contact a qualified service professional for assistance
The unit will not deliver air	**Cause:** There are a number of system functions that will prevent air flow. **Solution:** Check for the following: • In heating mode, the indoor fan may not start for three minutes if the room

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Split Air conditioners

Objectives: At the end of this lesson you shall be able to
- **explain the types of split air conditioner**
- **describe the details about the compounds.**

Split air-conditioners have become very popular because of -

1 They are an alternative for air-conditioning of partition rooms, where window model air-conditioners cannot be used.

2 They are very silent in operation.

3 The room side units can be selected to match the interior decorations of the rooms.

Types of split air-conditioners

1 Direct room mounted split unit

The evaporator unit can be installed in different models, like floor mounting, wall mounting and ceiling mounting. The condensing unit is kept outside in a suitable location.

2 Duct able split unit

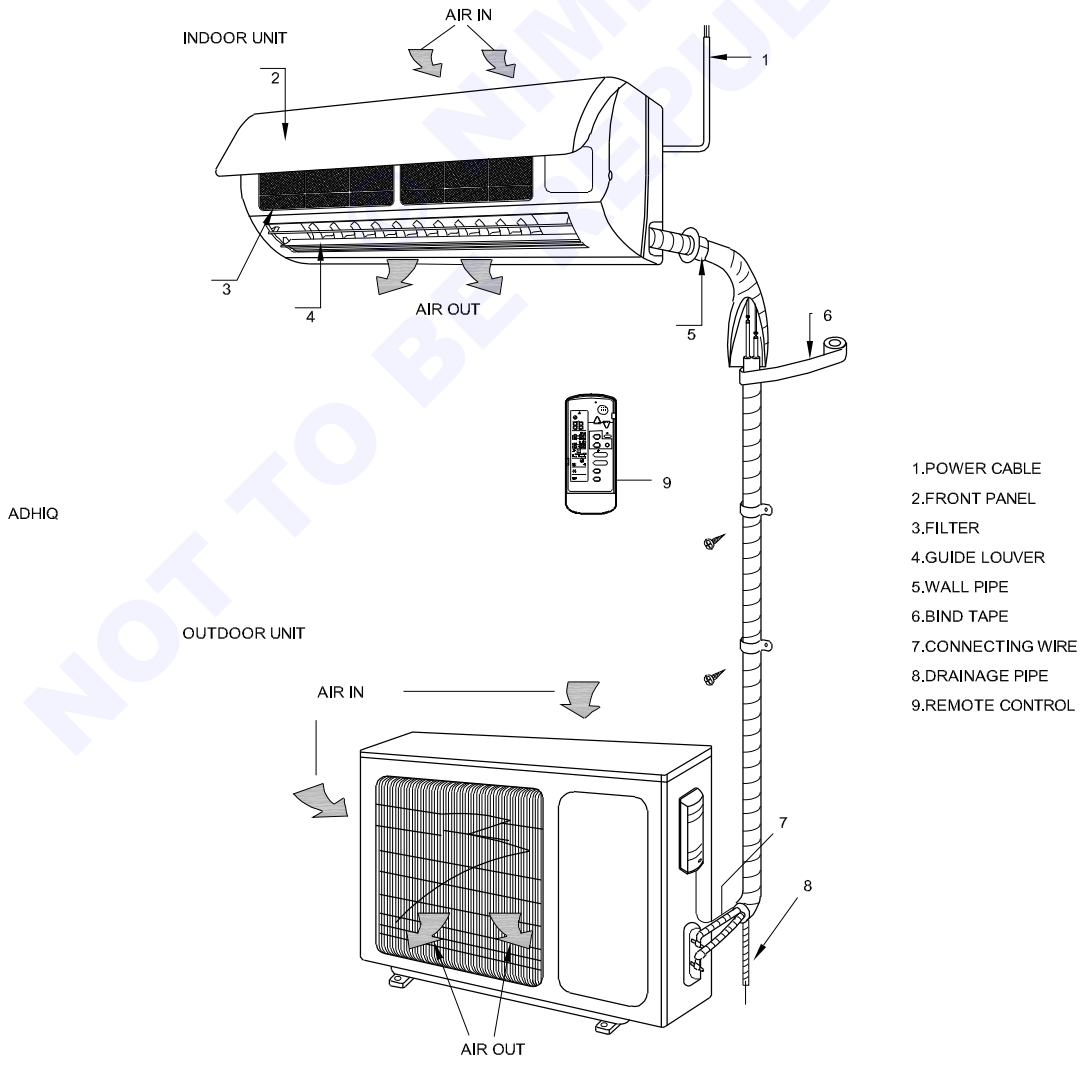
In this type the evaporator is normally mounted above false ceiling space and the cold air is supplied through ducting and delivered through the terminals (outlets) located at selected places.

3 Multi split unit

This system offers the feature of having individual room temperature control. Multi split units have been developed to cool two or three rooms simultaneously by having as many individual compressors and separate refrigerant circuits.

A typical split air conditioner is shown in Fig 1.

Fig 1



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Concept of neutral and earth

Objectives: At the end of this lesson you shall be able to
- **explain neutral**
- **explain earth.**

To understand what is earthing and neutral point, we will look at a three-pin electrical socket that we use in our everyday life. The three pins correspond to earth, neutral, and phase. The phase line is the one that carries current, the neutral line provides the return path to balance the flow of current, and finally earthing is purely used for safety purposes.

What is an Earthing?

Earthing, from a physics point of view, is the process of immediate transfer of electric energy into the earth. This process of earthing is always done with the help of a low resistance wire so that minimum resistance is provided to you while you are transferring the charge to earth.

Basically earthing is a precautionary connection that is made in many high-voltage devices and those devices that are costly as well as fluctuations on which can easily damage the device, such as that of air conditioners. We are provided with this earthing connection so that due to excess fluctuations in the devices, they may not get damaged.

If we talk about the main function of earthing, it is to protect humans from getting any kind of electric shock. Any electric equipment, when it comes into contact with a metal surface, a current is induced in it which results in electric shock. So in order to protect you from getting shocked while using them, earthing is done. Besides this, earthing provides you with a low resistance path, so that the extra current directly travels down to the ground.

Neutral

The neutral wire is used for providing a return path for the flow of current in an AC circuit. The neutral wire carries no current, yet without neutral wire the AC circuit is incomplete. In any electrical circuit, the neutral wire will redirect the path of the electrical current to its source point.

Basically, this neutral wire or neutral point in a three-phase circuit is where the sum of current will be zero and this neutral point is most commonly known as the zero potential point. In an AC circuit, the earth and the neutral point must be at the same potential, ideally, the potential difference between the two will be zero.

Earthing and Neutral - Their Differences

Earth	Neutral
It is the low resistance path used to prevent damage caused by the leakage current.	It is a conducting wire used in an AC circuit that provides a returning path for the flow of electrical current.
It doesn't carry any current. It will be having minor electricity during any electrical disconnections.	It always carries current.
It provides a grounding point for the flow of electricity.	It provides a returning point to the flow of electricity.
The earthing connection can be executed independently or it may be connected through a neutral line.	It has to be connected through a neutral line.

Importance of earthing

- To prevent the electrical shock the earthing concept was introduced.
- The Earth wire is a conductor embedded in the ground and electrically in contact with it. Earthing prevents wastage of electricity and electrical shocks.

Importance of neutral

- A neutral wire is half of the electrical circuit. It completes the AC circuit.
- A neutral wire is required to return the electric current to its source point, a circuit without a neutral wire will not conduct.

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Concentric/distributed, single/double layer winding and related terms

Objectives: At the end of this lesson you shall be able to
- **state the terms used in AC winding**
- **differentiate between the various types of AC winding.**

Motor windings in electric motors are insulated wires wrapped around a magnetic core. These wires are provided Generally, windings are made up of super enameled copper wire.

Types of winding

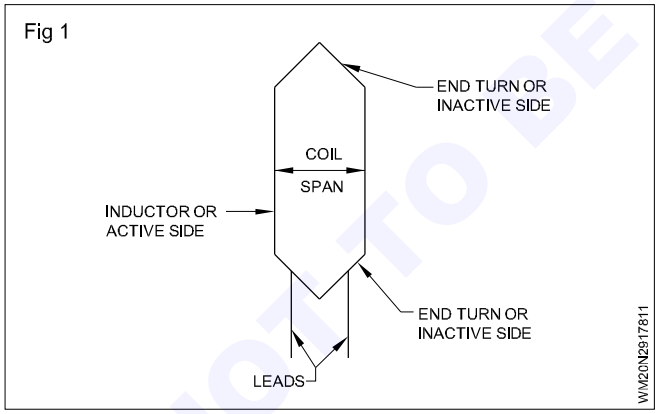
- Single layer winding
- Double layer winding
- Concentric winding
- Distributed winding
- Half coil winding
- Whole coil winding

Fundamental terms used in AC Winding: Before taking up AC winding, the trainee should be familiar with the terms used in AC winding as explained in the following paragraphs.

Coil : A number of turns connected in series is called a coil. A coil has two active sides and two inactive sides.

Turn: It is the closed path of the conductor which is formed by connecting the two inductors under two dissimilar poles N and S. (Fig 1)

Fig 1

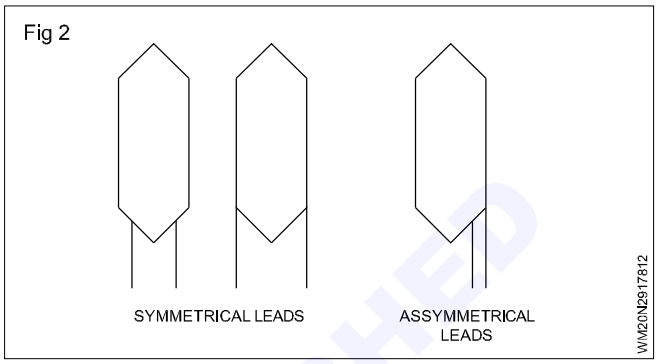


Leads of a coil : These are the two ends of a coil which are used for the connection. Leads are also known as jumpers which may be symmetrical or unsymmetrical as shown in Fig 2.

Pole pitch : The distance between the centre of two adjacent opposite poles is called the pole pitch. Pole pitch is measured in terms of slots or coil sides.

$$\text{Pole pitch} = \frac{\text{No. of slots in the stator}}{\text{No. of poles}}$$

Fig 2



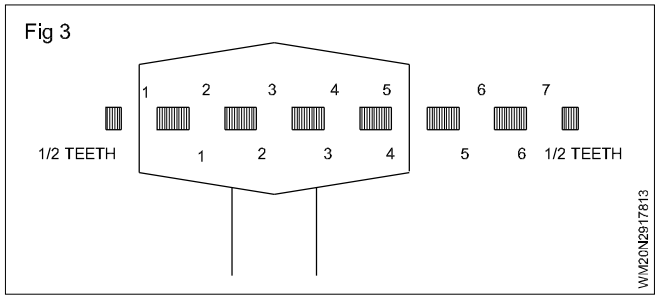
Coil pitch/span and coil throw : The distance between the two active sides of a coil under adjacent dissimilar poles is called coil pitch/span. Fig 3 shows the coil pitch/ span and coil throw (i.e. coil pitch/span = 4 and coil throw is 1-5).

Pitch factor : Winding pitch need not be equal to the pole pitch. If the pole pitch and winding pitch are equal, the winding is called full pitched winding. If the winding pitch is less than the pole pitch, the winding is called fractional pitch winding or short pitch winding. While rewinding, the original winding pitch should not be changed. The machine designer would have chosen the winding pitch after considering the different factors required for the better performance of the machine. Any change in the original winding pitch of a machine will affect the performance of that machine. If the winding pitch is 4, then the coil throw is 1 to 5, and one side of the coil is placed in slot No.1 and the other side of the coil is inserted in slot No.5 as shown in Fig 3. Then the winding pitch is 5-1 = 4. The ratio between the winding pitch and pole pitch is called the pitch factor.

$$\text{Pitch factor} = \frac{\text{Winding pitch}}{\text{Pole pitch}}$$

Short pitch winding is usually used in almost all machines except variable speed motors. The reasons for adopting short pitch winding are given below.

Fig 3



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1 Winding requires less copper.

2 Copper loss is less.

3 Efficiency of the machine is increased.

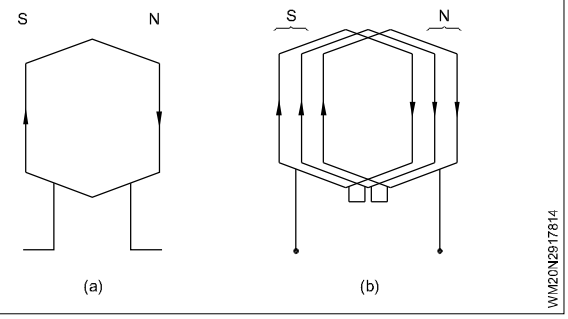
4 Winding occupies less space.

5 In alternators, the winding produces uniform sine wave.

Coil group : When you observe the direction of the current flow in a coil, you will see current in the two coil sides have opposite directions as shown in Fig 4(a).

Accordingly the current in a single coil produces two dissimilar poles. In an ordinary winding, according to the design, one or more coils may be connected in series to form a group as shown in Fig 4(b).(Three coils form one group) The total number of coil groups in a winding is equal to the number of phases multiplied by the number of poles.

Fig 4



Total No.of coil groups = No. of phases x No. of poles

$$\text{Coil group per phase} = \frac{\text{Total No. of coil groups}}{\text{No. of phases}}$$

$$\text{Coil group per phase per pole} = \frac{\text{Total No. of coil groups}}{\text{No. of phases x No. of poles}}$$

Further the number of coils in a group per phase per pole

$$= \frac{\text{Total number of coils}}{\text{No.of phases x No.of poles}}$$

$$= \frac{\text{Total number of coils}}{\text{Total number of groups}}$$

Coil connections : The connection which joins a coil lead of one coil to the other coil lead of the same coil group is called 'coil connection' and is shown in Fig 5.

Pole connection : The connection which joins a coil group of one phase to another coil group of the same phase of the winding is called pole connection or group connection, and is shown in Fig 5.

Whole-coil winding: A whole coil winding is one in which the number of coils per phase is equal to the number of poles in the machine. Refer to Fig 6.

Fig 5

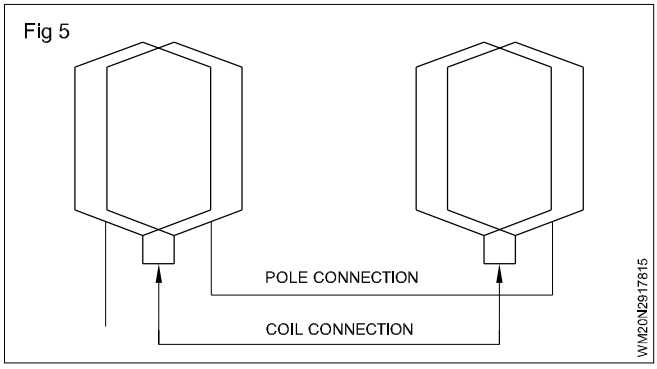
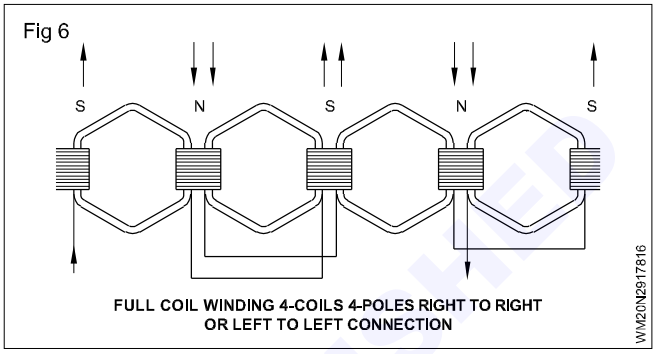
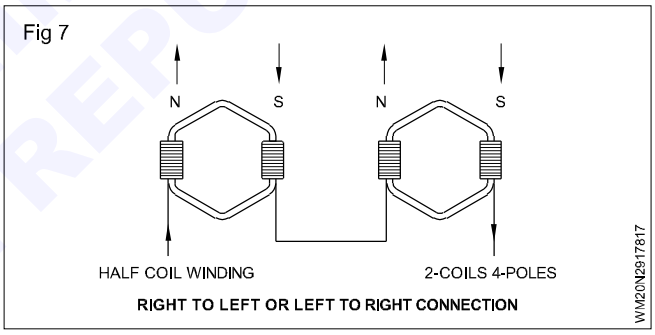


Fig 6



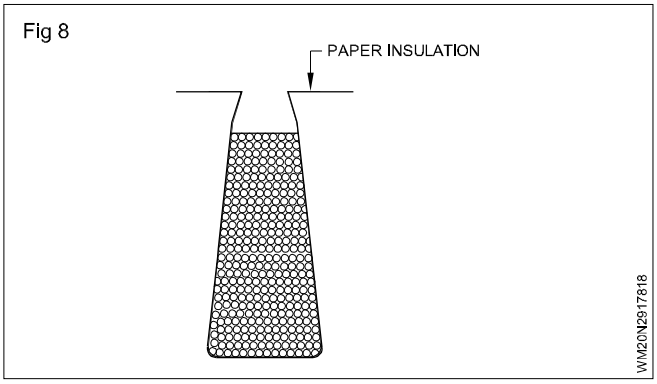
Half coil winding : A half coil winding is one in which the number of coils per phase is equal to half the number of poles in the machines. Half coil winding is generally done in the winding of ceiling fans, double speed motors etc. Refer to Fig 7.

Fig 7



Single layer winding : In single layer winding each slot contains only one coil side as shown in Fig 8 and the number of coils in the machine is equal to half the number of slots in the stator or armature. In single layer winding the coil pitch is usually taken in odd numbers.

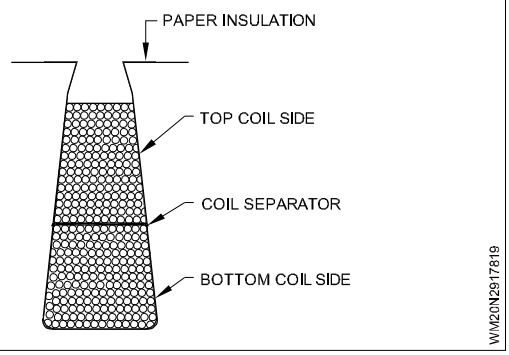
Fig 8



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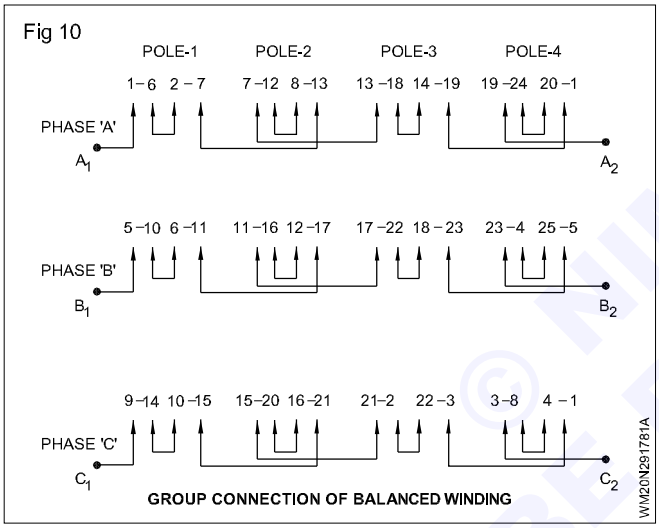
Double layer winding : In double layer winding each slot contains two coil sides (i.e.one upper and one lower) as shown in Fig 9 and the number of coils is equal to the number of slots in the stator.

Fig 9



Balanced winding : When the coil groups contain the same number of coils per phase per pole the winding is termed as 'balanced winding'. It is also known as 'Even Group' winding and is shown in Fig 10.

Fig 10



Unbalanced winding : If the coil group contains an unequal number of coils per phase per pole then the winding is called 'unbalanced winding'. It is also sometimes called 'odd group' winding and is shown in Fig 11.

It is important that there must be an equal number of coils in each phase whether the winding is balanced or unbalanced as shown in Figs 10 and 11.

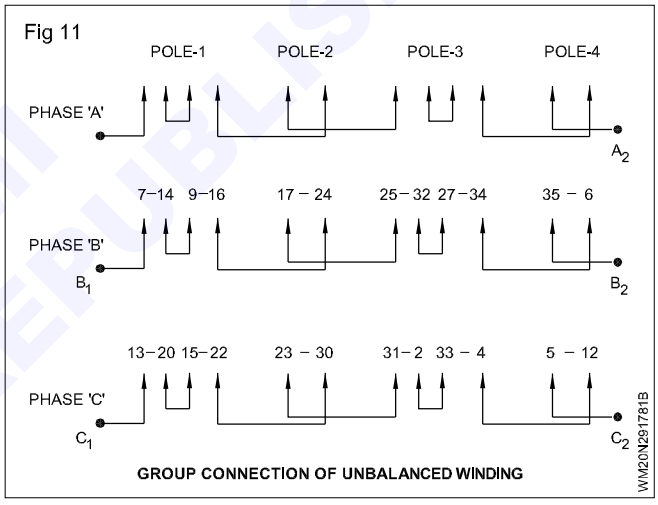
Concentrated winding : If in any winding the number of coils/pole/phase is one, then the winding is known as 'concentrated winding'. In this winding each coil side occupies one slot.

Distributed winding : In this winding the number of coil/pole/phase is more than one - arranged in different slots. In this case each coil has the same pole pitch.

Partially distributed winding: In this winding the coil sides do not occupy all the slots, but some slots remain empty and they are called dummy slots.

Fully distributed winding : It is a winding in which not a single slot remain empty.

Fig 11



Trouble shooting of single AC phase induction motor

Objectives: At the end of this lesson you shall be able to
- **explain the method of trouble shooting in single phase induction motor**
- **explain the rectification of single phase induction motor.**

During the operation of single-phase AC motors, it experiences various faults at the time of starting or stopping or while running. The faults in single-phase motors are due to many reasons like over currents or under-currents, over or under voltages, starter failure, motor overheating, over-loading, etc. Hence, it is essential to protect the motor from faults. Let us see the various faults and rectification or remedies for faults in single-phase induction motors.

Trouble shooting and rectification chart for single phase induction motor

Sl. No.	Causes	Rectification
1	Supply may be cut off.	Check the main supply with a test lamp at the terminals of the motor, at starters terminals. or in the main switch of the motor.
2	The capacitor may be defective in a capacitor-type motor.	Check the capacitor with a series test lamp
3	Stator winding may be open-circuited or reversed coil connections.	Check the windings and polarity of coils with the test lamp and if any end is found broken. join it or solder it and if the polarity is

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		wrong. correct them by doing the connections ends of each coil polarity.
4	Starter winding may be short-circuited or earthed.	Check the winding with a series test lamp or megger and correct it.
5	Connections of stator windings may be wrong.	Check the connections physically and also with a series test lamp and correct them.
6	Motor may be overloaded.	Check the load physically and reduce it.
7	Supply voltage may be too low.	Check the supply voltage with a voltmeter and switch off the motor till the voltage increases.
8	The rotor shaft may be jammed in the bearings or brushes.	Rotate the rotor shaft to see its free motion and check the bearings and play. Check and grease them.

Advantages And Disadvantages Of Single Phase Motors

Advantages

1 Lightweight, Compact Unit

2 Efficient Transmission

3 Less maintenance.

4 Cheep in cost

5 Rugged construction

Disadvantages

1 High Insulation Costs

2 Not Uniform Torque

3 Cannot Handle Overload

4 Low efficiency

Three-phase induction motor winding (single layer - concentric type - half coil connection)

Objectives: At the end of this lesson you shall be able to
- **state the general requirements pertaining to the concentric type of winding in 3-phase motors**
- **state the merits and demerits of concentric type winding**
- **explain the preparation of a winding table for concentric type winding**
- **explain how to draw the end and coil connection diagrams**
- **explain how to draw the developed and ring diagrams.**

3-phase concentric winding : In general, concentric winding is found in single phase motors, and occasionally, this type of winding is also used for 3-phase motors.

This concentric winding has to have two or more coils in a group consisting of different pitches. Further in 3- phase concentric winding, all the three phases consist of the same number of coils, and produce similar concentric poles. Stepped formers are used to prepare coils for concentric winding.

Merits and Demerits of concentric winding: This type of winding has some merits and demerits also.

Merits

1 This type of winding has more space for cooling.

2 No need of raising (lifting) the coil sides to interleave them during the winding.

3 It is easy to shape the coils uniformly.

4 Possible to save copper, because in distributed winding all the coils are of the same size; on the other hand in concentric winding, coil groups only will be uniform, but coils of different pitches in concentric form are used.

5 As there is no interleaving of the coil sides, the winding could be done by machine resulting in faster production.

6 It is easy to make the end connection.

7 Easy to wind, as there is no overlapping of coils.

Demerits

1 Skilled labour is required to insert the coils in the slots.

2 A stepped former is required.

3 Not as efficient as basket winding.

1 Grouping

The example given below will clarify the following:

a whether concentric type of winding is possible for a given stator

b If yes, whether it should be half coil or whole coil connected winding.

Example

3-phase induction motor having 36 slots 12 coils 4 pole stator

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We have

$$\text{No. of coils per phase} = \frac{\text{Total No. of coils}}{\text{No. of phases}}$$
$$= \frac{12}{3} = 4 \text{ coils/phase}$$

For whole coil connection

$$\text{No. of coils/phase/pole} = \frac{\text{No. of coils/phase}}{\text{No. of poles}}$$
$$= \frac{4}{4} = 1 \text{ coils/phase/pole}$$

As such there will be only one coil in a group. But concentric winding should have two or more coils in a group. In this case concentric winding is not possible. Alternatively grouping can be done for half-coil connection, i.e.

$$\text{No. of coils/phase/pair of poles} = \frac{\text{Total No. of coils}}{\text{No. of phase x No. of pair of poles}}$$
$$\text{As per the example } \frac{12}{3 \times 2} = 2 \text{ coils}$$

i.e. 2 coils/phase/pair of poles.

As per the above example, only half-coil connected concentric winding is possible whereas for the following example having data 48 slots, 24 coils, 4-pole, 3-phase stator winding both whole coil and half coil connections are possible. Hence it is necessary to trace the group connection very carefully before stripping the stator to determine whether the winding connection is whole coil or half coil.

2 Pitch

1 $\text{Pole pitch} = \frac{\text{No . of slots}}{\text{No . of poles}}$

As per the example $= \frac{24}{4}$ 6 slots

As the winding is concentric, there should be 2 or more pitches normally. According to the above example 2 pitches for half-coil connections are required.

Further it is necessary to have the average pitch equal i.e. to the pole pitch.

(i.e.) coil pitch = pole pitch $\pm$1

As per the example coil pitch is 6$\pm$1.

Therefore outer coil pitch = 6 + 1 = 7

and inner coil pitch will be = 6 - 1 = 5

(i.e.) Coil throw = 1 - 8 and 1 - 6 In practice it is written as 1 - 8 and 2 - 7.

3 Power degrees

i Total Power degrees = 180° x No. of poles.

As per the example = 180° x 4 = 720°.

ii Slot distance in degrees $= \frac{180° \times 4}{\text{No.of slots}}$

$= \frac{180° \times 4}{24} = 30°$

4 Phase displacement

i For three-phase winding phase displacement should be equal to 120°

ii Phase displacement in terms of slots

$= \frac{120°}{\text{slot distance in degrees}}$

As per the example $= \frac{120°}{30°} = 4$ slots

5 Winding sequence

As per the example

A phase starts from 1st slot.

B phase starts from 1+4 = 5th slot and

C phase starts from 1+4+4 = 9th slot.

6 Arrangement of coils

As in the example 12 coils with pitches as 7 & 5 slots.

1-8,2-7; 5-12, 6-11; 9-16, 10-15; 13-20, 14-19; 17-24, 18-23; 21-4, 22-3.

Grouping of coils

The coil should start from every alternate 2 slots (i.e.) 2 slots for top sides and two slots for bottom sides. As per the example, coils start from 1 & 2, 5 & 6, 9 & 10, 13 & 14, 17 & 18, 21 & 22.

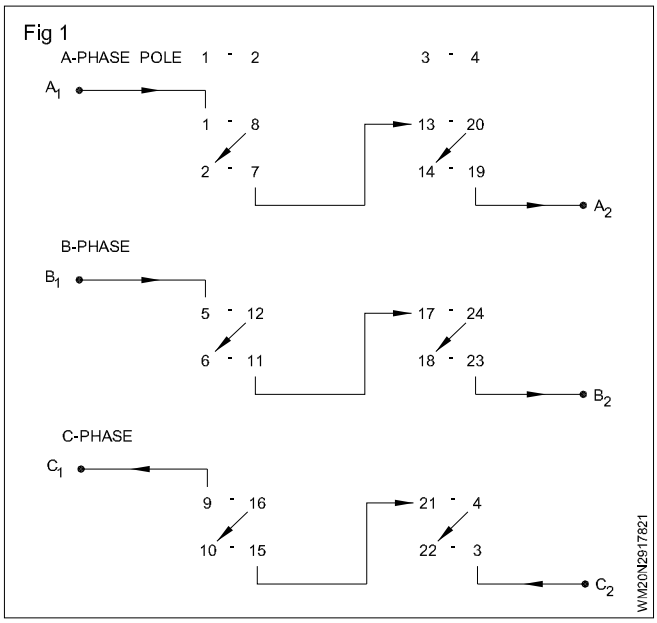
As the connection is half-coil type, with the help of one group of coils, 2 poles need to be created. Hence grouping is as follows:

A	B	C
1-8, 2-7	5-12, 6-11	9-16, 10-15
13-20, 14-19	17-24, 18-23	21-4, 22-3

In whole coil connection, the starting end connection is from the alternative groups (i.e.) if 'A' starts from the first group, 'B' starts from third group and 'C' starts from fifth group. Whereas in half-coil connection, the starting ends will be from continuous group, if 'A' starts from the first group, 'B' starts from second group and 'C' starts from the third group. Refer to the developed diagram given in Fig 49.

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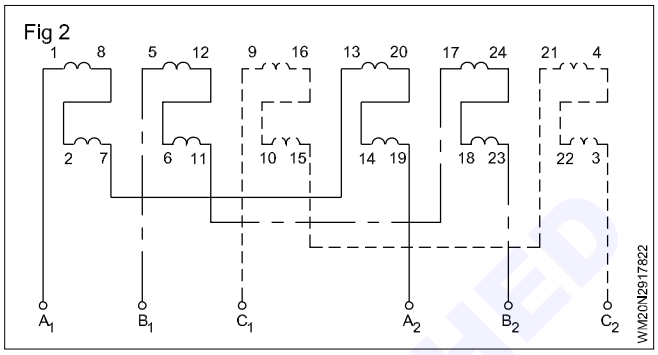
7 End connections (Fig 1): Half coil connection.(End to start and start to end)

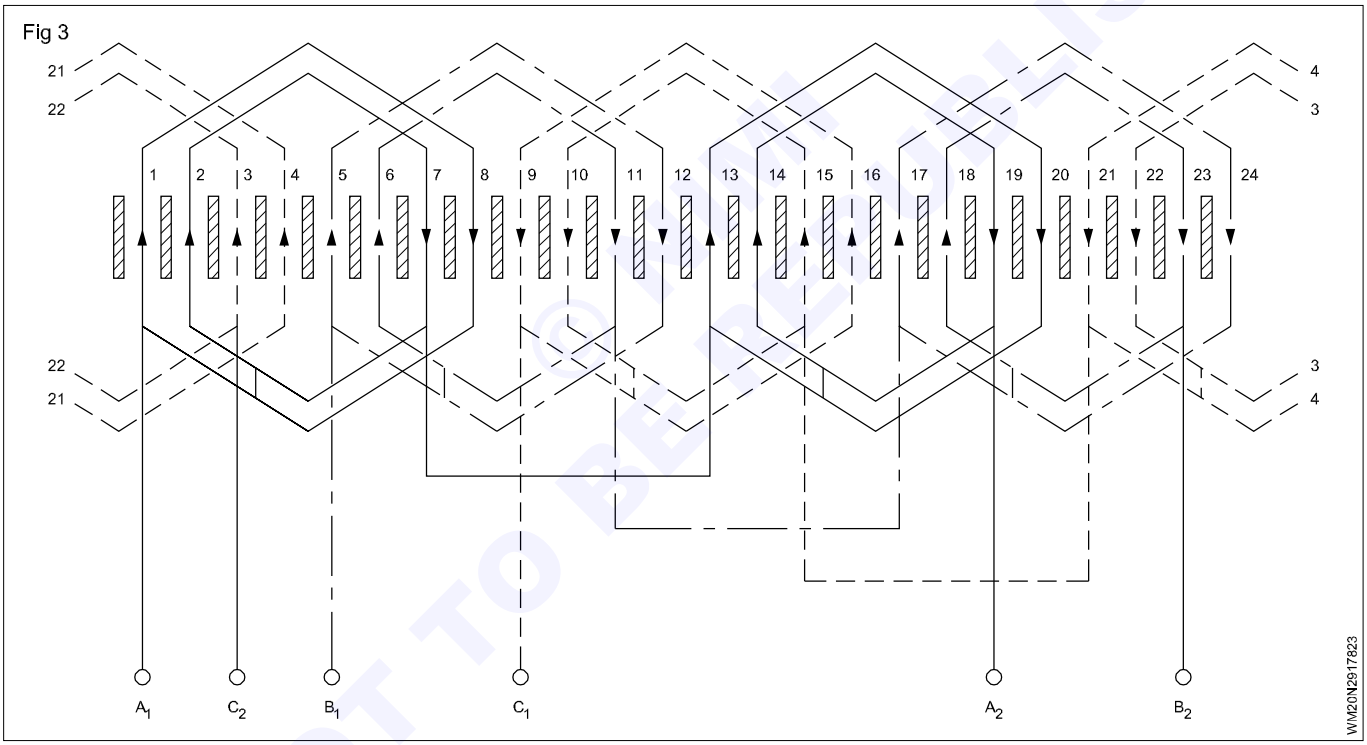


Coil connections : Half coil connection. (Fig 2)

In half coil connection, the connection of the coil group shall be from the finish end to the start end and then from the start end to the finish end of the group coils as shown in Fig 2.

Development diagram : Draw the development diagram showing the coil group and end connection. As an example a development diagram is shown in Fig 3.





10 Ring diagram

Cross check the end connection with the help of the ring diagram as explained below. Write the end connection table and mark the direction of current using the clock rule. Note that when a three-phase supply is given to the windings at an instant, and if two phases carry current in one direction, the third phase carries current in the opposite direction as shown in Fig 4.

PHASE	P_1 & P_2	P_3 & P_4
A phase	↑1 - 8↓	↑13 - 20↓
	↑2 - 7↓	↑14 - 19↓
B phase	↑5 - 12↓	↑17 - 24↓
	↑6 - 11↓	↑18 - 23↓
C phase	↓9 - 16↑	↓21 - 4↑
	↓10 -15↑	↓22 - 3↑

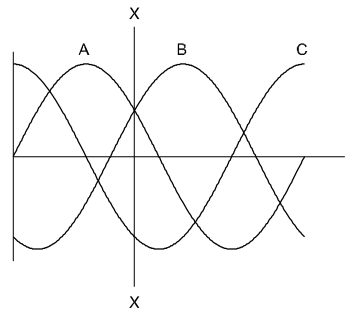
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Refer to Fig 4 in which at the instant shown in x-x we have phases A and B as positive polarity and C has negative polarity.

Mark the direction of current in the slot and it shall represent production of the required number of poles as per the example given below.

Whenever you come across a 3-phase induction motor having a single layer concentric type half coil winding follow the above mentioned procedure and prepare the winding table. Subsequently draw the end connection, development and ring diagrams.

Fig 4



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↑ ↑ ↑ ↑ ↑ ↑	↓ ↓ ↓ ↓ ↓ ↓	↑ ↑ ↑ ↑ ↑ ↑	↓ ↓ ↓ ↓ ↓ ↓
1 2 3 4 5 6	7 8 9 10 11 12	13 14 15 16 17 18	19 20 21 22 23 24
N	S	N	S

Troubleshooting of universal motor

Objectives: At the end of this lesson you shall be able to
- **state the advantages and disadvantages of universal motor**
- **explain the method of troubleshooting in universal motor.**

As the name suggest universal motors can operate on either AC or DC supply. By a compromise of design fractional horse power motors may be built to operate satisfactorily on either 240 V 50 Hz AC or direct current at 240 volts. Such motors are known as universal motors. Advantages of universal motors

Advantages of universal motors

- These motors develop high starting torque and have the ability to adjust the torque and speed proportionally when loaded.
- Universal motors can operate on direct current or AC supply.
- Tapped fields provide an easy method of controlling speed.

Disadvantages of universal motors

- Since these motors operate at very high speed upto 40,000 rpm considerable air noise is present.
- Because of the large increase in the power input under stalled conditions and the loss of motor cooling, they can burn out within a short time when overloaded too much.
- Useful for intermittent duty application only.
- They produce radio and television interference.

Troubleshooting chart for universal motor: Table 1 gives possible faults, which occur in universal motor, their causes, mode of testing and suggested rectification. As a universal motor is similar in design to the DC machine, trainees are advised to refer trouble shooting chart pertaining to DC machines also.

Table 1

Troubleshooting chart for universal motor

Trouble	Causes	Mode of testing	Rectification
Motor fails to start	a) No voltage due to blown fuse	a) Test by test lamp or voltmeter	a) Replace the blown fuse.
	b) Open overload relay of starter.	b) Test by test lamp or voltmeter	b) Reset or rectify the overload relay contact
	c) Low voltage due to improper supply voltage.	c) Test by voltmeter.	c) Rectify the loose connections at the switch & fuse.
	d) Open circuited field or armature.	d) Test by ohmmeter or Megger.	d) If possible join properly or replace the winding.
	e) Improper contact of carbon brushes with commutator.	e) Visual inspection and test by test lamp	e) Adjust for proper contact of carbon brush with commutator.

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	f) Dirty commutator.	f) Visual inspection and test by test lamp.	f) Clean by buffing the commutator using smooth sandpaper.
Shock to the operator	a) Grounded field or armature circuit due to weak insulation.	a) Test by Megger or test lamp.	a) Rectify the defect and apply shellac varnish to armature and field winding
	b) Insufficient earth.	b) Test by Megger or test lamp.	b) Provide proper earth to the motor.
Over heating of motor	a) Shorted coil of field or armature.	a) Visual inspection and resistance measurement	a) Rewind field or armature coil which is shorted
	b) Tight bearing due to worn out or locked bearing.	b) Test the shaft for free rotation. Check the shield for overheating.	b) Clean the bearings and check for damage. Replace bearing if necessary.
	c) Heavy sparking at commutator due to pitted commutator.	c) By visual inspection.	c) Clean the commutator and true the surface of the commutator.
	d) Shorted commutator.	d) Test the armature by growler.	d) Replace or repair the commutator
	e) Grounded field or armature.	e) Test by Megger.	e) Repair or rewind the field or armature.
Humming sound. Lack of torque due to overheat	a) Short circuited field.	a) Test by ohmmeter.	a) Rewind the field winding.
	b) Shorted armature coil.	b) Test by Growler.	b) Rewind shorted armature winding.

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Concept and principles of estimation and costing

Objectives: At the end of this lesson you shall be able to
- **explain concept and principles of estimation and costing.**

Estimation and costing in electrical wiring involves the process of determining the approximate quantities and costs associated with the installation of electrical wiring systems in buildings or structures. It is an essential aspect of electrical engineering and construction, as it helps in planning, budgeting, and ensuring the efficiency and safety of electrical installations. The concept and principles of estimation and costing in electrical wiring can be summarized as follows:

Concept of Estimation: Estimation involves predicting or calculating the quantities of various materials, equipment, and labor required for the installation of electrical wiring systems. It begins with studying the electrical drawings, specifications, and project requirements. The estimation process includes determining the length and size of cables, the number and type of switches, outlets, and fixtures, and the quantity of conduit, wiring accessories, and other components needed. Accurate estimation relies on a thorough understanding of electrical codes, standards, and industry practices.

Principles of Estimation: Estimation in electrical wiring follows certain principles to ensure accuracy and reliability. These principles include:

a **Study of Drawings and Specifications:** Careful examination of electrical drawings and specifications is essential to grasp the project requirements and identify the electrical components and systems involved.

b **Standardization:** Estimation is based on standardized electrical components, such as cables, wires, conduits, switches, and outlets. Standardization simplifies the estimation process and ensures uniformity in installations.

c **Quantity:** Accurate quantity involves measuring and calculating the quantities of materials required for each component of the electrical wiring system. It considers factors such as cable length, number of outlets, switches, and fixtures.

d **Unit Cost Analysis:** Determining the unit cost of each material and labor component is crucial for estimating the overall project cost. Unit costs can be obtained from market rates, previous project data, or supplier quotations.

e **Contingencies:** Estimation includes accounting for contingencies, such as wastage, additional material requirements, and unforeseen circumstances, to ensure that the estimated quantities and costs are sufficient.

Costing Principles: Costing involves assigning monetary values to the estimated quantities to determine the overall project cost. The principles of costing in electrical wiring include:

a **Material Cost:** Calculating the cost of materials based on the estimated quantities and unit costs.

b **Labor Cost:** Assessing the labor requirement and cost based on factors like the complexity of the installation, labor rates, and productivity.

c **Overheads:** Including indirect costs such as supervision, administration, transportation, and site overheads in the overall project cost.

d **Profit Margin:** Adding a reasonable profit margin to the estimated cost to account for business expenses and ensure profitability.

e **Contingency Allowance:** Allotting a contingency allowance to cover any unforeseen expenses or changes during the execution of the project.

By adhering to these principles, estimation and costing in electrical wiring enable accurate budgeting, resource planning, and successful execution of electrical installations. It ensures that projects are financially viable, meet regulatory requirements, and are completed within the allocated time frame.

Bill of material for 3 phase domestic and commercial wiring

Objectives: At the end of this lesson you shall be able to
- **state specific rules related to 3-phase wiring installations**
- **estimate the wiring by load calculation, load distribution, layout diagram, wiring diagram, selection of cables, selection of conduit, calculation of conduit length, cable length, accessories required and the cost of wiring.**

3-phase wiring installation : The following provisions must be maintained for electrical installation:

1 Separate and distinct circuits for lighting, fan, heating and power wiring shall be kept.

2 All the wiring conductors shall be run at a height of 2.5 metres along the wall or on ceiling.

3 Proper distribution of load should be done at the main distribution load and also at the branch distribution board.

4 The load should be arranged in such a way that it is balanced on all the phases in case of 3-phase 4 wire system or poly phase system.

5 Distribution boards should be located at convenient points, preferably at the load centre.

6 The third pin of all the wall sockets must be earthed with minimum size of earth conductor of GI 14SWG or Aluminium 1.4mm^2

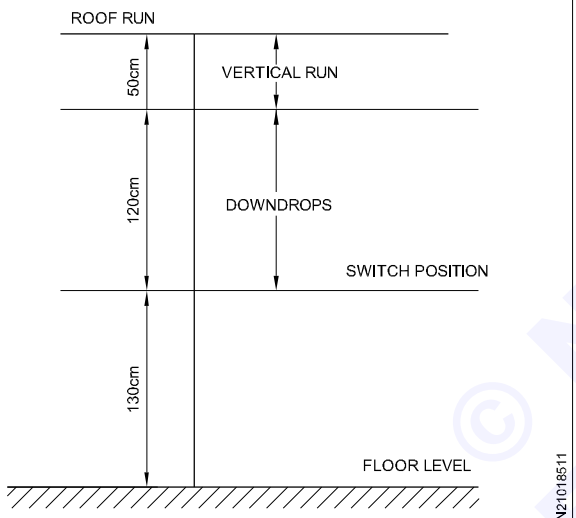
7 All the metal boards must be double earthed for medium and high voltage installation.

8 The phase, neutral and earth wire shall be distinctly marked at the main and branch distributed loads as per Indian Electricity Rule 32 of 1956.

Estimation of wiring

Fig 1 shows the vertical and down drops and switch position measurement from the ground level.

Fig 1



VERTICAL RUN AND DOWN DROPS

Study the consumer's requirement of light, fan and power points in each room (Fig 2).

Divide the load equally in 3-phases while doing so, as a requirement, the light and fan circuits of one room should be from the same phase.

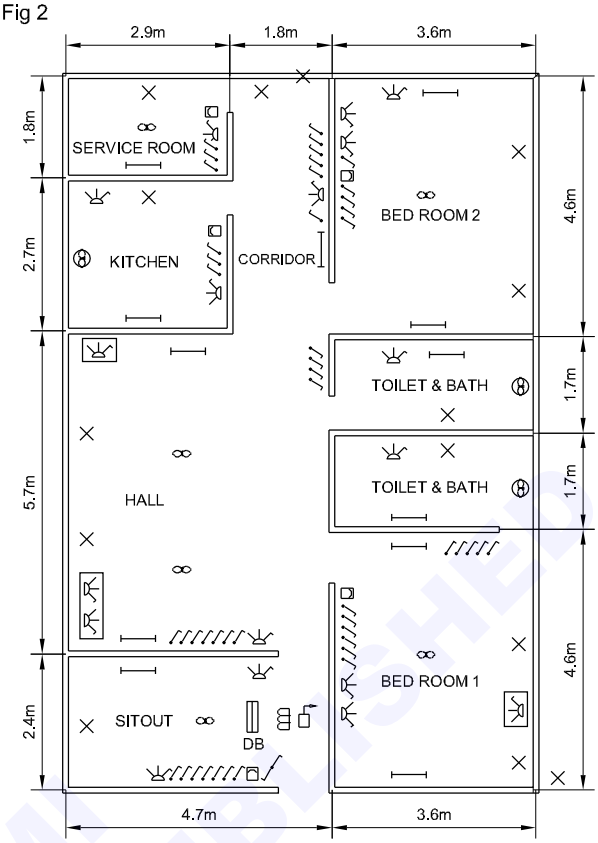
In other words a single room should not get supply from two phases as this will pose a great danger to maintenance electrician and also separate line for individual phase is to be taken through the separate conduits. Clubbing of two or three phases through single conduit should be avoided.

Calculate the wattage of light, fan and power circuits in individual branch circuits of each phase. Then calculate the total connected load of the installation as well as current in each branch circuit.

Refer to the position of accessories diagram and also the load division, then draw the layout diagram showing individual phase lines feeding to various rooms and exterior of the building. Fig 3 shows the layout diagram of phase L_1.

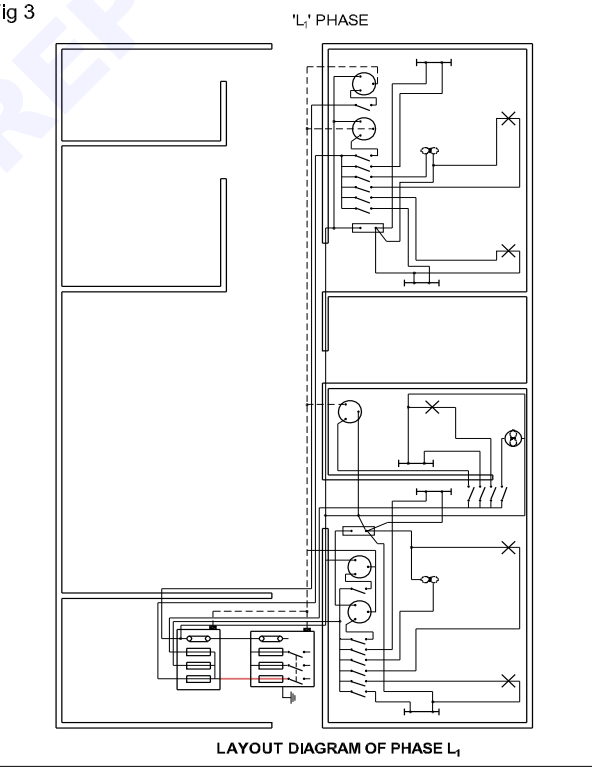
After finalizing the layout, the wiring diagram to be drawn.

Fig 2



ACCESSORIES POSITION DIAGRAM

Fig 3



LAYOUT DIAGRAM OF PHASE L_1

Check the current capacity of each branch and select the size of the cable. After selecting the size of the cable and number of cables in each conduit run refer the PVC conduit table and select the size of the conduit (In the govt. installation CPWD has prescribed 19mm conduit as the minimum size to be used).

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Required conduit length has to be calculated as per given method.

NE code recommends the horizontal run of cables should be at a height of 2.5m (250cm) and the height of switches from floor level should be 130cm. The example taken here for the roof height is 3m (300cm) from floor level. In all cases the dimension of the rooms should be available for estimating.

Vertical run : As such all vertical runs can be calculated as under (Refer Fig 4) for L_2 phase.

Length of selected conduit =

Roof height - (down drop + switch height) x No. of vertical runs

= 3m - (1.20m + 1.30m) x No. of vertical heights
= (3m- 2.5m) x No. of vertical heights
= 0.5m x No. of vertical heights (Eqn. 1)

The value 0.5m will change if there is difference in roof height and height of horizontal run of conduit changes.

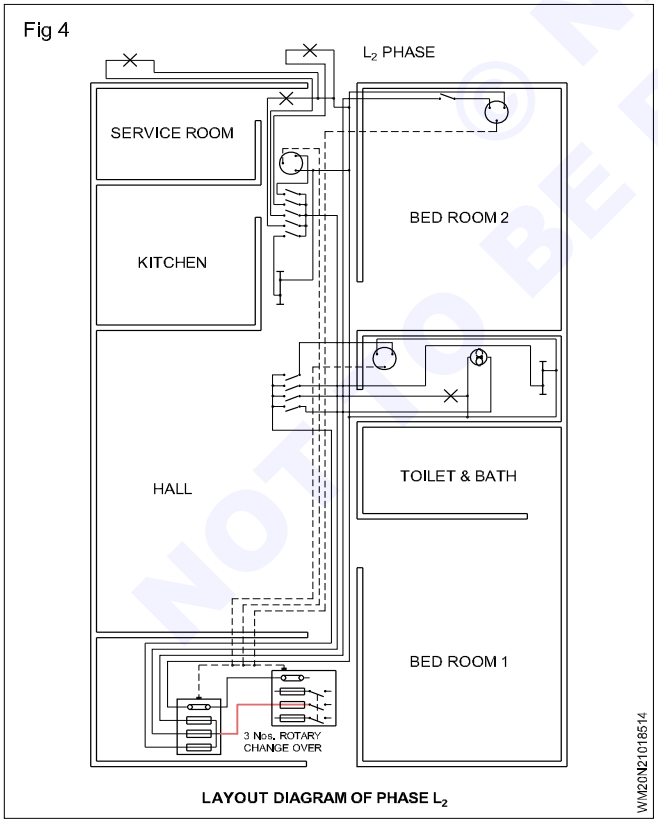
Length of conduit required for down drops

This could be calculated as under:

Length of selected conduit = Height of conduit in horizontal run - Switch position height x No. of down drops for switches

= (2.5m - 1.3m) x No. of down drops for switches
= 1.2m x No. of down drops to switches

Fig 4



LAYOUT DIAGRAM OF PHASE L_2

Length of conduit required for roof runs

This could be calculated as under

Length of selected conduit = Sum of the actual length of roof run taken in each case.

For each size the total requirement is to be calculated.

Length of conduit required for horizontal run

Length of selected conduit = sum of the actual length of horizontal run taken in each case.

Length of conduit required for the distance between main switch and DB is to be calculated. In most of the cases wall is thickness has to be taken into account.

Example

(Refer the layout and wiring diagram with respect to phase L_1) In all cases except for main switch and DB the cable used is 1/1.12 copper cable and maximum number of cable it can accommodate in 19mm conduit is 7 cables. Hence PVC conduit of 19mm is chosen.

1 Length of conduit required for vertical run

Length for vertical run = 0.5m x No. of vertical height

A careful study of layout indicates there are 8 vertical height runs

= 0.5m x 8 = 4m of 19mm PVC conduit

2 Length of conduit required for down drops

Length of down drops = 1.2m x No. of down drops

A careful study of layout indicates there are 9 down drops = 1.2m x 9 = 10.8m

3 Length of conduit required for roof runs

Length of conduit = 2.35m + 2.35m + 2.35m + 2.35m + 1.45m + 0.9m = 9.75m

4 Length of conduit required for horizontal runs

Length of conduit = 4.7m + 3.6m + 1m + 1m + 1.2m + 4.7m + 2.4m + 1.35m + 1.2m + 2m + 2.35m + 5.7m + 2.9m + 2.9m + 1.35m + 2.7m + 2.5m + 1.45m + 1.8m + 1.45m = 48.25m

5 Length of conduit required for main switch and DB

If individual phase line is to be drawn through 19mm PVC conduit will be sufficient on the other hand if all three phase cables to be drawn through single pipe, the requirement to be calculated separately.

Assuming individual phases will be drawn through individual conduits the 19mm PVC conduit will be sufficient to draw two cables of sizes upto 1/2.8 or 7/1.06 aluminium and copper cables respectively.

Length of conduit required for the distance between main switch and DB : Length of conduit = wall thickness + allowance for connection = 0.36m + 0.5m + 0.5m = 1.36m

Total length of PVC conduit 19mm for wiring phase L_1 as per layout and wiring diagram

= Vertical run + down drops + roof runs + horizontal runs + switch DB
= 4m + 10.8m + 9.75m + 48.25m + 1.36m = 74.16 m

Assuming 10% wastage, the total required length of 19mm PVC conduit will be 73.81m + 7.3m = 81.11m or say 80m

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Calculation of length of cable required for wiring phase L_1: For calculating the length of cable accurately the layout and wiring diagrams should be referred. Selected cable in this case is 1 sq.mm copper cable.

Cable required = For outside runs ((L_1 + L_2 + L_3 + L_4) down drop + Horizontal run + switch board to outside wall (thickness of wall)
+ DB to switch board (DD + HR + DD)
+ Switch board to L_5 + (DD + HR)
+ L_5 to F_1 (VR + RR)
+ L_5 to L_6 L_7 (HR + HR)
+ DB to SB_2 (DD + HR + DD)
+ SB_2 to L_9 (DD + HR)
+ L_9 to F_2 (VR + RR)
+ SB_2 to S_3, S_4 (DD + HR + DD)
+ L_9 to L_{10} (HR)
+ L_{10} junction to F_3 (VR + RR)
+ L_{10} junction to L_{11} (HR)
+ S_3, S_4 to S_5 (DD + HR + DD)
+ From DB to S_6 (DD + HR +DD)
+ From S_6 to L_{12} (DD + HR)
+ L_{12} to F_5 (HR)
+ S_6 to F_4 (DD + HR + DD)
+ S_6 to L_{13} (DD + HR)
+ S_6 to S_8 (DD + HR + DD)
+ S_6 to S_7 (DD + HR + DD)
+ S_8 to F_6 (DD + RR)
+ F_6 to L_{15}
+ F_6 to L_{14}

=	+ (3.6m + 1m)2 + (4.7m + 1m)3	26.3m
	+ (0.36M+ 0.5m) x 5 + (1.2m + 3m + 1.2m)2	15.1m
	+ (1.2m + 3m + 1.2m)2	10.8m
	+ (1.2m + 4m + 1.2m)5	32.0m
	+ (0.5m + 2.35m)2	5.7m
	+ (1.2m + 2.35m)3 + 2.35m x 2	15.35m
	+ (1.2m + m2 + 1.2m)2	8.8m
	+ (1.2m + 4m + 2m)6	43.2m
	+ (0.5m + 2.35m)2	5.7m
	+ (1.2m + 1.5m)2	5.4m
	+ (1.2m + 4m + 2m + 1.2m)2	14.8m
	+ 2m x 4	8.0m
	+ (0.5m + 2.35m)2	5.7m
	+ (2m + 2.5m)2	9.0m
	+ (1.2m + 5m + 1.2m)2	14.8m
	+ (1.2m + 4m + 5.7m + 2.9m + 2m + 1.2m)2	34.0m
	+ (1.2m + 1.4m + 1.5m)3	12.3m
	+ (1.5m + 1.35m)2	5.7m
	+ (1.35m x 3m) + (1.35m x 2m)	6.75m
	+ (1.35m + 1.45m + 1.2m)2	8.00m
	+ (1.2m + 1.4m + 0.9m + 1.2m)2	9.4m
	+ (1.2m + 1.45m + 1.2m)2	7.7m
	+ (1.2m + 1.45m)3	7.95m
	+ 0.9m x 2m	1.8m
	+ 0.9m x 2m	1.8m
		325.95m
	Add 10%	32.59m
	Say 360m of 1 sq.mm copper	358.54m

The length of the cable required for power circuit in phase L_1. The cable chosen is 4 sq.mm copper cable which can carry 24 amps

Total length of cable = (1.2m + 0.36m + 2.4m + 3.6m + 2.4m + 1.2m)2
= 11.16m x 2
= 22.32m

Add 10% for wastage = 2.2m

24.52m

Say 25m of 4 sq.mm copper cable is required.

In the same way for the circuits in L_2 and L_3 phases should be calculated. After the list of accessories for entire wiring is prepared the cost of the accessories could be obtained from any local electrical dealer.

Instructor is requested to discuss with the trainees about the mandays required to complete the job alongwith the cost of labour.

Total cost of wiring comprisis of following components.

Total cost of wiring = cost of the accessories
+ cost of cable
+ cost of conduit
+ cost of hardware items
+ labour cost

Bill of material for industrial wiring

Objectives: At the end of this lesson you shall be able to
- **calculate the full load current and size of cables**
- **estimate the cost for workshop wiring**
- **tabulate the material required.**

The trainees can be instructed to estimate the cost of materials for the workshop wiring. Some of the guidance are given below for the trainees and instructor reference.

A sample requirement is given below for trainee's reference

1 One 5HP, 415V 3 phase motor

2 One 3HP, 415V 3 phase motor

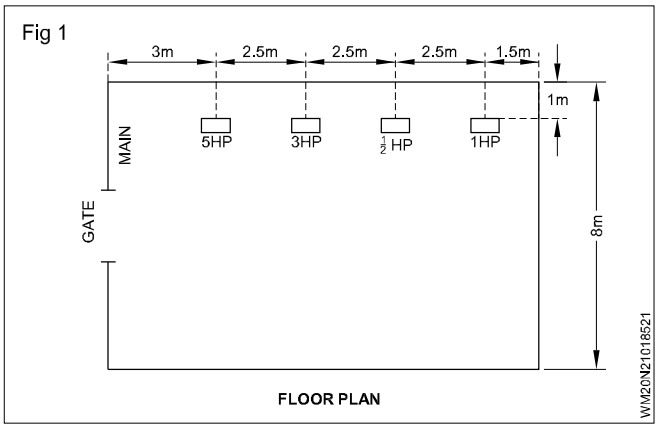
3 One ½ HP, 240V 1 phase motor

4 One 1HP, 415V 3 phase motor

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The motors are to be arranged in row (Fig 1).

Fig 1



The main switch, motor switch and starters are to be mounted at a height of not more than 1.5m from the ground level and the height of horizontal run from ground level will be 2.5 m.

Calculation for the size of cable:

Assuming the motor efficiency to be 85% and the power factor to be 0.8 for all the motors and the supply voltage is 400V.

$$\text{FL current of 5HP motor} = \frac{5 \times 735.5}{\sqrt{3} \times 400 \times 0.85 \times 0.8} = 7.8\text{A}$$

$$\text{FL current of 3HP motor} = \frac{3 \times 735.5}{\sqrt{3} \times 400 \times 0.85 \times 0.8} = 4.68\text{ A}$$

$$\text{FL current of ½ HP motor} = \frac{0.5 \times 735.5}{240 \times 0.85 \times 0.8} = 2.25\text{ A}$$

$$\text{FL current of 1HP motor} = \frac{1 \times 735.5}{\sqrt{3} \times 400 \times 0.85 \times 0.8} = 1.56\text{ A}$$

The main switch and the cable from meter to main switch should be capable of handling starting current of one motor of high rating plus full load current of the all other motors.

i.e, 15.6+4.68+2.35+1.56 = 24.19A

Assuming the starting current of each motor will be two times of their full load current Table 1 gives cable size of each motors to be installed for guidance.

Table - 1

Sl. No.	Motor	FL current I_L in Amp	Starting current $I_s = 2I_L$ in Amp	Recommended cable size
1	5HP motor	7.5	15.6	2.0mm² copper conductor cable (17A) or 2.5mm² aluminium conductor cable (16A)
2	3HP motor	4.68	9.36	2.0mm² copper conductor cable (17A)
3	1/2 HP motor	2.25	4.5	1.0mm² copper conductor cable (11A) minimum recommended cable
4	1HP motor	1.56	3.12	1.0mm² copper conductor cable (11A) minimum recommended cable

The type and gauge of cable shall be selected by referring the table - 1

Some guidance are given below to select the suitable switches and distribution board for trainees reference.

- A 32A, 415V ICTP switch with fuses can be used as main switch.
- 16A, 415V, ICTP switches with fuses can be used for 5HP, 3HP, & 1HP motors.
- 16A, 240V, ICDP switch with fuses can be used for ½ HP motor.
- 415V, 4 way, 16A per way IC distribution board with neutral link can be used for power distribution.

The single typical line diagram of power wirings (Fig.2)

Calculation for the sizes and length of conduit:

19mm heavy gauge conduit should be used for 3 cable runs and 24.4 mm heavy gauge conduits should be used for 6 cable runs.

- 19 mm heavy gauge conduit

Length from main board to 5HP motor starter = 1+1+3+1 = 6.0m

Length from main board to 3HP motor starter = 1+1+5.5+1 = 8.5m

Length from main board to ½ HP motor base = 1+1+8+1+1.5+1.5 = 14.0m

Length from main board to 1HP motor base = 1+1+10.5+1+1.5+1.5 = 16.5m

Total = 45.0 m

10% wastages = 4.5m

Total length = 49.5m, say 50.0m

- 25.4 mm heavy gauge conduit.

Length from meter to main switch = 0.75 m

Length from 5HP motor starter to 5HP motor base (1.5 +1.5) 3.0 m

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Length from 3HP motor starter to motor base = 3.0 m

Total = 6.75 m

10% wastage = 0.67 m

Total = 7.42m, Say 8.0m

- 25.4 mm flexible conduit for 5HP & 3 HP motor (0.75+0.75) = 1.5, Say 2.0m
- 19mm flexible conduit for 1/2 HP & 1 HP motor (0.75+0.7) = 1.5, Say 2.0m

Calculation for the length of cables:

2.0mm^2 copper conductor from main board to 5HP motor terminals = 3(1+1+3+1) + 6(1.5+1.5+0.75) = 40.5m

15% wastages & end connections = 7.2 m

Total = 55.2m , Say = 56.0m

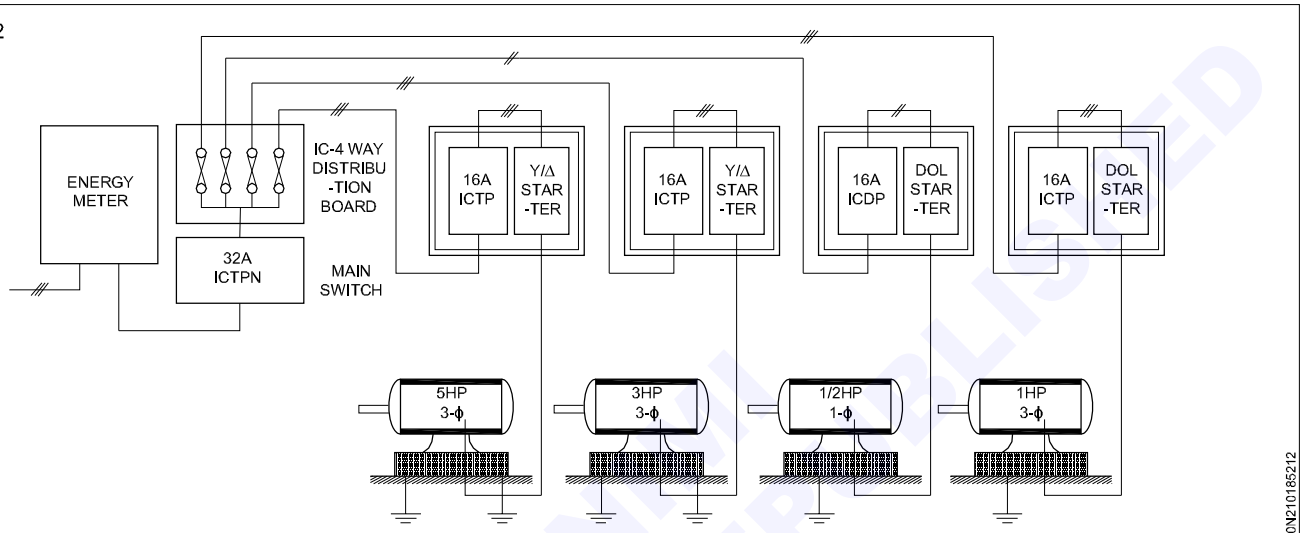
1.0mm^2 copper conductor from main board to 1/2 HP motor terminals = 2(1+1+8+1+1.5+1.5+0.75) = 29.5 m

15% wastages & end connections = 7.76m

Total = 59.51m, Say 60.0m

Trainees may be instructed to tabulate the list of materials.

Fig 2

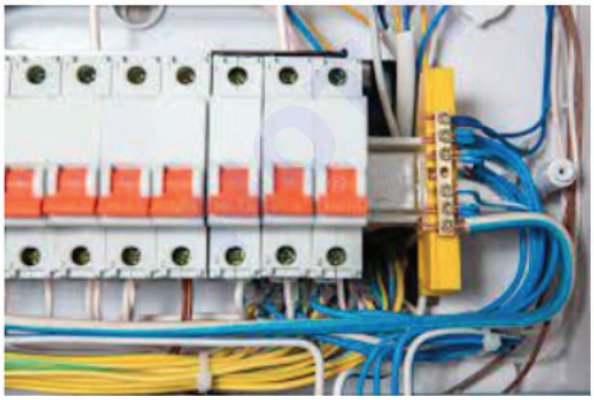


SINGLE LINE DIAGRAM OF POWER WIRING IN WORKSHOP

Smart wiring concept (Fig 3)

Smart wiring is a concept that involves the integration of advanced technology into the electrical wiring of a building to enhance functionality, convenience, and efficiency. It is an innovative approach that revolutionizes traditional electrical systems by incorporating intelligent features and automation capabilities.

Fig 3



Smart wiring concept

The core idea behind smart wiring is to create a networked infrastructure that enables seamless communication and control between various devices, appliances, and systems within a building. This network is typically based on the Internet of Things (IoT) technology, which allows for the interconnectivity and interoperability of smart devices.

Smart wiring offers a range of benefits to both residential and commercial spaces. It enables centralized control and management of lighting, heating, cooling, security systems, and other electrical devices through a user-friendly interface such as a smartphone or a tablet. This allows users to conveniently adjust settings, monitor energy consumption, and receive notifications or alerts remotely.

Additionally, smart wiring enhances energy efficiency by optimizing the use of resources. It can automatically adjust lighting levels based on occupancy, regulate heating and cooling systems based on environmental conditions, and even detect and respond to changes in energy demand. This results in significant energy savings and reduced utility costs.

Furthermore, smart wiring enhances safety and security by integrating advanced sensors, alarms, and surveillance systems. It can detect smoke, gas leaks, or intrusions and immediately alert occupants or emergency services. It also allows for remote monitoring and control of security cameras, door locks, and access control systems.

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In conclusion, smart wiring represents a transformative concept that brings intelligence, connectivity, and automation to electrical systems. By leveraging technology and IoT, it offers enhanced convenience, energy efficiency, and safety to buildings, making them more comfortable and sustainable.

Procedure for taking wireman permit and competency certificate in INDIA

In India, obtaining a wireman permit and competency certificate is essential for individuals who wish to work as electricians or wiremen in various industries. Here is a general procedure for obtaining these certifications:

Eligibility: To apply for a wireman permit and competency certificate, you must meet certain eligibility criteria, which may vary slightly depending on the state or region. Generally, applicants must have completed a minimum level of education (e.g., 10th or 12th grade) and possess the necessary technical knowledge in electrical systems.

Training: Enroll in a recognized technical institute or vocational training center that offers courses in electrical wiring and installation. These programs typically cover theoretical knowledge as well as practical hands-on training. Ensure that the institute you choose is accredited and recognized by the relevant government authority.

Course Completion: Successfully complete the prescribed course, which usually includes a specified number of training hours or semesters. The duration of the course may vary depending on the institute and program.

Examinations: After completing the training, you will need to appear for examinations conducted by the concerned authority. The exams assess your understanding of electrical concepts, wiring techniques, safety practices, and related regulations. The exam format may include written tests and practical assessments.

Application: Once you have cleared the examinations, you can apply for a wireman permit and competency certificate. Obtain the application form from the appropriate authority, which could be the licensing board for electrical workers in your state.

Documentation: Fill out the application form accurately and attach the required documents, which typically include your educational certificates, training completion certificate, examination result documents, identification proof, address proof, and passport-sized photographs.

Fees: Pay the requisite fees as specified by the authority or board. The fee structure may vary depending on the state and the type of certificate you are applying for.

Verification and Issuance: Submit your application form, along with the supporting documents and fees, to the designated office. The authorities will verify your application, and if everything is found to be in order, they will issue you the wireman permit and competency certificate.

It's important to note that the specific procedure and requirements may vary across different states in India. Therefore, it is advisable to consult the local electrical licensing board in your region to obtain accurate and up-to-date information regarding the process

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