LAB MANUAL

INSTALLATION, COMMISSIONING AND MAINTENANCE.
(Code: 3360902)

Diploma Electrical Engineering

- Mr. Lomeshkumar C. Mahajan

INSTRUCTIONS

SAFETY RULES

1. **SAFETY** is of paramount importance in the Electrical Engineering Laboratories.
2. Electricity NEVER EXECUSES careless persons. So, exercise enough care and attention in handling electrical equipment and follow safety practices in the laboratory. (Electricity is a good servant but a bad master).
3. Avoid direct contact with any voltage source and power line voltages. (Otherwise, any such contact may subject you to **electrical shock**)
4. Wear rubber-soled shoes. (To insulate you from earth so that even if you accidentally contact a live point, current will not flow through your body to earth and hence you will be protected from electrical shock)
5. Girl students should have their hair tucked under their coat or have it in a knot.
6. Do not wear any metallic rings, bangles, bracelets, wristwatches and neck chains. (When you move your hand/body, such conducting items may create a short circuit or may touch a live point and thereby subject you to electrical shock)
7. Ensure that the power is OFF before you start connecting up the circuit.(Otherwise you will be touching the live parts in the circuit)
8. Switch on the power to your circuit and equipment only after getting them checked up and approved by the staff member.
9. Take the measurement with one hand in your pocket. (To avoid shock in case you accidentally touch two points at different potentials with your two hands)
10. In case you notice any abnormal condition in your circuit (like insulation heating up, resistor heating up etc), switch off the power to your circuit immediately and inform the staff member.
11. Some students have been found to damage meters by mishandling in the following ways:
    i. Keeping unnecessary material like books, lab records, unused meters etc. causing meters to fall down the table.
    ii. Putting pressure on the meter (especially glass) while making connections or while talking or listening to somebody.

- **STUDENTS ARE STRICTLY WARNED THAT FULL COST OF THE METER WILL BE RECOVERED FROM THE INDIVIDUAL WHO HAS DAMAGED IT IN SUCH A MANNER.**
- **Copy these rules in your Lab Record. Observe this yourself and help your friends to observe.**
- I have read and understand these rules and procedures. I agree to abide by these rules and procedures at all times while using these facilities. I understand that failure to follow these rules and procedures will result in my immediate dismissal from the laboratory and additional disciplinary action may be taken.

CERTIFICATE

This is to certify that Mr./Miss ____ of Diploma in Electrical Engineering of Semester 6th, Enrollment No.: _______________________completed his/her Laboratory term work in the subject "**Installation, Commissioning and Maintenance**" subject code **3360902** satisfactorily as per Gujarat Technological University Ahmedabad curriculum for Academic Year – 20 / 20

Signature of Faculty

Signature of Head of Department

Sign of Examiner *Date of Exam:*

*1-*___________

Date of Submission:

*2-*___________

LABORATORY PRACTICAL INDEX

Sr. No	Name of Experiment	Page no.	Date of Start	Date of Comp	Grade	Sign.
1.	Prepare complete layout of wiring for installation of given machine with specifications.					
2.	Prepare technical report on installation of electrical equipments/machines.					
3.	Perform various tests applied to Insulation Oil.					
4.	Measure insulation resistance of a winding/cable/wiring installation and write procedure.					
5.	Prepare test report of an electrical machine after commissioning.					
6.	Prepare maintenance schedule for power transformer.					
7.	Prepare maintenance schedule for Induction motor.					
8.	Dismantle and trouble shooting of ceiling fan.					
9.	Dismantle and trouble shooting of Fluorescent Tube Light.					
10.	Measure Earth Resistance of Installation In Building/Domestic Fitting And Appliances Etc.					
11.	Prepare plate/pipe earthing as per IS and measure the earth resistance.					
12.	Read and interpret I.E. Rules pertaining to safety.					

EXPERIMENT NO.1

Aim: Prepare complete layout of wiring for installation of given machine with specifications.

Equipments/Accessories: All equipments are used as per requirements.

- DOL starters
- Main Switches
- Fuses
- Ammeters
- Voltmeters
- Star – Delta starters
- Selector switches
- 415/230 V star-delta Transformer
- Panel boards
- Thermal Overload Relays
- Auto transformer
- ON – OFF switches

Wiring diagram of Delta connected 415 V, 5 HP 3 phase Induction Motor with DOL starter:

Fig. A shows wiring diagram of 3 phase squirrel cage Induction Motor connected with DOL starter. All 3 phases are connected in main switch from busbar. Output terminals of main switch are inserted in DOL starter. Ammeter is connected in series with one of the three phases. And voltmeter is connected across any two phases. 3 phases are coming out from starter. These 3 phases comes out from panel and are reached to motor through underground metal conduit. Starter is mounted on panel. Ammeter, voltmeter and main switch are also mounted on panel. Dotted line in diagram shows earth connection. The range of voltmeter should be 0 – 500 V due to 415 V, 3 phase supply system. The line current for 415 V, 3 phase I.M. may be 1.5 A per H.P. If the motor is of 5 H.P. then line current may be 5*1.5 = 7.5 A. So the range of ammeter should be 0 – 15 A or 0 – 10 A. Here only one motor is controlled by main switch so rating of main switch should be 30 A, 600 V.

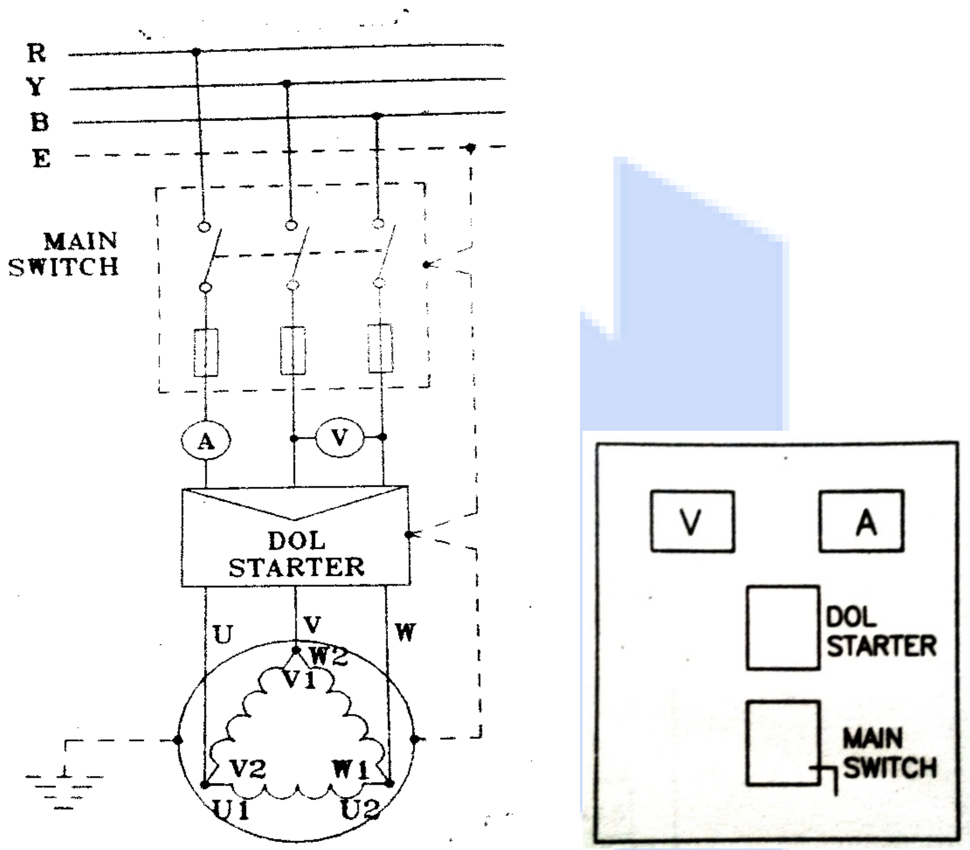


Fig. A. Wiring diagram of Delta connected 415 V, 5 HP 3 phase Induction Motor with DOL starter with panel lay out.

Wiring diagram of 415 V, 3 phases, 25 H.P. Induction Motor with Y-Δ Starter:

Fig. B shows the wiring diagram of 415 V, 3 phases, 25 HP I.M. connected with Y-Δ starter. 3 main phases from busbar are inserted in starter through main switch. Ammeter is connected in series in one of the three phases and voltmeter is connected across any two phases. Six wires are coming out from starter and reached to terminal box through underground metal conduit. Dotted line shows earth connection. The range of voltmeter should be 0 – 500 V. Full load current for 25 HP I.M. is 25*1.5 = 37.5 A. So the range of ammeter should be 0 – 50 A and rating of main switch is 60 A, 500 V.

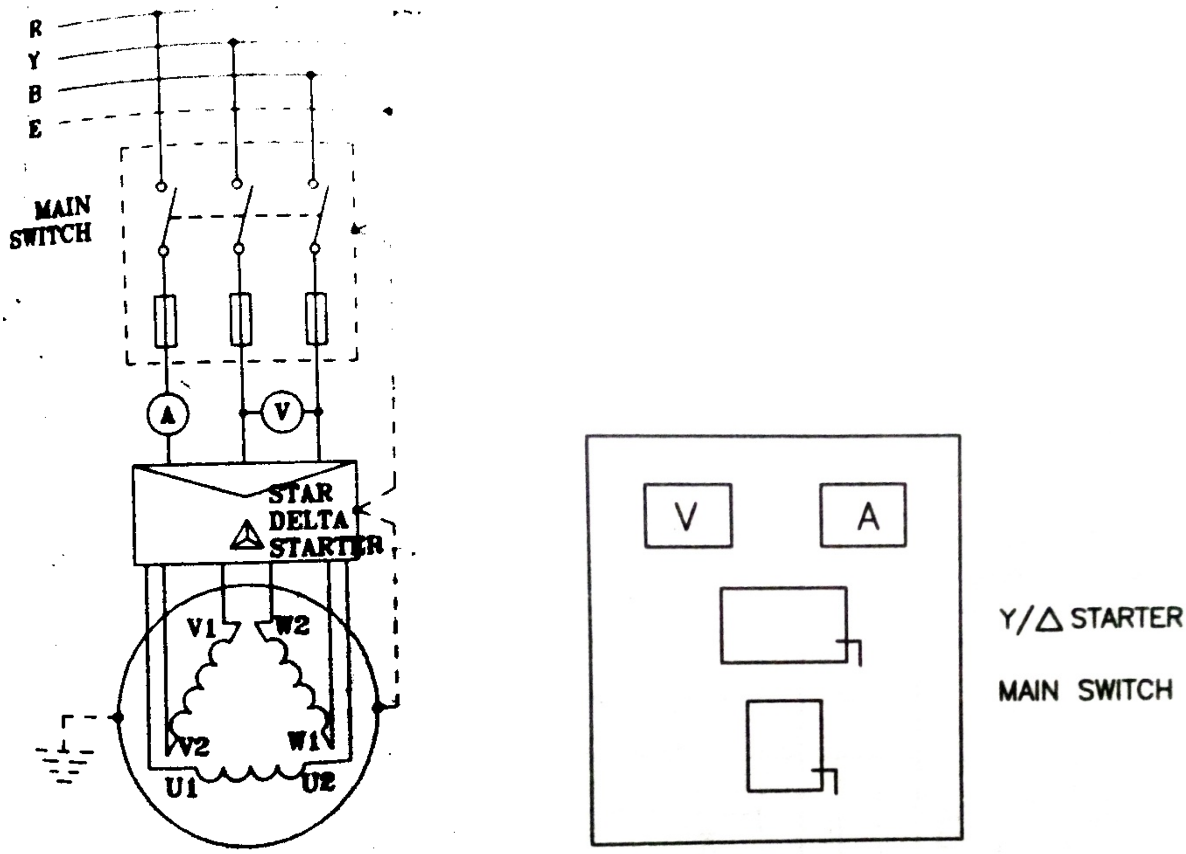


Fig. B Wiring diagram of 415 V, 3 phase, 25 H.P. Induction Motor with Y-Δ Starter with panel lay out

Wiring diagram of Squirrel cage I.M. D.C. compound generator set to get 230 V D.C. supply and wiring diagram of panel to get 3 phase, 230V A.C. supply with use of 415/230 V Transformer:

In fig. (a) wiring diagram of panel and in fig. (b) layout of panel is shown. 415 V, 3 phase supply is supplied by main switch 1 and this supply goes on 415 V A.C. bus. Voltage between RY, YB and BR is selected by using selector switch 1 and is measured by voltmeter V_1. Motor gets supply through main switch 2 and Y-Δ starter. D.C. compound generator is mechanically coupled with motor. D.C. voltage is regulated at desired value with use of field regulator R. With use of ammeter A load current of D.C. generator is measured. The supply is given to transformer with use of main switch 4. 230 V, 3 phase A.C. supply is obtained at output of main switch 5. Voltage can be selected by selector switch 2 and is measured by voltmeter V_3. Dotted lines show earth connection.

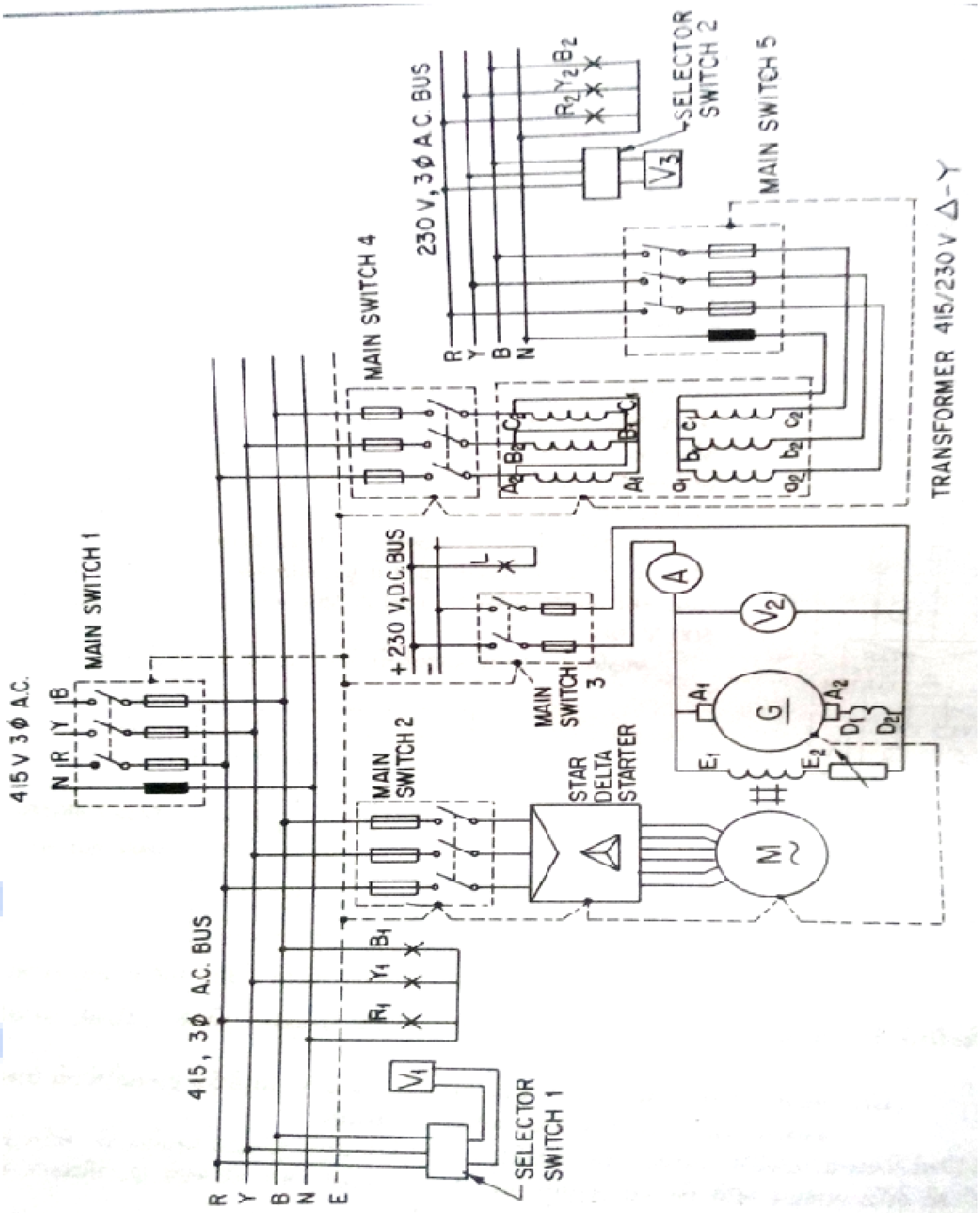

415 V 3Φ A.C.
MAIN SWITCH 1
MAIN SWITCH 2
MAIN SWITCH 3
MAIN SWITCH 4
MAIN SWITCH 5
415, 3Φ A.C. BUS
230 V, 3Φ A.C. BUS
+ 230 V, D.C. BUS
SELECTOR SWITCH 1
SELECTOR SWITCH 2
STAR DELTA STARTER
TRANSFORMER 415/230 V Δ-Y
R
Y
B
N
E

Fig C

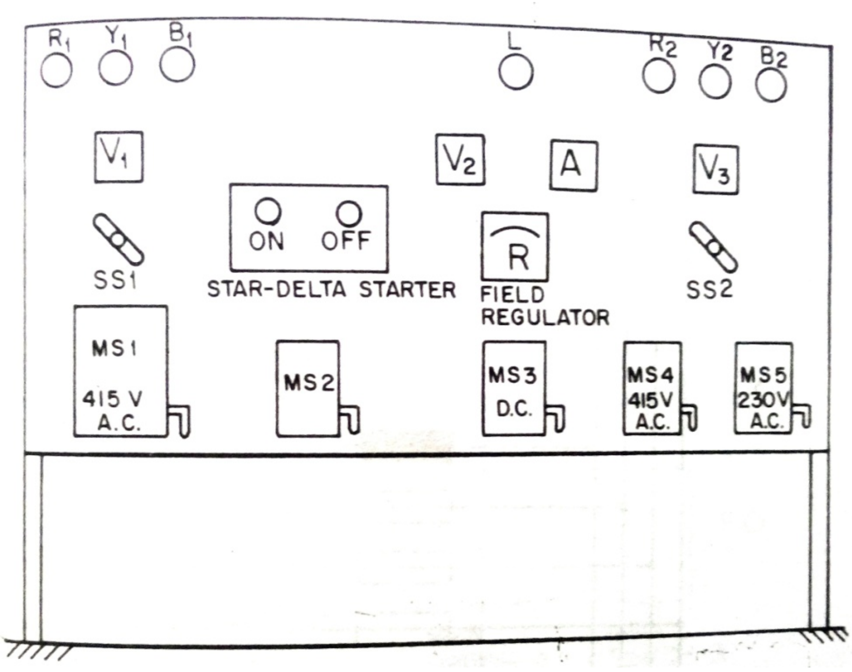


Fig C And Fig D Wiring diagram of Squirrel cage I.M. D.C. compound generator set to get 230 V D.C. supply and wiring diagram of panel to get 3 phase, 230V A.C. supply with use of 415/230 V Transformer with panel lay out.

Wiring diagram and panel layout of D.C. shunt motor – 3 phases Alternator:

In this D.C. shunt motor is mechanically coupled with 3 phase alternator. Schematic arrangement for it is shown in fig E and panel diagram is shown in fig E Lamp L_1 shows presence of D.C. supply. D.C. shunt motor gets D.C. supply through main switch 1. Motor is started by D.C. shunt motor starter. The speed of motor is adjusted by field regulator R. Voltage can be measured by voltmeter V_1. The supply current is measured by ammeter A_1. 3 phase voltage is generated by alternator. Supply voltage is selected by selector switch and A.C. line voltage is measured by voltmeter V_2. The frequency of generated supply voltage is measured by frequency meter F. All 3 lamps show the presence of supply phase. The A.C. supply is given to load by main switch 2. The load current is measured by ammeter A_2.

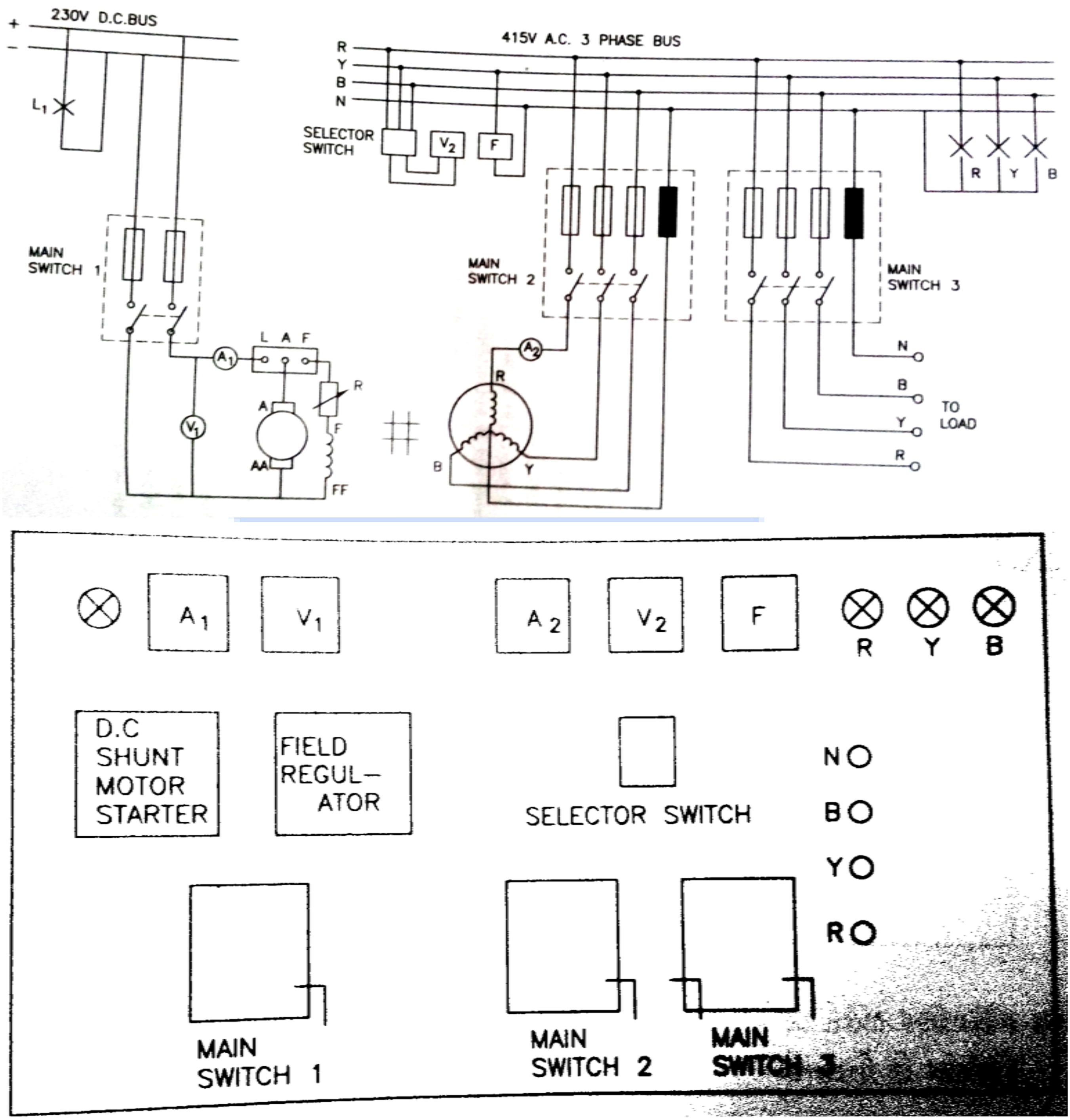


Fig. E Wiring diagram and panel layout of D.C. shunt motor – 3 phases Alternator

Wiring diagram and panel layout of 3 phase I.M. started with automatic auto transformer:

Fig. F shows schematic diagram and fig. F shows panel layout. Voltmeter and ammeter does not show in wiring diagram.

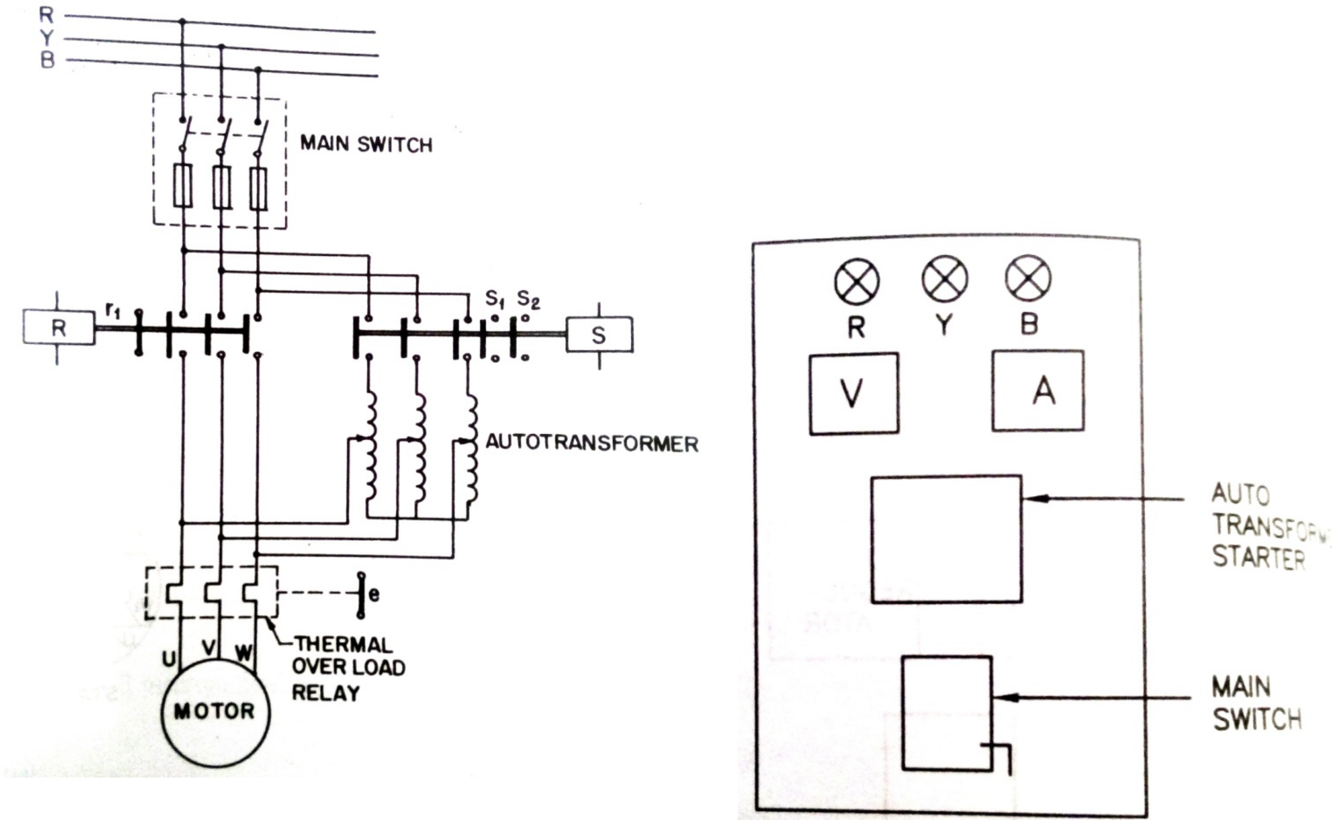
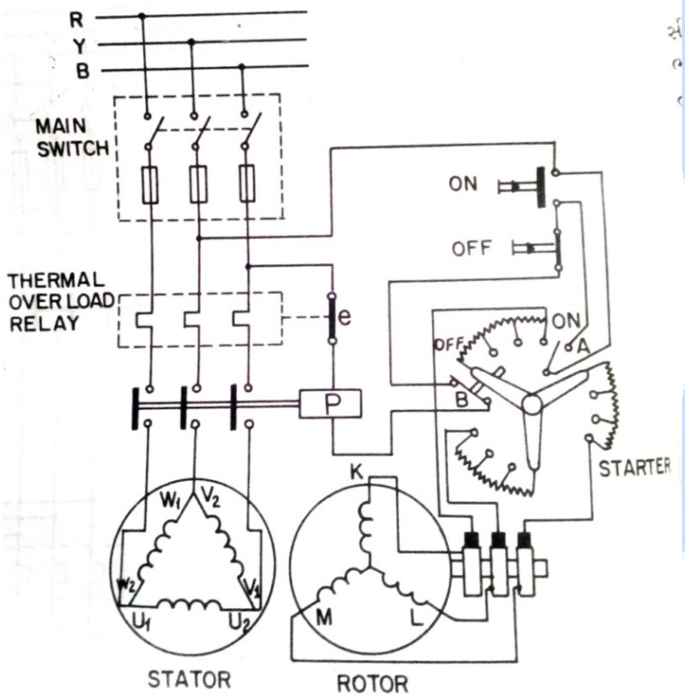


Fig. F. Wiring diagram and panel layout of 3 phase I.M. started with automatic auto transformer with panel layout.

Wiring diagram and panel layout of 3 phase slip ring Induction Motor:

Fig. G shows schematic diagram of 3 phase slip ring I.M. ammeter and voltmeter are not shown in schematic diagram.



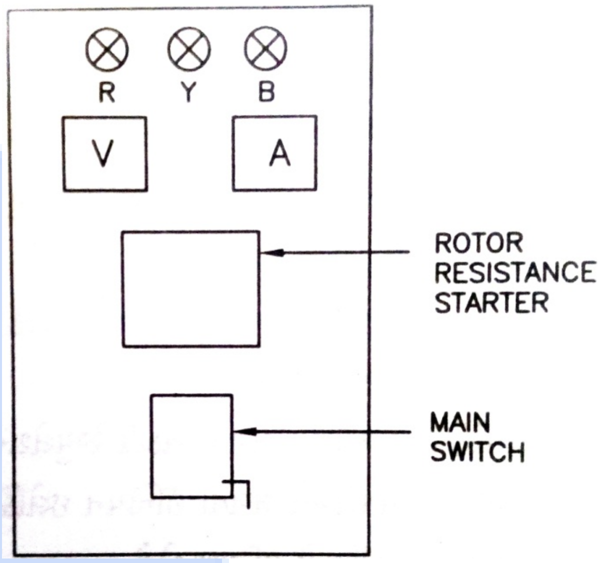


Fig. G Wiring diagram and panel layout of 3 phase slip ring Induction Motor

EXPERIMENT NO. 2

Aim: Prepare technical report on installation of electrical equipments/machines.

Notes for the person producing the Report:

1. This Report should only be used for reporting on the condition of an existing electrical installation. An installation which was designed to an earlier edition of the Regulations and which does not fully comply with the current edition is not necessarily unsafe for continued use, or requires upgrading. Only damage, deterioration, defects, dangerous conditions and non-compliance with the requirements of the Regulations, which may give rise to danger, should be recorded.

2. The Report, normally comprising at least six pages, should include schedules of both the inspection and the test results. Additional pages may be necessary for other than a simple installation. The number of each page should be indicated, together with the total number of pages involved.

3. The reason for producing this Report, such as change of occupancy or landlord's periodic maintenance, should be identified in Section B.

4. Those elements of the installation that are covered by the Report and those that are not should be identified in Section D (Extent and limitations). These aspects should have been agreed with the person ordering the report and other interested parties before the inspection and testing commenced. Any operational limitations, such as inability to gain access to parts of the installation or an item of equipment, should also be recorded in Section D.

5. The maximum prospective value of fault current (Ipf) recorded should be the greater of either the prospective value of short-circuit current or the prospective value of earth fault current.

6. Where an installation has an alternative source of supply a further schedule of supply characteristics and earthing arrangements based upon Section I of this Report should be provided.

7. A summary of the condition of the installation in terms of safety should be clearly stated in Section E. Observations, if any, should be categorized in Section K using the coding C1 to C3 as appropriate. Any observation given a code C1 or C2 classification should result in the overall condition of the installation being reported as unsatisfactory.

8. Wherever practicable, items classified as 'Danger present' (C1) should be made safe on discovery. Where this is not practical the owner or user should be given written notification as a matter of urgency.

9. Where an observation requires further investigation because the inspection has revealed an apparent deficiency which could not, owing to the extent or limitations of the inspection, be fully identified, this should be indicated in the column headed "Further investigation required" within Section K.

10. If the space available for observations in Section K is insufficient, additional pages should be provided as necessary.

11. The date by which the next Electrical Installation Condition Report is recommended should be given in Section F. The interval between inspections should take into account the type and usage of the installation and its overall condition.

EXPERIMENT NO. 3

Aim: Perform various tests applied to Insulation Oil.

Equipments Required: All equipments are used as per requirements.

Standard test cell (50*90*100 mm)
13 mm dia. Spheres of brass (2 nos.)
Metal rod of about 12.5 mm dia.
Test cell to carry oil
Solution (Neptune, xyline, acetone, mythalated spirit, phenolphthalein, alkaline, KOH, petrol, carbon tetrachloride)
Filter paper
Burette
Flask
Spirit lamp
Thermometer

Standard tests performed on insulating oil:

Dielectric strength test
Crackle test
Sludge test
Flash point test
Acidity test
Other tests

Dielectric strength test:

This test is carried out in standard test kit having standard cell and facility to provide test voltage as described in the IS specifications. The standard test cell has internal dimensions of 50 mm × 90 mm × 100 mm. There are two polished brass 13 mm diameters spheres. These electrode test spheres are fitted in the test cell 40 mm above its bottom.

As per IS standard separator for spheres is used. It keeps spheres away from each other by 2.5 mm ± 0.2 mm distance. The shape and size of the test cup is given in fig. First of all test cell is cleaned by petrol or carbon tetrachloride. Oil samples id filled up to the marked level in the test cell. After putting test cell in its position properly oil is allowed to be settled in the cell. Then voltage between two electrodes in a test cup is slowly increased up to 100 KV. If the oil sample is very good, it will be able to withstand such high voltage for 1 minute without any spark over between the electrodes. Transient sparking can be ignored. In this manner at least three readings are taken with separate filling. Good insulating oil can withstand for 1 minute 40 kg/mm.

Crackle test:

This test is carried out to verify the presence of water in the oil sample. The glass vessel capable of 250 ml oil is filled with a sample of oil up to full level. A metal rod of about 12.5 mm diameter is heated to a dull redness and it is lowered into the glass vessel filled with means of the rod. If the crackling noise is heard the oil is considered as having water particles in it. Such test is carried out 3 times in separate oil samples. During the test stirring can be continuing.

Sludge test:

In the transformer oil is subjected to high temperature for long period, it also absorbs moisture and oxygen from air as a result viscous acidic material called sludge is formed. This sludge is not easily detachable. For simple examination of used oil sample, it is diluted with naphthalene solution. This solution is filtered through the white filter paper. This filter paper is washed free from oil with naphthalene. A mixture of tree parts of xyline to one part of acetone is then pure through the paper. The paper color is turned brown, this suggest the presence of sludge in the oil. If the filter paper is left free from deposit after this washing, it can be concluded that all these solid matter was sludge. Then the oil is required to be filtered.

Acidity test:

The simplified method of testing oil sample for acidity is as follows.

Measure 50 ml of ethylated spirit into the flask. Add few drops of phenolphthalein indicator in the solution when oil sample is light in color. If the oil sample is dark in color add alkaline blue instead of phenolphthalein. Fill the burette with 0.01 N KOH solutions and carefully neutralize the ethylated spirit in the flask. Neutralization will take place at the point when the indication just changes its color. Measure 10 ml of sample of oil into the flask and mix it thoroughly. Note the burette readings and again neutralize the contents in the flask. Note the final burette reading and calculate the quantity of KOH solution required for neutralization.

The acidity of oil is expressed in mgm of KOH/1 gm of oil. This is equal to 0.664 × number of ml of KOH (0.01 N) solution. For good insulating oil acidity should be less than 0.4 mgm KOH/1gm of oil.

Flash point test:

Flash point test is done on insulating oil to verify any sign of production of unusual odor from oil, when it is subjected to high temperature. For this test oil sample is taken into a closed vessel having pipe like kettle. Vessel containing oil is heated slowly by means of spirit lamp. When temperature rises such that vapor coming out of the pipe makes flame brighter. This temperature is called flash point. For good insulating oil flash point is 140° C or more.

EXPERIMENT NO. 4

Aim: Measure insulation resistance of a winding/cable/wiring installation and write procedure.

Introduction:

In the electrical machines or equipments conducting and insulating materials are used. In the electrical circuits' conductors – wires are used, while insulating materials are used to separate out live current carrying parts and noncurrent carrying parts. So that no current flow between them. Leakage current if any should be kept as minimum as possible. It depends upon inversely on the resistance of insulating materials.

Classification of Insulating Materials:

Sr. No.	Class Of Insulation	Max. Working Temperature	Names Of Materials
1	Y (O)	90^0 C	Cotton cloth, Silk cloth, Paper, Wood, PVC, Rubber etc.
2	A	105^0 C	Cotton, Impregnated paper, Silk
3	E	120^0 C	Varnish which can work up to 120^0 C, Cloth/silk tape impregnated in varnish
4	B	130^0 C	Mica, Fiber glass, Asbestos compounds
5	F	155^0 C	Mica, Glass, Asbestos, Fiber with organic compound
6	H	180^0 C	Inorganic compound silicon, Silicon resins, Mica, Fiber, Asbestos
7	C	More than 180^0 C	Porcelain, Glass, Asbestos, Quartz

Equipments/Accessories: Specifications are as per requirement.

Megger
Insulation tester
Connecting wires

Methods Of Insulation Resistance Measurement:

There are various methods but most convenient methods are to use following two instruments.
Megger or Mega ohm bridge
Insulation Tester

Megger:

Insulation resistance of electrical equipments refers to the resistance between conducting part and earth. It is expressed in Mega ohms.

A simplified diagram of an internal connection of a megger is shown in the fig. The permanent magnets provide the field for both the generator and ohm meter, The moving element of ohm meter consists of 3 coils, current coil, pressure coil and a compensating coil mounted rigidly to a pivoted central shaft and free to rotate over stationary C shaped iron core.

The coils are connected to the circuit by means of flexible leads known as ligaments that exert no restoring torque on the movement of the coils. When generator is stationary, the moving system may take any position over the scale. The current coil is in series with the resistance R’ between on generator terminal and L terminal. The series resistance R’ protects the current coil by limiting the current value when the test terminals are shorted. It also controls the range of the instrument. The pressure coil is in series with a compensating coil and series protective resistance R, is connected across the generator terminals. Compensating coil provides better scale proportion.

The pressure coil tends to set itself at right angles to the field of the permanent magnet, when it carries current. When the test terminals are open, the current through deflecting or current coil is zero. The pressure coil governs the motion of moving system such that it moves to extreme anticlockwise position. The pointer indicates infinite resistance under such circumstances. Similarly when test terminals are shorted, there is zero external resistance hence the current flowing through the current coil is large enough to produce sufficient torque to overcome the anticlockwise torque produced by the pressure coil and the moving system moves to extreme clockwise position showing resistance reading.

The resistance under test is connected between terminals L and E. the generator handle is rotated to about a steady speed of 160 rpm. The handle must rotate at constant rpm continuously units the point on the scale gives steady reading. The larger the capacitance of the specimen under test. The longer time it will take to charge and give a steady reading.

Measurement Of Insulation Resistance Of The Machine:

When the I.R. of the machine is to be measured by megger, a D.C. voltage is applied to the specimen. Initially insulation draws charging current in addition to leakage current.

The megger reads $I_N R_0 = \dfrac{V_{DC}}{I_C + I_L}$

Where,
V_{DC} = Test voltage of a megger
I_C = Charging Current
I_L = Leakage current
$I_N R_0$ = Insulation resistance (Initial)

After continuous application of a D.C. voltage the capacitive current reduces to only leakage current ($I_C = 0$).

The megger reading after 60 sec for a small transformer,

$I_N R_{60} = \dfrac{V_{DC}}{I_L}$ (where $I_C = 0$)

$I_N R_{60}$ is greater than $I_N R_0$.
Hence the megger reading after 60 sec is higher than that of initial reading. The I.R. reading shows the quality of insulation of a machine and degree of dryness. For large capacity transformer 1 minute and 10 minutes reading are taken.

$I_N R_{1MIN} = \dfrac{V_{DC}}{I_C + I_L}$, $I_N R_{10MIN} = \dfrac{V_{DC}}{I_L}$

So from that absorption coefficient is found out, which should be more than 1.3.

$\dfrac{I_N R_{10MIN}}{I_N R_{1MIN}} = K_{ab} > 1.3$, where K_{ab} is absorption coefficient

Observation Table:

Sr. No.	I_NR_0 (Initial)	I_NR_{60} (after 1 minute)	I_NR_{10} (after 10 minutes)	$K_{ab} = I_NR_{10} / I_NR_{60}$

Insulation Tester:

Insulation tester is a battery operated device. It consists of a oscillator and transformer which can provide necessary high voltage of special waveforms and also standard impulse waveform to measure the insulation resistance of an insulator specimen.

Insulation tester has 3 terminals, positive, negative and earth terminal. It has no D.C. generator. But when push button is pressed the current starts flowing in the circuit and high voltage output is available at positive and negative terminals. Fig. shows the front view of a typical insulation tester. Earth terminals connected to earth terminal of step up transformer. If the battery emf is reduced, tester is not working properly. The battery is required to be replaced by new one.

Insulation Resistance of an Electrical Installation:

Insulation resistance of an electrical installation is measured by means of a megger. There are two methods of finding out I.R.

I.R. between phase and neutral wire

I.R. between phase plus neutral wire and earth

In first case, the measurement is carried out by removing all lamps, fans, fuses and neutral links are in position. Switches are made ON the megger terminals are connected between P an N and handle of megger is rotated at constant speed. The reading of megger is obtained. This reading should not be less than 5 MΩ. If the reading is less, it means the connections of wiring should be checked. The defects if found should be removed. The I.R. will be brought to specified value.

In second case, the phase and neutral wire is shorted together and connected to L terminals of the megger. The earth terminal (E) is connected to earthing point. All the loads, fuse, neutral link are kept in position. The measurement is taken by rotating handle at constant speed.

The readings are taken,

$$I_R = \frac{50}{\text{Nos. of outlets}}\ M\Omega = X\ M\Omega$$

The value of X should not be less than 5 MΩ.

Observation Table:

Sr. No.	I.R. between phase and neutral	I.R. between phase + neutral and earth

Insulation Resistance Of Rotating Electrical Machines:

For measurement of I.R. of electrical rotating machine by means of megger, the megger voltage should be double than the working voltage. For 400 volts, 3 phase I.M., 1000 volts megger is used. For a rotating machines I.R. should not be less than 2 MΩ at the room temp. say 30^0 C. It is a practice to indicate the temperature at which the I.R. was measured and enter into the record.

Insulation Resistance Of The Static Device:

The I.R. of a transformer winding, cable and capacitor etc. are measured by means of a megger. I.R. of electrical machine decrease as its temperature rises.

For a transformer of large capacity I.R. should be about 750 MΩ at 30^0 C. It is measured between phase winding and earth.

In case of a capacitor, the charging current should be considered. For cable the megger should provide D.C. voltage. First of all when megger handle is rotated, the charging current will flow through the capacitor, there after the pointer in the megger will become steady after say 25 seconds.

When measuring the cable I.R., with the help of D.C. megger, a polarization effect should be considered. Due to polarization higher readings are obtained. In this case megger terminals are interchanged and two readings are taken with changed megger polarity. Then average of two readings should be considered.

$$I_R = \frac{I_{R1} + I_{R2}}{2}$$

EXPERIMENT NO. 5

Aim: Prepare test report of an electrical machine after commissioning.

SCOPE

- The Physical Plant Department at the University of Manitoba has implemented a Quality Commissioning Program (QCP) that involves the review and verification of construction and renovation projects to ensure all aspects meet the quality standards set by the University.
- The Quality Commissioning Program is a comprehensive process that starts at the pre-design phase and continues through the post construction phase. Re-commissioning of the commissioned installations is performed every 5 years. For this reason, the initial commissioning process and the resulting documentation is critical to ensure that complete and accurate re-commissioning can take place in the following years.
- Under this contract all electrical systems shall be fully commissioned for compliance to the design documentation and specified performance. Documentation forms shall be prepared and be completed for each system and piece of equipment. Satisfactory equipment verification and performance forms shall be submitted when work is complete and they will be signed off by the University of Manitoba when accepted. Sample data sheets are attached which provide representative information sheets for electrical items.
- A **Commissioning Schedule** shall be prepared and be submitted for approval within 90 calendar days of contract award. This schedule shall cover all commissioning phases and provide a timeline, milestones, and define points of responsibility.
- All equipment supplied to this project will be checked prior to installation to ensure that the delivered product is as specified before it can be released for installation. An **Equipment Form** shall be prepared, completed, and be submitted for each piece of equipment when found to be satisfactory. See attached sample Equipment Forms at the end of this Section.
- All equipment and system installations shall be examined and functionally tested for compliance with design intent. An **Installation Form** shall be prepared, completed, and be submitted for each piece of equipment when found to be satisfactory. See attached sample Installation Forms at the end of this Section.
- Once the supplied equipment has been verified to be in compliance with the design intent, and the equipment has been properly installed and operation verified, the Commissioning program moves on to verify equipment and system

performance for compliance with design. This portion of the work requires the submittal of **<u>Performance Form</u>** when satisfactory performance has been achieved. See attached sample Performance Forms at the end of this section

Commissioning activities to include the following:

- Verification that all equipment has been supplied to the project in accordance with the specification. Every piece of equipment requires the satisfactory completion of an Equipment Form.
- Verification that all equipment has been installed as required by the contract documents and functions correctly. Each piece of equipment requires the satisfactory completion of an Installation Form.
- The functionality and performance of each piece of equipment and every system shall be verified as operating in accordance with the contract documents. This portion of the commissioning process requires that all items undergo trial performance testing, and final operating adjustments to verify acceptable performance. Each piece of equipment and every system requires the satisfactory completion of a Performance Form.
- All discrepancies are to be noted and a signed letter of acceptance from the Manager of Engineering Services attached for each item.
- Demonstration of satisfactory performance of mechanical, electrical, and control systems to the Consultant and the University of Manitoba required.
- Completion of all commissioning test reports, procedures, verification, acceptance, and Forms

COMMISSIONING SCHEDULE

- Provide a detailed schedule for all commissioning phases to the Consultant and Owner within 90 calendar days of contract award. The schedule shall include the equipment, installation, and performance commissioning.
- The Commissioning Plan shall be specific to the project, identifying all items to be commissioned along with a schedule for the commissioning.
- The Commissioning Plan shall include but is not limited to:
    - Objectives of Commissioning Plan
    - A listing of all items to be commissioned indicating trade responsible for required testing.
    - Typical commissioning check sheets for each type of equipment.
    - Commissioning schedule
- List of individuals / companies performing each test.
- Reports required resulting from testing.

EXPERIMENT NO. 6

Aim: Prepare maintenance schedule for power transformer.

EXPERIMENT NO. 7

Aim: Prepare maintenance schedule for Induction Motor.

EXPERIMENT NO. 8

Aim: Dismantle and trouble shooting of ceiling fan.

Trouble shooting And Dismantle:

When electrical equipments are used for a long period due to external and internal causes some faults occur in the equipments. If equipments are to be maintained regularly the faults occur are less, but equipment runs without fault or error is not possible for a long period. So it is necessary to inspect and to find proper method for finding these faults occurring in the equipments. Due to this right steps can be taken for correction of faults. This method of find out faults and solve the faults is called Trouble shooting.

Now when there is any fault occurs in electrical equipments or domestic appliances, they will be repaired for particular fault. For repairing such type of equipments or appliances they will be opened completely step by step. The process to open any appliance or equipment with the necessary tools or accessories from step by step is called dismantle of it. So for repairing, rewinding, oiling or to make appliance or equipment free from fault the process of complete open of it is called dismantle.

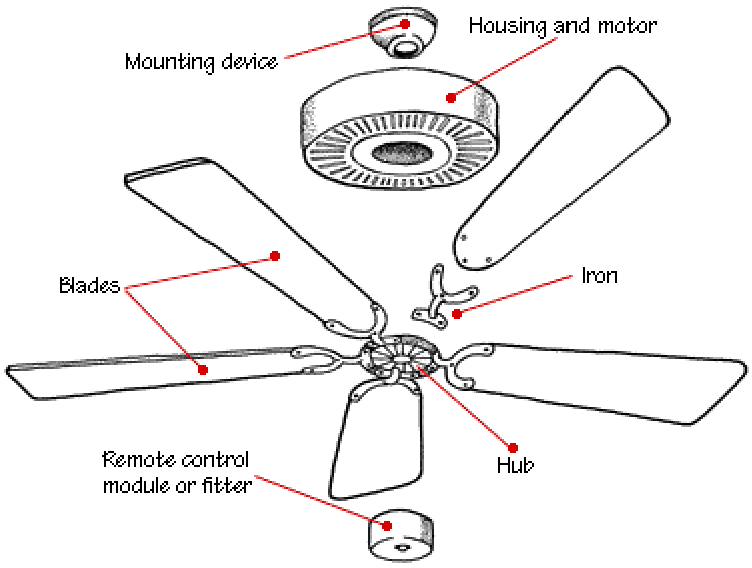
Tools required

Insulated combination pliers (150mm)-1
Screw driver (75mm)-1
Insulated nose plier (150mm)-1
Hammer (250gm)-1
D/E set of spanners.

Materials Required

Test lamp (200w) with testing leads of 2 m each; mobile oil; Grease; Empire sleeves – 4 m as per requirements.

Dismantling of ceiling fan:



To remove the fan from the ceiling when it is to be rewound or repaired, the following steps may be followed

1. Loosen the studs or screws fitted on the shank of blades with the upper cover of the ceiling fan. Remove them and the blades carefully so that angle / shape of the blades should not be disturbed.

2. Lower the upper canopy by unscrewing its machine screw and disconnect the connections from connector.
3. Loosen the nut of suspension bolt fitted in the 'U' shaped clamp of suspension rod, remove it and by holding / gripping the suspension rod into hand firmly, remove the bolt and down the fan carefully.

4. Unscrew the machine screw of lower canopy and set it upward.

5. Now disconnect the supply wires and fans' motor connections from connector fitted on the suspension rod or capacitor housing. Also disconnect the connections of capacitor and remove the capacitor.

6. Remove the split pin from suspension rod.

7. Unscrew the chuck nut and loosen the suspension rod and remove it from capacitor housing by holding the fan body and housing firmly.

8. Remove the split pin of housing, loosen the housing and remove it by holding the fans' body firmly.

9. Now loosen the machine screws of the bottom cover and remove it and remove the cover and chromium plated cup.

10. Remove the grease cup from underneath the chromium plated cup by unscrewing the machine screws.

11. Remove the black cover of motor by unscrewing the covers' screws with the help of wooden block and mallet etc.

12. Separate the rotor.

13. Remove the upper cover by striking the shaft on a wooden block.

14. Unscrew the machine screws of upper bearing cup. Remove the bearing cover.

15. Pull the bearing with the help of bearing puller.

16. Check the starter winding with the help of test lamp or megger set for open circuit earth or leakage fault separately.

17. Check also the two windings i.e. main and auxiliary winding for short circuit etc.

18. If the winding are short circuited or burnt then cut the coil with the help of hack saw blade remove the burnt coil, clean the slot of the stator and rewind the stator by inserting the new insulating material and new coil of proper gauge of winding wire as per the turns.

19. Complete the assembling of the parts of ceiling fan carefully and after doing all connections in the connectors hang it on the ceiling. Fix the blade and do the connections in the connector now the fan is ready.

Possible faults

1. Open circuit, short circuit and earth fault in main winding or running winding.
2. Open circuit, short circuit and earth fault in auxiliary winding or starting winding.
3. Open circuit, short circuit and earth fault in capacitor or condenser.
4. Other faults may be in bearings or bushes bent shaft, broken plug top or defective supply cord,

Trouble shooting chart of Ceiling fan:

Faults	Causes	Solution
1. Motor does not start	Fuse may be burnt	Change fuse
	Fault in starter	Check starter contacts, coil and connection and correct them
	Auxiliary winding may be open	Test for open circuit
	Main winding may be open	Test for it and correct open circuit
	Capacitor may be short	Test the capacitor for short circuit and if required change it
	Capacitor may be open	Test for open circuit and correct it and take required action for it correction
	overload	If there is overload remove some load and make it proper
2.Motor is overheated	Overload	Remove load and make it proper
	Contact does not open of starter	Overload relay does not operate on overload then check for it and remove the fault

	Low voltage	Measure voltage. If possible increase voltage and make it rated or if possible decrease some load
	High voltage	Measure voltage and if possible decrease voltage to its rated value
	Ventilation does not proper	Clean the ventilation holes and keep it proper
	Short circuit in stator coil	Remove short circuit in stator coil
	Faults in bearing	Check the bearing and lubrication system of it. If required lubricate the bearings
	Low frequency	Measure frequency if possible increase the frequency
	Rotor touches the stator when rotates	Make bearings proper and through the rotor
3.Motor works with reduced speed	Overload	Decrease the load and make it proper
	Low voltage	Measure voltage and if possible increase it to its rated value
	Low frequency	Measure frequency and if possible increase it to its rated value
	Rotor bars may be broken	Check for it and if bars are broken change them
	Short circuit in stator coil	If the coil is short change the coil

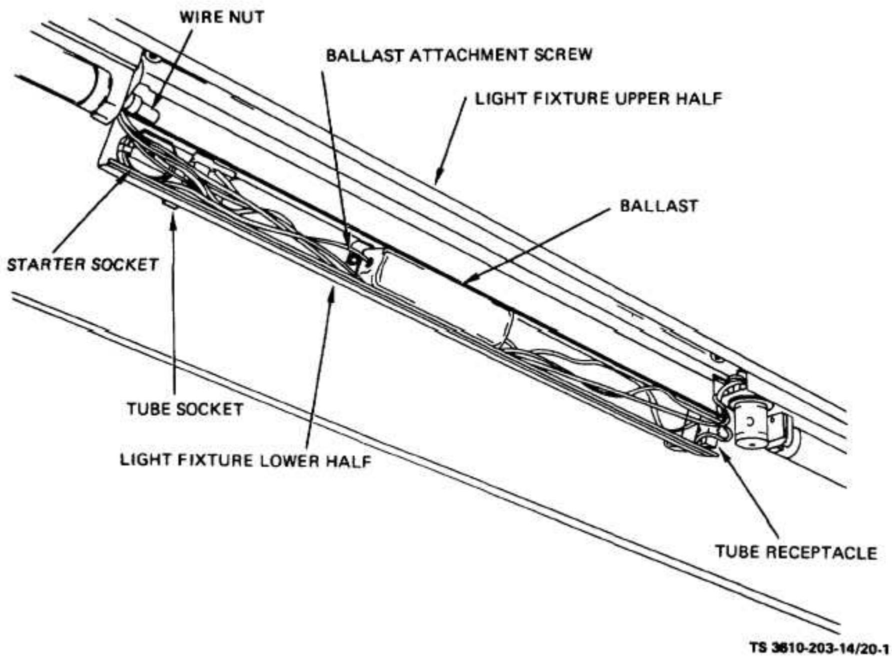
EXPERIMENT NO. 9

Aim: Dismantle and trouble shooting of Fluorescent Tube Light.

- **Various faults occurring in florescent tubes their possible causes and remedies are given below**

Symptoms	Possible causes	Remedies
1. Blinking on and off	1. Low circuit voltage. 2. Loose contact. 3. Defective starter. 4. Defective tube. 5. Wrong connections.	Change ballast tapping if required. Check all connections Replace starter. Replace tube. Check all connections.
2. ends of a tube remain lighted	1. short- circuited starter.	Replace starter.
3. Failure of lamp to light up.	1. Defective tube. 2. Defective starter. 3. Defective chokes. 4. Defective and loose holders.	Replace tube. Replace starter. Replace choke Turn tube through90° Try another starter and check connections.
4. Blackening of the end(early life) (normal life)	1. Low or high voltage. 1. Mercury deposite at the ends.	Adjust ballast tapping. It will evaporate as the lamp operates.
5. Burn out electrodes.	1. control unit in circuit or Choke short-circuited	Test with a new Choke.

6. Dark streaks along lamp.	Mercury globules	Rotate tube through 180˚
7. Snaking spiraling (with glow type starter)	1. In sufficient heating due to either starter opening quickly or wrong tapping made on the ballast.	Replace starter or ballast. In case of new lamp, it cures after few days.



EXPERIMENT NO. 10

Aim: Measure Earth Resistance of Installation in Building/Domestic Fitting and Appliances Etc.

Introduction:

The resistance of earth wire which is require to flow the fault current in abnormal or faulty condition is known as earth resistance. The earthing resistance should be as low as possible to pass the fault current. Now in this practical you will study various factors which are responsible for increasing earth resistance, which should be value of earth resistance, what should be value of earth resistance in different installation and remedial steps for improving earth resistance.

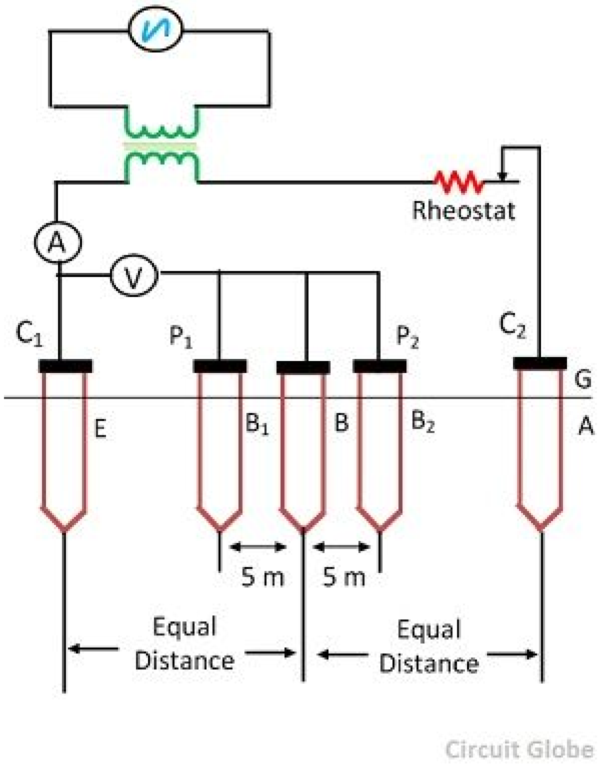
Equipments/Accessories:

Voltmeter
Ammeter
Megger earth tester
Ohm meter
Earth loop tester
1-Ø step down transformer with tappings on secondary side
Earth electrodes
Rods
Connecting wires

Methods of earth resistance measurement:

The names of particular method of earth resistance measurement are given by the main instruments used for measurement. Following are the common instruments used for earth resistance measurement.
Voltmeter-Ammeter method
Megger earth tester
Ohm meter
Earth loop tester

Voltmeter – Ammeter method:



The measurement of earth resistance is made by the potential fall method. The resistance area of the earth electrode is the area of the soil around which a voltage gradient is measured with a commercial instrument. In the figure shown below E is the earth electrode under rest, and A is an auxiliary earth electrode positioned so that two resistance areas do not overlap. B is the second auxiliary electrode which is placed between E and A.

An alternating current of steady state value passes through the earth path from E to A and the voltage drop between E and B is measured.

$$R_e = \frac{Voltage\ drop\ between\ E\ and\ B}{Current\ through\ earth\ path}$$

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

The electrode B is moved from position B1 and B2 respectively so that the resistance area do not overlap. If the resistance values determined are of approximately the same in all three cases, the mean of the three readings can be taken as the earth resistance of the earth electrode.

The auxiliary earth electrode A must be driven in at a point further away from E and the above test repeated until the group of three readings obtained are in good agreement. The alternating current source is used to eliminate the electrolytic effect.

The test can be performed, with current at power frequency from a double wound transformer, using a voltmeter and an ammeter as shown in the figure above by mean of an earth tester.

The earth tester is a special type of Megger, which sends AC through earth and DC through the measuring instrument. It has got four terminals. Two terminals are shorted to form a common point which is connected to the earth electrode under test. The other two terminals are connected to the auxiliary electrode A and B respectively. The value of the earth resistance is indicated by the instrument directly when its handle is turned at a uniform speed.

Observation Table:

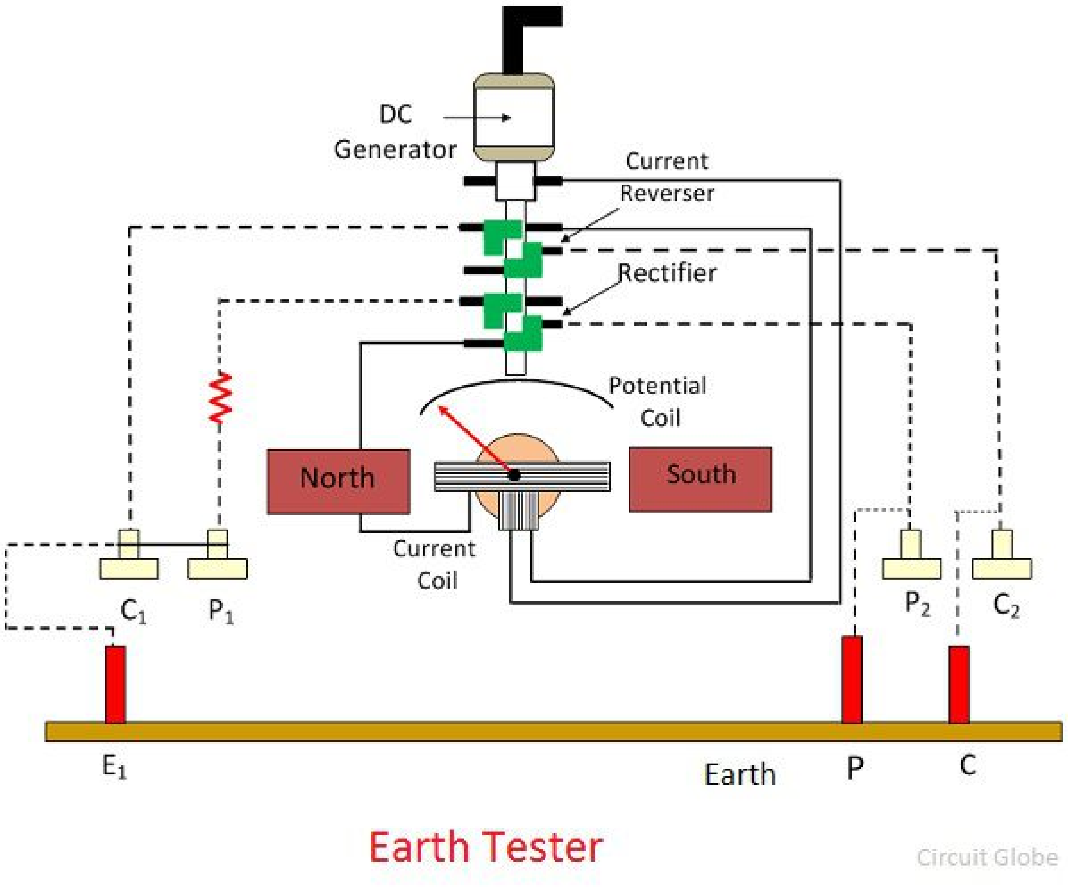
Sr. No.	Voltage	Current	Resistance (R=V\I)

Megger Earth Tester:

A megger earth tester is also uses the same principle as that of voltmeter-ammeter method. It is portable and convenient having its own hand driven D.C. generator which gives the testing current and permitting direct reading in the ohmmeter of the earth resistance without any special connection and calculation.

A hand driven D.C. generator produces the direct current but is eliminated electrolytic effect, it is necessary any to pass alternating current through the soil, so to change D.C. in to A.C. a rotary convertor is mounted on the same shaft of the D.C. generator. The alternating current in the coil will produce an alternating voltage drop in the soil, but the potential applied across the moving coil meter must be D.C. as the moving coil instrument working on D.C. alone synchronous rotary rectifier is also attached so as to change A.C. potential drop in to D.C. drop, to the shaft of the D.C. generator.

Three terminals are kept for connecting to earth electrode and auxiliary electrode. For measurement of earth resistance two auxiliary earth electrodes acting as current and potential electrode are driven in to the ground at a distance of 30 mtr and 15 mtr from earth electrode under test and are connected to the terminal C_2 and P_2 respectively, while P_1, C_1 are shorted and connected to earth electrode under test as shown in fig.

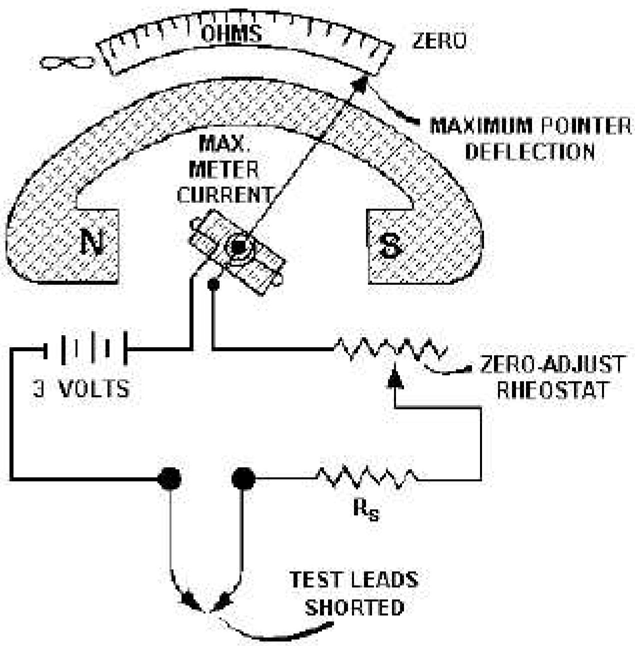


A megger is then placed on a horizontal, stand free from surrounding magnetic field. The range selector switch is set at the required position. The handle is rotated with the rated speed and deflection in meter is noted. Two or three readings are taken by placing the potential electrode to other position keeping the same distance as that of first reading. The average of these readings is the earth resistance.

Observation Table:

Sr. No.	Earth Resistance by Megger earth tester

Ohm-Meter:



For point to point continuity test, a small portable ohm-meter will be more convenient. The simple construction of such meter is shown in fig. It consists of a milli-ameter (0-30 mA) with a small dry battery (1.5 v) and adjustable resistance connected in series.

The calibrating resistance is adjusted initially, so that when test probe A and B are shorted together, the meter shows full scale deflection. If the test probes are now connected to an unknown resistance, the meter will show lesser readings depending upon the value of external resistance.

Observation Table:

Sr. No.	Earth Resistance by Ohm meter

Earth Loop Tester:

The current which will flow under earth fault condition and will thus be available for operating the over load protection depends upon the impedance of the earth return loop. This earth loop includes the line conductor fault, earth continuity conductor and earthing lead, earth electrode at consumer premises and substations and any parallel metallic returns to the transformer neutral as well as transformer windings.

An earth loop tester is just an ohm meter. The test probes being applied between the electrode and earthing point under test, and the neutral conductor of the supply mains. A mains operated earth loop tester is connected for testing of earth pin of a 3-pin socket as shown in fig.

Observation Table:

Sr. No.	Earth Resistance by Earth loop tester

EXPERIMENT NO. 11

Aim: Prepare plate/pipe earthing as per IS and measure the earth resistance.

Equipments/Accessories:-

Copper plate (600 × 600 × 3 mm)	-	1 Nos.
12.7 mm G.I. pipe	-	As required
6.3 mm MS rod	-	2 Nos.
19 mm G.I. pipe	-	As required
Charcoal	-	As required
Salt	-	As required
Wire mesh	-	3 Nos.
38 mm G.I. pipe	-	2.5 mtr.
Bolts and nuts	-	As required
8 SWG G.I. Coil	-	115 turns
CI cover hinged to CI frame	-	3 Nos.

Earthing:

Insulated conductors are used in electrical equipments. Normally the body of electrical equipment is made of metal. Body is earthed through wire of low resistance. This is called earthing.

For example there are three wires to join electrical iron. Red and black wires are joined to the coil of the iron. Third green wire is joined to the body of the iron. These are connected to mains using three pin top and socket. Green wire is connected to third big pin through which it is connected to earth.

Necessity of Earthing:

To understand the necessity of earthing let us first assume that the equipment is not earthed. There is no problem to touch the body of the equipment until the insulation over the conductor is okay. But if the insulation gets punctured due to some reason the live conductor comes in contact with the metal body and its potential becomes equal to the mains potential. So now if one touches the body he/she will receive a dangerous shock. But if the body is earthed then leakage current flows to the earth and person does not receive shock. If the leakage current is more the fuse melts and equipment is isolated from the mains supply.

<u>Provisions should be taken for earthing:</u>

According to Indian Electricity Rule 61, the following provisions shall apply to the connection with earth of a system at low voltage in cases where the voltage normally exceeds 125 volts and of the systems at medium voltage:

- The neutral conductor of a 3-phase 4-wire system and the middle conductor of a 2-phase 3-wire system shall be earthed by not less than two separate and distinct connections with earth both at the generating station and at substations. It may also be earthed at one or more points along the distribution system or service line in addition to any connection with earth which may be at the consumer's premises.
- The frame of every generator, stationary motor and so far as is practicable, portable motor and the metallic parts (not intended as conductors) of all transformers and any other apparatus used for regulating or controlling energy and all medium voltage energy consuming apparatus shall be earthed by the owner by two separate and distinct connection with earth.
- All metallic coverings containing electric supply wires, metallic apparatus vis., iron clad switches, distribution fuse boards, down rod of fan, water tight switches etc. should be earthed. In addition to running earth conductor, the main switch board at consumers' premises should be earthed with an earth electrode.
- All apparatus viz. refrigerator, energy meters, cooking range, oven, electric heaters, press etc. should be earthed.
- In an underground cable, metallic sheath should be earthed by two separate and distinct connections with the earth.
- Iron clamps, brackets, steel poles, steel tower stay wires of a distribution and transmission system should be earthed.
- No earth connection is made to that gas pipe.
- In case of D.C. supply, the middle conductor should be earthed at the generating station.

Methods of Earthing:

Pipe earthing
Plate earthing
Coil earthing

Pipe earthing:

If the water pipe cannot be used as an earth, a galvanized iron pipe of approved length and diameter can be used. The size of the pipe depends upon (a) the current to be carried, (b) the type of soil. According to I.S.I. Standard no. 732-1963 the galvanized iron pipe shall not be less than 38.1 mm. diameter and 2 m. long for ordinary soil but if the soil is dry and rocky, the length of the pipe should be increased to 2.75 m.

The pipe is placed upright as shown in fig. and must be placed in s permanently wet ground. The depth at which the pipe should be buried depends on the condition of the ground moisture. According to Indian Standard, the pipe should be placed at a depth of 4.75 m., it can be less if the soil provides sufficient moisture earlier. The pipe at the bottom should be surrounded by broken pieces of coke or charcoal for a distance of about 15 cm. around the pipe. The coke increases the effective areas of the earth practically to the outside of the coke bed.

Impregnating the coke with salt decreases the earth resistance. Generally alternate layers of salt and coke are used for best results as represented in fig. In India in summer season the moisture in the soil will decrease to a large extent which will increase the earth resistance. So in order to have an effective earth, whenever needed, 3 to 4 buckets of water should be put into the funnel connected to the main G.I. pipe through 19 mm. dia. Pipe.

The earth lead used must be G.I. wire or G.I. strip of sufficient cross sectional area to carry fault current safely. It should not be less than electrical equivalent of copper conductor of 12.97 sq. mm (8 SWG) cross sectional area. The earth wire from the G.I. pipe of 19 mm. dia. should be carried in a G.I. pipe of dia. 12.7 mm. at a depth of about 60 cm. below the ground. Further when the earth wire is carried over from one machine to the other, it should be will protected from mechanical injury, by carrying the earth wire in a recessed portion.

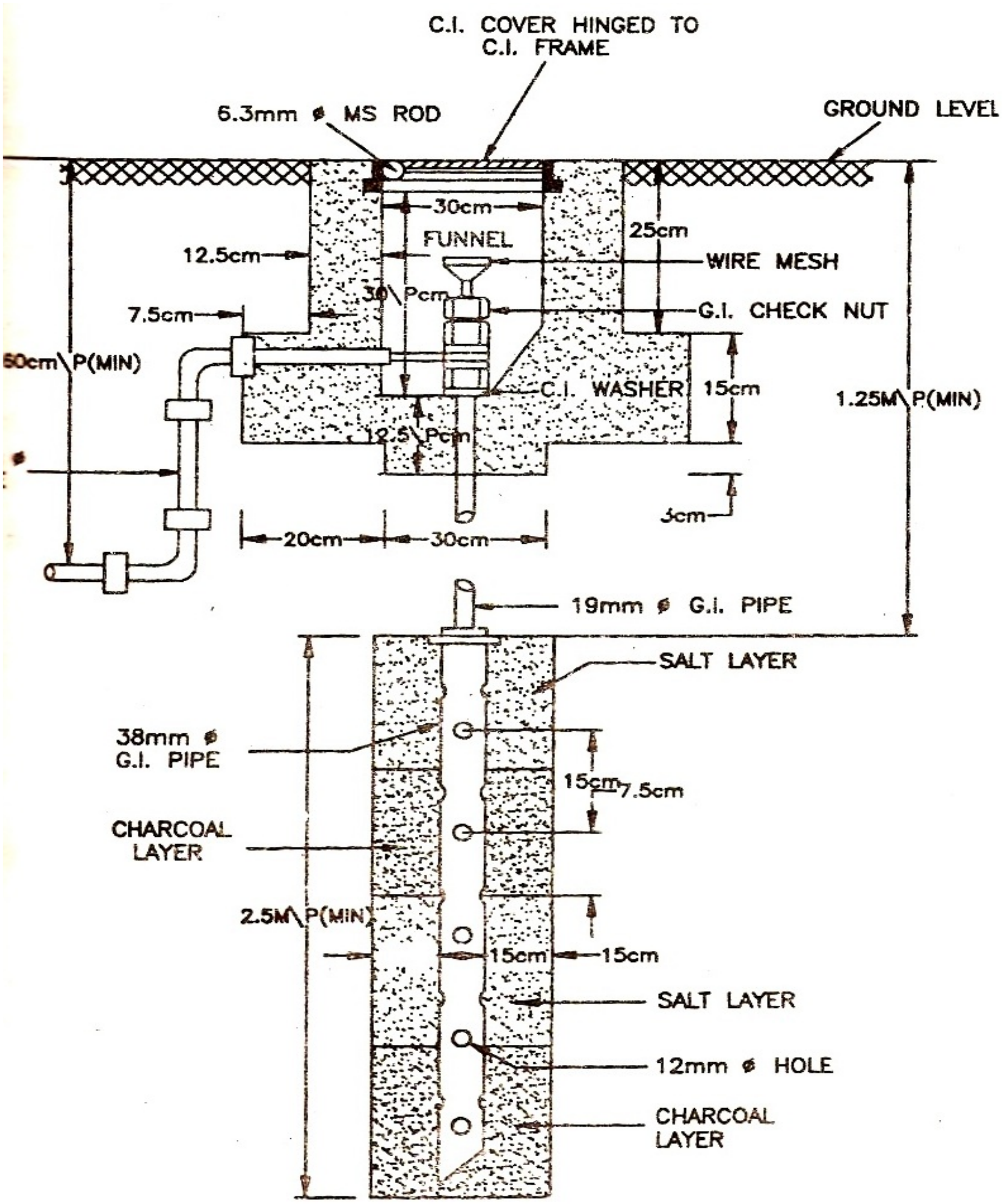
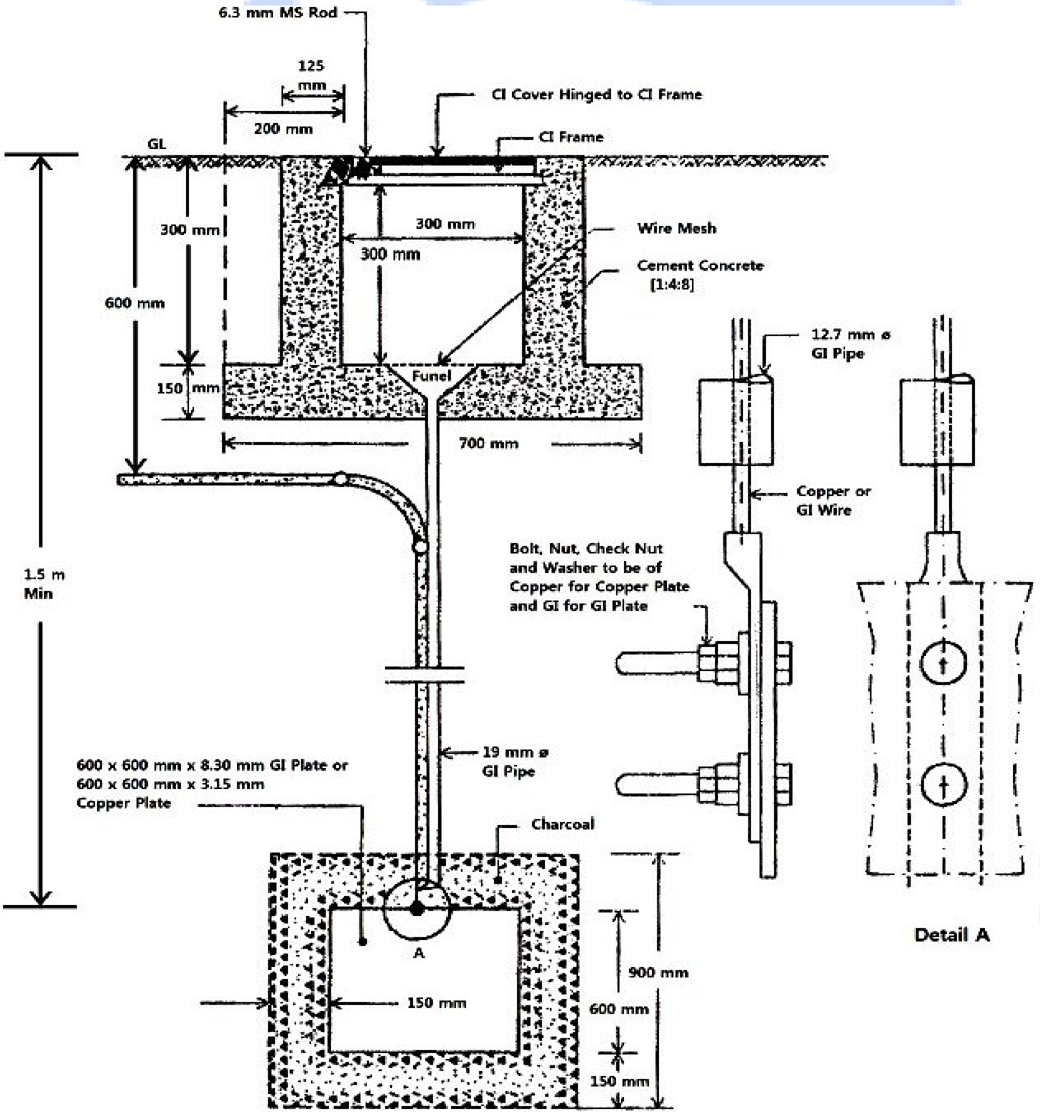


Plate earthing:

The earth connection can again be provided with the help of a copper plate or a G.I. plate. When G.I. plate is used it should not be of less than 60 cm. * 60 cm. * 6.35 mm. while for copper plate these dimensions may be 60 cm. * 60 cm. * 3.18 mm. However the use of the copper plate in these days is limited.

The plate is kept with its face vertical at a depth of 3 m. and is so arranged that it is embedded in an alternate layer of coke and salt for a minimum thickness of about 15 cm. in case earthing is done by copper plate and in coke layers of 15 cm. if it is dine with G.I. plate. The earth wire is securely bolted to the earth plate with the help of bolt, nut and washer, the details of which are shown in fig. It should be remembered that the nuts and bolts must be of copper for copper plate and should be of galvanized iron for galvanized plate. The other details of plate earthing are same as that of G.I. pipe earthing.



EXPERIMENT NO. 12

Aim: Read and interpret I.E. Rules pertaining to safety.

Causes for Electrical accidents:

Operation of high voltage equipment without proper safely measure
Improper electrical connections
Working on live line without proper protective precautions
Carelessness while operating and handling electrical equipments

Effects of an Electrical shock:

CURRENT RANGE	EFFECTS
1 TO 8m Amps	Shock is perceptible but not painful
8 to 15m Amps	Painful shock but muscular control is not lost
15 to 20m Amps	Painful shock and muscular control is lost
20 to 50m Amps	Serve muscular contraction resulting in difficulty in breathing
50 to 100m Amps	Due to serve muscular contraction heart stop working. Instantaneous death is possible

Indian Electricity Rules:

RULE NO. 29: All electric supply lines and equipments must be having standard size and enough mechanical strength. Its construction, installation, protection and function should be as per Indian standards.

RULE NO. 30: Equipments, wires, fittings and service line installed in consumer premises must be in safe condition.

RULE NO. 31: It states that supplier should provide an iron clad cut out for all unearthed conductors except neutral and earth.

RULE NO: 32: It states that the supplied should provide at the starting point of supply, a conductor which can be identified as neutral to enable connection with consumer earth system. No other switch, link or fuse should be used in neutral except it forms part of a multipole switch capable of cutting off entire supply.

RULE NO. 33: It states that consumer using medium, high voltage should provide his own earthing system with separate electric and maintain it carefully.

RULE NO. 34: It states that the bare conductor used in building should be inaccessible. I.e. it should not be reach without the use of ladder. Special isolation device must be there.

RULE NO. 35: It states that caution notice about "DANGER" in Hindi as were in local language should be affixed to motors, generators, transformers, transmission lines, poles etc.

RULE NO. 36: It states that before working on any electric conductor or apparatus is under taken, it should be discharged by earthing. Precautions should be taken the same from being charged accidentally.

RULE NO. 37: It states that travelling cranes, vehicles and same type of other equipments receive the supply from outside service, owner should see all such equipments can easily isolated through supply by a single operation.

RULE NO. 38: It states that flexible cables used for drills, sprayer, transformers, rectifiers, motors, generators and other portable apparatus should be heavily insulated and enough protected from mechanical injury. If there is armoring, it must be connected to frame and earth also.

RULE NO. 40: It states that "street bases" must be free from water and gas. There should not be any overlapping of different supply lines which are passing through same "street base" periodically inspection of gas checking of street should be maintained.

RULE NO. 42: It states that each circuit and equipments should be so arranged that there is no danger of their getting charged with a voltage higher than for which they are intended.

RULE NO. 43: It states that fire buckets filled with dry sand and tetrachloride and liquid carbon dioxide fire extinguisher in generating stations and substations. They should have “First aid” boxes and training of first aid operation.

RULE NO. 44: It states that affixing of instruments in English, Hindi and local language. Initial treatment for restoration of person suffering from electrical shock.

RULE NO. 45: It states that prohibits unauthorized contractor or person not possessing competency certificate from doing adjustment, alteration, repair, and installation work, except replacement of lamps, fans, switches and law voltage domestic appliances. It also states that electric supply need not given to such installation by any supplier.

RULE NO. 46: It states that periodic inspection or installation at an interval or not exceeding 5 yrs. by the supplier or inspector.

FACTORY ACT (1948) :-

Safety provision made under this act are as follows:
1) All rotating machines must be protected with fencing. Mainly these machines are motor, generator, turbine etc.
2) No untrained worker is allowed to bell and unbolt the machine in running condition.
3) When the machine in running condition no lady worker is allowed to do relative adjustment of machine.
4) Untrained workers are not to be permitted to work on heavy machines.
5) When the various machines are installed in a room the main on/off control should be in the same room.
6) Avoid to install machines where the persons are moving here & there very frequently.
7) Factory building must be certified by factory inspector.
8) Where there is a possibility of "eye injury" safety devices must be provide to the workers.

9) A through system must be provided for disposal of polluted gas & smokes.
10) Sufficient exits should be provided to safeguard against electric fire & accidents