A Laboratory Manual for

Electrical Workshop (3110012)

B.E. Semester 1 & 2 (all branch)

Directorate of Technical Education, Gandhinagar, Gujarat

Vishwakarma Government Engineering College
Chandkheda – Ahmedabad
Certificate

This is to certify that Mr./Ms. ______________________________________ ________ Enrollment No. _______________ of B.E. Semester 1/2 **Electrical Engineering** of this Institute (GTU Code: 017) has satisfactorily completed the Practical work for the subject **Electrical Workshop (3110012)** for the academic year 2023-24.

Place: __________
Date: __________

Name and Sign of Faculty member

Head of the Department

Preface

Main motto of any laboratory/practical/field work is for enhancing required skills as well as creating ability amongst students to solve real time problem by developing relevant competencies in psychomotor domain. By keeping in view, GTU has designed competency focused outcome-based curriculum for engineering degree programs where sufficient weightage is given to practical work. It shows importance of enhancement of skills amongst the students and it pays attention to utilize every second of time allotted for practical amongst students, instructors and faculty members to achieve relevant outcomes by performing the experiments rather than having merely study type experiments. It is must for effective implementation of competency focused outcome-based curriculum that every practical is keenly designed to serve as a tool to develop and enhance relevant competency required by the various industry among every student. These psychomotor skills are very difficult to develop through traditional chalk and board content delivery method in the classroom. Accordingly, this lab manual is designed to focus on the industry defined relevant outcomes, rather than old practice of conducting practical to prove concept and theory.

By using this lab manual students can go through the relevant theory and procedure in advance before the actual performance which creates an interest and students can have basic idea prior to performance. This in turn enhances predetermined outcomes amongst students. Each experiment in this manual begins with competency, industry relevant skills, course outcomes as well as practical outcomes (objectives). The students will also achieve safety and necessary precautions to be taken while performing practical.

This manual also provides guidelines to faculty members to facilitate student centric lab activities through each experiment by arranging and managing necessary resources in order that the students follow the procedures with required safety and necessary precautions to achieve the outcomes. It also gives an idea that how students will be assessed by providing rubrics.

Workshop / Manufacturing practices (3110012) subject deals with the Mechanical workshop, IOT workshop and Electrical workshop. In Electrical workshop subject students will be able to understand working principle, construction and applications of electrical appliances. Students will also learn basic residential, commercial application of electrical wiring.

Utmost care has been taken while preparing this lab manual. However there is always chance of improvement. We welcome constructive suggestions for improvement and removal of errors if any.

Practical – Course Outcome matrix

Distribution of subject	Department	Weightage	CO
Mechanical workshop	Mechanical	50 %	1,2
IOT workshop	IT / Computer	25 %	4
Electrical workshop	Electrical	25 %	3

Course Outcomes (COs):

CO1: Comprehend the safety measures required to be taken while using the tools. equivalent circuit, phasor diagram and circle diagram

CO2: Prepare Fitting, Carpentry, Plumbing, Welding and Tin Smithy Job.

CO3: Measure different electrical quantities and trouble shoot electrical and electronics appliances

CO4: Conduct experiments with various kits such as Raspberry and Arduino for embedded system Development and Use basic commands of computer operating systems.

Sr. No.	Objective(s) of Experiment	CO1	CO2	CO3	CO4
1.	To study and perform the measurement of voltage, current, power and power factor for single phase system.			√	
2.	To demonstrate Working operation of MCB and ELCB.			√	
3.	To perform wiring connection for House-hold appliances connection and Troubleshooting.			√	
4.	To perform staircase and godown wiring connection practices and application.			√	
5.	To study the different types of Electrical Tools and Components.			√	
6.	Hardware-1			√	
7.	Hardware-2			√	
8.	Hardware-3			√	
9.	Hardware-4			√	

Industry Relevant Skills

Electrical Workshop 3110012

The following industry relevant competency are expected to be developed in the student by undertaking the practical work of this laboratory.

1. Student will be able to measure voltage, current, power and power factor.
2. Student will be able to do wiring for home appliances like celling fan, tube-light, staircase wiring, godown / lobby wiring, switch board connection.
3. Students will be able to identify appropriate tools for electrical wiring.

Guidelines for Faculty members

1. Teacher should provide the guideline with demonstration of practical to the students with all features.
2. Teacher shall explain basic concepts/theory related to the experiment to the students before starting of each practical
3. Involve all the students in performance of each experiment.
4. Teacher is expected to share the skills and competencies to be developed in the students and ensure that the respective skills and competencies are developed in the students after the completion of the experimentation.
5. Teachers should give opportunity to students for hands-on experience after the demonstration.
6. Teacher may provide additional knowledge and skills to the students even though not covered in the manual but are expected from the students by concerned industry.
7. Give practical assignment and assess the performance of students based on task assigned to check whether it is as per the instructions or not.
8. Teacher is expected to refer complete curriculum of the course and follow the guidelines for implementation.

Instructions for Students

1. Students are expected to carefully listen to all the theory classes delivered by the faculty members and understand the COs, content of the course, teaching and examination scheme, skill set to be developed etc.
2. Students shall organize the work in the group and make record of all observations.
3. Students shall develop maintenance skill as expected by industries.
4. Student shall attempt to develop related hand-on skills and build confidence.
5. Student shall develop the habits of evolving more ideas, innovations, skills etc. apart from those included in scope of manual.
6. Student shall refer technical magazines and data books.
7. Student should develop a habit of submitting the experimentation work as per the schedule and she/he should be well prepared for the same.

Common Safety Instructions

Electrical Workshop 3110012

1. Do not touch any terminals (or) Switch without ensuring that it is dead.
2. Wearing shoes with rubber sole is desirable.
3. Use a fuse wire of proper rating.
4. Use sufficient long connecting leads rather than joining two or three small ones, because in case any joint is open it could be dangerous.
5. Make sure that all the electrical connections are correct before switching on any circuit. Wrong connections may cause large amount of current which results damage of equipment.
6. The circuit should be de-energized while changing any connection.
7. In case of emergency or fire, switch-off the master switch on the main panel board.
8. Keep away yourself from all the moving parts as for as possible.
9. Do not renew a blown fuse until you are satisfied to the cause and rectified problem.
10. Do not touch an electric circuit when your hands are wet or bleeding from a cut.
11. Do not disconnect plug by pulling a flexing cable when the switch is on.
12. Do not throw water on live electrical equipment in case of fire.
13. Do not test the circuit with bear fingers.
14. Do not wear loose garments while working in Laboratory.
15. Do not open (or) close a switch (or) fuse slowly or hesitatingly. Do it quickly and positively.

CAUTION

- **Do not prepare any <u>Hardware Model</u> at your home/hostel.**
- **You have to prepare all these hardware model in institute laboratory ONLY and in-front of respective subject faculty ONLY.**
- **Do not give electric power supply 230 V, 50 Hz to any hardware model in any case.**
- **Term-work submission without testing of hardware model is permissible / acceptable for this subject.**

Assessment tools

Total Marks	**80 Marks [Viva]**			**20 Marks [Internal]**		
Workshop	Mech. W/S	IOT	**EW/S**	Mech. W/S	IOT	**EW/S**
Individual marks	40	20	**20**	10	5	**5**

Department	Workshop	Marks [V]	Marks [I]	Total Marks
		80	**20**	**100**
Mechanical	Mech. W/S	40	10	50
IT / Computer	IOT W/S	20	5	25
Electrical	Electrical W/S	20	5	25

Marks [V]	Marks [I]	Total Marks
20 marks	5 marks	25
Project Hardware	File / term work	
4 Hardware model	5 Practical	
• 4 nos of project hardware model. • Each has 5 marks. • 4 nos of hardware **x** 5 marks = **20 marks**	• 5 no.s of practical. • Each has 10 marks. • Total 50 marks / 10 = **5 marks**	**25**

Index
(Progressive Assessment Sheet)

Sr. No.	Objective(s) of Experiment	Page No.	Date of performance	Date of submission	Assessment Marks	Sign. of Teacher with date	Remarks

1.	To study and perform the measurement of voltage, current, power and power factor for single phase system.							
2.	To demonstrate and study working principle and operation of Fuses, MCB & ELCB.							
3.	To perform wiring connection for House-hold appliances and troubleshooting.							
4.	To perform Staircase / Godown wiring connection practices and its application.							
5.	To study the different types of Electrical Tools and Components.							
6.	Hardware 1							
7.	Hardware 2							
8.	Hardware 3							
9.	Hardware 4							
Total								

Experiment No:1
To study and perform the measurement of voltage, current, power and power factor for single phase system.

Date:

Competency and Practical Skills:
1) Students will be able to identify different equipment in the laboratory
2) Students will be able to read meter scale.
3) Students will be able to understand different wattmeter terminals.
4) Students will be able to have judgement for various electrical measuring instruments to be connected in series / parallel.

Relevant CO:
CO-3 Measure different electrical quantities and trouble shoot electrical and electronics appliances

Objectives:
(a) To understand making of electrical connections.
(b) To recognize and read meter scale.
(c) To measure and understand various basic electrical quantities.

Equipment/Instruments: 1. Single phase variac, 0 to 230 V, 15 A
2. Single phase load bank 2000 W
3. Single phase choke coil
4. Ammeter 0 to 10 A
5. Voltmeter 0 to 300 V (3 nos)
6. Wattmeter 0 to 3000 W, 0-600 V

Meter: A meter is any device built to accurately detect and display an electrical quantity in a form readable by a human being. Usually this "readable form" is visual: motion of a pointer on a scale, a series of lights arranged to form a "bar graph," or some sort of display composed of numerical figures. In the analysis and testing of circuits, there are meters designed to accurately measure the basic quantities of voltage, current, and resistance.

Most modern meters are "digital" in design, meaning that their readable display is in the form of numerical digits. Older designs of meters are mechanical in nature, using some kind of pointer device to show quantity of measurement.

Galvanometer: The great majority of DC ammeters and voltmeters are based upon the simple galvanometer. A *galvanometer* is an instrument for detecting small currents. It consists of a coil of fine wire mounted so that it can rotate in the field of a permanent magnet. When current flows through the coil, the field of the permanent magnet exerts a torque on the coil and makes it rotate until equilibrium is established between the torque due to the field and that exerted by a restoring spring. Therefore, the angle of rotation depends on the current flowing through the coil and a needle attached to the coil can be calibrated to give the current. (In many designs, the field of the permanent magnet is uniform in the region of the coil and the angle is linearly proportional to the current).

Ammeter: An *ammeter* is a measuring instrument used to measure the electric current in a circuit. Electric currents are measured in amperes (A), hence the name. Instruments used to measure smaller currents, in the mill ampere or microampere range, are designated as millimeters or micrometers.

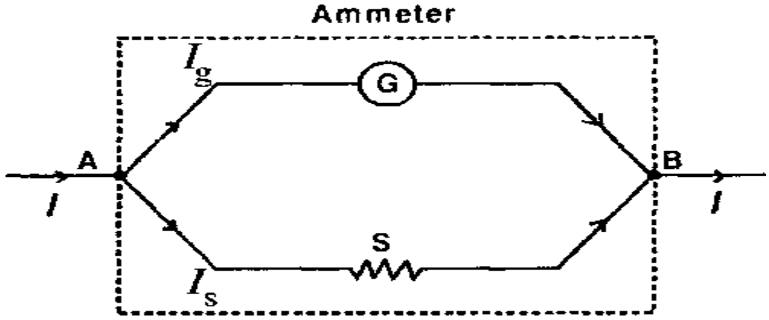


Fig 1.1: Ammeter (Galvanometer with shunt)

A typical analog ammeter consists of a sensitive galvanometer with a low resistance called a *shunt* connected in parallel with it. Adjacent fig 1.1 shows such arrangement. The shunt allows currents to flow through the ammeter which would otherwise burn out the galvanometer. The shunt also allows the ammeter to have a low resistance so that it will have a small effect on the circuit whose current is to be measured.

Voltmeter: A voltmeter is an instrument used for measuring electrical potential difference between two points in an electric circuit. Analog voltmeters move a pointer across a scale in proportion to the voltage of the circuit where as digital voltmeters give a numerical display of voltage by use of an analog to digital converter.

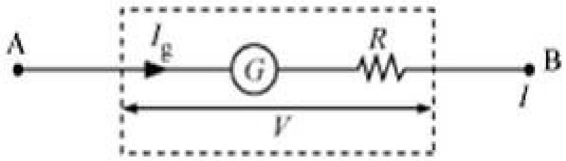


Fig 1.2: Voltmeter
(Galvanometer with Series Resistance)

A typical analog voltmeter consists of a sensitive galvanometer in series with a high resistance, known as a *multiplier*. Since a voltmeter is placed in parallel with the voltage to be measured, it should have a high resistance so that it does not appreciably alter the circuit being measured.

The range or full-scale reading of an ammeter or voltmeter can be changed by changing the shunt or multiplier resistor. The above fig 1.2 shows arrangement to obtain Voltmeter from Galvanometer. From knowledge of the full-scale galvanometer current *Ig*, the galvanometer resistance *Rg*, and the desired range of the meter, the needed shunt or multiplier resistance can be easily calculated by means of Ohm's law.

Wattmeter: The *wattmeter* is an instrument for measuring the electric power (or the supply rate of electrical energy) in watts of any given circuit. Electromagnetic watt meters are used for measurement of utility frequency and audio frequency power; other types are required for radio frequency measurements. Fig 1.3 shows construction of a typical Wattmeter.

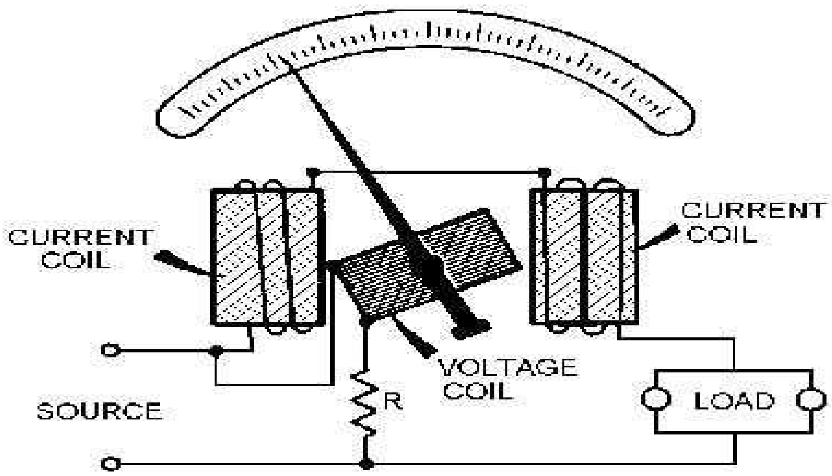


Fig 1.3: Wattmeter

The traditional analog wattmeter is an electrodynamic instrument. The device consists of a pair of fixed coils, known as *current coils*, and a movable coil known as the *potential coil*. The current coils connected in series with the circuit, while the potential coil is connected in parallel.

Also, on analog watt meters, the potential coil carries a needle that moves over a scale to indicate the measurement. A current flowing through the current coil generates an electromagnetic field around the coil.

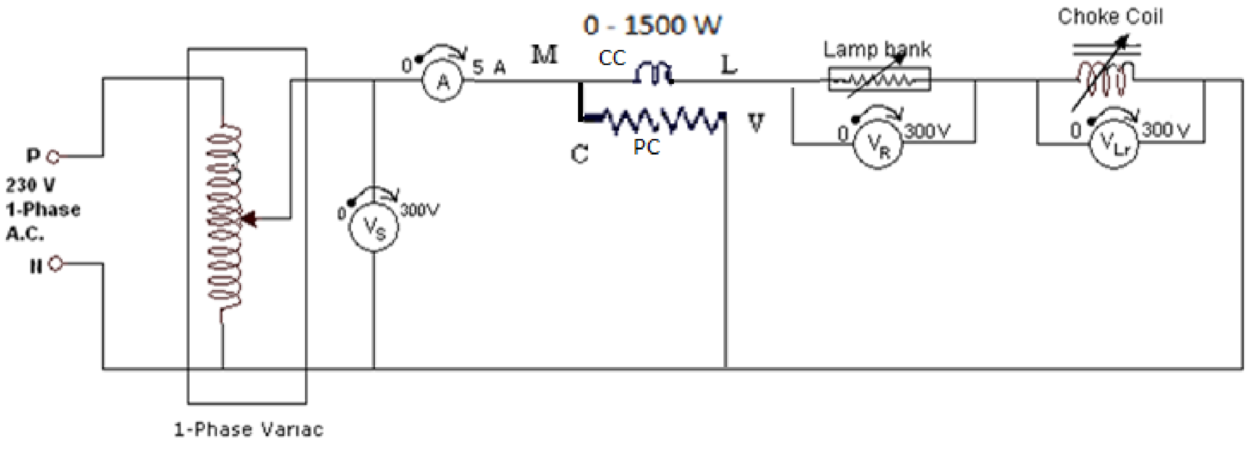
The strength of this field is proportional to the line current and in phase with it. The potential coil has, as a general rule, a high-value resistor connected in series with it to reduce the current that flows through it. The result of this arrangement is that on a dc circuit, the deflection of the needle is proportional to *both* the current *and* the voltage, thus conforming to the equation W=VA or *P=VI*.

Power Factor: The power factor of an AC electrical power system is defined as the cosine of angle between Voltage supplied to the load and Current drawn by it. It can also be defined as the ratio of the real power flowing to the load, to the apparent power in the circuit, and is a dimensionless number between -1 and 1. Real power is the capacity of the circuit for performing work in a particular time. Apparent power is the product of the current and voltage of the circuit. Due to energy stored in the load and returned to the source, or due to a non-linear load that distorts the wave shape of the current drawn from the source, the apparent power will be greater than the real power. A negative power factor occurs when the device which is normally the load generates power which then flows back towards the device which is normally considered the generator.

In an electric power system, a load with a low power factor draws more current than a load with a high power factor for the same amount of useful power transferred. The higher currents increase the energy lost in the distribution system, and require larger wires and other equipment. Because of the costs of larger equipment and wasted energy, electrical utilities will usually charge a higher cost to industrial or commercial customers where there is a low power factor.

Power Factor Meter: The power factor in a single-phase circuit (or balanced three-phase circuit) can be measured with the wattmeter-ammeter-voltmeter method, where the power in watts is divided by the product of measured voltage and current. The power factor of a balanced poly-phase circuit is the same as that of any phase. The power factor of an unbalanced poly-phase circuit is not uniquely defined. A direct reading power factor meter can be made with a moving coil meter of the electrodynamic type, carrying two perpendicular coils on the moving part of the instrument. The field of the instrument is energized by the circuit current flow. The two moving coils, A and B, are connected in parallel with the circuit load. One coil, A, will be connected through a resistor and the second coil, B, through an inductor, so that the current in coil B is delayed with respect to current in A. At unity power factor, the current in A is in phase with the circuit current, and coil A provides maximum torque, driving the instrument pointer toward the 1.0 mark on the scale. At zero power factor, the current in coil B is in phase with circuit current, and coil B provides torque to drive the pointer towards 0. At intermediate values of power factor, the torques provided by the two coils adds and the pointer takes up intermediate- positions.

Circuit diagram:



Draw Circuit diagram:

Procedure:

1. Connect ammeter, voltmeter, wattmeter and power factor meter with the load as shown in circuit diagram.
2. Connect 1-ϕ AC supply to the circuit via Variac to step down the supply voltage.
3. Set Variac voltage to 230 V.
4. Now take the readings of ammeter, voltmeter, wattmeter and pf meter.
5. Repeat the process by changing variac voltage to different values.

Observation Table:

Sr. No.	**Voltage (V)**	**Current (A)**	**Power (W)**	**Power Factor**
1.				
2.				
3.				
4.				

Conclusion:

Review Question:

1. Give a difference between Voltmeter and Ammeter. Draw its symbolic notation also.
2. What is Wattmeter? Draw an electrical symbol of Wattmeter.
3. What is the theoretical resistance of an Ammeter and a Voltmeter?
4. How to measure the resistance of a resistor with an Ammeter and a Voltmeter?
5. Why always Voltmeter is connected in parallel with load terminals?
6. Why always Ammeter is connected in series with load terminals?

Suggested Reference:

1. J B Gupta, “Electrical Installation Estimating & Costing”, Katson Books Publication, 2009.
2. Surjit Singh, “Electrical Estimating and Costing”, Dhanpat Rai & Co., 2010.
3. K. B. Raina, S. K. Bhattacharya, “Electrical Design Estimating and Costing”, New Age International Publishers, 2009.
4. S. L. Uppal, “Electrical Wiring, Estimating and Costing”, Khanna Publishers, 1999.
5. “Electrical Estimating and Costing”, Technical Teachers Training Institute (Madras), TATA Mc-Grow Hill.

References used by the students:

Rubric wise marks obtained

Rubrics	1 Understanding of circuit diagram/Theory information (2)	2 Connections and Procedure (2)	3 Readings, Calculation and Result (2)	4 Conclusion and Applications (2)	5 Participation (2)	Total (10)
Marks						

Experiment No:2
To demonstrate and study working principle and operation of Fuses, MCB & ELCB.

Date:

Competency and Practical Skills:

1) Students will be able to differentiate between Fuse, MCB and MCCB.
2) Students will be able to understand tripping mechanism of safety equipment.
3) Students will be able to explain the concept of leakage current.
4) Student will be able to understand human safety.
5) Student will be able to understand "why fuse is obsolete in option to MCB.

Relevant CO:

CO-3 Measure different electrical quantities and trouble shoot electrical and electronics appliances

Objectives:

(a) To understand human safety.
(b) To know principle and operating mechanism of Fuse, MCB & ELCB.

Equipment/Instruments:

Sr.no	Name of apparatus	Specification	Qty
1	MCB	0-6 A	1
2	ELCB	16 A, 30 mA	1
3	Ammeter	0-20 A	1
4	Ammeter	0-50 mA	1
5	S.P.D.T Switch	415V,15 A	1

[A] Fuses:

Theory:

Low voltage fuses:

The fuse is the oldest device used to protect electrical circuits and equipment against overload and short circuits. The fuse can have many forms and shapes depending on its application. Its rating can start from few mA to several kA.

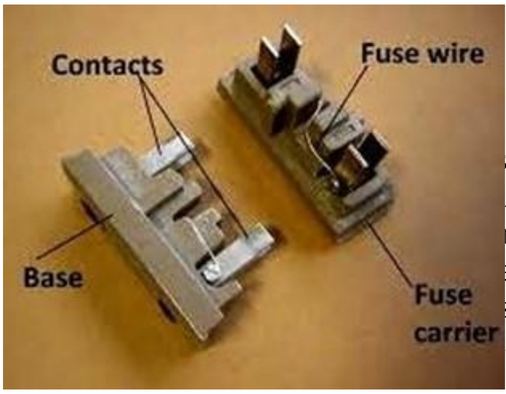
Type of Fuses:

Depending on the fuse current rating, the fuses can be one of the following types for low voltage applications:

1- Semi - enclosed Fuse (Re-wirable)
2- Cartridge Fuse.
3- High Rupturing Capacity (H.R.C) or High Breaking Capacity (H.B.C) Fuses.

1. **The Semi-Enclosed Fuse:**

This type is made from two sections, the base and the carrier. Both of them are made from porcelain insulator. The fuse is so designed that the carrier can be safely withdrawn without danger of touching live parts and the fuse element is so enclosed that molten metal is safely contained and arcing effectively extinguished. The simple wire fuse is connected between two terminals in a porcelain carrier and is usually threaded through an asbestos tube.



Semi - enclosed Fuse (Re-wirable)

e may vary considerably. Circulating air can cool the wire, Air will also oxidize the wire in time, and this will cause a rimination is required, or accuracy in the value of the fusing e is most unreliable. The wires deteriorate and are subject to size of wire to be fitted. In circuits where the energy level is anger, as it may not be adequate in extinguishing the arc.

2. **The Cartridge Fuse:**

Some of the disadvantages of the Semi - enclosed fuse are overcome if the wire is enclosed in a cartridge-type container. The cartridge may vary in length to match the fuse rating of the circuit to be protected so that the wrong size of fuse cannot be fitted. The fuse wire does not deteriorate and is more reliable in operation

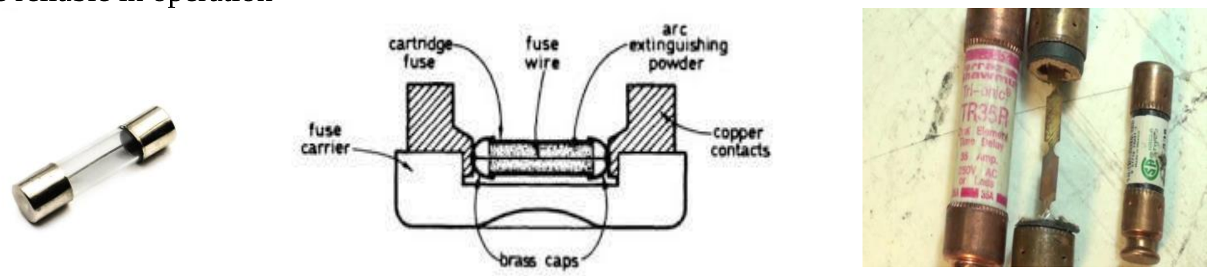


Fig. 2.2 Cartridge Fuse (Replaceable element)

3. High Breaking Capacity (H.B.C) Fuse:

For large currents and where the energy level is high, the high-breaking- capacity (h.b.c.) fuse is used. This is a cartridge-type fuse in which a silver fuse element is connected between two end-contacts of a ceramic tube filled with a special quartz powder. When the fuse blows there is a fusion of the silver vapor produced with the filling powder, so that globules of high-resistance material are formed in the path of the arc, causing it to be extinguished. This type of fuse is very reliable in performance and can be used when discrimination is required. It does not deteriorate and has a high speed of operation.

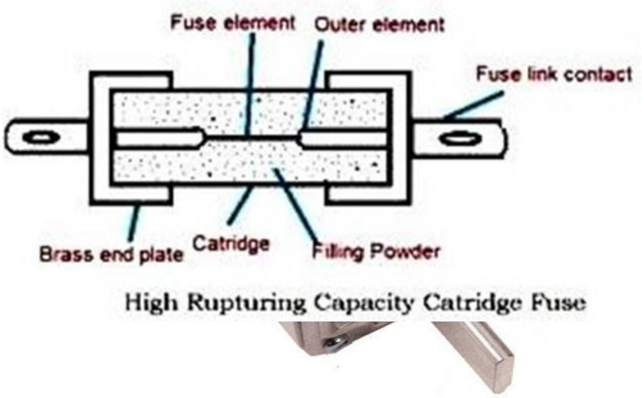


Fig. 2.3 HRC Fuse (one-time use)

The characteristic of an HRC fuse is compared with that of an induction relay. The disadvantage of all types of fuses, of course, is the fact that when they have operated they have to be replaced. The type of fuse chosen to protect a factory circuit will depend upon the type of load and the circuit conditions. It is important to realize the difference between the current rating of a fuse and its fusing current. The current rating of a fuse is the current the fuse will carry continuously without blowing or deteriorating. The rated minimum fusing current is the minimum current at which the fuse will blow in a specified time. This may vary between 1.25 and 2.5 times the current rating. The relationship between the rated minimum fusing current and the current rating is called the fusing factor.

Characteristics of Fuse Element:

The function of a fuse is to carry the normal current without overheating but when the current exceeds its normal value, it rapidly heats up to melting point and disconnects the circuit protected by it. In order that it may perform this function satisfactorily, the fuse element should have the following desirable characteristics:

- low melting point e.g., tin, lead.
- high conductivity e.g., silver, copper.
- free from deterioration due to oxidation e.g., silver
- low cost e.g., lead, tin, copper.

The above discussion reveals that no material possesses all the characteristics. For instance, lead has low melting point but it has high specific resistance and is liable to oxidation. Similarly, copper has high conductivity and low cost but oxidizes rapidly. Therefore, a compromise is made in the selection of material for a Fuses Definition.

Fuse Element Materials:

The most commonly used materials for fuse element are lead, tin, copper, zinc and silver. For small currents up to 10 A, tin or all alloy of lead and tin (lead 37%, tin 63%) is used for making the fuse element. For larger currents, copper or silver is employed. It is a usual practice to tin the copper to protect it from oxidation. Zinc (in strip form only) is good if a Fuses Definition with considerable time-lag is required i.e., one which does not melt very quickly with a small overload.

Important Terms in Fuses:

The following terms are much used in the analysis of fuses:

Current rating of fuse element: It is the current which the fuse element can normally carry without overheating or It depends upon the temperature rise of the contacts of the fuse holder, fuse material and the surroundings of the Fuses Definition.

Fusing current: It is the minimum current at which the fuse element melts and thus disconnects the circuit protected by it. Obviously, its value will be more than the current rating of the fuse element. For a round wire, the approximate relationship between fusing current I and diameter d of the wire is

$$I = k d^{3/2}$$

where k is a constant, called the fuse constant. Its value depends upon the metal of which the fuse element is made. W.H. Preece found the value of k for different materials as given in the table below:

S. No.	Material	Value of k	
		d in cm	d in mm
1	Copper	2530	80
2	Aluminium	1873	59
3	Tin	405·5	12·8
4	Lead	340·6	10·8

The fusing current depends upon the various factors such as:

- Material of fuse element
- Length-the smaller the length, the greater the current because a short fuse can easily conduct away all the heat
- Diameter
- Size and location of terminals
- Previous history
- Type of enclosure used

Fusing factor: It is the ratio of minimum fusing current to the current rating of the fuse element i.e.

$$\text{Fusing factor} = \frac{\text{Minimum fusing current}}{\text{Current rating of fuse}}$$

Its value is always more than one. The smaller the fusing factor, the greater is the difficulty in avoiding deterioration due to overheating and oxidation at rated carrying current. For a semi-enclosed or re-wirable Fuses Definition which employs copper wire as the fuse element, the fusing factor is usually 2. Lower values of fusing factor can be employed for enclosed type cartridge fuses using silver or bimetallic elements.

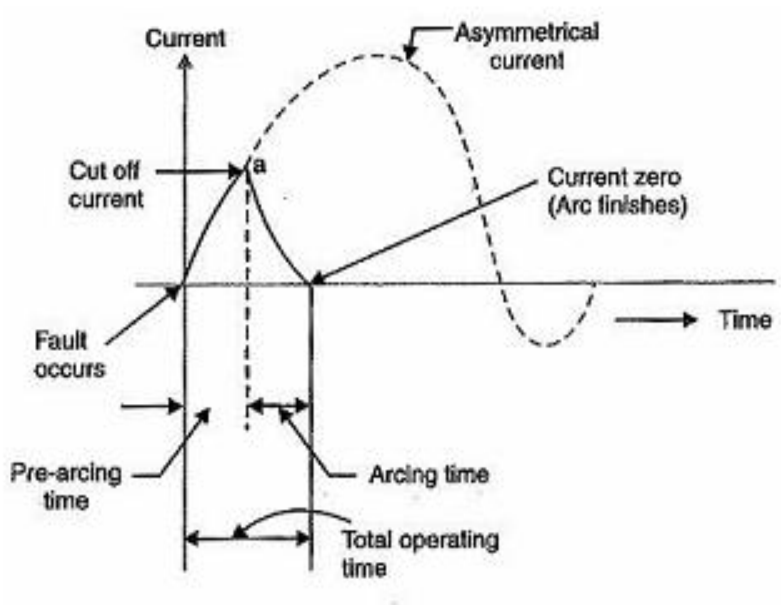


Fig. 2.4 Current Interruption and arcing

Prospective Current:

Fig. shows how a.c. current is cut off by a fuse. The fault current would normally have a very large first loop, but it actually generates sufficient energy to melt the fuseable element well before the peak of this first loop is reached. The r.m.s. value of the first loop of fault current is known as prospective current. Therefore, prospective current can be defined as under:

It is the r.m.s. value of the first loop of the fault current obtained if the fuse is replaced by an ordinary conductor of negligible resistance.

Cut-off current:

It is the maximum value of fault current actually reached before the fuse melts. On the occurrence of a fault, the fault current has a very large first loop due to a fair degree of asymmetry. The heat generated is sufficient to melt the fuse element well before the peak of first loop is reached (point ‘a’ in above Fig.). The current corresponding to point ‘a’ is the cut off current. The cut off value depends upon

- current rating of fuse
- value of prospective current
- asymmetry of short-circuit current

It may be mentioned here that outstanding feature of fuse action is the breaking of circuit before the fault current reaches its first peak. This gives the Fuses Definition a great advantage over a circuit breaker since the most severe thermal and electro-magnetic effects of short-circuit currents (which occur at the peak value of prospective current) are not experienced with fuses. Therefore, the circuits protected by fuses can be designed to withstand maximum current equal to the cut-off value. This consideration together with the relative cheapness of fuses allows much saving in cost.

Pre-arcing time:

It is the time between the commencement of fault and the instant when cut off occurs. When a fault occurs, the fault current rises rapidly and generates heat in the fuse element. As the fault current reaches the cut off value, the fuse element melts and an arc in initiated. The time from the start of the fault to the instant the arc is initiated is known as pre-arcing time. The pre-arcing time is generally small: a typical value being 0.001 second

Arcing time:

This is the time between the end of pre-arcing time and the instant when the arc is extinguished.

Total operating time:

It is the sum of pre-arcing and arcing times. It may be noted that operating time of a fuse is generally quite low (say 0.002 sec.) as compared to a circuit breaker (say 0.2 sec or so). This is an added advantage of a fuse over a circuit breaker. A fuse in series with a circuit breaker of low-breaking capacity is a useful and economical arrangement to provide adequate short- circuit protection. It is because the fuse will blow under fault conditions before the circuit breaker has the time to operate.

Breaking capacity:

It is the r.m.s. value of a.c. component of maximum prospective current that a fuse can deal with at rated service voltage.

[B] MCB and ELCB

Safety is first measure to be taken in to account while operating any electrical equipment. Under faulty condition undesirable path followed by current produces harmful effect to human being as well as equipment.

In order to prevent such hazardous conditions and subsequent effects various protective devices like fuse, Circuit Breakers(CB), MCB (Miniature Circuit Breaker), ELCB (Earth Leakage Circuit Breaker) are extensively used at domestic and industrial level.

Circuit protection devices are used to interrupt current flow or open the circuit. Circuit protection device must ALWAYS be connected in series with the circuit. A circuit protection device operates by opening and interrupting current flowing through the circuit. The opening of a protection device indicates faulty condition. After removal of fault, protection devices automatically get reclosed and attain normal operating condition. The protection device should NOT open during normal circuit operation.

Current always flows in the least resistance path in a circuit. Metals, wet wood, water provides conducting path to the flow of electrons. Human body is about 70% water, so that makes a good conductor. For example, if person touches live conductor or faulty appliance while the feet are touching the ground, electricity will automatically flow through body to the ground. Hence causing a harmful or even fatal shock and the ultimate effect of electric shock on human body may be death.

MCB (Miniature Circuit Breaker)

Circuit breakers used in residential and light commercial installations are referred to as miniature circuit breakers (MCBs). Miniature circuit breakers typically include an electrical contact mounted on a movable contact carrier which rotates away from a stationary contact in order to interrupt the current path.

An MCB is a device designed to protect a circuit's wiring from the serious damage which would be caused if it has to carry a current which is too high to withstand. Such a current could easily heat up the wires so much that their insulation melts. If that situation were allowed to develop further it would soon cause the conductor in a cable to short out and to burn so hot that they could easily cause a house fire.

Before circuit breakers were invented, simple wire fuses were used. The wire in the fuses was deliberately made much thinner than the wires in the circuits they were intended to protect. Thus, if a fault condition occurred, as the current in the circuit grew higher and higher, a point would be reached at which the thin wire of the fuse would get so hot that it would melt all safely contained within the body of the fuse - and thus break the flow of current in the circuit it was protecting.

The problem with fuses is that depending on their design, as some are faster-acting than others. it can take a significantly longer amount of time for them to operate compared with today's very-fast-acting circuit breakers. That fact means that, if a circuit overload current fault condition occurs, considerable damage can still occur both to the circuit wiring and/or to the unit it is supplying with power. Then, after the fault condition has been fixed, the melted or "blown" fuse wire in a rewire-able type of fuse has to be replaced. A circuit breaker, if it is still in good condition, only needs to be reset.

Miniature circuit breakers are compact devices used in distribution boards for protection against overload and short circuit. The overload protection is achieved by a thermal trip mechanism using a bimetallic strip. An electromagnetic trip mechanism is also incorporated for instantaneous tripping in the event of a short circuit. When there is a sudden increase in current due to a short circuit, the circuit should open immediately, but the bimetallic strip does not respond quickly. In this case, the solenoid attracts the plunger and thus triggers the trip mechanism. After clearing the fault, the MCB can be switched on manually.

For light load in domestic appliances like fans, tube lights, bulbs, iron, are protected by 5A current rated MCB and heavy load like geyser, air conditioner, washing machine are protected by 15A current rated MCB.

Fig. 2.5 Different configuration of MCB

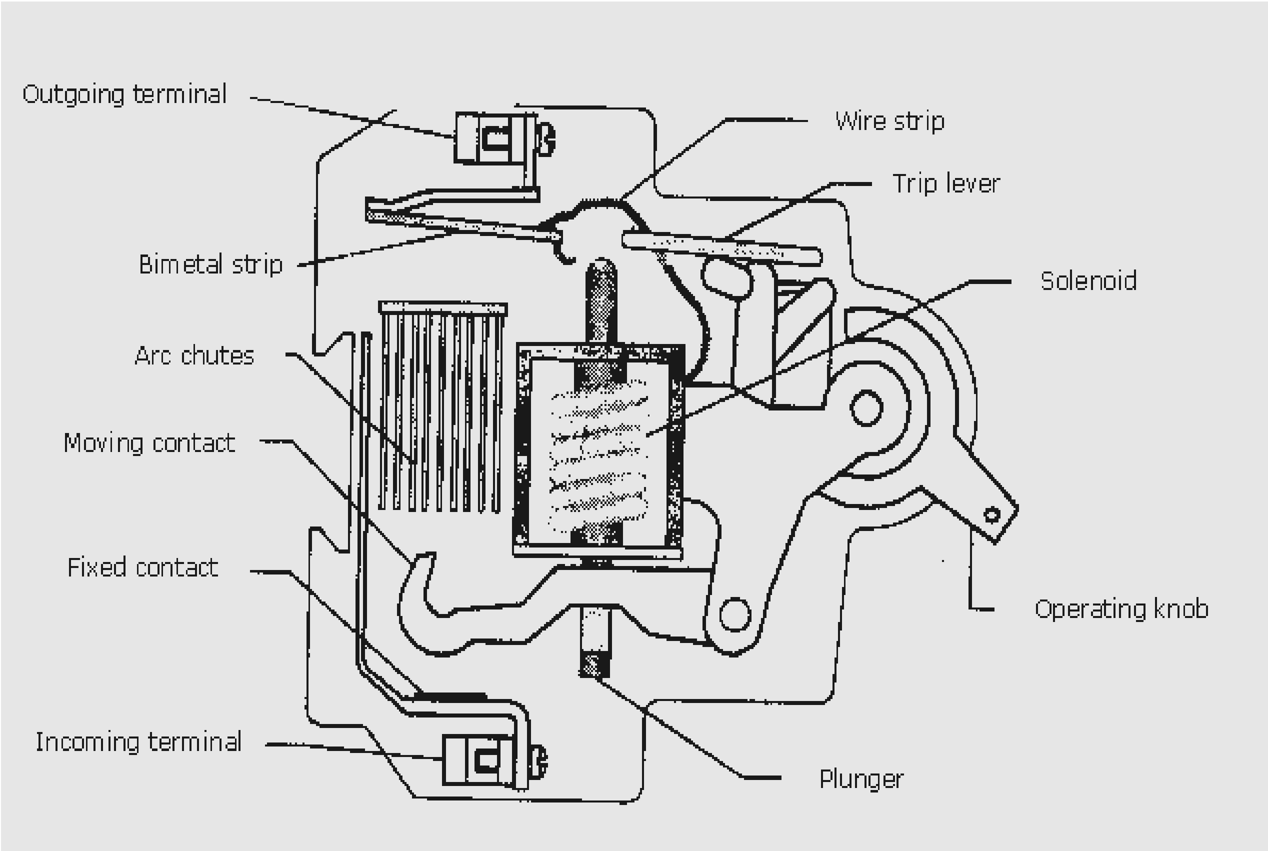


Fig.2.6 Internal structure of MCB

The principle of operation of an MCB is based on the following two principles.

A. Thermal operation
B. Magnetic operation

Thermal operation

In thermal operation, the extra heat produced by the high current warms the bimetal strip. This results in bending the bimetallic strip and trips the operating contacts. The thermal operation is slow. Hence, it is not suitable for speedy disconnection required to clear fault currents. However, it is ideal for operation in the event of small but prolonged overload currents. Thus, in general the thermal operation is suitable for opening the circuit in the event of excessive current due to the overloaded machines.

A. **Magnetic operation**

The magnetic operation, on the other hand is suitable for protection against high short circuit currents. This magnetic operation is due to the magnetic field set up by a coil carrying the current, which attracts an iron part to trip the breaker when the current becomes large enough. The magnetic operation is very fast and is used for braking fault currents. In most cases of MCB s, both types are provided so that overload currents and short circuit currents are handled with the same degree. It should however be remembered that the mechanical operation of opening the contacts takes a definite minimum time, typically 20ms, so that there can never be the possibility of truly instantaneous operation. In many installations, MCBs are preferred over fuses mainly because there is no need of rewiring the fuse wire or replacing the cartridge. MCBs are available in a range of 0.5A to 63A normal operating current and for the entire range, the, physical dimensions are almost identical.

The major advantages of MCBs are

- Instantaneous opening of the contact on short circuit faults
- Can be designed to operate even for very small overload currents
- They can be quickly reset by hand
- They cannot be reclosed if fault persist
- In many cases they preferred over fuses as there is no need to rewire it.

Procedure: (MCB)

1. First connect the circuit as shown in given circuit diagram.
2. Energized the circuit.
3. Increase load gradually.
4. Take the various readings and record them in the observation table.
5. Observe the function of safety device.

Circuit diagram:

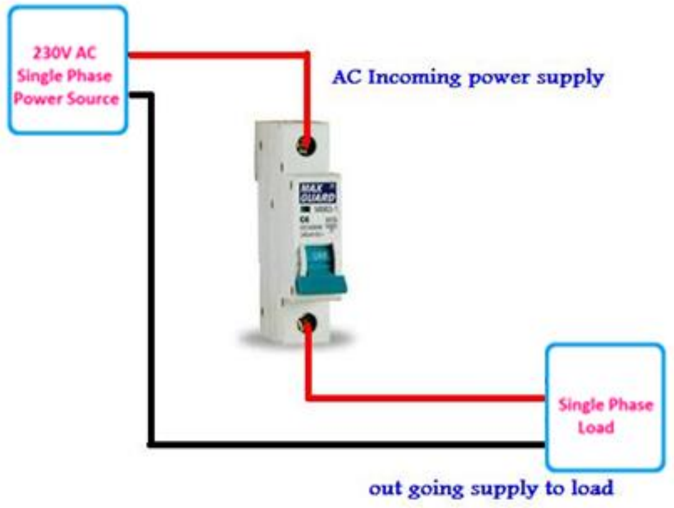


Fig. 2.7 Circuit diagram of single pole MCB

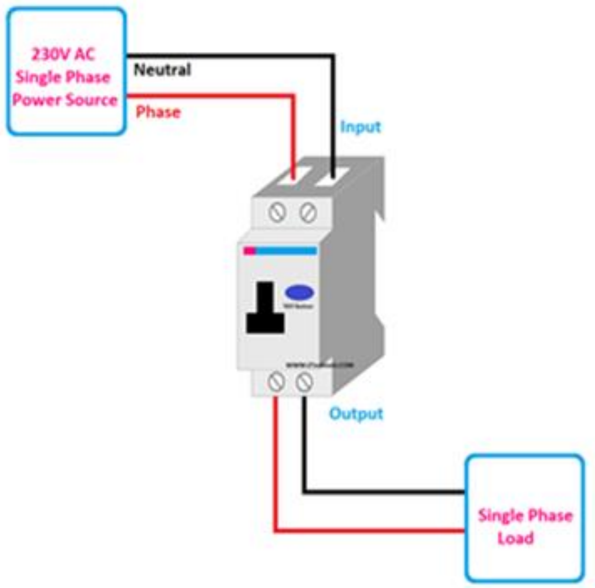


Fig. 2.8 Circuit diagram of double pole MCB

Draw circuit diagram:

Observation Table (MCB)

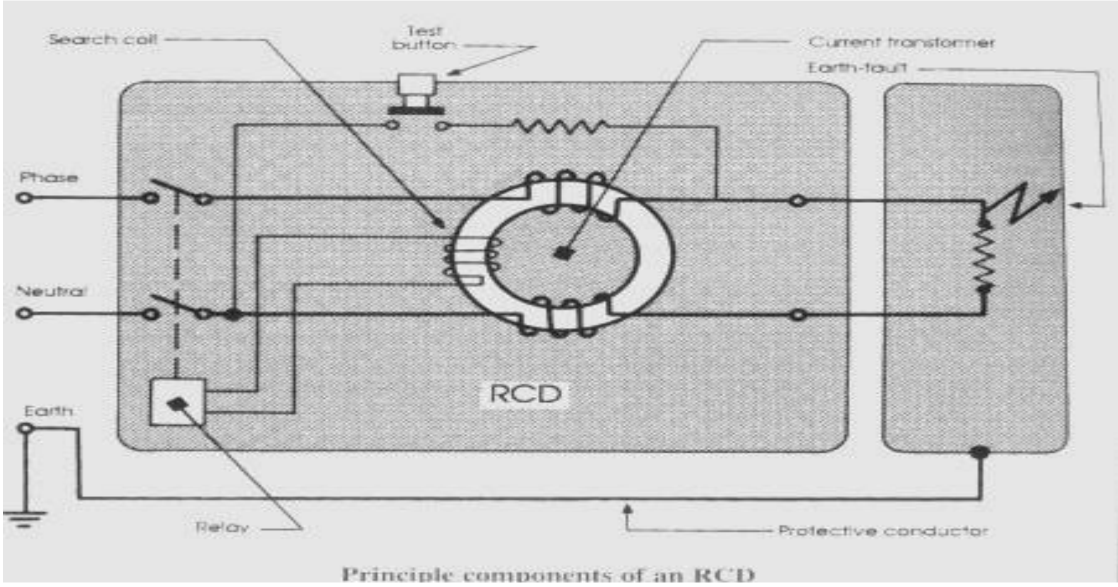
Sr. No	% Variation in Load	Current (A)	Tripping Time
1			
2			
3			
4			
5			

ELCB (Earth Leakage Circuit Breaker)

An Earth Leakage Circuit Breaker (ELCB) is a safety device used in electrical installations with high earth impedance to prevent shock. If there is no fault anywhere in a circuit supplying single-phase alternating power to a unit such as an electrical appliance, machine or other equipment, the current flowing to the unit at any instant in the "hot" or "live" wire should exactly match the current flowing away from the unit in the neutral wire. Similarly, there should be no current flowing in the unit's safety "ground" or "earth" wire.

An ELCB is a specialized type of latching relay that has a building's incoming mains power connected through its switching contacts so that the ELCB disconnects the power in an earth leakage (unsafe) condition. The ELCB detects fault currents from live (hot) to the earth (ground) wire within the installation it protects. If sufficient voltage appears across the ELCB's sense coil, it will switch off the power, and remain off until manually reset.

Fig.2.9 ELCB diagram



RCD: Residual Current Device. This is a generic term for the entire range of RCDs.

RCCB: Residual Current Circuit Breaker. This is basically a mechanical switch with an RCD function added to it. Its sole function is to provide protection against earth fault currents.

RCBO: Residual Current Breaker with Over Current Protection. This is basically an over current circuit breaker (such as an MCB) with an RCD function added to it.

Types of RCD:

RCDs can be divided into two categories based on the means by which they detect and respond to earth fault currents. The two types are Voltage Independent (VI) and Voltage Dependent (VD). These are sometimes also referred to as electromechanical and electronic types respectively. The VI type uses the output energy from the CT to activate a relay which in turn activates a tripping mechanism causing the RCD to trip. The VD type uses electronic circuitry to detect the earth fault current and to activate a tripping mechanism causing the RCD to trip. The VI device derives its operating energy from the earth fault current whereas the VD device derives its operating energy from the mains supply.

Circuit diagram:

Fig. 2.10 Circuit diagram of ELCB including MCB

Draw circuit diagram:

Procedure: (ELCB)

First connect the circuit as shown in circuit diagram.

1. Energized the circuit.
2. Increase load gradually.
3. Take the various readings and record them in the observation table.
4. Observe the function of safety device.

Observation Table: (ELCB)

Sr. no.	Current	Normal / healthy condition	Earth fault condition
1	Phase to Earth current		
2	Phase to Neutral current		

Conclusion:

Review Question:

1. What is a difference between a fuse and a circuit breaker?
2. Why must the connection to earth have a low resistance?
3. Explain why it is necessary to provide earthing in a domestic electric installation?
4. Why circuit breaker is always connected in series with load?

5. Does ELCB provide short circuit protection?
6. What is an electric shock and how to prevent it?
7. Why neutral wire doesn't give electric shock?
8. Give full names of below
(A) RCCB (B) RCD (C) GFCI
9. What do you mean by shock? Whether it depends on voltage or current?
10. What do you mean by ACB and VCB?

Suggested Reference:

1. J B Gupta, "Electrical Installation Estimating & Costing", Katson Books Publication, 2009.
2. Surjit Singh, "Electrical Estimating and Costing", Dhanpat Rai & Co., 2010.
3. K. B. Raina, S. K. Bhattacharya, "Electrical Design Estimating and Costing", New Age International Publishers, 2009.
4. S. L. Uppal, "Electrical Wiring, Estimating and Costing", Khanna Publishers, 1999.
5. "Electrical Estimating and Costing", Technical Teachers Training Institute (Madras), TATA Mc-Grow Hill.

References used by the students:

Rubric wise marks obtained:

Rubrics	1 Understanding of circuit diagram/Theory information (2)	2 Connections and Procedure (2)	3 Readings, Calculation and Result (2)	4 Conclusion and Applications (2)	5 Participation (2)	Total (10)
Marks						

Experiment No:3

To perform wiring connection for House-hold appliances and Troubleshooting.

Date:

Competency and Practical Skills:
1) Student able to draw schematic circuit diagram for basic house hold appliances.
2) Student able to identify different elements in tube light.
3) Student able to justify the need of starter in tube light.
4) Student able to identify different elements in celling fan.

Relevant CO:
CO-3 Measure different electrical quantities and trouble shoot electrical and electronics appliances

Objectives:
(a) To construct the circuit diagram of basic electrical appliances.
(b) To troubleshoot of basic electrical appliances.

Equipment/Instruments:

Sr.no	Name of apparatus	Specification	Qty
1	Celling Fan	60 W, 230 V	1
2	Tube light	40 W, 230 V	1

Theory:

Fan Wiring
Fan is an essential home appliance nowadays and is available in different style and facilities. Generally used types are table fan and ceiling fan. We can mount the ceiling fan on the ceiling for providing wind to whole the room. As per IE rule the minimum height from floor to fan must be 2.5 meter. Table fan can be places on tabletop or any flat surface. But it has minimum space limit compared to ceiling fan.

Construction

Main parts of a ceiling fan are

(a) Winding
(b) Capacitor
(c) Regulator

Winding of the motor can be done manually or by automated machine. Regulator may be electronic type or resistance type. Electronic type regulator has negligible power loss and compact size. But in the case of resistance type, resistances are connected in series with the circuit; this may cause power loss as heat. In table fan one permanent split capacitor run (PSC) motor is the heart of a fan. This motor consists of two windings one as starting winding and other as running winding. Starting winding of this motor has high resistance and low reactance but running winding has low resistance and high reactance. One capacitor is connected in series with the starting winding and whole of this circuit is put in parallel across running winding. In the case of ceiling fan these two windings are placed in stator in the inner side of the fan. Rotor has no winding; it is the outer body of the fan. Ceiling fan motor operates just in opposite manner as compared to general motor. That is actual rotor of the motor is blocked and the stator is free to rotate. So ceiling fan runs in anticlockwise direction.

At the same time table fan motor is operated as normal case and so it runs in clockwise direction. Capacitor connected in series with the starting winding should be value 2.5 microfarad. Insulated foil paper capacitor is using for this purpose. It helps to provide a split phase effect from single phase AC supply.

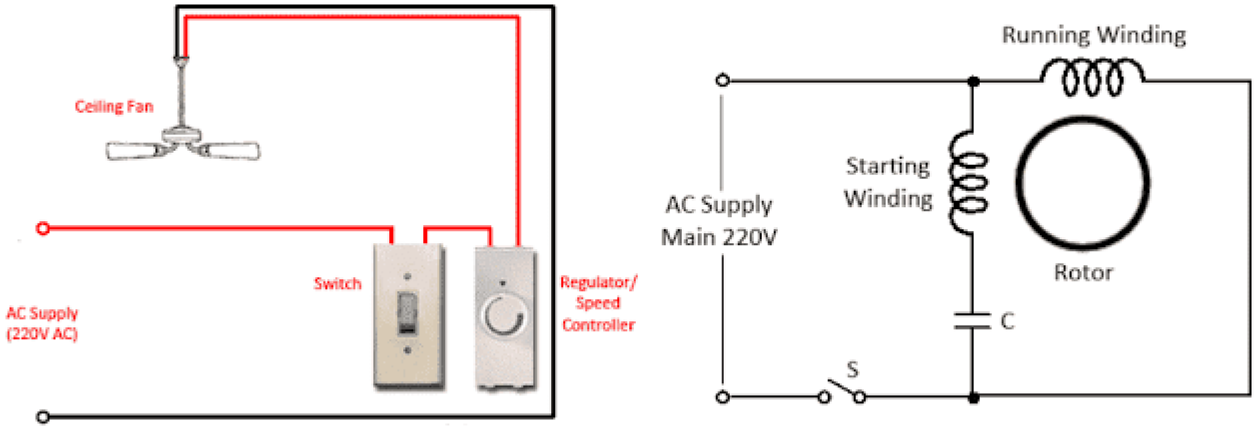


Fig. 3.1 Celling fan wiring diagram

Servicing:

Problems and solutions normally occurring in fans are as follows

1. Fan is not working when supply is given

- Check the supply at the consuming end.
- Dismantle the fan from ceiling and remove the cover. Check the windings, if it is burnt rewind it with proper gauge copper wire.
- Number of turns must be equal to the previous winding, because it may affect the speed of the fan. If starting winding is burnt, it alone can be replaced but in the case of running winding we want change these two sets of windings.

2. Fan is not starting and will work when push to start

- Check the voltage at the consuming end
- Dismantle the capacitor from fan and connect it to AC supply for 30 sec. Then disconnect and short circuit the capacitor terminals. At that time, we can hear one spot sound if it working, otherwise it can be replaced by new one.
- Check the bearing of the motor; if it is dirty grease may be applied.

Draw Circuit diagram:

Tube Light Wiring:

Fluorescent lamp is the most widely used discharge lamp. It is an energy efficient lamp available in low and medium wattage range making it suitable for domestic and commercial lighting purposes.

Construction:

The construction of a standard fluorescent lamp is shown in Fig. 3.2 It consists of a glass tube of around 36 mm diameter and a length of 1200 mm. The inner surface of the tube is coated with a fluorescent powder - usually phosphor coating. Tungsten wire electrodes with bi-pin cap are provided at both ends. There is an electrode shield around each electrode to reduce the blackening of the tubes due to deposition of evaporated tungsten. The tube is filled with an inert gas such as argon to a pressure of 1.5 to 5 mm of mercury. A small drop-let of mercury is also introduced into the tube. During normal operation this mercury vaporizes and helps to maintain the discharge.

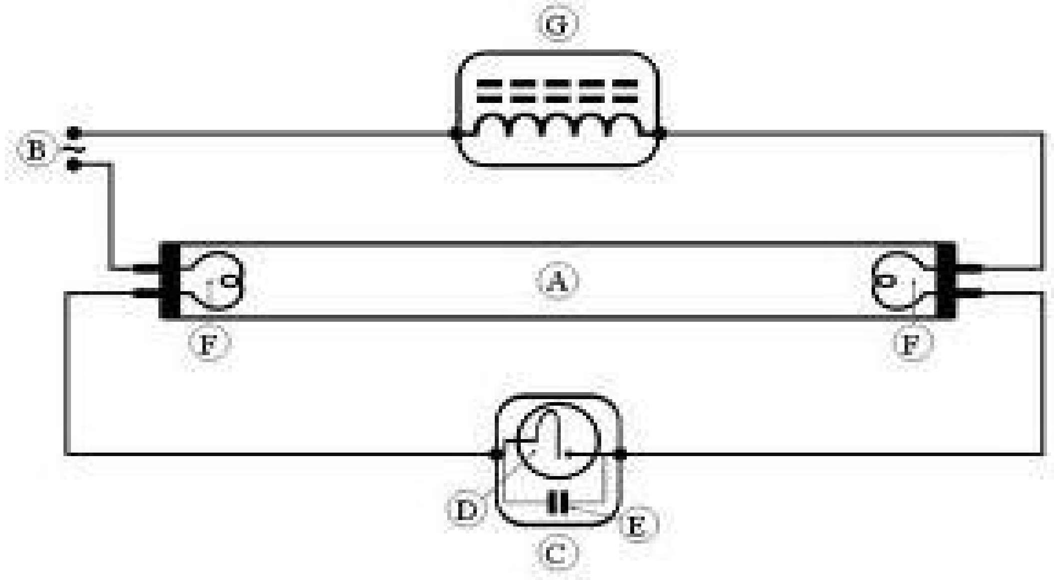


Fig.3.2 Connection of different elements of tube light

A: Tube with phosphorous coating, Argon gas & mercury

B: 1-Φ ac supply 240 V, 50 Hz

C: Capacitor starter
D: Bi-metallic strip
E: Capacitor
F: Electrodes
G: choke / Inductive Ballast

Operation:
Fluorescent lamps are designed for switch start operation. A typical switch start circuit is shown in Fig. The starter consists of two bimetallic contacts, housed in a small glass bulb filled with a noble gas at low pressure. The contacts are positioned with a narrow separation between them. When the normal voltage is applied, it creates a glow discharge between the bimetallic contacts and due to heating they bend towards each other. The contacts touch each other for one or two seconds and the current path is completed through the inductive ballast and the filament electrodes, this current result in preheating the electrodes. As the bimetallic contacts touch, the glow discharge stops and now the contacts cool down and leave apart to open the circuit. The sudden break of current will induce a high voltage (600-1500V) in the ballast and is applied across -the tube, which in turn trigger the discharge through the tube. The capacitor, which is connected across the starter contact, is provided to reduce the radio interference due to switching operations. The starter has no function once the lamp is started. Like other discharge lamps, fluorescent lamps are also having a negative temperature coefficient of resistance. This means the resistance of the tube decreases when temperature is increased, resulting in increase of current. Therefore, the ballast is essential during normal operation also to regulate the lamp current. When the ballast is connected in series with the circuit, it regulates the lamp current. The capacitor across the supply line is for power factor improvement.

When there is a discharge through the lamp, it produces radiations mainly in the ultraviolet region. This radiation is converted to visible radiation by the phosphor coating on the inner side of the glass tube.

Performance:

The luminous efficiency of the fluorescent lamp is around 75lumens/watt, which is much higher than incandescent lamps. The color rendering index of this lamp is in the rage of 50-

60 and this is sufficient for normal domestic or commercial lighting. Fluorescent tamps have an expected life varying from 6000 to 20000 hours. One disadvantage with this lamp is that the power factor of the circuit is low (around 0.5), but this problem can be solved to some extent by connecting a capacitor across the supply.

Draw Circuit diagram:

Conclusion:

Review Question:

1. What is standard diameter of the tube light?
2. Which material is used for coating the tube?
3. Which gas is used in tube light?
4. What is function of starter?
5. Why we use chock in tube light?
6. Name any two types of starter?

Suggested Reference:

1. J B Gupta, “Electrical Installation Estimating & Costing”, Katson Books Publication, 2009.
2. Surjit Singh, “Electrical Estimating and Costing”, Dhanpat Rai & Co., 2010.
3. K. B. Raina, S. K. Bhattacharya, “Electrical Design Estimating and Costing”, New Age International Publishers, 2009.
4. S. L. Uppal, “Electrical Wiring, Estimating and Costing”, Khanna Publishers, 1999.
5. “Electrical Estimating and Costing”, Technical Teachers Training Institute (Madras), TATA Mc-Grow Hill.

References used by the students:

Rubric wise marks obtained:

Rubrics	1 Understanding of circuit diagram/Theory information (4)	2 Connections and Procedure (4)	3 Readings, Calculation and Result (4)	4 Conclusion and Applications (4)	5 Participation (4)	Total (20)
Marks						

Experiment No:4

To perform Staircase / Godown wiring connection practices and its application.

Date:

Competency and Practical Skills:

1) Student able to draw circuit diagram of staircase wiring.
2) Student able to draw circuit diagram of godown wiring
3) Student able to explain different application of staircase wiring.
4) Student able to explain different application of godown wiring.
5) Student able to identify types of switches with application

Relevant CO:

CO-3 Measure different electrical quantities and trouble shoot electrical and electronics appliances

Objectives: (a) To troubleshoot staircase and godown wiring.
(b) To understand basic wiring concept.

Equipment/Instruments:

Sr.no	Name of apparatus	Specification	Qty
1	Lamp with holder	0-5 A, AC	6
2	2-way switch	0-250 V, AC	6
3	Wire	1/18 SWG, 5 meter	5
4	Wooden Ply board	5 mm thick, 2 feet x 1 feet	2

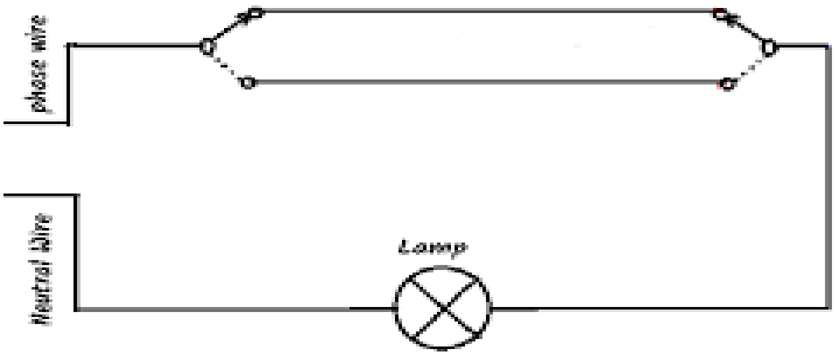
Theory:

In this experiment we will study different types of wirings those are used for domestic as well as commercial purpose like Stair case wiring (Domestic purpose), Godown wiring (Commercial purpose).

Staircase wiring

Sometimes it is necessary to control a light independently from two switches. Such an arrangement is usually necessary for a staircase, large rooms, corridors and multistory buildings. It is also called “one lamp control by two switches”. One switch is in ground floor and another is in upper floor. The connection diagram is as shown in figure 1. If one goes up in upper floor at that time he should put on the switch 1, bulb glows when reached in upper floor switch off the switch 2 bulb gets off. Ultimately the aim of energy conservation will be achieved.

Circuit diagram:



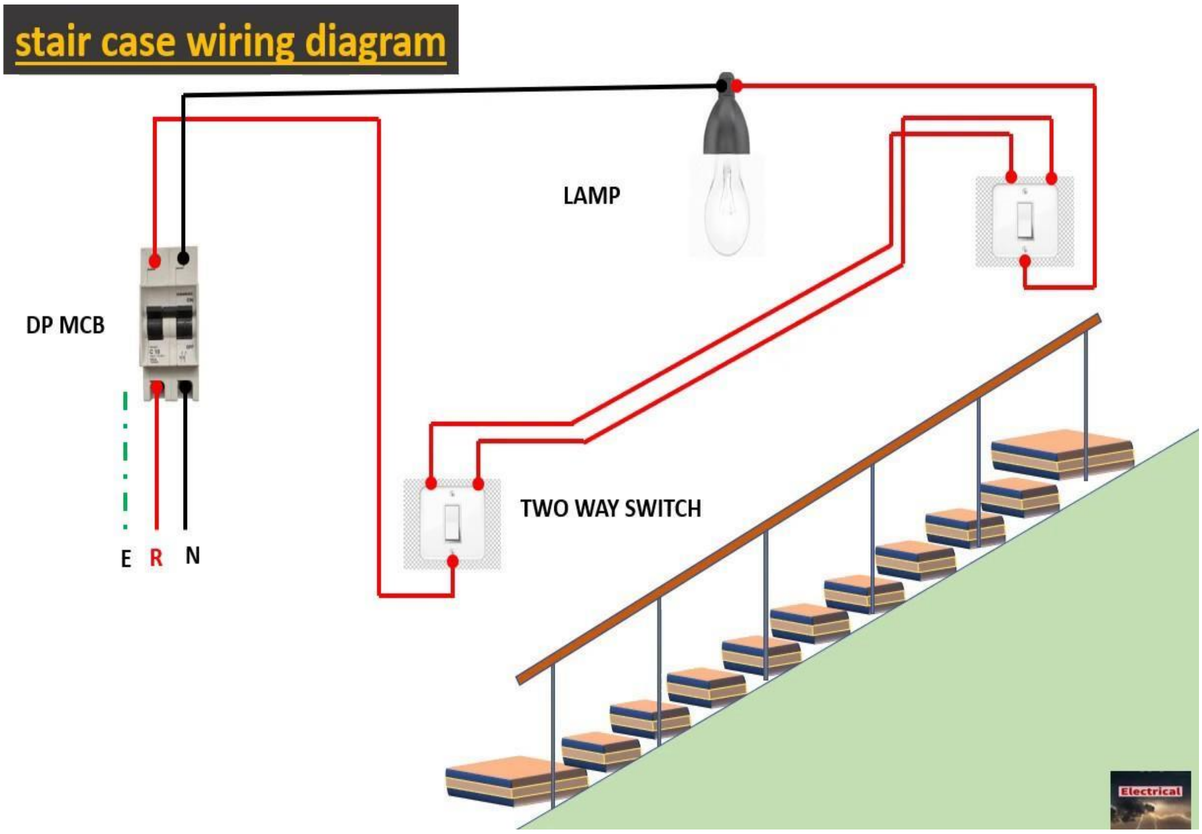


Fig. 4.1 Staircase wiring circuit diagram

Draw Circuit diagram:

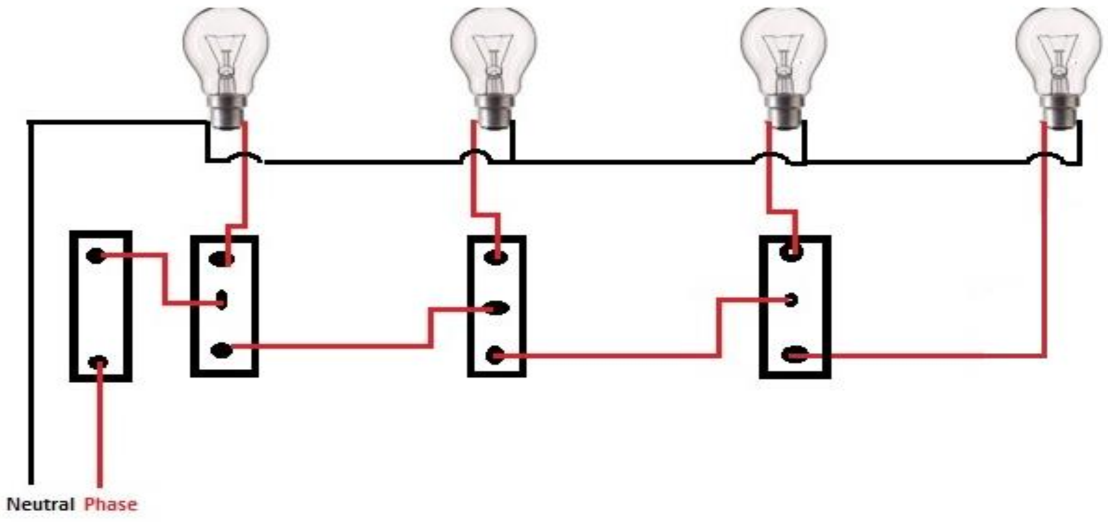
Observation table (1)

Sr. No.	Floor	SW 1	SW 2	Lamp
1	Ground floor	UP	DOWN	
		DOWN	DOWN	
2	Upper floor	DOWN	UP	
		UP	UP	

Godown wiring

This type of wiring scheme is used in godown or corridor. In godown sequential switching is required. When storekeeper is at zone 1 of the godown, at that time bulb in that portion should glow and as he goes forward bulb at zone 2 glows at the same time bulb at zone 1 should be off. Similar action continues for other zones. While returning back in the reverse direction, the whole procedure will be repeated in the reverse manner as shown in figure 2.

Circuit diagram:



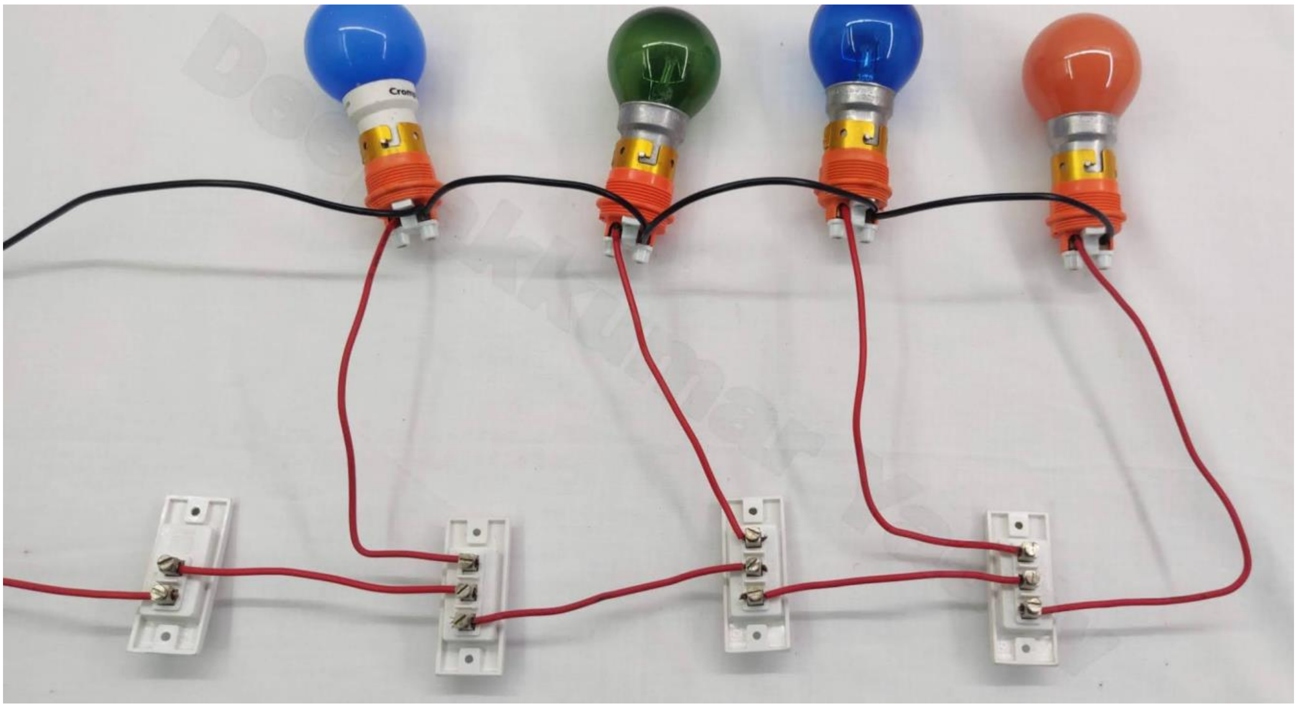


Fig. 4.2 Godown wiring circuit diagram

Observation table (2)

Sr. No.	Respective Zone	Bulb 1	Bulb 2	Bulb 3	Bulb 4
1	Zone I				
2	Zone II				
3	Zone III				
4	Zone IV				

Conclusion:

Review Question:

1. Flexible chords should not be used for fixed wiring. (True / False)
2. Explain various types of wiring and write their area of application.
3. List out the equipment used in wiring.
4. Third pin in a 3-pin plug is provided so as to provide ____________connection.
5. Lamps on street lighting are connected in_____________(series/parallel)
6. Fuse is provided only in phase wire, never on neutral wire. (T / F)

Suggested Reference:

1. J B Gupta, “Electrical Installation Estimating & Costing”, Katson Books Publication, 2009.
2. Surjit Singh, “Electrical Estimating and Costing”, Dhanpat Rai & Co., 2010.
3. K. B. Raina, S. K. Bhattacharya, “Electrical Design Estimating and Costing”, New Age International Publishers, 2009.
4. S. L. Uppal, “Electrical Wiring, Estimating and Costing”, Khanna Publishers, 1999.
5. “Electrical Estimating and Costing”, Technical Teachers Training Institute (Madras), TATA Mc-Grow Hill.

References used by the students:

Rubric wise marks obtained:

Rubrics	**1 Understanding of circuit diagram/Theory information (4)**	**2 Connections and Procedure (4)**	**3 Readings, Calculation and Result (4)**	**4 Conclusion and Applications (4)**	**5 Participation (4)**	**Total (20)**
Marks						

Experiment No:5

To study the different types of Electrical Tools and Components.

Date:

Competency and Practical Skills:
1) Student will be able to identify different tools of wiring.
2) Student will be able to identify application of tester.
3) Student will be able to use wire stripper and cutter.
4) Student able to wrap insulation tape on wire joints.

Relevant CO:
CO-3 Measure different electrical quantities and trouble shoot electrical and electronics appliances

Objectives: (a) To identify different electrical tools and its application.
(b) To understand basic needs of electrical tools for electrical wiring.

Theory:

A. **Introduction**

It is almost impossible to carry out any laboratory work or assembling electronic product without essential tools, which are used for component performing and their mounting on the PCB or bread board. Here various tools for electronics laboratory work have been described.

B. **Recommended Tools for Laboratory Work and Assembling Process**

Selection of the right tools based on required application is very much important. The common tools used for the electronic laboratory with their typical preferred applications are given below.

Various tools used for working in Electrical/Electronic laboratory and assembling electronics product are as given below.

1. Soldering process related tools
2. Cutters
3. Pliers
4. Wire strippers
5. Wire crimping tool
6. Tweezers
7. Lead forming tools
8. Clinching tools
9. Screw Drivers
10. Miscellaneous Tools like Vacuum suction pen placement tool, Chip inserter, IC lead straightener tool, IC popper

(1) Soldering Process Related Tools

Soldering process related tools are categorized mainly into two parts.

a) Soldering Equipment
b) De-soldering Equipment

They both are described in other experiments and laboratory work.

(2) Cutters

There are many types of cutters. Some of them are as given below.

(a) Flush Cutters
Flush cutters cutting nipper are used for vertical cuts above the work area. It provides shear cutting action with greatly reduced cutting effort to minimize fatigue related problems. Particularly suited for circuit board work. It has green ESD cushion grip handles.

Fig. 5.1 Flush Cutter

(b) Precision Lead Cutters
Precision lead cutters are used to cut the component leads precisely after assembling components on a PCB. These non- glare, black finish precision electronic flush - cut lead cutters require 50 % less operator effort and have a longer cutting life than conventional cutters.

Fig. 5.2 Precision Lead Cutter

(c) Diagonal Cutters (semi flush type)

It is used for cutting thick wires. Hard wires can be easily cut by this cutter. Less force needed than the conventional cutters. It is semi flush type cutter. It is high grade tool steel and ESD safe. It has anti- glare finish, compound action. It is less sharp than the standard flush cutter. It has high cutting capacity.

Fig. 5.3 Diagonal Cutter (semi flush type)

(d) Diagonal Cutters (flush cut type)

It Cuts the lead to a predetermined length of 0.8mm. It reduces mechanical shock on components. It is flush cut type cutter. It is high grade tool steel. It has polished tips and ESD safe.

Fig. 5.4 Diagonal Cutter (flush cut type)

(e) Tip Cutters

It is used for high precision SMD lead cutting. It has Micro-packages up to 0. 25 fine pitches before de-soldering. It is vertical tip cutter. It is made of high grade tool steel. It has anti - glare finish. It is ESD safe and re-shareable. It is miniature tip cutter.

Fig. 5.5 Tip Cutter

(f) Coax Cable Cutter

It is used for cutting coaxial cable. It cuts coaxial cable cleanly without compressed or frayed ends. It is not used for cutting steel cable. It is made from chrome vanadium steel. Functions like a tube cutter eliminates cable distortion during cable prep.

Fig. 5.6 Coax Cable Cutter

(g) Diagonal Cutter

Diagonal cutters are useful for cutting copper, brass, iron, aluminum and steel wire. Lower quality versions are generally not suitable for cutting tempered steel, such as piano wire, as the jaws are not hard enough. Attempting to cut such material will usually cause indentations to be made in the jaws, or a piece to break out of one or both jaws, thus ruining the tool. However higher quality side cutters can cut hardened steel. For electronics work, special diagonal cutters that are ground flush to the apex of the cutting edge on one side of the jaws are often used.

Fig. 5.7 Diagonal Cutters

(3) Pliers

Pliers are a type of hand tool used to hold objects firmly, or for cutting and bending tough materials such as wire. Generally, pliers consist of a pair of metal levers joined at a pivot positioned closer to one end of the levers, creating short jaws on one side of the pivot, and longer handles on the other side. This arrangement allows the power of the hand' s grip to be amplified and focused on the object with precision. The jaws can also be used to manipulate objects too small or unwieldy to be manipulated with the fingers. There are many types of pliers. Some of them are as given below.

(a) **Short Nose Pliers**

It is used for skinning wire and crushing insulation in nose slot. It is used to hold and crimp fine component lead wires. The front portion of the jaws is narrowed, and a portion of the inner face of one jaw is relieved to skin insulation from wire. The inner surface of the jaws is serrated to facilitate gripping wire.

Fig. 5.8 Short Nose Plier

(b) Curved Long Nose Pliers

It is used in confined areas. Its nose is bent 70° for maximum visibility. Its design includes knurled jaws for sure wrapping and looping. It has comfortable ergonomic handles. It can reach the defect location in a highly populated PCB.

Fig. 5.9 Curved Long Nose Plier

(c) Curved Needle Nose Pliers

It is used in confined areas for bending and forming fine wire. Its nose is bent 60° for maximum visibility. Inside these plier’s jaws and jaw edges are polished to prevent nicking the wire. These pliers have a spring loaded ergonomic design.

Fig. 5.10 Curved Long Nose Pliers

(d) Diagonal Pliers

It is used for cutting soft copper conductors. It has a "V" shaped notch between jaws, near the joint, for crushing the flameproof type of insulation on distributing frame wire. It also provides a "W" shaped notch on the plier’ s jaws for slitting textile insulation. It is used primarily for general purpose cutting in the electronic industry.

Fig. 5.11 Diagonal Pliers

(e) **Stripping Pliers**

It is used for all kinds of insulation and fiber optic outer jackets. It also used for gripping and forming of different wires and parts. It is made from high grade tool steel. It is ESD safe. It has anti- glare finish. It is adjustable for different diameters. Its diameter is adjustable with screw.

Fig. 5.12 Stripping Plier

(f) **Insertion / Extraction Pliers**

It is used for straightening multiple DIL/ IC leads. It straightens leads before insertion/ after soldering.

Fig. 5.13 Insertions / Extraction Plier

(4) Wire Strippers

A wire stripper is a small, hand-held device used to strip the insulation from electric wires. There are many types of strippers. Some of them are as given below.

(a) Manual wire strippers

It is used for cutting insulation without cutting the wire. A simple manual wire stripper is a pair of opposing blades much like scissors or wire cutters. This type of wire stripper is used by rotating i t around the insulation while applying pressure in order to make a cut around the insulation. Since the insulation is not bonded to the wire, it then pulls easily off the end. This is the most versatile type of wire stripper. Another type of manual wire stripper is very similar to the simple design previously mentioned, except this type has several notches of varying size. This allows the user to match the notch size to the wire size, thereby eliminating the need for twisting. Once the device is clamped on, the remainder of the wire can simply be pulled out, leaving the insulation behind.

Fig. 5.14 Manual Wire Strippers

(b) Automatic wire strippers

Automatic wire stripper simultaneously grips the wire from one side and cuts and removes the insulation from the other. For using automatic wire stripper, one simply has to place the wire in the jaws and squeeze the handle. While this device allows even a novice to strip most wires very quickly, it does have some drawbacks. An automatic wire stripper only works on wires in a certain size range. If a wire is too small it may be broken by the pulling force, and if a wire is too large it will not fit in the jaws. When stripping the wire, an individual should grip and pull outwards to prevent injury.

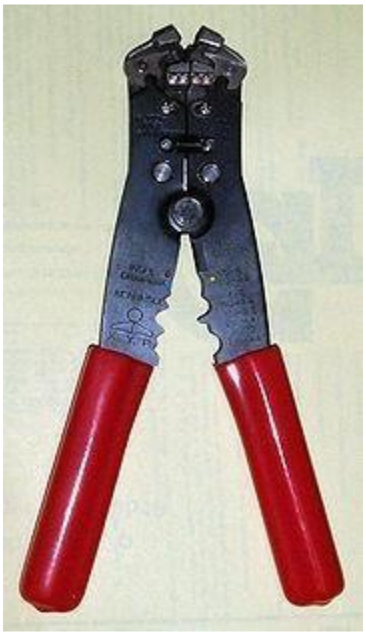


Fig. 5.15 Automatic wire stripper

(c) Fiber Optic Strippers

The Fiber Optic Stripper is used for stripping optical fiber. Preset at the factory so no adjustments are necessary. Its unique design prevents nicks or scratches on the optical fiber plus blades are ground and hardened for long life.

Fig: 5.16 Fiber Optic Stripper

(d) Wire Stripper and Cutter

This Wire Stripper and Cutter are used for stripping and cutting the most commonly used stranded and single wire gauges. Other features include like coil spring opening to reduce fatigue, wire looping, bending holes conveniently located, black oxide finish, locking mechanism, and cutting surfaces that are hardened, tempered and ground for superior performance.

Fig. 5.17 Wire Stripper and Cutter

(e) Wire Cut and Strip Tools

Wire cut and strip tool is used for easy and clean stripping of wires for wire wrapping, electronics and appliance applications. It should be easy to operate. Wire is cut and stripped to proper "wire wrapping" length. The hardened steel cutting blades and sturdy construction of the tool ensure long life. Strip length easily adjustable for required application. Blades are made from specially tempered spring steel for clean, nick -free wire stripping.

Fig. 5.18 Wire Cut and Strip Tools

(5) Wire Crimping Tool

Fig. 5.19 Wire Crimping Tools

(6) **Tweezers**

Tweezers can protect the flow and rise of solder in a wire beyond a specific limit. It is used for handling, placement and rework of surface mount devices. There are many types of tweezers. Some of them are as given below.

(i) Cutting Tweezers

It is made by carbon steel. It has anti- glare finish. This cutting tweezers has fine oblique head and induction hardened cutting blades for increasing life time.

(ii) Stripping Tweezers

Fig: 5.20 Cutting Tweezers

It is sensitive and self-closing wire tweezers. It strips Teflon wires only.

Fig. 5.21 Stripping Tweezers

(iii) Swiss Tweezers

It is made by stainless steel. It is non - magnetic and anti- glare finishing. SMD tweezers with angled head and blunt edges to avoid board damage. It is used for handling small components, mounting on SMD boards, hybrids ICs, watch hands, etc.

Fig. 5.22 Swiss Tweezers

(7) **Lead Forming Tools**

Resistor benders are fabulous for getting the leads bent squarely enough to go easily through the holes in PCB. It helps to keep the board looking neat, and keeps the resistors from sticking too far above the board. If there is circuit board with a lot of resistors, this tool can actually save lot of time. This tool helps in bending resistors to exactly the correct length so that they can go through the hole on the first try without any fuss. The tool itself is just a piece of injection -molded plastic, with slots on both sides for different sizes (i.e., power rating), and for different total lead lengths. Person should hold the resistor in the appropriately sized slot and bend the leads down. In the figure given below there are two resistors, one bent by hand, and one bent with the tool. The one bent with the tool looks much neater and only takes about half as much time to bend.

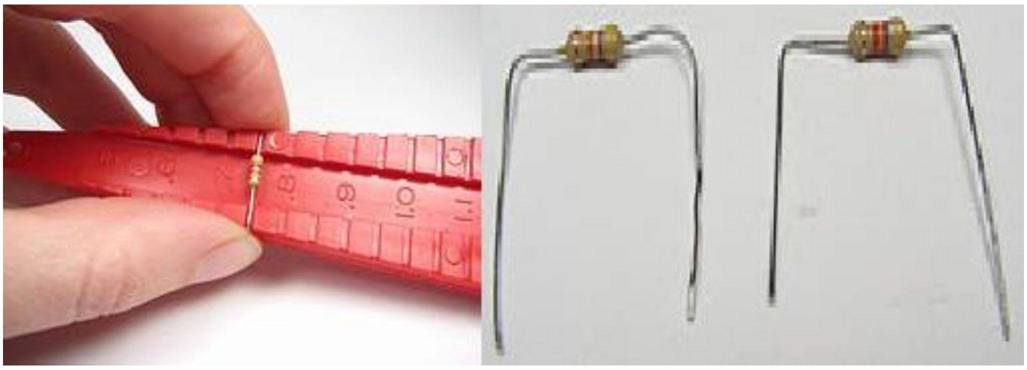


Fig. 5.23 Resistor Lead Forming Tools

(8) Clinching Tools

Clinching tools including a punch and a die. The die includes a sleeve, a riser, an elastomeric member, and a plurality of fingers. The riser is positioned within the sleeve and includes an upper reduced diameter anvil portion projecting upwardly through the open upper end of the sleeve.

It is said to be particularly proficient in the assembly of refrigerators, vending machines, bottle coolers, freezers, and HVAC appliances or in other applications where pre- painted, galvanized or stainless steel sheet metal is used. This assembly often includes intermediate adhesive tape. In addition, the tooling consumption may be exceptionally low compared to other techniques, such as stitch folding. All these advantages may lead to productivity gains and savings in maintenance costs.

Fig. 5.24 Clinching tool

(9) Screw Driver

The screwdriver is a device specifically designed for the insertion and tightening of screws. The screwdriver is made up of a head or tip, which engages with a screw, a mechanism to apply torque by rotating the tip, and some way to position and support the screwdriver. A typical hand screwdriver comprises an approximately cylindrical handle of a size and shape to be held by a human hand, and an axial shaft fixed to the handle, the tip of which is shaped to fit a particular type of screw. The handle and shaft allow the screwdriver to be positioned and supported and, when rotated, to apply torque. Screwdrivers are made in a variety of shapes, and the tip can be rotated manually or by an electric or other motor. A screw has a head with a contour such that an appropriate screwdriver tip can be engaged in it in such a way that the application of sufficient torque to the screwdriver will cause the screw to rotate. There are many types of Screw Drivers. Some of them are as given below.

(1) **Standard Stubby Screwdriver**

It has ergonomically designed tri -lobular handle design provides maximum tip torque, slip-resistant rubber grip increases user comfort, high strength nylon handle core over-molded onto bar for more torque handling and impact resistance, heat- treated tip built for durability.

Fig. 5.25 Standard Stubby Screwdriver

(2) **Torx Tip Screwdriver**

It has ergonomically designed tri-lobular handle for torque and comfort, Lacquer coated bar to resist rust, sand blasted and heat treated tip for durability and precision work

Fig. 5.26 Torx Tip screwdriver

(3) **Multi-Bit Screwdriver**

It has integral Clip-n-Grip Screw-Holding System, Bi-Material Handle for increased comfort, hardened and tempered Bar for Long-Life. It can be used with almost any type of screw – aluminum, brass, plastic and more.

Fig. 5.27 Multi-Bit Screwdriver

(4) **Magnetic head screwdriver set**

Some screwdriver heads are magnetic, so that the screw remains attached to the screwdriver without requiring external force. This is particularly useful in small screws, which are otherwise difficult to handle.

Fig. 5.28 Magnetic head screwdriver set

(10) Miscellaneous Tools

1. Vacuum suction pen placement tool

This vacuum pen provides a low cost alternative to active vacuum pen models for the occasional user. It is compact, ESD safe and comes with three different vacuum pads for different size parts. Use it for precision placement and removal of devices too large for tweezers or that have fragile pins that might be damaged.

How to use?

- Install a proper IC suction header on suction pencil
- Place the suction header level on IC
- Press down the button on the suction pencil to let out the air within the vacuum unit, then release the button to produce vacuum suction force to pick up IC

● Put the IC on a proper place, press down the button, the vacuum unit discharges air to let the IC fall off the suction header

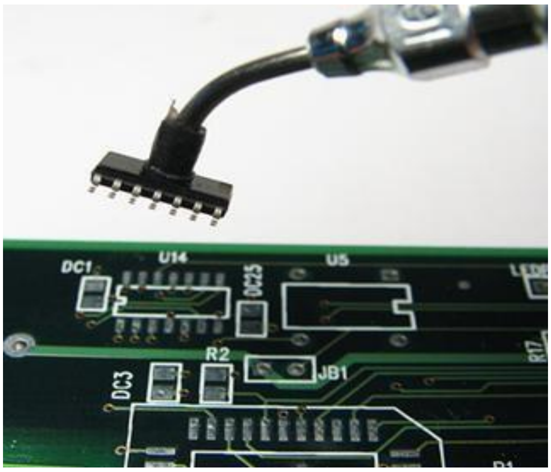


Fig. 5.29 Vacuum suction pen placement tools

2. Chip inserter

This tool is used to insert a DIP chip into a circuit board even though the leads are bent outwards. Person should slide the chip into the end of the tool, put it where it goes, and press the button to push it into the board

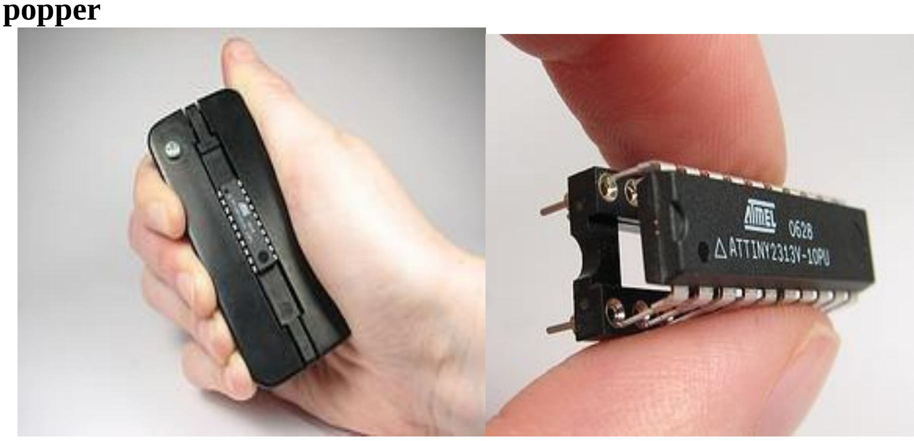
Fig. 5.30 Chip inserter

3. IC lead straightener tool

Every time leads of IC are not parallel, so they don't quite fit in a socket or PCB without some pre-bending. A quick squeeze of this crimper, and they fit perfectly. By performing the straightening role, it eliminates the primary need for the DIP insertion tool, which is to straighten the leads as they are inserted.

Fig. 5.31 IC lead straightener tools

4. IC popper



When there are scavenging parts off of boards, it needs a way to get the chips off. Slide the very fine wire ends under surface mount components to lift them off when using hot air to melt the solder.

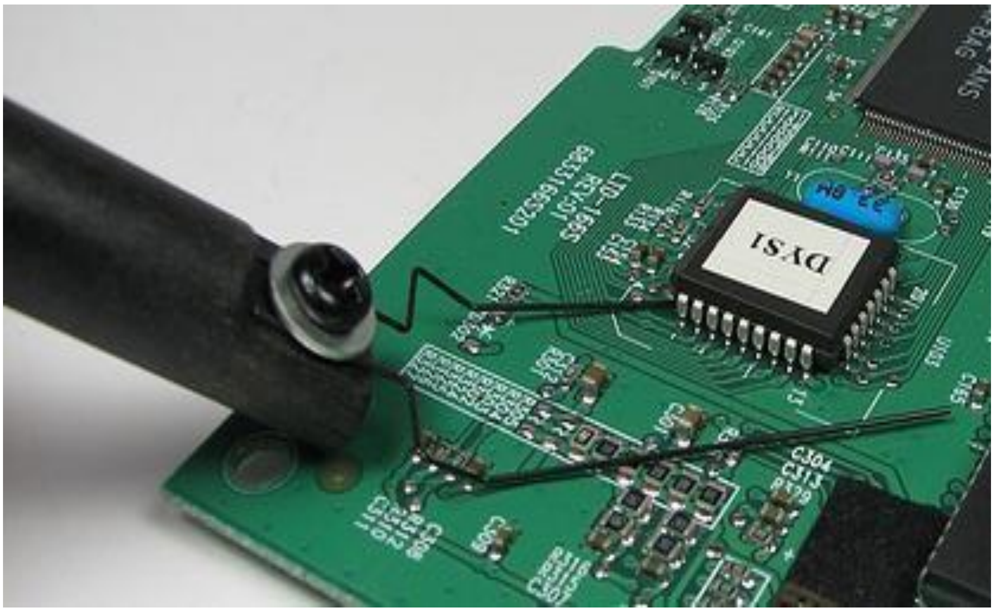


Fig. 5.32 IC popper

Conclusion:

Review Question:

1. Which tool is used for forming loop on small conductor, also cutting and stripping small conductors?
2. Which tool is used for turning bolts, nuts and small pipe fittings?
3. Which tool is used for Installing and removing Allen screws?
4. Which tool is also known as side cutters?
5. Which tool is used for checking circuit for power also checking fuses and breakers?

Suggested Reference:

1. J B Gupta, “Electrical Installation Estimating & Costing”, Katson Books Publication, 2009.
2. Surjit Singh, “Electrical Estimating and Costing”, Dhanpat Rai & Co., 2010.
3. K. B. Raina, S. K. Bhattacharya, “Electrical Design Estimating and Costing”, New Age International Publishers, 2009.
4. S. L. Uppal, “Electrical Wiring, Estimating and Costing”, Khanna Publishers, 1999.
5. “Electrical Estimating and Costing”, Technical Teachers Training Institute (Madras), TATA Mc-Grow Hill.

References used by the students:

Rubric wise marks obtained:

Rubrics	**1 Understanding of Construction/ Theory information (2)**	**2 Identification of parts (2)**	**3 Function of parts (2)**	**4 Conclusion and Applications (2)**	**5 Participation (2)**	**Total (10)**
Marks						

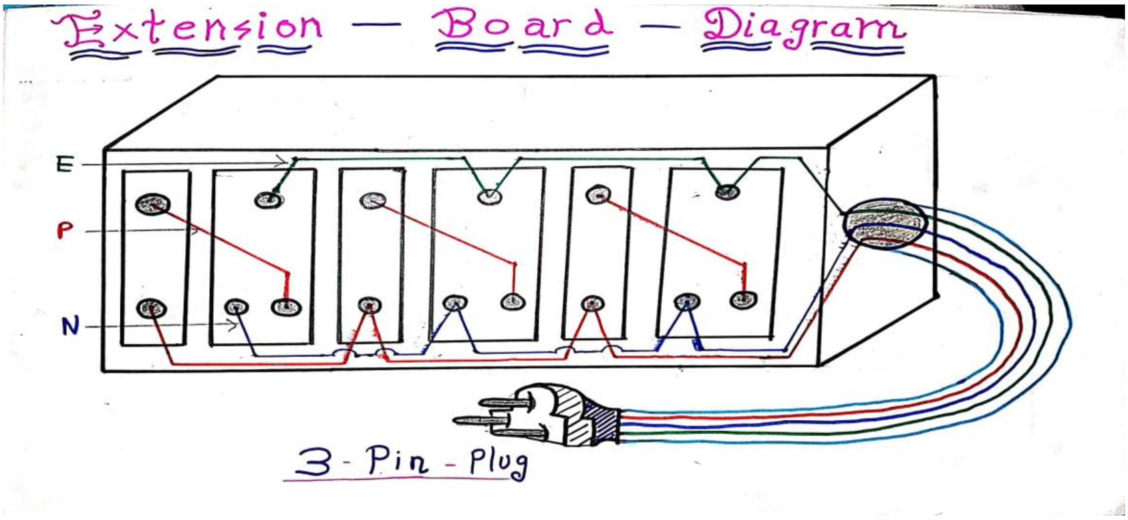
List of Hardware

- **Select any four hardware in the group of five students and mention same hardware model in index.**
- **Student can select any hardware other than listed hear with the consent of subject faculty.**
- **Do not prepare any hardware model at your home/hostel.**
- **You have to prepare all these hardware model in institute laboratory only and in-front of respective subject faculty only.**
- **Do not give electric power supply 230 V, 50 Hz to any hardware model.**

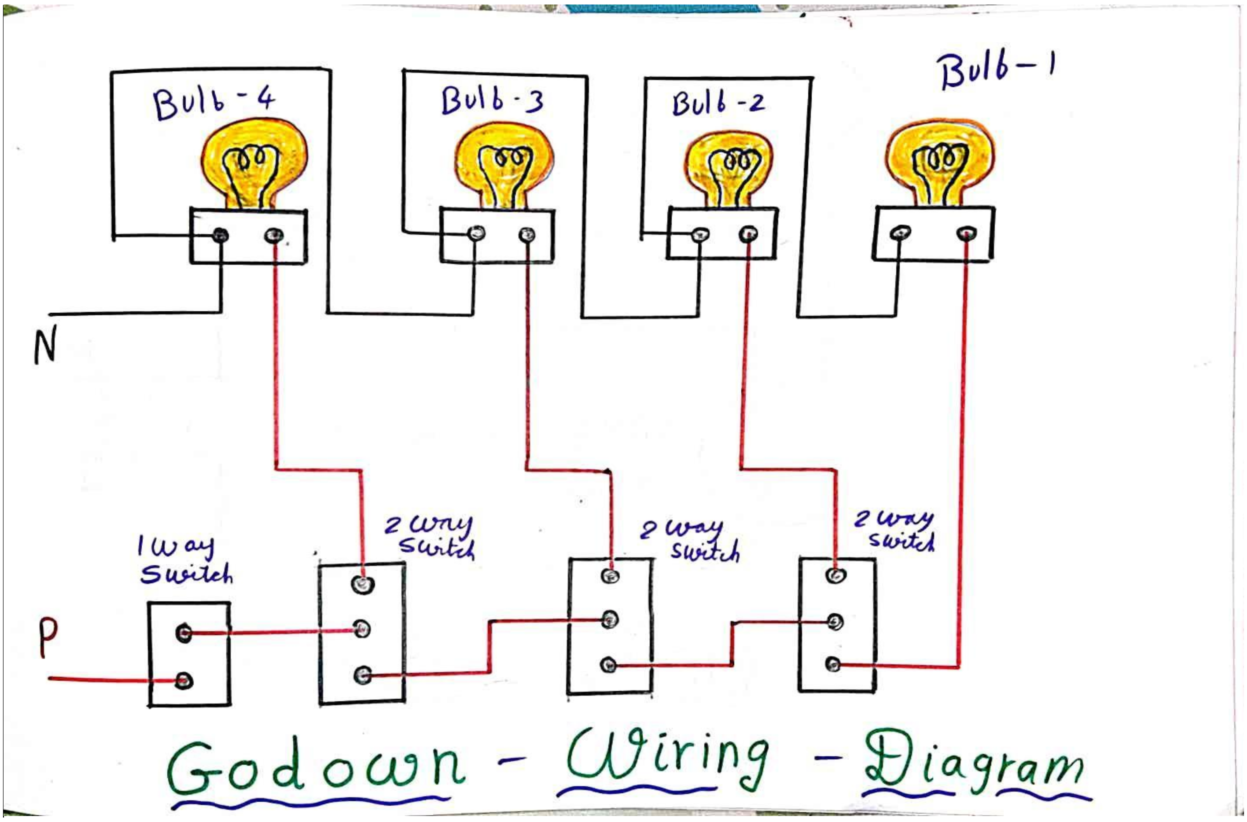
1. Extension board with 4 plug and 4 switch rectangle shape with 6-meter length and 1.5 Sq.mm diameter three core cable
2. Godown wiring / Lobby wiring
3. Staircase wiring for up to 2rd floor (2 Lamp and 4 two-way switch)
4. Star connection board
5. Delta connection board
6. House wiring / room wiring (4 switch, 1 plug socket, 1 fan regulator as a dimmer, 1 lamp holder with lamp)
7. Hospital wiring
8. Part demonstration of analog DC Voltmeter and Ammeter
9. Part demonstration of analog AC Voltmeter and Ammeter

Reference images of Hardware

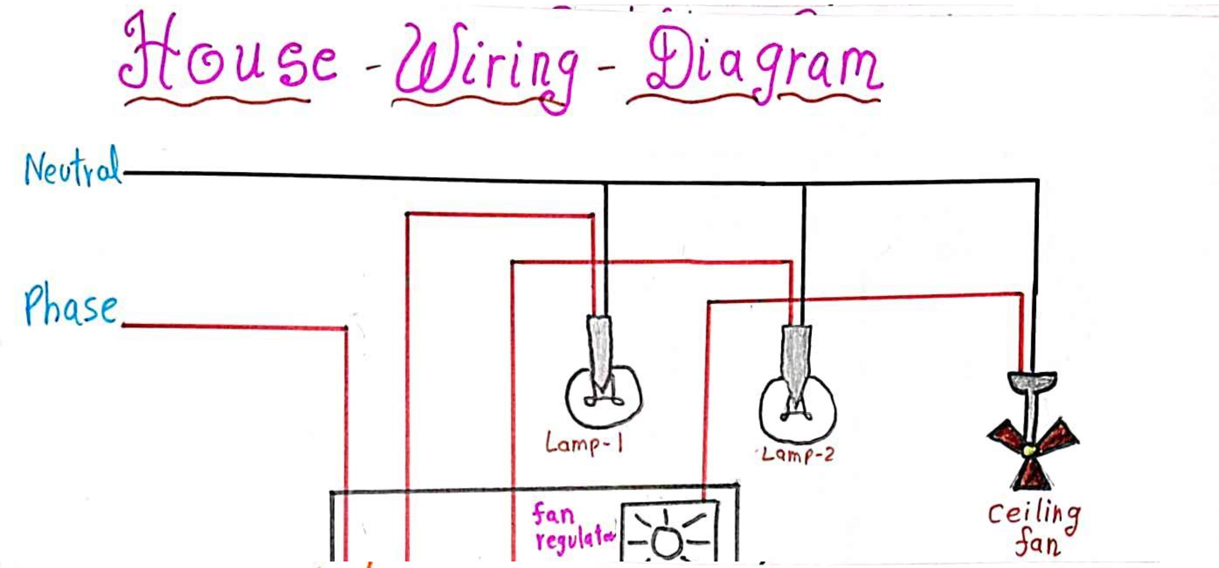
1. Extension board with 4 plug and 4 switch rectangle shape with 6-meter length and 1.5 Sq.mm diameter three core cable

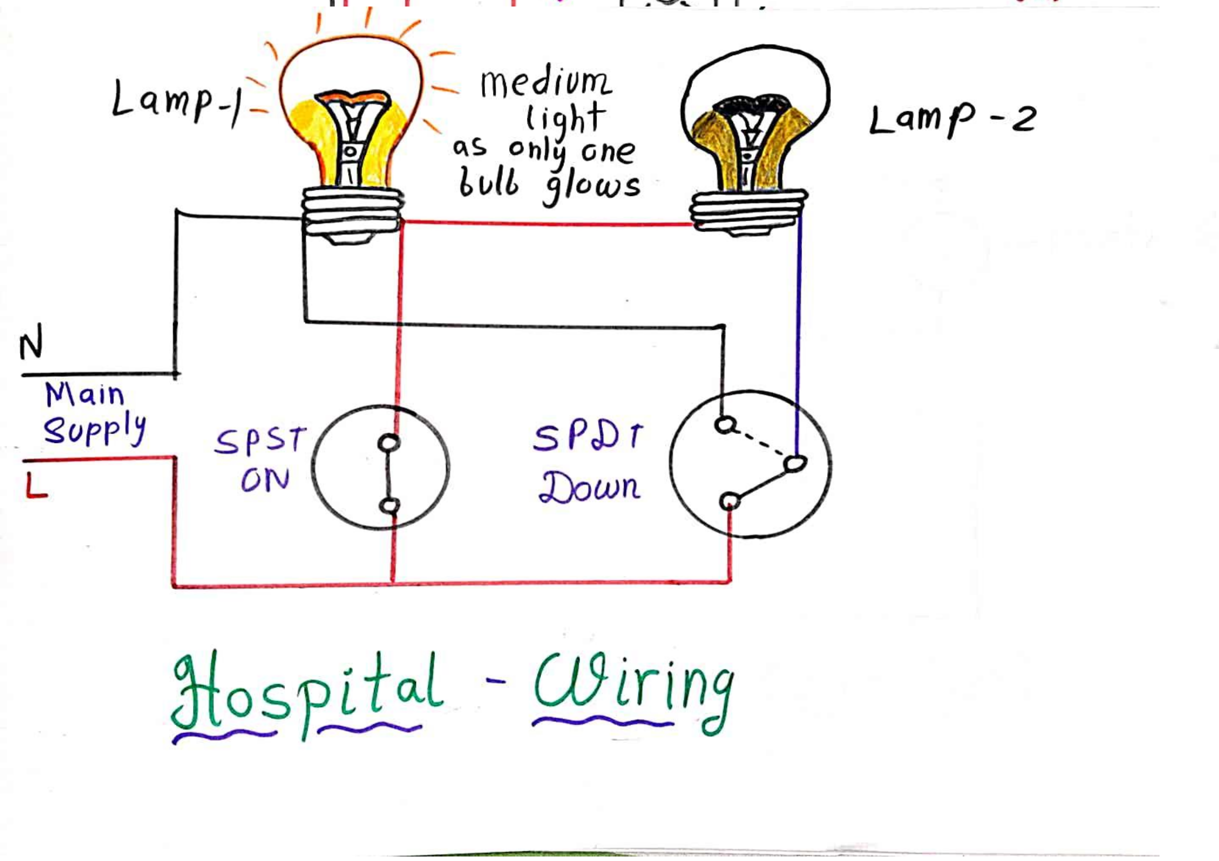


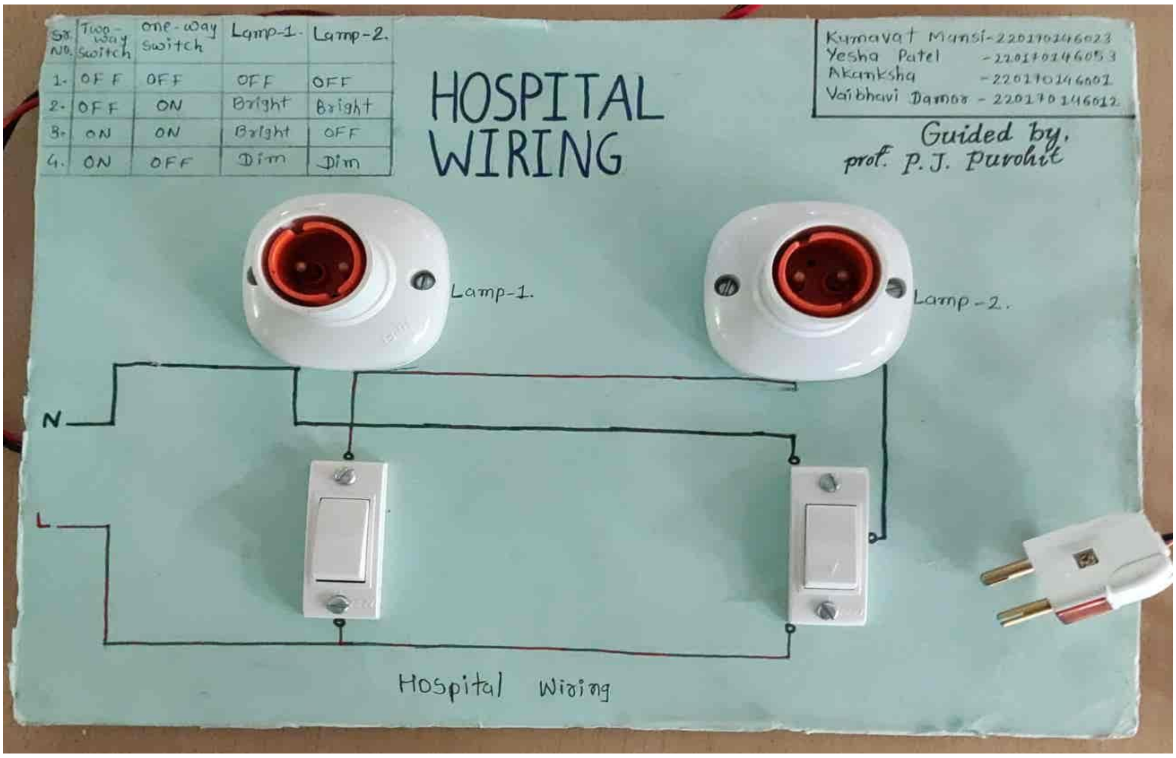
2. **Godown wiring / Lobby wiring**


Bulb-4
Bulb-3
Bulb-2
Bulb-1
N
1 way Switch
2 way switch
2 way switch
2 way switch
P
Godown - Wiring - Diagram


N
Delta - Board - Connection


House - Wiring - Diagram
Neutral
Phase
Lamp-1
Lamp-2
fan
regulator
Ceiling
fan


Lamp-1
medium
light
as only one
bulb glows
Lamp-2
N
Main
Supply
L
SPST
ON
SPDT
Down
Hospital - Wiring


Sr. No.
Two-way switch
one-way switch
Lamp-1.
Lamp-2.
1. OFF OFF OFF OFF
2. OFF ON Bright Bright
3. ON ON Bright OFF
4. ON OFF Dim Dim
HOSPITAL WIRING
Kumavat Mansi-220170146023
Yesha Patel -220170146053
Akanksha -220170146001
Vaibhavi Damor - 220170146012
Guided by,
prof. P. J. Purohit
Lamp-1.
Lamp-2.
N
L
Hospital Wiring

Electrical Workshop
< 3110012 >

Lab Manual prepared by
Prof. P. J. Purohit
Asst. Professor
VGEC, Chandkheda, GTU

Branch Coordinator
Dr. J.R.Iyer
Professor, Electrical Engineering
L.D. College of Engineering
Ahmedabad

Committee Chairman
Dr N M Bhatt
Professor of Mechanical Engineering
L. E. College, Morbi