ELECTRICIAN

TRADE PRACTICAL

NSQF LEVEL - 4.5

HANDBOOK FOR CRAFTS INSTRUCTOR TRAINING SCHEME

Directorate General of Training

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

NATIONAL INSTRUCTIONAL MEDIA INSTITUTE, CHENNAI

Post Box No. 3142, CTI Campus, Guindy, Chennai - 600 032

Published by

National Instructional Media Institute
Post.Box.No. 3142,
Guindy, Chennai - 600032
Email : chennai-nimi@nic.in
Website: www.nimi.gov.in

First Edition, 2024

Rs. 400/-

Printed in India at
National Instructional Media Institute
Post. Box. No. 3142,
Guindy,
Chennai - 600032

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A Comprehensive Training Program
under Crafts Instructor Training Scheme (CITS)
for Instructors

HANDBOOK ON TECHNICAL INSTRUCTOR TRAINING MODULES

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सचिव
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सत्यमेव जयते

भारत सरकार
कौशल विकास एवं उद्यमिता मंत्रालय
GOVERNMENT OF INDIA
MINISTRY OF SKILL DEVELOPMENT
AND ENTREPRENEURSHIP

Foreword

In today's rapidly evolving world, the role of skilled craftsmen and women is more crucial than ever. The Craft Instructor Training Scheme (CITS) stands at the forefront of this transformation, shaping the educators who will train the next generation of artisans and technicians. This book aims to provide an in-depth understanding of the subject, exploring its significance, methodologies, and impact on vocational training.

The Craft Instructor Training Scheme was established with the objective of enhancing the quality of instruction in industrial training institutes and other vocational training institutions. By equipping instructors with advanced skills and knowledge, the scheme ensures that they are well-prepared to impart high-quality training to their students. This, in turn, contributes to the creation of a highly skilled workforce capable of meeting the demands of modern industry.

The initial chapters provide the importance of specialized instructor training. Following this, detailed chapters delve into the curriculum covering advanced techniques, safety protocols, and instructional strategies. Each section is designed to offer both theoretical insights and practical applications, ensuring a well-rounded understanding of the subject.

The book offers recommendations for overcoming obstacles and enhancing the effectiveness of the program, with the ultimate goal of producing highly skilled instructors capable of shaping the future workforce.

This book is intended for a diverse audience, including current and aspiring instructors, vocational training administrators, policymakers, and industry stakeholders. It serves as a valuable resource for understanding the intricacies of the subject and its pivotal role in vocational education.

I extend my heartfelt gratitude to all contributors who have shared their experiences and expertise, enriching this book with their valuable insights. Special thanks to the contribution of the development team, reviewers and NIMI that have supported this endeavor, providing essential data and resources.

It is my sincere hope that this book will inspire and guide readers in their efforts to enhance vocational training, ultimately contributing to the development of a skilled and competent workforce.

ATUL KUMAR TIWARI, I.A.S.
Secretary, MSDE

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महानिदेशक
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सत्यमेव जयते

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MINISTRY OF SKILL DEVELOPMENT & ENTREPRENEURSHIP
DIRECTORATE GENERAL OF TRAINING

FOREWORD

The Craftsmen Training Scheme (CTS) implemented by the Directorate General of Training (DGT) provides skill training to the youth and ensures a steady flow of skilled manpower for the industry. It aims to raise quantitatively and qualitatively the industrial production by systematic training, and to reduce unemployment among the youth by providing them with employable skills.

The Craft Instructor Training Scheme (CITS) is an indispensable part of the Craftsmen Training Scheme (CTS). It offers comprehensive training both in 'skills' and in 'training methodology' to the instructor trainees to make them conversant with techniques of transferring hands-on skills.

I congratulate NIMI for taking the initiative of preparation of the course content for CITS. This will help institutionalize the mechanism for imparting training to the trainers all across the ecosystem. I also extend my gratitude to the Instructors and Officials of National Skill Training Institutes (NSTIs) and the DGT for their invaluable contribution in preparation of the CITS course content.

As we navigate the complexities of a rapidly changing world and the technological disruptions, the significance of CTS and CITS has increased manifold. It not only empowers individuals with practical skills but also lays the foundation for a prosperous future. I am confident that this book will serve as a guiding light to all instructor trainees for skill development and nation-building.

(Trishaljit Sethi)

PREFACE

The Craft Instructor Training Scheme is an indispensable module of the Craftsmen Training Scheme, which has been an integral part of the Indian skill development industry since its inception. This program aims to equip instructors with the necessary skills and teaching methodology to effectively transfer hands-on skills to trainees and promote a holistic learning experience. The first Craft Instructor Training Institute was established in 1948, followed by six more institutes across India in 1960. Today, these institutes, including the National Skill Training Institute (formerly Central Training Institute for Instructors), offer the CITS course, which is mandated by the Directorate General of Training (DGT).

The Craft Instructor training program is designed to develop skilled manpower for industries. The course aims to offer instructors an opportunity to improve their instructional skills, engage learners effectively, offer impactful mentoring, and make efficient use of resources, leading to a more skilled workforce in various industries. The program emphasizes collaborative and innovative approaches to teaching, resulting in high-quality course delivery. Overall, the Craft Instructor Training Scheme is a pivotal program that helps instructors grow in their careers and make a significant contribution to society. This program is essential for developing skilled manpower and promoting a robust learning environment that benefits both trainees and instructors alike.

ACKNOWLEDGEMENT

National Instructional Media Institute (NIMI) sincerely acknowledges with thanks for the co-operation and contribution extended by the following experts to bring out this Instructional material **(Trade Practical)** for **CITS Electrician (Common for Wireman) (NSQF Level - 4.5)** under the **Power** Sector for **Instructors**.

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

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

NIMI is grateful to all others who have directly or indirectly helped in developing this IMP.

ABOUT THE TEXT BOOK

The Vocational Instructor Training Program is a comprehensive initiative designed to equip aspiring students with the necessary skills and knowledge to effectively teach in vocational education settings. This program encompasses a range of pedagogical strategies, instructional techniques, and subject-specific content tailored to the diverse vocational fields. Participants engage in coursework that covers curriculum development, assessment methods, classroom management, and the integration of industry-relevant technologies. Practical experience and hands-on training are emphasized, allowing participants to apply theoretical concepts in real-world teaching environments. Through collaborative learning experiences and mentorship opportunities, aspiring vocational instructors develop the confidence and competence to facilitate engaging and impactful learning experiences for their students. This training program aims to cultivate a new generation of educators who are not only proficient in their respective vocational fields but also adept at fostering the success and employability of their students in today's competitive workforce.

This text book covers communication, self-management, information and communication technology, entrepreneurial and green skills. It has been developed as per the learning outcome-based curriculum.

G C Rama Murthy,
Joint Director,
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MSDE, New Delhi.

CONTENT

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EXERCISE 1: Electrical fires and identification of Fire Extinguishers

Objectives

At the end of this exercise you shall be able to

- identify different types of fire extinguishers
- select the fire extinguishers used for electrical fires
- practice to operate the fire extinguisher
- extinguish the fire by fire extinguisher

Requirements

Tools/Equipments/Instruments

- Combination Plier 165mm, insulated - 1 No.
- Screw Driver insulated stem 150mm - 1 No.
- Neon Tester 75mm, 500 V - 1 No.
- PPE kit as per standard - 1 Set
- Fire extinguisher Class A, B, C, D - 1 No each.

Materials/Components

- Cotton waste - as reqd.
- Fire wood & Kerosene - as reqd.

Procedure

TASK 1 : **Identify the types of fire extinguishers**

1 Identify and Read the details of different types of fire extinguishers.

2 Read the operating procedure of fire extinguishers.

3 Take the fire extinguisher to the open area and set a small fire on wood pieces.

4 Practice & operate the fire extinguisher by P A S S procedure and extinguish the fire.

— — — — — —

TASK 2: **Demonstrate of extinguish electrical fire**

1 Select the CO_2 type fire extinguisher for electrical fires.

2 Check the details / expiry date of fire extinguisher and ensure that fire extinguisher is fully refilled (observe its scale which must be in green mark)

3 Switch OFF the main electrical supply and remove the fuses.

4 Follow the **P A S S** procedure to operate the fire extinguisher

5 Extinguish the fire until the fire is put off.

— — — — — —

Safety precautions

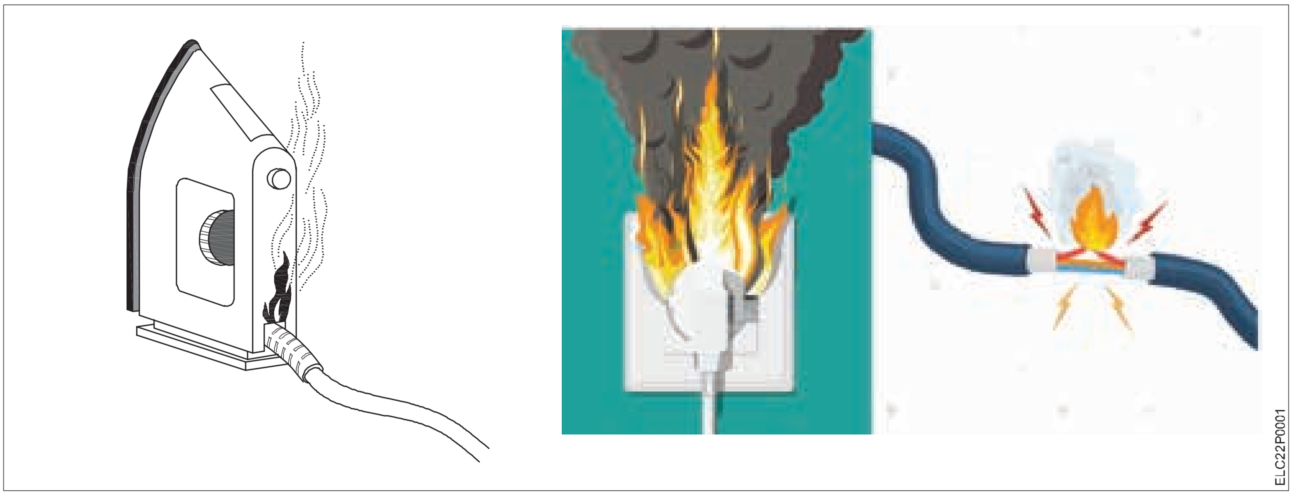
1 Handle the fire extinguisher carefully.

2 Operate the fire extinguisher carefully with proper procedure.

3 Do not throw the water on electrical fires.

4 Use proper PPE's while extinguishing electrical fires.

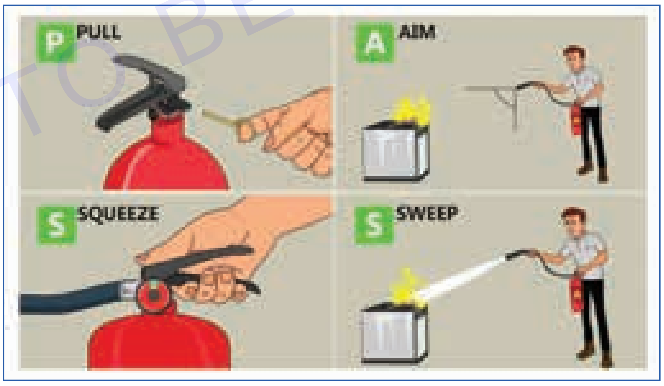
Electrical Fires

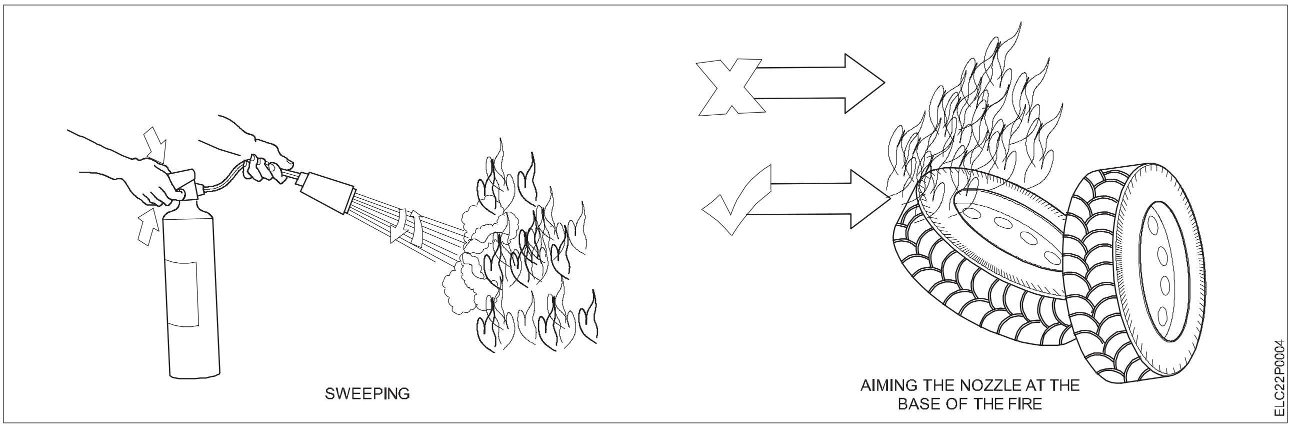


CO_2 Fire Extinguisher used for Electrical Fires

Fire Extinguisher

Follow P A S S procedure of fire extinguisher to extinguish the fire.





EXERCISE 2: Practice Proper use & General safety measures of Electrician hand tools

Objectives

At the end of this exercise you shall be able to

- identify and specify the electrician hand tools
- practice the proper use of electrician hand tools
- practice safe handling measures of electrician hand tools.

Requirements

Tools/Equipments/Instruments

- Combination Plier 165mm, insulated - 1 No.
- Nose plier 165mm, insulated - 1 No.
- Screw Driver 150mm, insulated stem - 1 No.
- Neon Tester 75mm, 500 V - 1 No.
- Electrician knife Insulated - 1 No.
- Wire stripper 100 mm - 1 No.
- Crimping tool 1.5^2 mm - 4^2 mm - 1 No.
- Spanners, open end 6 to 16mm - 1 Set
- Ball peen Hammer 0.5 kg - 1 No.
- Multi meter Digital, $3^{1/2}$ digit - 1 No.

Materials/Components

- PVC copper wire 1.5 sq.mm - 2 m.
- Test lamp 100 W, 230V - 1 No.
- Copper lugs Assorted size - as reqd.
- Cotton waste - as reqd.

Procedure

TASK 1: **Identify and specify the Electrician tools**

1 Collect the all the Tools required for experiment.

2 Draw the neat sketch of Electrician hand tools.

3 Identify & specify the different types of Electrician hand tools.

4 Check the specifications of Electrician hand tools.

— — — — — —

TASK 2: **Practice the proper use of Electrician hand tools**

1 Practice the use and safe handling of combination plier & Nose plier for cutting & twisting of PVC wires and holding the objects.

2 Practice the use and safe handling of neon tester by checking the supply in 1 Ph. Socket.

3 Practice the use and safe handling of screw drivers by driving the screws.

4 Practice the use and safe handling of crimping tool & wire striper by crimping the copper Lugs of different size on PVC copper wires.

5 Practice the use and safe handling of spanners and hammer.

6 Practice the use and safe handling of multi meter by measuring the AC & DC voltage, resistance and continuity.

— — — — — —

Safety precautions to be fallowed for Electrician hand tools

1 Do not cut steel /hard metal wires with combination plier.

2 Do not use combination plier as spanner. (It may only be used to hold the nut & bolts while tightening with spanner).

3 Never test the HT supply with neon tester. (It is suitable for checking the LT supply up to 500 V only).

4 Do not use the screw driver as a chisel.

5 Use fully insulated stem screw driver while working in Electrical power control panels.

6 Make proper lubrication for pliers, spanners, hammer to avoid rusting.

7 Multi meter must be used carefully and do not measure high voltage & current.

Electrician Hand Tools

Line Tester	
Combination Plier	
Screw Driver	
Spanner	
Nose Plier	
Multi meter	

EXERCISE 3: Demonstration of Rescue & Treat a Person is in Contact with Live Wire

Objectives

At the end of this exercise you shall be able to

- understand dangers of electric shock and hazards and follow safe working methods in Electrical Circuits.
- practice and follow the use of proper tools & PPE's during electrical work
- rescue a person from electric shock and make first Aid treatment & artificial respiration.

Requirements

Tools/Equipments/Instruments

- Combination Plier 165mm, insulated - 1 No.
- Screw Driver 150mm, insulated stem - 1 No.
- Neon Tester 75mm, 500 V - 1 No.
- PPE kit As per standard - 1 Set
- First Aid kit As per standard - 1 Set
- Respiration equipment As per standard - 1 No.

Materials/Components

- Dry wooden stick 2 mtr long - 1 No.
- Rubber mat OR wooden plank 1 sq.mtr - 1 No.

Procedure

TASK 1: **Practice and follow the safe working methods in Electrical circuits**

1 Use proper & insulated tools, PPE's and equipments during electrical works.

2 Never work in live electrical circuits, if unavoidable use rubber hand glows and wear shoes.

3 Know the level of voltage & frequency in main supply panel before starting the electrical repair work.

4 Do not touch the electrical accessories and equipments with wet / sweat hands.

5 Ensure proper earth connection to metal parts / enclosures of electrical equipments.

6 Display the danger sign board in main electrical supply panels.

— — — — —

TASK 2: **Rescue and treat a person in contact with live wire**

1 Switch OFF the main supply immediately and unplug the equipment.

2 If main switch is not easily accessible isolate the live wire from the victim with wooden stick.

3 Move the victim from the spot and lay down in comfortable position.

4 Loosen the clothes of victim near neck, chest and waist if victim is unconscious.

5 Initiate the artificial respiration with proper method if victim is unconscious.

6 Call the doctor OR shift the victim medical centre for further treatment.

— — — — —

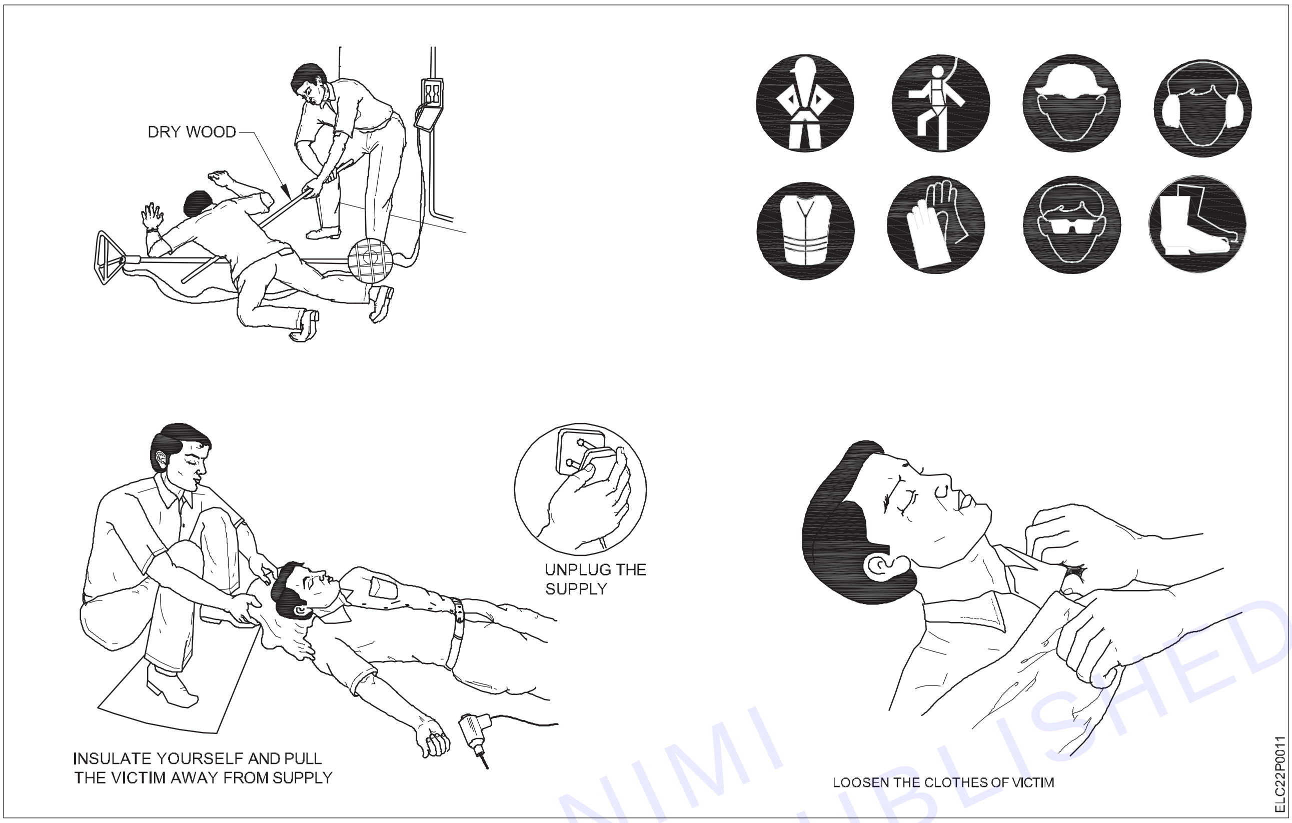
Safety precautions

1 Never attempt to rescue the person unless you are properly insulated.

2 Handle the respiratory equipments carefully.

3 Ensure proper light, ventilation and cleanliness during artificial respiration to the victim.

Rescuing a person from Electrocution **Use PPE's during Electrical works**



EXERCISE 4: Practice the use of discharge rod

Objectives

At the end of this exercise you shall be able to

- identify the discharge rod, check the voltage and insulation class of discharge rod
- practice the use of discharge rod in electrical power supply lines
- follow the safety precautions while using discharge rod.

Requirements

Tools/Equipments/Instruments

- Combination Plier 165mm, insulated - 1 No.
- Screw driver 200 mm, insulated - 1 No.
- Neon Tester 100mm, 500 V - 1 No.
- Discharge rod, fiber insulated 10 feet, 11KV - 1 No.
- PPE kit as per standard - 1 Set

Materials/Components

- PVC copper wire with crocodile clip 6 sq.mm - 25 ft.
- Test lamp 100 W, 230 V - 1 No.
- Capacitor Any value - 1 No.
- Emery paper - 1 Sheet
- Insulation tape - 1 role

Procedure

About Discharge rod

A discharge rod (Also known as earth rod) is a safety device used to discharge the static charge acquired in dead high tension lines, Bus- bars and cables after disconnecting the main power supply line. Discharge rod ensures life safety and treated as a life saving device. Discharge rod is made up of strong fiber / glass insulated material with extension handle and available in different sizes up to 10 to 20 ft. It is used to discharge the static charge acquired in HT lines & LT lines, Bus-bar panels & cables, power transformers, etc after switching OFF the main supply line during Electrical maintenance / repair work.

Note: The use of discharge rod is limited to experienced and authorized Electrician only. The trainees shall never attempt to use the discharge rod in HT lines.

TASK 1: **Check the Parts & rating of discharge rod.**

1 Check and identify the parts of discharge rod.

2 Check the voltage & insulation class of discharge rod.

3 Connect the PVC earth wire to the steel U hook of discharge rod.

4 Identify the earthing point, check and ensure the earth continuity with test lamp.

— — — — —

TASK 2: **Practice the use of discharge rod**

1 Wear the proper PPE's before the use of discharge rod.

2 For demo purpose practice the use of discharge rod on LT panel / cables of 3 Ph. 415 V AC

3 Switch OFF the LT breaker and ensure that No power supply in LT panel & cables. (Confirm by noticing lights, fans and other equipments goes OFF once LT breaker is switched OFF)

4 Firmly connect the earth wire of discharge rod to the terminals of ground / earthing point.

5 Now hold the discharge rod and touch its steel hook to line bus bars of LT panel & power cables including neutral terminal of LT panel.

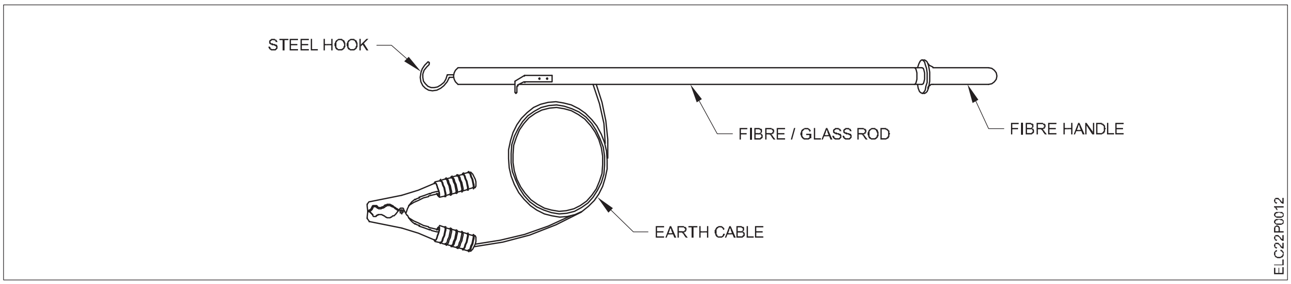
6 Also connect the discharge rod on capacitors, CT & PT terminals connected to line bus bars.

7 Remove the discharge rod from line bus bars, and confirm the discharge of static charge by testing with neon tester.

8 If no indication in neon tester, proceed to carry out Electrical maintenance / repair work.

Safety precautions

- Wear proper PPE's before using discharge rod.
- Never use discharge rod without disconnecting the main supply line.
- Ensure proper earth continuity before applying discharge rod.



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MODULE 2: Basic Electrical Circuits

EXERCISE 5: Verification of Ohms law

Objectives

At the end of this exercise you shall be able to

- make the circuit connections of ohms law
- measure the voltage, current & resistance in electrical circuit
- verify the ohms law by keeping circuit resistance constant
- verify the ohms law by keeping supply voltage constant.

Requirements

Tools/Equipments/Instruments

- Combination Plier 165mm, insulated -1 No.
- Screw driver 150 mm, insulated stem -1 No.
- Neon Tester 75mm, 500 V -1 No.
- Electrician Knife Insulated -1 No.
- Rheostat 300 Ω, 5 Amp -1 No.
- 1 Ph. Auto Transformer 0 - 270 V, 5 A -1 No.
- Voltmeter MI, 250 V -1 No.
- Ammeter MI, 10 Amp -1 No.
- Digital Multi meter 3 ½ Digit -1 No.

Materials/Components

- PVC copper wire 1.5 sq.mm - as reqd.
- DP switch 250 V, 16 A - 1 No.

Procedure

TASK 1: **Verify the ohms law with variable resistance & constant voltage method.**

1 Draw the circuit diagram of ohms law verification.

2 Make the connections of ohms law method-1 as per the circuit diagram.

3 Check the connections and switch ON the supply.

4 Note down voltmeter & Ammeter readings.

5 Keep the supply voltage constant and vary the resistance step by step in Rheostat.

6 Note down the voltmeter & Ammeter readings in each steps.

7 Verify the ohms law **I = V/ R** with measured values and plot the graph.

— — — — —

TASK 2: **Verify the ohms law with variable voltage & constant resistance method.**

1 Make the connections of method-2 as per the circuit diagram.

2 Check the connections and switch ON the supply.

3 Keep the circuit resistance constant and vary the input voltage step by step with Auto Transformer.

4 Note down the voltmeter & Ammeter readings in each steps.

5 Verify the ohms law **I = V/ R** with measured values and plot the graph.

— — — — —

Tabular column

Method-1 (Constant voltage & variable resistance method)

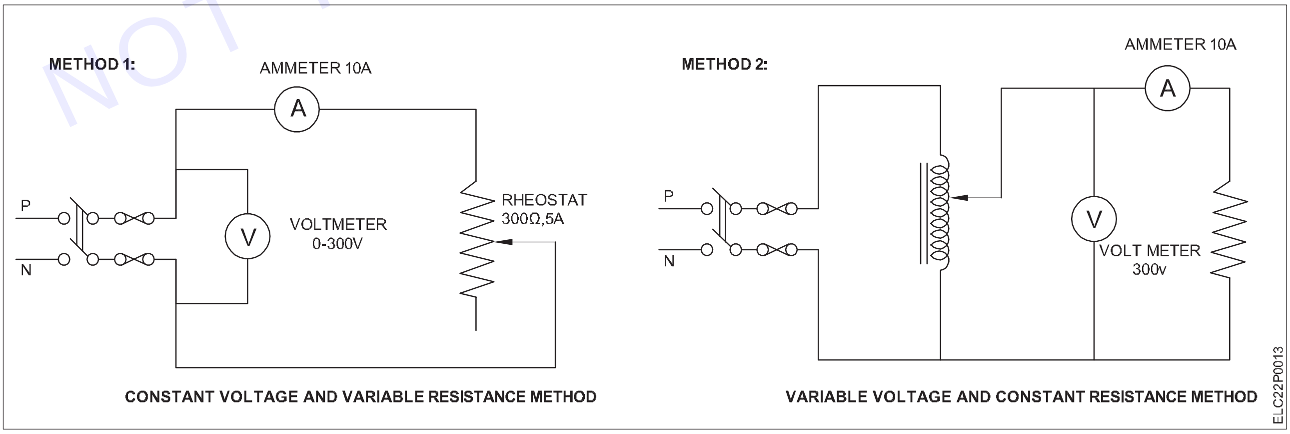
S.No.	Fixed Voltage (V)	Variable Resistance (R)	Current (I)	I = V/R

Method-2 (Constant resistance & variable voltage method)

S.No.	Fixed Resistance (R)	Variable Voltage (V)	Current (I)	I = V/R

Safety precautions

- Use proper and insulated tools.
- Select proper range in meters.
- Do not make wrong & loose connections.
- Ensure the current flow within the limit in Rheostat.



EXERCISE 6: To measure the voltage & current in series and parallel circuit

Objectives

At the end of this exercise you shall be able to:

- make the connections of series & parallel electrical circuits
- measure the voltage, current and resistance value in series & parallel circuits
- verify the ohms law in series & parallel circuits.

Requirements

Tools/Equipments/Instruments

- Combination Plier 165mm, insulated - 1 No.
- Screw driver 150 mm, insulated stem - 1 No.
- Neon Tester 75mm, 500 V - 1No.
- Electrician Knife Insulated - 1 No.
- Lamp load panel Wooden with 4 lamps - 1 No.
- 1 Ph. Auto Transformer 0 - 270 V, 5 A - 1 No.
- Voltmeter MI, 250 V - 2 Nos.
- Ammeter MI, 10 Amp - 2 Nos.
- Digital Multi meter 3 ½ Digit - 1 No.

Materials/Components

- Connecting PVC patch cards 1.5 sq.mm - as reqd.
- DP switch 250 V, 16 A - 1 No.

Procedure

TASK 1: **Connection of series circuit**

1 Draw the circuit diagram of series and parallel circuit.

2 Make the connections of series circuit as per the circuit diagram.

3 Check the connections and switch ON the supply.

4 Note down voltmeter & Ammeter readings.

5 Change the number & value of lamps / resisters and note voltmeter & Ammeter readings.

6 Enter the readings in tabular column and calculate the total resistance, current and voltage drop.

7 Switch OFF the supply and disconnect the circuit.

— — — — —

TASK 2: **Connection of parallel circuit**

1 Make the connections of Parallel circuit as per the circuit diagram.

2 Check the connections and switch ON the supply.

3 Note down voltmeter & Ammeter readings.

4 Change the number & value of lamps / resisters and note voltmeter & Ammeter readings.

5 Enter the readings in tabular column and calculate the total resistance, current and voltage.

6 Switch OFF the supply and disconnect the circuit.

7 Verify the ohms law and make comparison in series & parallel circuits.

— — — — —

Tabular column:

SERIES CONNECTION:

Sl. No	No. of Lamps or resistors	Total Resistance (R)	Applied Voltage (V)	Current (I)	Voltage drop across the lamps(V')						Total Voltage drop V-V'
					V_1	V_2	V_3	V_4	V_5	V_6	
1	3		230					--	--	--	
2	6		230								

Total Resistance (R) = $R_1+R_2+R_3+........R_6$

Total voltage (V) = $Ir_1+Ir_2+Ir_3+........Ir_6$ OR Total voltage (V) = $v_1 + v_2 + v_3.....v_6$

PARALLEL CONNECTION:

Sl. No	No. of Lamps or resistors	Total Resistance (R)	Applied Voltage (V)	Current (I)	Current average lamps(i)						Sum of Current ($I_1+I_2+....I_6$)
					i_1	i_2	i_3	i_4	i_5	i_6	
1	3		230					--	--	--	
2	6		230								

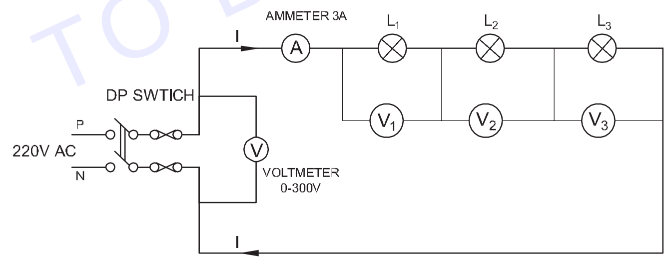
$$\text{Total Resistance } \frac{1}{R} = \frac{1}{r_1} + \frac{1}{r_2} + \frac{1}{r_3}$$

Total current (I) = $i_1 + i_2 + i_3.....i_6$

Safety precautions

- Do not make wrong and loose connections.
- Select correct / proper range in meters.
- Switch OFF the supply before disconnecting the circuit.

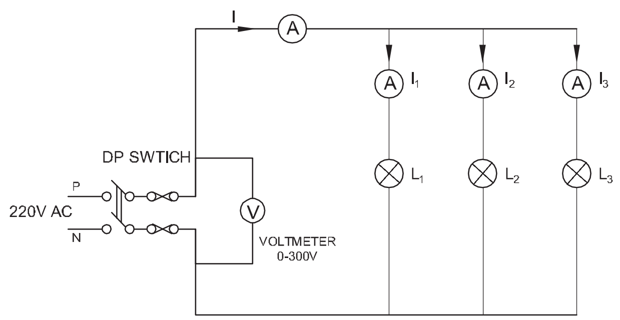
Series connection



SERIES CONNECTION OF LAMPS / RESISTERS

ELC22P0014

Parallel connection



PARALLEL CONNECTION OF LAMPS / RESISTERS

ELC22P0015

EXERCISE 7: Measurement of unknown resistance using Wheatstone bridge

Objectives

At the end of this exercise you shall be able to:

- Identify the terminals of a Wheatstone bridge
- Operate / Set the Wheatstone bridge to get null deflection in galvanometer
- Calculate the value of unknown resistance using the Wheatstone bridge.

Requirements

Tools/Equipments/Instruments

- Combination plier 150mm -1 No.
- Side cutter 150mm -1 No.
- Screw driver set 150mm -1No.
- DC power supply 0-30 V DC -1 No.
- Wheatstone bridge -1 No.

Materials/Components

- PVC copper wire 1 sq mm - 2 mtr.
- Resistance Unknown value - 2 No's.
- Known resistance Assorted value - 2 No's.

Procedure

TASK 1: **Measure the value of unknown resistance using the wheat stone bridge**

1 Identify the terminals / parts of a Wheatstone bridge

2 Connect the unknown resistor across terminals X, XX

3 Set the ratio arm to the approximate value of the unknown resistor

4 Set the sensitivity control to 'Low'

5 Close the switch and watch the deflection of the galvano meter.

6 Adjust the variable arm by closing the switch, to get a minimum deflection in the galvanometer. (In case the galvanometer needle over shoots, reset the ratio arm.)

7 Increase the sensitivity and repeat step 6

8 When 'Null' deflection is achieved in the galvano meter, note the value of the ratio arm and position of the variable resistance. Enter the values in Table 1.

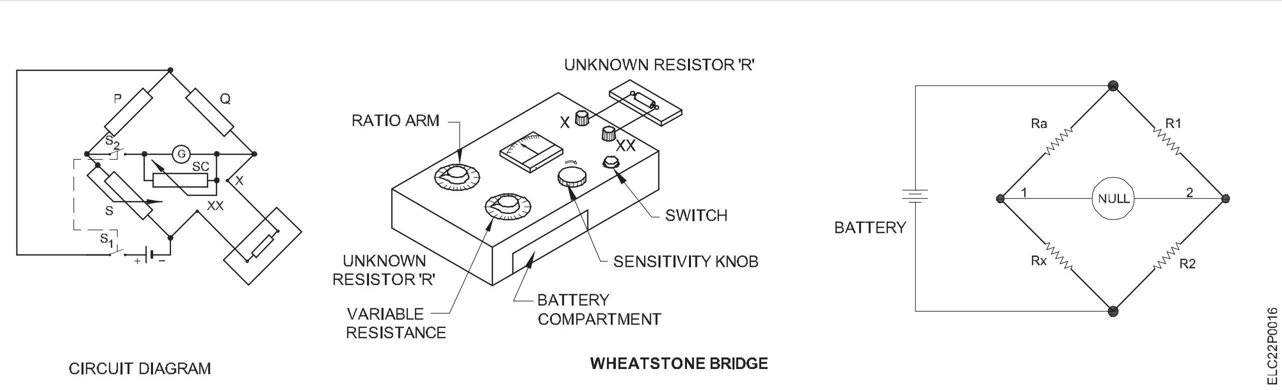
Tabular column:

	1st digit	2nd digit	multiplier	Value of the resister

Sample Calculation

$$\frac{R_2}{R_1} = \frac{R_x}{R_3}$$

$$R_x = \frac{R_2}{R_1}.R_3$$



Safety precautions

1 Handle the Wheatstone bridge carefully.

2 Do not make loose and wrong connections.

3 Take the reading correctly.

EXERCISE 8 : Measure the current and voltage in electrical circuits to verify Kirchhoff's Law

Objectives

At the end of this exercise you shall be able to:

- verify the Kirchhoff's Voltage Law - KVL
- verify the Kirchhoff's Current Law – KCL
- measure the voltage, current & resistance in complex circuit networks.

Requirements

Tools/Equipments/Instruments

- Combination plier 150mm -1 No.
- Side cutter 150mm -1 No.
- Screw driver set 150mm -1No.
- Variable DC power supply 0-200 v DC -1 No.
- Ammeter 0-1 A, MC -3 No's.
- Volt meter 0-250 V, MC -4 No's.
- Rheostat 0-300 Ω, 3A - 1 No.
- Rheostat 0-700 Ω, 1A - 1 No.
- Rheostat 0-400 Ω - 1 No.

Materials/Components

- PVC copper wire 1.0 sq mm - as reqd.

Procedure

TASK 1: **Verify Kirchhoff's Voltage Law - KVL**

1 Draw the circuit diagram.

2 Mark the polarity of the voltage drops across the resistors.

3 Make the connections as per circuit diagram.

4 Switch ON the power supply and set to 50 V.

5 Measure and record the voltage drops across the resistors.

6 Repeat these steps by setting the voltages to 100 V, 150 V and 200 V

7 Write the Kirchhoff's voltage equations for the closed paths. In any closed path he algebraic sum of all the voltages is zero.ie, $V= V_1+V_2$

TASK 2: **Verify Kirchhoff's Current Law - KCL**

1 Draw the circuit diagram for KCL.

2 Make the connections as per circuit diagram.

3 Keep the regulated power supply OFF while making connections.

4 Keep the voltage control knob at minimum.

5 Switch ON the Power supply. Set the supply voltage to 50 V.

6 Measure and record total circuit current I_1 and branch currents I_2 and I_3.

7 Repeat these steps by setting the PS voltages to 100 V and 150 V.

8 Write the Kirchhoff's current equation. The algebraic sum of currents meeting at a node equal to zero. Σ I=0 ie, $I_1= I_2 + I_3$

9 Verify the equation by substituting the measured values.

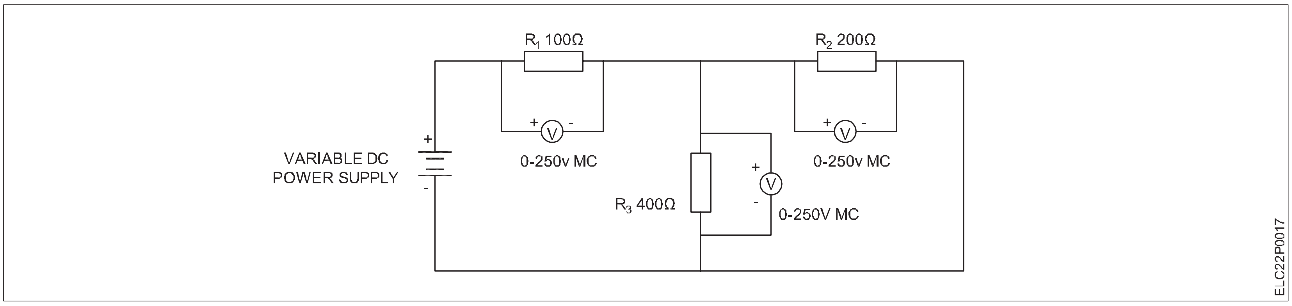


Table 1

S.No.	Applied voltage V_s	Voltage Across R_1 (V_1)	Voltage Across R_2 (V_2)	Voltage Across R_3 (V_3)	$V_1 + V_2$
1					
2					
3					
4					

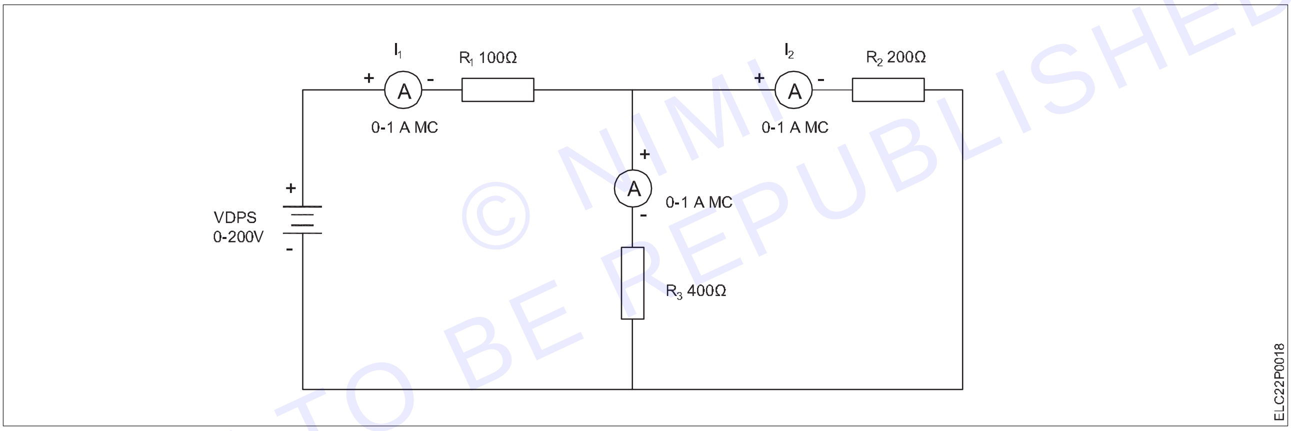


Table 2

S.No.	Applied voltage V_s	Ammeter Reading A_1 (I_1)	Ammeter Reading A_2 (I_2)	Ammeter Reading A_3 (I_3)	I_2+I_3
1					
2					
3					
4					

Safety precautions

- Do not make wrong and loose connections.
- Maintain the correct polarity in DC power supply.
- Take the readings correctly

EXERCISE 9 : To make bare conductor joint

Objectives

At the end of this exercise you shall be able to:

- measure the gauge of bare conductor with SWG
- cut the required length of bare conductor to make the joint
- prepare the straight joint of bare conductor.

Requirements

Tools/Equipments/Instruments

- Combination plier 165mm, insulated - 1 No.
- Flat Nose plier 150mm, insulated - 1 No.
- Electrician Knife Insulated - 1 No.
- Snip straight 200 mm - 1 No.
- Bench vice - 1 No.
- Steel rule 30 cm - 1 No.
- Rubber mallet 0.5 Kg - 1 No.
- Standard wire gauge 1 - 38 SWG - 1 No.

Materials/Components

- Bare copper conductor 10 SWG - 50 cm.
- Emery paper - 1 piece.
- Cotton waste - as reqd.

Procedure

TASK 1: **Cuts & straight the bare conductor**

1 Take the bare copper conductor of 50 cm length and clean it with emery paper.

2 Cut the bare copper conductor in two equal pieces by snip straight.

3 Straighten the both pieces of copper conductor with rubber mallet.

— — — — —

TASK 2: **Preparation of bare conductor joint.**

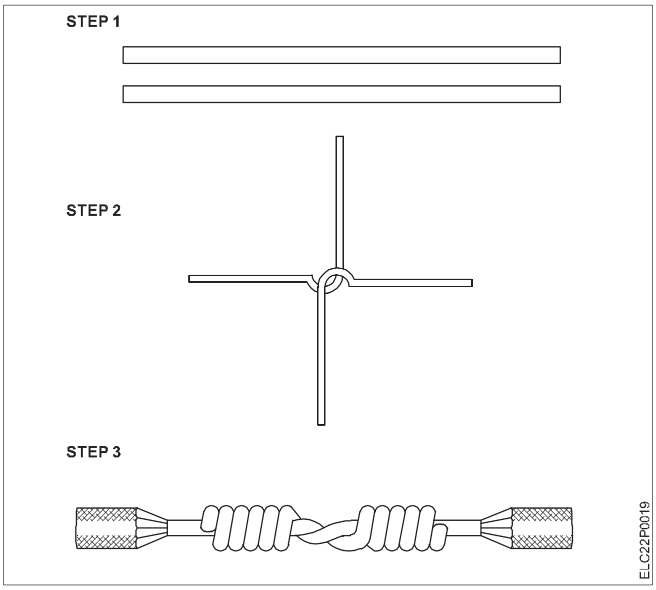
1 Hold both bare conductors tightly in bench vice. (Wrap the conductors with cotton cloth to avoid scratches / damage to conductors)

2 Twist the first conductor tightly over second conductor in one direction as shown in fig.

3 Twist second conductor tightly over first conductor in opposite direction as shown in fig.

4 Twist and bend the end portion of conductors with combination plier.

5 Take out the completed joint from bench vice and clean and remove the wrapped cotton cloth.



Safety precautions

- Don not over tight the bench vice to avoid damage to conductors.
- Do not make overlaps & gaps in the joint.
- Take care to avoid injury while cutting & bending the conductors.

EXERCISE 10 : To make PVC wire joint

Objectives

At the end of this exercise you shall be able to:

- mark and cut the required length of PVC copper wire
- skin the insulation of PVC wire and measure the gauge of conductors
- perform the straight joint on PVC copper wire.

Requirements

Tools/Equipments/Instruments

- Combination plier 165mm, insulated -1 No.
- Flat Nose plier 150mm, insulated -1 No.
- Side cutting plier 150mm, insulated -1 No.
- Electrician Knife Insulated -1 No.
- Steel rule 30 cm -1 No.
- Rubber mallet 0.5 Kg -1 No.
- Standard wire gauge 1 - 38 SWG -1 No.

Materials/Components

- PVC copper wire 7/20 - 50 cm.
- Cotton waste - as reqd.

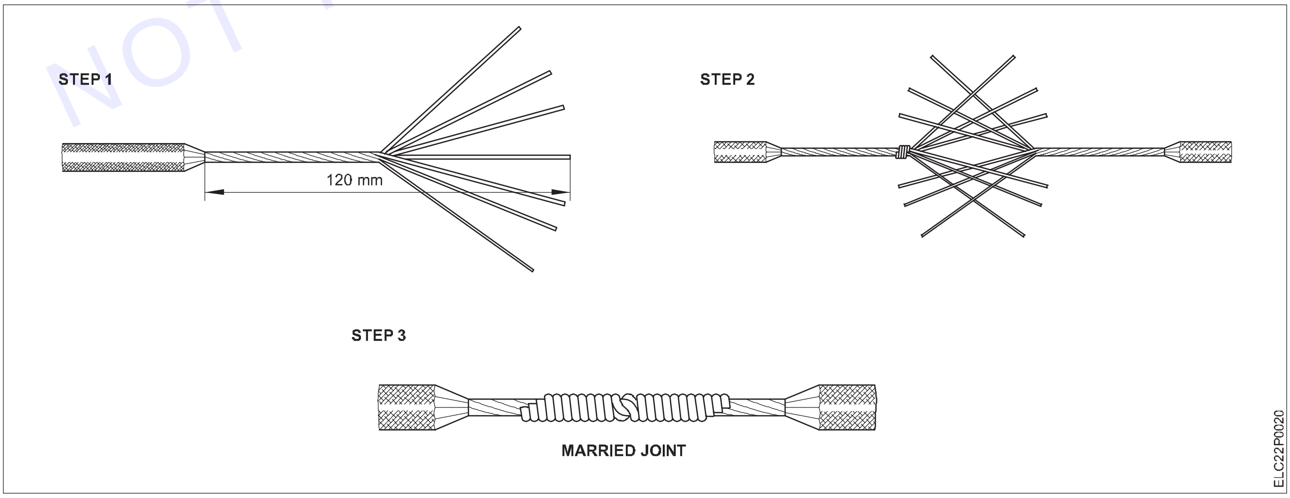
Procedure

TASK 1: **Cut & straight the PVC coppper wire**

1 Take the PVC copper wire and cut into two equal pieces.
2 Straighten the both pieces of copper wire with rubber mallet.
3 Make a small U bend at one end of both pieces of copper wire.

TASK 2: **Perform the straight joint on PVC copper wire**

1 Remove the insulation of 12 cm on both pieces of PVC copper wire with Electrician knife.
2 Spread the 7 conductors of both pieces of PVC copper wire as shown in fig.
3 Cut the centre conductor of both pieces of PVC copper wire with side cutting plier.
4 Now make the straight joint by twisting the conductors uniformly as shown in fig.
5 Straighten the completed joint with rubber mallet.



Safety precautions

- Use proper and insulated tools.
- Don not damage the conductors while removing insulation.
- Ensure No gaps & overlap of conductors while making the joint.
- Take care to avoid injury while removing insulation by knife.

EXERCISE 11 : To practice crimping of lugs on PVC wire

Objectives

At the end of this exercise you shall be able to

- identify the crimping tool and different types & size of lugs
- select the suitable die in crimping tool as per size of wire & lugs
- skin the insulation of wire and crimp the lug with crimping tool.

Requirements

Tools/Equipments

- Combination plier (150 mm, Insulated) -1 No.
- Wire stripper Automated (1.5 sq.mm - 4.0 sq.mm) -1 No.
- Crimping tool (1.5 sq.mm - 4.0 sq.mm) -1 No.
- Neon tester (75mm, 500V) -1 No.
- Screw driver set (150mm, 5 Blades) -1 Set.

Materials/Components

- PVC copper multi strand wire (1.5/2.5/4.0 sq.mm) - Each 1 meter.
- Copper lugs (1.5/2.5/4.0 sq.mm) - Each 2 No's.
- Insulation tape (19mm) -1 role.

Procedure

TASK 1 : **Identify the crimpimg tool and lugs**

1 Check and identify the types & size of copper lugs and PVC wire.

2 Check and identify the parts of crimping tool, and practice to operate the crimping tool.

3 Similarly, check and identify the parts of automated wire stripper and practice its usage.

— — — — —

TASK 2 : **Crimping of lugs on PVC wire**

1 Take the PVC copper multi strand wire of required length and suitable size of lug.

2 Remove the insulation of 10mm on both sides of PVC copper wire with automated wire stripper.

3 Insert the skinned part of PVC copper wire into the barrel of copper lug (Ensure that all strands of PVC copper wire inserted properly into the barrel of lug)

4 Place the wire and lug carefully into suitable die of crimping tool.

5 Ensure that both lug & wire are properly placed in the die, and crimp the lug by pressing the handle of crimping tool.

6 After lug is fully crimped release the handle of crimping tool which turns back automatically.

7 Remove the crimped wire from the die of crimping tool.

8 Crimp the other end of PVC copper wire in similar way.

9 Connect the crimped wire to the terminals of electrical accessories like relay, contactor, MCB etc

10 Practice the crimping with different size of wires and lugs.

Safety precautions

- Do not make loose crimping and double crimping on the lugs.
- Ensure all strands of wire inserted into the lug before crimping.
- Select proper die of crimping tool as per size of lug.
- Use the crimpingv tool carefully, else it may cause injury to hand.

Different types & size of lugs

Crimping of lugs on PVC wire with crimping tool

— — — — —

EXERCISE 12 : Soldering of PVC wire joint

Objectives

At the end of this exercise you shall be able to
- check & identify the rating of electric soldering iron
- skin the insulation of pvc copper wire and cleaning
- apply the flux & tinning of conductor of pvc wire
- perform the soldering on pvc copper wire and joints.

Requirements

Tools/Equipments
- Combination plier (165mm, insulated) - 1 No.
- Side cutting plier (150mm, insulated) - 1 No.
- Edge cutter (100 ssssmm) - 1 No.
- Wire stripper (150 mm) - 1 No.
- Neon tester (75mm, insulated) - 1 No.
- Soldering iron (25 W & 60 W, 230 V) - 1 No each.
- Soldering stand - 1 No.

Materials/Components
- PVC copper wire (1.5 sq.mm) - as reqd.
- Soldering lead (Resin core) - 100 gm.
- Soldering flux - as reqd.
- Emery paper - as reqd.
- Insulation tape (19mm) - 1 role

Procedure

TASK 1: **Identify and test the Electric soldering iron**

1 Check the rating of Electric soldering iron and test it for heating.

2 Take two pieces of PVC copper wire and remove the insulation of 10mm with electrician knife.

3 Clean the tip of soldering iron with emery paper.

— — — — —

TASK 2: **Perform the soldering on PVC copper wire & joints**

1 Connect soldering iron to the supply and allow it to heat.

2 Clean the conductors of PVC copper wire with Electrician knife and make the tinning with soldering lead.

3 Hold the tinned copper conductors joined together and solder with soldering iron.

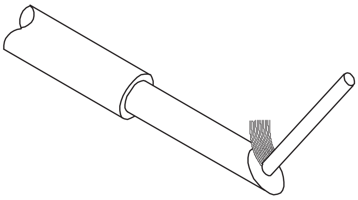
4 Insulate the soldered joint with insulation tape.

5 Practice the soldering on different types of wires and joints.

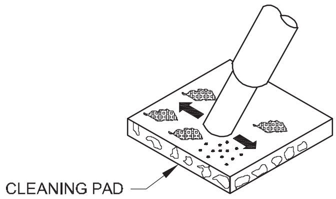
Safety precautions
- Do not make soldering without cleaning & tinning of conductors.
- Do not make loose and improper soldering.
- Don not touch the tip & metal part of soldering iron to avoid injury.
- Do not place the hot soldering iron wooden table, use soldering stand.
- Do not inhale the smoke during soldering, use exhaust fan while soldering

ELECTRIC SOLDERING IRON

TINNING AND CLEANING OF SOLDERING BIT



TINNING THE SOLDERING BIT



SOLDERING OF PVC COPPER WIRE

ELC22P0021

MODULE 3: Heating Effect, Cells and Batteries

EXERCISE 13 : To prepare the heating element & solenoid coil

Objectives

At the end of this exercise you shall be able to

- calculate the length & resistance of nichrome wire to prepare the heating coil
- prepare the heating element and test the heating
- prepare the solenoid coil and check the magnetic effect of electric current

Requirements

Tools/Equipments/Instruments

- Combination plier (165mm, insulated) - 1 No.
- Side cutting plier (150mm, insulated) -1 No.
- Neon tester (75mm, insulated) -1 No.
- Wire stripper (150 mm) -1 No.
- Screw driver, insulated (150 mm) -1 No.
- Soldering iron with stand (25 W, 230 V) -1 No.
- 1 Ph. Auto transformer (0-270 V, 10 A) -1 No.
- Digital Multi meter ($3^{1/2}$ digit) -1 No.

Materials/Components

- Nichrome wire (24 SWG) - 2 meter.
- Bare copper wire (36 SWG) - 2 meter.
- PVC connecting wire (1.5 sq.mm) - as reqd.
- Plastic Bobbin - 1 No.
- Soldering lead - as reqd.
- Soldering flux - as reqd.
- Porcelain heating plate - 1 No.
- GI bare conductor (8 SWG) - 1 meter.

Procedure

TASK 1: **Prepare the heating element and test**

1 Calculate the resistance of nichrome wire required to make heating coil of 1 KW, 230 V AC

2 Take required length of nichrome wire as per calculated value of resistance.

3 Wound the nichrome wire uniformly on GI bare conductor and prepare the heating coil.

4 Place the heating coil in the slots of porcelain heating plate and connect the end terminals to the connector.

5 Measure the resistance of heating coil and record it.

6 Connect the heating coil to the supply through auto transformer.

7 Switch ON the supply and slowly increase the voltage in auto transformer.

8 Observe the heat produced in heating coil.

9 Switch OFF the supply and disconnect the heating coil.

— — — — —

TASK 2: **Prepare the solenoid coil and test**

1 Fix the plastic bobbin vertically on wooden board.

2 Fix the nail tightly adjacent to the plastic bobbin.

3 Twist & tie one end of bare copper conductor tightly to the nail.

4 Now start winding of bare copper conductor uniformly on plastic bobbin and prepare the Solenoid coil

5 Make the solenoid coil of around 100 turns and wrap the insulating paper tightly on the coil.

6 Remove the solenoid coil winded from wooden board and connect the end terminals by Soldering.

7 Insert and fix the steel bolt in the solenoid coil.

8 Test the solenoid coil with low voltage supply and observe the magnetic effect.

Data for preparation of heating element.

Rated voltage: 230 V

Power rating of heating coil: 1000 W

Working temperature = 500º C

Current taken by heating coil $I = \frac{W}{V} = \frac{1000}{230} = 4.3$ Amp

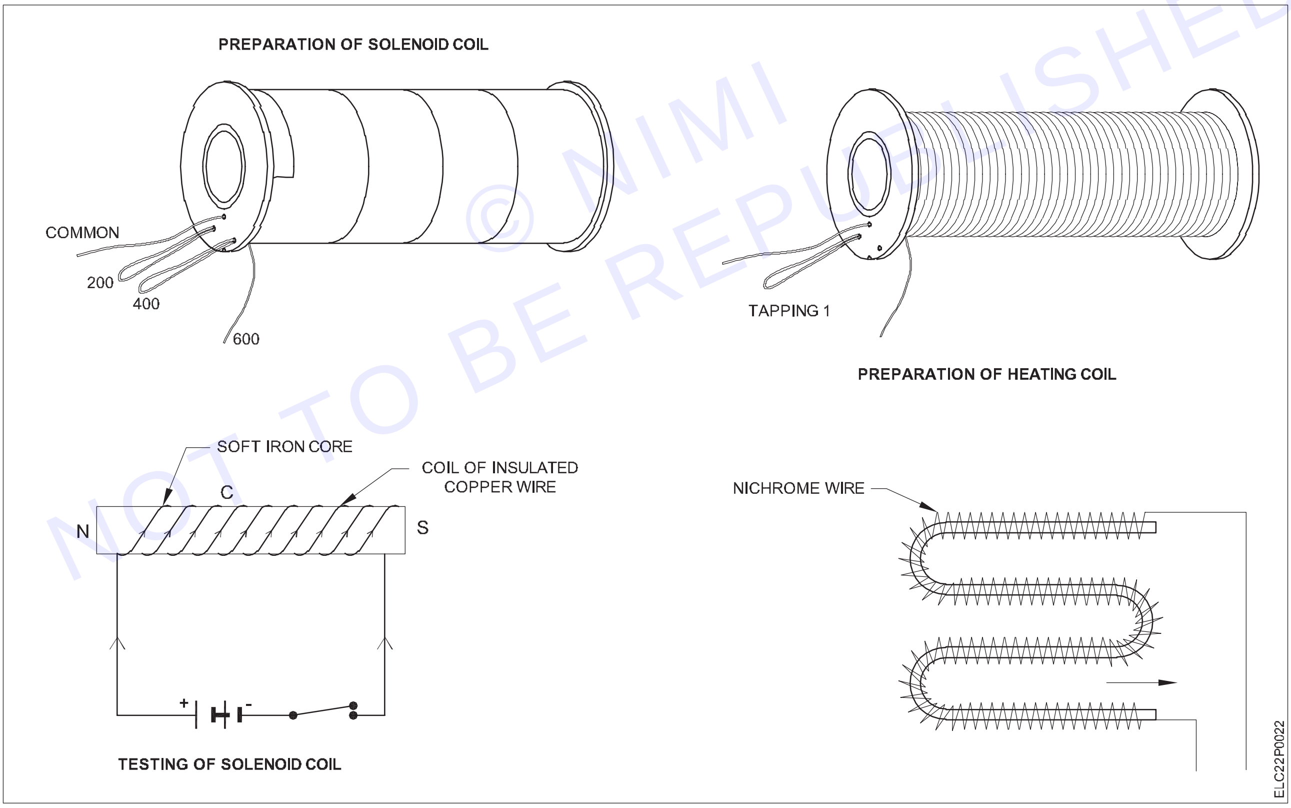
Resistance of heating coil $R = \frac{V}{I} = \frac{230}{4.3} = 53\,\Omega$

Refer the nichrome wire table for selecting the size & length of nichrome wire.

From the table, for 4.3 Amp the required size of nichrome wire is 24 SWG and resistance is 4.65 Ω per meter.

But total resistance of heating coil is 53 Ω.

So the length of nichrome wire required $= \frac{53}{4.65} = 11.40$ meter.



Safety precautions

- Wound the nichrome wire uniformly without overlapping.
- Don not touch the hot heating element.
- Do not apply higher voltage to solenoid coil.

EXERCISE 14 : Preparation of electrolyte for lead acid battery

Objectives

At the end of this exercise you shall be able to

- select the type of acid mixture required to prepare electrolyte
- prepare an electrolyte with proper ratio of acid mixture
- test the specific gravity of electrolyte
- follow the safety precautions & use of PPE to prepare an electrolyte.

Requirements

Tools/Equipments

- Combination plier (150mm, insulated) - 1 No.
- Hydrometer - 1 No.
- Neon tester (75mm, 500 V) - 1 No.
- Multi meter (Digital, $3^{1/2}$ digit) - 1 No.
- PPE kit (Standard) - 1 Set.
- Lead acid battery (12 V) -1 No.

Materials

- Sulfuric Acid (H_2SO_4) - as reqd.
- Distilled water - as reqd.
- Glass jar/bowl - 1 No.
- Glass rod - 1 No.

Procedure

TASK 1 : **Selection of acid mixture**

1 Wear the proper PPE before starting the experiment.

2 Carefully place the container of Sulfuric Acid and glass bowl on wooden table.

3 Empty the old electrolyte thoroughly from lead acid battery.

— — — — —

TASK 2 : **Preparation of Electrolyte**

1 Pour the required quantity of distilled water into the glass jar/bowl.

2 Take the container of Sulfuric Acid (H_2SO_4) and carefully open its lid. (An approximate ratio of solution to prepare the electrolyte is 37% of Sulfuric Acid & 63% of distilled water)

3 Now slowly and with extreme care pour the Sulfuric Acid drop by drop into the distilled water. (Never make the reverse action ie pouring the distilled water into Sulfuric Acid, which causes violent Reaction and generates extreme heat)

4 Continue the pouring of Sulfuric Acid slowly into the distilled water and stir with glass rod until the Solution is well mixed and specific gravity comes to 1.28

5 Allow the prepared solution to cool down to the room temperature and check the specific gravity.

6 Fill the prepared electrolyte into the compartment of cells of lead acid battery, and ensure that cells Are fully submerged in the solution of electrolyte.

7 Connect the lead acid battery for charging and measure the charging voltage & current.

Safety precautions

1 Handle the Sulfuric Acid very carefully, mishandling will cause severe injury.

2 Wear proper PPE while preparing an electrolyte.

3 Never mix the water into the Sulfuric Acid which causes extreme heat and severe injury.

4 Use only glass bowl and rod to prepare an electrolyte.

PREPARATION OF ELECTROLYTE

ELC22P0023

EXERCISE 15 : To measure the specific gravity of Electrolyte

Objectives

At the end of this exercise you shall be able to

- check the level of electrolyte and top up distilled water in battery.
- check the specific gravity of electrolyte with hydrometer.
- check the state of charge of battery by the value of specific gravity.

Requirements

Tools/Equipments/Instruments

- Combination plier (165mm, insulated) - 1 No.
- Neon tester (75mm, insulated) -1 No.
- Screw driver, insulated (150mm) -1 No.
- Hydrometer -1 No.
- Digital Multi meter ($3^{1/2}$ digit) - 1 No.
- Lead acid battery (12 V, 65 AH) -1 No.

Materials/Components

- Distilled water - 2 litre.
- Plastic funnel -1 No.
- Cotton waste - As reqd.

Procedure

TASK 1: **Check the battery and hydrometer**

1 Take the hydrometer and observe its scale.

2 Take the lead acid battery and clean it with wet cloth.

3 Check the battery voltage and AH rating of battery.

— — — — —

TASK 2: **Check the specific gravity of electrolyte**

1 Uncap the vent holes of battery and check the level of Electrolyte.

2 Top up with distilled water to maintain the level of Electrolyte.

3 Insert the tube of hydrometer into vent hole of battery.

4 Squeeze the rubber ball of hydrometer and draw the electrolyte in hydrometer.

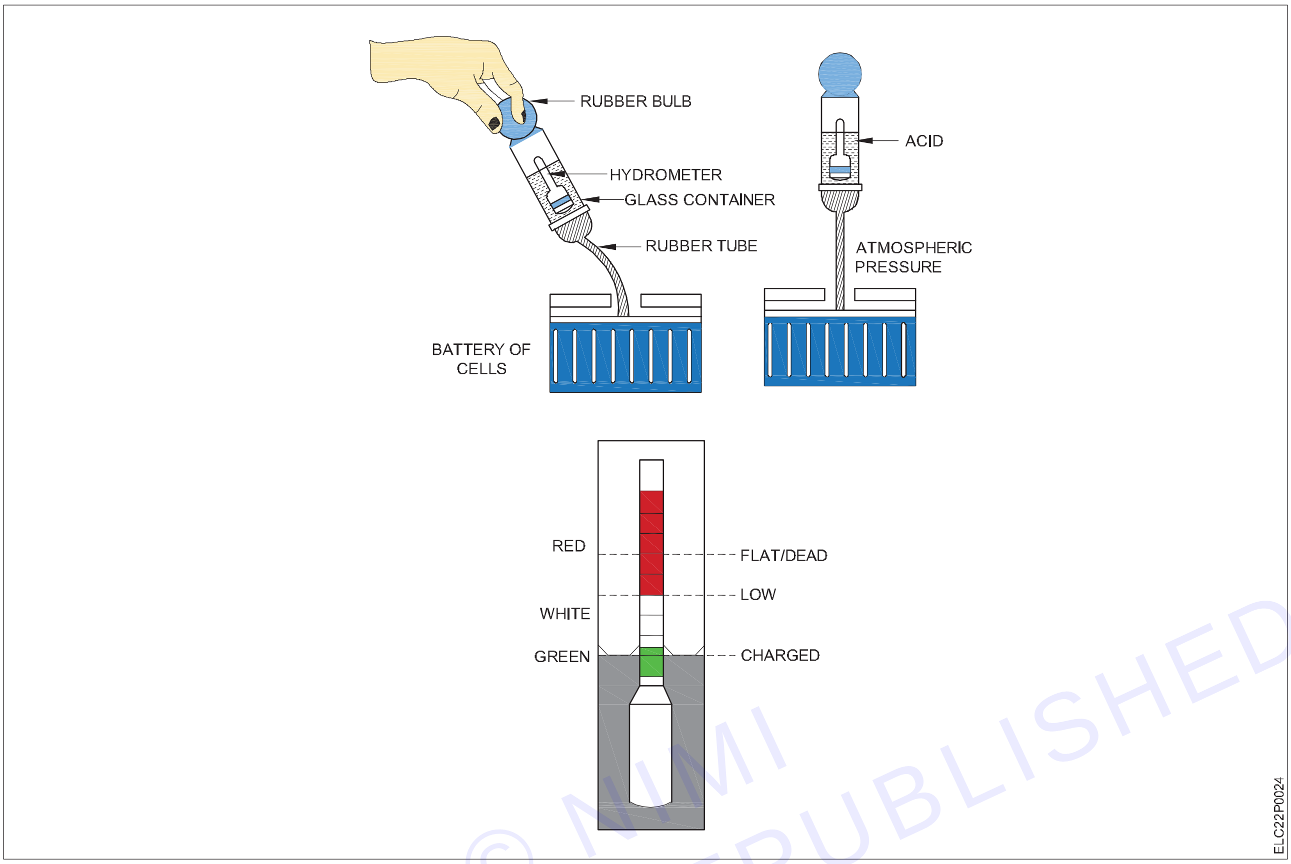
5 Now read the scale of hydrometer and check specific gravity of electrolyte.

6 Repeat the same for 2 - 3 samples and note the hydrometer readings.

Safety precautions

- Handle the hydrometer carefully to avoid damage.
- Wear necessary PPE's while handling the battery.
- Do not leak OR spill the electrolyte while checking specific gravity.
- Read the hydrometer scale correctly.

Measurement of specific gravity by Hydrometer



The chart below gives state of charge vs. specific gravity of the electrolyte.

State of Charge	Specific Gravity
100% Charged	1.265
75% Charged	1.239
50% Charged	1.200
25% Charged	1.170
Fully Discharged	1.110

EXERCISE 16 : Grouping of Cells

Objectives

At the end of this exercise you shall be able to

- identify the different types of primary cells and measure the EMF
- make the series & parallel connection of cells
- check the voltage & current in series and parallel connection of cells
- calculate internal resistance of cell.

Requirements

Tools/Equipments/Instruments

- Combination plier (165mm, insulated) - 1 No.
- Connector screw driver (100mm) - 1 No.
- Wire stripper (100mm) - 1 No.
- Digital Multi meter ($3^{1/2}$ digit) - 1 No.
- Variable resistance (0-10 Ω) - 1 No.
- DC Voltmeter (0-15 V) - 1 No.
- DC milli Ammeter (500 mA) - 1 No.

Materials/Components

- Connecting wire (1.0 sq.mm) - As reqd.
- Primary cells (1.5 V) - 8 No's.
- Cell holder - 1 No.

Procedure

TASK 1: **Connect the cells in series and test the voltage & current**

1 Draw the circuit diagram of series / parallel connection of cells.

2 Connect the cells in series as per circuit diagram.

3 Close the switch and measure the total voltage and current in the circuit.

4 Measure the voltage drop and calculate internal resistance in the cells.

5 Note down the measured values and record in tabular column.

__ __ __ __ __

TASK 2: **Connect the cells in parallel and test the voltage & current**

1 Connect the cells in parallel as per circuit diagram.

2 Close the switch and measure the total voltage and current in the circuit.

3 Measure the voltage drop and calculate internal resistance in the cells.

4 Note down the measured values and record in tabular column.

5 Compare and differentiate between series & parallel connection of cells.

Safety precautions

- Use proper and insulated tools.
- Connect the cells with proper polarity.
- Take the meter readings correctly.
- Do not short the terminals of cells

TABULAR COLUMN

Cells in Series

No. of cells	EMF of Cell (E) (On No Load)				Total EMF (E_T)	Voltage (V) (On Load)				Load Resistance (R)	Current (I)	Voltage drop in cells (E-V)				Internal Resistance of Cells (r)			
	E_1	E_2	E_3	E_4		V_1	V_2	V_3	V_4			1	2	3	4	1	2	3	4
2			--	--						7 Ω				-	-			-	-
4										7 Ω									

Total EMF (E_T) = $E_1+E_2.....+E_4$

Total internal resistance (r_t) = $r_1+r_2....+r_4$

Internal resistance $(r) = \frac{E - V}{I}$

Current $(I) = E_T / (R + r)$

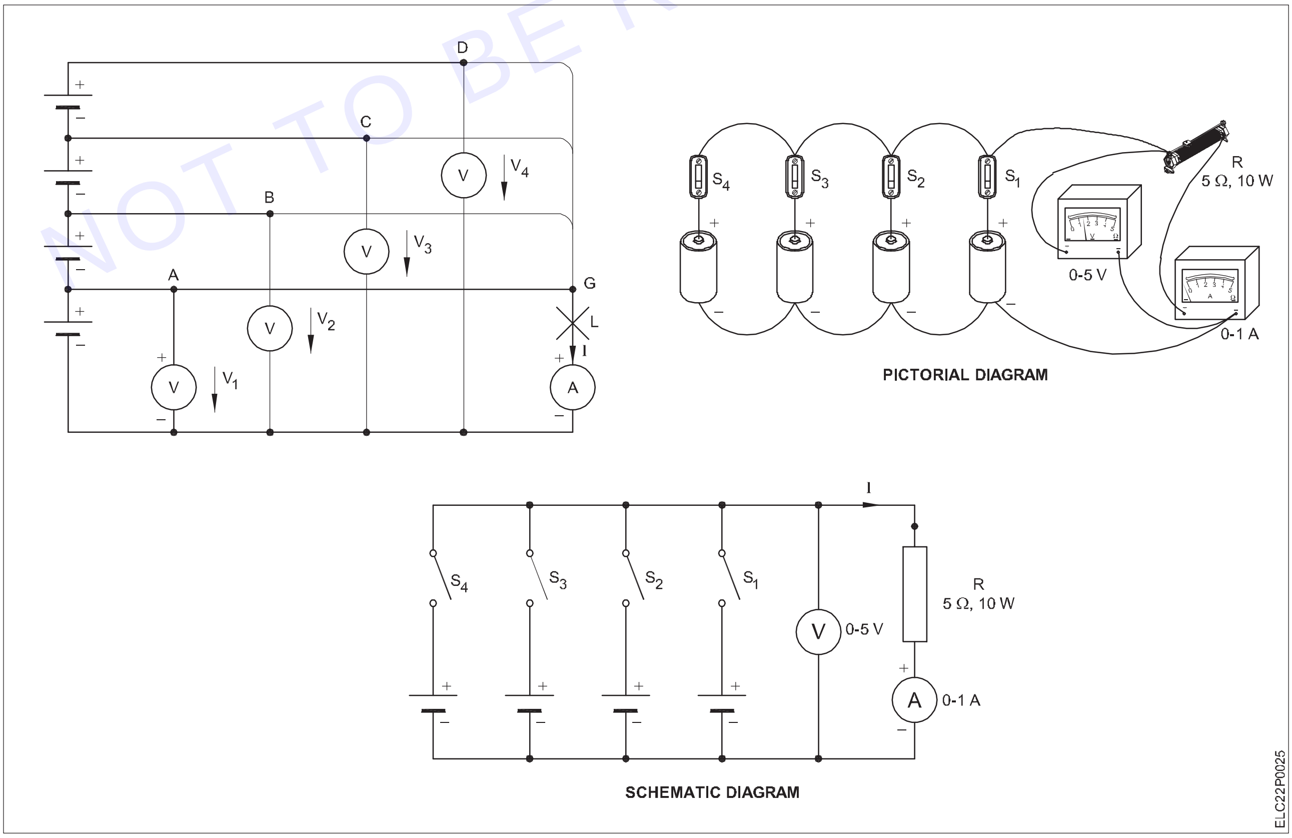
Cells in Parallel

No. of cells	EMF of Cell (E) (On No Load)				Total EMF (E_T)	Terminal Voltage (V) (On Load)	Load Resistance (R)	Current (I)	Current in cells				Voltage Drop (E-V)	Total internal Resistance (r)
	E_1	E_2	E_3	E_4					I_1	I_2	I_3	I_4		
2			--	--			7 Ω				-	-		
4							7 Ω							

Total EMF (E_T) = EMF of individual cell

Total internal resistance (1/r) = $1/r_1+1/r_2....+1/r_4$

Total Current $I = \frac{E_T}{R + 1/r}$



EXERCISE 17 : To test the battery cells with high rate discharge tester

Objectives

At the end of this exercise you shall be able to

- check the rating of high rate cell discharge tester & battery charger
- measure the specific gravity of electrolyte and battery voltage
- test Ah rating of battery cells with high rate discharge tester
- fallow the safety precautions.

Requirements

Tools/Equipments/Instruments

- Combination plier (150 mm Insulated) - 1 No.
- Screw driver (100mm) - 1 No.
- Hydrometer (1100-1300range) - 1 No.
- Battery charger (6 -12V, 6 A) - 1 No.
- Lead acid battery (12 V, 65 Ah) - 1 No.
- Digital multimeter3$^{1/2}$ digit - 1 No.
- High rate discharge tester (12/24 V, 50 Amp) - 1 No.

Materials/Components

- Test lead with crocodile clip (4.0 sq.mm) - 1 set.
- Distilled water - 1 litre.
- Petroleum jelly - As reqd.
- Sand paper - As reqd.
- Cotton waste - As reqd.

Procedure

TASK 1: **Test the specific gravity & battery voltage**

1 Clean the battery with wet cotton cloth & clean its terminals with sand paper.

2 Uncap the vent plugs, Check the level of electrolyte.

3 Top up the electrolyte to marked level in all cells with distilled water.

4 Check the initial specific gravity of electrolyte of each cell with hydrometer, and measure the battery voltage. Record the measured values.

5 Connect the battery terminals tightly to battery charger with proper polarity.

6 Set the charging voltage & current in battery charger and switch ON. (Charging voltage / current value should be as per manufactures instruction)

7 Record the initial & final charging voltage & current values.

— — — — —

TASK 2: **Test Ah rating of battery cells with high rate discharge tester**

1 Switch OFF the battery charger and disconnect battery when it is fully charged.

2 Check the specific gravity of electrolyte and battery voltage.

3 Fit the vent plugs, clean the battery surface, and apply petroleum jelly to the terminals.

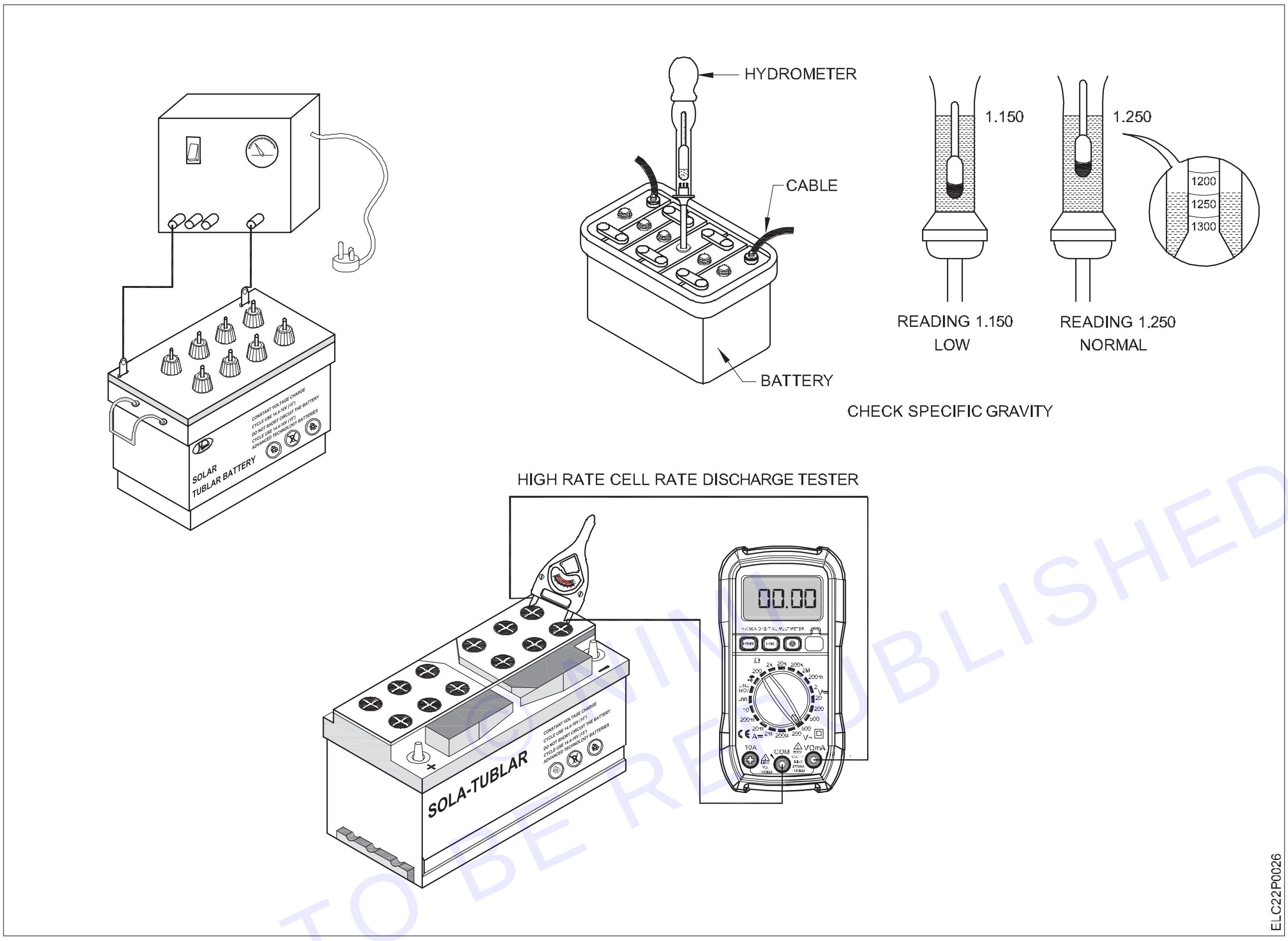
4 Connect the high rate cell discharge tester to the terminals of cells of battery.

5 Note the reading, It shows the ampere-hour capacity of the cell which should be in the “Green” range when fully charged.

6 Disconnect the cell discharge tester and similarly check other cells of battery. (Each cell should read equally)

Safety precautions

- Do not charge the battery with abnormal voltage / current.
- Do not connect high rate cell discharge tester for more than 5 sec
- Do not connect high rate cell discharge tester on discharged battery.



EXERCISE 18 : To charge lead acid battery by constant voltage & constant current method

Objectives

At the end of this exercise you shall be able to

- measure the voltage & specific gravity of lead acid battery
- charge the battery by constant voltage method
- charge the battery by constant current method.

Requirements

Tools/Equipments

- Combination plier (165mm, insulated) - 1 No.
- Neon tester (75 mm, insulated) - 1 No.
- Electrician Knife (Insulated) - 1 No.
- Spanner set (7 to 15mm) - 1 Set.
- Screw driver (150mm, insulated) - 1 No.
- Lead acid battery (12 V, 100 Ah) - 1 No.
- Battery charger (12-24 V, 15 A) - 1 No.
- Hydro meter - 1 No.
- Digital multi meter ($3^{1/2}$ digit) - 1 No.

Materials

- Connecting wire with crocodile clip (4.0 sq.mm) - 1 set.
- Distilled water - 2 litre.
- Petroleum jelly - As reqd.
- Sand paper - As reqd.

Procedure

TASK 1 : **Charge the battery by constant voltage charging method**

1 Draw the circuit diagram of constant voltage method of battery charging.

2 Clean the battery with wet cotton cloth & clean its terminals with sand paper.

3 Uncap the vent plugs, Check the specific gravity of electrolyte with hydrometer.

4 Connect the battery terminals to battery charger with proper polarity.

5 Set the charging voltage of 13.5 V in battery charger and switch ON the unit. (Charging voltage / value should be as per manufactures instruction)

6 Record charging voltage & battery voltage and wait until battery gets fully charged.

7 Disconnect the battery after it is fully charged, and measure the battery voltage.

8 Fix the caps of vent plugs and test the battery by connecting load.

— — — — —

TASK 2 : **Charge the battery by constant current charging method**

1 Draw the circuit diagram of constant current method of battery charging.

2. Uncap the vent plugs, Check the specific gravity of electrolyte with hydrometer.

3 Connect the battery terminals to battery charger with proper polarity.

4 Set the charging current at low rate in battery charger and switch ON the unit. (Charging / current value should be as per manufactures instruction)

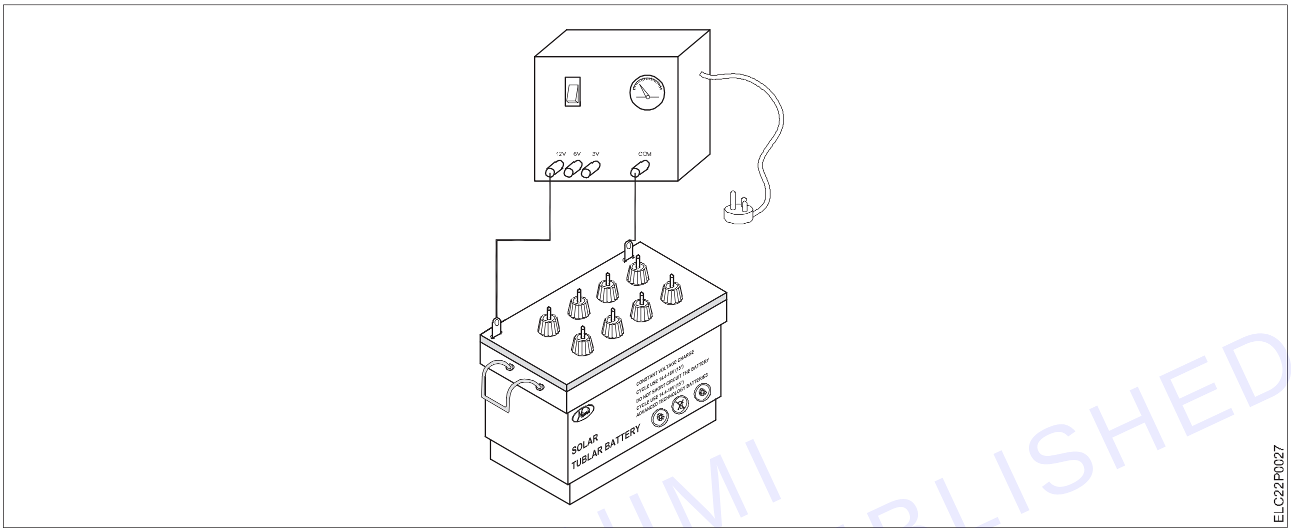
5 Record charging current & voltage, and wait until battery gets fully charged.

6 Disconnect the battery after it is fully charged, and measure the battery voltage.

7 Fix the caps of vent plugs and test the battery by connecting load.

Safety precautions

- Maintain proper polarity of battery charger and battery.
- Do not charge the battery with abnormal voltage / current.
- Do not overcharge the battery.
- Uncap the vent plugs during battery charging.
- The battery should be charged in well ventilated room.



EXERCISE 19 : To connect and test solar cells / PV models in series & parallel for given power

Objectives

At the end of this exercise you shall be able to

- identify & study the construction of solar cells / PV modules, and check the rating
- calculate the requirement of No. of solar cells to obtain the required power output
- connect the solar cells / PV modules in series & parallel
- measure the open circuit voltage & short circuit current of solar cells / PV modules and calculate the power output.

Requirements

Tools/Equipments/Instruments

- Combination plier (165mm, insulated) - 1 No.
- Screw Driver (150mm, insulated stem) - 1 No.
- Neon Tester (75mm, 500 V) - 1 No.
- Electrician knife (Insulated) - 1 No.
- Wire striper (100 mm) - 1 No.
- Solar PV modules (12 V, 16W) - 6 Nos.
- Solar spot light with radiation control (200 W, 230 V) - 1 No.
- Multi meter (Digital, 31/2 digit) - 1 No.
- Voltmeter (MC, 0-100V) - 1 No.
- Ammeter (MC, 0-5 Amp) - 1 No.
- Rheostat / Potentiometer (0-100 Ω) - 1 No.
- Soldering iron with stand (60 W, 230 V) - 1 No.

Materials/Components

- Solar connector with cable (MC 3/T4) - 10 set.
- PVC copper wire (4.0 sq.mm) - 2 meter.
- Soldering lead & flux - As reqd.
- Cotton waste - As reqd.

Procedure

Solar cells / PV modules and power output

When sun light / natural light falls on solar cells the light energy is converted into Electrical energy and causing electricity to flow. The electrical output is depends upon many factors like - No. of solar cells, type of connection, size of solar PV modules, irradiation and weather conditions.

The electrical power output of solar cells/PV modules is calculated by the product of open circuit voltage (VOC) and short circuit current (ISC) (peak value current)

The solar cells/PV modules are connected in both series and parallel connection depends upon No. of strings and arrays as per required power output.

For this experiment the given data is,

Required power output is 50 watts

No. of solar PV models & rating = 3 No's of PV modules of 12 V, 16 W (16 W x 3 = 48 watts)
(6 No's of PV modules of 12 V, 16 W for parallel connection)

TASK 1 :**Identify the solar cells and check the rating**

1 Draw the circuit diagram of connection of solar cells in series & parallel.

2 Check and study the construction, voltage & power rating of solar PV modules.

3 Calculate the required power output as the ratings of solar PV modules.

4 Arrange the experiment set up with solar PV modules, solar spot light and meters on wooden table.

— — — — —

TASK 2 : **Series and parallel connection of Solar cells / PV modules and testing**

1 Make the series connection of solar cells / PV modules by solar connector cables with proper polarity as per circuit diagram.

2 Connect the PV module output to the potentiometer/ load rheostat.

3 Properly place the series connected solar PV modules exactly below the solar spot light.

4 Keep the knob of potentiometer at maximum resistance position.

5 Switch ON the solar spot light and set the radiation level approximately 100 w/m^2

6 Record the readings of open circuit voltage & current in voltmeter and ammeter.

7 Slowly reduce the potentiometer resistance step by step and record the voltage & current in each step

8 Reduce the potentiometer resistance in steps until voltmeter & ammeter reading shows

V = 0 and I = Maximum (I_{sc})

9 Repeat the steps 4 to 8 for different radiation levels (150 w/m^2, 200 w/m^2) and take the readings.

10 Repeat the same procedure for parallel connection of solar PV modules.

11 Tabulate the voltage & current readings and calculate the power.

12 Switch OFF the solar spot light and disconnect the PV modules & circuit.

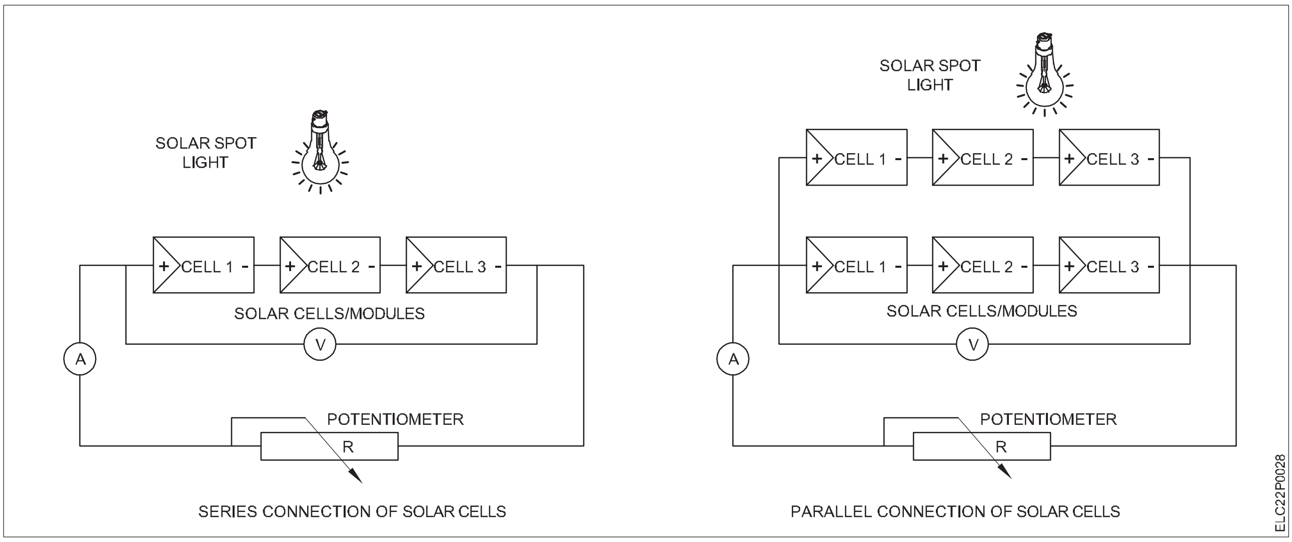
Tabular column

Series connection

S.No	Radiation	Voltage (V_{oc})	Current ($_{sc}$)	Power (W)

Parallel connection

S.No	Radiation	Voltage (V_{oc})	Current ($_{sc}$)	Power (W)



Safety precautions

1 Handle the solar PV modules carefully.

2 Do not make wrong & loose connection of solar PV modules.

3 Connect the solar PV modules with proper polarity.

4 Take the meter readings correctly.

MODULE 4: Electrical Wiring Practice, Earthing

EXERCISE 20 : To measure the diameter of conductor by using wire gauge and micro meter

Objectives

At the end of this exercise you shall be able to

- check the scale of standard wire gauge and micro meter
- identify the parts of micro meter, check zero error and least count
- set the job in micro meter and measure the dimension of job
- measure the gauge of different wires & conductors using wire gauge.

Requirements

Tools/Equipments

- Combination Plier (165mm, insulated) - 1 No.
- Connector screw driver (150mm, insulated stem) - 1 No.
- Electrician knife (Insulated) - 1 No.
- Steel rule (30cm) - 1 No.
- Micro meter (0-25 mm) - 1 No.
- Standard wire gauge (0-38 SWG) - 1 No.
- Micro meter stand - 1 No.

Materials

- Different PVC copper wire (Any size) - As reqd.
- Bare copper & GI wire (Any size) - As reqd.
- Emery paper - 1 sheet.
- Cotton waste - As reqd.

Procedure

TASK 1 : **Check the parts & xero error of micrometer**

1 Draw the neat sketch of standard wire gauge and micro meter.

2 Check the scale of wire gauge and micro meter.

3 Check & identify the parts of micro meter viz- U frame, moving spindle, main scale, sub scale.

4 Move the spindle towards the face of anvil by turning ratchet to check the zero error of micrometer.

5 Zero error:

> When zero mark of main scale is coinciding with zero mark of circular scale, the micro meter has No zero error.

> If the zero mark of circular scale is behind of main scale zero mark, the micro meter has positive zero error.

> If the zero mark of circular scale is ahead of main scale zero mark, the micro meter has negative zero error.

6 Calculate the least count of micro meter

$$\text{Least count (LC)} = \frac{\text{pitch of micro meter}}{\text{No. of divisions on circular scale}}$$

— — — — —

TASK 2 : **Measure the diameter of wire / object with micrometer**

1 Fix the micrometer firmly in micrometer stand. (Micro meter stand holds micrometer firmly and prevents error caused by shaking the micrometer OR Object while measuring the scale)

2 Open the distance between anvil and spindle by turning thimble OR ratchet.

3 Place the piece of conductor OR object whose diameter to be measured between anvil & spindle.

4 Close / move the spindle towards anvil by turning the ratchet.

5 Now, read the main scale, sub scale and circular scale and record the reading.

6 Open the micro meter spindle by turning ratchet and remove the object.

7 Calculate the diameter / thickness of object with measured readings. i.e,

Diameter = main scale reading + sub scale reading+ rotating scale reading X least count + zero error

— — — — —

TASK 3 : **Measure the gauge of wire with standard wire gauge (SWG)**

1 Take a piece of PVC copper wire and remove the insulation with electrician knife.

2 Hold the standard wire gauge and copper wire conductor whose diameter to be measured.

3 Insert the single conductor of PVC copper wire into the wire gauge slot which exactly match the thickness of conductor, and read the SWG scale of that slot.

4 In similar way, check the diameter of different conductors of copper, aluminum, GI and record the SWG value

— — — — —

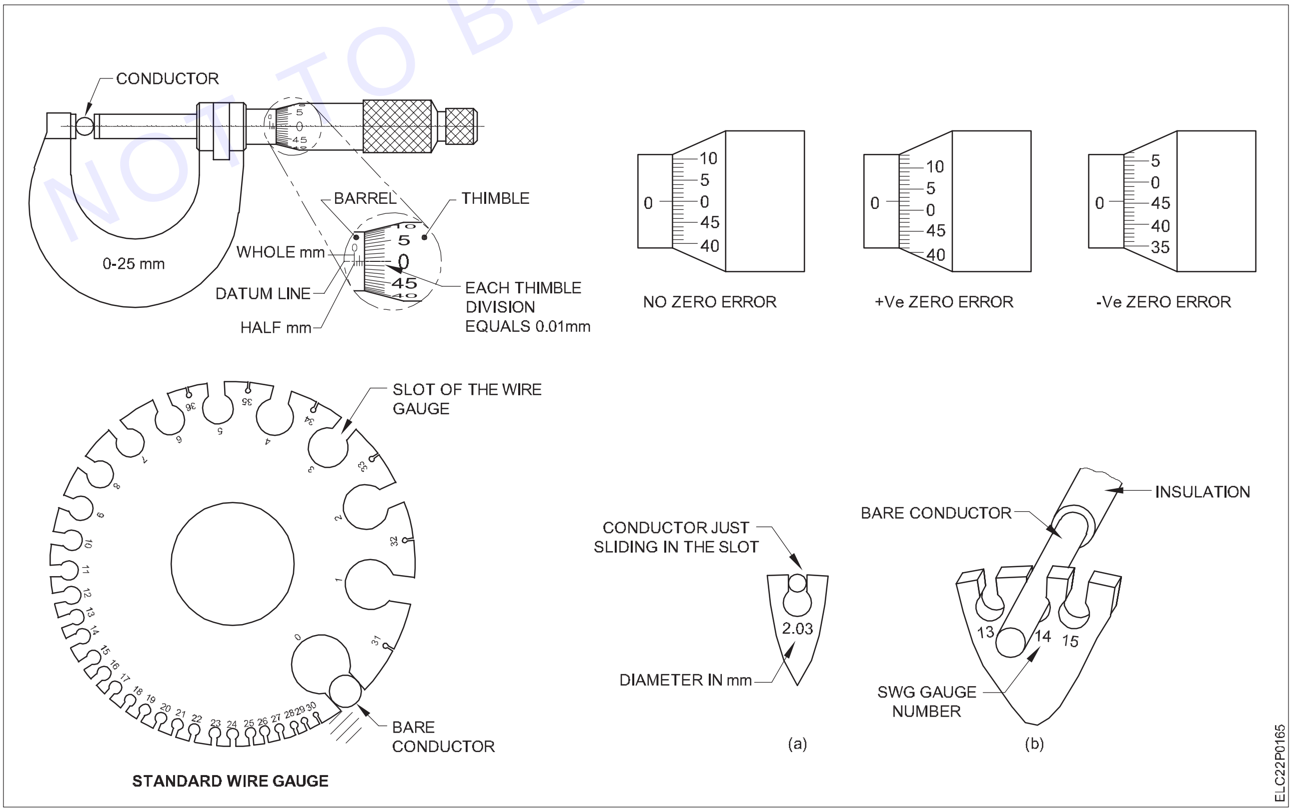
Safety precautions

1 Handle the micrometer carefully and do not drop it.

2 Do not over turn the thimble & ratchet of micrometer.

3 Do not measure heavy objects in micrometer.

4 Do not insert the whole wire / cable in wire gauge. Insert only single conductor.



EXERCISE 21 : To carry out Electrical wiring on PVC casing capping & PVC conduit pipe

Objectives

At the end of this exercise you shall be able to

- make layout diagram & draw wiring diagram
- selection of electrical wiring accessories and protective devices
- carry out electrical wiring, fixing of electrical accessories & termination
- testing of electrical wiring installation and connecting to main supply.

Requirements

Tools/Equipments

- Combination Plier 165mm, insulated - 1 No.
- Screw Driver 150mm, insulated stem - 1 No.
- Connector screw driver 150mm, insulated stem - 1 No.
- Neon Tester 75mm, 500 V - 1 No.
- Electrician knife Insulated - 1 No.
- Ball peen hammer 0.5 Kg - 1 No.
- Bradawl Steel, 150mm - 1 No.
- Steel rule 30cm - 1 No.
- Try square - 1 No.
- Hacksaw with frame 250mm - 1 No.
- Multimeter Digital, $3^{1/2}$ digit - 1 No.
- Megger 500 V - 1 No.

Materials

- PVC copper wire 1.5 sq.mm - 1 Coil
- DP switch 16 A, 250V - 1 No.
- SP switch 6 A, 250V, Non modular - 3 Nos.
- 2 way switch 6 A, 250V, Non modular - 3 Nos.
- Lamp holder 6 A, 250V, batten type - 3 Nos.
- PVC gang box 1 way, Non modular - 3 Nos.
- PVC round block 25mm - 3 Nos.
- PVC conduit pipe & accessories 19mm - as reqd.
- PVC casing capping & accessories 1 inch - as reqd.
- Teak wood wiring board 4’ x 4’ - 1 No.
- GI saddle with base 19 mm - as reqd.
- Wood screws Assorted size - as reqd.

Procedure

TASK 1: **Carry out PVC conduit pipe wiring**

1 Make the wiring layout on teak wood wiring board and draw the wiring diagram.

2 Fix the PVC conduit pipes with saddles on wiring board as per wiring layout

3 Fix the PVC round blocks and gang box as per No. of switch & light points of wiring diagram.

4 Draw / insert the wires into the PVC conduit pipe with GI fish wire as per wiring diagram.

5 Fix the electrical accessories viz- DP switch, SP switches and lamp holders after making end connections as per wiring diagram.

— — — — —

TASK 2: **Carry out PVC casing & capping wiring**

1 Make the wiring layout on teak wood wiring board and draw the wiring diagram.

2 Fix the PVC casing capping with wood screws on wiring board as per wiring layout.

3 Fix the PVC round blocks and gang box as per switch & light points of wiring diagram.

4. Draw the wires in the PVC casing as per wiring diagram.

5 Once all wires are drawn, close the casing with capping by gently tapping.

6 Fix the electrical accessories viz- DP switch, SP switches and lamp holders after making end connections as per wiring diagram.

TASK 3: **Testing of Electrical wiring and connecting to main supply service line**

1 As per IE rules, a tests are to be conducted on completed Electrical wiring before connecting to the main supply service line.

2 Conduct the continuity test of wiring with multi meter/test lamp by closing all switches and shorting all light points & socket points.

3 Conduct short circuit test of wiring with multi meter/test lamp by keeping all switches OFF and all light points & socket points open.

4 Conduct earth continuity and earth leakage test of wiring with megger.

5 After satisfactory test results connect the electrical wiring supply mains through the protective fuse & MCB's.

6 Test all the electrical points, socket points for working condition.

Safety precautions

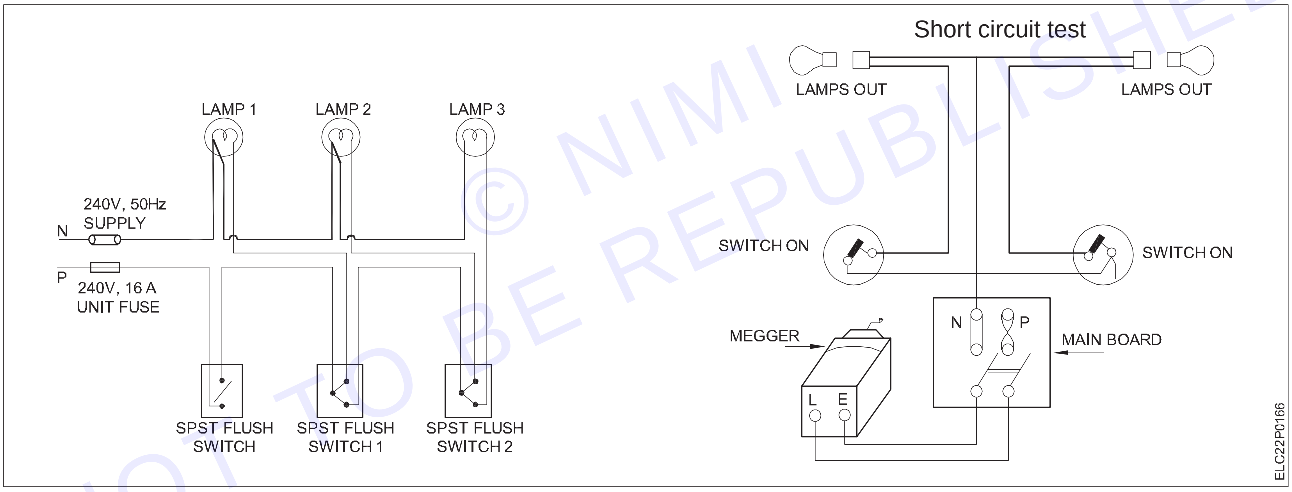
1 Use proper and insulated tools.

2 Maintain proper dimensions between each electrical point.

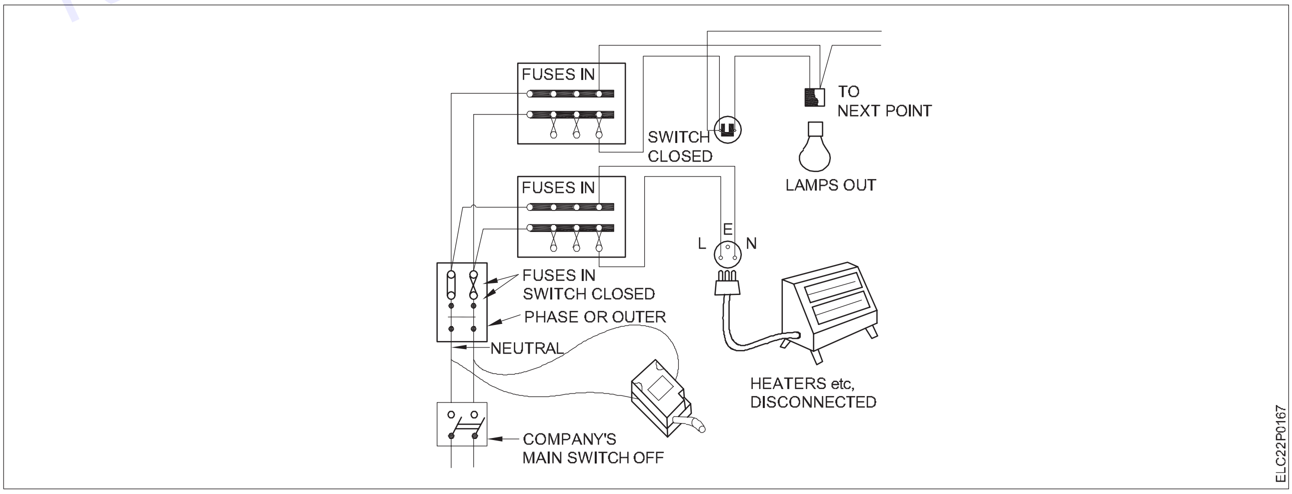
3 Fix the conduits, casing and electrical accessories tightly.

4 Never make joints in electrical wiring.

5 Never connect the wiring to the supply mains without conducting tests.



Insulation resistance test between conductors



EXERCISE 22 : To identify protective fuse, MCB, ELCB and testing

Objectives

At the end of this exercise you shall be able to

- identify the different types of protective fuses, MCB, ELCB and their ratings
- check the construction and parts of fuse, MCB and ELCB
- connect the fuse, MCB and test for over load & short circuit fault
- connect and test the ELCB for earth fault.

Requirements

Tools/Equipments

- Combination Plier 165mm, insulated - 1 No.
- Neon tester 75mm, insulated - 1 No.
- Electrician Knife Insulated - 1 No.
- Screw driver 150mm, insulated - 1 No.
- Multimeter Digital, $3^{1/2}$ digit - 1 No.
- Fuse / MCB trainer kit Standard - 1 No.

Materials

- Fuses - kit kat, cartridge, HRC, glass fuse Assorted ratings - 1 No. each
- MCB - 1 pole, 2 pole, 3 pole, 4 pole Assorted ratings - 1 No. each
- ELCB - 1 Ph. 16A, 30 mA - 1 No.
- Connecting wire - 1.5 sq.mm - as reqd.
- Test lamp - 60 W, 230 V - 1 No.

Procedure

TASK 1: **Connect and test the Fuse**

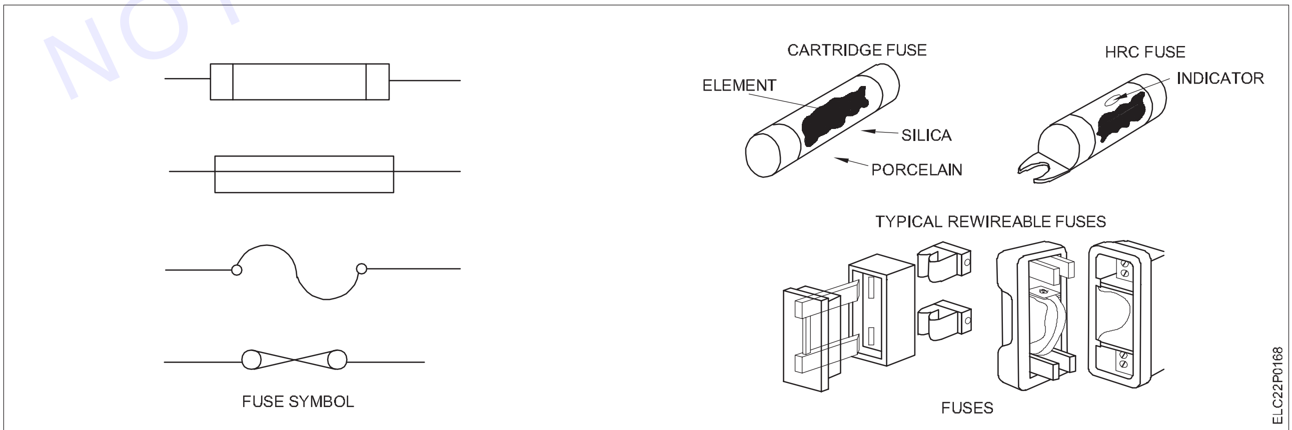
1 Identify the different types of fuses, their construction and ratings.

2 Make the connection of fuses in simple electrical circuit.

3 Connect the glass fuse in low voltage circuit.

4 Simulate the short circuit fault in the circuit and observe the fuse blowing.

5 Practice connection of HRC fuse in 3 phase circuits.



TASK 2 : **Connect and test the MCB**

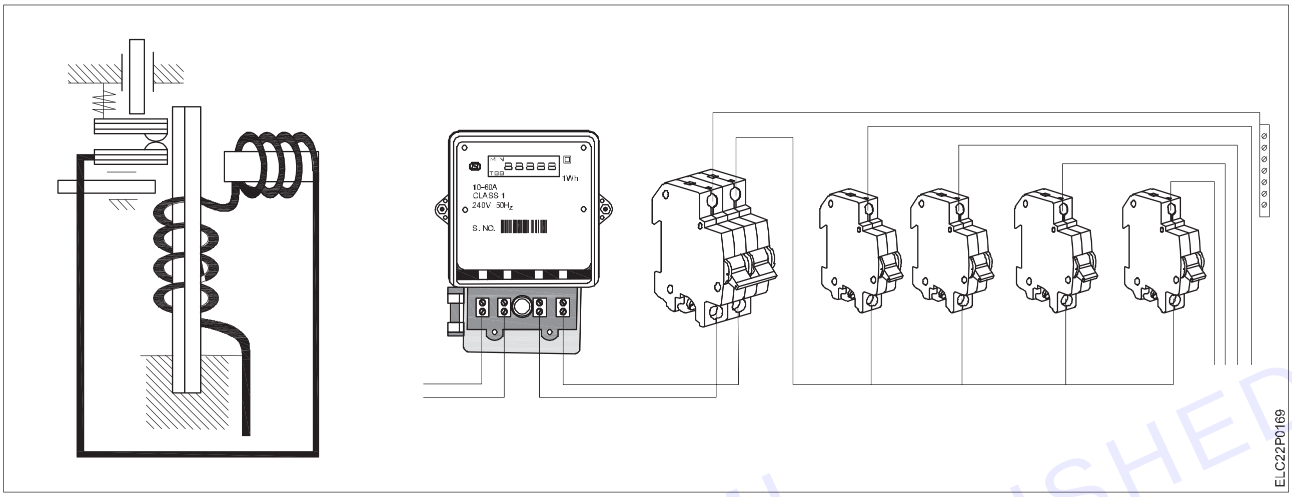
1 Identify the different types of MCB's, check the construction and ratings.

2 Make the connection of MCB in simple electrical circuit.

3 Connect the 1 pole MCB of small current (1 Amp) in the circuit.

4 Simulate the over current fault in the circuit and observe the tripping of MCB.

5 Connect and test the MCB in 1 phase & 3 phase circuits.



TASK 3: **Connect and test the ELCB**

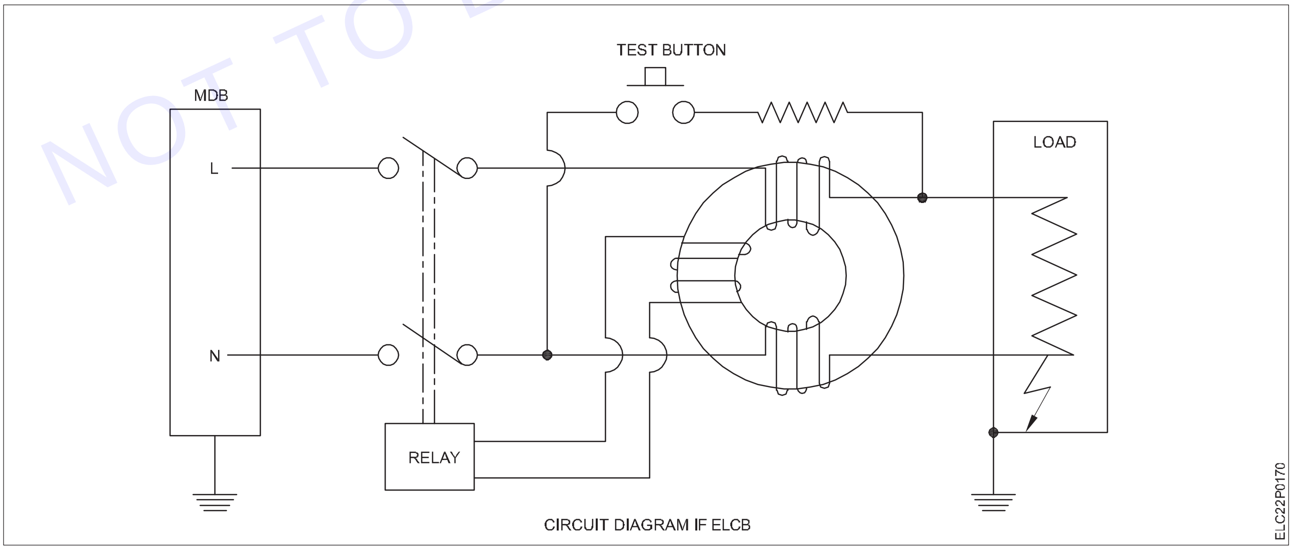
1 Check the terminals, ratings of ELCB.

2 Connect the ELCB in electrical circuit and switch ON the supply.

3 Press the ''Test'' button of ELCB and check the tripping of ELCB.

4 Simulate the earth fault in the circuit with test lamp and check the tripping of ELCB.

5 Connect and test ELCB in domestic wiring circuit.



Safety precautions

- Handle the cartridge fuse carefully and do not drop.
- Connect the fuse always in phase line.
- Do not make short circuit in high voltage circuit to test MCB.
- Earth fault should be simulated by test lamp to test ELCB.

EXERCISE 23 : To demonstrate multi-storied building wiring

Objectives

At the end of this exercise you shall be able to

- draw the layout diagram & wiring diagram of building wiring
- make the estimation and costing of multi-storied building wiring
- selection of electrical accessories required for multi-storied building wiring
- erection of multi-storied building wiring and testing.

Requirements

Tools/Equipments

- Combination Plier 165mm, insulated - 1 No.
- Screw driver 150mm - 1 No.
- Neon tester 75mm, 500 V - 1 No.
- Electrician Knife Insulated - 1 No.
- Ball peen hammer 500gm - 1 No.
- Cold chisel 25 x 150mm - 1 No.
- Potable electric drill machine 2-10mm - 1 No.
- Bradawl 150mm - 1 No.
- Megger 500 V - 1 No.
- Multi meter Digital, $3^{1/2}$ digit - 1 No.

Materials

- PVC copper wire 1.5 sq.mm - as reqd.
- Electrical wiring accessories - Any rating - as reqd.
- Test lamp 100 W, 230V - 1 No.
- DPST switch 16 A, 230 V - 1 No.

Procedure

TASK 1 : **Make the electrical wiring layout of building**

1 Draw the layout diagram & circuit diagram of multi-storied building wiring.

2 Calculate the No. of lighting & power points and total power requirement for the building.

3 Calculate current rating of main switch fuse and main distribution board.

4 Make estimation and costing of electrical accessories, protective elements, wires & cables etc.

5 Select the electrical accessories, protective elements, wires & cables etc required for the wiring.

— — — — —

TASK 2 : **Erection of building wiring**

1 Mark the position of meter board, main distribution board & electrical points in all the floors of building as per layout diagram.

2 Fix the PVC conduit pipes as per marked position of electrical points in all the floors of building.

3 Fix the flush type switch boxes, gang boxes, PVC junction boxes, ceiling rose as per No. of points.

4 Draw the PVC copper into the conduit pipes with the help of GI fish wire as per circuit diagram and No. of points.

5 Fix the meter board and main distribution board with appropriate rating of fuse/MCB’s

6 Fix all electrical accessories viz - switches, sockets, lamp holders etc in lighting circuit and Power circuit.

7 Make the end connections with electrical accessories as per the circuit diagram.

8 Check all the connections, conduct short circuit test and earth leakage test.

9 Connect the completed & tested wiring to the main 3 Ph. EB supply.

10 Switch ON all the electrical points and test the light points, fan points, socket points.

Safety precautions

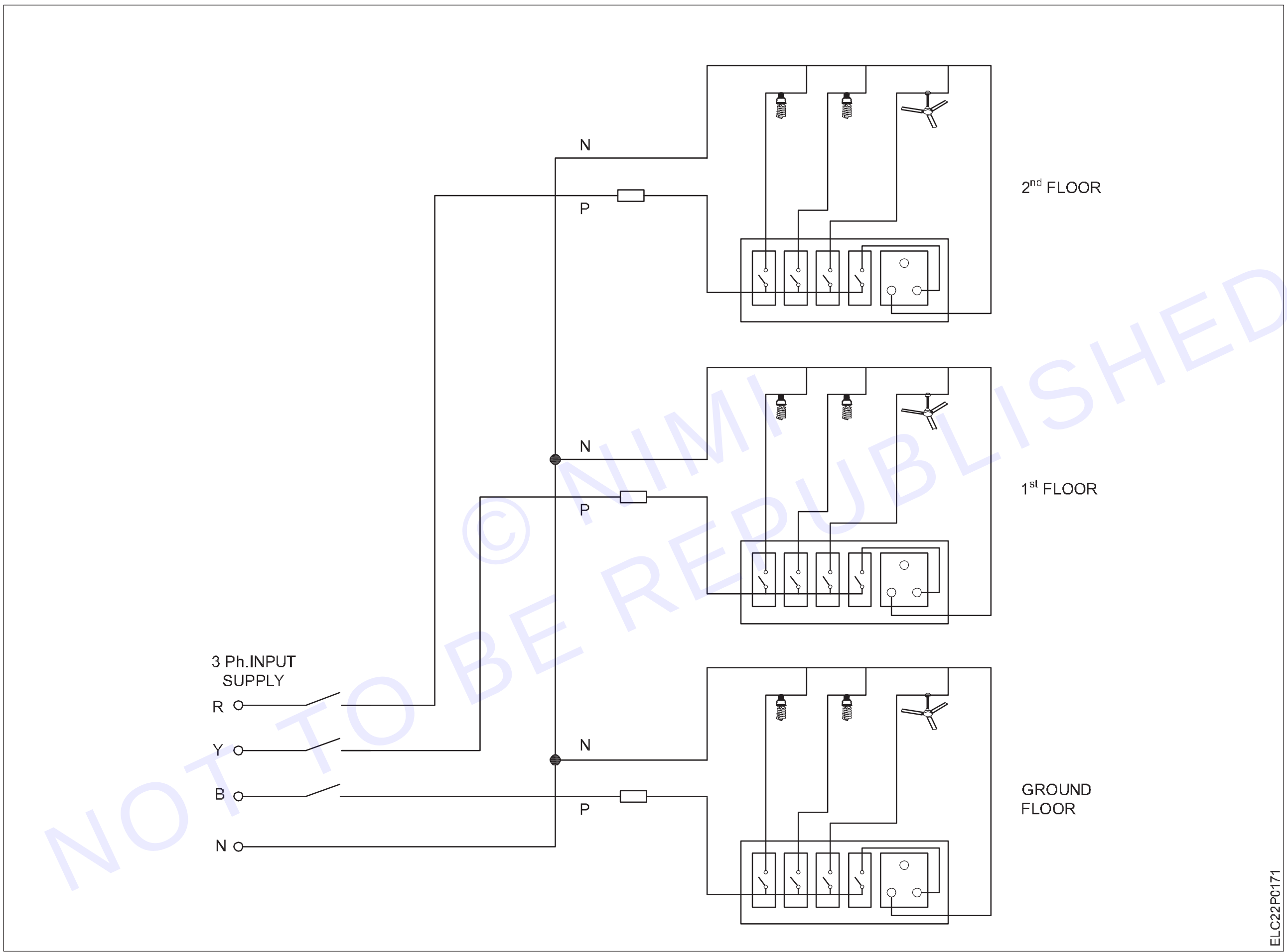
1 Use proper and insulated tools.

2 Use proper rating of fuse/MCB and electrical accessories.

3 Do not make wrong and loose connections.

4 Ensure proper earth connection for electrical wiring

5 Do not connect the main EB supply without testing of wiring



EXERCISE 24 : To measure the earth resistance by earth tester

Objectives

At the end of this exercise you shall be able to
- test the earth continuity of earthing point
- check the terminals & connections of earth tester
- measure the earth resistance of earthing point.

Requirements

Tools/Equipments

• Combination Plier 165mm, insulated	- 1 No.
• Neon tester 75mm, insulated	- 1 No.
• Screw driver, insulated 150mm	- 1 No.
• Spanner Adjustable	- 1 No.
• Ball peen hammer 0.5 Kg	- 1 No.
• Digital Multi meter $3^{1/2}$ digit	- 1 No.
• Earth tester 4 point, Digital	- 1 No.
• GI rods 10mm dia, 1.5 ft	- 2 Nos.
• Resistance 100 Ω	- 1 No.

Materials

• Connecting wire 1.0 sq.mm	- 90 meter
• Insulation tape PVC, 19mm	- 1 role
• Test lamp 60 W, 230V	- 1 No.
• Salt water	- as reqd.

Procedure

TASK 1 : **Identify & test the earthing point**

1 Identify the earthing point to be tested and clean the earth fit and its surrounding.

2 Check the earth conductor, earth connector strip for rigid connection, and damage / breakage If any.

3 Test the earth continuity with test lamp.

(The test lamp should glow bright, if lamp glows dim the earth connectivity is poor)

4 Pour the salt water sufficiently through funnel with mesh into the earth pit.

— — — — —

TASK 2 : **Check the earth tester**

1 Draw the circuit diagram of measurement of earth resistance.

2 Read the specifications, scale of earth tester and check its terminals.

3 It is necessary to calibrate the earth tester before testing of earth resistance.

4 For calibration, short the terminals C1 P1 & P2 C2 of earth tester and connect resistance of 100 Ω across shorted terminals.

5 Now turn ON the digital earth tester and test button, the earth tester should read 100 Ω

6 Disconnect the shorted wire on terminals of earth tester, and it is ready for measurement of Earth resistance.

— — — — —

TASK 3 : **Measure the earth resistance of Earthing point**

1 Switch OFF the main supply of Electrical installation and disconnect phase, neutral and earth connection in main distribution board.

2 Fix the one GI rod in the ground at distance of 5 ft (as per approx length of earth electrode) from earth pit.

3 Fix other GI rod in the ground at distance of 50 ft (10 x length of earth electrode) from earth pit.

4 Now make the connections of earth tester as shown in the diagram.

5 Now turn ON the earth tester and set the range of 10 Ω

6 Press the test button of earth tester note the resistance value recorded in earth tester.

7 Switch OFF the earth tester and fix the first GI rod at a distance of 10 ft from earth pit.

8 Press the test button of earth tester note the resistance value recorded in earth tester.

9 Repeat the procedure and take 3 to 5 readings of earth resistance and take average value which is measured value of earth resistance.

10 Disconnect earth tester from earth pit, and restore the main supply of electrical installation.

Safety precautions

- Handle and operate the earth tester carefully.
- Do not test earth resistance with main supply ON
- Do not disconnect the earth connection without disconnecting mains which causes electric shock.

Table

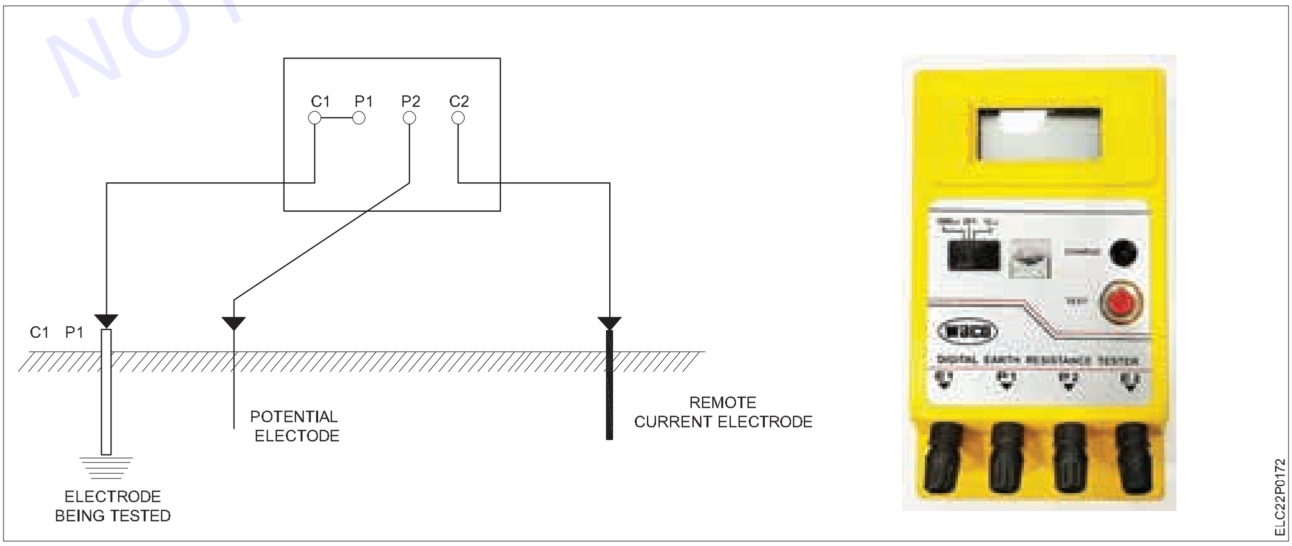
Earth Spike Distance	5ft	10ft	15ft	20ft	Average Value of earth resistance (Ω)
Earth Resistance	Ω	Ω	Ω	Ω	

Length of Earth Electrode: _____

Ideal Value of Earth Resistance: < 2 Ω

Measured Value of Earth Resistance: ______

4 point Digital Earth Tester



EXERCISE 25 : Testing of protective multiple earthing (PME) connection

Objectives

At the end of this exercise you shall be able to

- identify and test the Earthing installations
- measure the earth potential between phase & neutral
- connect and test the protective multiple earthing (PME) system.

Requirements

Tools/Equipments

- Combination Plier (165mm, insulated) - 1 No.
- Screw Driver 150mm - 1 No.
- Neon Tester 75mm, 500 V - 1 No.
- Electrician knife Insulated - 1 No.
- Multi meter Digital, $3^{1/2}$ digit - 1 No.

Materials

- PVC copper wire 1.5 sq.mm - as reqd
- Test lamp 100 W, 230 V - 1 No.

Procedure

Protective Multiple Earthing (PME) system : It is a method of earthing system in which an earth conductor is connected to the earthing point as well as neutral wire of main incoming supply. In this type of connection a fault current flows to ground and ensures protection from electric shock and damage of equipments in the event of failure/break of main supply neutral wire. This method is often used in power supply & distribution networks.

TASK 1 : **Check the earth continuity**

1 Draw the connection diagram of protective multiple earthing (PME) system.

2 Identify and test the earthing installation/s for working condition with test lamp.

3 Identify the main input supply and load switch of electrical installation.

TASK 2 : **Connect and test the protective multiple earthing (PME) circuit**

1 Switch OFF the main incoming supply of electrical installation.

2 Connect the earth conductor parallel to the earthing point and main neutral wire.

3 Check the connection and switch ON the supply, measure the earth potential with phase & neutral.

4 Test the PME circuit by breaking / disconnection of neutral wire and measure the voltage and current in the load circuit.

Safety precautions:

1 Do not make connection with live supply.

2 Do not make wrong & loose connections.

3 Ensure proper continuity of earth source.

MODULE 5: Magnetism, AC Circuits

EXERCISE 26 : To prepare an Electromagnet and Testing

Objectives

At the end of this exercise you shall be able to

- wound the bare copper conductor on plastic bobbin
- make the electro magnet and test the magnetic property
- test the polarity of electromagnet by magnetic needle
- vary the strength of magnetic field of electromagnet.

Requirements

Tools/Equipments

- Combination Plier (150 mm, insulated) - 1 No.
- Nose plier (100mm, Insulated) - 1 No.
- Connector screw driver 100 mm - 1 No.
- Electrician knife insulated - 1 No.
- Soldering iron 25 W, 230 V - 1 No.
- Neon tester 75mm, 500V - 1 No.
- Magnetic needle - 1 No.
- DC power supply 0-100V - 1 No.
- Auto transformer 0-250 V AC - 1 No.

Materials

- Bare copper conductor 26 SWG - 4 Mtr.
- Hook up wire Single strand - 0.5 Mtr.
- Soldering lead - as reqd.
- Soldering flux - as reqd.
- Plastic /paper bobbin (Any small size) - 2 Nos.
- Steel bolt 8mm X 50mm - 1 No.

Procedure

TASK 1 : **Construction of Electromagnet**

1 Take the plastic bobbin and fix it vertically on wooden board.

2 Fix the nail tightly adjacent to the plastic bobbin.

3 Take one end of bare copper conductor and twist it tightly on the nail.

4 Now start winding of bare copper conductor uniformly on plastic bobbin.

5 Make a coil of around 100 turns and wrap the insulating paper tightly on the coil.

6 Remove the coil winded bobbin from wooden board.

— — — — —

TASK 2 : **Testing the Electromagnet with DC supply**

1 Fix the coil winded bobbin horizontally on wooden board.

2 Make the end connection of coil terminals with hook up wire by soldering and insulate properly.

3 Insert the metal bolt into the bobbin with soft spring support.

4 Now Electro magnet is ready for testing, and connect its terminals to DC power supply.

5 Switch ON the DC power supply and slowly apply the voltage about 12 V

6 Check & observe the magnetic property of Electromagnet by touching with metal object.

7 Check the polarity of Electromagnet with magnetic compass needle.

8 Switch OFF the DC power supply and disconnect the electromagnet.

— — — — —

TASK 3 : **Vary the coil turns and supply voltage (AC)**

1 Follow the step 1 & 2 and prepare the electromagnet of 200 turns.

2 Connect the electromagnet to the low voltage AC supply through an auto transformer.

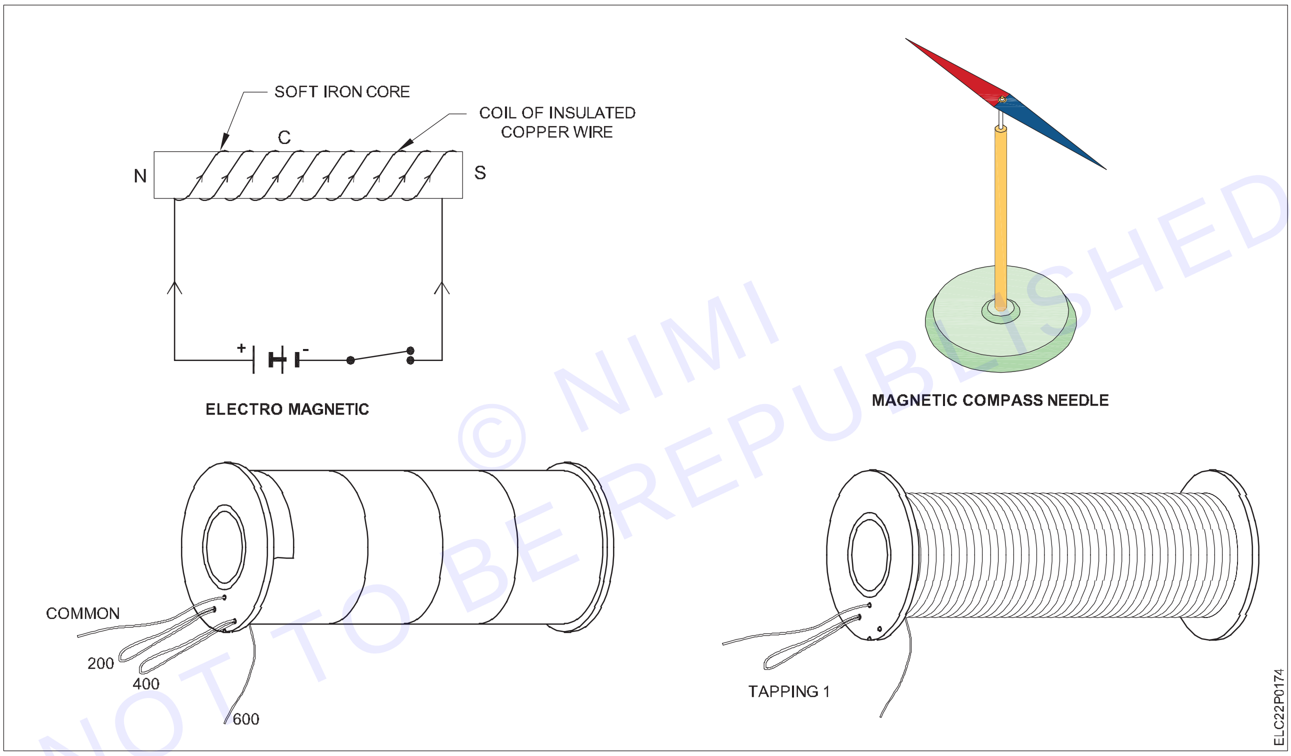
3 Check & observe the magnetic property of Electromagnet by touching with metal object.

4 Check the polarity of Electromagnet with magnetic compass needle.

5 Switch OFF the supply and disconnect the electromagnet.

Safety precautions

- Do not scrape the insulation of conductor while making a coil.
- * Do not overlap the conductor turns, wind the conductor uniformly.
- * Do not apply excess voltage to electromagnet.



EXERCISE 27 : Identify various types of capacitors, charging / discharging and testing

Objectives

At the end of this exercise you shall be able to

- identify the type of capacitor by visual inspection
- identify the capacitor's value and rating from the marking
- test the capacitor with DC supply for insulation and leakage
- test the capacitor for charge and discharge.

Requirements

Tools/Equipments

- Combination Plier (165 mm, insulated) - 1 No.
- Screw Driver (150mm, insulated stem) - 1 No.
- Neon Tester 75mm, 500 V - 1 No.
- Variable Dc power supply 0-30 v DC - 1 No.
- Digital multi-meter $3^{1/2}$ Digit, 750 V AC - 1 No.
- Ammeter 100mA MC - 1 No.
- Volt meter 0-250v, MC - 1 No.

Materials

- Capacitors - paper, mica, electrolytic, Mylar, tantalum, variable air core and mica (Assorted values/voltage ratings) - as reqd.
- Connecting wire 1.0^2 mm - as reqd.
- One way switch 6 A - 1 No.
- Two way Switch 6 A - 1 No.

Procedure

TASK1 : **Identification of capacitors**

1 From the capacitor provided by the instructor identify its type.

2 Read the value of capacitance and working voltage from the markings, if indicated, and record in table 1

— — — — —

TASK 2 : **Test the capacitor for charge and discharge**

1 Form the 12V circuit for testing the capacitor circuit elements.

2 Keep the switch S1 connected to the battery closed. And put the two way switch in position 1

3 Observe the deflection in the ammeter and voltmeter.

4 Record the deflection in the ammeter

5 Observe the voltmeter reading at equal intervals of time.

6 Open the switch 'S' and observe the voltmeter reading for few minutes.

7 Close the switch S to position 2 and observe the Close the switch S to position 2 and observe the voltmeter and ammeter readings.

— — — — —

TASK 3 : **Testing of capacitor with ohmmeter**

1 Discharge the given capacitor.

2 Connect the ohmmeter to test the capacitor and observe the deflection in the meter.

Result

Identified various types of capacitors and it's charging / discharging and testing.

Conclusion

1 **Charging:** at the time of charging capacitor voltage increases as the current and resistor voltage decrease

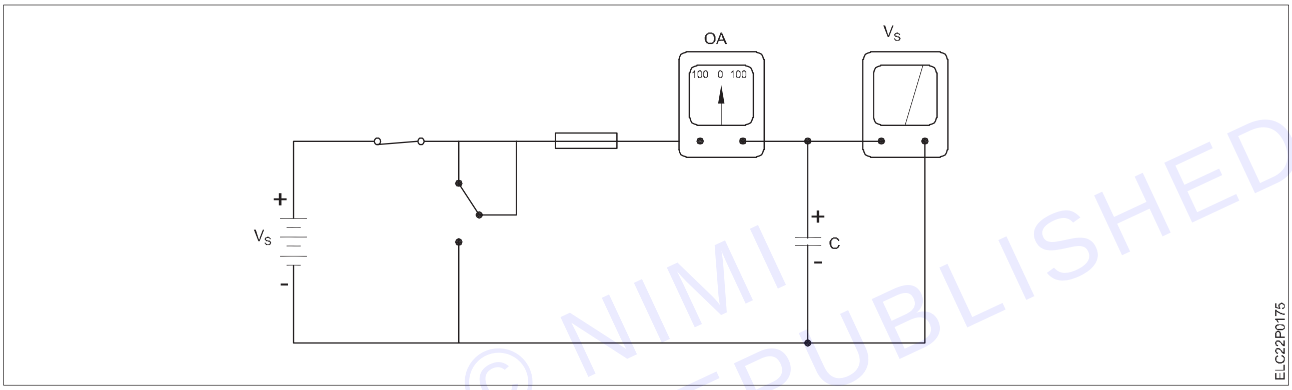
2 **Fully Charged:** capacitor voltage equals source voltage, current zero

3 **Discharging :** capacitor voltage, resistor voltage and current decreases rapidly. Discharge current is in opposite direction of charging current

Table 1

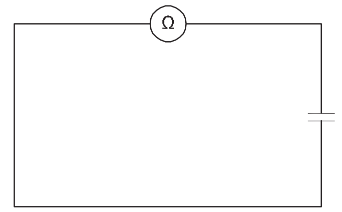
S.No.	Type of Capacitor	Capacitance value	Voltage rating

Test the capacitor for charge and discharge



Capacitor value	Resistance value	S. No.	Charging		Fully charged		Discharging	
			Time in sec	Voltage	Time in sec	Voltage	Time in sec	Voltage

Testing of capacitor with ohmmeter



Indication of Test instrument	Condition of Capacitor under test
Meter indicate some resistance	Leakage
No Deflection	Open
Deflects and return back slowly	Good Condition
Contineously shows zero reading	Short

EXERCISE 28 : Measurement of R, L, C, and PF in AC circuit

Objectives

At the end of this exercise you shall be able to

- draw RLC series circuit diagram
- identify the RLC components and make the connection of RLC series circuit
- measure / calculate the impedance and power factor in AC circuits.

Requirements

Tools/Equipments

- Combination Plier (150 mm, insulated) - 1 No.
- Wire stripper (150mm, insulated) - 1 No.
- Screw driver (150mm, insulated) - 1 No.
- Neon tester 75mm, 500V - 1 No.
- Voltmeter, MI 0-300 V - 1 No.
- Ammeter, MI 10 A - 1 No.
- Power factor Meter 1ph 10A - 1 No.
- 1 Ph. Auto transformer 0-270 V, 10 A - 1 No.
- Frequency meter 0-60 Hz, 250 V - 1 No.

Materials

- PVC insulated copper wire 1 sq mm - as reqd.
- Resistance 150 Ω - 1 No.
- Inductor 0.43H, 250V, 50Hz - 1 No.
- Capacitor 2.5μF, 400V - 1 No.
- Test lamp 60W, 230 V - 1 No.

Procedure

TASK 1 : **Identify the RLC components**

1 Collect the tools, equipments and materials required for experiment.

2 Note the values of resistor, inductor and capacitor.

3 Observe the terminals & scale of power factor meter.

4 Make the connection of resistance & inductance (RL) series circuit as per circuit diagram.

5 Switch ON the mains and gradually increase the voltage by auto transformer.

6 Take the reading and note down the value of current, voltage and power factor.

7 Switch OFF the supply and disconnect the circuit.

— — — — —

TASK 2 : **Connect & test RLC circuit**

1 Make the connection of resistance, inductance & capacitance (RLC) series circuit as per circuit diagram.

2 Switch ON the mains and gradually increase the voltage by auto transformer.

3 Take the reading and note down the value of current, voltage and power factor.

4 Switch OFF the supply and disconnect the circuit.

5 Observe the difference between both circuits.

Tabular column

SL No	Applied voltage	VR	VL	VC	Current	Power factor	Impedance
1							
2							

Calculations

Resistance R = V_R/I

Inductive reactance $X_L = 2\pi fL$

Capacitive reactance $X_C = \frac{1}{2\pi fC}$

Impedance $Z = \sqrt{R^2 + (X_L - X_C)^2}$

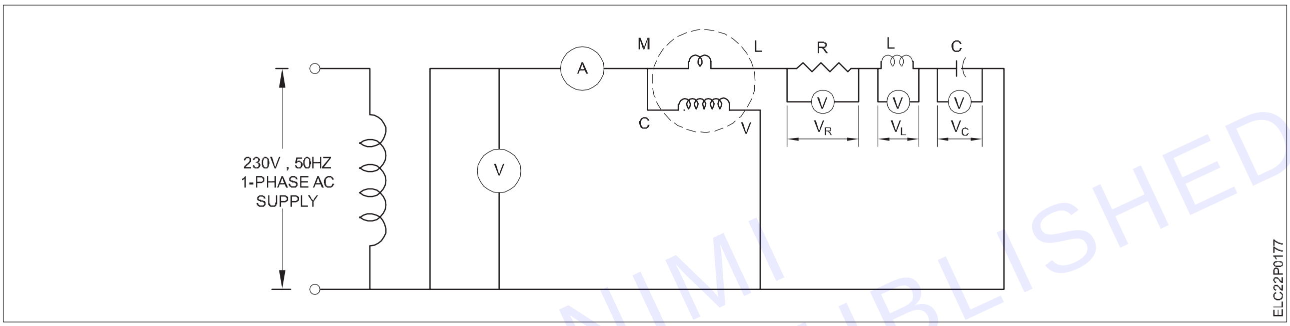
POWER FACTOR $= \cos\phi = \frac{R}{Z}$

Safety precautions:

1 Do not make loose & wrong connections.

2 Do not increase the voltage more than 240 V in auto transformer.

3 Connect power factor meter properly.



EXERCISE 29 : To measure the voltage & current in Star and Delta connection

Objectives

At the end of this exercise you shall be able to

- draw the circuit diagram of Star & Delta connection
- make the connection of Star & Delta circuit.
- measure the line voltage & current and phase voltage & current in Star - Delta.
- apply the Star-Delta applications in AC machines.

Requirements

Tools/Equipments

- Combination Plier (150 mm, insulated) - 1 No.
- Screw driver 150mm, insulated stem - 1 No.
- Neon tester 75mm, 500V - 1 No.
- Electrician knife
- Voltmeter, MI 500 V - 2 Nos.
- Ammeter, MI 10 A - 2 Nos.
- Induction motor 3 ph. 415 V, 2HP - 1 No.

Materials

- PVC copper wire 1.5 sq mm - as reqd.
- Incandescent bulb 100 W, 230 V - 6 Nos.
- Lamp holder 6 A, 250 V - 6 Nos.
- TPST switch 415 V, 32A - 1 No.
- Banana sockets 4mm, 10 A - 10 Nos.
- Wooden board TW, 2' X 2' - 1 No.

Procedure

TASK 1: **Connection of STAR circuit and testing**

1 Draw the circuit diagram of STAR connection.

2 Fix the lamp holders & banana sockets in STAR fashion on wooden board.

3 Make the connection of lamp holders & banana sockets.

4 Fix the bulbs in lamp holders and connect the voltmeter & ammeter as per STAR connection circuit.

5 Check the circuit and connect 3 ph. supply through TPST switch

6 Switch ON TPST switch and measure the line & phase voltage and line & phase current.

7 Switch OFF the supply and disconnect the circuit.

— — — — —

TASK 2: **Connection of DELTA circuit and testing**

1 Draw the circuit diagram of DELTA connection.

2 Fix the lamp holders & banana sockets in DELTA fashion on wooden board.

3 Make the connection of lamp holders & banana sockets.

4 Fix the bulbs in lamp holders and connect the voltmeter & ammeter as per DELTA connection circuit.

5 Check the circuit and connect 3 ph. supply through TPST switch.

6 Switch ON TPST switch and measure the line & phase voltage and line & phase current.

7 Switch OFF the supply and disconnect the circuit.

— — — — —

TASK 3 : **Apply STAR & DELTA connection in AC machines**

1 STAR & DELTA connection is applicable in AC 3 ph. Supply system and 3 ph. AC machines like Transformer, Alternator, induction motor.

2 Take 3 ph. Induction motor and connect in STAR fashion.

3 Apply 3 ph. Supply through TPST switch and record line & phase voltage and line & phase current.

4 Similarly, connect the motor in DELTA fashion and record line & phase voltage and line & phase current.

5 Switch OFF the supply and disconnect the motor.

6 Calculate the line & phase voltage and line & phase current as per Star Delta equations.

Safety precautions:

1 Follow the correct sequence in STAR and DELTA connection.

2 Never connect single bulb in the circuit, instead connect 2 bulbs in series.

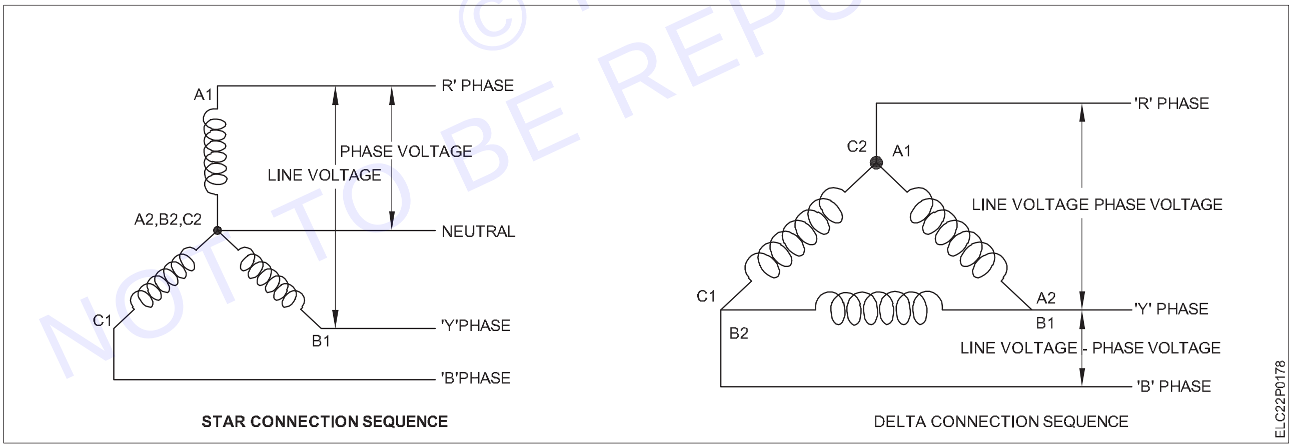
3 Do not make joints and loose connections.

4 Select proper range in voltmeter & ammeter.

5 Ensure proper earthing to TPST switch and induction motor.

Tabular column:

Connection	Line voltage (V_L)	Phase voltage (V_{PH})	Line current (I_L)	Phase current (I_{PH})
STAR				
DELTA				



$$V_{Line} = \sqrt{3} \times V_{Phase}$$
$$I_{Line} = I_{Phase}$$

$$V_{Line} = V_{Phase}$$
$$I_{Line} = \sqrt{3} \times I_{Phase}$$

MODULE 6: DC Generator and DC Motor

EXERCISE 30 & 34 : To identify the parts of DC Generator

Objectives

At the end of this exercise you shall be able to

- dismantle and reassemble of DC Generator
- identify the parts of DC Generator
- measure the resistance of field coils & armature
- check & identify the terminals of DC Generator.

Requirements

Tools/Equipments

- Combination Plier (165 mm, insulated) - 1 No.
- Screw Driver set 150mm, 5 blades - 1 Set
- Neon tester 75mm, 500V - 1 No.
- Electrician knife Insulated - 1 No.
- Spanner set 6 to 32 mm - 1 Set
- Allen key set 4 to 8 mm - 1 Set
- Ball peen hammer 0.5 Kg - 1 No.
- Bearing puller - 1 No.
- Rubber mallet 0.5 kg - 1 No.
- Old DC compound Generator 250 V DC - 1 No.
- Multi meter Digital, $3^{1/2}$ digit - 1 No.

Materials

- Test lamp 60 W, 230 V - 1 No.
- Emery paper - 1 Sheet
- Cotton waste / cloth - as reqd.

Procedure

TASK 1: **Read and note the name plate details of DC Generator**

1 Clean the given DC generator with cotton waste.

2 Read the name plate and record the specifications of DC generator

3 Place the DC Generator on wooden table and make a mark on both sides of end covers & yoke.

— — — — —

TASK 2: **Dismantling the DC Generator.**

1 Unscrew the assembly nut bolts & screws of DC Generator with spanner / Allen key

2 Remove the both side end covers of DC Generator.

3 Disconnect the terminals of field coils, armature.

4 Carefully remove the carbon brushes from the commutator.

5 Carefully take out the armature assembly without damaging field coils.

— — — — —

TASK 3: **Identify the parts of DC Generator and reassemble.**

1 Identify the parts of DC Generator, viz- Yoke, Armature, commutator, brush, field poles & coils.

2 Measure the resistance of field coils and armature with multi meter.

3 Check the Generator terminals in terminal box.

4 Reassemble the DC Generator properly.

5 Check the mechanical assembly, free rotation of shaft and friction if any.

6 Clean the machine and keep it in proper place.

Safety precautions:

1 Use proper tools for disassembling & assembling the DC Generator.

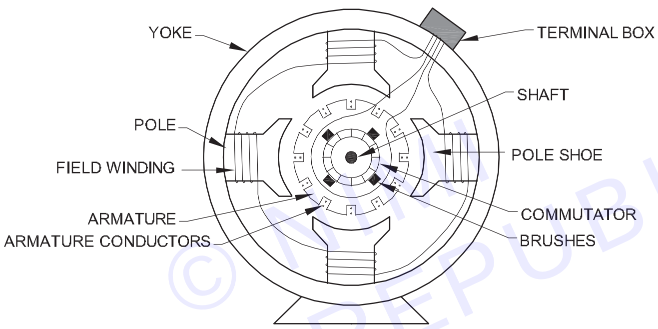
2 Do not hit the yoke and armature shaft directly with hammer.

3 Take extreme care while removing armature to avoid damage to field coils.

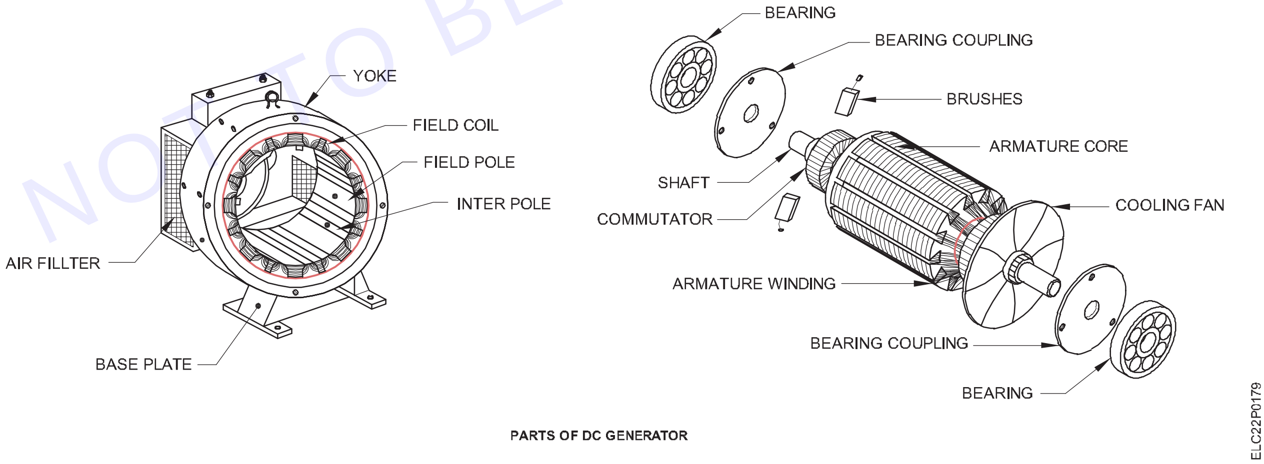
4 Do not damage the brushes and commutator.

Name Plate Details of DC Generator:

Rated Power :	
Voltage rating :	
Current rating :	
Field connection :	
Speed :	
No. of poles :	
Insulation class :	



COMPONENTS OF DC GENERATOR



PARTS OF DC GENERATOR

EXERCISE 31 : To build up the voltage in DC shunt Generator

Objectives

At the end of this exercise you shall be able to:

- check and identify the terminals of DC shunt Generator
- start & run DC shunt Generator with prime mover
- build up the voltage in DC shunt Generator
- record the field current & induced voltage in the Generator and plot OCC graph.

Requirements

Tools/Equipments/Instruments

- Combination Plier 165mm, insulated -1 No.
- Screw Driver 150mm, insulated -1 No.
- Neon Tester 75mm, 500 V-1 No.
- Electrician knife insulated -1 No.
- MG set (AC to DC) with DOL starter, DC shunt Generator 5 KW, 250 V -1 No.
- Voltmeter MC, 250 V -1 No.
- Ammeter MC, 5 A -1 No.
- Multi meter Digital, $3^{1/2}$ digit -1 No.
- Rheostat 700 Ω, 5A -1 No.
- Tacho meter 3000 RPM -1 No.

Materials/Components

- Test lamp 60 W, 230 V -1 No.
- Connecting wire 2.5 sq.mm - as reqd.
- Cotton waste / cloth - as reqd.

Procedure

TASK 1 : **Check the MG set details & terminals**

1 Clean the MG set with cotton waste and read its specifications.

2 Draw the circuit diagram of voltage build up of DC shunt generator.

3 Check and identify the terminals of MG set (AC induction motor and DC shunt Generator)

— — — — —

TASK 2 : **Connecting & Starting of MG set**

1 Make the connection of prime mover AC induction motor with DOL starter.

2 Make the connection of DC shunt Generator with field rheostat and meters.

3 Check all connections and keep the rheostat in cut in position.

4 Switch ON the mains and start the prime mover AC induction motor coupled with DC shunt Generator and measure the speed with Tacho meter.

— — — — —

TASK 3: **Build-up the voltage in DC shunt Generator**

1 On starting of MG set observe & record the induced residual voltage in voltmeter.

2 Slowly increase the field current in DC shunt Generator by adjusting field rheostat.

3 Further increase the field current until rated voltage (230 V) is build up in DC shunt Generator.

4 Record the field current and full rated voltage build up in DC shunt Generator.

5 Reduce the voltage to zero by adjusting field rheostat and stop the prime mover motor.

6 . Plot the graph to indicate the field current (IF) & induced voltage (E_G).

Safety precautions:

1 Ensure proper foundation and perfect coupling of MG set, else it may cause severe injury.

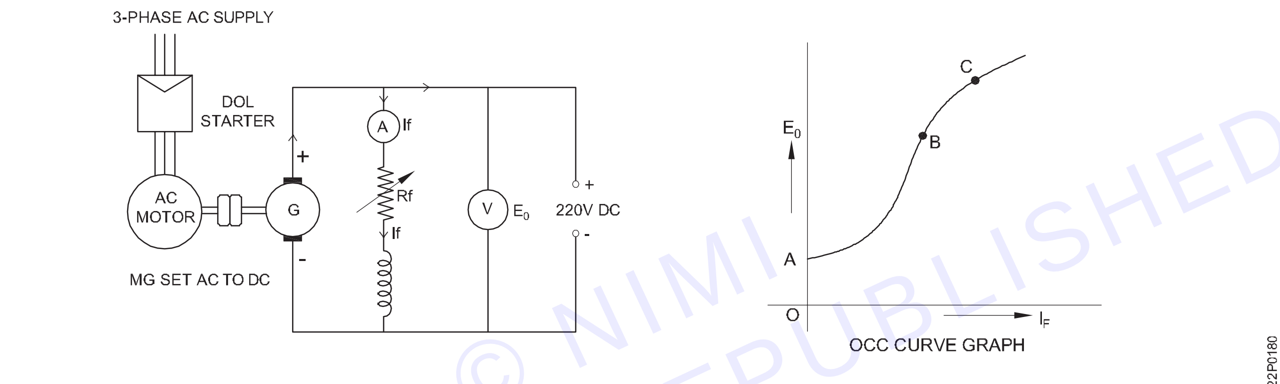
2 Ensure proper direction of rotation of DC generator to avoid demagnetizing of field poles and fails to build up voltage.

3 Do not make loose and wrong connections, check the connections before switching ON.

4 Ensure proper earthing to the MG set.

Tabular Column

Sl.No	Field Current (I_F)	Induced Voltage (E_G)	Speed (RPM)
1	0		
2			
3			
4			
5			



BUILD UP THE VOLTAGE IN DC SHUNT GENERATOR

EXERCISE 32 : To build up the voltage in DC compound Generator

Objectives

At the end of this exercise you shall be able to:

- check and identify the terminals of DC compound Generator
- start & run DC compound Generator with prime mover
- build up the voltage in DC compound Generator
- record the field current & induced voltage in the Generator and plot OCC graph.

Requirements

Tools/Equipments/Instruments

- Combination Plier 165mm, insulated -1 No.
- Screw Driver 150mm, insulated -1 No.
- Neon Tester 75mm, 500 V -1 No.
- Electrician knife insulated -1 No.
- MG set (AC to DC) with DOL starter,DC compund Generator 5 KW, 250 V -1 No.
- Voltmeter MC, 250 V -1 No.
- Ammeter MC, 5 A -1 No.
- Multi meter Digital, $3^{1/2}$ digit -1 No.
- Rheostat 700 Ω, 5A -1 No.
- Tacho meter 3000 RPM -1 No.

Materials/Components

- Test lamp 60 W, 230 V -1 No.
- Connecting wire 2.5 sq.mm - as reqd.
- Cotton waste / cloth - as reqd.

Procedure

TASK 1 : **Check the MG set details & terminals**

1 Clean the MG set with cotton waste and read its specifications.

2 Draw the circuit diagram of voltage build up of DC compound generator.

3 Check and identify the terminals of MG set (AC induction motor and DC compound Generator)

— — — — —

TASK 2 : **Connecting & Starting of MG set**

1 Make the connection of prime mover AC induction motor with DOL starter.

2 Make the connection of DC compound Generator with field rheostat and meters.

3 Check all connections and keep the rheostat in cut-in position.

4 Switch ON the mains and start the prime mover AC induction motor coupled with DC compound Generator and measure the speed with Tacho meter.

— — — — —

TASK 3: **Build-up the voltage in DC compound Generator**

1 On starting of MG set observe & record the induced residual voltage in voltmeter.

2 Slowly increase the field current in DC compound Generator by adjusting field rheostat.

3 Further increase the field current until rated voltage is build up in DC compound Generator.

4 Record the field current and full rated voltage build up in DC compound Generator.

5 Reduce the voltage to zero by adjusting field rheostat and stop the prime mover motor.

6 Plot the graph to indicate the field current (IF) & induced voltage (E_G)

Safety precautions

1 Ensure proper foundation and perfect coupling of MG set, else it may cause severe injury.

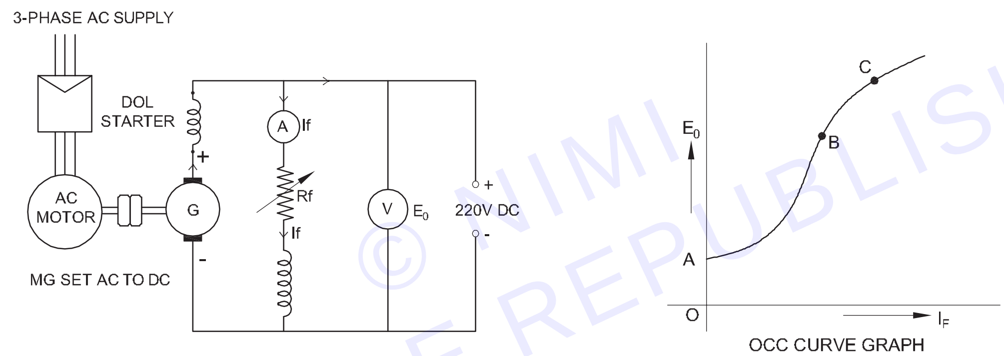
2 Ensure proper direction of rotation of DC generator to avoid demagnetizing of field poles and fails to build up voltage.

3 Do not make loose and wrong connections; check the connections before switching ON.

4 Ensure proper earthing to the MG set.

Tabular Column

Sl.No	Field Current (I_F)	Induced Voltage (E_G)	Speed (RPM)
1	0		
2			
3			
4			
5			



BUILD UP THE VOLTAGE IN DC COMPOUND GENERATOR

ELC22P0181

EXERCISE 33 : To study the characteristics of series, shunt & compound Generators

Objectives

At the end of this exercise you shall be able to:

- check the terminals & connections of series, shunt and compound Generators
- start & run the series, shunt and compound Generators and build up the voltage
- apply the load on Generators and study the performance characteristics
- plot the characteristics graph and compare series, shunt and compound Generators.

Requirements

Tools/Equipments/Instruments

- Combination Plier 165mm, insulated -1 No.
- Screw Driver 150mm, insulated -1 No.
- Neon Tester 75mm, 500 V -1 No.
- Electrician knife insulated -1 No.
- MG set (AC to DC) with DOL starter,DC compund Generator 5 KW, 250 V -1 No.
- Lamp load 5 KW, 250 V -1 No.
- Voltmeter MC, 250 V -1 No.
- Ammeter MC, 5 A -1 No.
- Ammeter MC, 20 A -1 No.
- Multi meter Digital, $3^{1/2}$ digit -1 No.
- Rheostat 700 Ω, 5A -1 No.
- Tacho meter 3000 RPM -1 No.

Materials/Components

- Test lamp 60 W, 230 V -1 No.
- DPST switch 250 V, 32 A -1 No.
- Connecting wire 2.5 sq.mm - as reqd.
- Cotton waste / cloth - as reqd.

Procedure

TASK 1 : **Check the MG set details & terminals**

1 Check the MG set and read specifications of motor & generator.

2 Check and identify the terminals of motor & generator.

3 Draw the connection diagram of loading of DC series, shunt and compound generators.

— — — — —

TASK 2: **Study the characteristics of DC Series Generator**

1 Make the connections of Prime mover AC motor and DC series Generator with voltmeter, Ammeter and output DPST switch.

2 Check the connections, start the prime mover AC motor coupled to DC series Generator and Observe induced voltage recorded in the voltmeter. (There will be no induced voltage, since series generator is to be started with load)

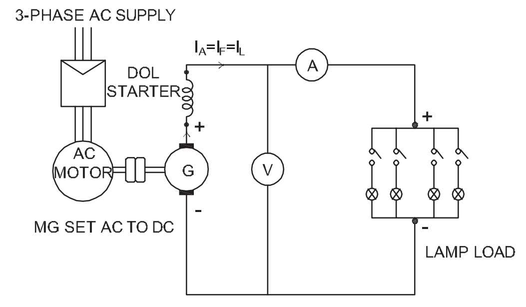
3 Switch OFF the prime mover motor, and connect the lamp load across generator terminals through DPST switch as per circuit diagram.

4 Now start the prime mover AC motor coupled to DC series Generator, close the DPST switch and switch ON the lamp load gradually.

5 Observe & record the induced voltage in voltmeter. Further increase the load until rated current of generator and record the induced voltage & load / field current.

6 Reduce the load gradually, switch OFF the load switch and stop the prime mover motor.

7 Plot the characteristics graph of generator.



LOAD CHARACTERISTICS DC SERIES GENERATOR

Tabular column:

Sl.No	Induced EMF (E_0)	$I_A = I_F = I_L$	Terminal voltage (V_T)	Speed (RPM)

— — — — —

TASK 3 : **Study the characteristics of DC Shunt Generator**

1 Make the connections of Prime mover AC motor and DC shunt Generator with voltmeter Ammeter as per circuit diagram.

2 Check the connections, start the prime mover AC motor coupled to DC shunt Generator and check residual voltage recorded in the voltmeter.

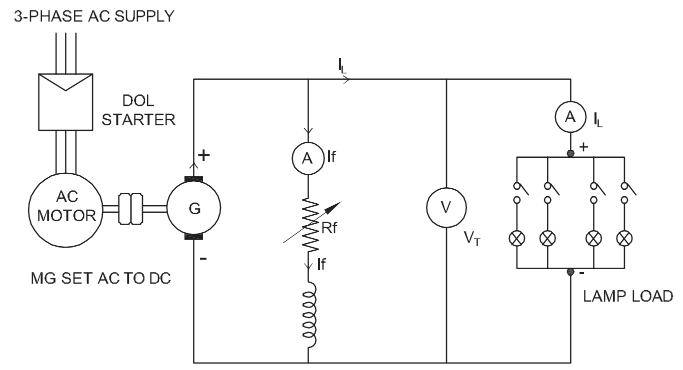
3 Increase the field current in shunt field and build up the voltage in DC shunt generator. Record the rated induced voltage and field current.

4 Now, connect the lamp load across the generator terminals through DPST switch, and increase the load gradually up to rated current of Generator.

5 Record the full load current and terminal voltage.

6 Reduce the load gradually, switch OFF the load switch and stop the prime mover motor.

7 Plot the characteristics graph of generator.



LOAD CHARACTERISTICS DC SHUNT GENERATOR

Tabular column:

Sl.No	Field current (I_F)	Induced EMF (E_0)	Load current (I_L)	Terminal voltage (V_T)	Speed (RPM)

— — — — —

TASK 4 : **Study the characteristics of DC compound Generator**

1 Make the connections of Prime mover AC motor and DC compound Generator with voltmeter Ammeter as per circuit diagram.

2 Check the connections, start the prime mover AC motor coupled to DC compound Generator and check residual voltage recorded in the voltmeter.

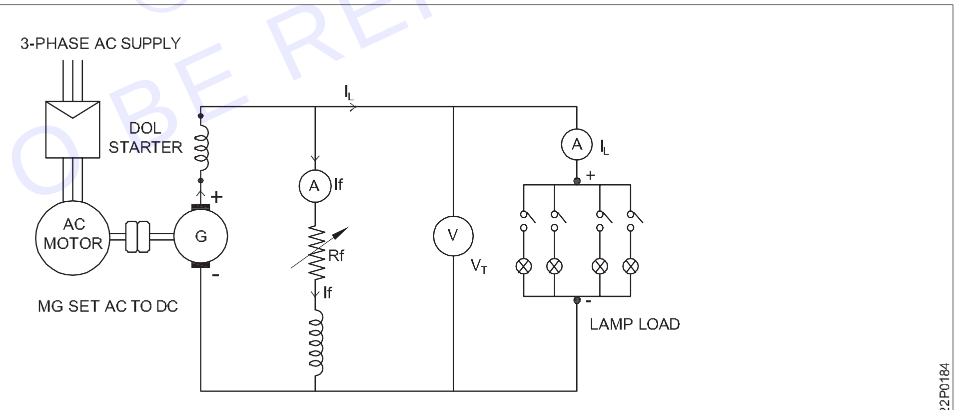
3 Increase the field current in shunt field and build up the voltage in the generator. Record the rated induced voltage and field current.

4 Now, connect the lamp load across the generator terminals through DPST switch, and increase the load gradually up to rated current of Generator.

5 Record the full load current and terminal voltage.

6 Reduce the load gradually, switch OFF the load switch and stop the prime mover motor.

7 Plot the characteristics graph of generator.

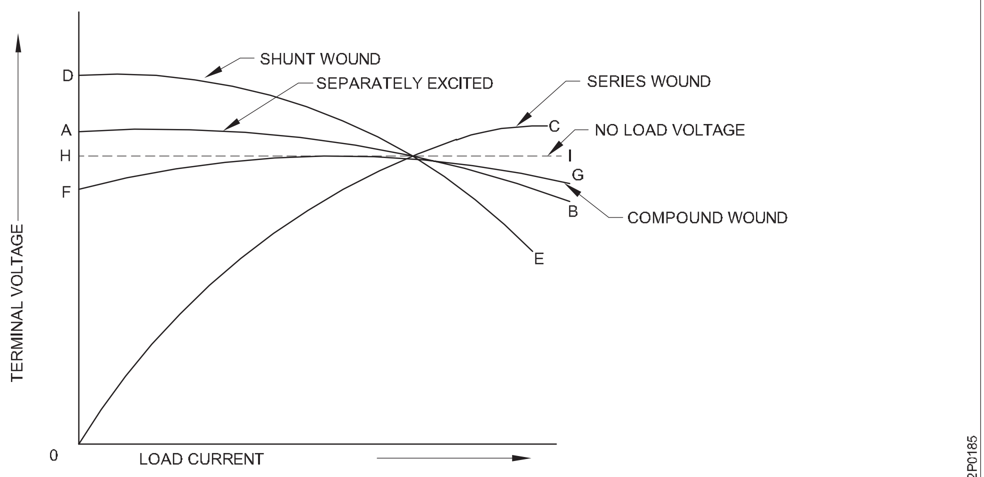


LOAD CHARACTERISTICS DC COMPOUND GENERATOR

Tabular column:

Sl.No	Field current (I_F)	Induced EMF (E_0)	Load current (I_L)	Terminal voltage (V_T)	Speed (RPM)

Conclusion : The characteristics of DC series, shunt and compound generators are different and vary each other. Compare the characteristics of generators from the data recorded in the experiment.



PERFORMANCE CURVES OF DC GENERATOR

Safety precautions:

1 Ensure proper foundation and perfect coupling of MG set, else it may cause severe injury.

2 Ensure proper direction of rotation of DC generator to avoid demagnetizing of field poles and fails to build up voltage.

3 Do not make loose and wrong connections, check the connections before switching ON.

4 Ensure proper earthing to the MG set.

EXERCISE 35 : Manual voltage control in DC Generator

Objectives

At the end of this exercise you shall be able to:

- make the connections of DC Generator
- start & run the Generator, and build up the voltage
- connect the load on DC Generator, and measure the load current & terminal voltage
- control the terminal voltage by varying the field current.

Requirements

Tools/Equipments/Instruments

- Combination Plier 165mm, insulated -1 No.
- Screw Driver 150mm, insulated -1 No.
- Neon Tester 75mm, 500 V -1 No.
- Electrician knife insulated -1 No.
- MG set (AC to DC) with DOL starter,DC shunt Generator 5 KW, 250 V -1 No.
- Voltmeter MC, 250 V -1 No.
- Ammeter MC, 5 A -1 No.
- Ammeter MC, 20 A -1 No.
- Multi meter Digital, $3^{1/2}$ digit -1 No.
- Rheostat 700 Ω, 5A -1 No.
- Tacho meter 3000 RPM -1 No.
- Lamp load 5 KW -1 No.

Materials/Components

- Test lamp 60 W, 230 V -1 No.
- DPST switch 250 V, 32 A -1 No.
- Connecting wire 2.5 sq.mm - as reqd.
- Cotton waste / cloth - as reqd.

Procedure

TASK 1 : **Check the MG set details & terminals**

1 Read and note down the specifications of MG set.

2 Draw the circuit diagram of voltage build up and loading of DC shunt generator.

3 Select the required meters and equipments for the experiment.

— — — — —

TASK 2 : **Starting the Generator and building up voltage**

1 Make the connection of prime mover AC induction motor with DOL starter.

2 Make the connection of DC shunt Generator as per circuit diagram.

3 Check all connections and switch ON the prime mover motor.

4 Now build up the voltage in generator by increasing field current.

5 Record the rated induced voltage, field current and speed of generator.

— — — — —

TASK 3 : **Loading of Generator and manual control the terminal voltage by field rheostat**

1 Connect the lamp load on generator terminals through DPST switch.

2 Close the DPST / load switch, increase the load gradually on the generator and record the load current & terminal voltage.

3 As load current increases on generator, the terminal voltage tends to decrease.

4 Control & maintain the terminal voltage to approx. 250 V by increasing the field current by manually adjusting field rheostat.

5 Now decrease load gradually, and observe the decrease of load current & increase of terminal voltage more than rated voltage.

6 Control the terminal voltage to approx. 250 V by decreasing the field current by manually adjusting field rheostat.

Safety precautions:

1 Ensure proper foundation and perfect coupling of MG set, else it may cause severe injury.

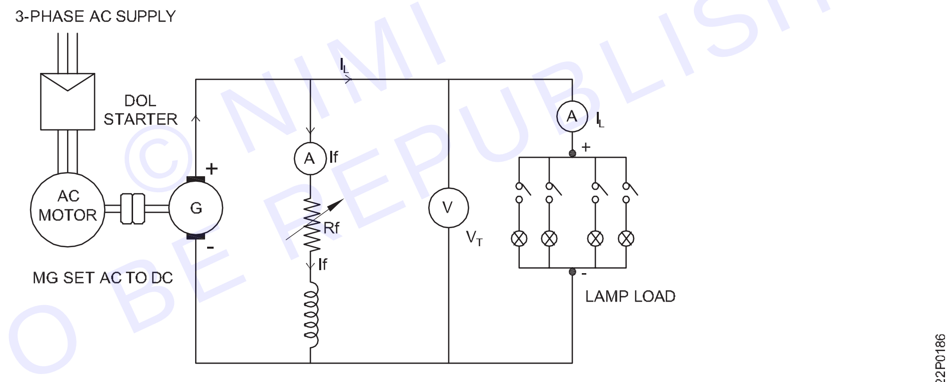
2 Ensure proper direction of rotation of DC generator to avoid demagnetizing of field poles and fails to build up voltage.

3 Do not make loose and wrong connections; check the connections before switching ON.

4 Ensure proper earthing to the MG set.

Tabular column:

Sl.No	Field current (I_F)	Induced EMF (E_0)	Load current (I_L)	Terminal voltage (V_T)	Speed (RPM)



LOAD OF DC GENERATOR AND MANUAL VOLTAGE CONTROL

EXERCISE 36 : To identify the parts of DC Motor

Objectives

At the end of this exercise you shall be able to:

- dismantle and re-assemble of DC Motor
- identify the different parts of DC Motor
- measure the resistance of field coils & armature
- check & identify the terminals of DC Motor.

Requirements

Tools/Equipments/Instruments

- Combination Plier 165mm, insulated -1 No.
- Screw Driver set 150mm, 5 blades -1 No.
- Neon Tester 75mm, 500 V -1No.
- Electrician knife insulated -1 No.
- Spanner set 6 to 32 mm -1 set.
- Allen key set 4 to 8 mm -1 set.
- Ball peen hammer -1 No.
- Bearing puller -1 No.
- Rubber mallet 0.5 kg -1 No.
- Old DC compound Motor 250 V DC -1 No.
- Multi meter Digital, $3^{1/2}$ digit -1 No.

Materials/Components

- Test lamp 60 W, 230 V -1 No.
- Emery paper -1 sheet.
- Cotton waste / cloth - as reqd.

Procedure

TASK 1 : **Check the name plate details of DC Motor**

1 Clean the given DC motor with cotton waste.

2 Read the name plate and record the specifications of DC motor.

3 Place the DC motor on wooden table and make a mark on both sides of end covers & yoke.

— — — — —

TASK 2 : **Dismantling of DC Motor**

1 Unscrew the assembly nut bolts & screws of DC motor with spanner / Allen key.

2 Remove the both side end covers of motor by gently tapping with mallet.

3 Disconnect the terminals of field coils and armature.

4 Carefully remove the carbon brushes from the commutator.

5 Carefully take out the armature assembly without damaging field coils.

— — — — —

TASK 3 : **Identify the parts of DC Motor and re-assemble**

1 Check & identify the parts of DC Motor, viz- Yoke, Armature, commutator, brush, field coils, pole shoe

2 Measure the resistance of shunt field coil, series field coil and armature with multi meter.

3 Check & identify the motor terminals in terminal box.

4 Reassemble the DC Motor in properly.

5 Check the motor for proper mechanical assembly, free rotation of shaft.

6 Clean the machine and keep it in proper place.

Safety precautions

1 Use proper tools for dismantling & assembling the DC motor.

2 Do not hit the yoke, end covers and shaft directly with hammer.

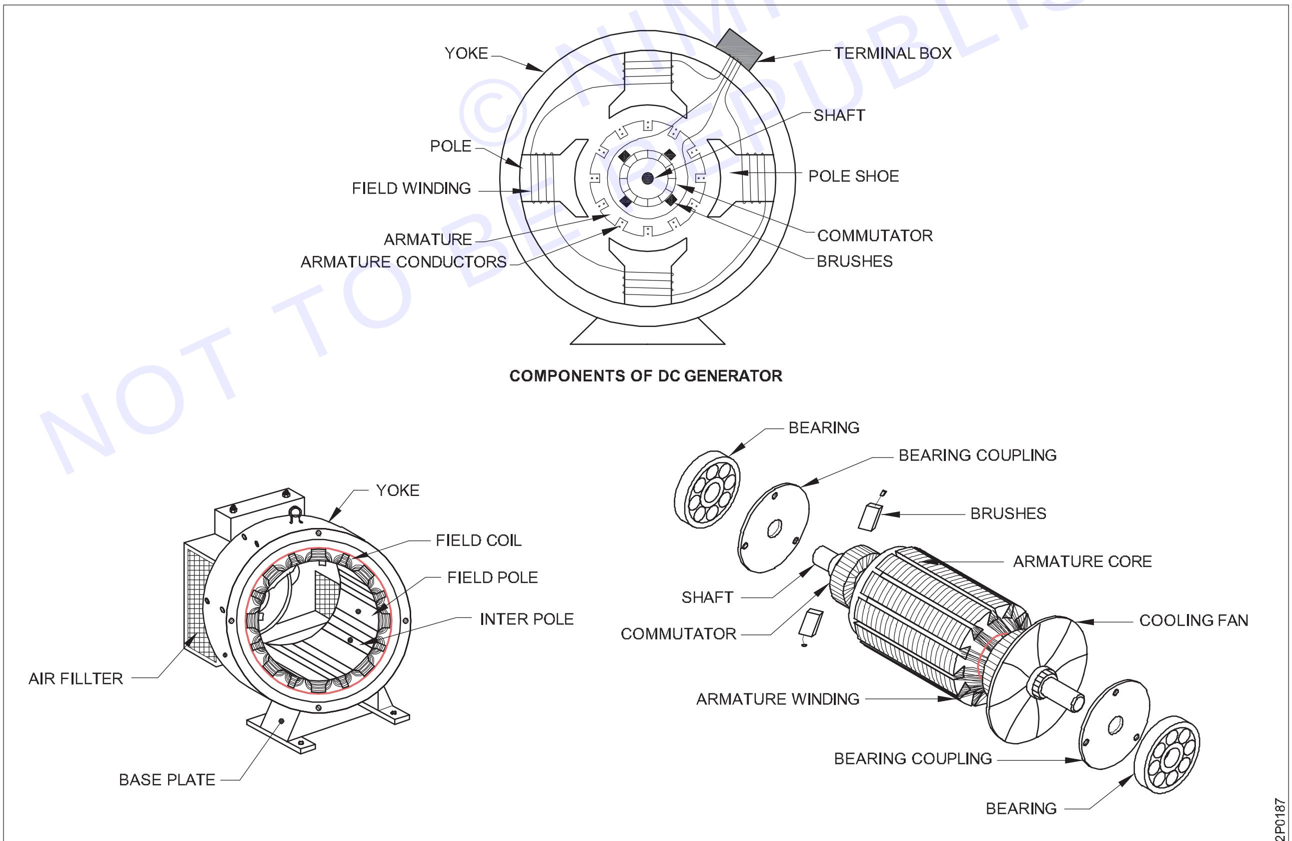
3 Take extreme care while removing armature to avoid damage to field coils.

4 Do not damage the brushes and commutator.

Name Plate Details of DC Motor

Rated Power :	
Voltage rating :	
Current rating :	
Field connection :	
Speed :	
No. of poles :	
Insulation class :	

Parts of DC Motor



PARTS OF DC MOTOR

EXERCISE 37 : To start & run DC series, shunt & compound motors

Objectives

At the end of this exercise you shall be able to:

- check the terminals & connections of DC series, shunt and compound motors
- start & run the series, shunt and compound motors with DC starters
- apply the mechanical load on DC motors and measure the speed & torque.

Requirements

Tools/Equipments/Instruments

- Combination Plier 165mm, insulated -1 No.
- Screw Driver 150mm, insulated -1 No.
- Neon Tester 75mm, 500 V -1 No.
- Electrician knife insulated -1 No.
- DC series motor with mechanical load arrangement 3 HP, 250 V -1 set.
- DC compound motor with mechanical load arrangement 3 HP, 250 V -1 set.
- DC starter-2 point, 3 point, 3 point 3 HP, 250 V -Each 1 No.
- Voltmeter MC, 250 V -1 No.
- Ammeter MC, 5 A -1 No.
- Ammeter MC, 20 A -1 No.
- Multi meter Digital, $3^{1/2}$ digit -1 No.
- Rheostat 700 Ω, 5A -1 No.
- Tacho meter 3000 RPM -1 No.
- DC power supply unit 30 A, 250 V -1 No.

Materials/Components

- Test lamp 60 W, 230 V -1 No.
- DPST switch 250 V, 32 A -1 sheet.
- Connecting wire 2.5 sq.mm - as reqd.
- Cotton waste / cloth - as reqd.

Procedure

TASK 1 : **Check the terminals of DC Motors**

1 Check & read the specifications of DC series, shunt and compound motors

2 Check and identify motor terminals, measure the resistance of armature & field coils.

3 Draw the connection diagram of start & run of DC series, shunt and compound motors.

— — — — —

TASK 2 : **Start & run of DC Series motor**

1 Make the connections of DC series motor with 2 point starter as per circuit diagram.

2 Apply the mechanical load on the motor (Never start DC series motor without load).

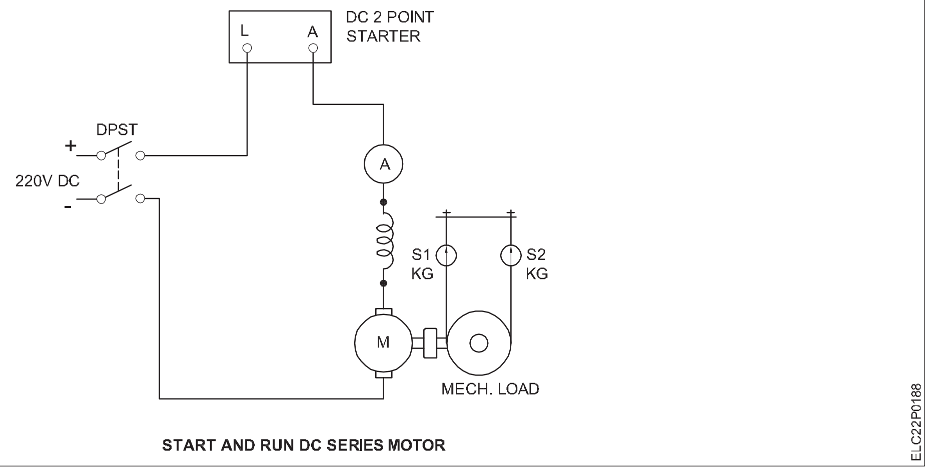
3 Check the connections & connect the motor to DC power supply unit through DPST switch.

4 Start the motor by operating DC 2 point starter.

5 Record the starting & running current, voltage and speed of the motor.

6 Reduce the load slightly and check the speed of motor by tacho meter. (Note- Never reduce the mechanical load fully when motor is running)

7 Switch OFF the supply and disconnect the motor.



START AND RUN DC SERIES MOTOR

Tabular column:

Sl.No	Supply Voltage (V)	Starting Current (I_S)	Load/Running Current (I_L)	Speed(RPM)

— — — — —

TASK 3 : **Start & run of DC Shunt motor**

1 Make the connections of DC shunt motor with 3 point starter as per circuit diagram.

2 Ensure that there is no mechanical load on the motor (Do not start DC shunt motor with load).

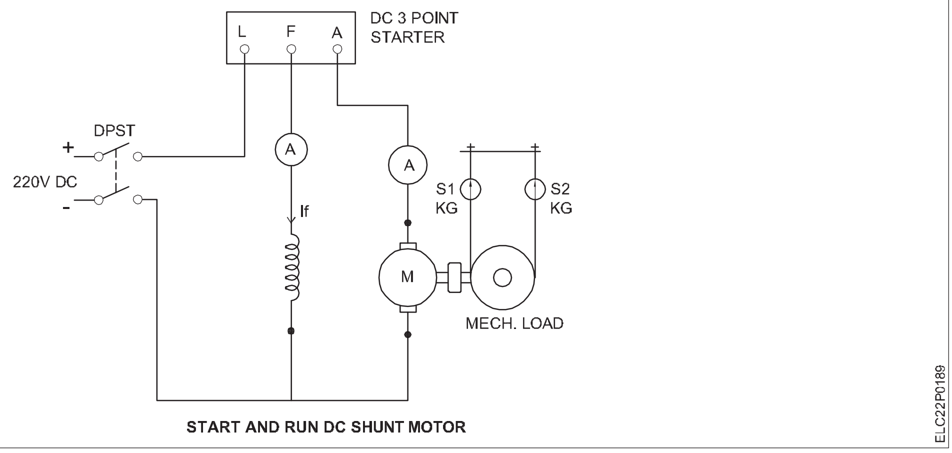
3 Check the connections & connect the motor to DC power supply unit through DPST switch.

4 Start the motor by operating DC 3 point starter.

5 Record the starting & running current, voltage and speed of the motor.

6 Now apply the mechanical load gradually on the motor and check the speed of motor by tacho meter. (Note- do not over load the motor as shunt motor is not capable to heavy load).

7 Switch OFF the supply and disconnect the motor.



START AND RUN DC SHUNT MOTOR

Tabular column:

Sl.No	Supply Voltage (V)	Starting current (I)	Field current (I_F)	Load current (I_L)	Speed (RPM)

— — — — —

TASK 4 :**Start & run of DC compound motor**

1 Make the connections of DC compound motor with 4 point starter as per circuit diagram.

2 Ensure that there is no mechanical load on the motor. (However, motor can be started with nominal load).

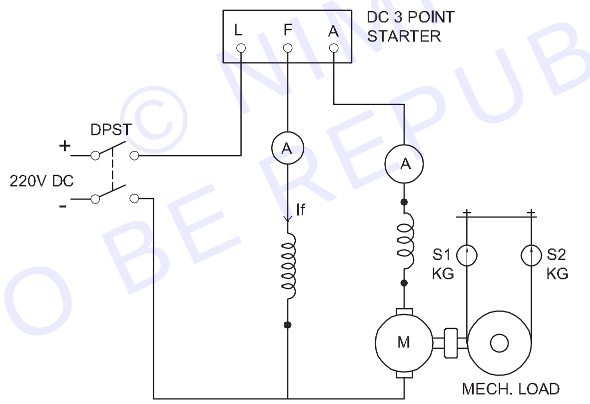
3 Check the connections & connect the motor to DC power supply unit through DPST switch.

4 Start the motor by operating DC 4 point starter.

5 Record the starting & running current, voltage and speed of the motor.

6 Now apply the mechanical load gradually on the motor and check the speed of motor by tacho meter. (Note- Compound motor is capable to take heavy loads).

7 Switch OFF the supply and disconnect the motor.



START AND RUN DC SHUNT MOTOR

ELC22P0190

Tabular column:

Sl.No	Supply Voltage (V)	Starting current (I)	Field current (I_F)	Load current (I_L)	Speed (RPM)

Safety precautions:

1 Ensure proper foundation & fixing of DC motors.

2 Never start DC series motor without mechanical load.

3 Never start DC motors without starter & protective MCB.

4 Ensure proper earthing for motors.

5 Do not load the motors excessively.

MODULE 7: Electrical Power, Power Factor & Electrical Energy

EXERCISE 38 : To measure the 3 Ph. Power by two wattmeter method

Objectives

At the end of this exercise you shall be able to:

- check the terminals & connection of 3 ph. Wattmeter
- make the connection of 3 phase resistive and inductive load
- measure the power in balanced / unbalanced 3 Ph. Circuits.

Requirements

Tools/Equipments/Instruments

- Combination Plier 165mm, insulated -1 No.
- Screw Driver 150mm, insulated -1 No.
- Neon Tester 75mm, 500 V -1 No.
- Electrician knife insulated -1 No.
- Voltmeter MI, 0 - 600 V -2 No's.
- Ammeter MI, 10 A -2 No's.
- Poly Ph. Watt meter, UPF MI, 600V, 2KW -2 No's.
- Poly Ph. Watt meter, LPF MI, 600V, 2KW -2 No's.
- 3 Ph. Auto transformer 0 - 460 V -1 No.
- Multi meter Digital, $3^{1/2}$ digit -1 No.
- 3 Ph. Resistive load 5 KW -1 No.
- 3 Ph. Inductive load 3 KW -1 No.

Materials/Components

- Test lamp 60 W, 230 V -1 No.
- TPST switch 415 V, 32 A -1 No.
- Connecting wire 2.5 sq.mm -as reqd.
- Cotton waste / cloth - as reqd.

Procedure

TASK 1 : **Identify the 3 ph load and watt meters**

1 Draw the circuit diagram of 3 Ph. Power measurement by two watt meter method.

2 Check and identify the type of 3 Ph. Loads - inductive & resistive, type of connection & rating.

3 Check and identify the Watt meters - Type (UPF/LPF), terminals and voltage & current rating.

— — — — —

TASK 2: **Connect & measure the power in 3 Ph. Balanced & unbalanced load**

1 Make the connections as per the circuit diagram.

2 Check the connections and set the knob of 3 Ph. Auto transformer to zero position.

3 Connect 3 Ph. Input supply and switch ON the TPST switch.

4 Make sure that load switch is OFF, and slowly rotate the knob to set the line voltage (415 V) in 3 ph. Auto transformer.

5 Record the line voltage (415 V) readings in voltmeter.

6 Close load switch and apply approximately balanced resistive load.

7 Take the readings of wattmeter 1 & 2 and ammeters and record in the tabular column. (Note: For balanced load ammeters and both watt meters shows equal readings)

8 Switch OFF the mains, and connect the unbalanced load of both resistive & inductive.

9 Switch ON the supply and take the readings of wattmeter 1 & 2 and ammeters and record in the tabular column. (Note: For unbalanced load ammeters and both watt meters shows unequal readings).

10 Switch OFF the main supply, disconnect the circuit.

11 Calculate the total power (P) consumed in both 3 ph. Loads, as per recorded readings.

Important observations:

1 If the load power factor is unity, both watt meters W_1 & W_2 shows equal readings. Then total power of 3 Ph. Load is **$P = W_1 + W_2$ watts**

2 If the load power factor is lies between 0.5 & unity, watt meters W_1 & W_2 shows unequal readings. Now also, total power of 3 Ph. Load is **$P = W_1 + W_2$ watts**.

3 If the load power factor is exactly 0.5, only one watt meter W_1 or W_2 shows reading and other doesn't. Now, total power of 3 Ph. Load is **P= Reading of one watt meter**.

4 If the load power factor is less than 0.5, the needle of one of the watt meter kicks back. In that case Interchange the terminals of CC or PC of that particular watt meter and after which reading recorded by that wattmeter should be taken Negative value. In this case the total power **$P = W_1 - W_2$ watts**.

5 The power factor (PF) of the circuit / load is determined by the equation,

$$\frac{W_1 - W_2}{W_1 + W_2} = \frac{V_L I_L \sin\varphi}{\sqrt{3}\, V_L I_L \cos\varphi}$$

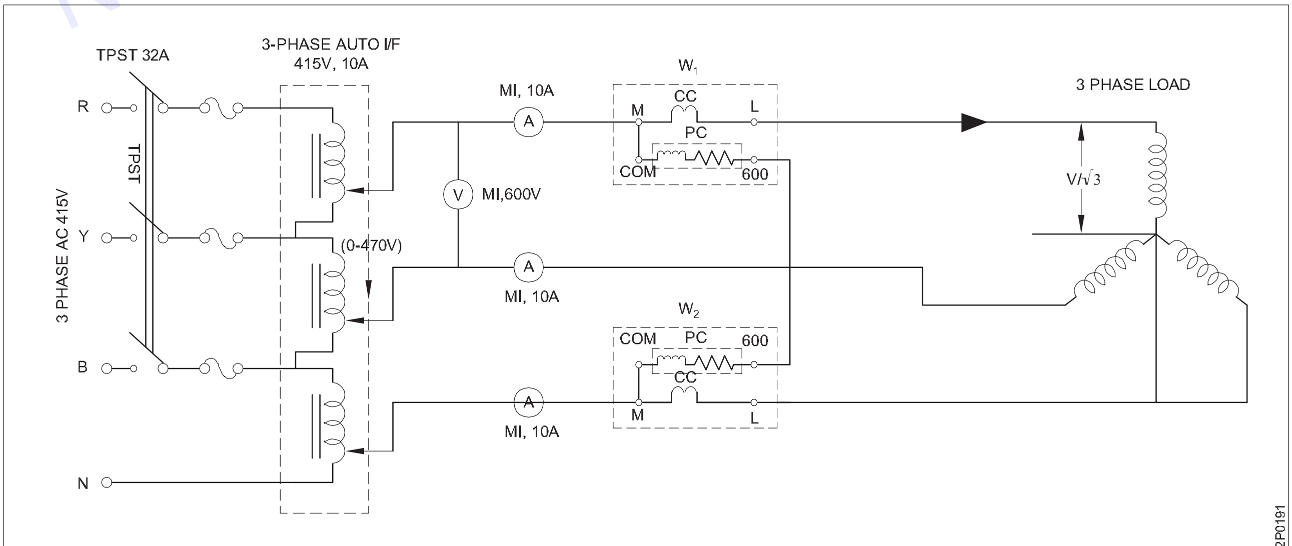
OR

$$\tan\varphi = \sqrt{3}\,\frac{W_1 - W_2}{W_1 + W_2}$$

Tabular column:

Type of load	Line voltage (V_L)	Line current (I)			Power (P) in watts		Total power $P = W_1 + W_2$	Cos φ= $\tan\varphi = \sqrt{3}\,\frac{W_1 - W_2}{W_1 + W_2}$
		(I_R)	(I_Y)	(I_B)	W_1	W_2		
Resistive Balanced								
Resistive + inductive Unbalanced								

Circuit Diagram:



MEASUREMENT OF 3-PHASE POWER BY TWO WATTMETER METHOD

Safety precautions:

1 Do not make wrong and loose connections.

2 Make sure that, knob of auto transformer is at zero position before switching ON the main supply.

3 Ensure that the voltage and current flow must be within the range of meters.

4 Ensure proper earthing for all the equipments.

EXERCISE 39 : To measure and improve the Power factor of AC circuit

Objectives

At the end of this exercise you shall be able to:

- identify the power factor meter, check its terminals, scale, rating and connection
- connect the inductive & resistive loads in AC circuit and measure the power factor
- connect the required value of capacitors to improve the power factor in AC circuits.

Requirements

Tools/Equipments/Instruments

- Combination Plier 165mm, insulated -1 No.
- Screw Driver 150mm, -1 No.
- Neon Tester 75mm, 500 V -1 No.
- Electrician knife insulated -1 No.
- Voltmeter MC, 300 V -1 No.
- Ammeter MI, 10 A -1 No.
- 1 Ph. Power factor meter, Analog 10 A, 230 V -1 No.
- Multi meter Digital, $3^{1/2}$ digit -1 No.
- Resistive (lamp) load 1 Ph. 230V, 5KW -1 No.
- Inductive load (Ind. Motors, choke) 1 Phase, 230 V -1 No.

Materials/Components

- PVC copper wire 1.5 sq.mm -2 meter.
- Static capacitors 2.5 μf 400 V,5 μf 400 V -Each 4 Nos.
- Test lamp 100 W, 230V -1 No.
- DPST switch 16 A, 230 V -1 No.

Procedure

TASK 1 : **Identify the resistive & inductive loads & PF meters**

1 Draw the neat circuit diagram of measurement of power factor in 1 Ph. AC resistive load, Inductive load and capacitive load.

2 Check & study the Power factor meter- check the terminals, scale, rating & connection.

3 Collect the different static capacitors and check their values

4 Calculate the VAR / KVAR value of capacitors required to improve the power factor of AC circuit.

— — — — —

TASK 2 : **Connect and measure the power factor in AC resistive & inductive circuits**

1 Make the circuit connection of resistive load as per circuit diagram.

2 Check the circuit and connect to 1 Ph. AC supply through DPST switch.

3 Switch ON the supply, check the power factor meter reading and record in tabular column

4 Switch OFF the supply and make the circuit connection of inductive load as per circuit diagram.

5 Switch ON the supply, check the power factor meter reading and record in tabular column.

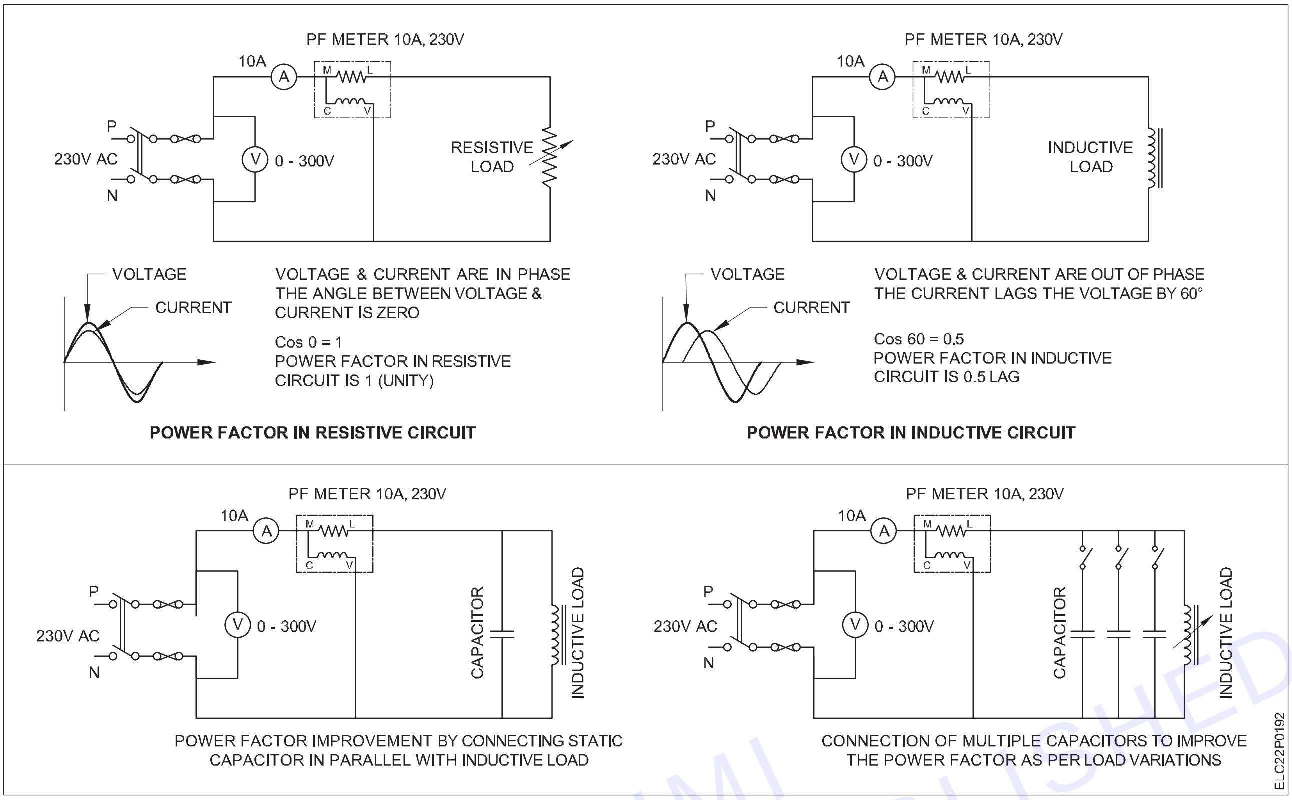
6 Switch OFF the supply, and connect one static capacitor in parallel with inductive load.

7 Switch ON the supply and check the change in power factor meter reading & record the same.

8 Connect multiple No. of capacitors until the power factor improves to 1 (unity).

9 Check the ammeter reading for decrease in current when power factor value comes to 1 (unity).

10 Switch OFF the supply and disconnect the circuit.



Tabular column:

Type of load	Voltage (V)	Current (I)	Power factor (cos j)	PF observation
Resistive	230 V	1 Amp	1	1 (Unity) Ideal
Inductive	230 V	1.5 Amp	0.5	0.5 lagging Poor
Inductive + capacitive (1 capacitor parallel with load)	230 V	1.2 Amp	0.8	0.8 lagging
Inductive + capacitive (2 capacitors parallel with load)	230 V	1 Amp	1	1 (Unity) Ideal
Inductive + capacitive (4 capacitors parallel with load)	230 V	1.3 Amp	0.8	0.8 leading Over excited

Safety precautions:

1 Do not make wrong and loose connections.

2 Do not connect higher value and more No. of capacitors which causes high current in the circuit.

3 Do not touch the capacitor terminals without discharging.

4 Take the meter reading correctly.

EXERCISE 40 : To measure the Electrical energy in single Ph. load

Objectives

At the end of this exercise you shall be able to:

- check & identify the terminals and parts of 1 Ph. Energy meter, check meter constant
- connect the energy meter to 1 Ph. Supply with lighting load
- measure the energy recorded in energy meter for given load and time.

Requirements

Tools/Equipments/Instruments

- Combination Plier 165mm, insulated -1 No.
- Screw Driver 150mm, -1 No.
- Neon Tester 75mm, 500 V -1 No.
- Electrician knife insulated -1 No.
- KWH meter 1 Ph. 240V, 10A -1 No.
- Voltmeter MC, 300 V -1 No.
- Ammeter MI, 10 A -1 No.
- Multi meter Digital, $3^{1/2}$ digit -1 No.
- Lamp load 1 Ph. 230V, 5KW -1 No.
- Stop watch -1 No.

Materials/Components

- PVC copper wire 1.5 sq.mm -2 meter.
- Test lamp 100 W, 230V -1 No.
- DPST switch 16 A, 230 V -1 No.

Procedure

TASK 1: **Check & identify the terminals, meter constant of Energy meter**

1 Draw the circuit diagram of measurement of electrical energy in 1 Ph. load

2 Check the 1 Ph. Energy meter, record the meter constant, voltage & current rating, initial reading.

3 Check the terminals, resistance of current coil & potential coil of energy meter with multi meter.

— — — — —

TASK 2: **Connect the Energy meter and measure the Electrical energy**

1 Make the connection of energy meter and load as per circuit diagram.

2 Check the connections and connect the circuit to 1 Ph. Supply through DPST switch.

3 Switch ON the main supply, keep the load switch OFF and observe any disc vibrations OR very slow disc rotation of energy meter on No-load.

Note: When load is OFF if a very small disc rotation is found it is known as creeping error of meter.

4 Note down the initial reading and meter constant (K) of energy meter.

5 Close the load switch and increase the lamp load up to 10 Amp

6 Record the voltmeter and ammeter readings, observe the disc rotation.

7 Start the Stop watch and count 50 No. of disc revolutions of energy meter, and record the time taken for 50 disc revolutions.

8 After completion of 50 disc revolutions switch OFF the load and record the final reading of energy meter.

9 Switch OFF the supply and disconnect the circuit.

10 Calculate the true energy & recorded energy as per formula given in tabular column.

11 Compare the true energy & recorded energy which must be approximately equal.

12 Repeat the experiment with another energy meter and compare the result.

Electrical Energy = Power X Time OR E = V x I x t

Electrical Energy = Kilo Watt Hour (KWH)

1 KWH = 1 Unit

Tabular column:

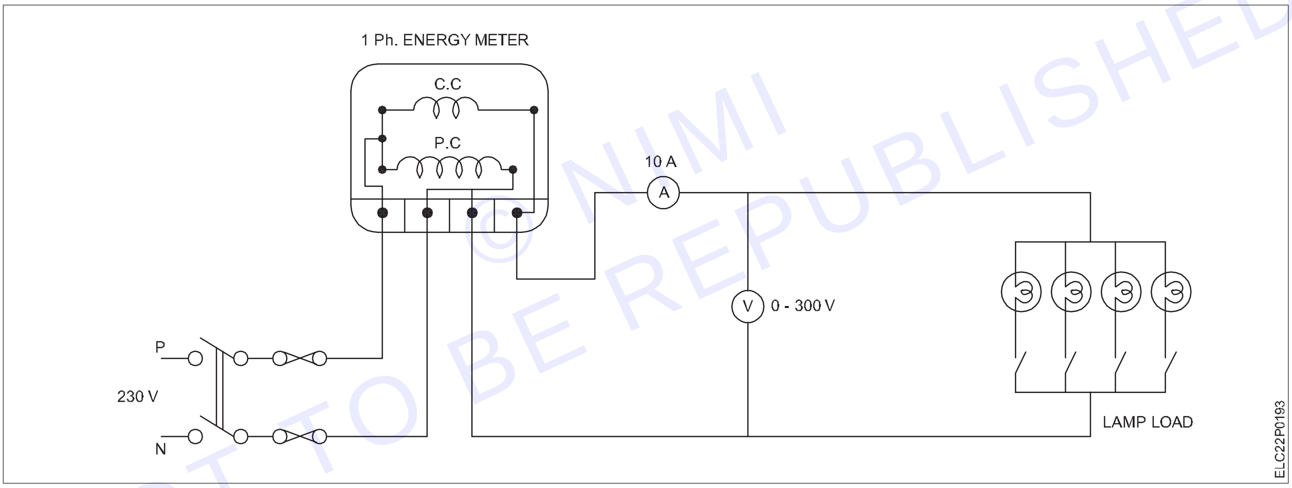
	Voltage (V)	Current (I)	Time (t) in sec	Meter Constant (K)	No. of disc Revolution (N)	True energy TE = V x I x t	Recorded energy RE=N/K
Energy meter 1	230			1500	50		
Energy meter 2	230			3200	100		

Safety precautions:

1 Handle the energy meter carefully.

2 Do not make wrong and loose connections

3 Do not exceed the load current of energy meter.



MODULE 8: Transformer Connection and Testing

EXERCISE 41 : To measure the transformation ratio of single ph. transformer

Objectives

At the end of this exercise you shall be able to

- identify the different types of transformers and their rating
- identify the primary and secondary winding, type of core of transformer
- connect the transformer to supply and measure primary & secondary voltage
- measure the transformation ratio of transformer.

Requirements

Tools/Equipments/Instruments

- Combination Plier (165mm, insulated) - 1 No.
- Screw Driver (150mm, insulated stem) - 1 No.
- Neon Tester (75mm, 500 V) - 1 No.
- Electrician knife (Insulated) - 1 No.
- Voltmeter (MI, 300 V) - 2 Nos.
- 1 Ph. Step up Transformer (110V/220V) - 1 No.
- 1 Ph. Step down Transformer (230V/115V) - 1 No.
- Multi meter (Digital, $3^{1/2}$ digit) - 1 No.
- 1 Ph. Auto transformer (0-260 V) - 1 No.

Materials/Components

- PVC copper wire (1.5 sq.mm) - 2 meter.
- Test lamp (100 W, 230V) - 1 No.
- Insulation tape (PVC, 19mm) - 1 role.
- Cotton waste - as reqd.

Procedure

TASK 1 : **Identify primary & secondary of transformer**

1 Collect the Tools, equipments and materials required for experiment.

2 Draw the connection diagram of single phase transformer.

3 Check and identify primary & secondary windings and type of core of transformers.

4 Check the primary & secondary voltage rating of transformers in the name plate.

5 Identify the step up OR step down transformer as per primary & secondary voltage ratings.

— — — — —

TASK 2 : **Connecting step up transformer and measure transformation ratio**

1 Make the connection of step up transformer as per circuit diagram.

2 Check the connections and connect the transformer to the supply through the variac.

3 Switch ON the supply and record the primary & secondary voltages.

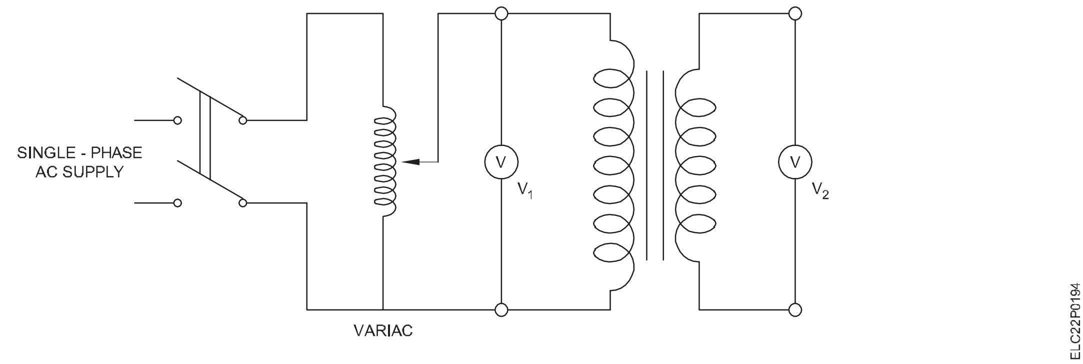
4 Switch OFF the supply and disconnect the transformer.

5 Calculate the transformation ratio of transformer as per equation.

— — — — —

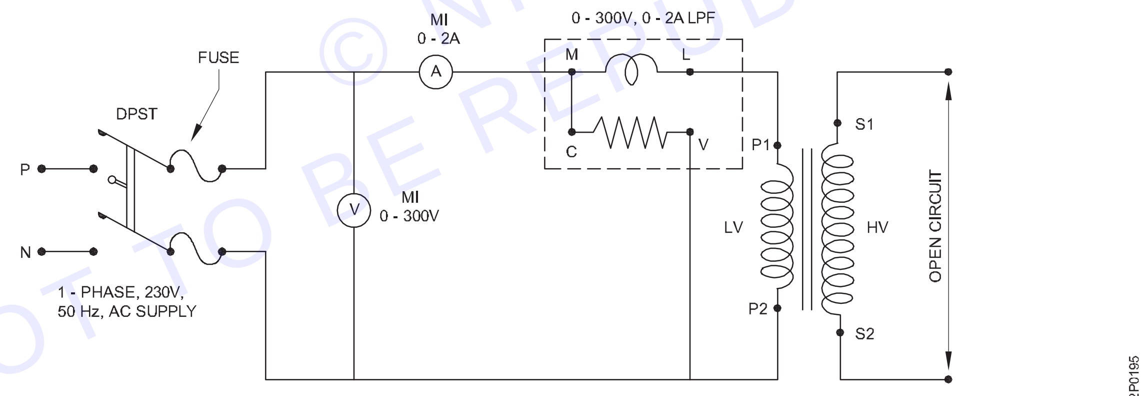
$$\frac{V_2}{V_1} = \frac{N_2}{N_1} = K \qquad \frac{V_1}{V_2} = \frac{I_2}{I_1} = \frac{1}{K}$$

$$\therefore \frac{I_1}{I_2} = \frac{V_2}{V_1} = \frac{N_2}{N_1} = K$$



TASK 3: **Connecting step down transformer and measure transformation ratio**

1 Make the connection of step down transformer as per circuit diagram.
2 Check the connections and connect the transformer to the supply through the variac.
3 Switch ON the supply and record the primary & secondary voltages.
4 Switch OFF the supply and disconnect the transformer.
5 Calculate the transformation ratio of transformer.



OPEN CIRCUIT TEST OF TRANSFORMER

Tabular column:

Transformer Type	**Primary Voltage (V1)**	**Secondary voltage (V2)**	**Transformer ratio (K)** $K=\frac{V2}{V1}$	**Remarks**
Step up				If K > 1 step up transformer
Step down				If K < 1 step down transformer
Isolation T/f				If K = 1 Isolation transformer

Safety precautions:

1 Do not make wrong and loose connections.

2 Check & ensure the input supply voltage of transformer before connecting to supply.

3 Select proper range of voltmeters.

EXERCISE 42 : To conduct OC and SC test of transformer

Objectives

At the end of this exercise you shall be able to

- identify the HV & LV terminals of transformer, and check KVA of transformer.
- make the connections of transformer with wattmeter, voltmeter & ammeter.
- conduct open circuit test & short circuit test of transformer.
- measure the iron losses & copper losses of transformer.

Requirements

Tools/Equipments/Instruments

- Combination plier (165mm, insulated) - 1 No.
- Screw Driver (150mm, insulated) - 1 No.
- Neon Tester (75mm, 500 V) - 1 No.
- Electrician knife (Insulated) - 1 No.
- Voltmeter (MI, 0 - 600 V) - 1 No.
- Voltmeter (MI, 0 - 300 V) - 1 No.
- Ammeter (MI, 0 - 10 A) - 2 Nos.
- 1 Ph. Watt meter (MI, 2KW) - 1 No.
- 1 Ph. Transformer (1 KVA, 415 V/230 V) - 1 No.
- Multi meter (Digital, $3^{1/2}$ digit) - 1 No.
- 1 Ph. Auto transformer (0 - 260 V, 10 A) - 1 No.

Materials/Components

- Test lamp (60 W, 230 V) - 2 meter.
- DPST switch (250 V, 32 A) - 1 No.
- Connecting wire (2.5 sq.mm) - 1 role.
- Cotton waste / cloth - as reqd.

Procedure

TASK 1 : **Identify the HV & LV terminals of transformer**

1 Collect the Tools, equipments & materials required for experiment.

2 Draw the circuit diagram of OC test and SC test of transformer.

3 Check and identify the HV & LV side and KVA rating of transformer.

4 Check the voltage rating of HV & LV side of transformer.

— — — — —

TASK 2 : **Conduct OC test of transformer**

1 Make the connection of OC test of transformer as per circuit diagram.

2 Connect LV side of transformer to the supply.

3 Ensure that all meters are connected on LV side and HV side terminals are is kept open.

4 Check the connections and switch ON the supply.

5 Record the readings of voltmeter, ammeter and watt meter.

6 Switch OFF the supply and disconnect the transformer and meters.

— — — — —

TASK 3 : **Conduct SC test of transformer**

1 Make the connection of SC test of transformer as per circuit diagram.

2 Connect HV side of transformer to the supply through the auto transformer.

3 Ensure that all meters are connected on HV side and LV side terminals are shorted with thick copper conductor OR connected with ammeter.

4 Check the connections and ensure that auto transformer knob in zero position..

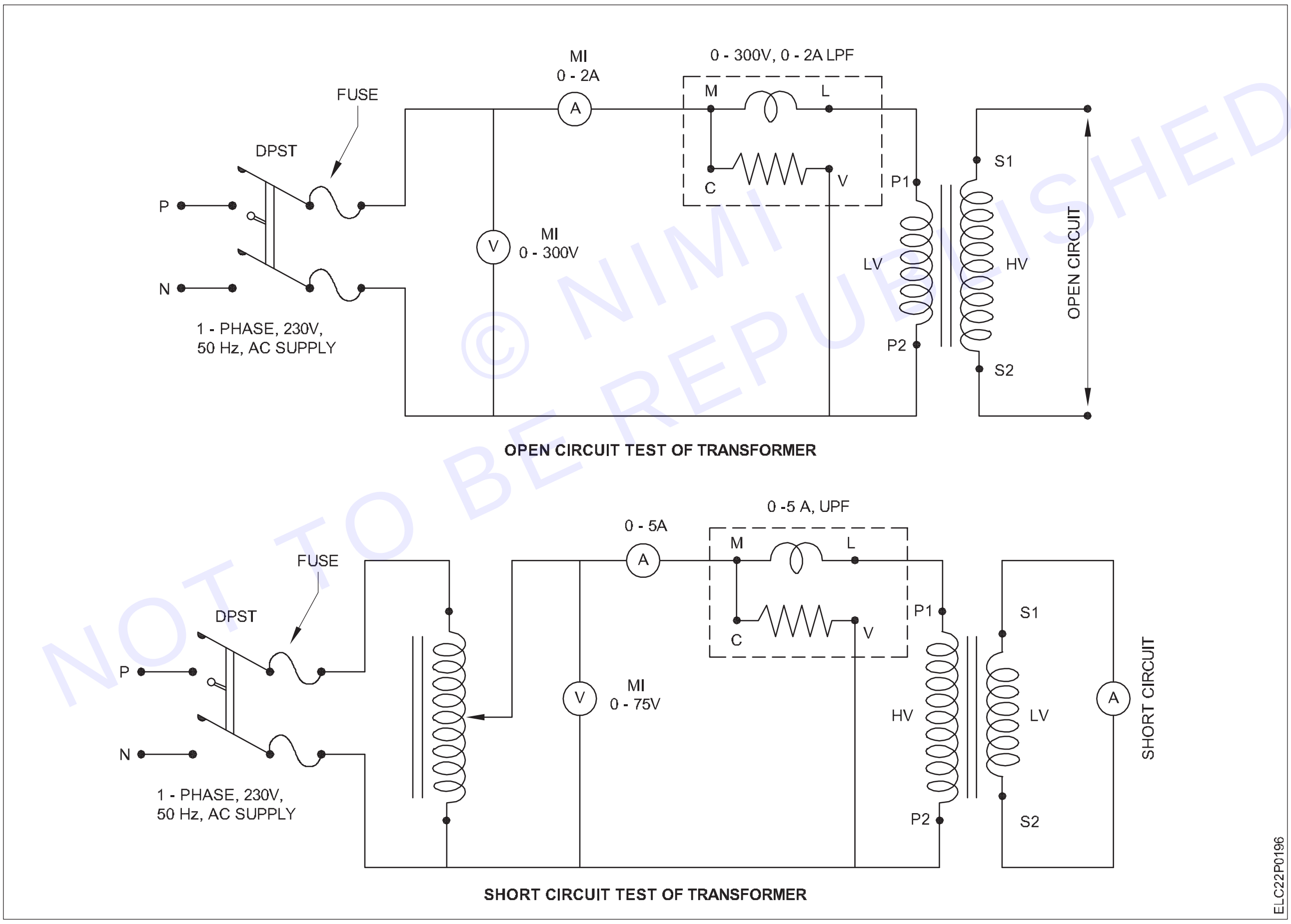
5 Switch ON the supply and slowly increase the voltage in auto transformer until LV side ammeter reads rated full load current of transformer.

6 Record readings of voltmeter, ammeter and watt meter.

7 Switch OFF the supply and disconnect the transformer and meters

Tabular column:

	Voltage (V)	**Current (I)**	**Watts (W)**	**Total loss**
OC Test to measure iron losses (WI)				$W_T = W_I + W_C$
SC Test to measure copper losses (WC)				



OPEN CIRCUIT TEST OF TRANSFORMER

SHORT CIRCUIT TEST OF TRANSFORMER

Safety precautions:

1 Do not make loose & wrong connections.

2 Do not apply more voltage while conducting SC test.

3 Check the voltage range of watt meter before switching ON the circuit .

4 While conducting SC test do not short the LV terminals for long time, it may overheat and damage the transformer.

EXERCISE 43 : Loading and determine the efficiency of single phase transformer

Objectives

At the end of this exercise you shall be able to

- check the primary & secondary voltage and KVA of transformer
- connect and apply resistive & inductive load on transformer
- calculate the losses occurred in transformer and find the efficiency of transformer
- calculate the efficiency of transformer at different loads and power factor.

Requirements

Tools/Equipments/Instruments

- Combination plier (165mm, insulated) - 1 No.
- Screw Driver (150mm, insulated stem) - 1 No.
- Neon Tester (75mm, 500 V) - 1 No.
- Electrician knife (Insulated) - 1 No.
- Voltmeter (MI, 300 V) - 2 Nos.
- Ammeter (MI, 10 A) - 2 Nos.
- Watt meter (MI, 10A, 400 V) - 2 Nos.
- 1 Ph. Transformer (400V/230V) - 1 No.
- Lamp load (250 V, 5 KW) - 1 No.
- Inductive load (AC motor) (230V, 2 HP) - 1 No.

Materials/Components

- PVC copper wire (1.5 sq.mm) - 2 meter.
- Test lamp (100 W, 230V) - 1 No.
- Insulation tape (PVC, 19mm) - 1 role.
- Cotton waste - as reqd.

Procedure

TASK 1 : **Identify the rating of transformer**

1 Collect the Tools, equipments and materials required for experiment.

2 Draw the connection diagram of loading & efficiency of 1 ph. transformer.

3 Check the primary & secondary voltages and KVA of transformer.

4 Identify HV & LV side and check full load current of transformer.

5 Collect the data of total losses of transformer determined by OC & SC test.

— — — — —

TASK 2 : **Connecting and loading of transformer**

1 Make the connection of transformer with all meters and lamp load.

2 Check the connections and connect HV winding of transformer to the supply.

3 Switch ON the supply and record the reading of voltmeter, ammeter and watt meter on HV & LV side.

4 Close the load switch on LV side and increase the load step by step until full load current of transformer.

5 Record the reading of voltmeter, ammeter and watt meter at each steps.

6 Connect the inductive load on the transformer and repeat the steps 2 to 5.

7 Switch OFF the supply, disconnect the circuit & transformer.

TASK 3 : **Calculate the efficiency of transformer**

1 Record all the readings in the tabular column.

2 Calculate primary input power as per readings recorded by voltmeter & ammeter on primary side of transformer.

3 Similarly, calculate secondary output power as per readings recorded by voltmeter & ammeter on secondary side of transformer.

4 Compare both calculations with primary & secondary watt meter (W1 & W2) readings.

5 Record the total losses of transformer (WT) determined by previous experiment OC & SC test of transformer.

6 Now, calculate the efficiency of transformer by the formula

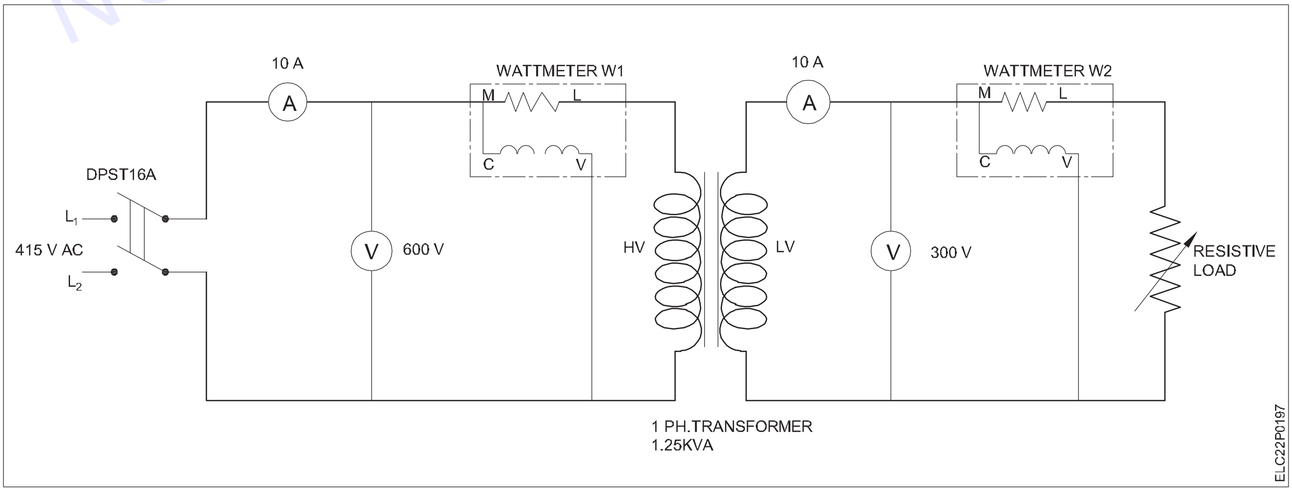
Tabular column

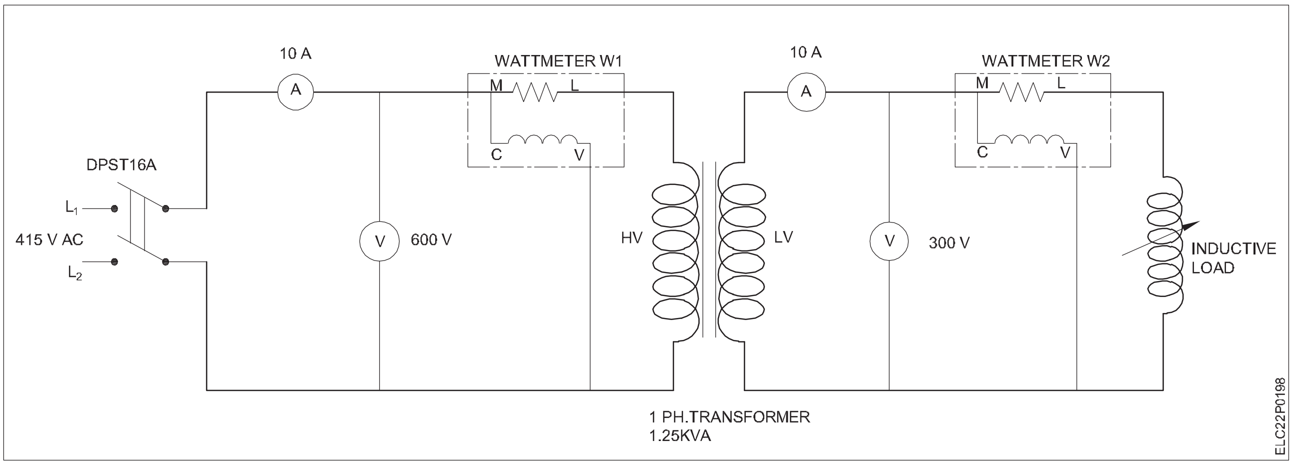
Load	Primary			Secondary					
	Voltage (VP)	Current (IP)	Watts (WP)	Voltage (VS)	Current (IS)	Watts (WS)	Power factor	Total Losses (WT)	Efficiency of T/f
25%									
50%									
75%									
100%									

$$\text{Efficiency} = \frac{\text{Power Output}}{\text{Power Input}} = \frac{P_S}{P_P} \times 100$$

$$\text{Efficiency} = \frac{\text{Power Output}}{\text{Power Output} + \text{Copper Loss} + \text{Core Loss}} \times 100$$

$$\text{Efficiency} = \frac{V_S\ I_S \times PF}{(V_S\ I_S \times PF) + \text{Copper Loss} + \text{Core Loss}} \times 100$$





Safety precautions:

1 Use proper and insulated tools.

2 Do not make wrong and loose connections.

3 Do not over load the transformer.

4 Select proper range in voltmeter, ammeter and watt meters.

EXERCISE 44 : To conduct parallel operation of two 1 ph. transformers

Objectives

At the end of this exercise you shall be able to

- identify the similar terminals and measure the impedance of transformer.
- check the voltage, frequency, impedance and phase sequence of transformers.
- connect two identical transformers in parallel and test.
- apply the load on transformers connected in parallel and observe the load sharing.

Requirements

Tools/Equipments/Instruments

- Combination plier (165mm, insulated) - 1 No.
- Screw driver (150mm, insulated stem) - 1 No.
- Neon Tester (75mm, 500 V) - 1 No.
- Electrician knife (Insulated) - 1 No.
- Voltmeter (MI, 400 V) - 2 Nos.
- Ammeter (MI, 10 A) - 2 Nos.
- 1 Ph. Transformer (400V/230V, 1 KVA) - 2 Nos.
- Multi meter (Digital, $3^{1/2}$ digit - 1 No.
- Lamp load - 1 No.

Materials/Components

- PVC copper wire (1.5 sq.mm) - 2 meter.
- Test lamp (100 W, 230V) - 1 No.
- DPST switch (16 A, 230 V) - 1 No.
- Cotton waste - as reqd.

Procedure

TASK 1 : **Check the terminals & sequence of both transformers**

1 Collect the Tools, equipments and materials required for experiment.

2 Draw the circuit diagram of parallel operation of 1 ph. transformer.

3 Check and identify the voltage, current and KVA rating of transformers.

4 Check & identify the primary & secondary similar terminals of transformer and mark the terminals numbers with marker.

5 Place both transformers side by side and primary terminals facing towards incoming line bus-bar, and secondary terminals facing towards load circuit.

6 Ensure and fulfill the following conditions for parallel operation of transformers.

a) The voltage rating of both transformers must be same.

b) The transformation ratios of both transformers must be equal.

c) The polarity of primary & secondary terminals of both transformers must be identical.

— — — — —

TASK 2 : **Connecting and loading of transformer**

1 After proper placing of transformers and fulfilling conditions as per step 1, perform the parallel connection of transformers.

2 Make the connection of transformers as per the circuit diagram.

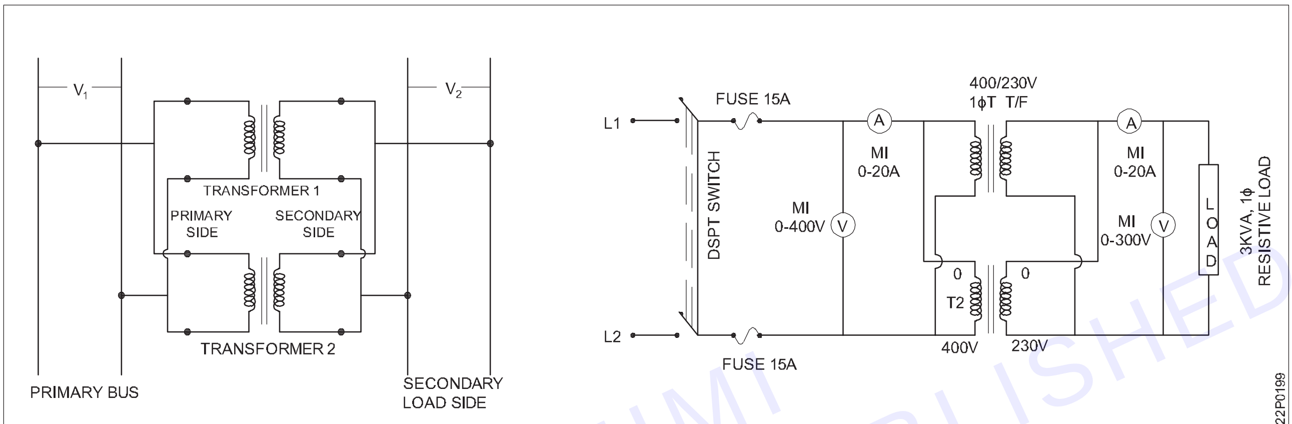
3 Switch ON the supply and record the primary and secondary voltages.

4 Apply the load step by step up to the full load current of transformers.

5 Note down the voltage and current readings and record in tabular column.

6 Verify that load current of both transformers are same, and load is shared by two transformers.

7 Switch OFF the supply and disconnect the circuit & transformers.



CIRCUIT DIAGRAM

Tabular column

Primary Bus Voltage (VP)	Primary Bus Current (IP)	Secondary voltage (VS)	T/f -1 load current (I1)	T/f -2 load current (I2)	Total load current (IL)
400 V		230 V			

Note: With above readings it is observed that, load current is equally shared by two transformers Connected in parallel.

Safety precautions:

1 Do not make wrong and loose connections.

2 The conditions for parallel operation of transformer should be fulfilled

3 Do not load the transformers excessively.

4 Take the meters reading correctly.

EXERCISE 45 : To perform STAR-DELTA connection of 3 phase transformer

Objectives

At the end of this exercise you shall be able to

- check the construction of 3 phase transformer, identify the parts and ratings.
- identify the primary and secondary terminals of 3 ph. Transformer.
- perform the STAR & DELTA connection in primary and secondary windings of 3 ph transformer.
- connect the transformer to 3 ph. Supply and measure voltage & current in STAR & DELTA connection.

Requirements

Tools/Equipments/Instruments

- Combination plier (165mm, insulated) - 1 No.
- Screw driver (150mm, insulated stem) - 1 No.
- Neon Tester (75mm, 500 V) - 1 No.
- Electrician knife (Insulated) - 1 No.
- Voltmeter (MI, 600 V) - 2 Nos.
- Ammeter (MI, 10 A) - 2 Nos.
- Multi meter (Digital, $3^{1/2}$ digit) - 2 Nos.
- 3 Ph. Transformer (5 KVA, 3 Ph. 415 V) - 1 No.
- 3 ph. Auto transformer (0-450 V AC) - 1 No.
- 3 ph. Lamp load (5 KW) - 1 No.

Materials/Components

- PVC copper wire (1.5 sq.mm) - 2 meter.
- Test lamp (100 W, 230V) - 1 No.
- TPST switch (32 A, 415 V) - 1 No.
- Cotton waste - as reqd.

Procedure

TASK 1 : **Identify the primary & secondary of 3ph transformer**

1 Collect the Tools, equipments and materials required for experiment.

2 Draw the diagram of STAR & DELTA connection and equations.

3 Draw the connection diagram of 3 ph. Transformer with STAR-DELTA connections.

4 Check the construction of 3 ph. Transformer, rating & specifications.

5 Identify the primary and secondary terminals of 3 ph. Transformer and mark the terminals as

Primary terminals $U_1 - U_2$, $V_1 - V_2$, $W_1 - W_2$

Secondary terminals $X_1 - X_2$, $Y_1 - Y_2$, $Z_1 - Z_2$

— — — — —

TASK 2: **Perform STAR - DELTA Connection of transformer and connect to the supply**

1 Make the STAR connection of primary terminals of transformer as per STAR sequence.

2 Make the DELTA connection of secondary terminals of transformer as per DELTA sequence.

3 Connect the primary terminals U_1 V_1 W_1 to 3 ph. Auto transformer terminals with Voltmeter and Ammeter.

4 Connect the secondary terminals X_1 Y_1 Z_1 to 3 ph. Lamp load terminals with Voltmeter & Ammeter.

5 Check the connections, connect the 3 ph. Auto transformer to main supply & ensure that its knob kept at 0 volts

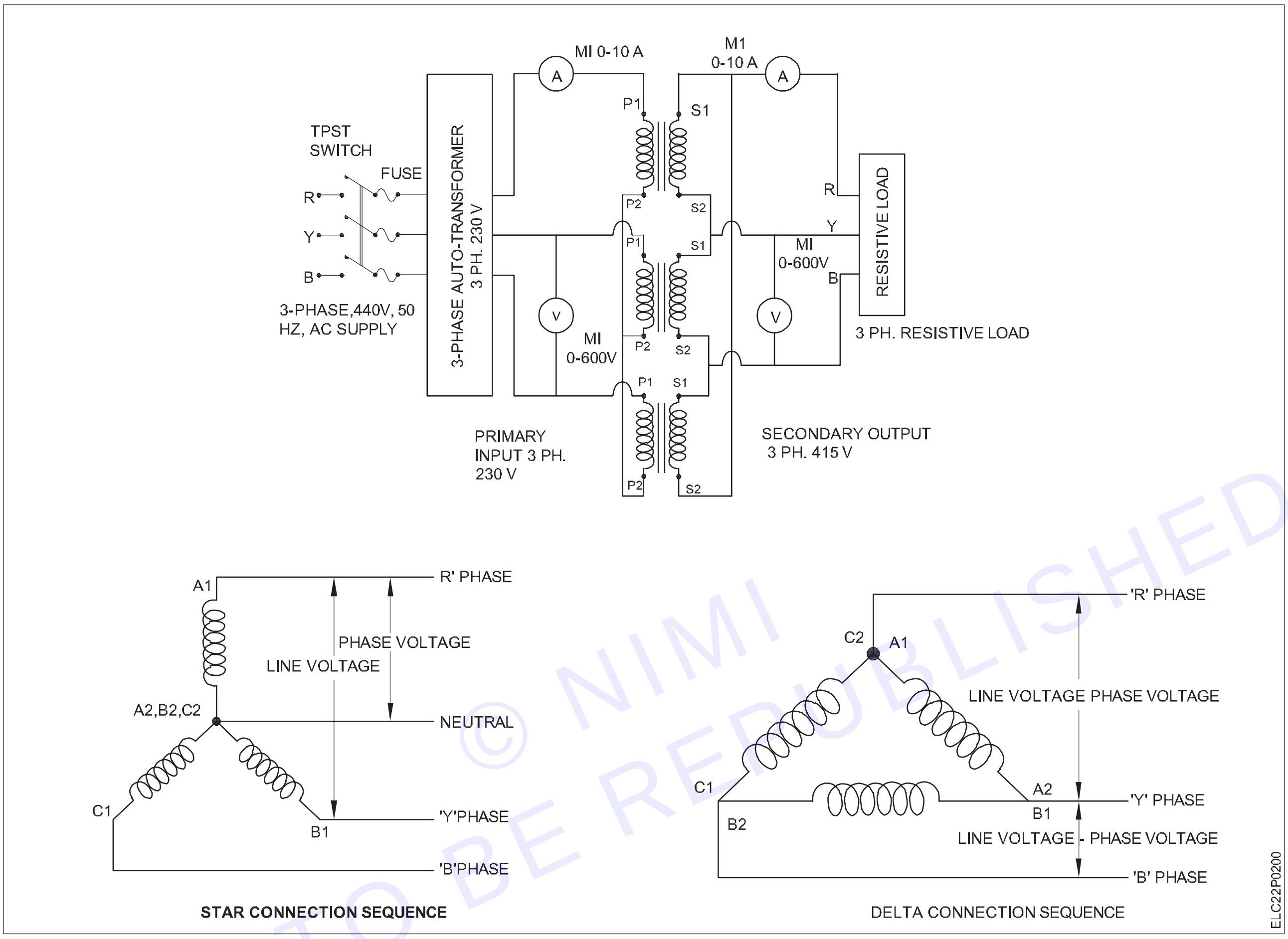
6 Switch ON the mains with TPST switch, and slowly increase the primary voltage in 3 ph. Auto transformer until voltmeter reads line voltage of 230 V

7 Note down the voltmeter and ammeter readings on primary & secondary side of transformer.

8 Apply the lamp load on secondary of transformer and increase step by step up to the rated load current of transformer.

9 Take all meter readings and record in the tabular column, decrease the load.

10 Reduce the voltage in Auto transformer, switch OFF the mains and disconnect the transformer.



Tabular column:

Primary side of T/f			Secondary side of T/f		
Connection	**Line voltage (VL)**	**Line current (IL)**	**Connection**	**Line voltage (VL)**	**Line current (IL)**
STAR			DELTA		

Safety precautions:

1 Identify and mark primary & secondary terminals correctly.

2 Ensure correct sequence of connection of STAR & DELTA.

3 Ensure proper earthing for transformer and equipments.

4 Be cautious of high voltage and do not touch open terminals.

EXERCISE 46 : BDV Testing of different transformer oils

Objectives

At the end of this exercise you shall be able to

- identify the different types of transformer oils and grades.
- check & identify the parts, rating of BDV testing equipment.
- practice to operate the BDV testing equipment.
- perform the BDV testing of different transformer oils.

Requirements

Tools/Equipments/Instruments

- Combination plier (165mm, insulated) - 1 No.
- Screw driver (150mm, insulated stem) - 1 No.
- Neon Tester (75mm, 500 V) - 1 No.
- Electrician knife (Insulated) - 1 No.
- BDV testing equipment (60 KV) - 1 No.

Materials/Components

- Transformer oil sample (Any grade) - 2 or 3 meter.
- PVC wire (2.5 sq.mm) - 2 m
- Rubber hand glows - 1 Set
- Cotton waste - as reqd.

Procedure

TASK 1 : **Check the rating of BDV test equipment**

1 Collect the Tools, equipments and materials required for experiment.

2 Draw the circuit diagram of BDV testing of transformer oil.

3 Collect 2 to 3 samples of transformer oil with different grades.

4 Check & identify the parts and rating of BDV testing equipment.

5 Place the BDV testing kit and oil samples on wooden table.

— — — — —

TASK 2: **Perform STAR - DELTA Connection of transformer and connect to the supply**

1 Open the testing cabinet of BDV testing equipment and connect the HTV terminals to ground for discharging the static charge.

2 Take out the oil testing bowl of BDV testing equipment and adjust the gap of 2.5mm between the electrodes.

3 Pour the oil sample in glass oil testing bowl in such a way that both Electrodes are fully immersed in the oil.

4 Close the lid of glass oil testing bowl and carefully place it across the HTV terminals of BDV tester.

5 Close the testing cabinet and connect the BDV test equipment to 1 ph. AC supply socket.

6 Switch ON the supply and press the HT start push button of BDV testing equipment, observe the voltmeter reading & indicating lamps.

7 Slowly turn the knob of auto transformer to increase the HTV voltage of BDV test equipment.

8 Increase the voltage until a spark occurs between the electrodes and equipment get trips.

9 Now press the memory push button and observe the HT voltage in voltmeter & record it.

10 The recorded HT voltage in voltmeter is the BDV value of tested transformer oil.

11 Repeat the test procedure of same oil sample 3 to 4 times and record the BDV value.

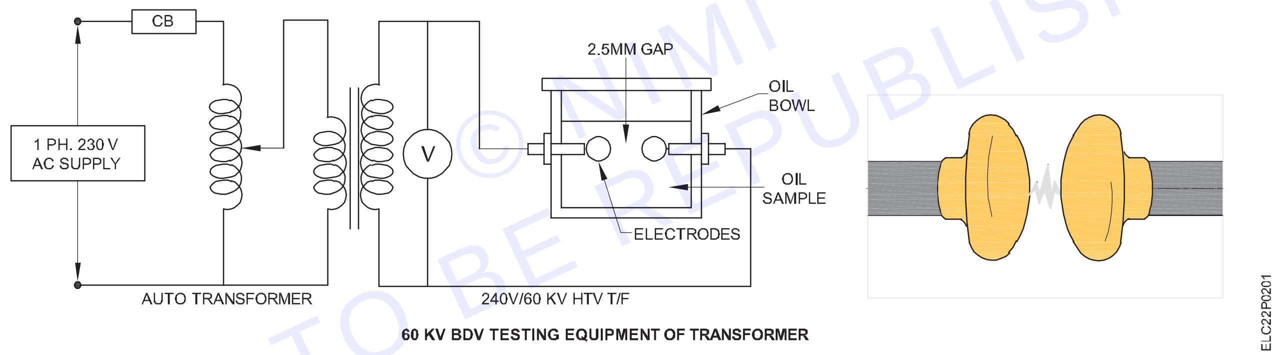
12 In similar way, perform the BDV test for different grades of transformer oil samples.

13 Switch OFF the main supply & unplug the equipment from supply socket.

14 Discharge the HTV terminals and take out the oil testing bowl from BDV test equipment.

Tabular column:

Oil sample Grade	No. of sample test	BDV test Value (KV)	Average of Test values	Final BDV Value (KV)
1	1	--KV	1+2+3+4 4	--KV
	2	--KV		
	3	--KV		
	4	--KV		
2	1	--KV	1+2+3+4 4	--KV
	2	--KV		
	3	--KV		
	4	--KV		



60 KV BDV TESTING EQUIPMENT OF TRANSFORMER

Safety precautions:

1 Do not touch the HTV terminals of BDV test equipment.

2 Do not spill the oil on HTV terminals of BDV test equipment.

3 Discharge the HTV terminals before performing BDV test

4 Use hand glows while performing BDV test.

EXERCISE 47 : To demonstrate testing & trouble shooting of transformer

Objectives

At the end of this exercise you shall be able to

- list the common faults & defects in transformer
- test & measure the continuity of windings of transformer
- test the short circuit & earn fault in transformer
- prepare the trouble shooting chart of transformer

Requirements

Tools/Equipments/Instruments

- Combination plier (165mm, insulated) - 1 No.
- Screw Driver set (150mm. 5 blades) - 1 Set.
- Neon tester (75mm, 500 V) - 1 No.
- Electrician knife (Insulated) - 1 No.
- Spanner set (As required) - 1 No.
- Hammer (1 Kg) - 1 No.
- Rubber mallet (0.5 kg) - 1 No.
- Multi meter (Digital, $3^{1/2}$ digit) - 1 No.
- Megger (500 V) - 1 No.
- Tong tester (1000V, 200 A) - 1 No.
- 3 ph. Transformer, oil cooled (Any rating) - 1 No.
- 3 ph. Auto transformer (0-460 V) - 1 No.

Materials/Components

- PVC copper wire (1.5 sq.mm) - 2 meter.
- Test lamp (100 W, 230V) - 1 No.
- Transformer oil (Any grade) - as reqd.
- Silica gel (Any grade) - as reqd.
- Cotton waste - as reqd.

Procedure

TASK 1 : **Testing of transformer for faults/defects**

1 Check the rating & specification of transformer to be tested.

2 Make the visual inspection of all parts of transformer for any mechanical damage.

3 Check the continuity and resistance of primary & secondary windings with multi meter.

Observations- a Both windings must show continuity and resistance value.

b If Multi meter does not show continuity – open circuit in windings.

c If Multi meter shows continuity with zero resistance – short circuit in windings.

4 Check the insulation resistance between primary & secondary windings with megger.

Observations- a Insulation resistance value must be above 5 MΩ OR as per manufacturer guideline.

b If Meggar value is less than 5 MΩ – Insulation resistance is poor.

c If Meggar value is zero – Short circuit in the windings.

5 Check the insulation resistance between transformer core and windings.

Observations- a Insulation resistance value must be above 5 MΩ

b If Meggar value is less than 5 MΩ – Insulation resistance is poor.

c If Meggar value is zero – windings shorted with core of transformer.

6 Check the oil level in transformer tank, conservator, buccholz relay.

Observations- a Oil level must be above the transformer core

b If oil level is below the transformer core – top up the oil.

7 Check the primary & secondary bushings / terminals.

Observations- a Bushings / terminals must be well tight and clean without any damage / crack.

b If Bushings / terminals have damage /burnt – Replace the same.

8 Check the Breather of transformer.

Observations- a Breather must have good silica gel with blue colour and correct oil level.

b If silica gel colour is brown – replace the same.

c Top up the oil.

9 Check the oil tank, cooling pipes for any mechanical damages & leakage.

Observations- a Oil tank and cooling pipes must be mechanically strong with good painting.

b If found any mechanical defects - take appropriate action.

10 Test the transformer with 3 Ph. Variac and measure the output voltage and transformer ratio.

Observations- a. The output voltage must be as rating of transformer.

11 Prepare the trouble shooting table of transformer.

Safety precautions:

1 Use proper tools and meters for testing of transformer.

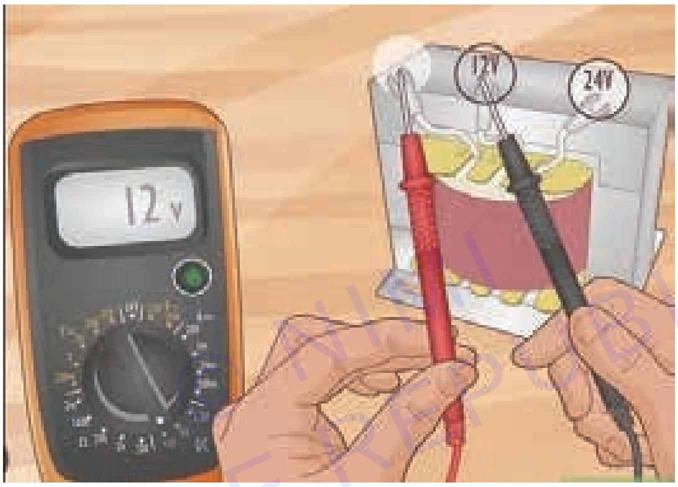
2 Make sure that earth connection is made while testing the transformer.

3 Never test the transformer with full input voltage.

Trouble shooting table of transformer

Sl.No	Problem	Cause	Remedy
1	Transformer does not turn ON	Absence of input supply Supply fuse failure Primary winding open	Check the input supply & rectify Check & replace the fuse Rewinding to be done
2	No output voltage	Secondary circuit fuse failure Low primary voltage Single phasing Secondary winding open	Check & replace the fuse Check the input supply voltage Inform to EB authorities to check Rewinding to be done
3	Low output voltage	Single phasing of input supply Input supply fuse failure One of secondary winding is open	Inform to EB authorities to check Check & replace the fuse Rewinding to be done
4	Vibration/ Humming noise	Core assembly is loose. Low supply frequency Improper foundation/ installation.	Tighten the core assembly bolts. Inform to EB authorities to check Install the transformer properly
5	Over heating of transformer	Excessive loading Internal short in windings Grounding of windings / core Low oil level	Reduce the load Rewinding to be done Improve the insulation Top up the T/f oil

6	Sparking in terminals	Loose contact on terminals/ bushes Over loading	Tighten the terminals & cable Reduce the load
7	Burning smell/smoke	Winding insulation failure Short circuit in windings High supply voltage Excessive load on transformer	Rewinding to be done Rewinding to be done Inform to EB authorities to check Reduce load
8	Oil leakage	Oil seal/gasket damage Loosen bolts of transformer tank Mechanical damage to tank	Replace the oil seal/gasket Tighten the bolts of oil tank Drain the oil and weld/braze the damaged part of oil tank



EXERCISE 48 : Test and verify the voltage of 1 Ph & 3 ph. auto transformer:

Objectives

At the end of this exercise you shall be able to

- check & identify the construction, parts and rating of auto transformer.
- connect and measure the variable output voltage of 1 Ph. Auto transformer.
- connect and measure the variable output voltage of 3 Ph. Auto transformer.
- test the electrical appliances with auto transformer.

Requirements

Tools/Equipments/Instruments

- Combination plier (165mm, insulated) - 1 No.
- Screw driver (150mm, insulated stem) - 1 No.
- Neon Tester (75mm, 500 V) - 1 No.
- Electrician knife (Insulated) - 1 No.
- Voltmeter (MI, 600 V) - 2 Nos.
- Multi meter (Digital, 31/2 digit) - 1 No.
- 1 Ph. Auto transformer (0 to 270 V) - 1 No.
- 3 Ph. Auto Transformer (0 to 460 V) - 1 No.

Materials/Components

- PVC copper wire (1.5 sq.mm) - 2 meter.
- Test lamp (100 W, 230V) - 1 No.
- Cotton waste - as reqd.

Procedure

TASK 1 : **Identify the terminals of 1Ph & 3Ph auto transformer**

1 Draw the diagram of 1 Ph. Auto transformer & 3 Ph. Auto transformer.

2 Check the construction, rating and identify the parts of 1 Ph & 3 Ph. Auto transformers.

3 Check the primary and secondary portion of winding of Auto transformers.

4 Check the input & output terminals of 3 Ph. Auto transformer and mark as,

R S T – Input (primary) terminals.

U V W – Output (secondary) terminals.

— — — — —

TASK 2 : **Connect and verify the voltage of 1 Ph. Auto transformer**

1 Connect the 1 Ph. Auto transformer to the supply and set its knob to zero position.

2 Switch ON the supply and measure the primary input voltage & record.

3 Slowly rotate the knob clockwise and measure the output voltage on secondary terminals.

4 Increase the voltage step by step and record the output voltage until last taping of winding.

5 Reduce the voltage to zero and switch OFF the supply & disconnect the auto transformer.

— — — — —

TASK 3 : **Connect and verify the voltage of 3 Ph. Auto transformer**

1 Connect the primary input terminals (R S T) of 3 Ph. Auto transformer to 3 ph. Mains, and set its knob to zero position.

2 Connect the voltmeter across secondary output terminals (U V W)

3 Switch ON the main supply and measure the primary input line voltage & record.

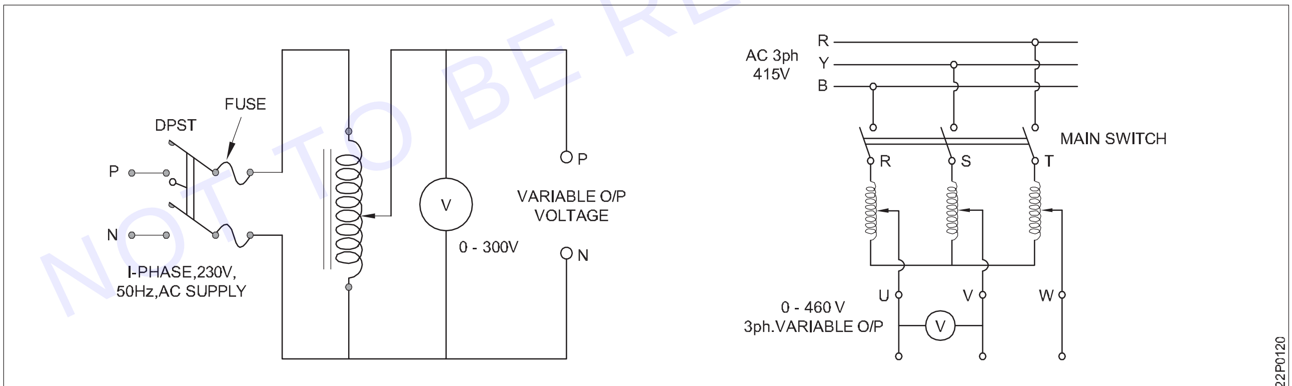
4 Slowly rotate the knob clockwise and measure the variable 3 Phase output voltage across secondary terminals.

5 Increase the voltage step by step and record the output voltage until last taping of winding.

6 Reduce the voltage to zero and switch OFF the supply & disconnect the auto transformer.

Tabular column:

	Primary Input Voltage (V_P)	Tapping No.	Secondary Output Voltage (V_S)
1 Ph. Auto Transformer	1 Ph. 230 V	1	
		2	
		3	
		4	
3 Ph. Auto Transformer	3 Ph. 415 V	1	
		2	
		3	
		4	



1 PH. AUTO TRANSFORMER   3 PH. AUTO TRANSFORMER

Safety precautions:

1 Handle the auto transformer carefully as it is heavy.

2 Select higher range in voltmeter while measuring 3 Ph. voltage

3 Set knob to zero position before switching ON the auto transformer.

4 Ensure the earthing for auto transformers.

EXERCISE 49 : To measure high current & voltage using CT and PT

Objectives

At the end of this exercise you shall be able to

- check and identify the different types of CT's & PT's, and their ratio's & ratings.
- test the polarity of CT & PT and marking the terminals.
- measure the high voltage & current with CT & PT.

Requirements

Tools/Equipments/Instruments

- Combination plier (165mm, insulated) - 1 No.
- Screw Driver (150mm) - 1 No.
- Neon Tester (75mm, 500 V) - 1 No.
- Electrician knife (Insulated) - 1 No.
- Voltmeter (MI, 600 V) - 1 No.
- Voltmeter (MI, 150 V) - 1 No.
- Ammeter (MI, 30 A) - 1 No.
- Ammeter (MI, 5 A) - 1 No.
- Multi meter (Digital, $3^{1/2}$ digit) - 1 No.
- CT (Demo type) (30/1 A) - 1 No.
- PT (Demo type) (440/110 V) - 1 No.
- Current injection kitj (0-50A) - 1 No.
- Voltage injection kit (0-600 V) - 1 No.

Materials/Components

- PVC copper connecting probes (2.5 sq.mm) - 5 Nos.
- Test lamp (100 W, 230V) - 1 No.

Procedure

TASK 1 : **Identify the terminal of CT & PT**

1 Collect the Tools, equipments and materials required for experiment.

2 Draw the connection diagram of CT and PT.

3 Check the type, construction, voltage & current ratio of CT and PT.

4 Check & identify the polarity of terminals of CT and PT, and mark the terminals as

Primary- P1 & P2

Secondary- S1 & S2

5 Check the connection and rating of current injection kit & voltage injection kit.

Note: 1 For practical experiment purpose use only demo CT & PT's

2 Never test the High tension CT & PT's which are tested only under expert supervision.

— — — — —

TASK 2 : **Connect and test the CT**

1 Make the connection of primary terminals P1 & P2 of CT in series with current injection kit.

2 Make sure that current injection kit is OFF and its knob is at zero position.

3 Connect the secondary terminals S1 & S2 of CT to the ammeter of low range.

4 Switch ON the current injection kit and gradually increase the CT primary current until CT secondary current reaches 1 Amp.

4 Note down the primary current and secondary current

— — — — —

5 Check & verify the CT ratio with different primary input current within the CT range.

6 Switch OFF the current injection kit and disconnect the CT connection.

7 Calculate the primary current with CT ratio.

— — — — —

TASK 3 : **Connect and test the PT**

1 Make the connection of primary terminals P1 & P2 of PT across the voltage injection kit.

2 Make sure that voltage injection kit is OFF and its knob is at zero position.

3 Connect the secondary terminals S1 & S2 of PT to the voltmeter of low range.

4 Switch ON the voltage injection kit and gradually increase the PT primary voltage until PT secondary voltage reaches 110 V

4 Note down the primary voltage and secondary voltage.

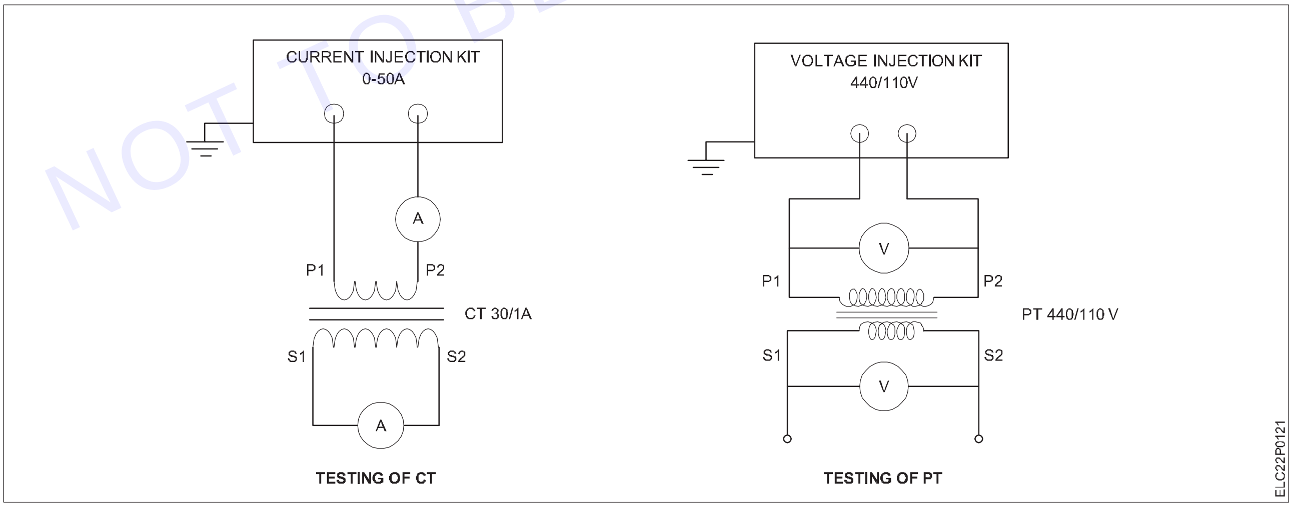
5 Check & verify the PT ratio with different primary input voltage within the PT range.

6 Switch OFF the voltage injection kit and disconnect the PT connection.

7 Calculate the primary voltage with PT ratio.

Tabular column:

	Ratio	**Primary input**	**Secondary output**
CT	30/1 A	10 A	
		20 A	
		30 A	
PT	440/110 V	220 V	
		300 V	
		440 V	



Safety precautions:

1 Do not make wrong and loose connections.

2 Do not inject the voltage and current to CT & PT more than rated value.

3 CT secondary should always be kept shorted.

4 Do not test High Tension CT's & PT's

MODULE 9: Electrical Meters and Calibration

EXERCISE 50 : To identify different types of electrical measuring instruments

Objectives

At the end of this exercise you shall be able to

- check & identify the different types of Electrical meters used in AC & DC circuits.
- check & identify the scale, terminals and range of Electrical meters.
- understand connection of Electrical meters in Electrical circuits.
- connect & test the Electrical meters in simple electrical circuits and record readings.
- follow the safety measures while connecting the meters in high voltage & current circuits.

Requirements

Tools/Equipments/Instruments

- Combination (Plier 165mm, insulated) - 1 No.
- Screw Driver (150mm, insulated stem) - 1 No.
- Neon Tester (75mm, 500 V) - 1 No.
- Electrician knife (Insulated) - 1 No.
- Analog Voltmeter (MI, 0-600 V, 0-300 V) - 2 Nos.
- Analog Voltmeter (MC, 0-300 V, 0-30 V) - 1 No.
- Analog Ammeter (MI & MC, 10 A) - 1 No.
- 1 Ph. Watt meter, Analog (2 KW, UPF, 230V) - 1 No.
- Poly Ph. Watt meter, Analog (3 KW, LPF, 600V) - 1 No.
- 1 Ph. PF meter, Analog (10A, 230 V) - 1 No.
- Frequency meter, Analog (0-60 Hz, 230 V) - 1 No.
- Multi meter (Digital, $3^{1/2}$ digit) - 1 No.

Materials/Components

- PVC copper wire (1.5 sq.mm) - 2 m.
- Test lamp (100 W, 230V) - 1 No.
- DP switch (16 A, 230 V) - 1 No.

Procedure

TASK 1 : **Identify the different types of electrical meters**

1 Collect the Tools, meters and materials required for experiment.

2 Draw the symbol & connection diagram of Electrical meters.

3 Check the scale, terminals and rating of Electrical meters

4 Check the resistance of shunt coil, series coil in voltmeter, ammeter and wattmeter.

5 Compare the scale & terminals of AC and DC meters.

— — — — —

TASK 2 : **Connect and test the Electrical meters**

1 Connect the ammeter in series with a load & supply, and measure the current in ammeter.

2 Connect the ammeter with different loads and measure the current.

3 Connect the voltmeter in parallel with supply OR load, and measure the voltage in voltmeter.

4 Connect the current coil terminals (M & L) of wattmeter in series with load, and potential coil terminals (C & V) in parallel with supply OR load, and measure the power of load.

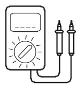
5 Connect the current coil terminals (M & L) of power factor meter in series with load, & potential coil terminals (C & V) in parallel with supply OR load, and measure the power factor of different loads.

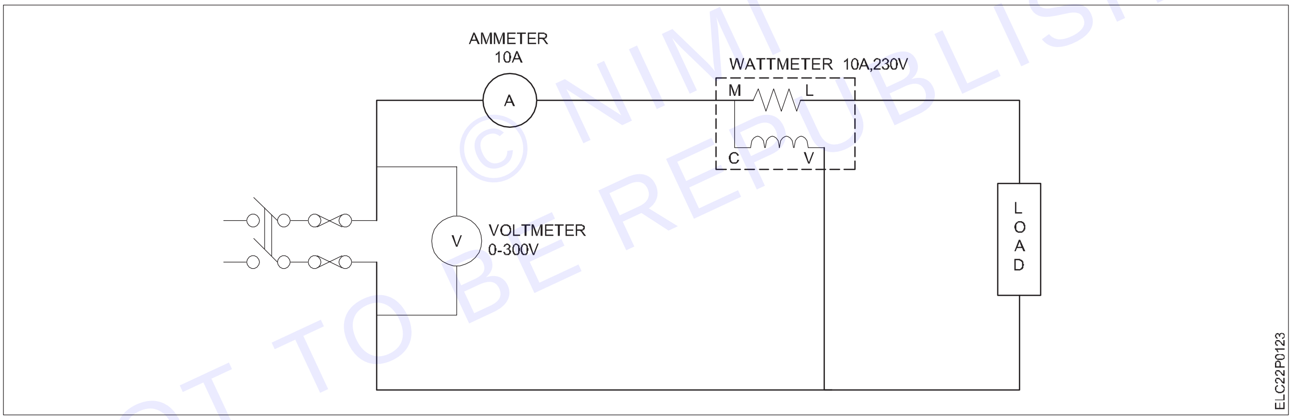
6 Connect the frequency meter in parallel with supply, and measure the frequency of AC supply.

7 Take the multi meter and check its range of voltage, current, resistance and other parameters.

8 Measure the resistance of rheostat, continuity of coil, supply voltage and current in the circuit with multi meter.

Table for details of Basic Electrical meter

Sl.No	Name of the meter	Symbol	Connection Type	Application
1	Ammeter	A	In series with load only	Ammeter is used to measure the current
2	Voltmeter	V	In parallel with supply OR load	Voltmeter is used to measure the voltage
3	Wattmeter	W	Series & parallel with load & supply	Wattmeter is used to measure the power
4	Frequency meter	W	In parallel with supply	It is used measure supply frequency
5	PF meter	COS ϕ	Series & parallel with load & supply	It is used to measure power factor in AC
6	Multi meter		Series & parallel with load & supply	It is used to measure voltage, current, resistance, continuity etc



Safety precautions:

1 Handle carefully and do not drop the Electrical meters.

2 Never connect the ammeter in parallel.

3 Check the current & voltage range of meters before connecting to supply.

4 Always set the multi meter at high voltage range while testing AC supply.

EXERCISE 51 : To determine the errors in PMMC and MI meters

Objectives

At the end of this exercise you shall be able to:

- identify the different types of PMMC and MI meters
- read, compare and differentiate the scale of PMMC and MI meters
- connect and measure the electrical quantities by PMMC and MI meters
- calibrate & determine the errors in PMMC and MI meters with standard meters.

Requirements

Tools/Equipments/Instruments

- Combination Plier 165mm, insulated -1 No.
- Screw Driver 150mm, insulated stem -1 No.
- Neon Tester 75mm, 500 V -1 No.
- Electrician knife insulated -1 No.
- DC Voltmeter (Standard/New) PMMC, 0-300 V -1 No.
- DC Voltmeter (Old) PMMC, 0-300 V -1 No.
- DC Ammeter (Standard/New) PMMC, 10 A -1 No.
- DC Ammeter (Od) PMMC, 10 A -1 No.
- AC Voltmeter (Standard/New) MI, 0-300 V -1 No.
- AC Voltmeter (Old) MI, 0-300 V -1 No.
- AC Ammeter (Standard/New) MI, 10 A -1 No.
- AC Ammeter (Od) MI, 10 A -1 No.
- Lamp load 5 KW, 230 V -1 No.
- 1 Ph. Auto transformer 0-270 V -1 No.
- ICDP switch 16 A -1 No.
- Digital Multi meter 3$^{1/2}$ digit -1 No.
- Rheostat 750 Ω, 1.5 A -1 No.

Materials/Components

- PVC copper wire 2.5 sq.mm - 5 meter
- Test lamp 100 W, 230V -1 No.
- Cotton waste -as reqd.

Procedure

Calibration of Electrical meters:

The Electrical meters are classified as PPMC (DC) meters and MI (AC) meters which measures the electrical quantities like voltage, current and power in electrical circuits. The electrical meters are manufactured with accuracy which varies from + 0.05 % to + 5 %

The accuracy of Electrical meter will be reduced after long usage due to electrical & mechanical errors, aging etc. Therefore electrical meters are to be calibrated periodically to ascertain their standard values.

The electrical meters are calibrated by comparing the true value of voltage OR current in the circuit with a standard meters.

TASK 1: **Iedntify the PMMC & MC instruments**

1 Draw the circuit diagram of calibration of voltmeter & ammeter.

2 Check and identify different types of PMMC and MI electrical meters.

3 Check the scale, terminals and range of PMMC and MI meters

4 Connect and measure the voltage & current values by PMMC and MI meters.

— — — — —

TASK 2: **Test and calibrate the PPMC & MI Voltmeter and Ammeter with standard meter**

1 Make the connections for calibration of PMMC Voltmeter as per circuit diagram.

2 Check the connections and set the rheostat to cut-in position.

3 Switch ON the DC supply, slowly vary the resistance in rheostat step by step.

4 Record the voltage readings in Standard voltmeter and Old voltmeter which to be calibrated.

5 Make the connections for calibration of MI Voltmeter as per circuit diagram.

6 Check the connections and set the auto transformer knob to zero position.

7 Switch ON the supply, slowly increase the voltage by auto transformer step by step.

8 Record the voltage readings in Standard voltmeter and Old voltmeter which to be calibrated.

9 Make the connections for calibration of PMMC Ammeter as per circuit diagram.

10 Check the connections and keep the load switch in OFF position.

11 Switch ON the DC supply and increase the lamp load step by step.

12 Record the current readings in Standard ammeter and Old ammeter which to be calibrated.

13 Make the connections for calibration of MI Ammeter as per circuit diagram, and repeat the steps 10 to 12

14 Calculate the percentage error in PMMC & MI meters to be tested as per the formula

Where:

$$\text{Percentage errror} = \frac{V_I - V_S}{V_S} \times 100 \text{ or } \frac{I_T - I_S}{I_S} \times 100$$

T = Test value of voltage OR current recorded in meter to be tested.

S = Standard value of voltage OR current recorded in standard meter

Tabular column:

Calibration of PMMC Voltmeter:

Sl.No	Standard voltage (V_S)	Test voltage (V_T)	Percentage error

Calibration of MI Voltmeter:

Sl.No	Standard voltage (V_S)	Test voltage (V_T)	Percentage error

Calibration of PMMC Ammeter:

Sl.No	Standard current (I_S)	Test current (I_T)	Percentage error

Calibration of MI Ammeter:

Sl.No	Standard current (I_S)	Test current (I_T)	Percentage error

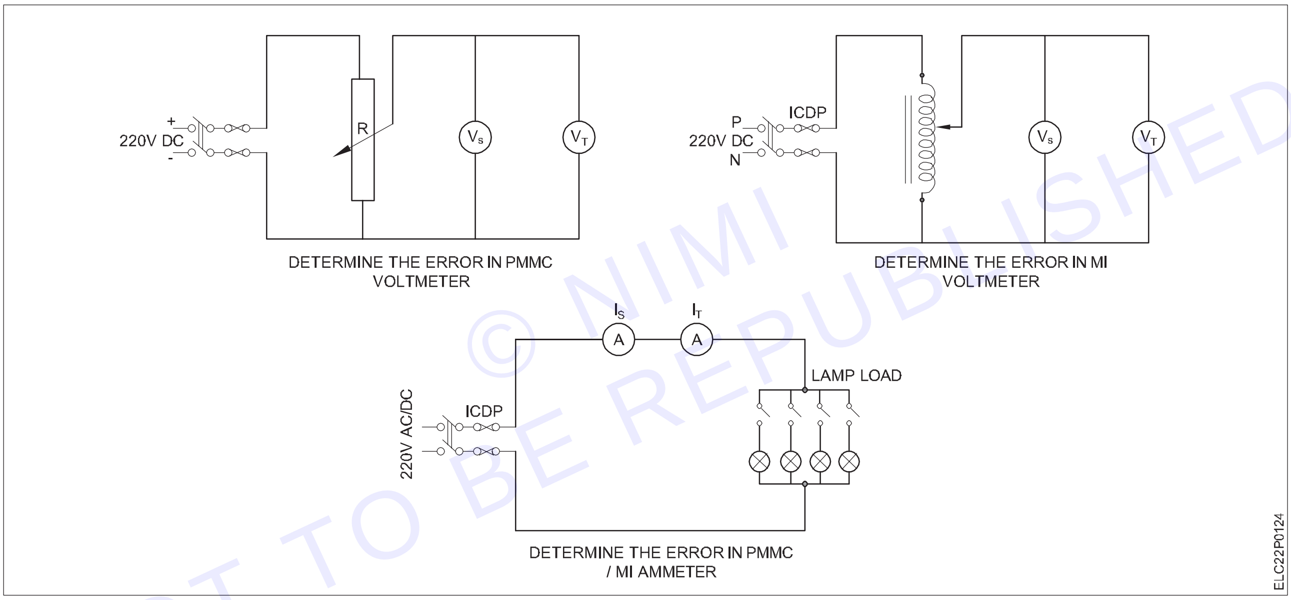
Safety precautions:

1 Handle the measuring instruments carefully.

2 Do not make wrong and loose connections.

3 Do not apply the voltage OR current beyond the range of meters.

4 Take the reading and calculate the error correctly.



EXERCISE 52 : Test and calibration of 1 Ph. Energy meter

Objectives

At the end of this exercise you shall be able to:

- check and identify the parts of 1 Ph. Energy meter, check meter constant
- connect the energy meter to 1 Ph. load and find the Electrical & mechanical errors
- calibrate the defective energy meter with standard energy meter.

Requirements

Tools/Equipments/Instruments

- Combination Plier 165mm, insulated - 1 No.
- Screw Driver 150mm, - 1 No.
- Neon Tester 75mm, 500 V - 1 No.
- Electrician knife insulated - 1 No.
- Standard KWH meter, induction type 1 Ph. 240V, 10A - 1 No.
- Old KWH meter, induction type 1 Ph. 240V, 10A - 1 No.
- Volt meter MI, 300 V - 1 No.
- Ammeter MI, 10 A - 1 No.
- Multi meter Digital, $3^{1/2}$ digit - 1 No.
- Lamp load 1 Ph. 230V, 5KW - 1 No.
- Stop watch Digital - 1 No.

Materials/Components

- PVC copper wire 1.5 sq.mm - 2 meter
- Test lamp 100 W, 230V - 1 No.
- DPST switch 16 A, 230 V - 1 No.

Procedure

TASK 1: **Check the energy meter & meter constant**

1 Draw the circuit diagram of calibration of 1 Ph. energy meter.

2 Check the standard & old energy meters, record the meter constant, voltage & current rating and initial reading.

3 Check the terminals, resistance of current coil & potential coil of energy meter with multi meter.

Electrical Energy = Power X Time OR $E = V \times I \times t$

Electrical Energy = Kilo Watt Hour (KWH)

1 KWH = 1 Unit

— — — — —

TASK 2: **Connect the Energy meter to load and measure the Electrical energy**

1 Make the connection of energy meter and load as per circuit diagram.

2 Check the connections and connect the standard energy meter to 1 Ph. Supply through DPST switch.

3 Switch ON the main supply, keep the load switch OFF and observe any disc vibrations OR very slow disc rotation of energy meter on No-load.

(Note: When load is OFF if a very small disc rotation is found it is known as creeping error of meter)

4 Note down the initial reading and meter constant (K) of standard energy meter.

5 Close the load switch and apply the load in steps of 10%, 50% & 110% of full load current of energy meter.

6 Record the voltmeter and ammeter readings in each step of load, and observe the speed of disc rotation.

7 Start the Stop watch and count 50 No. of disc revolutions of energy meter, and record the time taken for 50 disc revolutions.

8 After completion of 50 disc revolutions switch OFF the load and record the final reading of energy meter.

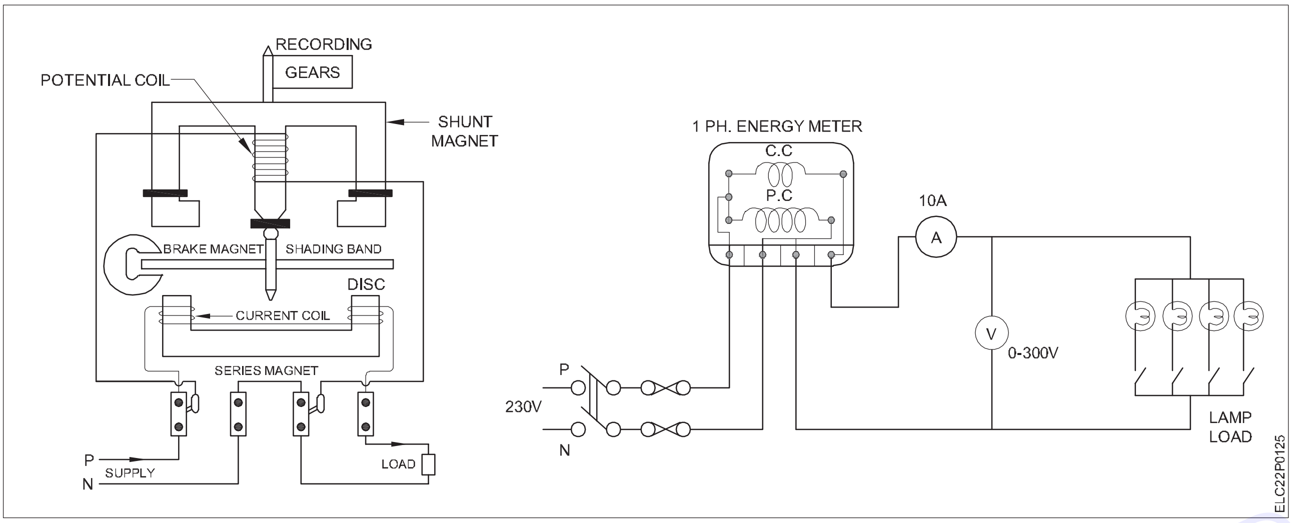
9 Switch OFF the supply and disconnect the energy meter & circuit.

10 Calculate the true energy & recorded energy as per formula given in tabular column.

11 Compare the true energy & recorded energy which must be approximately equal.

12 Repeat the experiment for old energy meter and record & compare the values.

Parts of Energy Meter (Induction type)



Tabular column:

Calibration of Standard Energy meter								
Load	**Voltage (V)**	**Current (I)**	**Time (t) in sec**	**Meter Constant (K)**	**No. of disc Revolution (N)**	**True energy TE =V x I x t**	**Recorded energy RE=N/K**	**%Error =** $\frac{TR-RE}{TE}\times 100$
10% of full load current	230			1500	50			
50% of full load current	230			1500	50			
110% of full load current	230			1500	50			
Calibration of old Energy meter								
10% of full load current	230			3200	100			
50% of full load current	230			3200	100			
110% of full load current	230			3200	100			

Note: If error value is +ve, the meter runs fast

If error value is -ve, the meter runs slow

The % error must be less than + 3%

Safety precautions:

1 Do not make wrong and loose connections.

2 Do not exceed the load current of energy meter.

3 Do not make reverse connection of energy meter.

EXERCISE 53 : To measure the insulation resistance of Electrical machineries

Objectives

At the end of this exercise you shall be able to:

- check & identify the insulation resistance tester (Megger), its construction, scale & terminals
- practice the use of megger and testing of insulation resistance
- test the insulation resistance of Electrical machines- Motors, Generators, Transformers and cables
- prepare table of insulation resistance of different Electrical machineries.

Requirements

Tools/Equipments/Instruments

- Combination Plier 165mm, insulated - 1 No.
- Screw Driver 150mm, insulated stem - 1 No.
- Neon Tester 75mm, 500 V - 1 No.
- Electrician knife Insulated - 1 No.
- Megger, dynamometer type 500 V - 1 No.
- Megger, electronic type 500 V - 1 No.
- Multi meter Digital, $3^{1/2}$ digit - 1 No.
- Electric Motor, Generator, transformer Any rating - 1 No. each
- Defective Motor, Generator, transformer Any rating - 1 No. each

Materials/Components

- PVC copper probes with crocodile clip 1.5 sq.mm - 1 Set
- Test lamp 100 W, 230V - 1 No.
- Cotton waste - as reqd.
- Armored cable 25^2 mm, 4 core - 2 m.

Procedure

TASK 1: **Check the construction of megger and its scale**

1 Draw the diagram of megger and measurement of insulation resistance.

2 Check and identify the construction, scale & rating of dynamometer megger & Electronic megger.

3 Check the battery of Electronic megger for good condition.

4 Keep the different Electrical machineries on wooden table for testing insulation resistance.

— — — — —

TASK 2: **Measure the insulation resistance Electrical machineries with megger**

1 Test the megger for its working condition before conducting insulation resistance test.

2 Short the L & E terminals of megger and rotate the handle at 160 RPM, see the deflection of needle which should move towards zero for good working condition of megger. If doesn't megger is defective

3 Similarly, check the Electronic megger by pressing its Test button.

4 Connect the L & E terminals of megger between A coil & B coil of induction motor and test the Insulation resistance. The IR value should be greater than 2 MΩ.

5 Similarly, check the insulation resistance between motor coils & body of motor, and IR value must be greater than 2 MΩ

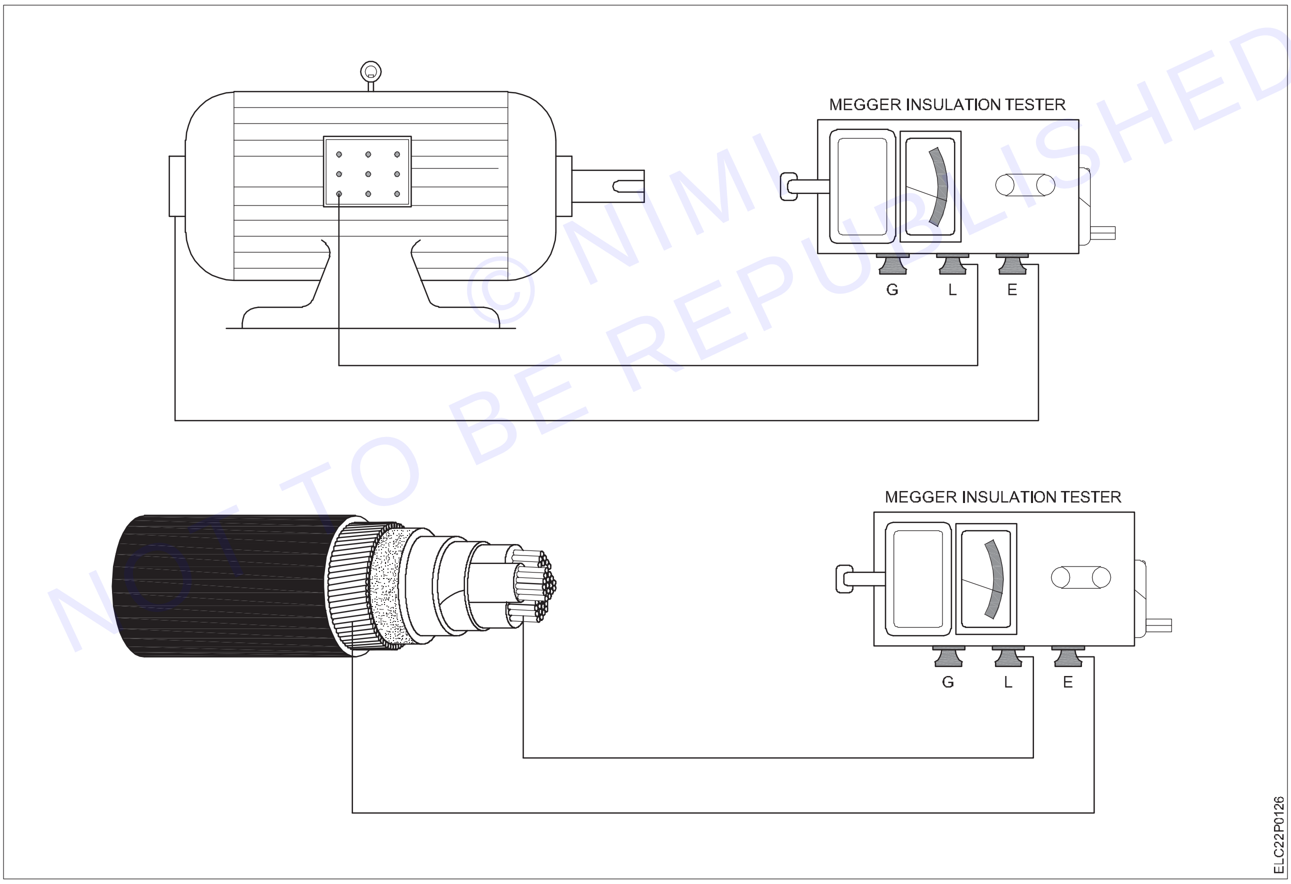
6 In similar way, check the insulation resistance of transformer, armored power cable and other Electrical appliances.

7 Conduct the insulation resistance test in defective Electrical machines & equipments and note the IR value

8 Record the test values in data sheet

Test value of IR of electrical machines

Sl. No	Name of the machine/ Equipment	Recommended IR value (MΩ)	Recorded Value (MΩ)	Remarks
1	Induction motor 3 Ph. 415 V	> 2 MΩ	100 MΩ	Very good IR
2	Transformer 3 Ph. 400/230 V	> 2 MΩ	150 MΩ	Very good IR
3	AC Generator 3 Ph. 415 V	> 2 MΩ	120 MΩ	Very good IR
4	Armored UG cable 4 core, 25^2 mm	> 2 MΩ	100 MΩ	Very good IR
5	Ballast 230 V AC	> 2 MΩ	0	Short circuit
6	Universal motor 230 V AC	> 2 MΩ	1 MΩ	Poor



Safety precautions:

1 While operating megger do not touch its terminals which gives electric shock.

2 Handle the megger properly and avoid mechanical damage.

3 Ensure to switch OFF the main supply while checking insulation resistance of power cables.

4 Do not use the megger for checking continuity of coils of motors, relays etc

MODULE 10: Illumination,Connection of Electrical Lights

EXERCISE 54 : To connect and test different types Electric lamps

Objectives

At the end of this exercise you shall be able to:

- identify the different types of electric lamps, their construction & ratings
- connect and test all kinds of electric lamps
- check the illumination of lamps.

Requirements

Tools/Equipments/Instruments

- Combination Plier 165mm, insulated -1 No.
- Screw Driver 150mm, insulated stem -1 No.
- Neon Tester 75mm, 500 V -1 No.
- Electrician knife Insulated -1 No.
- Multi meter Digital, $3^{1/2}$ digit -1 No.

Materials/Components

- PVC copper wire 1.5 sq.mm -as reqd.
- Incandescent lamps Assorted rating -3 No's.
- Fluorescent tube light fitting with choke 40 W, 230V -1 No.
- HPMV lamp fitting with ballast, capacitor 150 W, 230 V -1 No.
- HPSV lamp fitting with ballast, igniter 150 W, 230 V -1 No.
- Halogen lamp fitting 500 W, 230 V -1 No.
- CFL light fitting 36 W, 230 V -1 No.
- LED Bulbs Assorted rating -3 No's.
- LED tube light with driver 22 W, 230 V -1 No.
- LED recess type fitting with driver 36 W, 230 V -1 No.

Procedure

TASK 1: **Identify the different types of lamps**

1 Draw the circuit diagram of connection of different types of lamps.

2 Identify the different types of electric lamps, their construction and ratings.

3 Test the continuity of lamps and ballast with test lamp.

— — — — —

TASK 2 : **Connect and test all types of lamps**

1 Connect and test the incandescent lamps of different wattage and check the illumination.

2 Make the connection of gas discharge lamps - HPMV lamp & HPSV lamp as per circuit diagram.

3 Connect gas discharge lamps to the supply, measure the starting & running current and illumination.

4 Make the connection of fluorescent tube light as per circuit diagram.

5 Connect the fluorescent tube light to the supply and check the illumination.

6 Connect the halogen lamp and the check the brightness.

7 Connect all types LED bulbs, tube lights, recess fittings and check the illumination.

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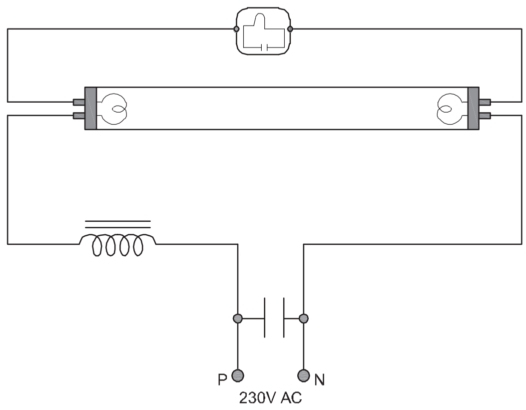
Safety precautions:

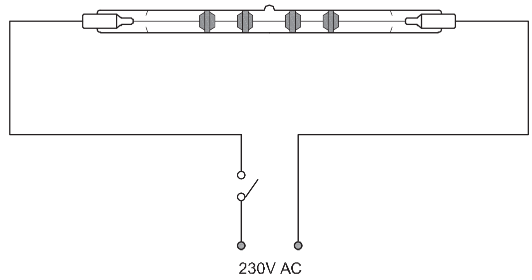
1 Handle the electric lamps carefully and do not drop.

2 Do not make wrong & loose connections.

3 Check the ballast before connecting gas discharge lamps.

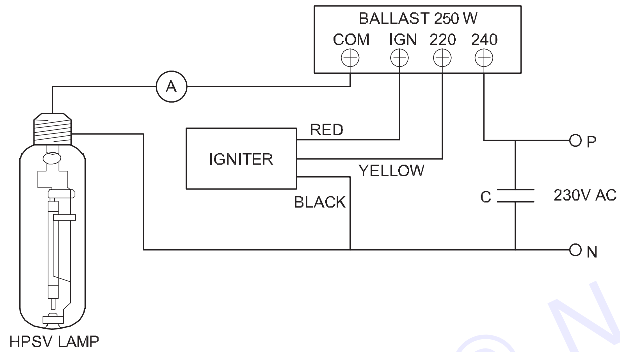


CONNECTION OF FLUORESCENT TUBE LIGHT

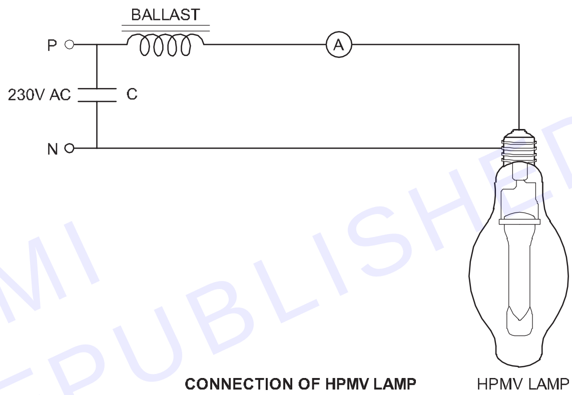


CONNECTION OF HALOGEN LIGHT

ELC22P0127



CONNECTION OF HPSV LAMP



CONNECTION OF HPMV LAMP

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EXERCISE 55 : To connect single & twin tube light fitting

Objectives

At the end of this exercise you shall be able to:

- identify the parts of fluorescent tube light fitting
- test the ballast, starter, capacitor and tube light
- make the connection of single & twin tube light and test.

Requirements

Tools/Equipments/Instruments

- Combination Plier 165mm, insulated - 1 No.
- Screw Driver 150mm, insulated stem - 1 No.
- Connector screw driver 150mm, insulated stem - 1 No.
- Neon Tester 75mm, 500 V - 1 No.
- Electrician knife Insulated - 1 No.
- Multi meter Digital, $3^{1/2}$ digit - 1 No.
- Tube light fitting- single & twin With choke, starter, capacitor 4' 40 watts, 230 V - 1 No. each

Materials/Components

- PVC copper wire 1.0 sq.mm - 2 m
- Hook up wire Single strand - 2 m
- Test lamp 100 W, 230V - 1 No.
- Fluorescent tube light 4' 40 W, 230 V - 3 Nos.
- Insulation tape PVC, 19mm - 1 role

Procedure

TASK 1:**Testing of ballast starter and tubelight**

1 Draw the circuit diagram of single tube light connection.

2 Take the single tube light fitting and identify the ballast, starter, capacitor and side holders.

3 Test the ballast by connecting it to the supply in series with test lamp.

Observation: 1. The lamp should glow dim for good condition.

2. If lamp glows bright OR does not glow, ballast is defective.

4 Test the starter by connecting it to the supply in series with test lamp.

Observation: 1. The lamp should glow with flickering for good condition.

2. If lamp glows constantly OR does not glow, starter is defective.

5 Make the connections of single fluorescent tube light as per circuit diagram.

6 Check the connections and connect to 1 ph. AC supply, observe the intensity of light.

7 Switch OFF the supply and disconnect the fluorescent lamp.

— — — — —

TASK 2: **Connecting & Testing of twin fluorescent lamp fitting**

1 Draw the circuit diagram of twin tube light connection.

2 Take the twin tube light fitting and identify the ballast, starter, capacitor and side holders.

(Twin tube light fitting has each 2 No's of ballast, starter, capacitor and tube light)

3 Test the ballast and starter before making connections.

4 Make the connections of twin fluorescent tube light as per circuit diagram.

5 Check the connections and connect to 1 ph. AC supply, observe the light intensity of both tubes.

6 Switch OFF the supply and disconnect the fluorescent lamp.

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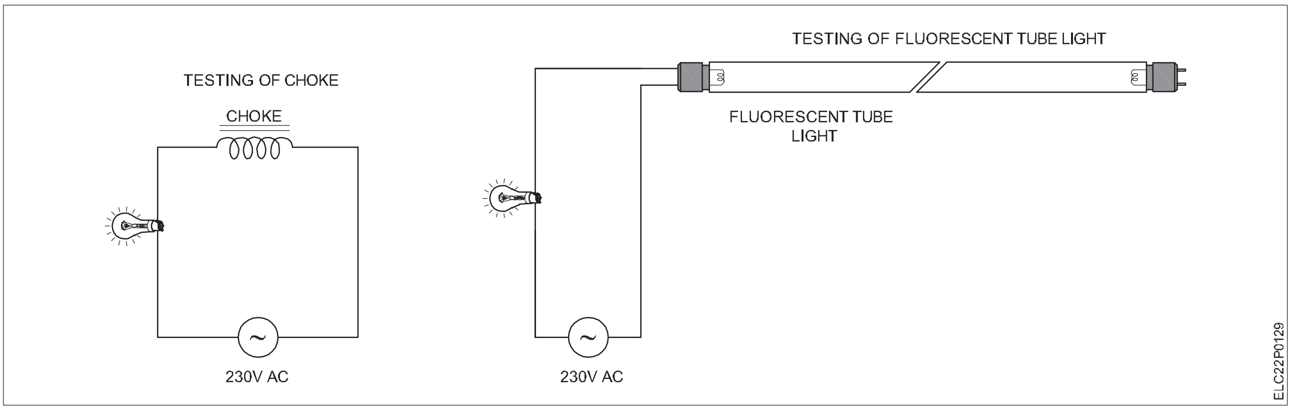
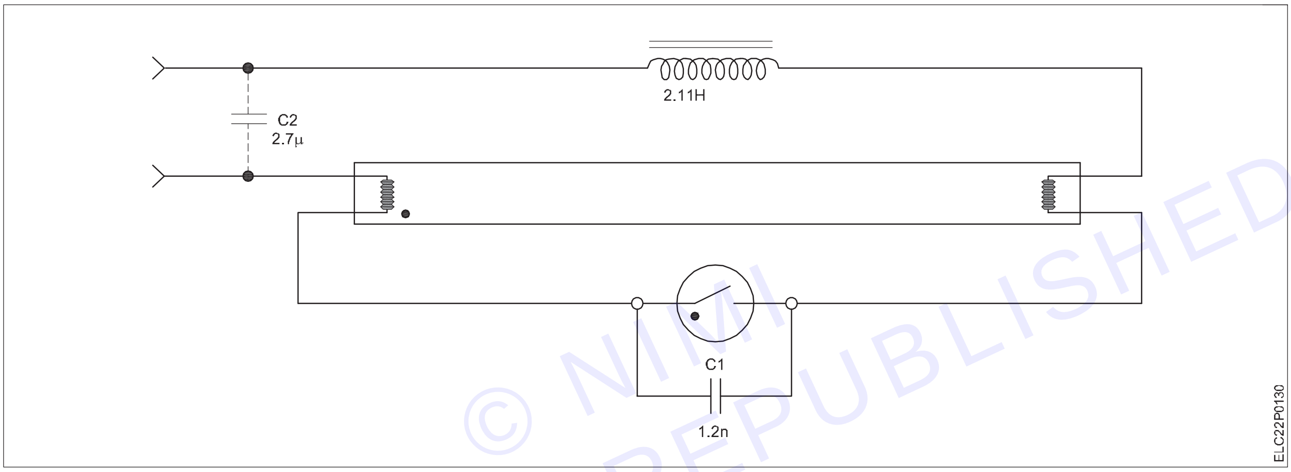
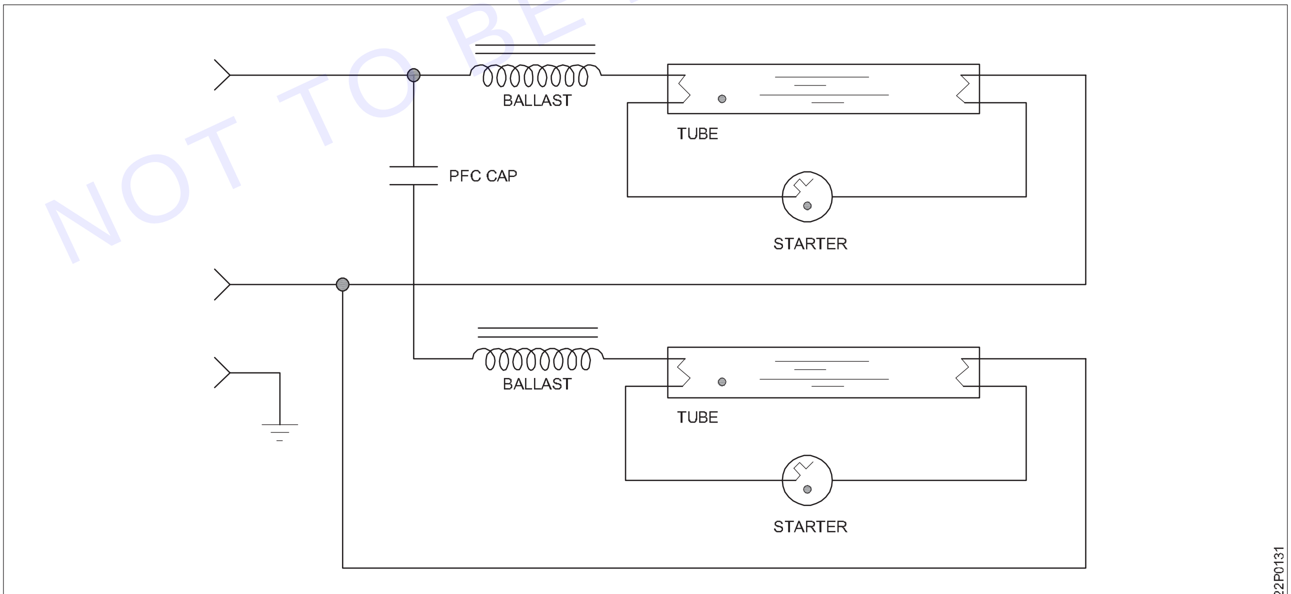
Testing of choke and tube light



Fluorescent tube light connection



Twin Fluorescent tube light connection



TWIN FLUORESCENT TUBE LIGHT CONNECTION

Safety precautions:

1 Use proper and insulated tools.

2 Do not make wrong and loose connections.

3 Handle the fluorescent tube carefully and do not drop it.

4 Check the choke before connecting tube light.

EXERCISE 56 : To connect and test HPMV & HPSV Lamps

Objectives

At the end of this exercise you shall be able to:

- Identify & study the construction, parts and rating of HPMV & HPSV lamps
- Identify and test the ballast, igniter, lamp holder & capacitor required for HPMV & HPSV lamps
- Connect and test the HPMV & HPSV lamps
- Measure the starting & running drawn by the lamps and check the illumination & color of light.

Requirements

Tools/Equipments/Instruments

- Combination Plier 165mm, insulated - 1 No.
- Screw Driver 150mm, insulated stem - 1 No.
- Neon Tester 75mm, 500 V - 1 No.
- Electrician knife Insulated - 1 No.
- Ammeter MI, 10 A - 1 No.
- Multi meter Digital, $3^{1/2}$ digit - 1 No.

Materials/Components

- PVC copper wire 1.5 sq.mm - 2 m.
- Test lamp 100 W, 230V - 1 No.
- HPMV Lamp 250 W, 230 V - 1 No.
- HPSV Lamp 250 W, 230 V - 1 No.
- Ballast 250 W, 230 V - 2 Nos.
- Igniter 230 V - 1 No.
- Threaded lamp holder Goliath Edison, 250 W - 2 Nos.
- Capacitor 5 μf, 400V - 2 Nos.

Procedure

TASK 1: **Test the ballast,Igniter & capacitor**

1 Draw the circuit diagram of HPMV lamp and HPSV lamp.

2 Check & study the construction, parts and wattage of HPMV & HPSV lamps.

3 Check the rating of ballast, igniter, lamp holder & capacitor required for HPMV & HPSV lamps.

4 Check the ballast and capacitor with test lamp before the connection of lamps.

TASK 2: **Connect and test the HPMV lamp**

1 Make the connections of HPMV lamp as per circuit diagram.

2 Check the connections, and connect the circuit to 1 Ph. AC supply.

2 Switch ON the supply, note down the starting current drawn by HPMV lamp.

3 Allow some time to glow the lamp with full brightness which takes about 5 minutes.

4 After lamp glows with full brightness record the running current in ammeter & observe color of light.

5 Switch OFF the supply and disconnect the circuit and lamp.

TASK 3: **Connect and test the HPSV lamp**

1 Make the connections of HPSV lamp with ballast & igniter as per circuit diagram.

2 Check the connections, and connect the circuit to 1 Ph. AC supply.

2 Switch ON the supply, note down the starting current drawn by HPSV lamp.

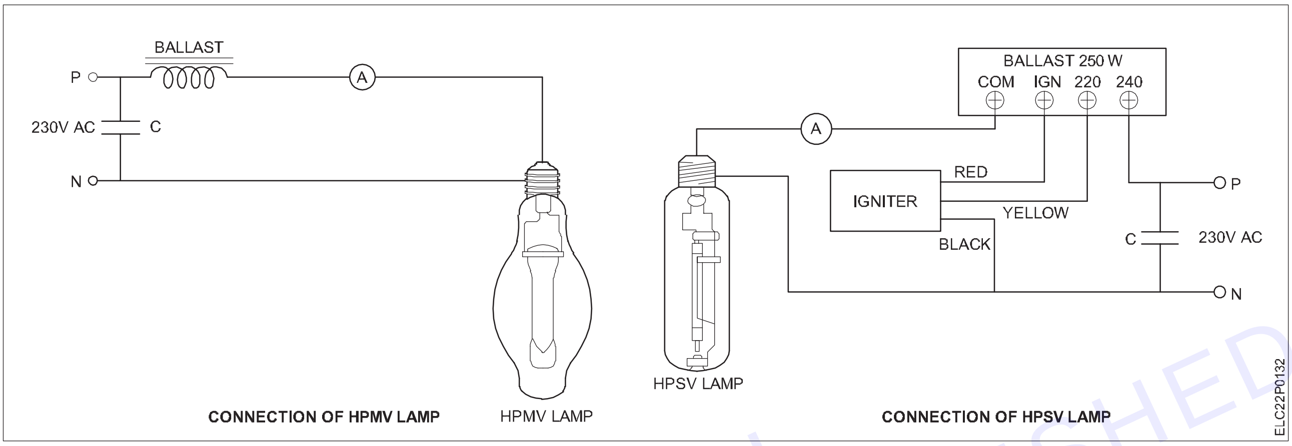
3 Allow some time to glow the lamp with full brightness which takes about 5 minutes.

4 After lamp glows with full brightness record the running current in ammeter & observe color of light.

5 Switch OFF the supply and disconnect the circuit and lamp.

Tabular column:

	Voltage (V)	StartingCurrent (I_1)	Running Current (I_2)	Color of light
HPMV Lamp				
HPSV Lamp				



Safety precautions:

1 Handle the HPMV & HPSV lamps very carefully.

2 Never connect the lamps without ballast.

3 Do not touch the lamps during ON condition as lamps are hot.

4 Do not see the light directly as it may harm the eyes.

EXERCISE 57 : To design & construct decorative light

Objectives

At the end of this exercise you shall be able to:

- design the decorative light circuit for given supply voltage
- select the appropriate bulbs and construct the decorative light
- test and repair the decorative lights.

Requirements

Tools/Equipments/Instruments

- Combination Plier 165mm, insulated -1 No.
- Connector screw driver 100 mm -1 No.
- Neon Tester 75mm, 500 V -1 No.
- Electrician knife Insulated -1 No.
- Soldering iron with stand 25 W, 230 V -1 No.
- Multi meter Digital, $3^{1/2}$ digit -1 No.

Materials/Components

- Flexible copper wire 1.0 sq.mm -1 Coil.
- Test lamp 100 W, 230V -1 No.
- Screw cap bulb 6 V, 100 mA -50 No's.
- Screw type lamp holder 6 V, 100 mA -50 No's.
- Soldering lead -1 role.
- Soldering flux Resin core -as reqd.

Procedure

TASK 1: **Designof decorative lights**

1 Draw the circuit diagram of series & parallel connection of serial lights / decorative lights.

2 Check the type and voltage rating of decorative serial lamps.

3 Design / calculate the No. of bulbs required for given supply voltage and type of connection.

Calculation:

Supply voltage = 230 V

Rated voltage of decorative lamp = 6 V

No. of lamps required = $\frac{230}{6}$ = 38 lamps

Add 5% voltage fluctuation - 38 + 5% of 38 = 1.9

= 38 + 1.9 = 39.9 (say 40 lamps)

40 No's of 6 V lamps to be connected in series for one group of circuit.

Make 3 OR more groups and connect all the groups in parallel to increase the No. of lamps in decorative serial lights.

— — — — —

TASK 2: **Construction of decorative lights**

1 Cut the PVC flexible wire into pieces as per required No. and lengths.

2 Remove the insulation of flexible wire pieces and make a tinning with soldering.

3 Make the tinning on the terminals of 40 No's of 6V screw type lamp holders.

4 Now connect all 40 No's of screw type lamp holders in series with a flexible wire pieces by soldering.

5 Insert the 6V bulbs in lamp holders properly.

6 Connect the flasher in series with decorative serial lamp circuit.

7 Connect & test the constructed decorative serial lights with 1 Ph. AC supply, and check flashing of decorative lights.

8 Fallow the steps 1 to 5 & construct 3 OR more groups of decorative lights and connect the groups.In parallel.

9 Connect & test with 1 Ph. AC supply.

10 Switch OFF the supply and disconnect decorative lights from socket.

— — — — —

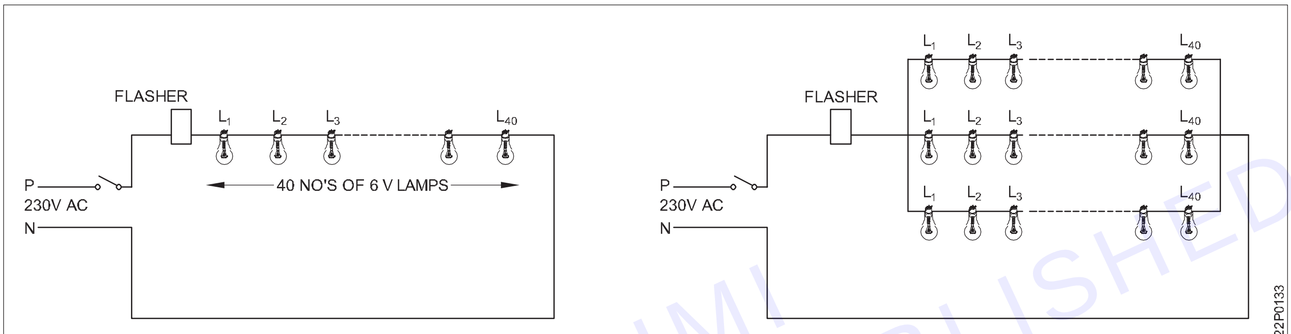
Safety precautions:

1 Do not make loose connection / improper soldering.

2 Do not connect less No. of lamps than the calculated No. of lamps.

3 Do not touch the open terminals of decorative lamps.

4 In case any lamp is fused, switch OFF the supply and replace the lamp.



DECORATIVE SERIAL LIGHT CIRCUIT

SERIES PARALLEL CONNECTION OF DECORATIVE SERIAL LIGHTS

EXERCISE 58 : To measure the intensity of light by Lux meter

Objectives

At the end of this exercise you shall be able to:

- check the lux meter, its display and range
- measure the light intensity of different lights by lux meter
- measure the light intensity in different locations of building by lux meter.

Requirements

Tools/Equipments/Instruments

- Combination Plier 165mm, insulated - 1 No.
- Neon tester 100mm, 500V - 1 No.
- Digital Lux meter 0-200000 lux - 1 No.
- Measuring tape 15 ft - 1 No.

Materials/Components

- Test lamp 230 V - 1 No.
- LED bulb 10 W, 30 W, 50 W - 1 No. each
- Incandescent bulb 60 W, 100 W, 200 W - 1 No. each
- Pendent lamp holder 6 A - 1 No.

Procedure

Lux meter:

A Lux meter is an instrument which measures the light intensity of natural light as well as artificial light produced by different Electrical lamps/Bulbs. Lux is the unit of light intensity OR illumination. The Lux meter directly measures the light intensity in terms of Lux.

The lux meter consists of light sensor, plastic enclosure, range selector switch, battery and digital display. The lux meter converts light source into Electric current, the amount of current is depends on brightness of light that falls on light sensor. Lux meter calculate the appropriate value of current and displays in terms of Lux

TASK 1: **Identify the lux meter**

1 Check the lux meter and its parts.

2 Check the battery of lux meter for working condition.

3 Measure the area of different rooms of house / office.

4 Fix the bulbs / lights of different wattage in the rooms.

— — — — —

TASK 2: **Measure the intensity of light by lux meter**

1 Switch ON the lux meter and observe the zero reading in the display.

2 Hold the lux meter in one hand and hold light sensor in other hand.

3 Measure the natural light intensity and record the reading.

(Measure the natural light during sun set, mid day, sun set and night)

4 Measure the light intensity in the rooms of house / office and record the readings.

5 Measure the light intensity with different types of lights / bulbs and record the readings.

6 Ensure that no shadows while measuring the light intensity by lux meter.

7 Switch OFF the lux meter, remove the battery and keep it safely.

— — — — —

S.No.	Place	Area (Sq. meter)	Light intensity (Lux)
1	Natural light		
2	Leaving room		
3	Bed room		
4	Kitchen		
5	Bath room		
6	Passage		

Safety precautions:

- Handle the lux meter & its light sensor carefully
- Do not hold the lux meter very close to light source.
- Avoid shadows while measuring the light intensity.

EXERCISE 59 : Repair of LED Lights

Objectives

At the end of this exercise you shall be able to:

- check and identify the parts/components of LED lights
- test the circuit and all the components of defective of LED light step by step
- find the cause of defect and Replace the defective components
- repair and test the LED light.

Requirements

Tools/Equipments/Instruments

- Combination Plier 150 mm, insulated - 1 No.
- Connector screw Driver 100mm, insulated - 1 No.
- Neon Tester 75mm, 500 V - 1 No.
- Electrician knife Insulated - 1 No.
- Wire stripper 100mm - 1 No.
- Soldering iron 25 watts, 230 V - 1 No.
- De-soldering pump - 1 No.
- Multi meter Digital, $3^{1/2}$ digit - 1 No.

Materials/Components

- Defective LED Bulb/light Any rating - 2 Nos.
- PVC hook up wire 0.5 sq.mm - as reqd.
- Capacitors AC/DC Any rating - as reqd.
- LED Any rating - as reqd.
- Soldering lead & flux - as reqd.

Procedure

TASK 1: **Check the parts & circuit of LED light**

1 Draw the circuit diagram of LED light/bulb.

2 Identify the parts/components of LED light/bulb and study the circuit.

3 Test & observe the type of defect in LED light.

— — — — —

TASK 2: **Repair of LED light / bulb**

1 Check the loose connection / de-solder of wires and components in defective LED light.

2 Check for defective LED's if any, and remove the same by de-soldering.

3 Dismantle the parts / components of LED light.

4 Test the driver circuit and check for damage of components if any.

5 Connect the driver with AC supply and check the voltage with multi-meter in each section.

6 Repair / replace the damaged components like capacitors, LED

7 After repair/replacement of defective components test the circuit with AC supply.

8 On successful working re-assemble the LED light and test once again with supply.

— — — — —

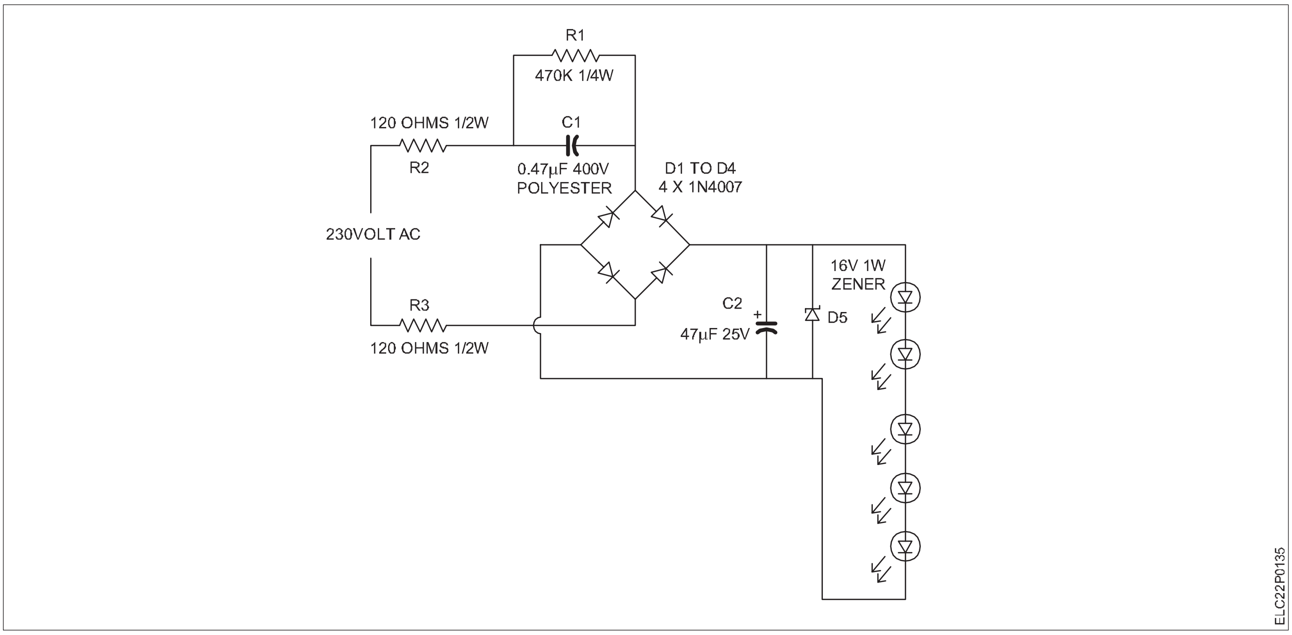
Safety precautions

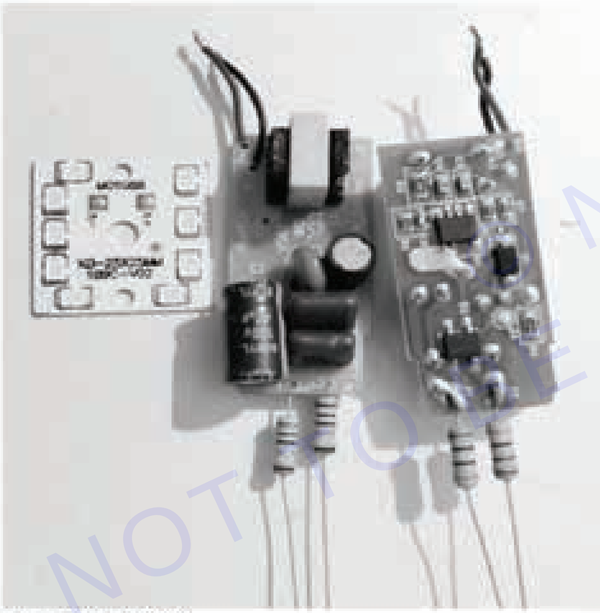
1 Handle the LED light/bulb carefully.

2 Connect the capacitors with proper polarity.

3 Do not over heat the components while soldering.

4 Do not touch PCB while testing with AC supply.




Parts of LED light


Repair of LED light

EXERCISE 60 : Identify different colour coding of resistors

Objectives

At the end of this exercise you shall be able to

- explain the colour code Table and letter code resistance values
- identify the colour bands, and decode the resistance value of given resistance
- calculate the tolerance value by the colour band
- measure the actual value with a multimeter and verify with calculated value.

Requirements

Tools/Equipments/Instruments

- Multimeter/Ohmmeter -1 No.

Materials/Components

- Various types of resistors (assorted values) including potentiometers of carbon track and wire-wound type and SMD -as reqd.

Procedure

TASK 1 : **Write the Digit, multiplier and tolerance of each colour mentioned in Table (1)**

1 Write the Digit, multiplier and tolerance of each colour mentioned in Table (1)

Table-1

Colour	Digit	Multiplier	Tolerance (%)
Black			
Brown			
Red			
Orange			
Yellow			
Green			
Blue			
Violet			
Grey			
White			
Gold			
Silver			
(none)			

No of bands	Digit bands	Multiplier band	Tolerance band	Temp. co efft band
4	1,2	3	4	
5	1,2,3	4	5	
6	1,2,3	4	5	6

(An informative Table for coding with varying digit bands is shown above)

For precision resistors, 5 or 6 band are used. 5th band of 6 band resistor may be for fail rate indication, in case of Military grade application. Refer manufactures catalogue for information.

— — — — —

TASK 2 : **Identify the colour bands, and decode the resistance value of given resistance**

1 Identify the value of resistors shown in Fig 1 from the colour bands and enter (Refer Task 1 Table 1).

Fig 1

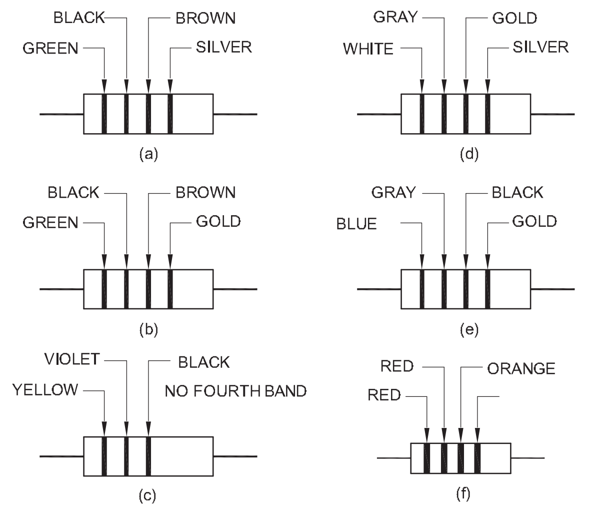
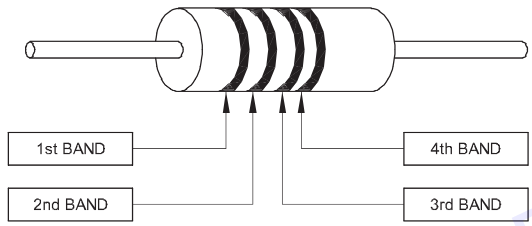


Fig 2



2 Identify the first two colour bands of the resistors given by the instructor (in sequence commencing from the 1st colour band closer to one end of the resistor – Refer Fig 2.

3 Write the 1st number and 2nd number in Table 2.

4 Identify the colour of the 3rd band and write the multiplier value in the respective column in Table 2.

Table 2

Sl. No.	Band				Recorded resistance value	Tolerance in Ohm	Max. value of resistance	Min. value of resistance	Measured value	Remarks OK or not OK
	1st Band	2nd Band	3rd Band	4th Band %						
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										

— — — — —

TASK 3 : **Calculate the tolerance value by the colour band**

1 Compute the value of the resistor and record in (Refer Task 2 -Table 2).

2 Identify the 4th band colour and fill up the tolerance in (Refer Task 2 -Table 2).

3 Determine the resistance value and the tolerance for various given resistors and record in (Refer Task 4 -Table 3) Table 3 by repeating the above steps.

— — — — —

TASK 4 : **Measure the actual value with a multimeter and verify with calculated value**

1 Measure the value of the resistors by using a multimeter and enter the values in Table 3 by following the procedure given below.

Table 3

S. No.	Colour				1st No.	2nd No.	3rd No.	Multiplier	Resistance value	Tolerance limit (±) in percentage
	1st Band	2nd Band	3rd Band	4th Band						
A										
B										
C										
D										
E										
F										
G										

2 Write the value of resistance in letter code in Table 4

Table 4

Letter code	Value of resistance
R47	
4R7	
470R	
4K7	
47K	
47K3	
470K	
4M7	

— — — — —

EXERCISE 61 : Construct Rectifier circuits

Objectives

At the end of this exercise you shall be able to

- assemble the half wave rectifier, full wave rectifier and bridge rectifier circuits
- measure the input AC voltage and output AC voltage and DC voltage by CRO
- calculate the V_{rms}, V_{dc}, and ripple factor
- plot the input and out wave shapes.

Requirements

Tools/Equipments/Instruments

- Insulated Combination pliers (150mm) -1 No.
- Side cutting plier (150mm) -1 No.
- Electrician knife (75mm) -1 No.
- Tweezer (75mm) -1 No.
- Multimeter (digital) -1 No.
- CRO (30MHZ) -1 No.

Materials/Components

- Diode (IN4007) - 4 Nos.
- Resistors (1kohm) - 1 Nos.
- capacitor (470micro farad/50 v) - 1 No.
- Step down transformer (230/12-0-12v/50Hz) - 1 No.
- Bread board (175x 67 x 8mm) - 1 No.
- Connecting wire - 1 mtr.

Procedure

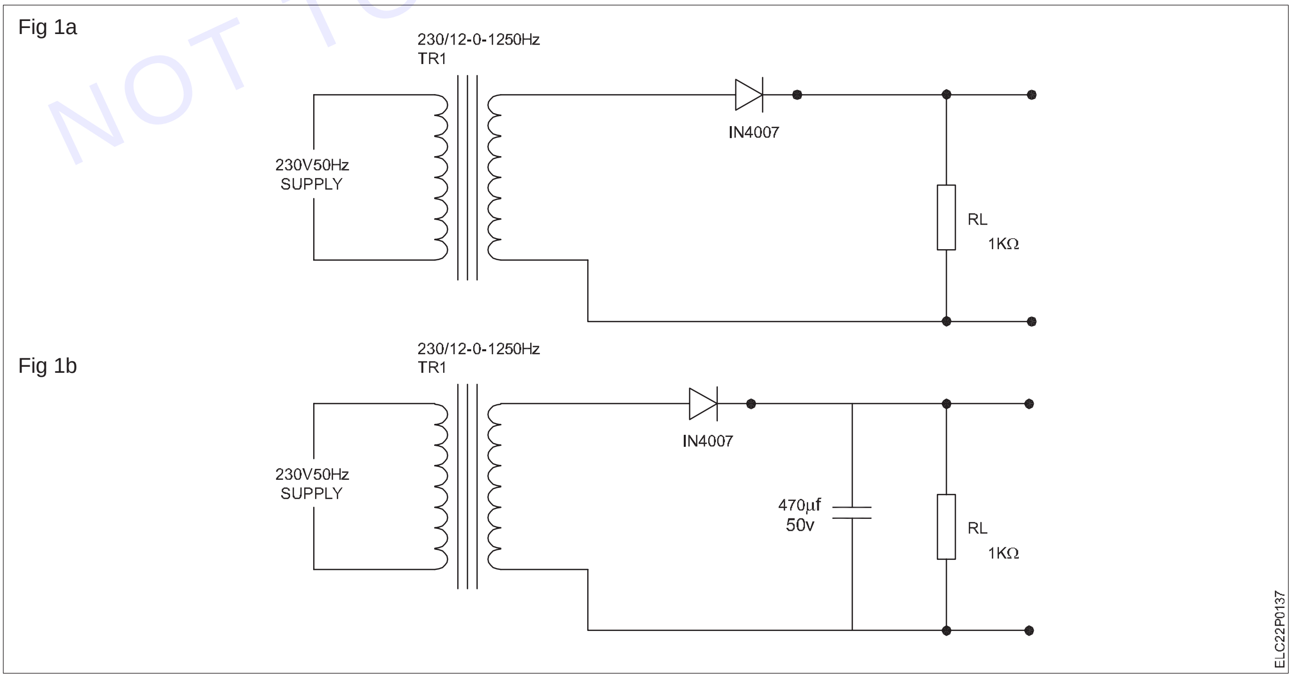
TASK 1 : **Assemble the half wave rectifier, full wave rectifier and bridge rectifier circuits**

1 Draw the circuit diagrams the half wave rectifier (Fig1a, Fig1b), full wave rectifier (Fig 2a, Fig 2b) and bridge rectifier (Fig 3a, Fig 3b) circuits with and without filter capacitor

2 Connect the equipment and materials as per the circuit diagram

Ensure correct polarity while connecting diode

3 Connect the supply and switch ON the circuit.



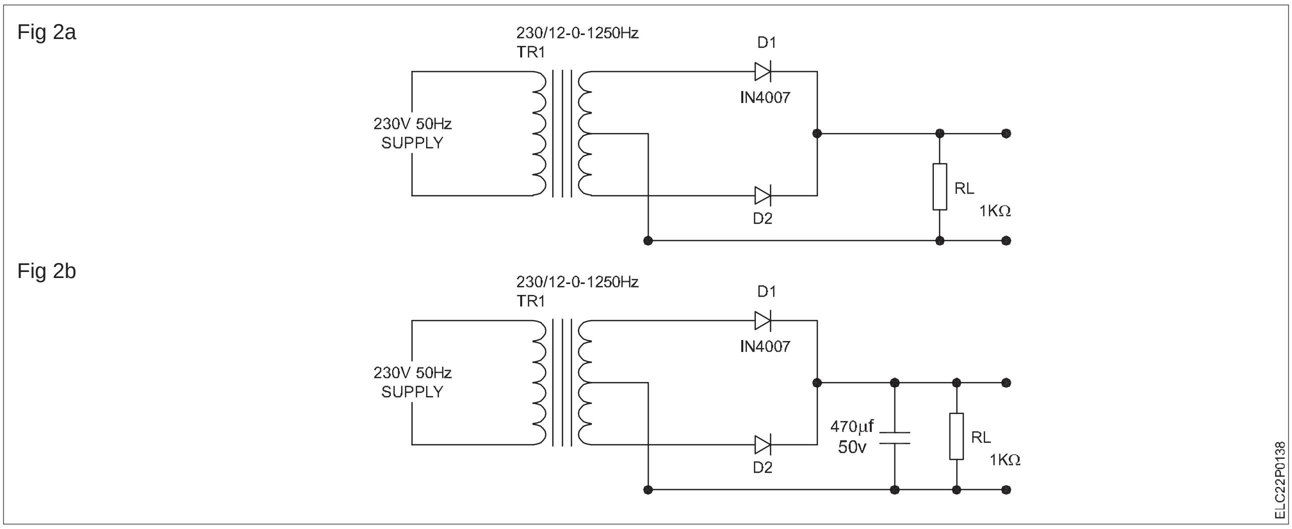


Fig 2a

Fig 2b

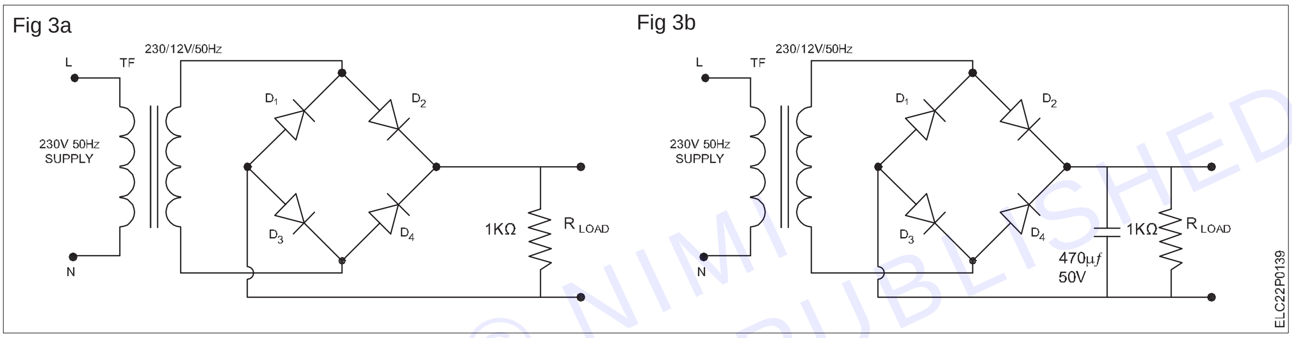


Fig 3a

Fig 3b

— — — — —

TASK 2 : **Measure the input AC voltage and output AC voltage and DC voltage by CRO**

1 Connect the input and output terminals of the rectifier to the probes of CRO.

2 Measure the peak voltage AC input voltage and measure the time period of cycle by CRO.

3 Measure the peak value of output DC voltage by CRO and note it.

Sl.No	Input AC peak voltage	Output DC peak voltage	Time period T (ms)

— — — — —

TASK 3 : **Calculate the Vrms , Vdc, and ripple factor from the measured peak value**

$V\,rms = Vm/\sqrt{2}$

$Vdc = Vm/\pi$ (for Half Wave rectifier), $2Vm/\pi$ (for Full Wave rectifier)

Ripple factor $= \sqrt{(Vrms/Vdc)^2 - 1}$

With filter : Ripple factor, $r = 1/(2\sqrt{3}\, f\, C\, RL)$ for HW and $1/(4\sqrt{3}\, f\, C\, RL)$ for FW

With filter: Ripple factor, r = 1/ (2√3 f C RL) for Half Wave rectifier and 1/ (4√3 f C RL) for Full Wave rectifier

2 Tabulate the results in Table 1

Calculations without filter capacitor

Table 1

Rectifier type	V_m	V_{rms}	V_{DC}	Ripple factor
Half wave rectifier				
Full wave rectifier				
Bridge rectifier				

— — — — —

TASK 4 : **Plot the input and out wave shapes**

1 Observe the waveforms for each rectifier circuit.

2 Plot the input ac wave and output waveforms of half wave rectifier, full wave rectifier and bridge rectifier circuits with and without filter capacitor

— — — — —

EXERCISE 62 : Check the different wave shape using CRO

Objectives

At the end of this exercise you shall be able to

- identify the various controls of the function generator
- operate the function generator and set the required frequency and wave form
- measure the time and frequency of the set waveform using CRO.

Requirements

Tools/Equipments/Instruments

- 30 MHz oscilloscope dual Trace -1 Nos.
- Function generator -1 Nos.

Procedure

TASK 1: **Identify the various controls of the function generator**

1 Write functions of function generator controls

Sl.no	Description	Function
1	Coarse knob	
2	Fine knob	
3	Freq.range buttons	
4	Duty cycle knob	
5	INV button	
6	Function buttons	
7	ATTN button	
8	SYNC terminal	
9	DC Offset knob	

— — — — —

TASK 2: **Operate the function generator and set the required frequency and wave form**

1 Switch ON the function generator

2 Set the wave shape of the function generator to sine wave (refer Fig1) and record in Table 1

3 Set the range of frequency in function generator to 10kHz

Fig 1

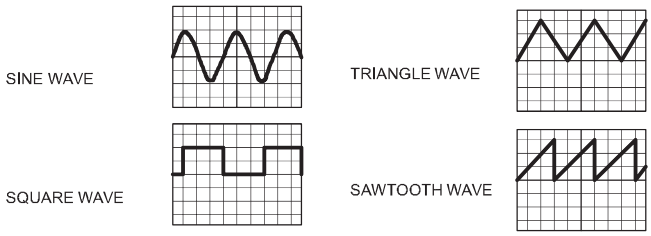


Table 1

Sl. No	Selected waveform	Set frequency in Function generator	Set Volt/div on CRO	Measured Vp in CRO	Set Time/ div on CRO	Measured time period (Time/div x division for 1 cycle)	Frequency (1/T)

— — — — —

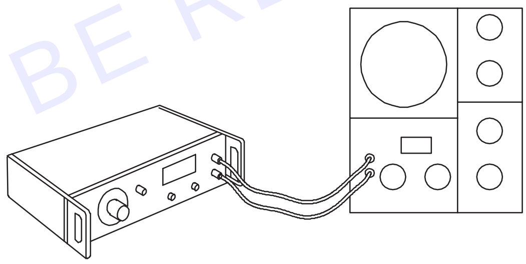
TASK 3: **Measure the time and frequency of the set waveform using CRO**

1 Switch ON the CRO

2 Connect BNC cable to CRO and calibrate the CRO by adjusting the Time/div and volt/div and other measuring conditions.

3 Connect the function Generator output to CRO input as in Fig 2

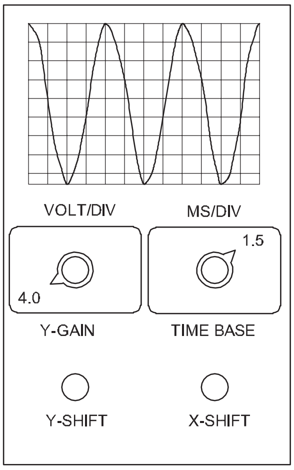
Fig 2



4 Adjust the trace on the center of CRO

5 Set the volt/div and time/div of the CRO to properly display the waveform in CRO and adjust amplitude in function generator (refer Fig 3)

Fig 3



6 Adjust horizontal shift in CRO to accurately measure the horizontal divisions between a cycle

7 Calculate the time period of the wave by multiplying the selected base time.

8 Vary the frequency of input and calculate the time period and frequency

9 Change the wave shape to square and triangular and repeat steps 7 and 8

— — — — —

EXERCISE 63 : Test the Transistor Single stage Amplifier circuit

Objectives

At the end of this exercise you shall be able to

- assemble the amplifier as per circuit diagram
- operate the single stage amplifier
- calculate the gain of the single stage transistor amplifier.

Requirements

Tools/Equipments/Instruments

- Side cutting pliers (150mm) -1 No.
- Combination pliers (150mm) -1 No.
- Electrician knife (75mm) -1 No.
- Tweezer (75mm) -1 No.
- Function generator (0-20 M Hz) -1 No.
- CRO (30MHz) -1 No.
- DC power supply (0-24 V,2A) -1 No.

Materials/Components

- Transistor (BC 107) - 1 No.
- Resistor (47K,2.2K,10K,680Ω,820 Ω) - 1 No Each.
- Capacitors (10μF,22 μF,50 V) - 2 Nos.
- Bread board (175 X 67 X 8 mm) - 1 No.
- Connecting wires - 1 mtr.

Procedure

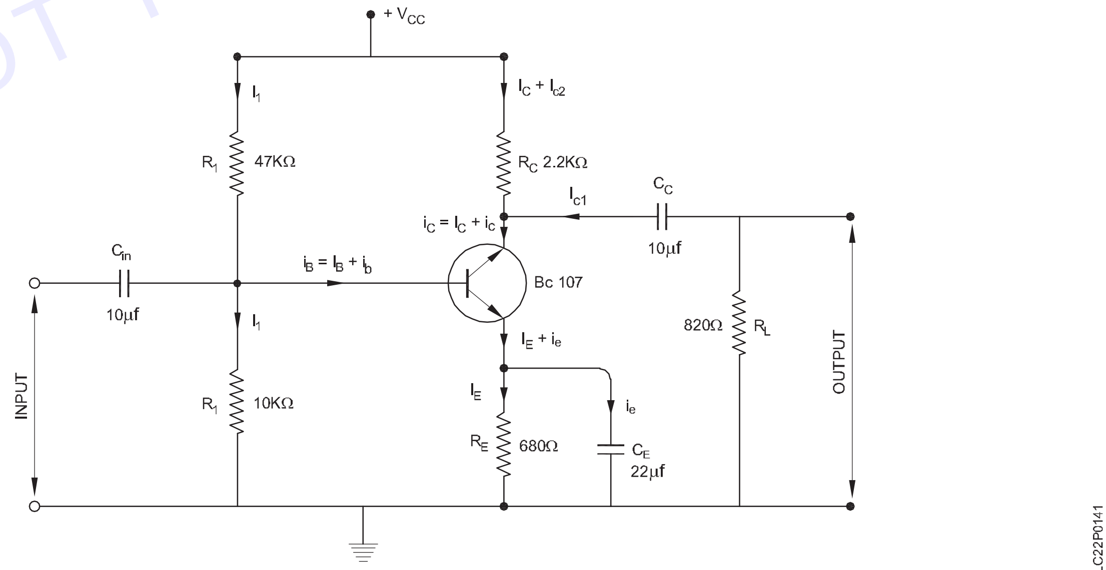
TASK 1 : **Assemble the amplifier as per circuit diagram**

1 Draw the circuit diagram of common emitter single stage amplifier voltage divider bias.

2 Connect the items as per the circuit diagram. Fig 1.

Observe the correct polarity while making connections.

Fig 1



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TASK 2 : **Operate the single stage amplifier.**

1 Connect the power supply and switch ON the circuit.

2 Connect the function generator to input terminals

3 Observe the input wave forms.

4 Calculate the frequency and input voltage from CRO and note down it.

5 Connect the output terminals to the CRO.

6 Observe the output wave form. Adjust the frequency of input signal so that a sine wave is obtained at output.

7 Measure the output voltage. It should be a high value because of amplification due to transistor action.

8 Calculate the frequency of wave form. [f =1/T]

9 Switch off the supply.

— — — — —

TASK 3 : **Calculate the gain of the single stage transistor amplifier**

1 Calculate the gain of the amplifier as per the formula given below.

Gain = Output voltage / Input voltage

Gain in dB = 20 log V_{output} / V_{input}

2 Tabulate results in Table 1.

Table 1

Frequency	Input voltage	Output voltage	Gain	Gain in dB

— — — — —

EXERCISE 64 : Design Simple circuit containing power diode & power transistor

Objectives

At the end of this exercise you shall be able to

- design circuit diagram of 12V,3A DC power supply
- test the components
- assemble the circuit of general-purpose PCB
- test the power supply.

Requirements

Tools/Equipments/Instruments

- Side cutting pliers (150mm) -1 No.
- Combination pliers (150mm) -1 No.
- Electrician knife (75mm) -1 No.
- Tweezer (75mm) -1 No.

Materials/Components

- Stepdown transformer (230V/15V) - 1 No.
- NPN Power Transistor (2N3055) - 1 No.
- Rectifier Diode (SB 550) - 4 Nos.
- Zener Diode (12V, 1N4742A) - 1 No.
- Heat Sink - 1 No.
- Resistor (680 ohm) - 2 Nos.
- Capacitors (5000μF, 50V) - 2 Nos.
- Capacitors (0.01μF,20V) - 1 No.
- General purpose PCB - 1 No.

Procedure

TASK 1 : **Design circuit diagram of 12V,3A DC power supply**

1 Calculate power output P = V X I , =12 X 3 = 36 watts.

2 Select a suiTable transformer. [considering the output DC of 12V, transformer of 15V,5A is selected, which will supply the losses too]

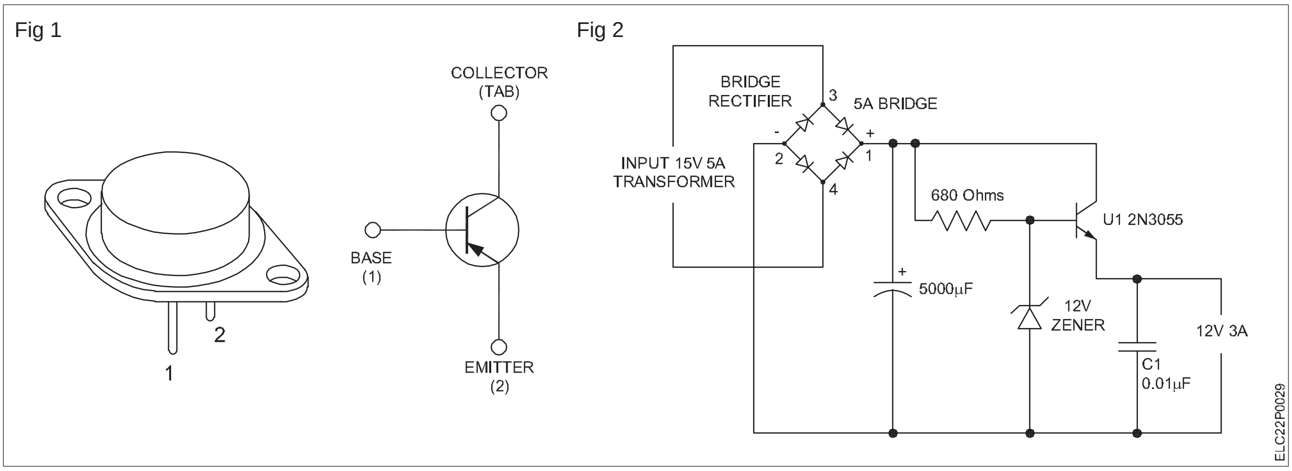
3 Select diode for rectification, which should handle 3A. [SB550 is a Schottky power diode which can handle 50V and 5A]

4 Select a regulator diode for the circuit and assess. [A 12V Zener (1N4742A)can regulate 12V,however can not act as a current source due to its power limitation]

5 Select a power transistor to amplify current. [Common base power transistor 2N3055 can handle 5A, refer Fig 1]

6 Select a current limiting resistor to zener regulator and current to base of the transistor. [For 1N4742A the standard test current is 21mA for 1 watt. To limit current to safe value 680ohms can be used. (DC rectified expected 21V approx. and 12V, effectively give 9V drop across resistor.)]

7 Draw the circuit diagram. (Fig 2)



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TASK 2: **Test the components**

1 Verify the transformer output by supplying rated input

2 Test the rectifier diodes

— — — — —

TASK 3 : **Assemble the circuit of general-purpose PCB**

1 Mount the power transistor on heat sink.

2 Assemble the components on general purpose PCB as per circuit diagram

— — — — —

TASK 4 : **Test the power supply**

1 Switch on the supply

2 Test the voltage output of power supply.

3 Load the power supply and make the voltage and current measurements

4 Tabulate the readings in Table 1

Table 1

Sl.No	Voltage	Current

EXERCISE 65 : Construct UJT triggering circuit

Objectives

At the end of this exercise you shall be able to:

- construct UJT relaxation oscillator circuit
- test UJT triggering circuit.

Requirements

Tools/Equipments/Instruments

- DC power supply 0-15V,1A -1 No.
- UJT 2N2646 -1 No.
- Resistor 12K1, POT 470K1/2w, 200E,100E -1 No.
- Capacitors 0.01μF -1 No.
- General purpose PCB -1 No.
- Diode 1N4007 -1 No.
- Trainee tool kit -1 No.
- Dual channel oscilloscope 20 MHZ -1 No.
- Power supply unit 0-15V, 1A variable -1 No.

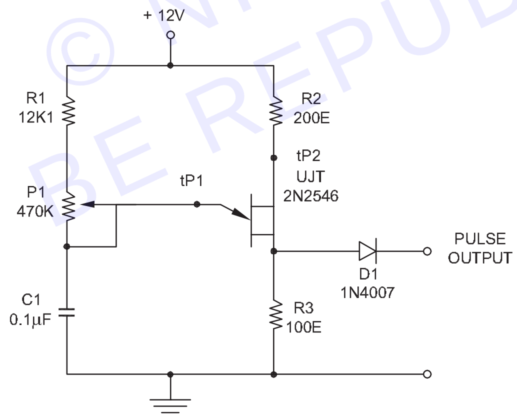
Procedure

TASK 1: **Construct UJT triggering circuit**

1 Assemble the circuit as per diagram in Fig 1 in general purpose PCB.

2 Get the assembled circuit checked by instructor

Fig 1



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TASK 2: **Test UJT triggering circuit**

1 Connect +12V dc power supply at their indicated position from external source.

2 Adjust the potentiometer 470k to reduce the frequency.

2 Switch ON the power supply.

3 Connect the oscilloscope CHI between output and ground and CHII between tp1 and ground and observe the waveform of pulse output and RC time constant.

4 Vary the potentiometer P1 so as to increase the frequency of the output.

5 calculate Time seconds = $(R_1 + R_2)$ x C where R_1 = 12K1, PI= 0 At start, C=0.01μF

6 calculate frequency = 1/T

7 Observe the pulse output wave form in CRO

8 Check the time period

9 plot the observed waveform in graph sheet

10 Enter the calculated and observed data in Table below.

S. No.	Pot position	Calculated frequency $(R_1 + R_2) \times C$	Time observed	Frequency measured by CRO (f = 1/T)
1	Minimum, P1 = 0 OHM			
2	Maximum, P1= 470k OHM			

— — — — —

EXERCISE 66 : Use FET & MOSFET as an amplifier

Objectives

At the end of this exercise you shall be able to:

- construct FET amplifier circuit
- test FET amplifier circuit
- construct MOSFET amplifier circuit
- test MOSDFET amplifier circuit.

Requirements

Tools/Equipments/Instruments

- DC power supply 0-15V,1A -1 No.
- FET 2N5951 -1 No.
- MOSFET 2N7000 -1 No.
- Resistor 1M,2.2K,1K,10K -1 No.
- Resistor 2.2K,10K,1K,100K -1 No.
- Capacitor 0.01UF50v, 1UF50v,10UF50v -1 No.
- General purpose PCB -1 No.
- TRAINEE tool kit -1 No.
- Dual channel oscilloscope 20 MHZ -1 No.

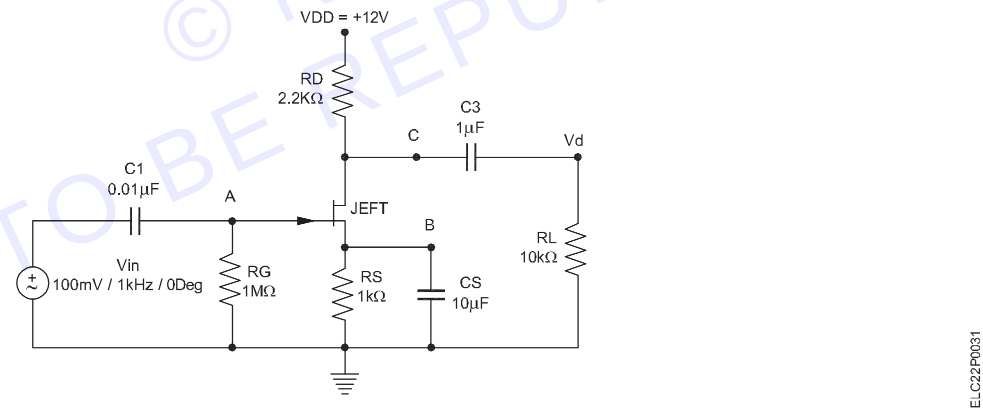
Procedure

TASK 1: **Construct FET Amplifier circuit**

1 Assemble components in general purpose PCB as per Fig 1

2 Get the circuit assembly checked by instructor

Fig 1



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TASK 2: **Test FET amplifier circuit**

1 Connect +12V dc power supply at their indicated position from external source.

2 Switch ON the power supply.

3 Apply signal of 100mV,1 khz to the source of FET

3 Observe the signal input and output wave form in CRO

4 Check Vs and Vd from plotted wave

5 Calculate gain Vd/Vs

6 Vary Vs for 1 more varied amplitude and repeat steps 4 to 6

8 Tabulate (Table 1) the readings and calculate voltage gain to verify the amplifying action of FET

Table 1

Sl.No	V_s	V_d	Voltage Gain	dB Gain = 20 log (Vo/Vi) dB
1				
2				

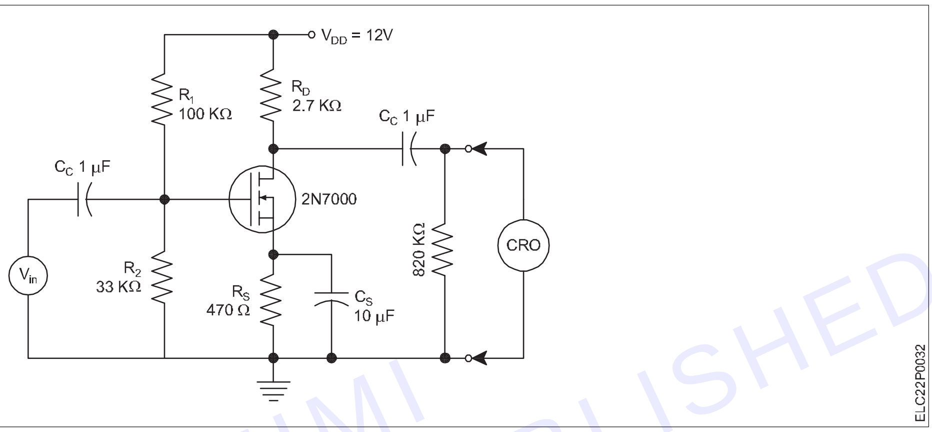
— — — — —

TASK 3: **Construct MOSFET amplifier circuit**

1 Assemble components in PCB as in Fig 2

2 Get the circuit assembly checked by instructor

Fig 2



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TASK 4: **Test MOSFET amplifier circuit**

1 Connect +12V dc power supply at their indicated position from external source.

2 Switch ON the power supply.

3 Observe the signal input and output wave form in CRO

4 Check Vs and Vd from plotted wave

5 Calculate gain Vd/Vs

6 Vary Vs for 1 more varied amplitude and repeat steps 3 to 5

7 Tabulate (Table 2) the readings and calculate voltage gain to verify the amplifying action of MOSFET

Table 2

Sl.No	V_s	V_d	Voltage Gain
1			
2			

— — — — —

EXERCISE 67 : Assess construction of control circuits for – SCR, DIAC, TRIAC, IGBT

Objectives

At the end of this exercise you shall be able to:
- construct and test a power control circuit using SCR
- assemble and test a lamp dimmer-cum-fan speed regulator using TRIAC and DIAC
- construct and test a power control circuit using IGBT.

Requirements

Tools/Equipments/Instruments

- SCR 2P4M -1 No.
- Resistor 1K,1/4W -2 Nos.
- Resistor 330R,1/4W -1 No.
- Resistor 2.2kΩ/¼ W -2 Nos.
- Wire wound resistor 10k,10W -1 No.
- Pot 500k,0.5w -1 No.
- Pot 100k,3w -1 No.
- LDR -2 Nos.
- LED GREEN 3MM -1 No.
- Diode 1N4007 -1 No.
- General purpose PCB -2 Nos.
- Power supply DC 0-32v -1 No.
- Isolation Transformer 230V, 1A - 1 No.
- TRIAC TYN404 - 1 No.
- Heat Sink - 2 Nos.
- Capacitors 0.5uF,600V - 1 No.
- General purpose PCB - 2 No.
- CRO 30MHz - 1 No.
- IGBT 5SMV 86M1731 - 1 No.
- ON/OFF Switch - 2 Nos.
- Socket for IGBT - 1 No
- Breadboard - 1 No.
- 12V lamp 5W - 1 No.

Procedure

TASK 1: **Assess SCR control circuit for dark sense light**

1 Connect circuit as per diagram in Fig 1

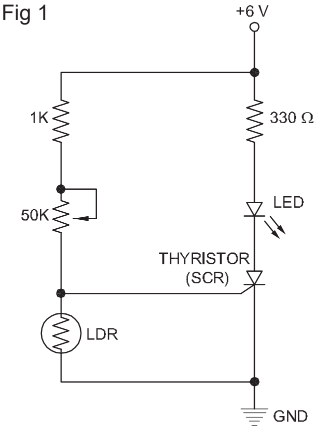
2 Adjust the pot 50k to set dark sensitivity required

3 Cover the LDR to make dark condition effect.

4 Remove the cover of LDR to change dark condition of LDR.

5 Observe the LED ON/OFF condition with respect to LDR dark and not dark condition.

Fig 1



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TASK 2: **Assess phase power control circuit using TRIAC and DIAC**

1 Connect circuit as per diagram in Fig 2

2 Keep the pot 100k to the maximum resistance position.

3 Connect CRO across load terminal

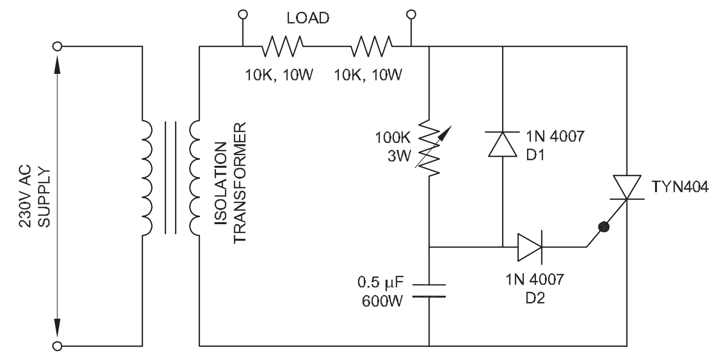
4 Switch on the supply.

5 Vary the potentiometer and observe the waveform across load.

6 Record the output waveform

7 Repeat steps 5 and 6 for further pot settings.

Fig 2



Use multistrand flexible insulated wire for these connections as these wires will carry A.C mains voltage and large current of the order of a few hundred milli amperes.

— — — — —

TASK 3: **Construct and test IGBT test circuit**

1 Collect and check the working condition of all the given components by Multimeter.

2 Assemble the circuit on breadboard as shown in Fig 3

3 Insert IGBT in socket.

4 Power ON the supply & Press switch S1 and observe that lamp load will glow this means IGBT is turned ON

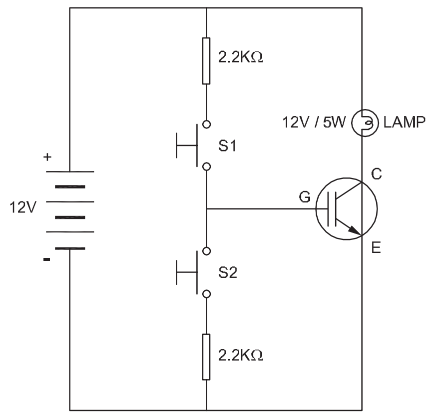
5 Switch OFF S1 and press switch S2 observe that lamp will turn OFF this means IGBT is turned OFF.

6 Tabulate the observed conditions of switch position, Lamp ON/OFF and IGBT status in Table 1

Table 1

S1 position	S2 position	Lamp ON/OFF	IGBT status

Fig 3



EXERCISE 68 : Assemble different OP-AMP circuits using IC 741

Objectives

At the end of this exercise you shall be able to:
- assemble the voltage follower circuit using OPAMP 741 and observe the input and output waveform
- assemble the zero-crossing detector circuit using OPAMP 741 and observe the input and output waveform
- assemble the inverting amplifier circuit using OPAMP 741 and observe the input and output waveform
- assemble the NON- inverting amplifier circuit using OPAMP 741 and observe the input and output waveform
- assemble the integrator circuit using OPAMP 741 and observe the input and output waveform
- assemble the differentiator amplifier circuit using OPAMP 741 and observe the input and output waveform

Requirements

Tools/Equipments/Instruments

- Side cutting pliers 150mm -1 No.
- Electrician knife 75mm -1 No.
- Tweezers 75mm -1 No.
- Function generator 20MHz -1 No.
- CRO 30MHz -1 No.
- OPAMP IC UA 741 -1 No.
- Bread board 175x67x8mm -1 No.
- DC power supply 0-30V -1 No.
- Hook up wire -1 m.

Procedure

TASK 1: **Assemble the voltage follower circuit using OPAMP 741 and observe the input and output waveform**

1 Draw the circuit diagram

2 Connect the circuit as per circuit diagram. Refer Fig1a

3 Connect +Vcc 15V to pin 7 and –Vcc 15V to pin 4.

4 Apply the input signal with function generator.

5 Observe the input and output waveforms and record voltage level in Table1. (Fig 1b provides indicative waveforms)

6 Plot the input and output waveform.

Fig 1a

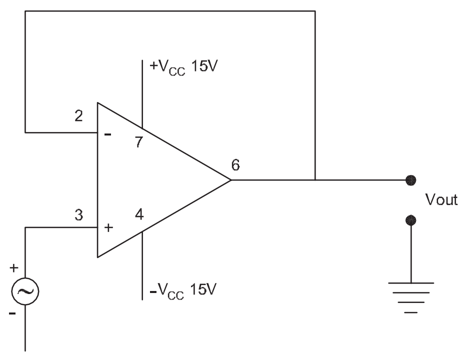


Fig 1a Voltage follower

Fig 1b

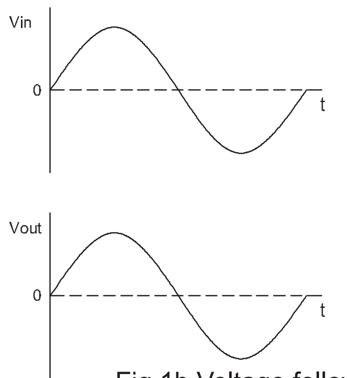


Fig 1b Voltage follower

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Table 1

Sl.No	Vin peak	Vout peak

TASK 2: **Assemble the zero-crossing detector circuit using OPAMP 741 and observe the input and output waveform**

1 Draw the circuit diagram.

2 Connect the circuit as per circuit diagram. Refer Fig 2.

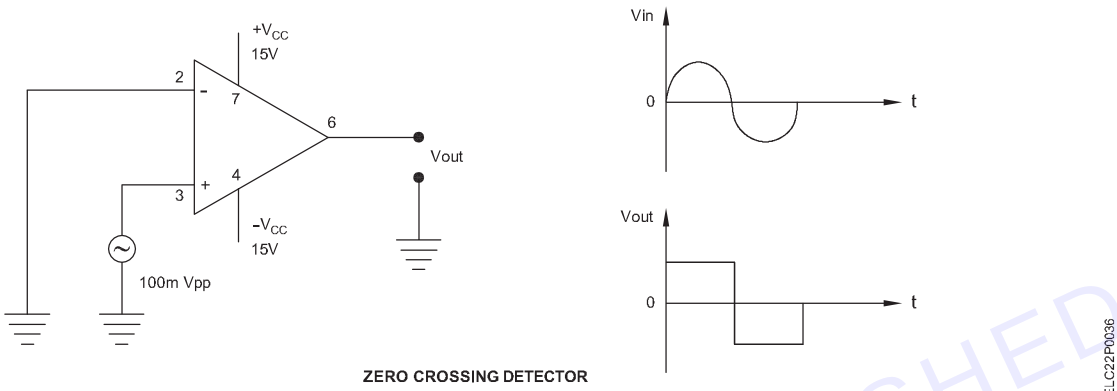
3 Connect +Vcc 15V to pin 7 and –Vcc 15V to pin 4.

4 Apply the input signal with function generator.

5 Observe the input and output waveforms and record voltage level in Table 2

6 Plot the input and output waveform.

Fig 2



ZERO CROSSING DETECTOR

Table 2

Sl.No	V_{in} peak	Input waveshape	V_{out} peak	Output waveshape

TASK 3 : **Assemble the inverting amplifier circuit using OPAMP 741 and observe the input and output waveform**

1 Draw the circuit diagram.

2 Connect the circuit as per circuit diagram.Refer Fig 3

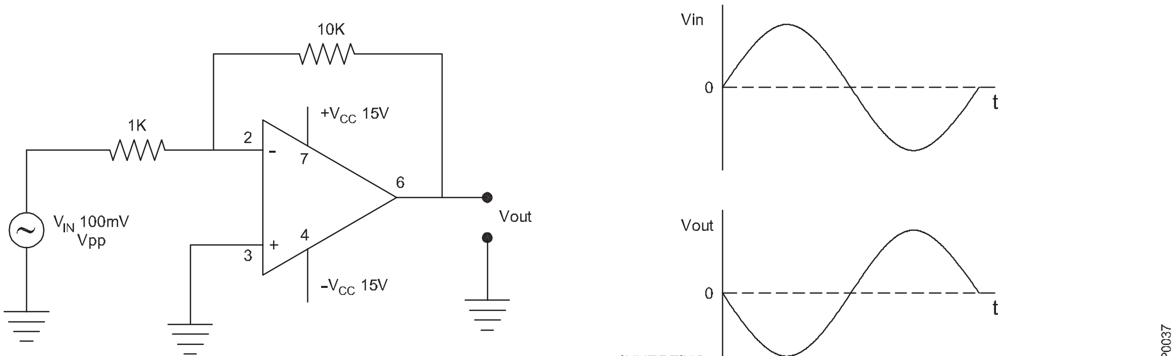
3 Connect +Vcc 15V to pin 7 and –Vcc 15V to pin 4.

4 Apply the input signal with function generator.

5 Observe the input and output waveforms and record voltage level in Table 3

6 Plot the input and output waveform.

Fig 3



INVERTING AMPLIFIER

Table 3

Sl.No	V_{in} peak	Input waveshape	V_{out} peak	Output waveshape

— — — — —

TASK 4 : **Assemble the NON- inverting amplifier circuit using OPAMP 741 and observe the input and output waveform**

1 Draw the circuit diagram.

2 Connect the circuit as per circuit diagram. Refer Fig 4

3 Connect +Vcc 15V to pin 7 and –Vcc 15V to pin 4.

4 Apply the input signal with function generator.

5 Observe the input and output waveforms and record voltage level in Table 4

6 Plot the input and output waveform.

Fig 4

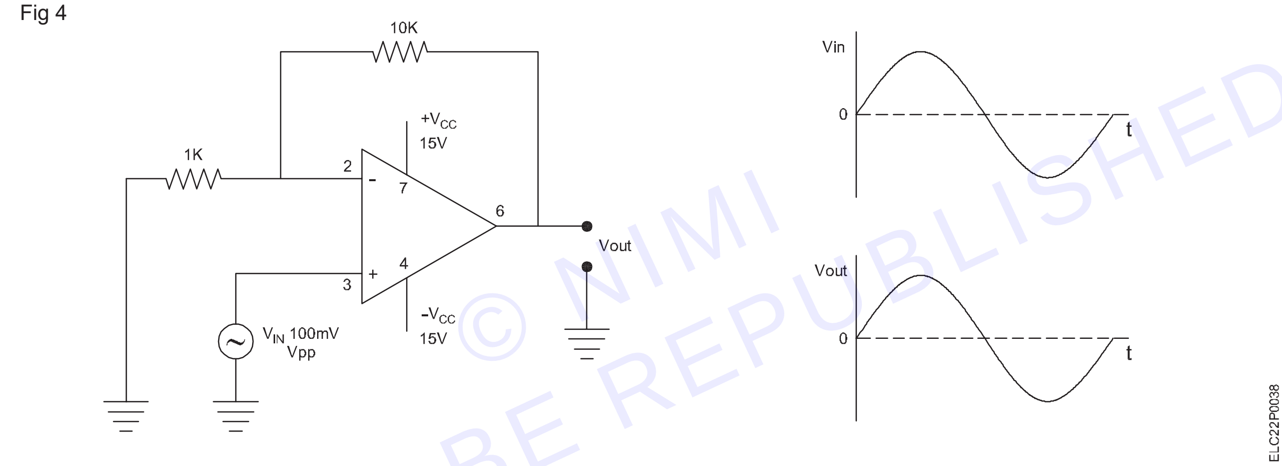


Table 4

Sl.No	V_{in} peak	V_{out} peak

— — — — —

TASK 5 :**Assemble the integrator circuit using OPAMP 741 and observe the input and output waveform**

1 Draw the circuit diagram.

2 Connect the circuit as per circuit diagram. Refer Fig 5

3 Connect +Vcc 15V to pin 7 and –Vcc 15V to pin 4.

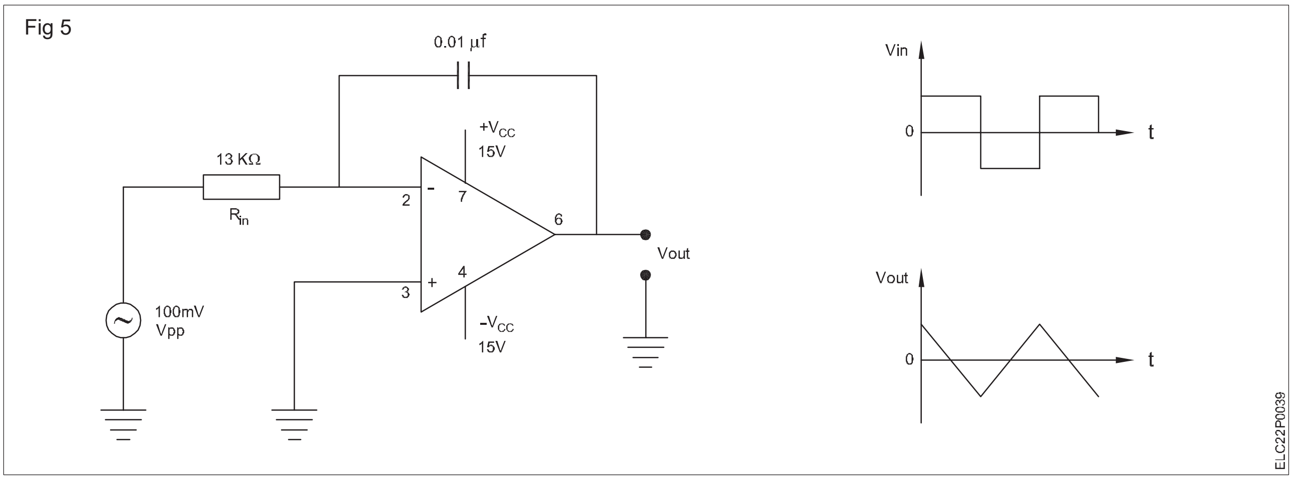
4 Apply the input signal with function generator.

5 Observe the input and output waveforms and record voltage level in Table 5

6 Plot the input and output waveform.

Table 5

Sl.No	Vin peak	Vout peak



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TASK 6 : **Assemble the differentiator amplifier circuit using OPAMP 741 and observe the input and output waveform**

1 Draw the circuit diagram.

2 Connect the circuit as per circuit diagram. Refer Fig 6

3 Connect +Vcc 15V to pin 7 and –Vcc 15V to pin 4.

4 Apply the input signal with function generator.

5 Observe the input and output waveforms and record voltage level in Table 6

6 Plot the input and output waveform.

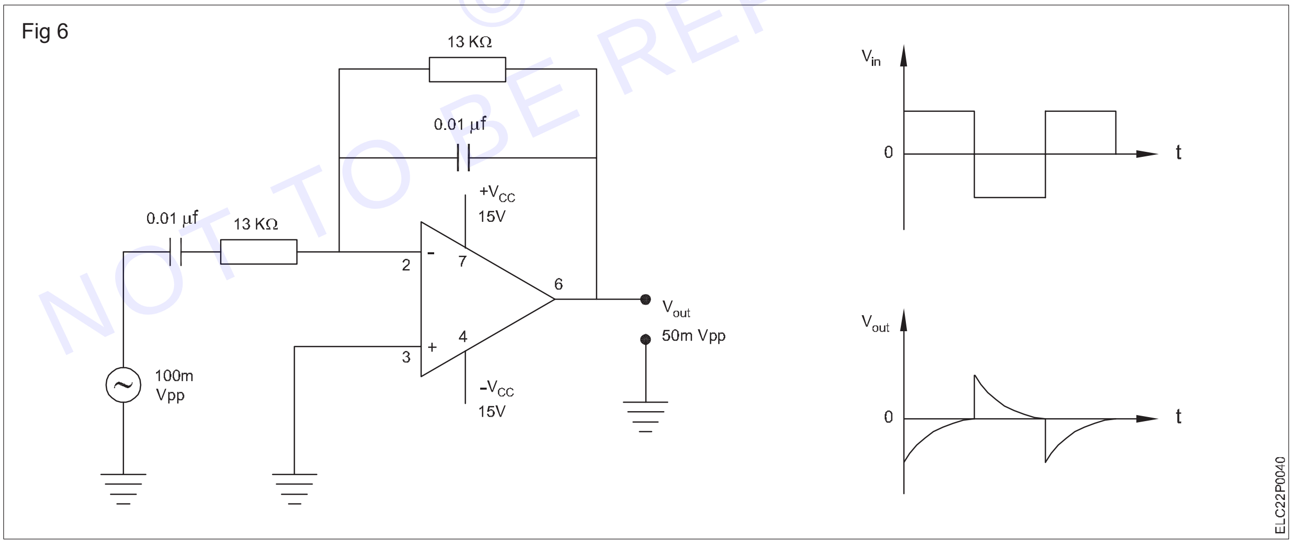


Table 6

Sl.No	Vin peak	Input waveform	Vout peak	output waveform

EXERCISE 69 : Verify truth Tables of Logic gates

Objectives

At the end of this exercise you shall be able to:

- Draw the logic IC connection diagrams
- assemble the circuit
- verify the truth Tables of OR, AND, NOT, EXOR, NAND, NOR logic gates.

Requirements

Tools/Equipments/Instruments

- Insulated combination pliers 150mm -1 No.
- Electrician knife 75mm -1 No.
- Tweezers 75mm -1 No.
- Multi meter Digital -1 No.
- LED -1 No.
- DC power supply 0-30 V -1 No.
- Gate IC's 7408,7432,7404, 7486,7400,7402 -1 No Each.
- Bread board 175 X 67 X 8 mm -1 No.
- Hook up wire -1 m.

Materials

- Resistor 470 Ω -1 No.

Procedure

TASK 1: **Draw the logic IC connection diagrams**

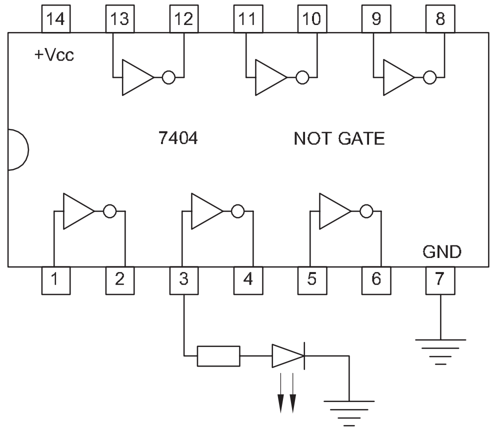
1 Draw the circuit diagram for each logic gate IC's.(Refer Fig 1 to Fig 6)

2 Identify pins for inputs and outputs, Vcc and Ground for each IC.

3 Record pin numbers in the Table 1

Table 1

Sl. No	IC Part number	IC Logic	Vcc pin number	Ground Pin number	Input pin (A) number	Input pin (B) number	Output pin(Q) number
1		NOT					
2		OR					
3		AND					
4		NAND					
5		NOR					
6		EXOR					



A	$Y = \bar{A}$
0	1
1	0

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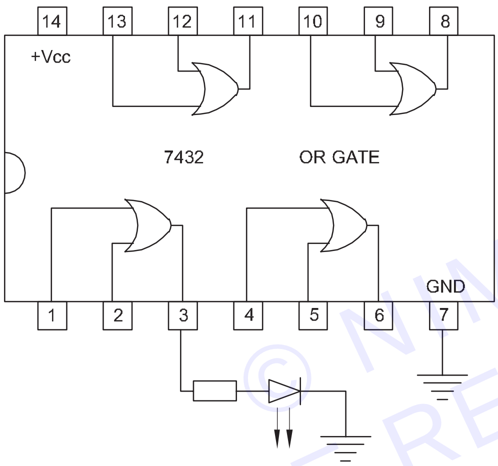
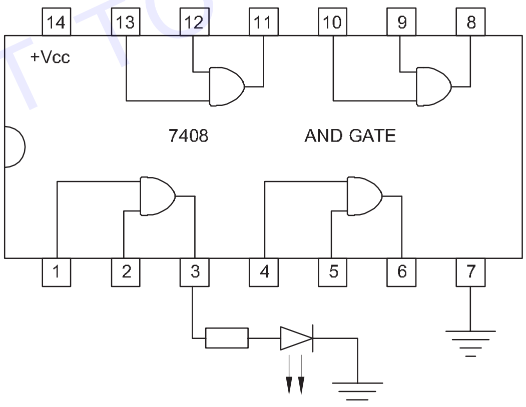


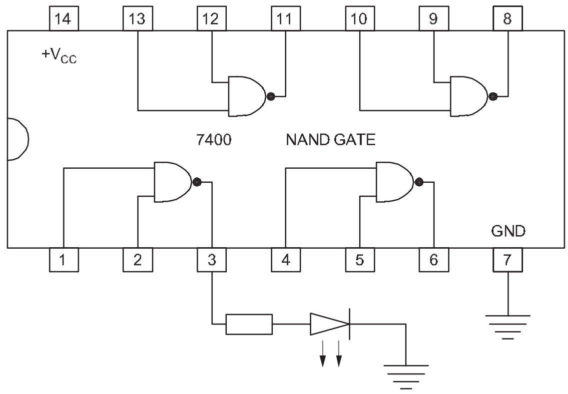
A	B	Y = A+B
0	0	0
0	1	1
1	0	1
1	1	1

ELC22P0226



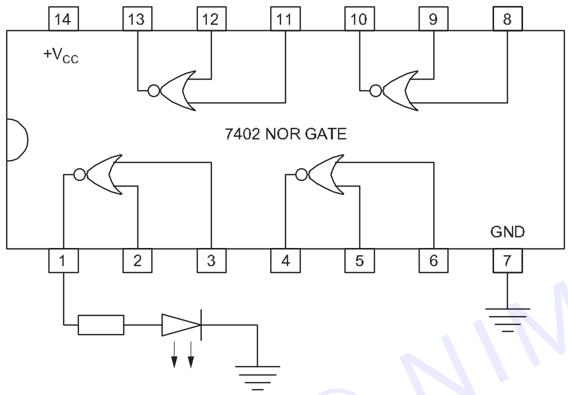
A	B	Y = A.B
0	0	0
1	0	0
0	1	0
1	1	1

ELC22P0227



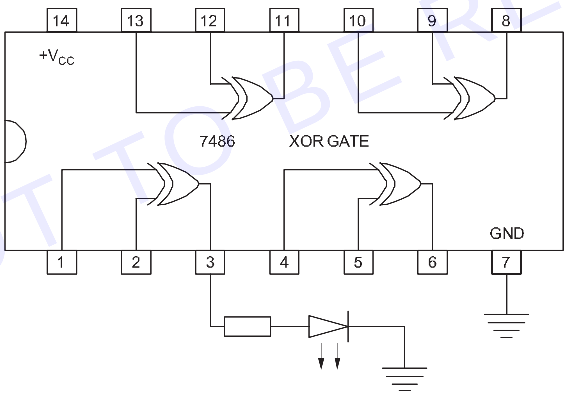
A	B	Y = $\overline{A.B}$
0	0	1
1	0	1
0	1	1
1	1	0

ELC22P0043



A	B	$\overline{A+B}$
0	0	1
1	0	0
0	1	0
1	1	0

ELC22P0041



A	B	Y = A $\oplus$ B
0	0	0
0	1	1
1	0	1
1	1	0

ELC22P0042

TASK 2 : **Assemble the circuit.**

1 Assemble the circuit as per the given diagram

TASK 3 : **Verify the truth Tables of OR, AND, NOT, NAND, NOR, EXOR logic gates.**

1 Connect 5 V Vcc to gate IC's and connect the inputs to each gate of the IC's as per truth Table

2 Verify the output conditions of each gates of IC's. It should satisfy the truth Table.

3 Record the truth Table of NOT gate in Table 1.

4 Record the truth Table of OR gate in Table 2.

5 Record the truth Table of AND gate in Table 3.

6 Record the truth Table of NAND gate in Table 4.

7 Record the truth Table of NOR gate in Table 5.

8 Record the truth Table of EX-OR gate in Table 6.

Table 1

NOT GATE	
Input	Output

Table 2

OR GATE		
Input A	Input B	Output Q

Table 3

AND GATE		
Input A	Input B	Output Q

Table 4

NAND GATE		
Input A	Input B	Output Q

Table 5

NOR GATE		
Input A	Input B	Output Q

Table 6

EX-OR GATE		
Input A	Input B	Output Q

— — — — —

MODULE 12: Induction Motors and Special Motors

EXERCISE 70 : Analyse connection of various starters

Objectives

At the end of this exercise you shall be able to:
- explain and connect DOL control circuit and power circuit
- connect semi-automatic star delta control circuit and power circuit
- connect automatic star delta control circuit and power circuit
- connect manual star delta control circuit and power circuit
- connect rotor resistance starter control circuit and power circuit
- connect auto transformer starter and run motor.

Requirements

Tools/Instruments

- Combination pliers 150mm -1 No.
- Screw driver 100mm -1 No.
- Electrician knife 75mm -1 No.
- Test lamp 60W -1 No.
- Ammeter 0 – 25A MI -1 No.
- Voltmeter 0 – 500V MI -1 No.

Equipments/Machines

- 3Φ Squirrel cage Induction Motor HP,1440rpm -1 No.
- STARTER as in objective 5 HP/440V -1 No.
- TP switch 32A/440V -1 No.

Materials

- PVC Copper wire 2.5mm^2 -1 No.
- 4 core cable 650 – 1100V -1 No.

Procedure

TASK 1: **Draw the power circuit & control circuit of the given starter**

1 Draw the diagram of the power circuit and control circuit of the starter as in Table 1

Starter 1	Fig 1	DOL starter, power and control circuit
	Fig 2	Power circuit for semi-automatic and automatic star delta starter
Starter 2	Fig 3	Semi-automatic star delta starter control circuit
Starter 3	Fig 4	Automatic star delta starter control circuit
Starter 4	Fig 5	Manual star delta starter power and control circuit
Starter 5	Fig 6	Rotor resistance starter power and control circuit
Starter 6	Fig 7	Auto transformer starter power and control circuit

Fig 1

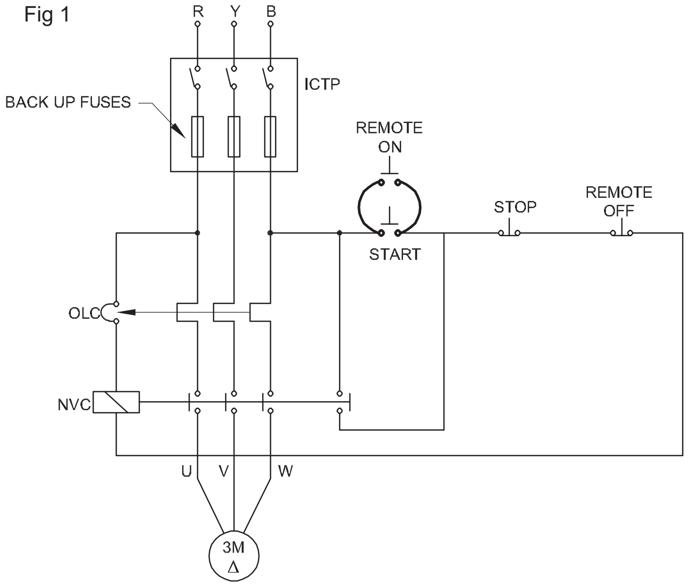


Fig 2

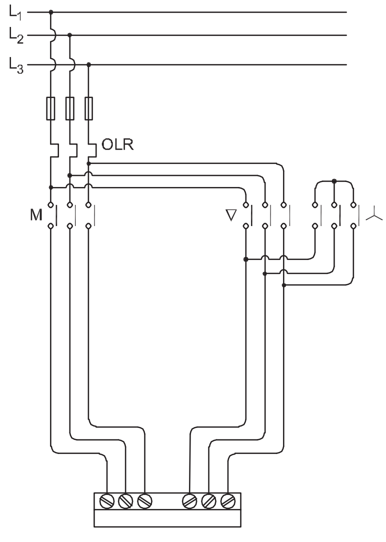
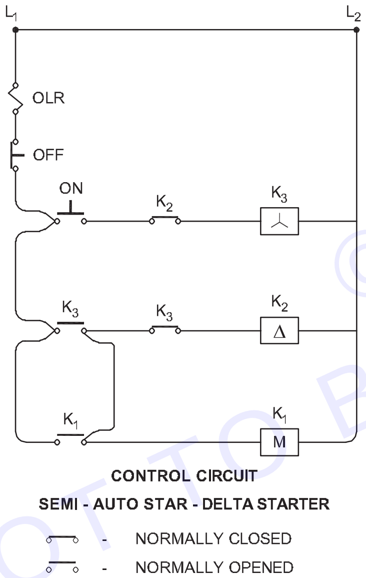


Fig 3



CONTROL CIRCUIT

SEMI - AUTO STAR - DELTA STARTER

Fig 4

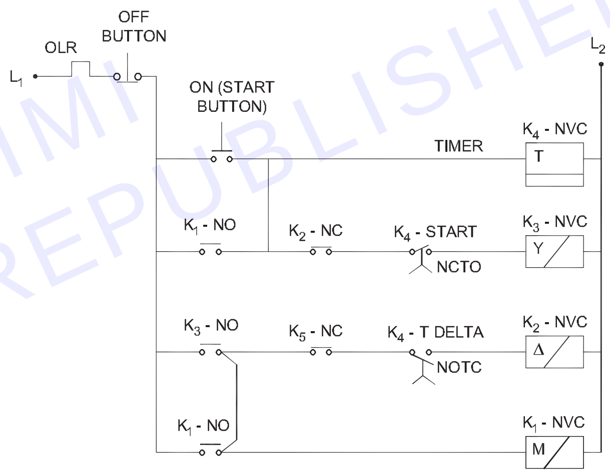


Fig 6

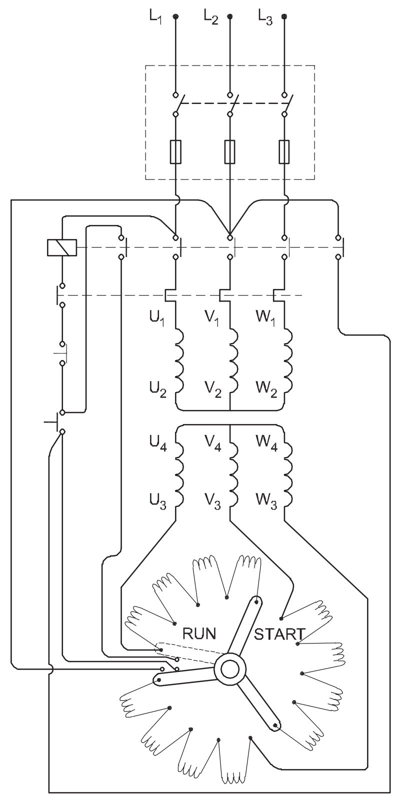
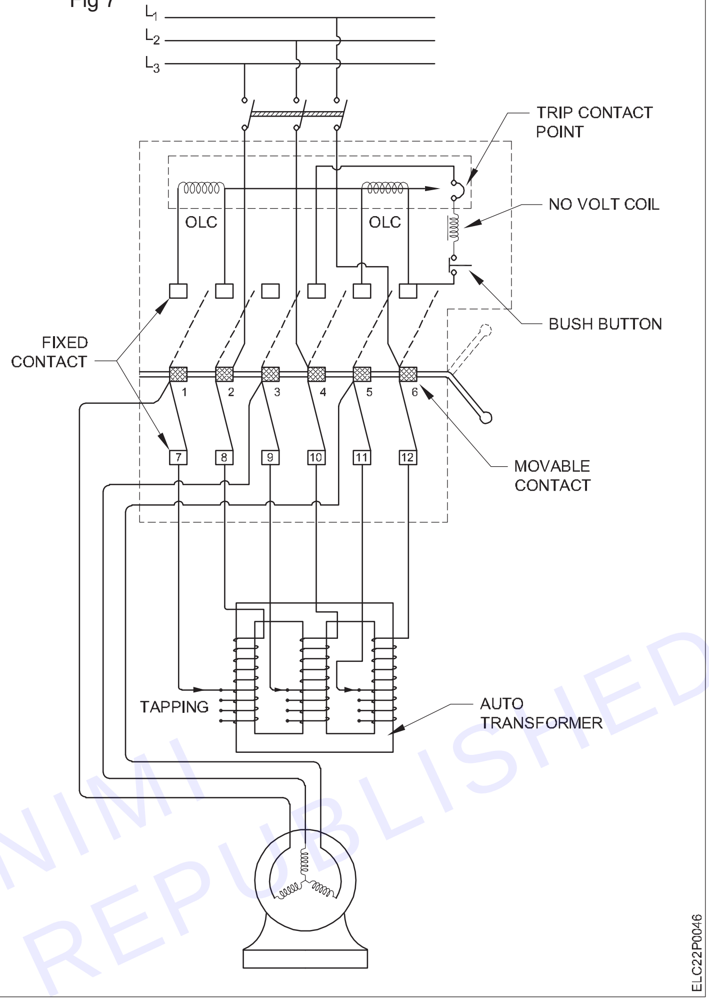
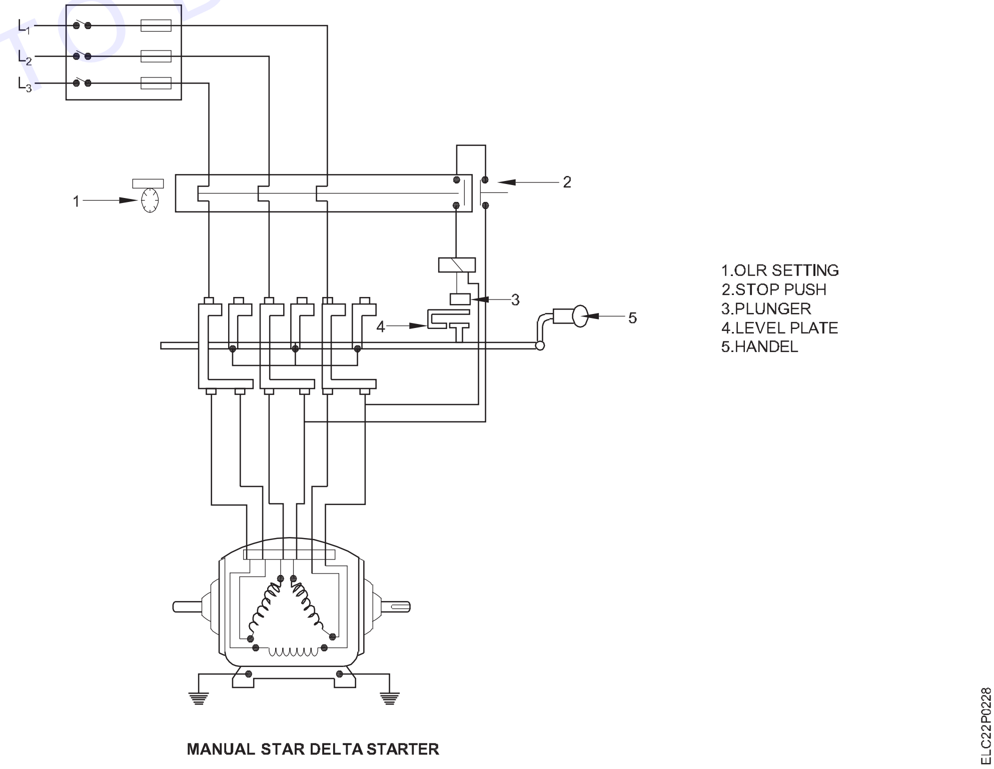


Fig 7





MANUAL STAR DELTA STARTER

TASK 2: **Record the name plate details**

1 Note down the name plate details of the 3Φ Squirrel Cage Induction Motor and slip ring induction motor.

— — — — —

TASK 3: **Measurement of starting current & running current**

1 Connect the motor as per diagram for starter 1

2 Trace the connections of power and control circuits.

3 Set the over load relay current.

4 Switch on the ICTP.

5 Start the motor by pressing the start button.

6 Measure the starting current and running current.

7 Switch OFF the motor by pressing the stop button.

8 Switch off the supply and disconnect.

9 Repeat steps 1 to 2 for starers 2 to 6 as in Table 1

10 Tabulate currents in Table 1

Table 1

Sl.No	Starter	Starting current (A)	Nol load running current (A)
1	DOL		
2	Semi-automatic star delta		
3	Automatic star delta		
4	Manual star delta		
5	Rotor resistance starter		
6	Auto transformer starter		

— — — — —

EXERCISE 71 : Start, run & load ac 3 phase Squirrel cage & Wound rotor Induction motors for performance testing

Objectives

At the end of this exercise you shall be able to:

- measure phase resistance of the winding
- carry out the No-load test on three phase Squirrel cage induction motor
- carry out the blocked test on three phase Squirrel cage induction motor
- calculate the efficiency of 3 phase induction motor.

Requirements

Tools/Instruments

- Combination pliers 150mm -1 No.
- Screw driver 100mm -1 No.
- D.E. spanner set 20mm -1 Set.
- Electrician knife 75mm -1 No.
- Series test lamp 60W -1 No.
- Voltmeter MI 500V -1 No.
- Ammeter MI 2A -1 No.
- Voltmeter MC 30V -1 No.
- Ammeter MC 2.5A -1 No.
- Wattmeter 500V, 2.5A -1 Nos.

Equipments/Machines

- 3Φ Squirrel cage Induction Motor 3HP, 415V -1 No.
- DOL starter 3HP,415V -1 No.
- Autotransformer 16A,500V -1 No.
- ICTP 16A,500V -1 No.
- Variable DC supply 0-30V, 5A -1 No.

Materials

- PVC Copper wire 1.5mm^2 -1 No.

Procedure

TASK 1: **To measure phase resistance of the motor winding**

1 Note down the name plate details of the three phase Squirrel cage induction motor.

2 Check the no. of terminals of motor.

3 identify each phase winding, if six terminals are available.

4 Draw the circuit diagram for phase resistance measurement.

5 Make the connections as per circuit diagram Fig 1

Connections should be tight and neat.

6 Connect the variable DC supply to one phase winding if 6 terminals are available

7 Connect ammeter and voltmeter to the circuit.

8 Apply DC low voltage.

9 Read and record the ammeter and voltmeter readings in Table.

10 Calculate the resistance per phase as R= V/I

11 Connect low voltage DC to 2 terminals, if the motor has only three terminals out.

12 Calculate the resistance per phase based on three phase connection type of motor as given below;

13 Tabulate phase resistance in Table 1

For star connection

Resistance per phase Rp = V/I x ½

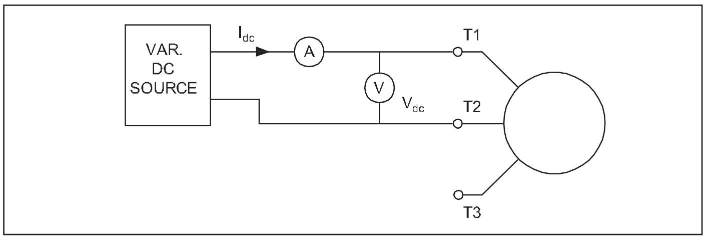
Rp = R/2

For delta connections

Resistance between two terminals R = V/I

Measured resistance = 2/3 Rp

Rp = 3/2 R



Tabel 1

DC supply voltage	Ammeter reading	Resistance of stator (one phase)

TASK 2: **To carry and no-load test on 3Φ squirrel cage induction motor**

1 Connect the motor for no load test as per diagram Fig 2

2 Check the supply for rated value and switch ON the ICTP.

3 Adjust the autotransformer to set the voltage to the rated value

4 Start the motor without any load.

5 Read and record the meter readings in Table 2.

6 Switch OFF the motor.

7 Keep the auto transformer at zero output voltage position

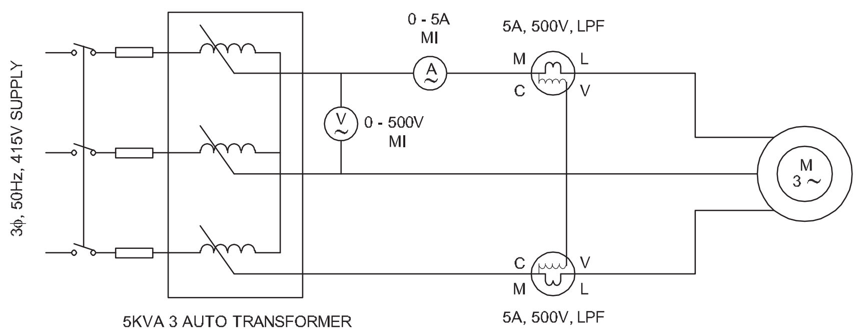
8 Switch OFF the supply and disconnect the circuit.

9 Calculate the constant losses of the motor

Table 2

Sl.No	Line Voltage	Line current I	Wattmeter 1	Wattmeter 1	Total No load input power W0	Constant losses
1						
2						
3						

Fig 2



NO - LOAD TEST

TASK 3 :**Carry out blocked rotor test on 3Φ induction rotor**

1 Connect the motor for blocked rotor test as per diagram Fig 3

2 Keep the autotransformer to zero voltage position

3 Switch on the ICTP.

4 Ensure safety precaution: do not supply rated voltage during blocked rotor test

5 Increase the output of the autotransformer gradually, and adjust current equal to full load current.

6 Read and record meter readings in Table.

7 Keep the auto transformer at zero output voltage position

8 Switch off the motor.

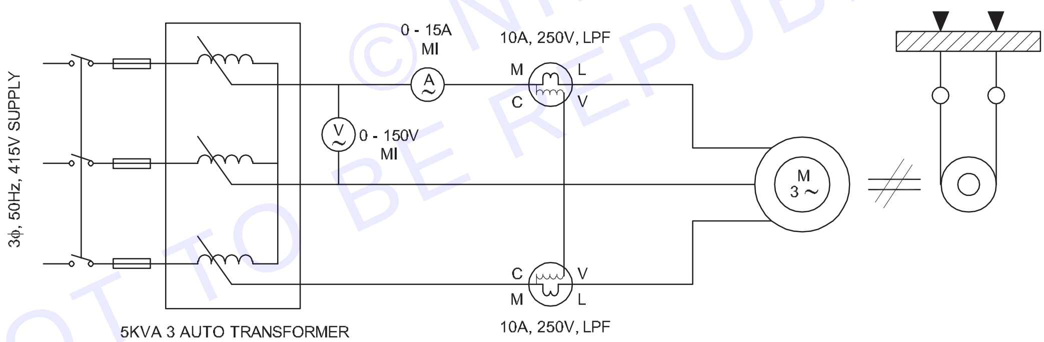
9 Switch off the supply and disconnect the circuit.

10 Tabulate the total copper losses in Table 3

Table 3

Sl.No	Line Voltage	Line current	Wattmeter 1	Wattmeter 1	Total copper loss(W1+W2)

Fig 3



BLOCKED ROTOR TEST

TASK 4: **Calculate the efficiency of 3Φ induction motor**

1 Calculate the output of motor in watts, HP X 746 Watts

2 Total loss = Full load I2R loss + Constant loss (Blocked rotor wattmeter reading + constant loss)

3 Calculate the efficiency of motor, Efficiency =output / input = (output) / output + total losses

(Total losses = Blocked rotor wattmeter reading + Constant losses)

4 Tabulate the calculated result in Table 4

Table 4

A	B	C	D	E	F	G
Output (HP)	Output (W) (A x 746)	Full load copper loss(W)	Constant loss(W)	Total loss (C+D)	Input (B + E)	Efficiency (B / F)

EXERCISE 72 : Check the change of direction of rotation

Objectives

At the end of this exercise you shall be able to:

- draw the circuit diagram to run the motor by DOL starter
- run the motor and measure starting and running current
- reverse the direction of rotation
- construct forward reverse control logic for motor.

Requirements

Tools/Instruments

- Combination pliers 150mm -1 No.
- Screw driver 100mm -1 No.
- Electrician knife 75mm -1 No.
- Test lamp 60W -1 No.
- Ammeter 0 – 25A MI -1 No.
- Voltmeter 0 – 500V MI -1 No.

Equipments/Machines

- 3Φ Squirrel cage Induction Motor 5 HP,1440rpm -1 No.
- DOL starter 5 HP/440V -1 No.
- ICTP 32A/440V -1 No.

Materials

- PVC Copper wire 2.5mm^2 - 18 m.
- 4 core cable 650 – 1100V - 6 m.
- Contactor 440V, 16A -1 No.
- Overload relay set 0 – 10A -1 No.
- Push button switch NO 16A -2 Nos.
- Push button switch NC 16A -1 No.

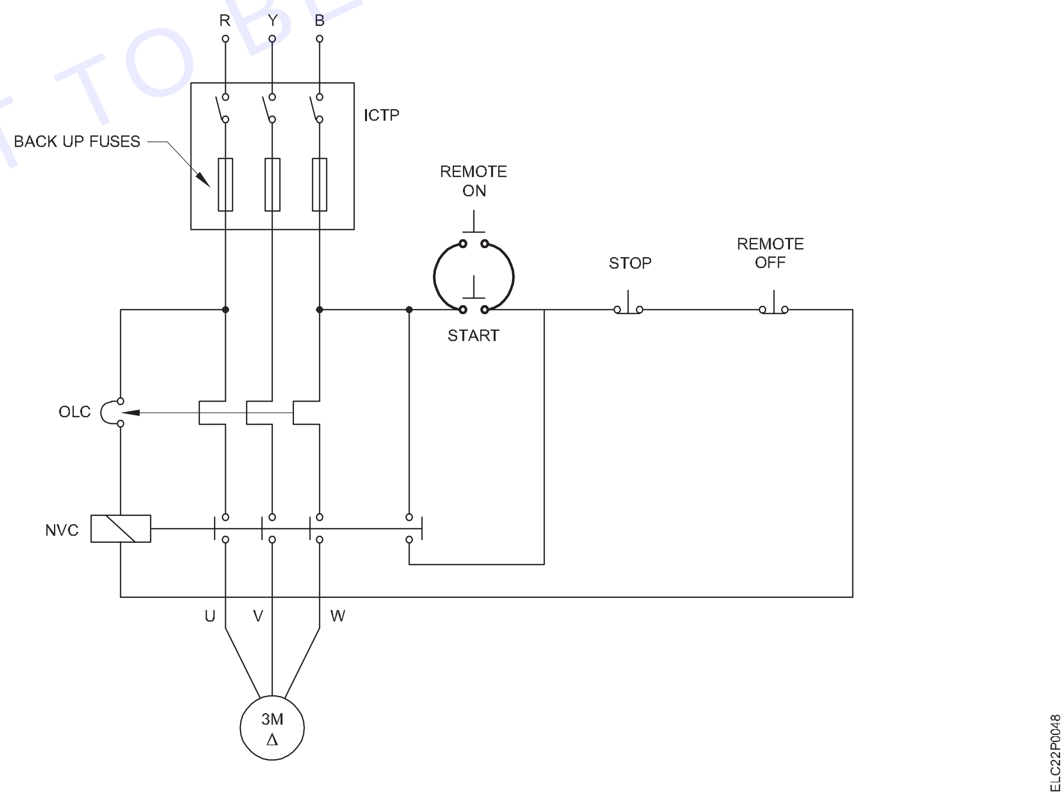
Procedure

TASK 1: **Draw the circuit diagram to run the motor by DOL starter**

1 Draw the circuit diagram as in Fig 1

2 Note down the name plate details of the 3Φ Squirrel Cage Induction Motor.

Fig 1



TASK 2: **Run the motor and measure starting and running current**

1 Connect the motor as per diagram.

2 Switch on the ICTP.

3 Start the motor by pressing the start button and observe the direction of rotation.

4 Measure the starting current and running current and record in Table 1

5 Switch OFF the motor by pressing the stop button.

Table 1

Sl.No	Starting current (A)	No load running current (A)

— — — — —

TASK 3: **Reverse the direction of rotation**

1 Interchange any two connections to the motor to reverse the direction of rotation.

2 Start the motor by pressing the start button.

3 Observe the direction of rotation. It should be of reverse direction.

4 Stop the motor by pressing the stop push button

5 Switch off the supply and disconnect.

— — — — —

TASK 4: **To construct a forward switch control circuit and run 3Φ Induction Motor**

1 Draw the circuit diagram as in Fig 2a

2 Make the connections as per the circuit diagram.

3 Trace control circuit as per Fig 2b

3 Set the over load relay current.

4 Switch on the supply and run the motor in forward direction by the first contactor.

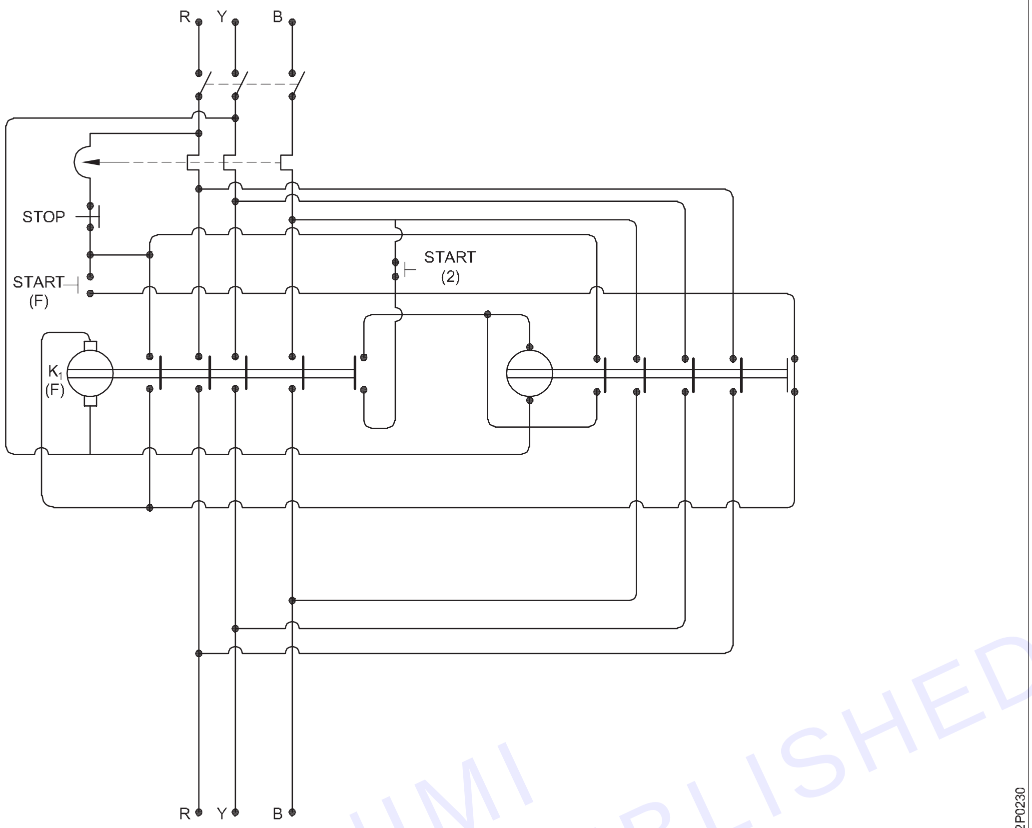
5 Stop the motor by switching off the stop switch.

6 Switch on the second contactor and run the motor in the reverse direction.

7 Stop the motor by pressing STOP push button.

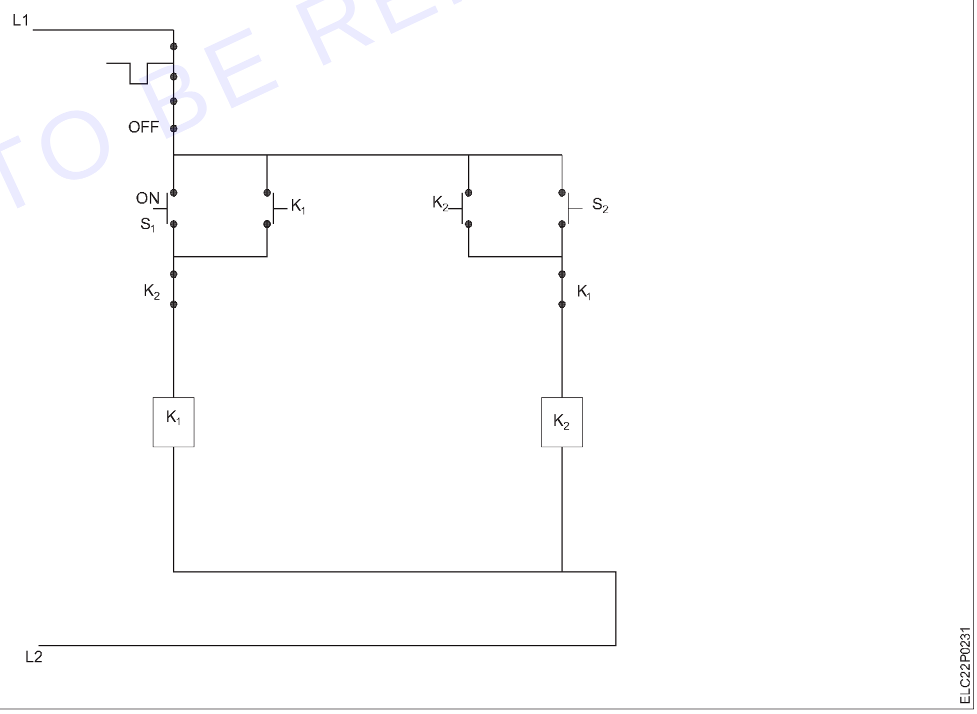
8 Switch OFF the supply and remove the connections.

Fig 2a



FORWARD- REVISE SWITCH

Fig 2b



EXERCISE 73 : Measure speed, torque, slip, current, power,PF

Objectives

At the end of this exercise you shall be able to:

- carry out the direct loading test on motor with brake arrangement
- calculate the Torque developed by motor from the readings of the spring balance
- calculate the power factor of the motor .

Requirements

Tools/Instruments

- Combination pliers 150mm -1 No.
- Screw driver 100mm -1 No.
- D.E. spanner set 20mm -1 Set.
- Electrician knife 75mm -1 No.
- Test lamp 60W -1 No.
- Voltmeter 0 – 500V MI -1 No.
- Ammeter 0 – 25A MI -1 No.
- Wattmeter 500V,5/10A, UPF -2 Nos.
- Power factor meter 500V,5/10A, -1 No.

Equipments/Machines

- 3Φ Squirrel cage Induction Motor 5 HP,1440rpm -1 No.
- DOL starter 5 HP/440V -1 No.
- ICTP 32A/440V -1 No.

Procedure

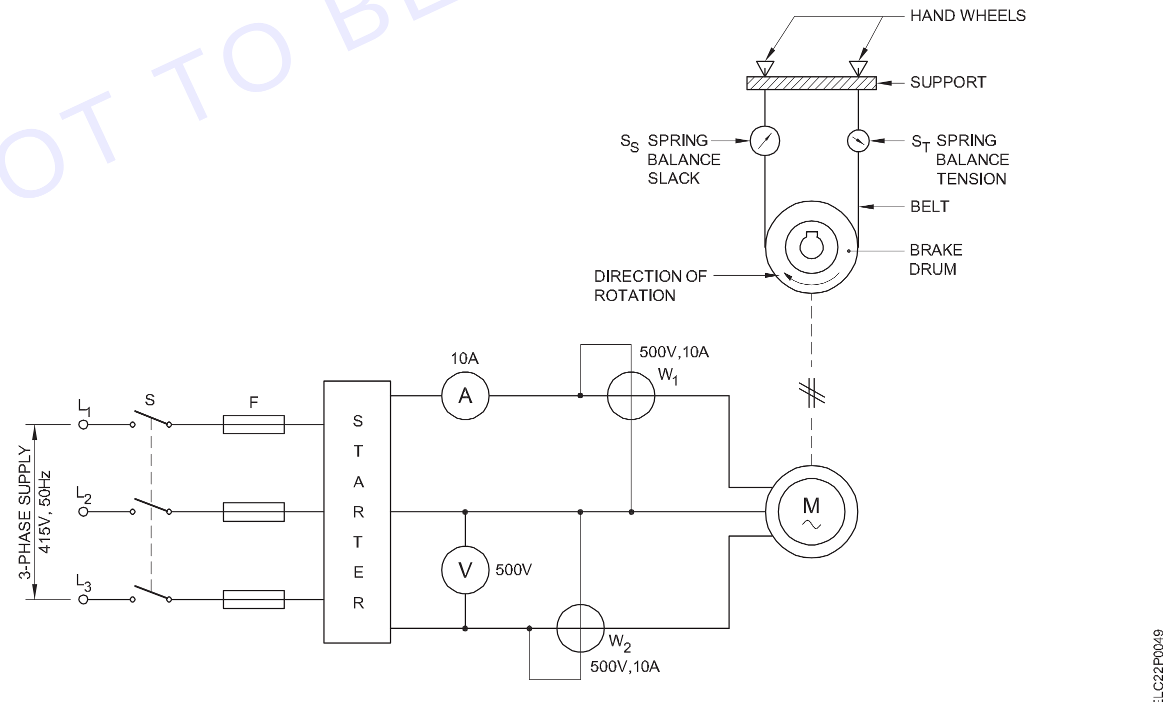
TASK 1: **Carry out the direct loading test on motor with brake arrangement**

1 Note the name-plate details of the squirrel cage induction motor

2 Select the voltmeter, ammeter and wattmeter range suiTable to the specification given in name-plate details.

3 Make connection as per circuit diagram. (Fig 1)

Fig 1



Check the mounting of the motor to the base is firm. Check the brake drum is properly keyed to the shaft.

4 Fix the brake drum's rope or belt with the spring balances in slack condition.

5 Switch 'ON' ICTP switch 'S' and start the motor at no- load.

6 Measure the speed and record in Table 1.

Table 1

Sl.No	Load	Line current(A)	Line voltage(volt)	Speed(rpm)	Slip
1	Full				
2	Half				
3	Quarter				

7 Tighten the belt to apply brake action on the brake drum, until the motor takes 1/4 full load current

8 Read the spring balances (Tension side ST, slack side SS) and record in Table 2.

9 Record the voltmeter, ammeter and wattmeter readings in Table 2.

10 Measure the speed of the motor at this loaded condition and record in Table 2.

11 Repeat the steps 6 to 9 for different load currents, say about 1/2 and full load.

Table 2

Sl. No	Load	Drum radius + belt thickness (m)	S1 (kg)	S1 (kg)	Torque calculated	Wattmeter reading 1(watts)	Wattmeter reading 2(watts)	Power (watts)	Pf angle	Power factor
1	Full									
2	Half									
3	Quarter									

— — — — —

TASK 2: **Calculate the Torque developed by motor from the readings of the spring balance**

1 Measure the diameter of the brake drum and the thickness of the rope/belt.

2 Record Drum radius 'R' =m.

3 Record Rope/belt thickness 't'= m

4 Calculate the torque, T = (ST - SS) x (R + t) Kg m where (R + t) is in meter, (ST - SS) is in Kg.

5 Measure the speed in rpm

6 Calculate the slip s = Ns-N/Ns where Ns is the synchronous speed calculated from equation= 120f /p (F=50Hz, P=2/4/6/8 ETC, Ns is next higher to the actual speed measured)

7 Measure "Power" by 2 wattmeter method P=W1+W2

— — — — —

TASK 3: **Calculate the power factor of the motor**

Calculate Power factor angle Φ = $\Phi = \tan^{-1}\sqrt{3}\left[\dfrac{P_2 - P_1}{P_2 + P_1}\right]$

Calculate power factor cos Φ

Tabulate result in Table 2.

— — — — —

EXERCISE 74 : Demonstrate starting and running of Single-phase motors & change DOR (direction of rotation)

Objectives

At the end of this exercise you shall be able to:
- connect and run capacitor- start capacitor -run motor
- reverse the DOR of capacitor- start capacitor-run motor
- connect and run capacitor-start capacitor-run motor after reversing DOR

Requirements

Tools/Instruments

- Combination pliers 150mm -1 No.
- Side cutter 150mm -1 No.
- Electrician's knife 75mm -1 No.
- Neon tester 0-500V -1 No.
- Ammeter 0-25A, MI -1 No.
- Series Test lamp 60W -1 No.
- Screw driver 100mm -1 No.
- Tachometer Digital -1 No.
- Multimeter Digital -1 No.

Equipments/Machines

- Capacitor start capacitor run motor 1ϕ,1HP, 230V -1 No.
- ICDP 16A, 230V -1 No.

Materials

- PVC insulated copper wire 1.5mm^2 - 4m.
- Capacitor 150mfd, 275V -1 No.
- Capacitor 30mfd, 440V -1 No.

Procedure

TASK 1: **Connect & run Capacitor - start,capacitor - run motor**

1 Draw the circuit diagram as in Fig 1

2 Record the name plate details.

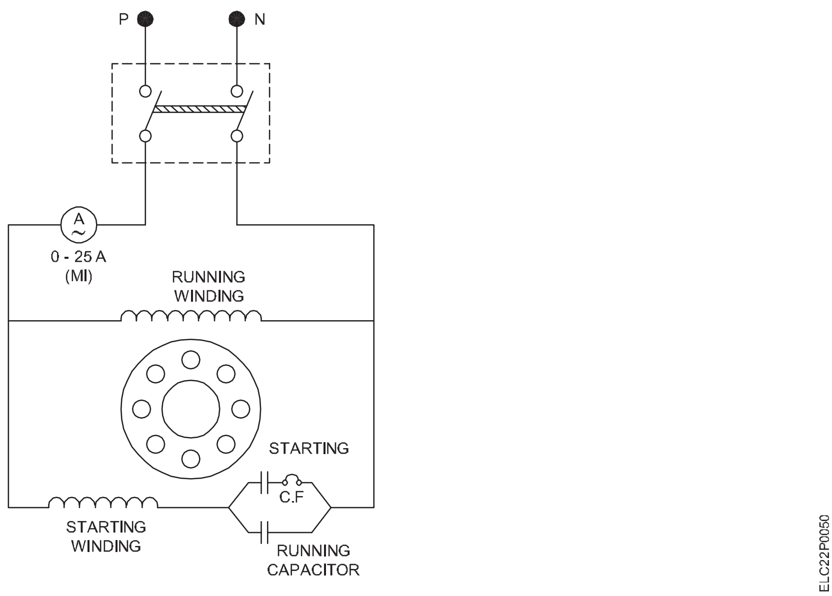
3 Identify the starting and running capacitor.

4 Test the capacitor using test lamp.

5 Identify the terminals of centrifugal switch by multimeter.

6 Check the centrifugal switch.

Fig 1



The centrifugal switch will be in a closed condition when the motor is not running

7 Measure the resistance of each winding.

8 Identify the starting and running windings.

9 Check for non-continuity between both windings.

10 Check both the winding whether it is short.

The starting winding is having comparatively higher resistance.

11 Make the connections as per the circuit diagram

Get permission from instructor before switching ON the supply.

12 Switch ON the ICDP and run the motor.

13 verify that Centrifugal switch is open when motor attaining 75% of its rated speed.

14 Measure speed, starting and running current.

If any undue noise or vibration is noticed, stop the motor and inform the instructor

15 switch OFF the ICDP.

— — — — —

TASK 2: **Reverse the DOR of capacitor- start,capacitor - run motor**

1 Interchange terminals of running winding

2 Start and run the motor

3 Verify the change in direction of rotation of motor

— — — — —

TASK 3: **Connect 2 run capacitor - start capacitor run motor after reversing DOR**

1 Note down the name plate details of the induction motor and explain.

2 Test the capacitor.

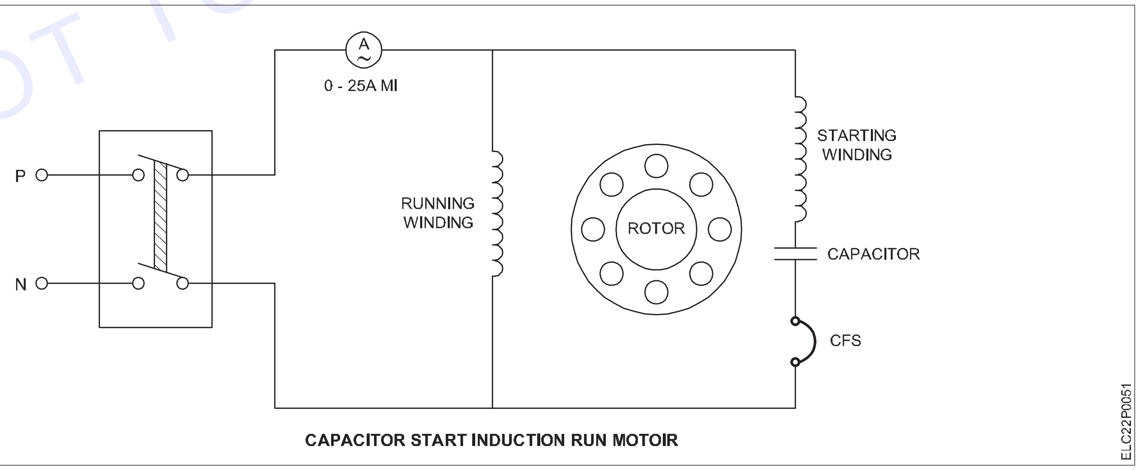
3 Identify the terminals of centrifugal switch by multimeter.

4 Identify the starting and running windings using multimeter by resistance method.

5 Connect the motor as per diagram in Fig 2

6 Switch on the supply and start the motor.

Fig 2



CAPACITOR START INDUCTION RUN MOTOIR

7 Verify that CFS (Centifugal switch) is open when the motor attains 75% of its rated speed

8 Measure the starting and running currents.

9 Check the direction of rotation of motor.

— — — — —

EXERCISE 75 : Check,dismantle and reassemble of different types of 1ϕ motors

Objectives

At the end of this exercise you shall be able to:

- dismantle the motor
- inspect the performance of the motor
- reassemble the motor
- test the motor in no-load condition.

Requirements

Tools/Instruments

- Combination pliers 150mm -1 No.
- Screw driver 100,150,200mm -1 No.
- D.E. spanner set 5mm – 30mm -1 No.
- Ring spanner 5mm to 30mm -1 No.
- Cold chisel 25mm x 200mm -1 No.
- Ball peen hammer 500gms -1 No.
- Nylon hammer 75mm x 100mm -1 No.
- Pulley puller 200mm 3 jaws -1 No.
- Centre punch 10mm x 150mm -1 No.
- Megger 500 V -1 No.

Equipments/Machines

- 1Φ Squirrel cage Induction Motor 1.5HP,1440rpm -1 No.

Materials

- Cotton waste -100gm
- Grease lithium based -250gm
- Sand paper 220size -1 No.

Procedure

TASK 1: **Dismantle the given motor**

1 Collect the name plate details and record it.

2 Remove the shaft key or grab screw holding the pulley Fig 1

3 Remove the pulley by using suiTable pulley puller. Fig 2

Fig 1

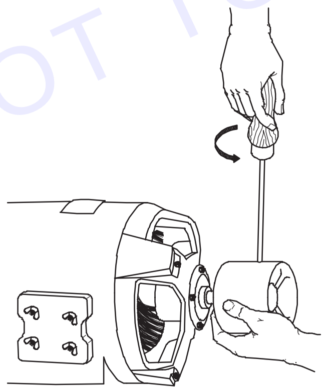
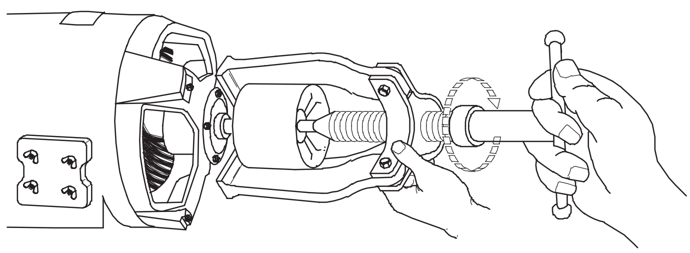


Fig 2



4 Make a centre punch alignment mark on the stator and the end shield cover.Fig 3

To avoid confusion, make a single punch mark on one side and dual punch mark on the other end of the motor.

5 Remove the grease cup screw.

6 Loosen the bolts gradually, switching from side to side until they can be removed.Fig4

Fig 3

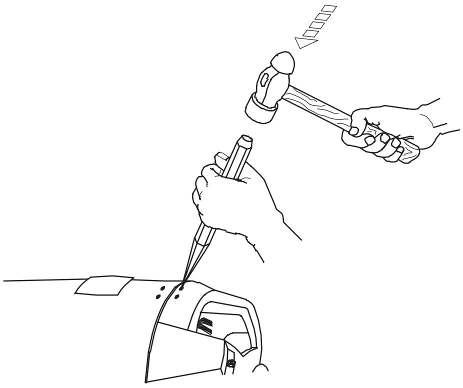
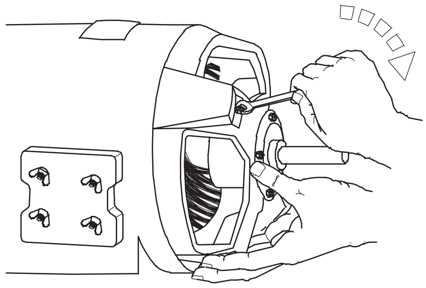


Fig 4



7 Keep the cold chisel tip between the stator and cover and gently tap the chisel with a hammer and separate the stator and the end shield cover.Fig5

8 Pull off the end shield cover and rotor together parallel to the motor shaft. Fig 6

Fig 5

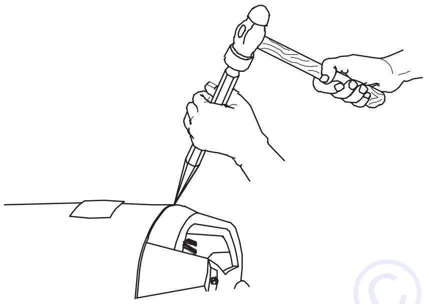
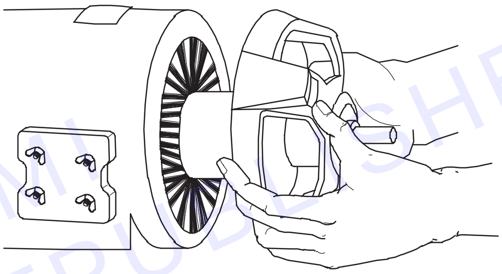


Fig 6

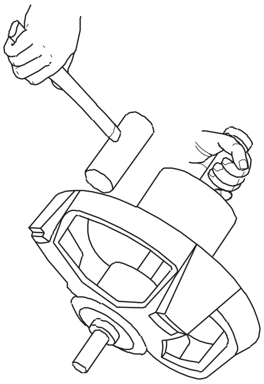


Do not touch the rotor on the stator winding while removing the rotor, it may damage the stator winding.

9 Hold the shaft in one hand; rotate the end cover tap hit gently with a nylon mallet to remove it from rotor. Fig 7

10 Remove the other end shield cover also by gently priming it out.

Fig 7



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TASK 2: **Inspect the performance of the motor**

1 Remove the capacitor and test it

2 Measure the resistance between R1-R2, S1-S2 and record it.

3 Measure the insulation resistance between the winding and the stator core with 500.V megger and record it.

4 Measure the insulation resistance between the winding with a 500.V megger and record it.

The resistance value should not be less than one mega ohm in any case.

5 preheat the winding to a temperature of 100 degree and impregnate the winding with varnish, if the megger value is less than one mega ohm Dry the varnish slowly either in impregnating bath or open air.

6 Remove the bearing using bearing puller.

7 Check the bearing for its condition.

8 replace the bearing with same number, If the bearing has any abnormal sound or damage

9 Clean the shaft and inspect for any wear or tear.

10 Heat up the new bearing and insert the same in shaft with a slight push. Check the squirrel cage rotor for any abnormalities.

— — — — —

TASK 3: **Reassamble the dismantled motor**

Follow the steps of Task 1 in rever order to reaasamble the motor. get it checked by the instructor.

1 Fix the end cup of non-drive end to the bearing and shaft accordingly to the punch mark.

2 Insert the rotor to the stator.

3 Fix the non-drive end shield and tighten all the bolts.

4 Rotate the shaft by hand to check whether it is freely moving.

5 Connect the capacitor in position.

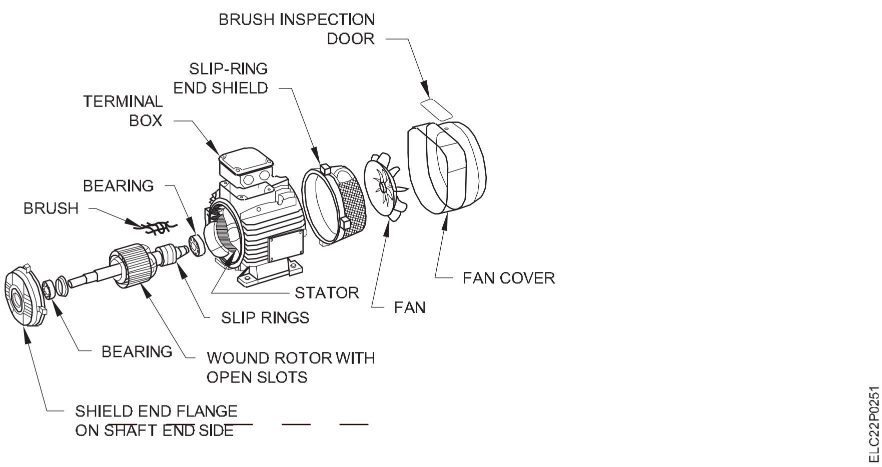
— — — — —

TASK 4: **Test the motor in no-load condition**

1 Test run the motor for at least eight hours in no load.

2 Note down the no load current.

3 Check for any abnormal sound and temperature rise.



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MODULE 13: Synchronous Machines

EXERCISE 76 : Install an alternator and identify various parts and terminals of the same

Objectives

At the end of this exercise you shall be able to:

- identify the prime mover and alternator mounting requirements
- identify terminals of alternator
- wire up the alternator and prime mover to a panel.

Requirements

Tools/Instruments

- Combination pliers 150mm -1 No.
- Side cutting pliers 150mm -1 No.
- Heavy duty screw driver 250mm -1 No.
- Screw driver 100mm, 150mm -1No. each.
- D.E. spanner set 5 – 30mm -1 No.
- Electrician knife 75mm -1 No.
- Test lamp 60W -2 Nos.
- Multimeter Digital -1 No.
- Meggar 500v -1 No.

Equipments/Machines

- Alternator 5 KVA Alternator -1 No.
- DC Shunt motor 7.5HP 230V -1 No.

Procedure

TASK 1: **Identify the prime mover and alternator mounting requirements**

1 Record the name plate details of Alternator and AC induction motor [Depending on the availability of machines available at lab, instructor need to modify the details of prime mover]

Sl. No	Description	Value
1.	Make	
2.	Model	
3.	Serial number	
4.	No of phases	
5.	Voltage	
6.	Power	
7.	Frequency	
8.	Current	
9.	Class of insulation	
10.	Excitation voltage	
11.	Excitation current	
12.	Protection class	

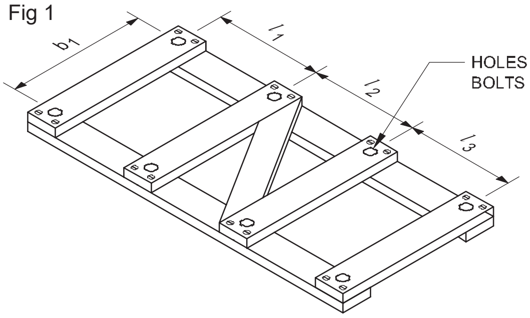
2 Identify the frame sizes of motor and alternator.

3 Verify the mounting hole dimensions of the motor – alternator set and prepare a template for mounting Fig 1

4 Mount foundation bolts for coupled motor alternator set

5 Mount the motor generator assembly on level ground by foundation bolts erected.

Fig 1



TASK 2: **Identify terminals of alternator**

1 Identify the field coil of the alternator and measure resistance by multimeter. The field winding resistance is higher than that of armature windings.

2 Identify the output terminals of alternator. Measure the resistance between phase and neutral and record.

	Field winding	Between phase 1 and neural	Between phase 2 and neural	Between phase 3 and neural
Resistance, ohms				

3 Identify the Automatic Voltage Regulator (AVR) section provided in the alternator.

4 Identify the slip rings of the alternator.

5 Label the part numbers on the alternator

Sl. No	Part number	Name of the part
1.		
2.		
3.		
4.		
5.		
6.		
7.		
8.		

TASK 3: **Wire up the alternator and prime mover to a panel.**

1 Set the meters and switchgear as per Fig 1

2 Wire up the DC motor terminals and Alternator terminals to the panel and make connections of the measuring instruments and switchgear.

EXERCISE 77 : Demonstrate build up voltage, excitation, loading Characteristics

Objectives

At the end of this exercise you shall be able to:

- draw the circuit diagram and read the name plate details
- connect start and run the motor
- set the voltage and frequency to rated value
- plot the load characteristics of the alternator with lamp.

Requirements

Tools/Instruments

- Combination pliers 150mm -1 No.
- Screw driver 100mm -1 No.
- Electrician's knife 75mm -1 No.
- Tachometer 0-10000rpm -1 No.

Equipments/Machines

- 3Φ Induction Motor 3kVA, 415V,50Hz -1 No.
- Variable DC Power Supply 0-260V, 10A -1 No.
- DOL starter 3HP, 440V -1 No.
- ICTP 16A, 440V -1 No.

Equipments/Machines

- PVC Copper wire 2.5mm² -18m.
- 4 core cable 650-1100V -1 No.

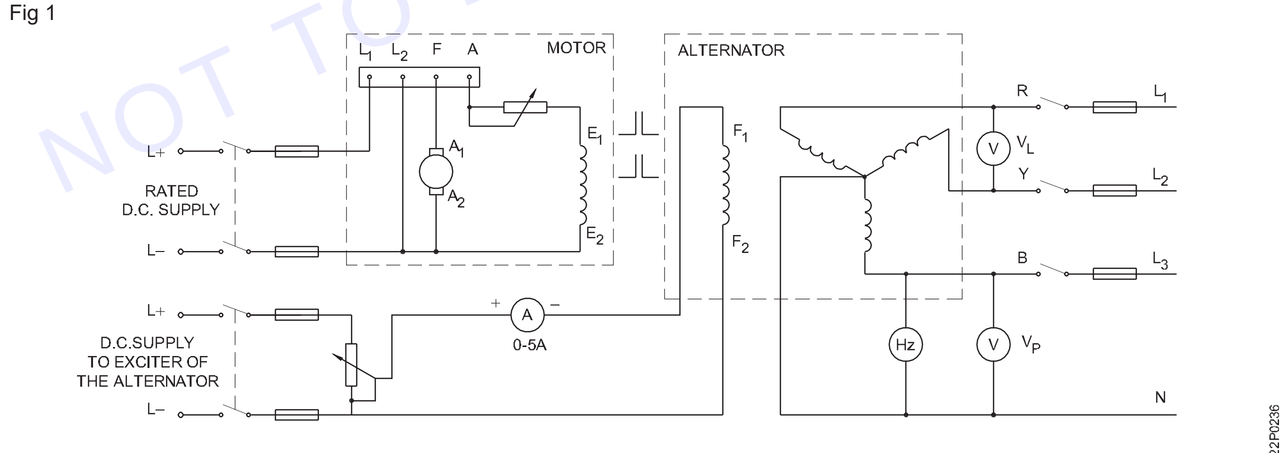
Procedure

TASK 1: **Read,Enterpret record the name plate detail of the motor**

1 Note down the name plate details of the DC shunt Motor and the Alternator.

2 Draw the circuit diagram to run the Alternator and to measure the voltage and frequency.(Fig 1)

Fig 1



CONNECTIONS FOR MAGNETISATION CHARACTERISTIC OF THE ALTERNATOR

Name plate details of alternator

Manufacturer	:	Serial number :	
Type and model	:		
Type of connection	:	P.F.	: ....
Rated voltage	:	Rated current	: ....amps
Frequency	:	Rated speed	: ....r.p.m.
Rated power	:	Rated exc. current	: ....amps
Rated exc. voltage	:	Direction of rotation	: ....
Rating class	:	Protection class	: ....
Insulation class	:		

Name plate details of DC shunt Motor

Name plate details			
Manufacturer	:	Type of motor	: ....
Serial No.	:	Insulation class	: ....
Rated voltage	:		
Rated current	:		
Rated power	:		

— — — — —

TASK 2: **Connect start and run the motor**

1 Connect the circuit as per diagram in Fig1
2 Set the alternator on No load condition
3 Connect the instruments as per circuit diagram.
4 Connect the field winding of alternator as per diagram.
5 Connect the voltmeter to measure the alternator output voltage.
6 Connect the frequency meter in the circuit.
7 Switch on the ICDP switch.
8 Start the DC motor by 3-point starter.
9 Note the direction of rotation.

— — — — —

TASK 3: **Set the voltage and frequency to rated value**

1 Adjust the speed of DC shunt motor to set the frequency of alternator to rated value
2 Note the alternator output voltage.
3 Increase the field current gradually till alternator builds up rated voltage
4 Note field currents (I_f) and generated voltage (E_g) in Table 1
5 Plot graph between E_g and I_f

Table 1

Sl.No	Voltage E_g	Field current I_g

— — — — —

TASK 4: **Plot the load characteristics of the alternator with lamp**

1 Load the alternator step by step

2 Measure the load current IL and terminal voltages V_T

3 Plot graph between V_T and I_L in Table 2

Table 2

Sl.No	Voltage V_T	Load current I_L

EXERCISE 78 : Calculate load regulation & performance Efficiency

Objectives

At the end of this exercise you shall be able to:

- draw circuit and connect the alternator as per circuit diagram
- load the alternator and observe the variation of voltage
- find the regulation of alternator.

Requirements

Tools/Instruments

- Combination pliers 150mm -1 No.
- Screw driver 100mm -1 No.
- D.E. spanner set 5 – 20mm -1 set.
- Electrician's knife 75mm -1 No.
- Series test lamp 60W -1 No.
- Voltmeter MI 0 – 300V -1 No.
- Ammeter MI 0 – 10A -1 No.

Equipments/Machines

- 1Φ Alternator 5KVA, 240V
- 3 phase induction motor 7.5HP -1 No.
- Lamp load 5KW -1 No.
- ICDP 16A,240V -1 No.

Materials

- PVC Copper wire 6mm² -18m.

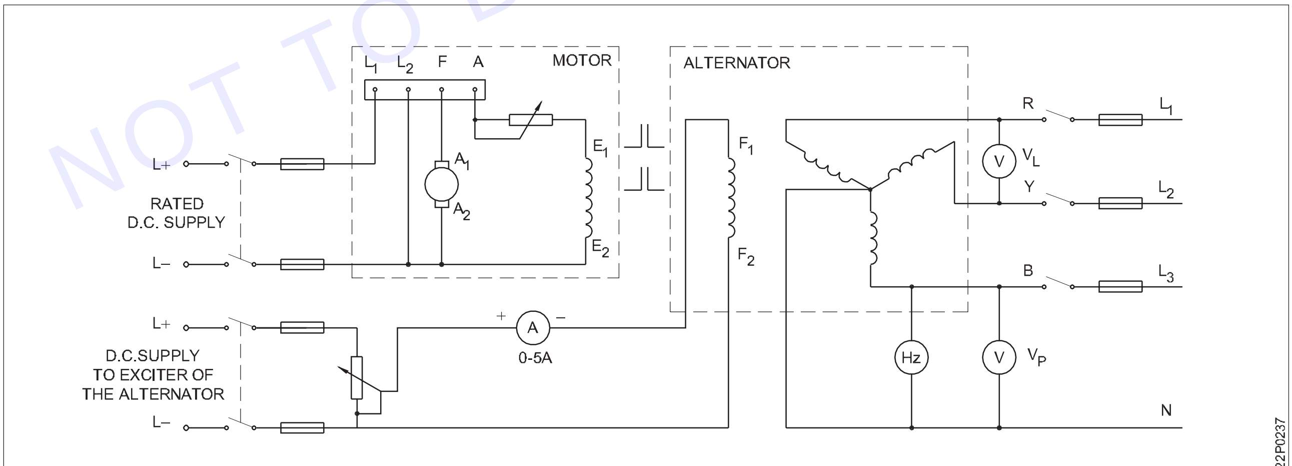
Procedure

TASK 1: **Draw circuit and connect the alternator as per circuit diagram**

1 Note down the name plate details of the 3Φ Alternator and prime mover

2 Draw the circuit diagram.

3 Make the connections as per circuit diagram.(Fig 1)



CONNECTIONS FOR MAGNETISATION CHARACTERISTIC OF THE ALTERNATOR

— — — — —

TASK 2: **load the alternator and observe the variation of voltage**

1 Start the prime mover and run the alternator.

2 Switch ON the lamp load one by one.

3 Note down the voltmeter and ammeter readings.

4 Tabulate the readings. Table 1

Table 1

Sl.No	Voltage V_T	Load current I_L

— — — — —

TASK 3: **Find the regulation of alternator**

1 Calculate the voltage regulation.

2 Voltage regulation = $\dfrac{\text{No load voltage – full load voltage.}}{\text{full load voltage}}$

No load Voltage (V)	Load Current (A)	Frequency (Hz)	Voltage at Load (V)	Regulation

— — — — —

EXERCISE 79 : Synchronise (by Parallel Operation) Alternators by Different Methods

Objectives

At the end of this exercise you shall be able to:

- draw the circuit diagram to synchronize an alternator by dark lamp method
- connect the circuit to synchronize the alternator to the busbar by bright lamp method
- synchronize the alternators by synchroscope method.

Requirements

Tools/Instruments

- Combination pliers 150mm -1 No.
- Screw driver 100mm -1 No.
- Electrician's knife 75mm -1 No.
- Frequency meter 47-53Hz -1 No.
- Voltmeter MI 0 – 500V -1 No.

Equipments/Machines

- 3Φ Alternator 2kVA, 2.9A, 50Hz -2 Nos.
- 3Φ Auto-transformer 0-415V, 16A -1 No.
- DOL starter 3HP, 440V -2 Nos.
- ICTP 16A, 440V -2 Nos.
- Phase sequence meter 3HP, 415V -1 No.
- Variable DC source 0 – 250V -1 No.
- Synchroscope 1500 W,230 V -1 No.

Materials

- PVC insulated Copper wire 1.5mm^2 -9 m.
- 4 core cable 650-1100V -6 m
- Lamp 40W -6 Nos.

Procedure

TASK 1: **Dark lamp method**

1 Make the connections as per the circuit diagram for bright lamp method. Fig 1

2 Switch on the supply and run the prime mover and alternator.

3 Switch ON and vary the DC excitation supply to build rated voltage of alternator.

4 Check the phase sequence of the bus bar and incoming machine using phase sequence indicator.

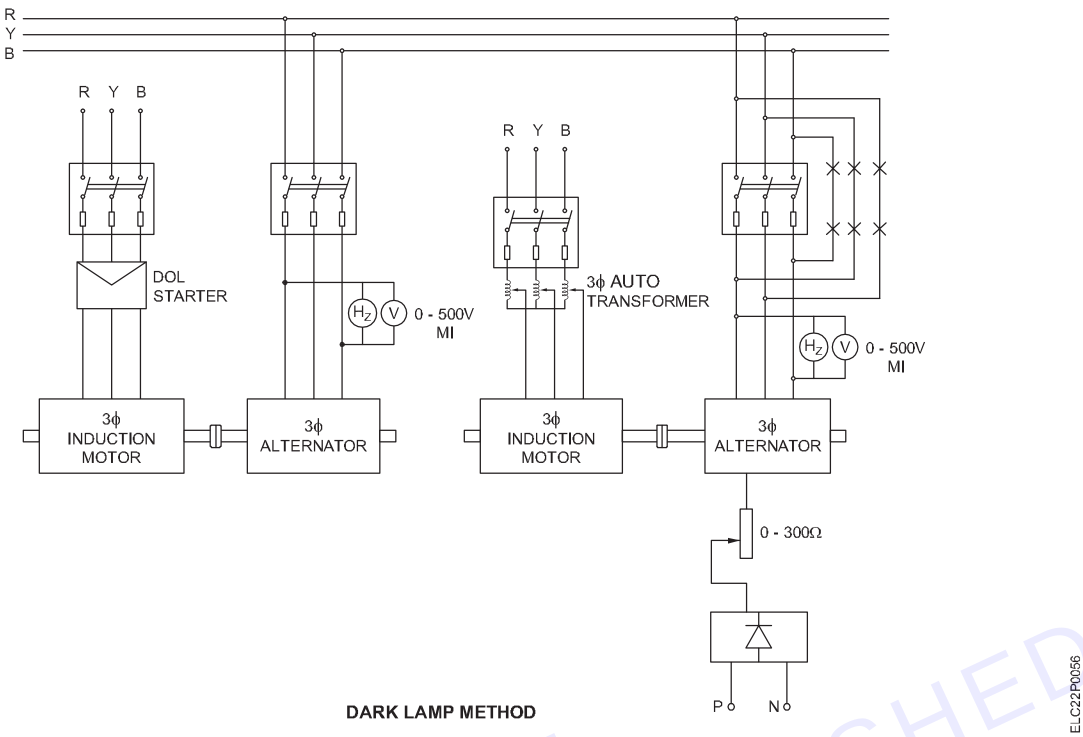
5 Connect the phases of incoming machine in ICTP so as to match the phase sequence of busbar.

6 Adjust the voltage of incoming alternator to match that of busbar by varying excitation.

7 Adjust the frequency of incoming alternator to match that of busbar by varying speed of prime mover.

8 Vary the prime mover to get the dark condition of the lamps connected directly between two phases

9 Close the synchronizing switch when the condition at above step is met.



DARK LAMP METHOD

— — — — —

TASK 2: **Bright lamp method**

1 Make the connections as per the circuit diagram for bright lamp method. Fig 2

2 Switch on the supply and run the prime mover and alternator.

3 Switch ON and vary the DC excitation supply to build rated voltage of alternator.

4 Check the phase sequence of the bus bar and incoming machine using phase sequence indicator.

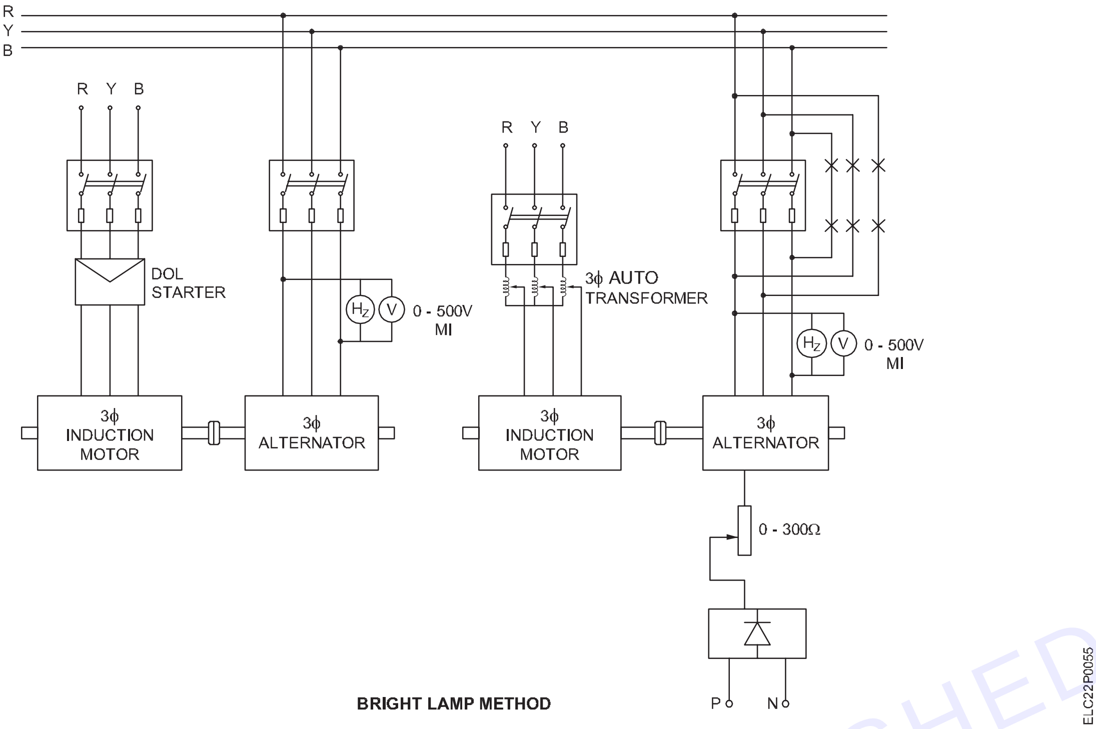
5 Connect the phases of incoming machine in ICTP so as to match the phase sequence of busbar.

6 Adjust the voltage of incoming alternator to match that of busbar by varying excitation.

7 Adjust the frequency of incoming alternator to match that of busbar by varying speed of prime mover.

8 Vary the prime mover to get the dark condition of the lamp connected directly between two phases and to get the equally dim condition of lamps interposed between two phases.

9 Close the synchronizing switch when the condition at above step is met.



BRIGHT LAMP METHOD

— — — — —

TASK 3: **Synchroscope method.**

1 Draw the circuit diagram for conducting synchronization by synchroscope method.

2 Read and note the name plate details of alternators.

3 Switch on the supply and run the prime mover and alternator 1.

4 Switch ON and vary the DC excitation supply to build rated voltage of alternator and connect to busbar.

5 Switch on the supply and run the prime mover and incoming alternator (2).

6 Switch ON and vary the DC excitation supply to build rated voltage of alternator.

All connections should be tight and neat.

7 Check the phase sequence of the bus bar and incoming machine using phase sequence indicator.

8 Connect the phases of incoming machine in ICTP so as to match the phase sequence of busbar.

9 Adjust the voltage of incoming alternator to match that of busbar by varying excitation.

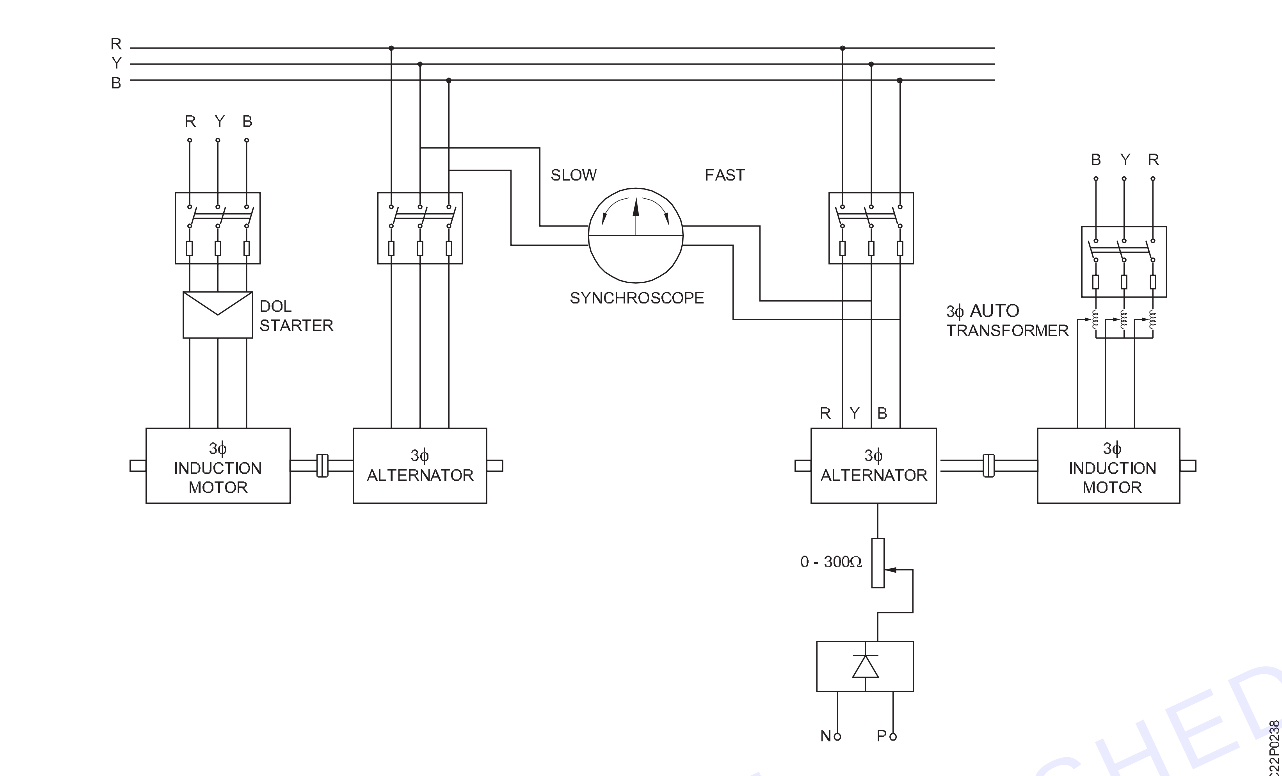
10 Adjust the frequency of incoming alternator to match that of busbar by varying speed of prime mover.

11 Check the needle position of synchroscope.

12 Adjust the speed of the incoming alternator by controlling the prime mover, so as to read zero in the synchroscope.

13 When the needle of synchroscope is sTable at zero position, close the synchronizing switch.

Care should be taken while switching ON the supply at the exact zero position of the synchroscope.



SYNCHROSCOPE METHOD

— — — — —

EXERCISE 80 : Start and run, build up voltage and load MG set

Objectives

At the end of this exercise you shall be able to:

- record the name plate details of alternator
- connect an alternator with separate excitater,ammeter and voltmeter
- plot the open circuit charactered by varring voltage
- load the alternator and record readings.

Requirements

Tools/Instruments

- Electrician Tool kit - 1 No.
- MI Voltmeter 0-500V - 1 No.
- MIAmmeter0-15A - 1 No.
- MC Ammeter 0 to 2.5A - 1 No.
- MCAmmeter 0 to 15A - 1 No.
- MCVoltmeter 0 to 250 volt - 1 No.
- Power factor meter 500V 15A 0.5 lag to 0.5 lead - 1 No.
- Tachometer multi-range 0-300/1000/3000 rpm - 1 No.

Equipments/Machines

- DC Shunt Motor 5 HP, 440V - 2 Nos.

Materials

- ICTP switch 16A 500V - 1 No.
- Lamp holder pendent - 2 Nos.
- Lamp 250V, 60 or 100 watts bulb - 2 Nos.
- Stranded PVC insulated wire 7/1.5 aluminium cable -as reqd.
- D.P.S.T. Switch 16A, 250V - 1 No.
- PVC insulated connecting cable - 1 No.
- ICDP switch 16A 250V - 1 No.
- Graph sheet - 1 No.

Procedure

TASK 1:Record the name plate details of alternator

1 Draw the connection diagram of the alternator coupled to DC shunt motor.

2 Note down the name plate details of the 3Φ Alternator and DC shunt Motor.

— — — — —

TASK 2: **Connect an alternator with separate excitater,ammeter and voltmeter**

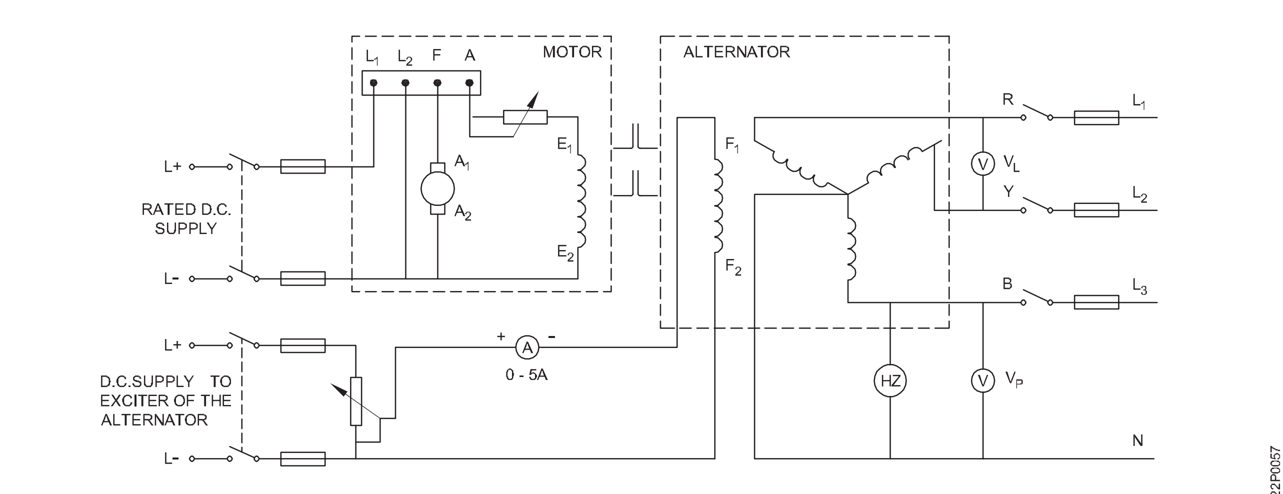
1 Test and identify the terminals of the Alternator.

2 Connect the prime mover as per the circuit diagram.(Fig 1)

3 Connect the alternator as per circuit diagram.

4 Wire up the exciter as per diagram.

5 Start prime mover.



CONNECTIONS FOR MAGNETISATION CHARACTERISTIC OF THE ALTERNATOR

TASK 3: **Plot the open circuit charactered by varring voltage**

1 Adjust the DC excitation voltage to zero.

2 Connect the DC excitation supply to the exciting coil of the alternator.

3 Vary the excitation field current (If) gradually.

4 Record different excitation currents and corresponding generated emf (Eg) of the alternator.

5 Plot field current (If) along X axis

6 Plot generated emf (Eg) along Y axis.

7 Plot the Open circuit characteristics from the recorded readings.

— — — — —

TASK 4: **Lead the alternator with lamp and record readings**

1 Run the alternator with lamp load at rated speed and generate rated voltage

2 Load alternator gradually with lamp load and note VT and IL (Terminal voltage and Load current)

— — — — —

EXERCISE 81 : Identify different parts of Synchronous Motor

Objectives

At the end of this exercise you shall be able to:
- read and interpret the name plate details of given shynchronous motor
- identify the parts of synchronous motor.

Requirements

Tools/Instruments

- Masonry tools like travel Spirit level etc. - 1 Set
- Drilling machine electric 12.mm capacity with drills - 1 No
- Measuring tape 3 meters - 1 No
- Electrician hand tool kit - 1 Set

Equipment/Machines

- Synchronous motor 3 KVA, 500V. 3 phase 50Hz with suiTable starter - 1 No.
- DC source/rectifier suiTable for above motor - 1 No.
- TPIC switch 32A, 500V - 1 No.
- DPIC switch 16A 250V - 1 No.
- SuiTable field Rheostat - 1 No.

Procedure

TASK 1 : **Install a given sychronous motor**

1 Read the name-plate details and record

Name plate details

Manufacturer	:	....	Speed	:	...................................rpm
Type	:	....	Insulation Class	:	....
Serial No.	:	....	Excitation voltage	:	....
Function	:	....	Excitation Current	:	....
Type of connection	:	....	Direction of Rotation	:	....
Voltage	:	...................................Volt	Rating Class	:	....
Current	:	...................................Amp			
Power	:	...................................KW	Protection	:	....

— — — — —

TASK 2: **Identify the parts of synchronous motor**

1 Identify three phase supply input terminals

2 Identify the DC excitation terminals

3 Identify sliprings

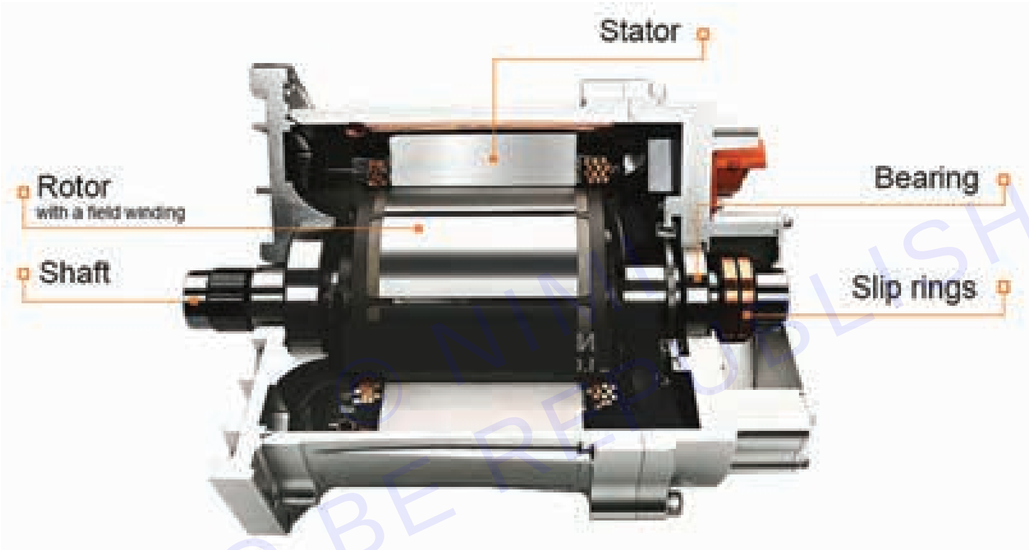
4 label parts with number tags.

5 Write the name of the parts of each labelled number in the Table.

Table

Sl. No.	Label No.	Name of Part

For guidance, trainees can refer the below picture for their work.



EXERCISE 82 : Connect, Start and Run the Synchronous Motor

Objectives

At the end of this exercise you shall be able to:

- connect three phase synchronous motor as per diagram
- start the motor as induction motor
- run the motor as synchronous motor.

Requirements

Tools/Instruments

- Electrician Tool kit - 1 Set
- MI Voltmeter 0-500V - 1 No
- MIAmmeter0-15A - 1 No
- MC Ammeter 0 to 2.5A - 1 No
- MC Ammeter 0 to 15A - 1 No
- MC Voltmeter 0 to 250 volt - 1 No
- Power factor meter 500V 15A 0.5 lag to 0.5 lead - 1 No
- Tachometer multi-range 0-300/1000/3000 rpm - 1 No

Equipment/Machines

- Synchronous motor - 5HP 415V three phase

Materials

- ICTP switch 16A 500V - 1 No
- Lamp holder pendent - 2 Nos
- Lamp 250V, 60 or 100 watts bulb - 2 Nos
- Stranded PVC insulated wire 7/1.5 aluminium cable - 4 m
- D.P.S.T. Switch 16A, 250V - 1 No
- PVC insulated connecting cable - as reqd
- ICDP switch 16A 250V - 1 No
- Graph sheet - as reqd

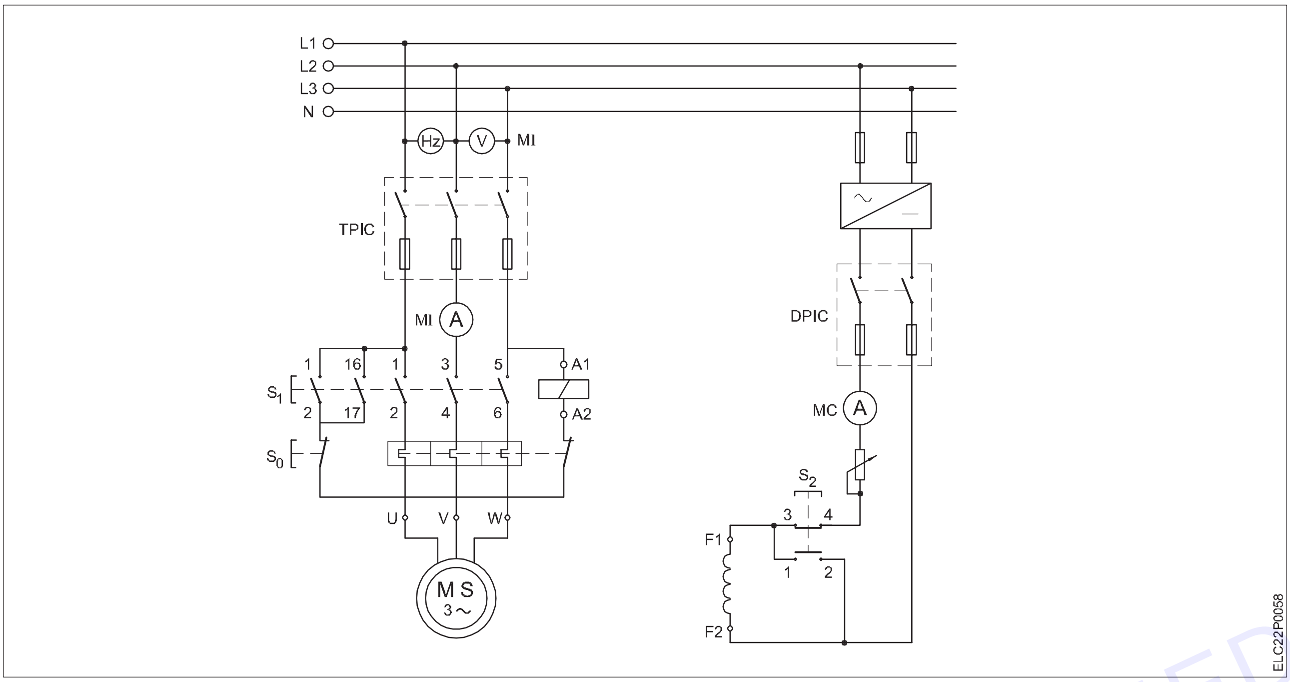
Procedure

TASK 1 : **Connect three phase synchronous motor as per diagram**

1 Record the name plate details of the synchronous motor

Manufacturer	:	....	Speed	:	..................................rpm
Type	:	....	Insulation Class	:	....
Serial No.	:	....	Excitation voltage	:	....
Function	:	....	Excitation Current	:	....
Type of connection	:	....	Direction of Rotation	:	....
Voltage	:	..................................Volt	Rating Class	:	....
Current	:	..................................Amp			
Power	:	..................................KW	Protection	:	....

2 Make the connections as shown in circuit diagram. Fig 1



TASK 2: **Start the motor as induction motor**

1 Adjust the field rheostat of DC supply to rated current, and keep the potential divider at zero output position and without engagement of mechanical load.

2 Keep the DC field winding shorted, by pressing button S2.

3 Keep S2 depressed, switch on the 3-ph. supply, start the synchronous motor and let motor reach 95% of rated speed

— — — — —

TASK 3: **Run the motor as synchronous motor**

1 Release switch s2 to excite the field winding by DC supply. (motor pulls into synchronism now)

2 Measure the speed by tachometer

3 Measure speed, supply voltage, frequency, line current, and field excitation current and record

4 Calculate the synchronous speed of the motor by using the formula.NS =120 f/P

5 Compare the synchronous speed with the measured speed, and ensure measured speed is equal to synchronous speed.

— — — — —

EXERCISE 83 : Demonstrate Plotting of V-curve

Objectives

At the end of this exercise you shall be able to:

- connect and run 3-phase synchronous motor
- vary the excitation and control the power factor at no load and full load
- plot the V-curve

Requirements

Tools/Instruments

- Electrician Tool kit - 1 Set
- MI Voltmeter 0-500V - 1 No
- MIAmmeter0-15A - 1 No
- MC Ammeter 0 to 2.5A - 1 No
- MC Ammeter 0 to 15A - 1 No
- MC Voltmeter 0 to 250 volt - 1 No
- Power factor meter 500V 15A 0.5 lag to 0.5 lead - 1 No
- Tachometer multi-range 0-300/1000/3000 rpm - 1 No

Materials

- ICTP switch 16A 500V - 1 No
- Lamp holder pendent - 2 Nos
- Lamp 250V, 60 or 100 watts bulb - 2 Nos
- Stranded PVC insulated wire 7/1.5 aluminium cable - 4 m
- D.P.S.T. Switch 16A, 250V - 1 No
- PVC insulated connecting cable - as reqd
- ICDP switch 16A 250V - 1 No
- Graph sheet - as reqd

Equipment/Machines

- Synchronous motor - 5HP 415V three phase

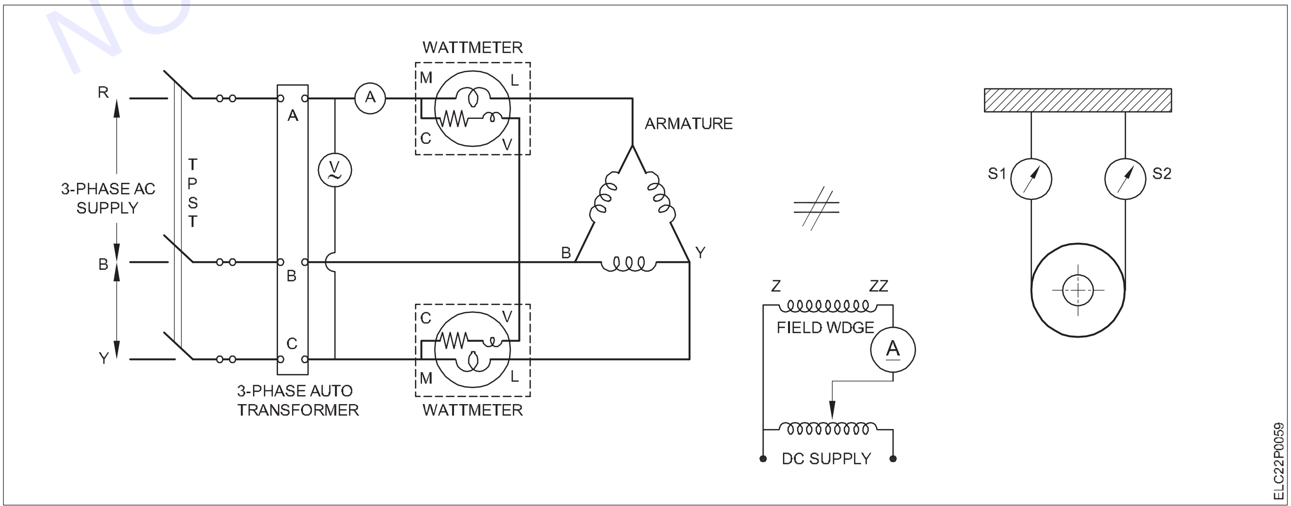
Procedure

TASK 1 : **Connect and run 3-phase synchronous motor**

1 Make the connections as shown in circuit diagram and start as 3 phase induction motor

2 Run the motor as synchronous motor by providing DC excitation to rotor near to rated synchronous speed

3 Measure the speed by tachometer.



TASK 2: **Vary the excitation and control the power factor at no load and full load**

1 Vary the field current from zero to rated value and note down corresponding power factor and armature current covering a range from low lagging to low leading power factor through a unity power factor.

2 Tabulate Field current and armature current

3 verify the armature current is minimum when the p.f. in unity.

4 Repeat step No.1 to 3 for full load on the synchronous motor, by mechanical load.

Readings on no load

Sl.No	Armature Current (I_a)	Field Current (I_f)

Readings at full load

Sl.No	Armature Current (I_a)	Field Current (I_f)

— — — — —

TASK 3: **Plot the V-curve**

1 Plot V curve as Armature current Vs filed current for half load and full load.

Follow the manufacturer recommended range of power factor in operation as current at lagging and leading power factors will be more to take the load.

— — — — —

EXERCISE 84 : Demonstrate different applications of synchronous motor

Objectives

At the end of this exercise you shall be able to:

- start the synchronous motor
- run the synchronous motor as a constant speed motor
- run the synchronous motor as a synchronous condenser

Requirements

Tools/Instruments

- Electrician Tool kit - 1 Set
- MI Voltmeter 0-500V - 1 No
- MI Ammeter0-15A - 1 No
- MC Ammeter 0 to 2.5A - 1 No
- MC Ammeter 0 to 15A - 1 No
- MC Voltmeter 0 to 250 volt - 1 No
- Power factor meter 500V 15A 0.5 lag to 0.5 lead - 1 No
- Tachometer multi-range 0-300/1000/3000 rpm - 1 No

Materials

- ICTP switch 16A 500V - 1 No
- Lamp holder pendent - 2 Nos
- Lamp 250V, 60 or 100 watts bulb - 2 Nos
- Stranded PVC insulated wire 7/1.5 aluminium cable - 4 m
- D.P.S.T. Switch 16A, 250V - 1 No
- PVC insulated connecting cable - as reqd
- ICDP switch 16A 250V - 1 No
- Graph sheet - as reqd

Equipment/Machines

- Synchronous motor - 5HP 415V three phase

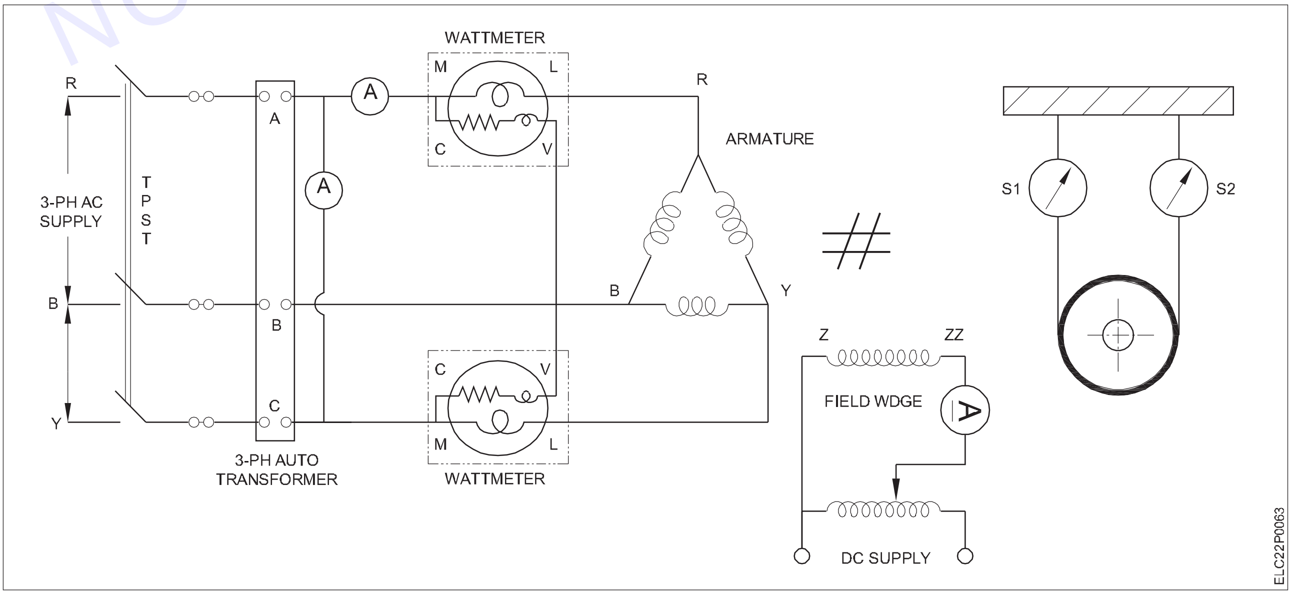
Procedure

TASK 1: **Start the synchronous motor**

1 Make the connections as shown in circuit diagram and start as 3 phase induction motor

2 Run the motor as synchronous motor by providing DC excitation to rotor near to rated synchronous speed

3 Measure the speed by tachometer.



TASK 2: **Run the synchronous motor as a constant speed motor**

1 Vary the mechanical load from zero to rated load

2 Measure the speed at various loads

3 Tabulate the speeds and check for constant speeds

Sl. No	Load current (A)	Speed (rpm)

— — — — —

TASK 3: **Run the synchronous motor as a synchronous condenser**

1 Start and run the synchronous motor

2 Apply constant mechanical load

3 Apply a constant voltage

4 Vary the filed current

5 Note the power factor at various excitation currents

6 Tabulate the field current and power factor

7 plot inverted v curve

Sl.No	Power factor	Armature current

— — — — —

EXERCISE 85 : Check and correct Power factor

Objectives

At the end of this exercise you shall be able to:

- connect 3-phase motor with the starter as load requiring pf improvement
- connect 3 phase synchronous motor as synchronous condenser
- improve the power factor of lagging motor load.

Requirements

Tools/Instruments

• Electrician Tool kit	- 1 Set
• MI Voltmeter 0-500V	- 1 No
• MI Ammeter0-15A	- 1 No
• MC Ammeter 0 to 2.5A	- 1 No
• MC Ammeter 0 to 15A	- 1 No
• MC Voltmeter 0 to 250 volt	- 1 No
• Power factor meter 500V 15A 0.5 lag to 0.5 lead	- 1 No
• Tachometer multi-range 0-300/1000/3000 rpm	- 1 No

Equipment/Machines

- 3 phase induction motor - Synchronous motor - 5HP 415V three phase

Materials

• ICTP switch 16A 500V	- 1 No
• Lamp holder pendent	- 2 Nos
• Lamp 250V, 60 or 100 watts bulb	- 2 Nos
• Stranded PVC insulated wire 7/1.5 aluminium cable	- 4 m
• D.P.S.T. Switch 16A, 250V	- 1 No
• PVC insulated connecting cable	- as reqd
• ICDP switch 16A 250V	- 1 No
• Graph sheet	- as reqd

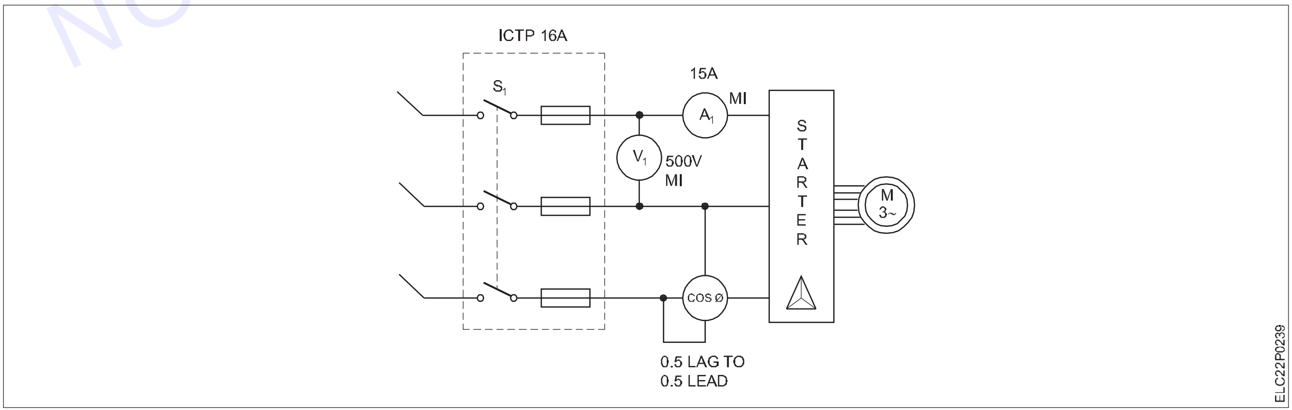
Procedure

TASK 1: **Start the synchronous motor**

1 Connect three phase induction motor as per diagram Fig 1

2 Start and run three phase induction motor at no load.

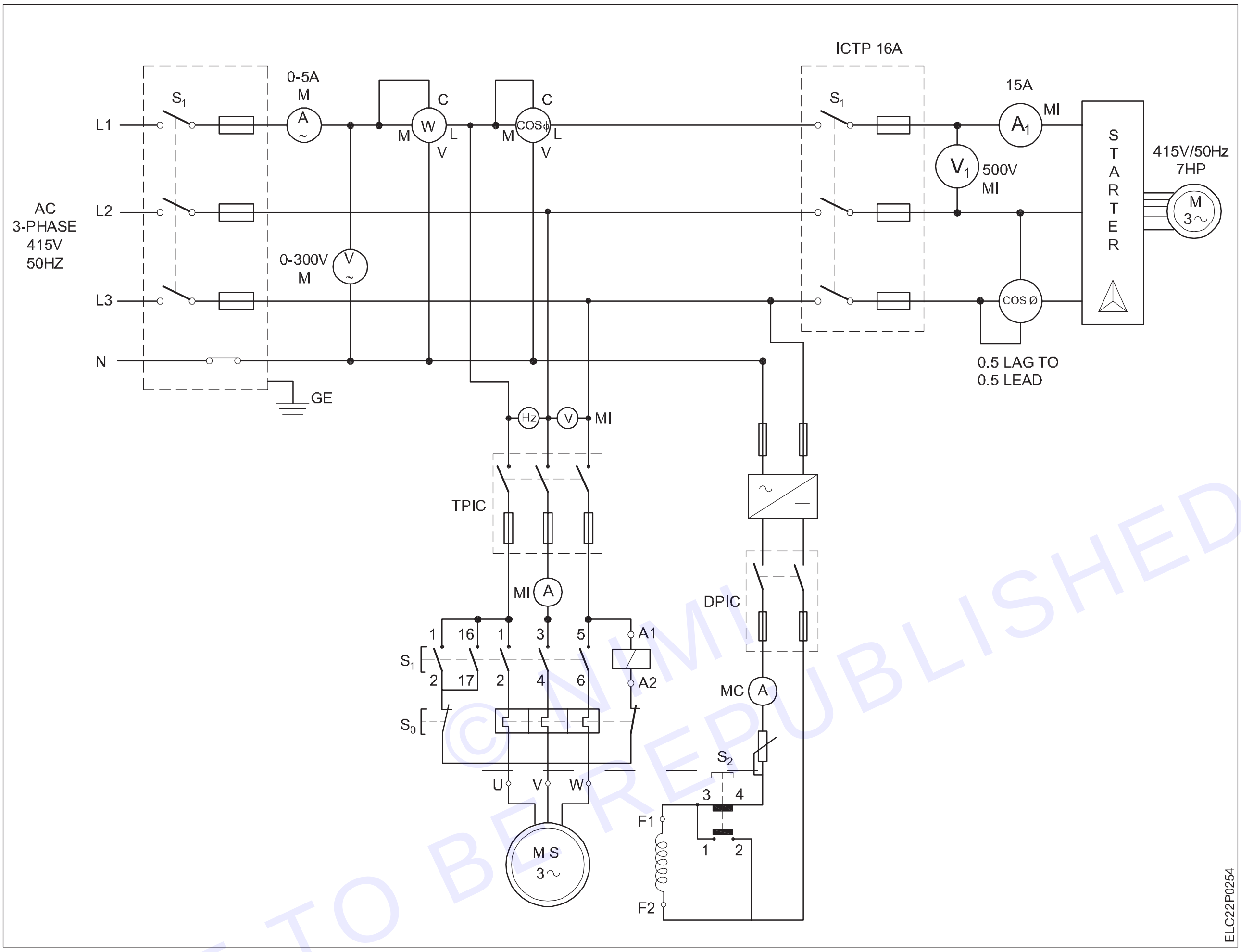
3 Measure the power factor.



TASK 2:

1 Connect synchronous motor as per circuit Fig 2

2 Start and run 3 phase synchronous motor



TASK 3:

1 Vary the filed current

2 Record the power factor at various excitation currents

3 Record the total load current under varying field currents.

4 Tabulate the field current and power factor.

5 Note the induction motor load current with varying field currents

6 Tabulate the readings.

7 Verify the reduction in no load current from power source with improved power factor.

Total load current	Power factor	Synchronous motor load current	Synchronous motor Filed current	Induction motor load current

EXERCISE 86 : Demonstrate small transformer winding

Objectives

At the end of this exercise you shall be able to:
- dismantle the transformer cores
- measure and determine the size of winding wire for primary and secondary winding
- take the dimensions of a bobbin and prepare the bobbin from suiTable materials
- wind the primary and secondary windings layer by layer
- stack the cores and fasten them
- terminate the winding end in a terminal board
- test the transformer for insulation, transformation ratio and performance
- design a transformer when power and voltage ratings are known.

Requirements

Tools/Instruments

- Scissors 150 mm - 1 No
- Steel rule 300 mm - 1 No
- Firmer chisel 20 mm - 1 No
- Hammer ball pein 0.5 kg - 1 No
- Iron soldering 25 W, 240V - 1 No
- DE spanner 6 mm to 25 mm - 1 No
- Mallet hardwood 0.5 kg - 1 No
- Nylon mallet 5 cm dia. - 1 No
- D.B. Knife 100 mm - 1 No

Materials

- Super-enamelled copper wires - as reqd
- Empire sleeves 1 mm, 2mm - 1m each
- Air-dry varnish - 100ml
- Resin-core solder 16 SWG - 10 g
- Soldering paste - 5 g
- Smooth emery paper - 1 piece
- Fabric based fibre sheet and 6 mm thick - 3 mm
- Cotton cloth for cleaning - 500 sq.cm
- Insulation papers - as reqd

Procedure

TASK 1 : **Dismantling the transformer for rewinding**

1 Note down the name plate details in Table 1.
2 Draw the end connection terminal marking of the transformer in your record.
3 De-solder the leads and remove the terminal strips if they are attached to the core.
4 Loosen the nuts of the core assembly and remove the screws if any.
5 Remove the clamps attached to the core.
6 Gently tap the transformer core with a nylon mallet so that the core gets loosened.
7 Remove the stampings starting from the centre of the core using Hylam/fibre knife.

In the case of hard stacked stamping, occasionally use a thinner to loosen the stamping.

Table 1

Transformer raring plate

No of Phase	SI.No................................
V.A rating	Frequency ....
Primary voltage......................volt	Secondary voltage............volt
Primary current......................amp	Secondary current.............amp
Manufacturer	

If a metal knife is used to remove the tight and sticky stampings, care should be taken not to damage the stampings.While stripping the core see that the stampings are taken out straight without bends.

8 Remove all the stampings and record the following in Table 2.

Table 2

Core details

Type of core ....
No.of.stampings of shape...............No.............
No. of . stamping of shape..............No.............

9 Wipe the bobbin and winding with a cloth.

10 Record the dimensions of the coil in Table 3 with and without insulation and prepare a template to check the winding's height and length.

Table 3

Size of the coil

Description	With insulation	Without insulation	Remarks
Coil height Coil height	............cm ....cm	............cm ....cm	

11 Strip off the winding carefully. During the stripping process record all the particulars in Table 4.

Table 4

Winding details

Total No. of winding/turns .... No. of layers .... No. of turns/layer Min .... Layer insulation Type ....Thickness..........mm.			
	With Insulation	**Without Insulation**	**Wt.of the coil**
Primary winding			
1st Tapping, No. of turns.............diameter of wire	............mm.	...........mm	.......g
2nd Tapping, No. of turns.............diameter of wire	............mm.	...........mm	.......g
3rd Tapping, No. of turns.............diameter of wire	............mm.	...........mm	.......g
Secondary winding			
Winding 1, No. of turns................diameter of wire	............mm.	...........mm	.......g
Winding 2, No. of turns................diameter of wire	............mm.	...........mm	.......g
Winding 3, No. of turns................diameter of wire	............mm.	...........mm	.......g
Coil insulation - type ....thickness........mm. Connecting lead............size			

12 Draw the schematic diagram of the primary and secondary sides of the transformer from the above findings in your record.

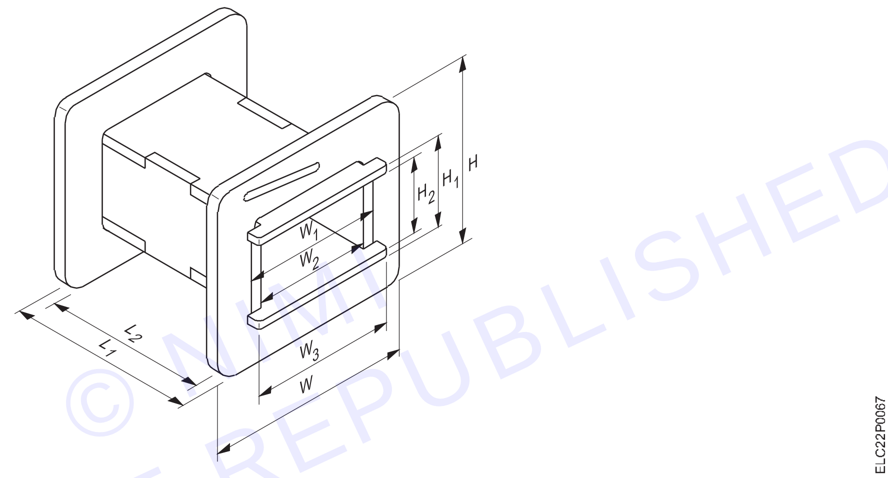
13 Clean the bobbin, write down the bobbin particulars in Table 5 for your guidance.

Table 5

Bobbin details

1	Type of bobbin.................Injection moulded/Built up
2	Bobbin material ....Thickness.......mm.
3	Length of the bobbin L......mm, L_1......mm, L_2........mm.
4	Width of the bobbin W.......mm, W_1.......mm, W_2.........mm, W_3......mm.
5	Height of the bobbin H ....mm, H_1.......mm, H_2.........mm

The same bobbin can be used if it is not damaged.



TASK 2 : **Preparation of bobbin**

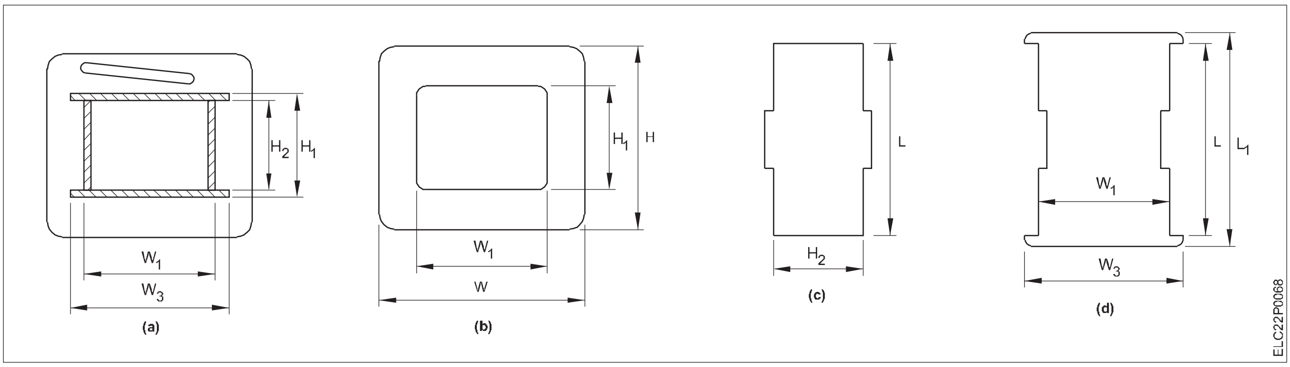
1 Referring to the data taken in Table 5 and as per Fig 1, prepare the bobbin parts from a hylam/fibre sheet of the same thinckness.

Bobbin parts of standard sizes are also avail- able in the market which can be assembled to form the bobbin.

2 Assemble the parts of the bobbin as shown in Fig 2 which is given for your guidance.

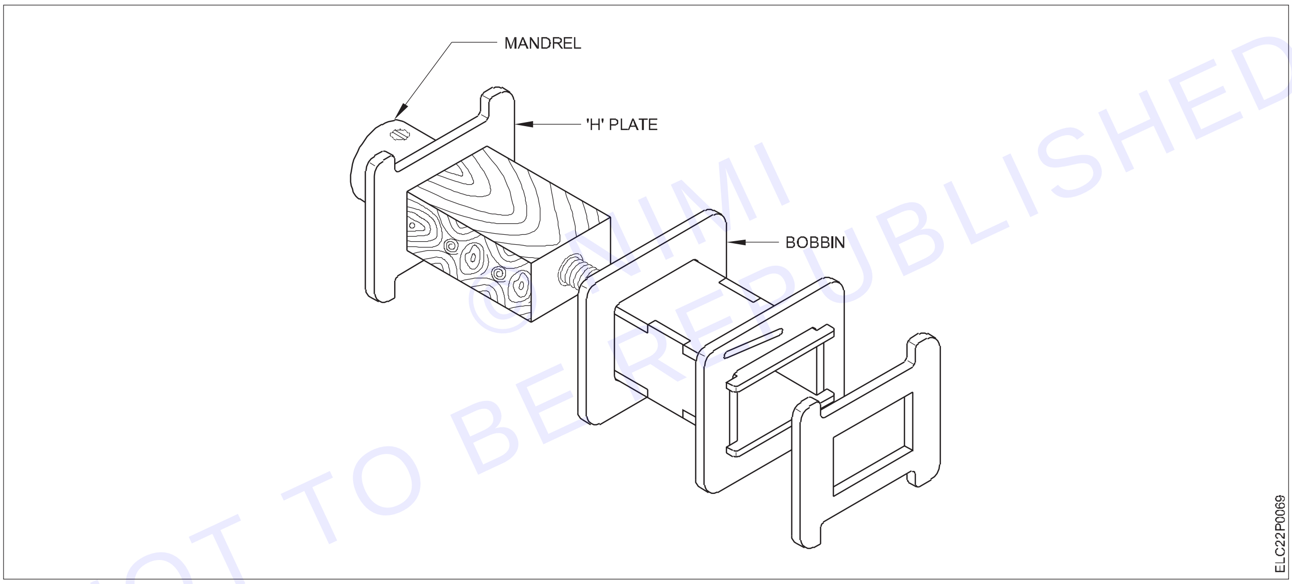
3 Check the size of the assembled bobbin and verify it with the data taken and recorded in Table 5.

In the case of an injuction moulded bobbin it can be purchased from the market assuming it is of standard size.



TASK 3 : **Rewinding of transformer**

1 Prepare/select a suiTable mandrel for the prepared bobbin as shown in Fig 3 or prepare a wooden block as shown in Fig 4 depending upon the design of the winding machines.

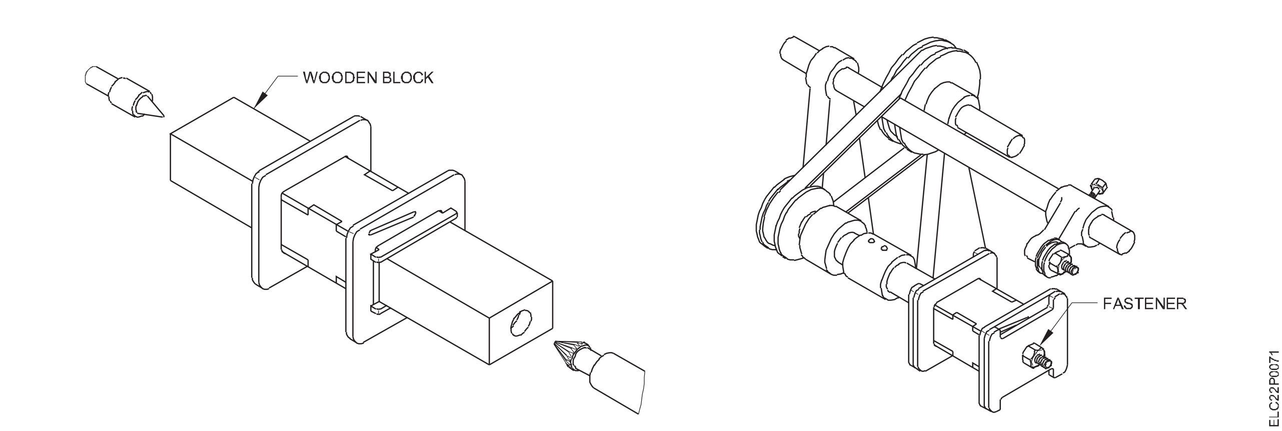


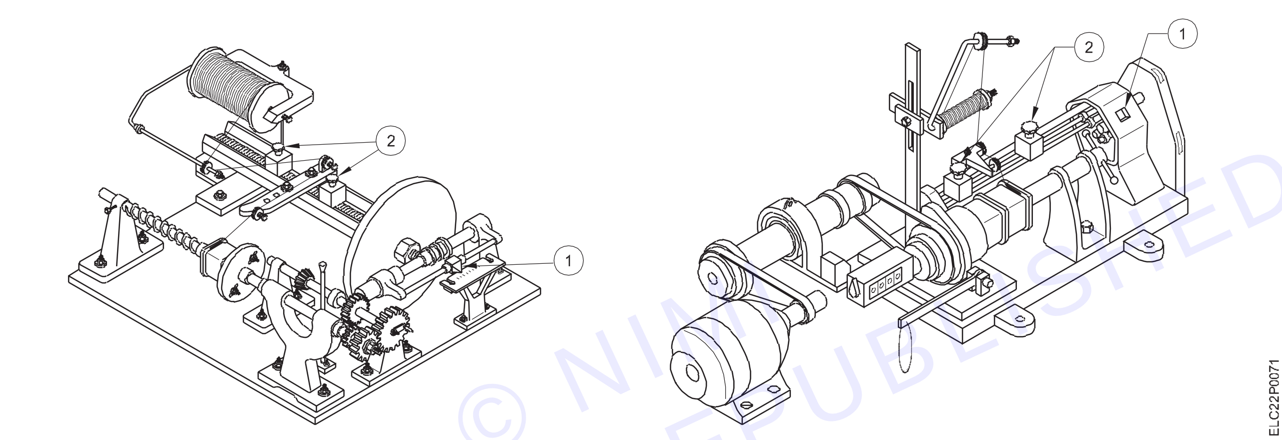
2 Clamp the mandrel/wooden block in the winding machine.

See to it that while clamping the mandrel/ wooden block, under no circumstances the work becomes loose during winding.

3 Fit the bobbin tightly to the mandrel of the winding machine with the help of fasteners as the bobbin must turn along with the mandrel without play. (Fig 5).

4 Adjust the feed of the winding machine to suit the selected winding wire size by friction drive or by changing the gear as shown in number 1 of Fig 6 and7.



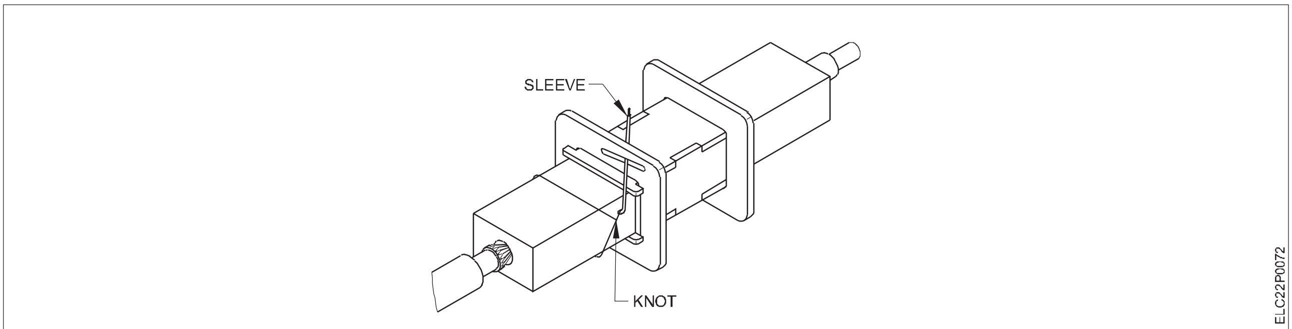


5 Adjust the transverse feed of the winding machine guides such that the length of the inner side of the bobbin so as to maintain the length of the coil as in the original. Refer to number 2 of Figs 6 and 7. You may need several trials before final setting.

6 Place one layer of paper or cloth as core insulation on the bobbin smoothly without crease.

7 Solder a connecting lead and sleeve the same with the beginning end of the selected winding. Place the lead wire at one end of the bobbin and take it through the bobbin flange outlet and tie with a knot to avoid slipping as shown in Fig 8.

If the winding wire thickness is sufficiently large, soldering of connecting lead wire is not necessary.



8 Start the winding and complete atleast one layer to check whether the coil length is well within the bobbin as in the original. If not, readjust the transverse feed.

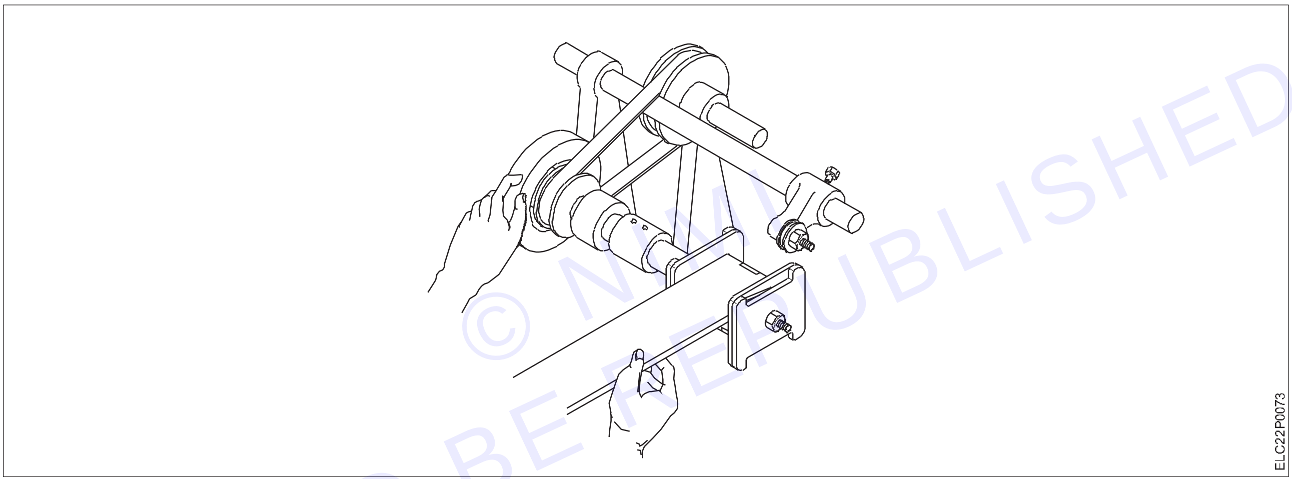
Adjacent turns of the winding wire should not overlap or have a gap in between them. if incorrect, readjust the feed

9 Start and ontinue the winding layer by layer providing the necessary in-between insulation and specified number of turms in each layer as per data taken in Table 4.

10 After the designated number of turns are wound, solder the end lead and take it out through the bobbin flange outlet.

If a coil has a number of taps of winding, never cut the wire. Instead fold the length into a long loop and carry the wire to continue the winding. The looped wire can then be bared and connected outside the coil.

11 After inspecting the primary winding, wrap the winding as shown in Fig. 9 with sufficient insulation according to the data taken in Table 4.



12 Select a suiTable secondary winding wire as shown in the data taken in Table 4 and proceed as in steps 4 to 7.

The transformer may be provided with one or more secondary windings or tapped windings. In such a case follow the data recorded and also refer to the connection diagram shown in step 12, Task 1.

13 At the end of the winding, wrap and bind the insulation on the winding tightly.

Bindings must cover the winding fully and must be free of crease and must not project beyond the coil disc (flange).

14 Inspect the coil for proper termination of lead and check the size by using a template and data taken in Table 3.

15 Test the windings for continuity and short circuit.

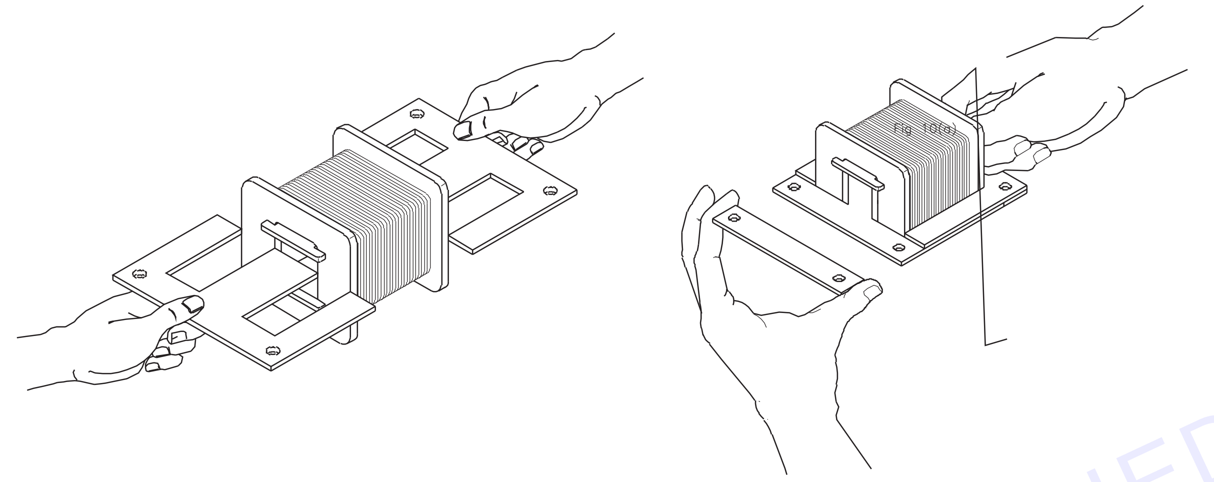
— — — — —

TASK 4 : **Stacking of transformer cores (E & I)**

1 Insert an ‘E’ lamination into the bobbin from both sides as shown in Fig 10a.

2 Place the right hand side (R.H.S.) laminations below the one inserted from the left hand side (L.H.S.).

3 Place an ‘I’ lamination to the free end of the L.H.S. ‘E’ piece as in Fig 10b.



4 Ensure that the slot in the ‘I’ is above the corresponding slot in the R.H.S. ‘E’ lamination.

The laminated assembly should be flush and lying flat.

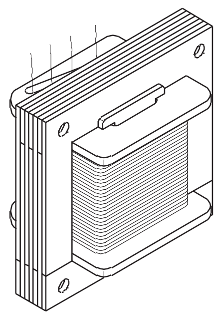
5 Insert the second ‘E’ shaped laminations from the opposite side.

Ensure that it fits snugly against the bobbin.

6 Place an ‘I’ shaped lamination in position.

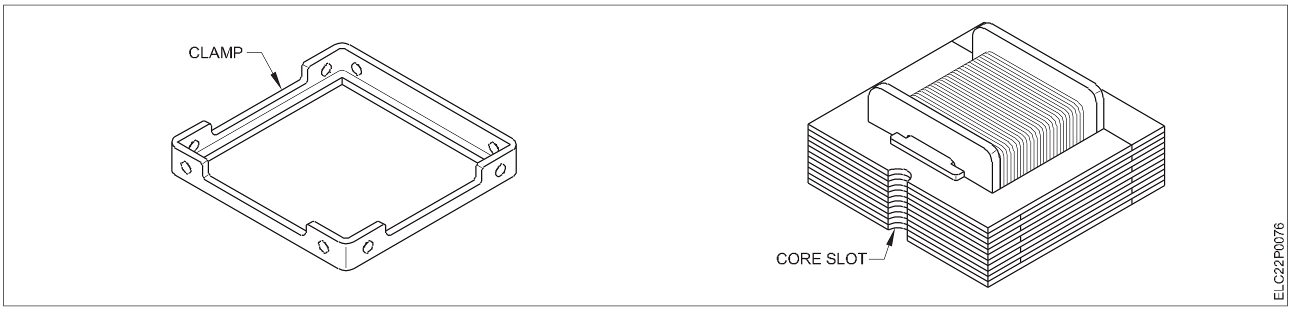
Ensure that it lies flat on the first “E” lamination.

7 Likewise insert the laminations alternately without any gap as shown in Fig 11.



Ensure that when all of the specified quantity of laminations are inserted, the assembly has the right dimension, from loose laminations and correct interpolated laminations.

8 Fit both the top and bottom clamp plates on the assembly as in the original. (Figs 12a and 12b)



Pay particular attention to align the core slots in the laminations.

Ensure that the fixing bolts can be easily inserted.

9 Push the fixing bolts through the clamp plates.

10 Use the specified fasteners and tighten the assembly.

11 Varnish the transformer by dipping in an air-dry varnish and drain it.

12 Fit the specified insulating sleeves over the lead-out wires.

13 Obtain the specified terminal board and pass each lead-out through the specified hole.

Ensure that all the sleeved leads are correclty positioned.

Check that all the sleeved leads terminate at each hole i.e. no bare leads should be visible in the terminal board.

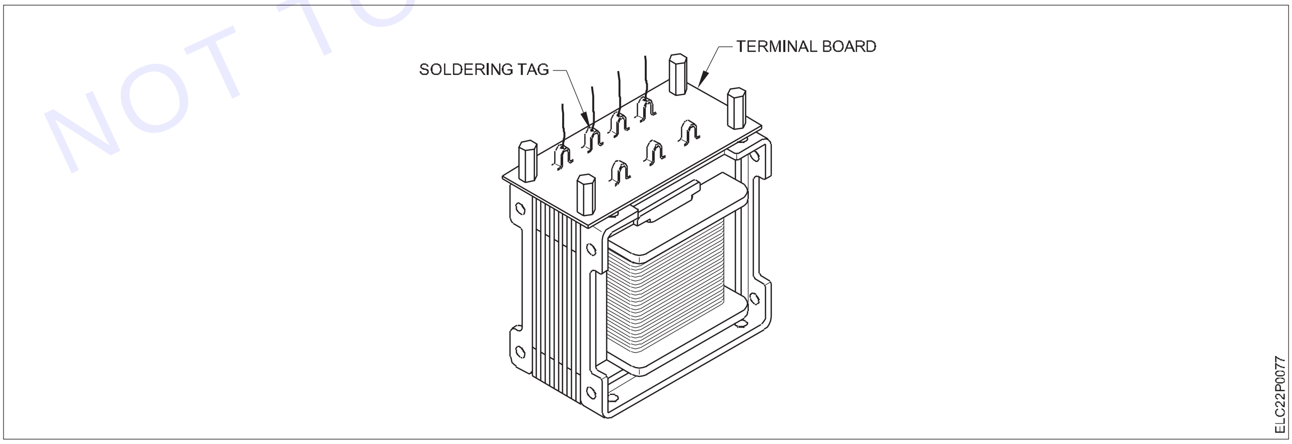
14 Place the terminal board in position as shown in Fig 13.

15 Secure the terminal board with the specified studs.

16 Check that no leads have been trapped between the terminal board and the core.

17 Make the specified mechanical joint between each lead- out wire and its soldering tag.

18 Solder each joint and cut off the surplus wire ends as seen in Fig 13.



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TASK 5 : **Testing of transformer after winding**

1 Test the primary and secondary windings for continuity with a megger.

2 Measure and record the primary and secondary winding resistance in Table 6.

Table 6

Transformer winding resistance

Primary resistance.............ohm

Secondary 1 resistance.................ohm

Secondary 2 resistance.................ohm

Secondary 3 resistance.................ohm

3 Measure and record the insulation resistance, between windings and frame in Table7.

Table 7

Insulation resistance between

Primary & secondary windings..............megohm

Secondary windings..............................megohm
(in case of seperate windings)
Windings and frame.............................megohm

4 Connect the primary winding of the transformer with the rated voltage. Keeping the secondary open, test the primary and the secondary voltage. Record the finding in Table 8

Table 8

No-load measurement

Primary voltage.......................volt

Secondary voltage

1 ....volt

2 ....volt

3 ....volt

5 Observe for vibration sound of the core. If it is abnormal, tighten the stampings, also check for tightness of the coil.

6 Connect the transformer with suiTable load so that full load current passes through the secondary, and record the voltage and current at load in Table 9.

Table 9

Load measurement

Primary voltage.................volt

Primary current.................amp

Secondaryvoltage.............volt

Primary current.................amp

7 Keep the transformer on full load for eight hours continously. Observe the change in temperature of the winding and core by touching. If the temperature raise is within the class of insulation, the transformer is O.K.

TASK 6 : **Testing of transformer after winding**

1 Collect the following data from the customer.

- output, power and frequency
- input and output volt
- duty rating, (intermittent or continuous)

2 Follow the procedure outlined in Related Theory for determining the dimensions of the transformer, bobbin, number of turns in primary and secondary and the size of winding wire for primary and secondary.

3 Follow the procedure stated in this job sheet except dismantling of the transformer core and complete the winding.

— — — — —

EXERCISE 87 : Test burnt out DC machine for re- winding

Objectives

At the end of this exercise you shall be able to:

- test the armature for short in the coil with an external growler
- test the armature for open in the coil with an external growler.

Requirements

Tools/Instruments

- Armature winding stand - 1 No
- Electric soldering iron 25W/240V - 1 No
- Hack saw blade - 1 No

Equipment/Machines

- External growler 240V, 50HZ - 1 No
- DC armature - 1 No

Materials

- Soldering paste - 10 g
- Resin core solder 60:40 - 50 g

Procedure

TASK 1 : **Short circuit test**

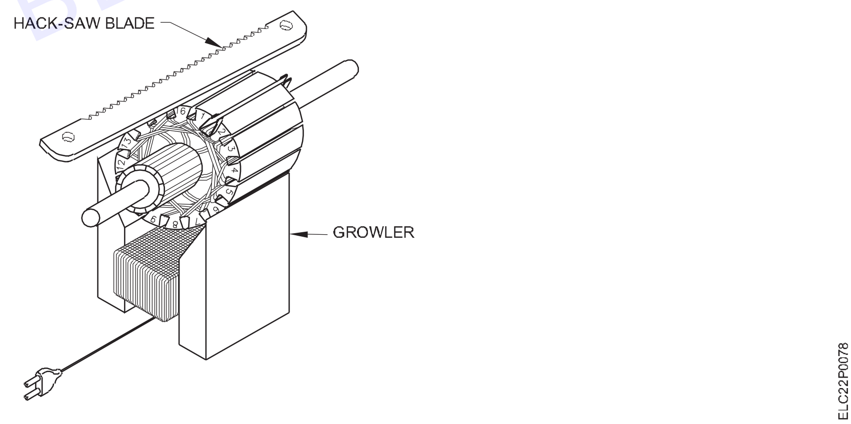
1 Place the armature on the yoke of the growler.

2 Switch ON the growler.

3 Hold the hacksaw blade over the top of the slot and along the length of the armature.

4 Rotate the armature slowly and observe the hacksaw blade vibration and growling noise.

5 Vibration of blade and growling noise indicate short in the coil.



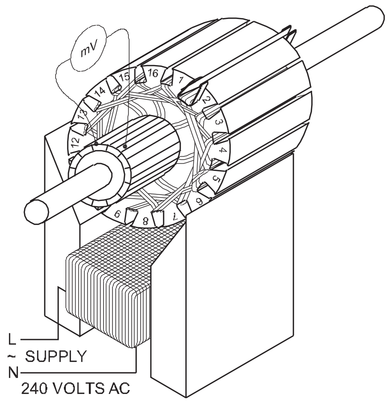
TASK 2: **Open circuit test**

1 Connect the AC Milli- voltmeter /Ammeter (normally provided with growler) leads to the top two adjacent segments keeping the growler switch ON.

2 Rotate the armature and continue testing all the adjacent commutator segments.

3 The low value of readings shows short in between the armature coils.

While rotating the armature the geometrical position of the test leads should not be changed for subsequent testing.



TASK 3: **Body short circuit test or ground fault test**

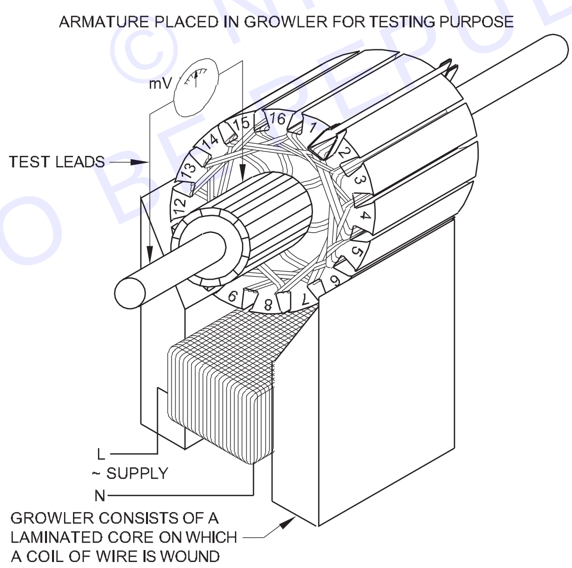
1 Place the armature to be tested on the growler as shown in the Figure

2 Switch on AC supply is given to the growler to induced voltage in the armature winding.

3 Connected by AC milli voltmeter between the commutator segment and the shaft of the armature.

4 Observe for the deflection of the pointer of the milli voltmeter in every commutator segment.

5 Mark the commutator in which the pointer does not deflect, as it indicates contact with iron parts of the armature.



TASK 4: **Drop test**

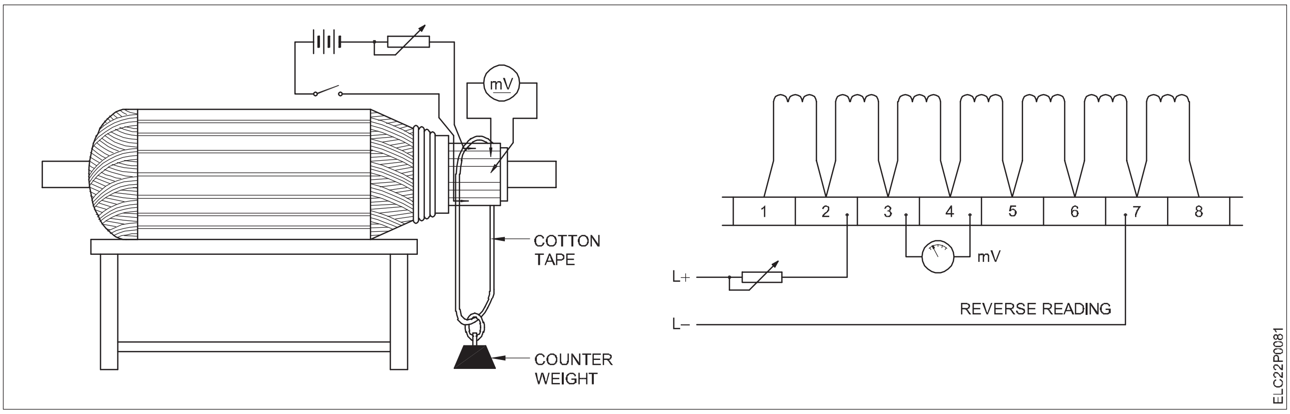
1 Connect a low voltage DC supply through a variable resistance in series across the commutator segment at distance of pole pitch. (eg. For two pole machines DC supply is given to the opposite brushes, and in four pole machine DC supply is given to the adjacent brushes)

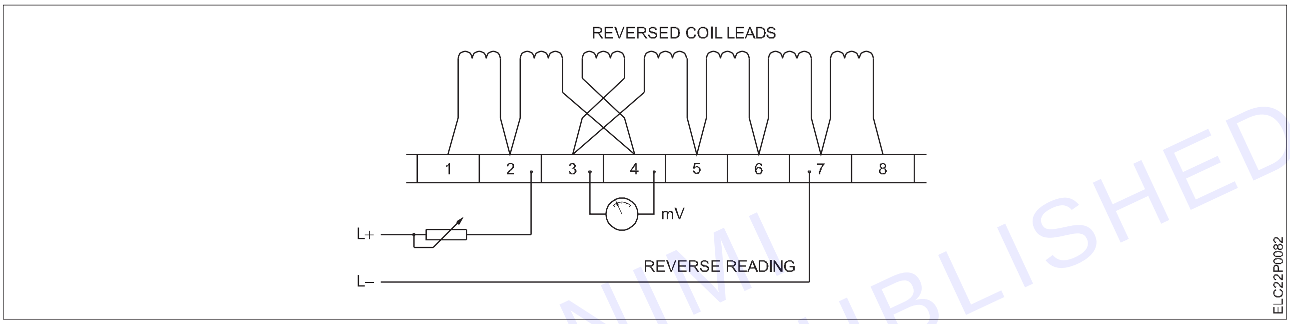
2 Now place the DC milli volt meter leads with the adjacent bars and find the readings for all commutator segments as in Figure

3 Assess the windings is in good connection ff all the readings are same

4 Assess the coil as short across 2 segments if the meter reads zero or low voltage.

5 Assess the coil as open across 2 segments if the meter reads high voltage.





6 Assess the coil is reversed across 2 segments If the milli voltmeter deflects in the reverse direction as in Figure above

— — — — —

EXERCISE 88 : Demonstrate Winding procedure

Objectives

At the end of this exercise you shall be able to:

- demonstrate collecting the armature winding data
- draw the winding diagram of small armature
- demonstrate small armature rewinding.

Requirements

Tools/Instruments

- Electrician tool kit - 1 Set
- Insulated cutting pliers 200mm - 1 No.
- Scissors 150 mm - 1 No.
- Mallet hardwood 0.5kg - 1 No.
- Soldering iron 25W, 125W, 240 V - 1 No.
- Tray 200 mm x 200 mm x 50 mm - 1 No.
- Scale with weights 1 to 450 g - 1 No.
- Outside micrometer 0-25mm - 1 No.
- Tweezer 100mm - 1 No.
- Stand winder for armature - 1 No.
- Power hack saw blade used - 1 No.
- Centre punch 150mm - 1 No.

Equipment/Machines

- Burnt out armature - 1 No.

Materials

- 7 Mill millinex paper - as reqd.
- 30 SWG super-enamelled copper wire - 300 g
- Empire sleeve 1mm, 2mm - 1 m each
- Cotton tape 20mm - 1 m
- Binding/hemp thread - 1 roll
- Hylam/fibre wedge 2mm thick - as reqd.
- 10 milli triplex paper - as reqd.
- V-32 insulation varnish - 1/2 litre
- Thinner - 1/2 litre
- Resin core solder 60/40 - 20 g
- Resin flux (power type) - 10 g
- Air dry varnish - 1/2 litre
- Used hack saw blade - 1 No.
- Soldering paste - 10 g

Assumption: To facilitate easy approach, the procedural steps are for a mixer similar to Sumeet make. However NIMI does not take any resopnsibility for the correctness of the specification given in this information as the specifications are bound to change by the manufacturer from time to time.

Procedure

TASK 1 : **Dismantle of armature from the body**

1 Note the name-plate details of the given mixer in Table 1.

2 By turning the mixer upside down, make the position of the closing cover.

3 Dismatle the rubber bush and unscrew the fixing screw from the closing cover.

4 Trace the main supply lead and its connection to the internal parts.

5 Trace the internal connection from the field, armature, speed selector switch and draw the connection diagram.

Fig 1 is given for your guidance.

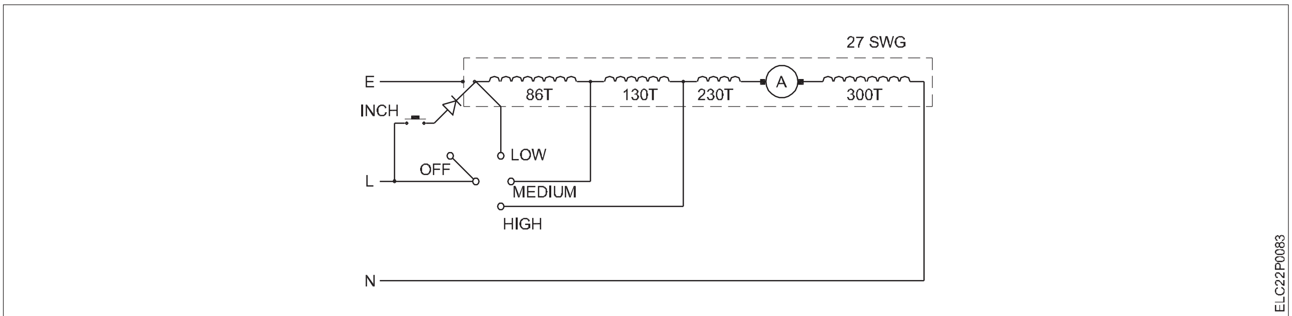


Table 1

Data Sheet

Make .... Type...................

KW...................... Volt .... Amp............... No. of poles..................

R.p.m................ Frame............ Model......................

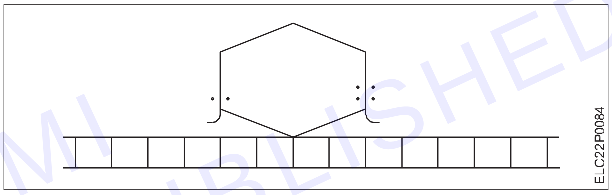
Rotor	Size of wire	No. of Turns	Coil Pitch	Coils/ Slot	Wt. of one coil	Wt. of the winding	No. of slots	No. of commutator	Remarks

Centre of slots.

to

Centre of bars

Centre of mica



Commutator

Pitch

Lap Wave

6 Remove the top cover screw which is fitted in the inner side of the body of the mixer.

7 Remove the top cover of the mixer.

8 Remove the coupling pulley

9 Disconnect the main supply lead and inner leads from the speed selector swich terminals.

10 Remove the motor from the plastic cover assembly

11 Remove the carbon brushes.

12 Mark the position of the bottom cover and the body for the mixer with the help of a centre punch.

13 Loose the through machine screw and remove the bottom cover.

14 Remove the fan blade from the armature shaft.

15 Remove the armature out of the stator

TASK 2: **Collect and record the armature datas**

1 Check visually the armature for fault symptoms and then by an external growler.

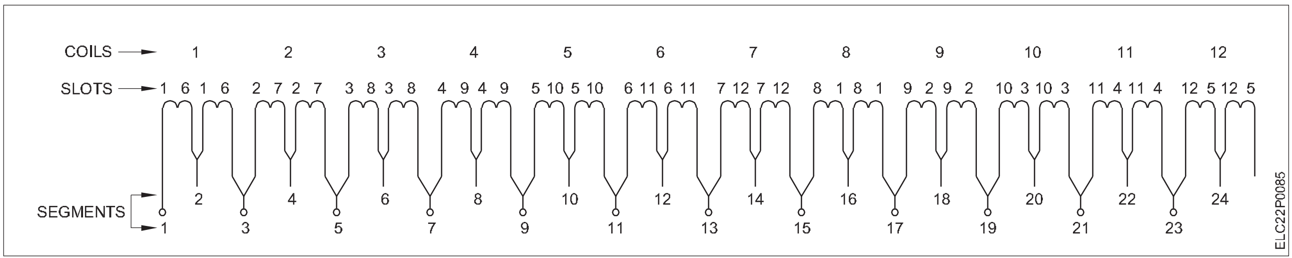
2 Note down your findings in Tables 1 under symptoms of defects

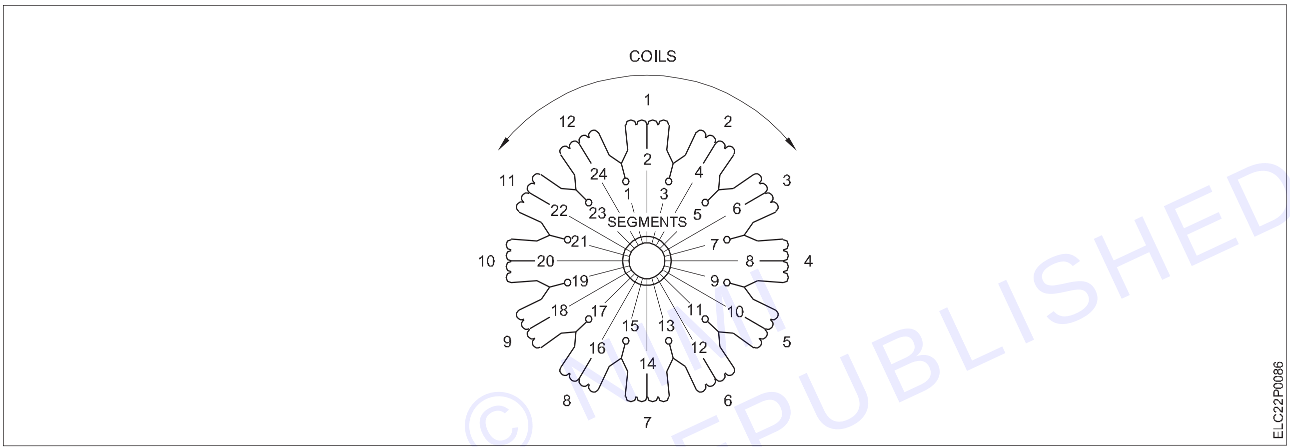
3 Place the armature in the winding stand. Count the number of slots, number of segments and record in Table 1.

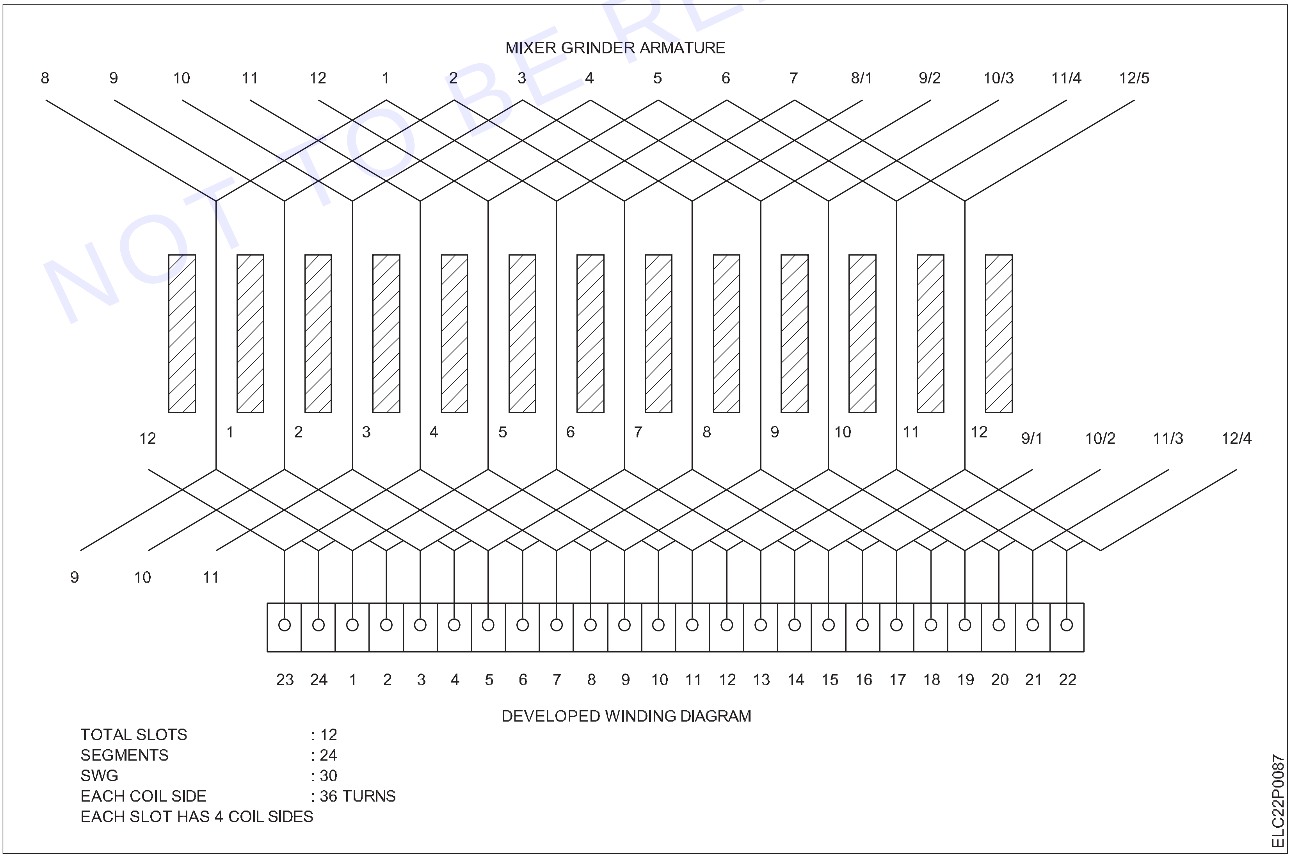
4 Draw the developed diagram with the help of the data obtained.

To give proper guidance to the trainees a particular make mixer (similar to sumeet mixer) is considered here.

The connection diagram is shown in Fig 3, the ring diagram is shown in Fig 4 and the developed diagram is shown in Fig 5.





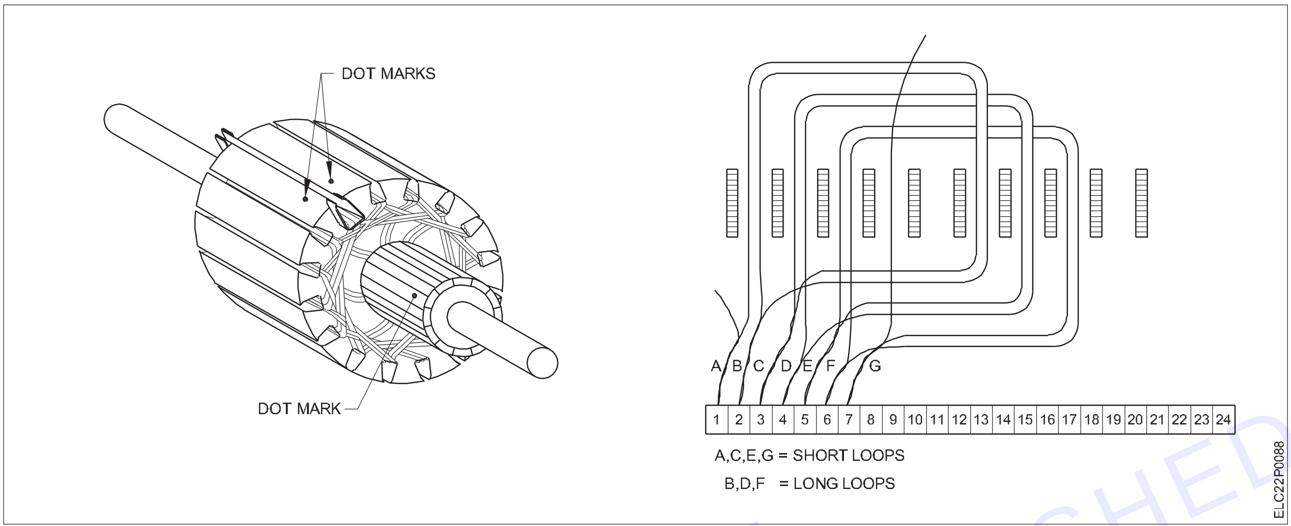


5 Identify one slot and mark a dot each on the side of slot with the help of a centre punch. (Fig 6)

6 Trace the end connection from the slot to the commutator segment.

7 Mark one dot on the lightly ends of the identified commutator segment by using a centre punch. (Fig 6)

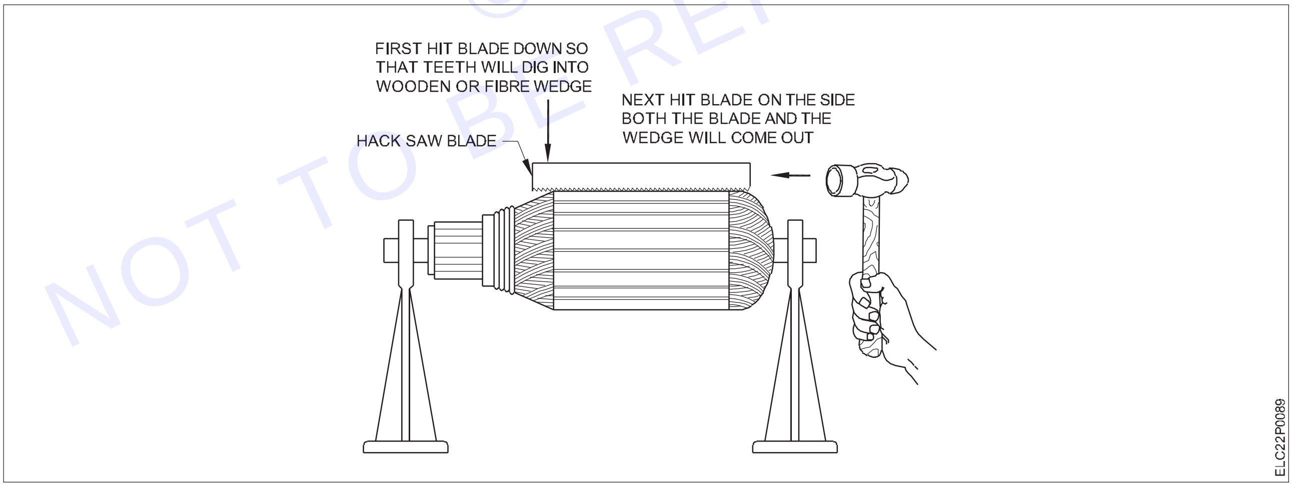
Fig 7 shows the lead swing as found in the mixer taken as the example



8 Record the findings in Table. 1

9 Cut the armature leads from the commutator raisers. 10 Apply a thinner to the armature slots and winding.

11 Remove the fibre/Hylam wedges from the armature slots (Fig 8).



12 Count the coil pitch and record it in Table. 1

13 Remove the armature coil one by one from the solts

14 Count the number of turns, size of winding wires weight of each coil, weight of whole winding and type of slot insulation. Record them in Table 1.

15 Practice the exercise for three or four times with different armature assemblies.

16 Keep all the parts safely for using at the next exercise

— — — — —

TASK 3: **Perform winding of armature**

1 Select the winding wire according to the original winding and mount the spool on a stand.

For sumeet mixer use winding wire of size 30SWG.

2 Insert a guide paper in the identified slots in which the coil is to be placed. (Fig 9)

For the sumeet mixer, taken as an example, we have

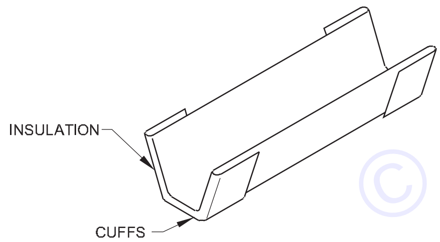
Total number of slots	**= 12**
Segments	**= 24**
Winding wire	**= 30 SWG**
Number of coil sides in each slot	**= 4**

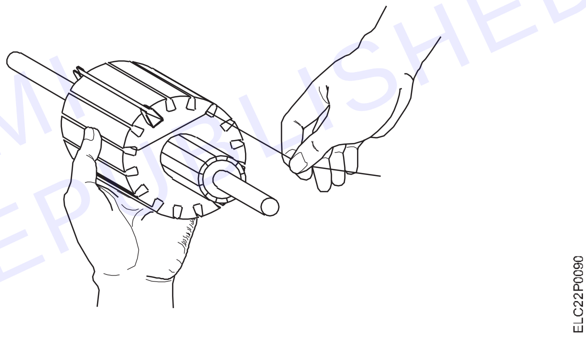
(2 coil sides are looped together and the loops are connected to the segments)

Number of turns in each coil = 36 turns identified slot pitch 1-6.

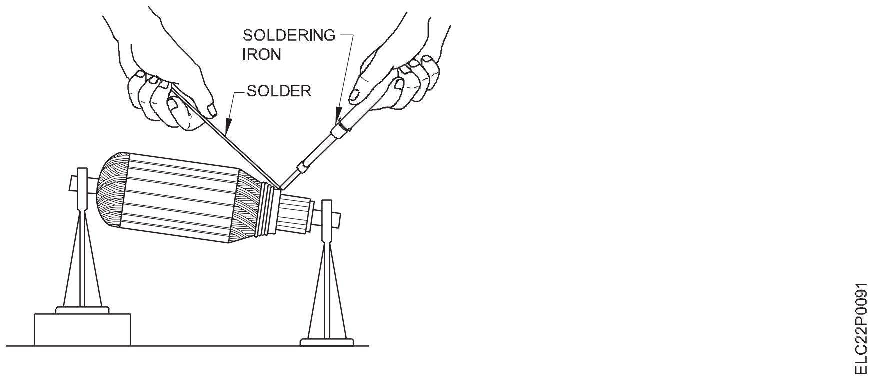
3 Place a guide paper in slots 1 and 6. (Fig 9)

4 Hold the armature in hand. (Fig 10)





Large size armatures are to be supported by stands (horses during winding). (Fig 11)



5 Wind the armature by hand placing one end of the coil side in slot No.1 and the other in slot No.6

6 Count 36 tuns and then make a longer loop.

Do not make mistakes in counting. Wrong number of turns will result in unbalanced armature.

7 Make another 36 turns in the same solts (1 and 6) by holding the loop with your fingers of the hand.

TASK 4: **Solder the armature after rewinding**

1 Measure the lead swing length so as to reach the identified commutator raisers.

2 Remove the insulation of the winding wire loops at the connection points to the raisers.

3 Place the end connection wires in the risers in proper sequence and tie a rubber band on the commutator so as to hold the extended wire connections from the raisers in position.

4 Solder the end connections with the raisers properly.

5 Remove the excess solder from the raisers.

6 Check the connections and then bind the end connections with the armature.

— — — — —

EXERCISE 89 : Check small armature winding, impregnation, baking

Objectives

At the end of this exercise you shall be able to:

- check a rewound armature winding
- impregnate the rewound armature
- bake the rewound armature

Requirements

Tools/Equipments/Instruments

• Trainees kit	- 1 No
• Soldering iron 25W/250V	- 1 No
• Digital multimeter	- 1 No
• Winding baking oven	- 1 No
• External growler	- 1 No
• Amarture static balancer	- 1 No

Materials

• Insulating varnish	- 100ml
• Emery paper	- as reqd
• Thinner	- as reqd

Procedure

TASK 1 :

1 Test the rewound armature with an external growler for shorts, open and grounding.

TASK 2:

1 As per the available infrastructure preheat armature as any one of the following steps from 3 to 6

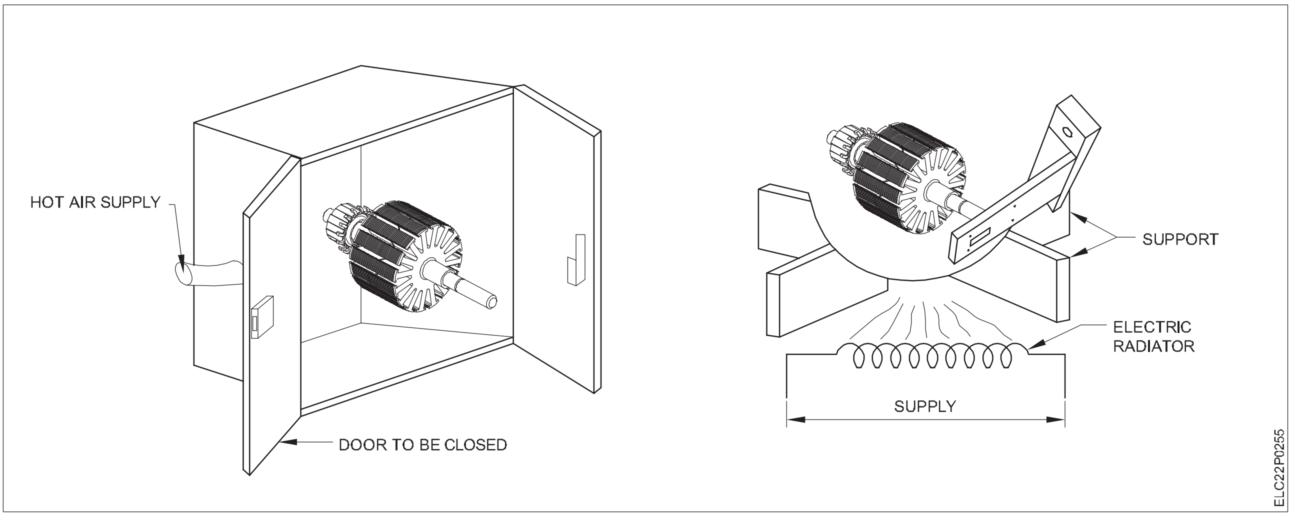
2 Place the armature in baking oven at a temperature and time specified by the varnish/ resin manufacturer (less than 90degree) and preheat it to remove moisture from the windings and increases the perpetration of the varnish.

3 Blow hot air for smaller dc armature within a closed chamber with clean air and temperature not more than 90

4 Place the armature on electric heat radiator

5 Heat the armature with carbon filament lamp, without making any contact with windings. Reduce ventilation if sufficient high temperature is not available.

6 Monitor for a temperature during preheating.



7 Measure the insulation resistance every hour during the heating period to note a fall in IR value and recovery by end period.

8 Cool down armature to approximately 60-degree Celsius.

9 Select the varnishing method as dipping or pouring with spoon based on the size of armature.

10 Dip the rotor vertically with commutator segments upside to a container of insulation varnish compatible with the type of wire used.

11 Loosen the varnish by thinner to penetrate the same in winding

12 monitor the thickening of varnish and control thickness by thinner

13 Soak the winding in the varnish for approximately one-half hour or until all bubbling has ceased.

14 remove armature from the dip container and allow varnish to drip.

— — — — —

TASK 3: **Bake the rewound armature**

1 place the armature on baking oven after varnish for 8 hours or as recommended by the varnish manufacturer

2 measure the insulation resistance of armature and cool to about 60-degree Celsius.

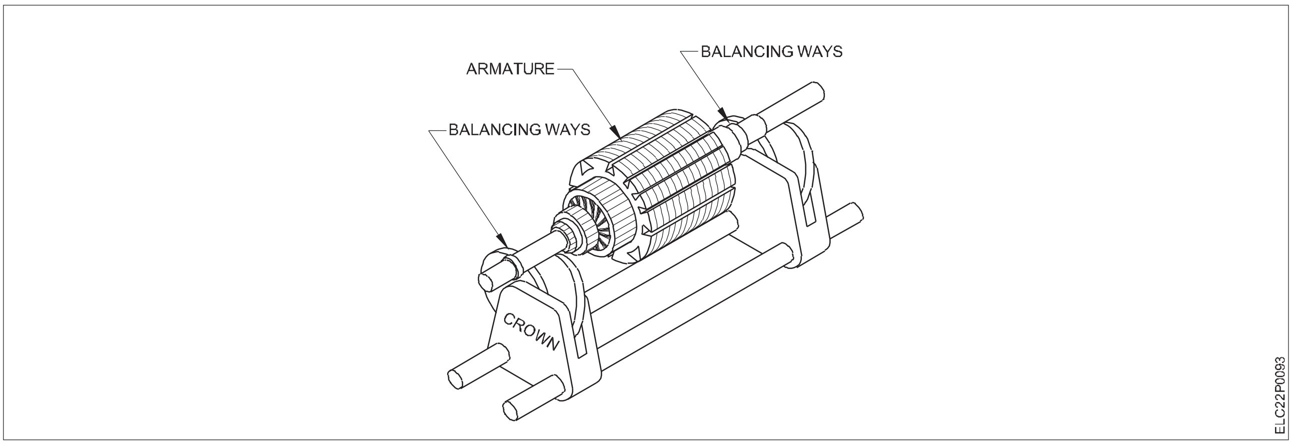
3 Repeat steps from 11-16 for second impregnation.

4 scrap the surface of armature to remove the adhering varnish, and to maintain clear airgap

5 use solventless polyester varnish /resin alternatively that can be applied to windings in less time.

6 check the armature for balance in a dynamic balancing machine / static balancing machine. The rotated armature will stop at different position, if balanced. Apply small seal non-conducting paste to balance and retest.

7 Assemble armature to the rotor and test run it with load.



EXERCISE 90 : Test burnt stator and demonstrate rewinding procedure

Objectives

At the end of this exercise you shall be able to:

- test ac motor winding by growler
- collect data for rewinding and record
- demonstrate rewinding of ac motor.

Requirements

Tools/Instruments

- SEC cu wire - 400 g
- Electric soldering iron 25W/240V - 1 No.
- Hack saw blade - 1 No.
- Standard wire gauge

Equipment/Machines

- Winding former

Materials

- Soldering paste - 10 g
- Resin core solder - 50 g

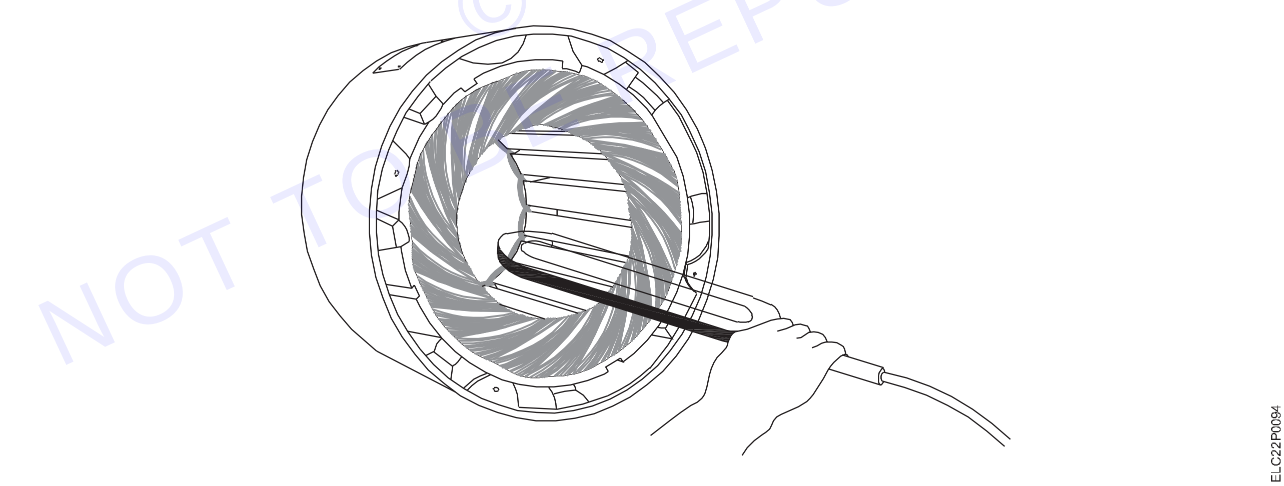
Procedure

TASK 1 :

1 Switch on the power to the internal growler.

2 Move the internal growler over the coils of the stator.

3 Identify the shorted coil by buzzing/growling sound.



4 Test for open by series test lamp in any phase winding.

5 Identify the open in phase winding by testing continuity of the coil

6 Record name plate details.

7 Remove pulley by pulley puller, remove fan cover and fan blade.

8 Mark and remove connection leads from terminal box.

9 Loosen screw from end shields and remove centrifugal switch

10 Remove rotor from stator

11 Inspect for any defect/

12 Mark stator for connection lead side with respect to terminal box

13 Trace the internal connection from and draw the connection diagram

14 Apply thinner to the armature slots and winding to thin down the varnish.

15 Remove the fibre/Hylam wedges from the armature slots.

— — — — —

TASK 2:

1 Count the coil pitch and record it.

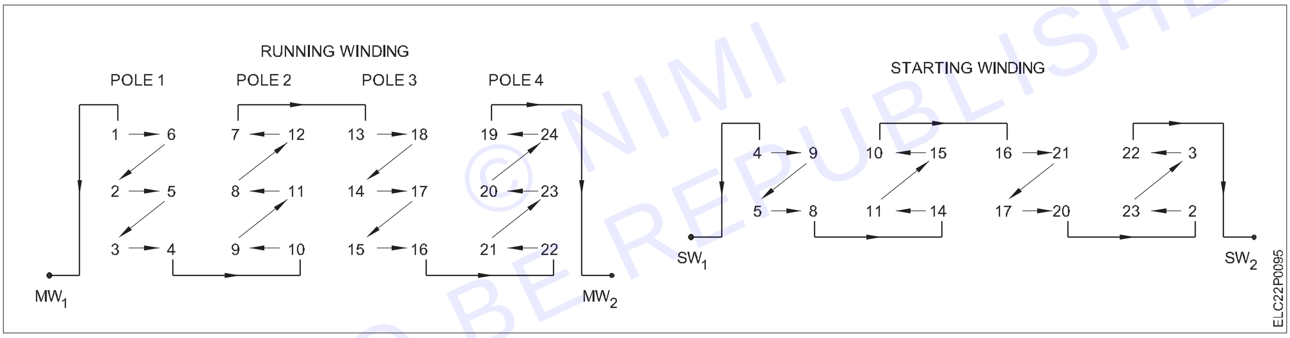
2 record data of stator, viz wire gauge, no of turns, coil pitch, coils/slot, no of slots, no of total coils, coil connection and pole connection. Sample of single phase motor with 24 slots, 20 coils is given here.

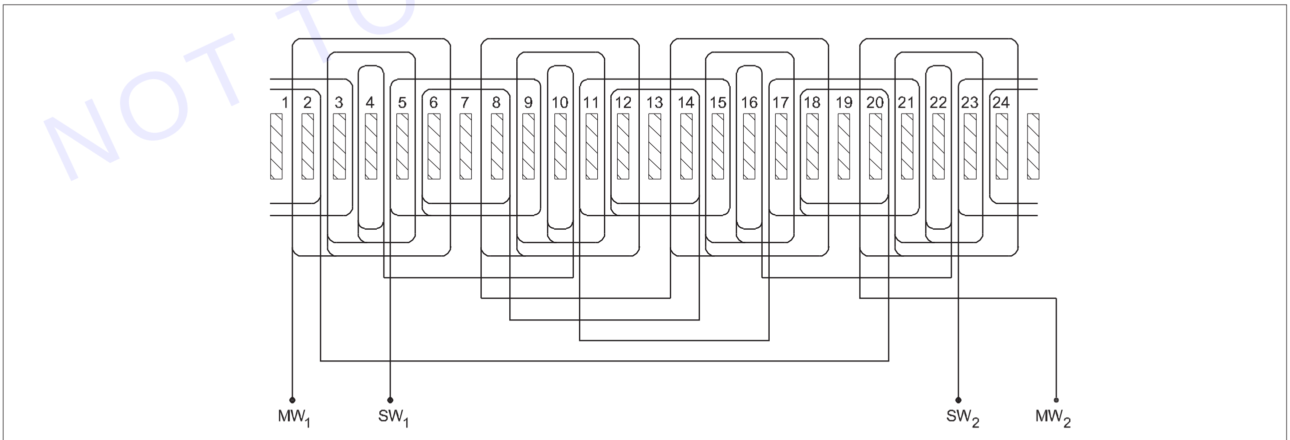
	Main winding	Starting winding
Coil pitch	5,3,1	5,3
Coil throw	1-6,2-5,3-4	1-6,2-5
No of coils	12	8

No of slots	24

Coil connection – End to End (whole coil)

Reference winding diagram





DEVELOPED DIAGRAM OF SINGLE PHASE INDUCTION MOTOR
(HAVING 24 SLOTS, 20 COILS, FOUR POLES, CONCENTRIC WINDING)

3 Strip the old winding from stator slot, use heating by blow lamp If necessary

4 Measure size of wire, dimensions of coil.

5 Clean the slots, (for damges sand blasting may be required).

6 Measure the weight of the discarded winding.

TASK 3:

1 Set the winding former for the size of measured coil with overhang dimension.

2 Wind the coil manually to dimension as per the pitch recorded, and as per recorded wire gauge in a former if available. Or place 4 nails on a board suitably and wind.

3 Insert slot insulation material

4 Place the wound coil to the stator and verify the accommodation.

5 Repeat step 15-18 for balance main winding coils

6 Terminate the coil end connections through fibre glass sleeves

7 Put wedges permanently for single layer slot and temporary wedge for double layer.

8 Dress the winding and tighten the overhang with cotton tape and tie with binding thread.

9 Connect the pole connections as per data recorded.

10 Check main winding for continuity and insulation resistance.

11 Apply slot insulation in between main and auxiliary winding id double layer slots

12 Place starting winding in the slot's as per recorded data

13 Shape the sides overhang with mallet.

14 Wedge the windings

15 Route the end connection to the terminal box, insulated with sleeve.

16 Check connection as per recorded diagram.

17 Test the winding with internal growler

18 Test the insulation resistance between body and the winding

19 Reassemble the motor, with centrifugal switch.

20 Test the motor with supply.

— — — — —

EXERCISE 91 : Check single - & double-layer winding

Objectives

At the end of this exercise you shall be able to

- demonstrate rewinding of three phase single layer winding
- demonstrate rewinding of three phase double layer winding.

Requirements

Tools/Instrument

- SEC cu wire - 400g.
- Electric soldering iron 25W/240V - 1 No.
- Hack saw blade - 1 No.
- Standard wire gauge

Tools/Instrument

- Winding former

Materials

- Soldering paste - 10g.
- Resin core solder 60:40 - 50g.

Procedure

Task 1:

1 Demonstrate to calculate no of poles of motor from recorded name plate details

2 Dismantle motor

3 Identify motor winding as single layer or double layer, whole coil or half coil.

(Single layer,no coils=half no of slots, double layer, no coils=no of slot)

(whole coil, no polesxno of phases=no of groups and half coil, no of ploes x no of pair poles = no of groups)

4 Record no of slot, no of coils and pitch

5 Demonstrate the group and lead connection

6 Measure overhang projection at both side

7 Record size of wire, whether single strand or multi wires, wire insulation

8 Remove wedges from slot.

9 Use thinner in winding and remove carefully it to measure coil length, coil width and coil thickness

10 Remove all the coils and measure the weight.

11 Clean the stator slot by brush or compressed air

12 Record the coil length, coil width and coil thickness

13 Prepare stepped winding former to suit recorded dimensions

14 Wind the recorded number of turns, with wire of measure size and insulation

15 Tie the coils with binding thread on overhead sides

16 Keep a connection length at both ends of around 150mm

17 Remove wound coil from stepped former

18 Verify the dimension correctness by placing in the motor slot

19 Make corrections if necessary for dimensions and make required no of coils

20 Shape the coils for inserting into slots with overhang

21 Prepare slot insulation to project above the slot by 10mm both sides

22 Insert left coil side of coils, as per developed diagram for slot upto right side of first coil.

23 Insert right coil side of first coil, continued by other coils

24 Repeat previous 2 steps till completion of insertion of all coils

25 Tie overhang with cotton tape and press carefully near to the core for preventing obstruction to end cover and use nylon hammer to shape coils.

26 Insert slot wedges to tightly pack the coil

27 Connect group connections of each phase, solder and sleeve them.

28 Tie the joints to overhang and make phase connections

29 Measure the resistance of the winding

30 Test the insulation resistance between windings, windings and body

31 Varnish the windings

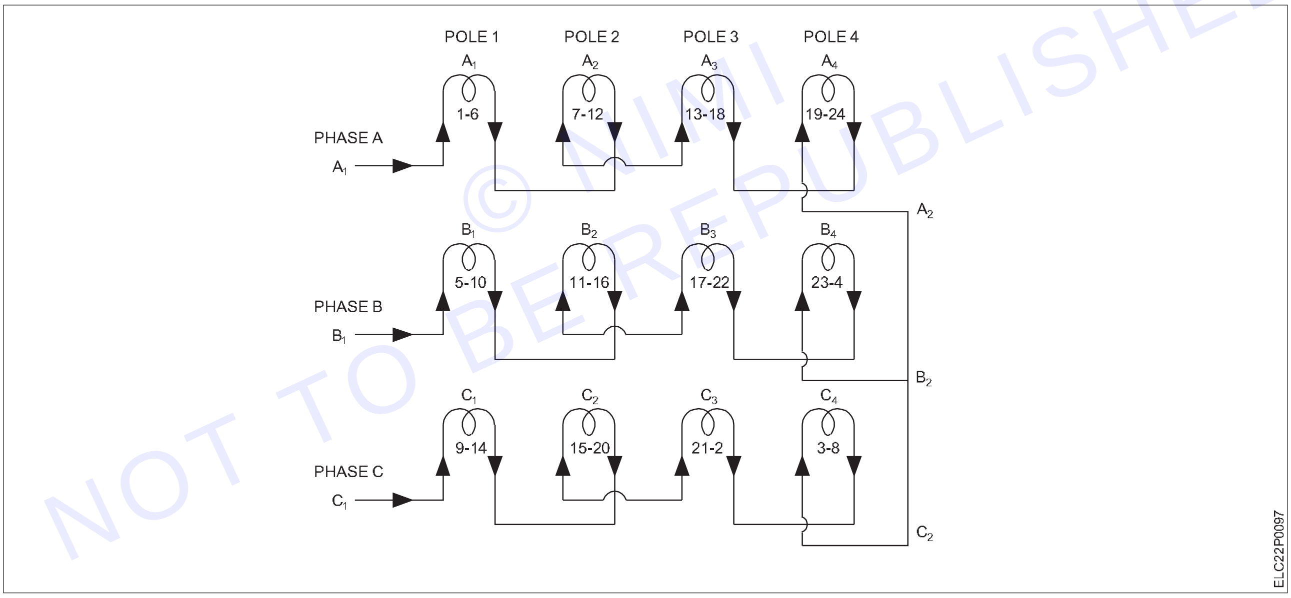
32 Run the motor, measure currents and asses performance

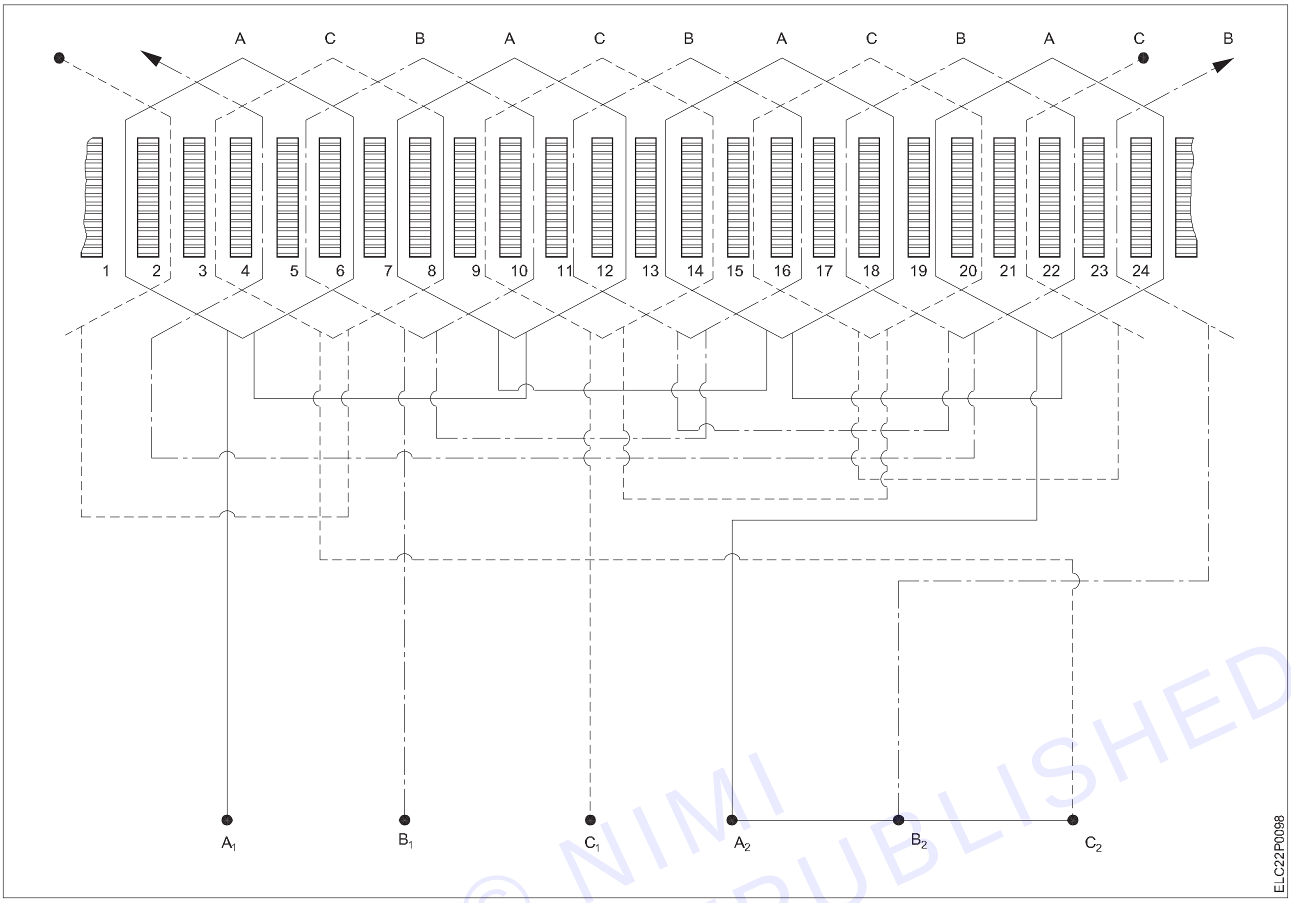
For the double layer winding, insert left coil-sides of coils till the winding pitch.

Right side of first coil is to be inserted above the left side coil of next pole as per winding diagram.

Single layer winding example :

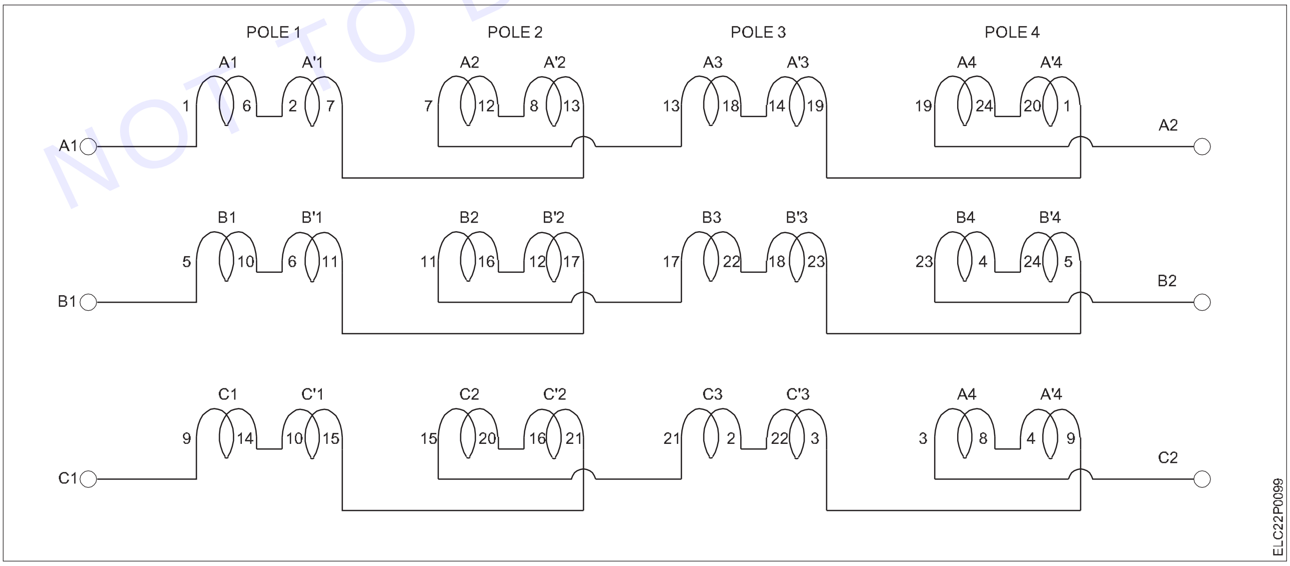
star connected, three phase , 50Hz, 1450rpm, squirrel cage induction motor having 24 slots

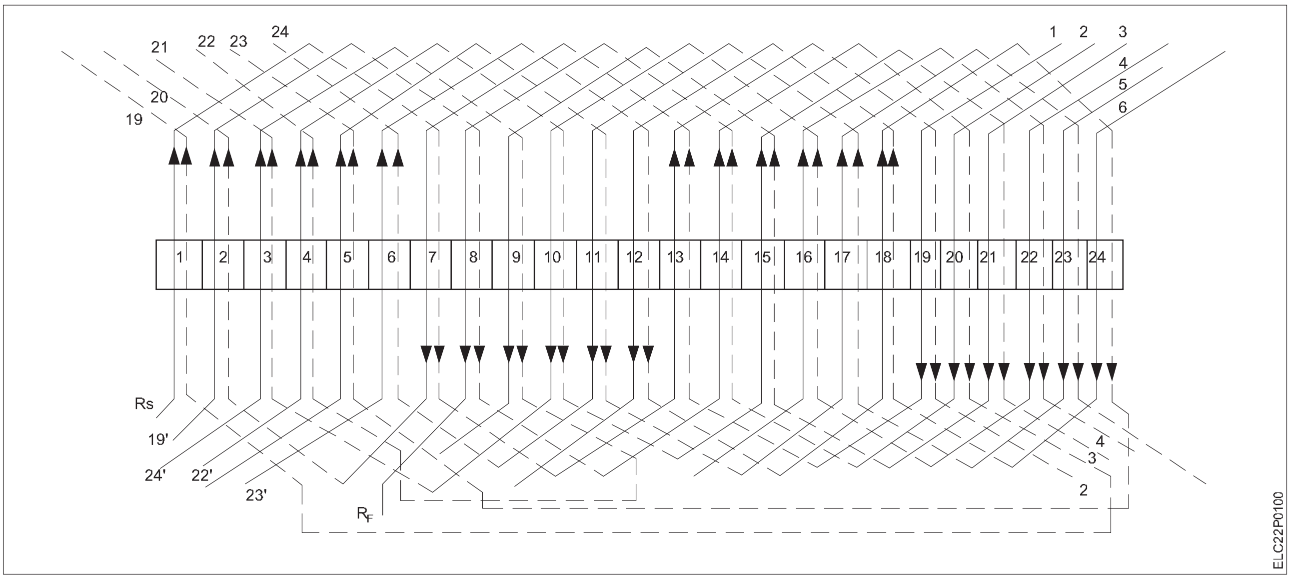




Double layer distrusted winding example

SLOT- 24,NO. OF COIL- 24,NO.OF POLES- 4,DOUBLE LAYER,BALANCE WINDING,WINDING PITCH-5,COIL SPAN-1-6




21
22
23
24
20
19
1
2
3
4
5
6
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
Rs
19'
24'
22'
23'
RF
4
3
2
ELC22P0100

EXERCISE 92 : Demonstrate Impregnations, Varnishing, Baking & Assembling

Objectives

At the end of this exercise you shall be able to

- demonstrate varnishing of rewound three phase induction motor stator
- demonstrate assembling of rewound three phase induction motor.

Requirements

Tools/Instrument

- SEC cu wire - 400g.
- Electric soldering iron 25W/240V - 1 No.
- Hack saw blade - 1 No.
- Standard wire gauge

Tools/Instrument

- Winding former

Materials

- Soldering paste - 10g.
- Resin core solder 60:40 - 50g.

Procedure

TASK 1: **Demonstrate varnishing of rewound three phase induction motor stator**

1 Connect between coils, poles of the rewinding completed motor

2 Connect leads to terminal box and tie

3 Place the stator in baking oven at a temperature of approximately 250°F and preheated for approximately 1 hour to remove moisture from the windings and increases the perpetration of the varnish.

4 Dip the stator is then dipped in to a container of insulation varnish compatible with the type of wire used.

5 Loosen the varnish by thinner to penetrate the same in winding

6 Monitor the thickening of varnish and control thickness by thinner

7 Soak the winding in the varnish for approximately one-half hour or until all bubbling has ceased

8 Remove stator from the dip container and allow varnish to drip.

9 Place the stator on baking oven after varnish stopped for 8 hours or as recommended by the varnish manufacturer

10 Scrap the inner surface of stator to remove the adhering varnish, and to maintain clear airgap

11 Use solventless polyester varnish /resin alternatively that can be applied to windings in less than 20 minutes.

12 The resin is then poured through the heated windings while the stator is kept in a horizontal position the resin is permitted to trickle through the slots.

13 Heat the winding is by applying half the rated voltage and sending current through winding.

14 Clean the motor parts by compressed air / blower

15 Test the winding by internal growler

— — — — —

TASK 2: **Demonstrate assembling of rewound three phase induction motor.**

1 Reassemble the motor in reverse of the dismantling sequence

2 Ttest the insulation resistance and winding resistances and record

3 Test the motor and run it for approximately 6 hours.

◆ MODULE 15: Industrial Programmable Systems ◆

EXERCISE 93 : Assemble circuits of battery charger and Inverter

Objectives

At the end of this exercise you shall be able to

- assemble the battery charging circuit wired on PCB and test it
- construct and test inverter.

Requirements

Tools/Instrument

- Trainees tool kit - 1 Set
- soldering iron 35W/250V - 1 No.
- De soldering gun 65W/250V - 1 No.
- Star screw driver set (set of 6 Nos) - 1 Set
- Ammeter 0-10 A M.C - 1 No.
- Voltmeter 0-50V M.C - 1 No.
- Digital multimeter (31/2 digits) - 1 No.

Tools/Instrument

- Auto transformer 0-270 V-5A - 1 No.
- Step down transformer 240/40V, 300VA - 1 No.
- Charger transformer with centre tapping 6V-0-6V,500mA - 1 No.
- Sealed maintenance Free battery 6V/120AH - 1 No.
- Relays double pole - 3 Nos.

Materials

- PCB -115 -General purpose - 2 Nos.
- Push button switches - 2 Nos.
- Toggle switches 250V/6A - 2 Nos.
- Diodes 1N4002 - 4 Nos.
- Diodes for bridge 1N112 - 4 Nos.
- Capacitors -250mfd /12V - 1 No.
- Resistors,10Δ 1W - 1 No.
- Pot 1.5Δ/10W - 1 No.
- Low voltage lamp 6.3V - 1 No.
- Fuse 250 mA - 3 Nos.
- Neon lamp - 1 No.
- Buzzer 250V - 1 No.
- Soldering flux and 60/40 solder - as reqd.
- Diode IN 5402 - 3 Nos.
- LED : Red and Green - 1 No.
- Transistor - 2N 3055 - 1 No.
- Resistor : 2.2Δ , 22Δ , 50Δ - 1 No each.
  1K (1 Watt) - 2 Nos.
- Electrolytic capacitors 1000 µfd/25V, 10 µfd, 25V - 2 Nos each.
- 2.2 µfd/250V - 1 No.
- Relay NC/No 6V - 1 No.
- Transformer 240V/7.5 - 0 - 75V, 2A - 1 No.
- Inverter transformer- iron core laminated 21 SWG - 25 turns, 29 SWG - 15 turns - Primary 36 SWG - 285 turns - Secondary - 1 No.
- Fuse 2.5A, 0.5A - 1 No Each.
- SP Switches (Toggle - 6V) -2 Nos.

Procedure

TASK 1: **Assemble the battery charging circuit**

1 Select suiTable PCB (wired PCB)and other components

2 Check all components ie. transformer, relays, battery for their good condition

3 Construct the transformers relays, and other components on PCB. (Fig 1)

4 Connect the charger Transformer (X1)to the auto transformer (X2).

5 Connect the secondary of charger transformer (X1) to the full wave bridge rectifier which supplies rectified voltage to the battery under charge through ammeter, voltmeter and potentiometer.

Note : Step down transformer (X3) keeps the cut off relay in energised condition when the main AC supply is cut off to the charger circuit. Relay (RL1) is used to cut off the AC main supply to the charger circuit.

6 Connect the pole (P1) of relay (RL1)to A.C main supply and connect pole (P2) is cut off circuit.

7 Connect the poles (P1 & P2) to normally open (N/O) pin, which will switch ‘OFF’ AC Main supply to the circuit.

8 Connect the test switch (S3) to check battery polarity.

Note : Reset switch (S4) is used to reset the charger, when any fault occurs and the charger is cut off. The switch (S1) for ON/OFF.

9 Connect the ON/OFF switch (S1) to the input of AC main supply.

Note : Normally a fully charged lead acid battery voltage 2.1 V/cell, During on charge ,and can be increased up to 2.7 V/cell .The voltage of a battery is multiple of the number of cells in that battery. The voltage on Fully discharged condition is 1.8 V.

10 Connect the diodes neon lamps, fuses, capacitor, resistor, buzzer, low voltage lamp in correct position as in the circuit.

11 Solder all PCB connection neatly and clean the PCB, without making any short circuit.

12 Set the auto transformer (X2) is in zero level position, before charging the battery.

13 Keep the switches S1,S2 & S5 on open position .

14 Connect the battery to the charger output terminal (positive terminal to the battery positive pole and negative terminal to the battery negative pole)and close the switch S3.

15 Check the readings in voltmeter which is connected through diode D9 and switch S3.

Note : If the battery is connected in wrong/reverse polarity, then the diode will block the battery voltage and no reading in voltmeter. Correct the battery polarity by charging the connection to read the volt meter.

16 Close the main ON/OFF switch (S1) by keeping the zero position of an autotransformer (X2) and neon lamp (N1) and Lamp (L1) will indicate 'ON'.

17 Vary the setting of Auto transformer slowly from zero position until the voltmeter shows the reading nearer to the voltage of battery to be charged.

18 Switch 'ON' the charging switch (S2) and increase the voltage by varying auto transformer till, the required charging current (5 Amp) is displayed by the ammeter.

19 Leave the charger on to charge the battery to the required level.

Note : If the battery is fully charged automatic cut-off circuit will switch 'OFF' the supply to the battery, and automatically switch 'OFF' the charging current which flows through potentiometer VR1 , to cut off relay RL1.

When the battery is fully charged the current through the potentiometer increases and relay RL1 is energised through diode D7 and D8, and the pole of relay RL1 (ca) is connected to N/O contact which will cut off main A.C supply to auto transformer X2 and switch on the error indicator buzzer and the warning neon 'N2' lamp.

20 Switch 'OFF' the buzzer by the switch (S5).

Note : The error indicator neon lamp (N2) and the buzzer stays on till the charger is reset.

21 Press the reset switch (S4), only, if the process to be continued once again.

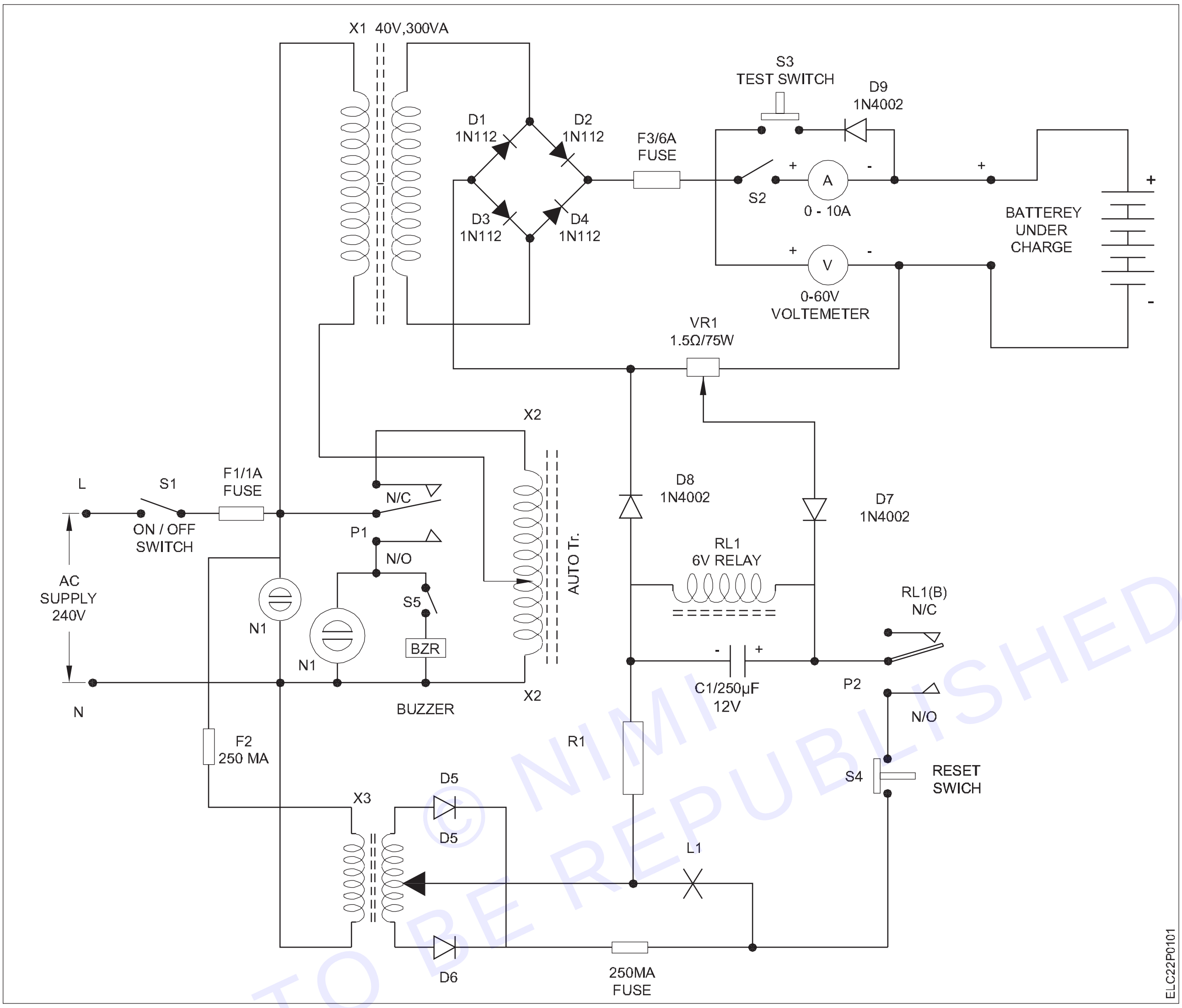
Note : If the reset switch is pressed without correcting the problem which activated the cut off and again it will operate instantly. To reset the charger, the reset button (S4) to be pressed for about one second, only to let the capacitor C1, discharge.

The following precautions to be followed when charging the battery.

1 The level of electrolyte should be about 1.2 cm above the plates.

2 Add distilled water to electrolyte if the level of electrolyte is low (acid should not be added to the electrolyte).

3 Charge the battery continuously unless the battery temp. exceeds 37° C stop charging for some time to cool down the battery.



TASK 2 : **Construct and test inverter circuit**

Note : The inverter made for emergency light (Ex. No.4.4.184) can be utilised for this exercise.

1 Collect the inverter circuit assembled in the emergency light. (Fig 1) (Ex. No.4.4.184)

2 Remove the tube light and make the terminals free.

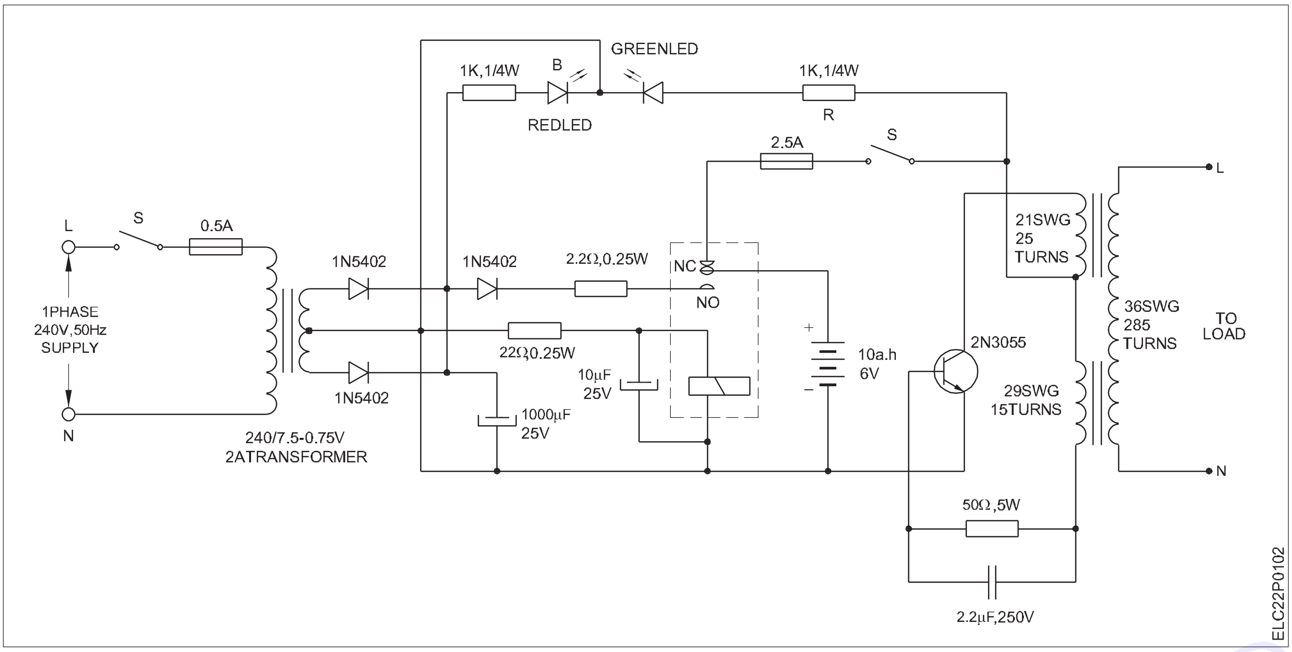
3 Connect the terminals of mains to the supply and switch ‘ON’.

4 Check the corresponding LED’s are glowing and measure the output voltage.

5 Connect the inverter circuit with supply. Disconnect the main AC supply and test the output of inverter by connecting load and note the performance.

6 Report your instructor and get his approval

Note : Check the backup time of the inverter and verify the same with manufacture’s manual.


GREENLED
1K,1/4W
B
1K,1/4W
REDLED
R
2.5A
S
L
S
0.5A
1N5402
1N5402
2.2Ω,0.25W
NC
NO
21SWG
25
TURNS
1PHASE
240V,50Hz
SUPPLY
22Ω0.25W
10μF
25V
+
10a.h
6V
2N3055
36SWG
285
TURNS
TO
LOAD
1N5402
29SWG
15TURNS
1000μF
25V
N
240/7.5-0.75V
2ATRANSFORMER
N
50Ω,5W
2.2μF,250V
ELC22P0102

EXERCISE 94 : Demonstrate Speed control of DC Motor using DC Drive

Objectives

At the end of this exercise you shall be able to

- read and interpret the name plate details of DC drive
- connect the input/ output terminals of DC drive to motor operate the load
- control the motor speed by using DC drive and operate motor with 1/4th, 1/2th, 3/4th, load
- reverse the DOR by using DC drive and operate motor with different speed.

Requirements

Tools/Instrument

- Insulated combination pliers 150 mm - 1 No.
- Screw driver 200 mm - 1 No.
- Connector screw driver 100 mm - 1 No.
- Electrician's knife 100 mm - 1 No.
- Round nose plier 150 mm - 1 No.
- MC voltmeters - 0 - 250 V - 1 No.

.Tools/Instrument

- DC motor 3 HP, 220V coupled with DC generator 2KW, 220V - 1 No.
- Lamp load : 2000 W (500W x 4) - 1 No.
- DC drive 3HP, 220V - 1 No.

Materials

- PVC insulated strandard copper cable 1.5 sq.mm, 660V - 15 m.
- PVC insulated flexible cable 14/0.2 mm - 3 m.
- Insulation tape - 1 No.

Procedure

TASK 1 : **Connect the input/ output terminals of DC drive to DC motor to operate the load**

1 Note down name plate details of the given motor DC drive and lamp load. (Table 1, Table 2 and Table 3)

2 Check and identify terminals of the DC motor and DC drive.

Table 1

DC Motor name plate - details

Manufacturer	____________	Speed	____________ RPM
Make	____________	Insulation class	____________
Armature voltage	____________ V	Rated current	____________ A
Field voltage	____________ V		
Power	____________ KW/HP		

Table.2

Name plate details of DC drive

1	Rated supply voltage armature	V	
2	Rated input current armature	A	
3	Rated supply voltage electronics supply	V	
4	Rated supply voltage field	V	
5	Rated frequency	Hz	
6	Rated DC current	A	
7	Overload capability	A	
8	Rated output	KW	
9	Power at rated DC current (approx.)	w	
10	Rated DC voltage field	V	
11	Rated DC current field	A	
12	Operational ambient temperature	°C	
13	Storage and transport temperature	°C	
14	Installation altitude above sea level	°C	
15	Dimensions (H x W x D)	mm	

Lamp load

Connect with main switch/MCB, 4 Nos of 500 W clear lamps fitted in a enclosure having individual ON - OFF facility.

Table 3

Make & Sl.No		
Rated Mains	V	
Rated Power	KW	

3 Remove the drive cover. Identify and trace the internal connection and get it approved by the instructor.

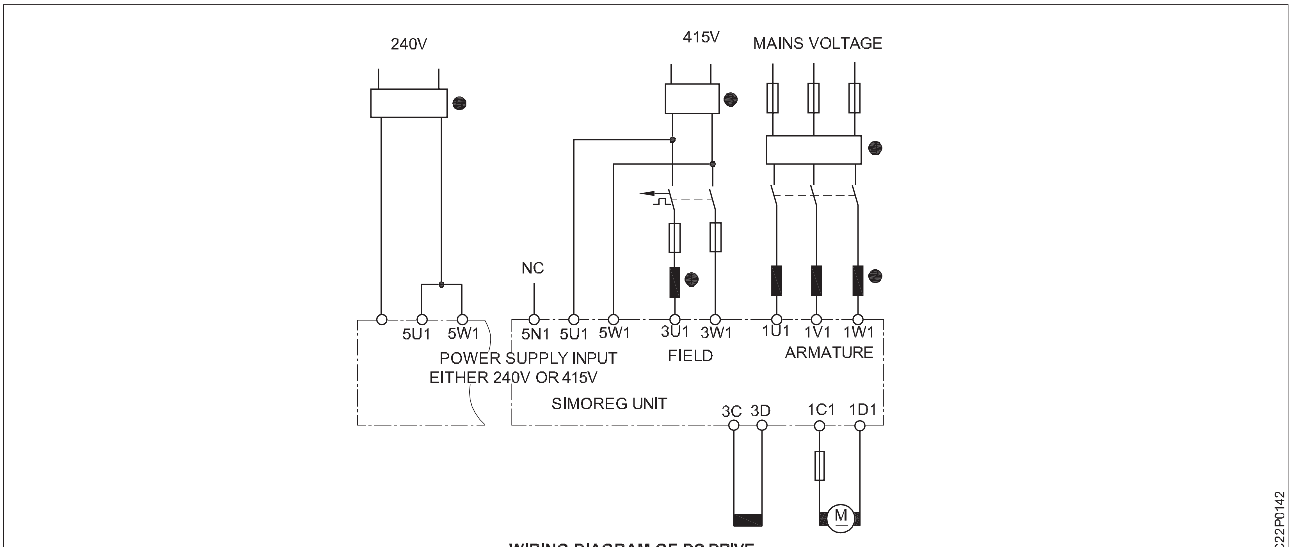
4 Select the ICTP switch /MCB, cables and fuse - wire according to the rating of the motor.

5 Draw the circuit diagram and connect the ICTP, MCB, drive and the motor, and get it approved by the instructor. (Fig 1)

6 Connect double earth independently for the main switch, DC drive and the motor.

7 Check the supply and ensure for proper rating of fuses main switch according to the motor rating.

Note : Improper connection of DC drives leads to shock and material damage.



WIRING DIAGRAM OF DC DRIVE

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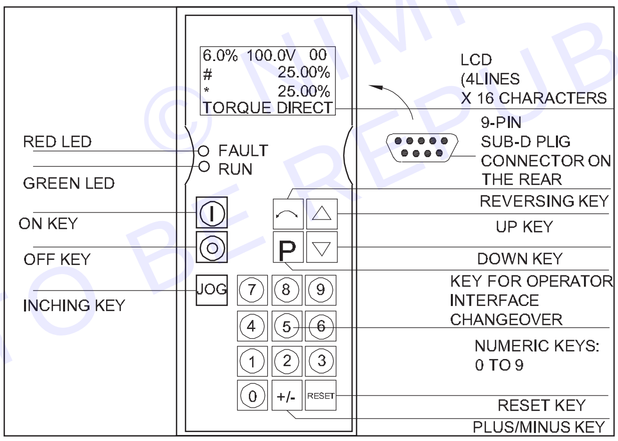
TASK 2 : **Control the speed by setting the parameter of different load and speed**

1 Select the suiTable type of model DC drive with code. (Fig 1)



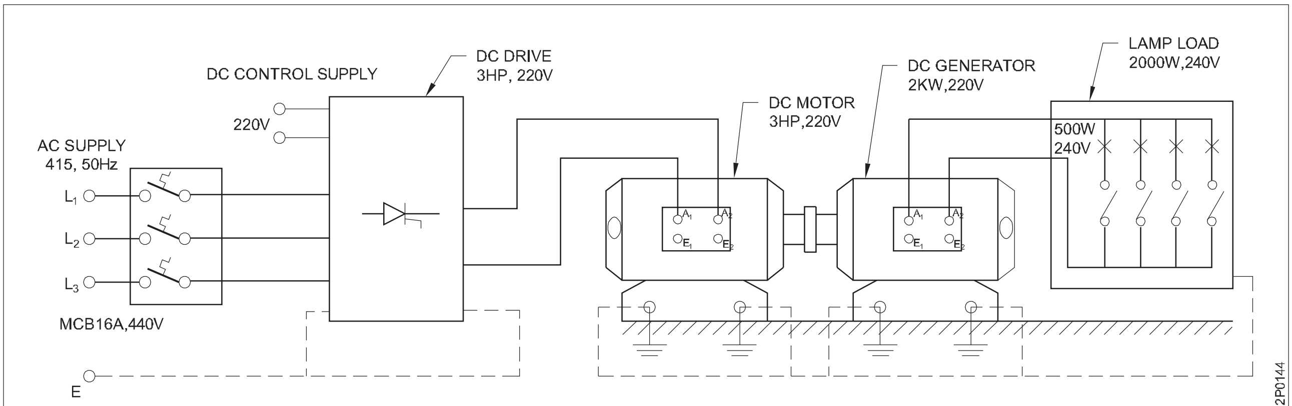
CONTROL PANEL OF DC DRIVE

2 Connect MCB, DC drive, M.G set and lamp load. (Fig 2)

3 Switch ON power supply.

4 Press ON button and measure the speed of the motor by using the Tachometer before loading. Record the readings in Table 4.

5 Load the motor by 1/4th load; by switching ‘ON’ one lamp.Record the current , voltage, frequency and voltage in load terminal, vary the speed and observe the readings.



CONNECTION DIAGRAM SPEED CONTROL OF DC MOTOR USING DC DRIVE

Table 4

Sl.No	Load	Armature voltage in volt	Field voltage in volt	Load		Motor speed in RPM
				Voltage (Volts)	Current (Amp)	
1	1/4th					
2	1/2th					
3	3/4th					
4	Full					

6 Load the motor further and switch ON another lamp (Total load now (500 W + 500W=1000W). Record all the readings in Table 4. Vary the speed with 1/2th load and observe the readings and record in Table 4.

7 Load further to 3/4th load (500+ 500 + 500=1500W) and repeat step 5 and record the reading in Table 4.

Note : Switch 'OFF' the motor instantly, if anything noticed irregular consult your Instructor.

8 If motor maintaining the rated frequency after loading 3/4th load. Load the motor to full load (500+ 500 + 500+500=2000W) condition and switch 'ON' all the four lamps . Record all readings and repeat step 5.

9 Press 'OFF' switch once it is over and check the readings you recorded.

Note : If the frequency reduced considerably when the motor operates in higher loads; Do not run the motor. Consult with your instructor.

10 Remove all the connection and supply cables from the motor and supply.

11 Record your observations.

— — — — —

TASK 3 : **Reverse the direction of rotation by using DC drive**

1 Connect the AC supply to the input and output terminals of DC drive when the output terminals connected to armature and field of the motor, without connecting load.

2 Switch 'ON' power supply main switch.

3 Press 'ON' key and note the direction of running (forward direction).

4 Press reversing key and check the changing of direction of rotation of DC motor.

Note : Wait, until the motor will obtain stability and then change the DOR.

5 Press 'OFF' key to stop the drive.

6 Turn 'OFF' main power supply to DC drive and disconnect the DC drive.

Note : Improper connection of DC drive results shock and material damage.

You may have DC drive of different model / make. So refer the drive instruction in manual and take help of your instructor.

The DC drive can be programmed through PC after loading the software in the PC.

The programming procedure /keys may differ according to make /model of the drive in your institute refer to the instruction m a n u a l before connecting the drive.

Thyristor Controlled DC motor drive, with Tachogenerator Feed Back

Objectives

At the end of this exercise you shall be able to

- connect the input/ output terminals of DC drive to motor operate the load
- control the motor speed by using DC drive and control speed of motor.

Requirements

Tools/Instrument

- Insulated combination pliers 150 mm - 1 No.
- Screw driver 200 mm - 1 No.
- Connector screw driver 100 mm - 1 No.
- Electrician's knife 100 mm - 1 No.
- Round nose plier 150 mm - 1 No.
- MC voltmeters - 0 - 250 V - 1 No.

.Tools/Instrument

- DC motor 3 HP, 220V coupled with DC generator 2KW, 220V - 1 No.
- DC drive 2HP, 220V - 1 No.

Materials

- PVC insulated strandard copper cable 1.5 sq.mm, 660V - 15 m.
- PVC insulated flexible cable 14/0.2 mm - 3 m.
- Insulation tape - 1 No.

Procedure

1 Note the name plate details of the DC motor.

H.P	
Armature Voltage	
Armature Current	
Field Voltage	
Field Current	
Speed	
Insulation	
Frame	

2. Identify the components of DC drive and write functions in the Table.

1	Potentiometer	
2	A-AA terminals	
3	F -FF terminals	
4	Thyristors	

5	Free wheeling diode	
6	Reference set voltage Vs	
7	Feedback voltage Vf	

3. Connect the DC motor and tacho generarator as in block diagram

Note : This example provides with tacho generator feedback.Refer manual of available DC drive

4 Keep the potentiometer in centre position

5 Switch on the supply.

6 Raise the speed by varying potentio meter

7 Note the armature voltage, armature current, set voltage Vs, feedback voltage Vf and speed(rpm)

8 Increase the speed and repeat previous step

9 Load the motor to the 1/4th rated current, observe speed variation and record final speed.

10 Load the motor to the ½ the rated current, observe speed variation and record final speed.

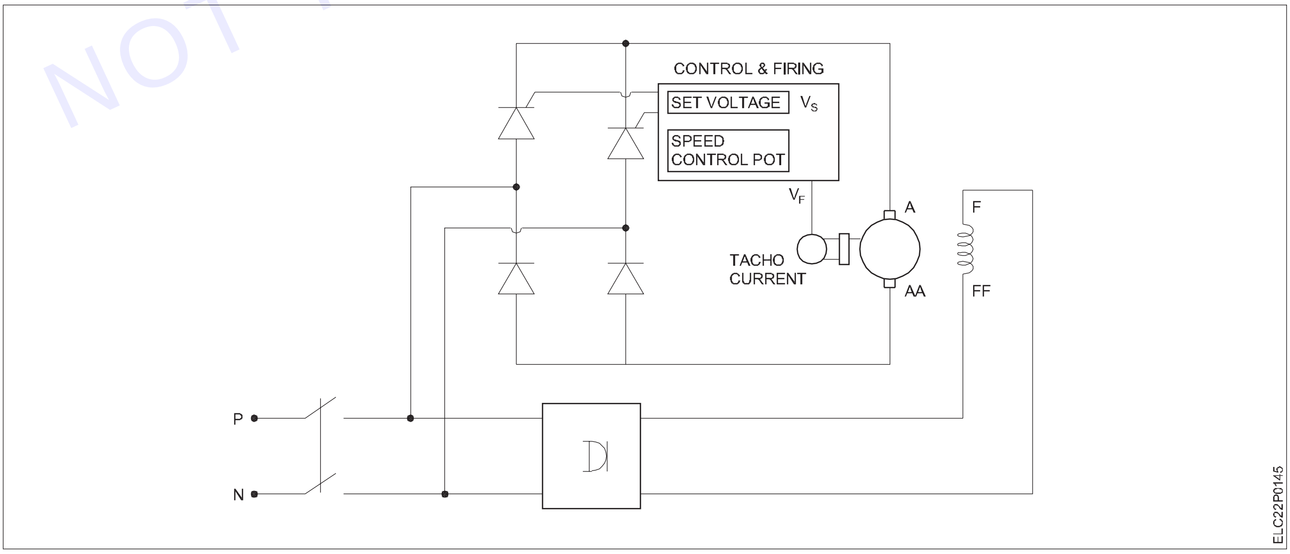
11 Load the motor to the rated current, observe speed variation and record final speed.

12 Reduce the Load to zero

13 Switch off the DC drive.

14 Switch off the mains supply to the unit.

Sl. No.	Armature Voltage Va Volts	Armature Current Ia Amps	Set Voltage Vs	Feed back voltage Vf	Speed in RPM
1					
2					
3					
4					
5					
6					



EXERCISE 95 : Verify speed control of AC Motor (Induction Motor) using AC Drive

Objectives

At the end of this exercise you shall be able to

- identify the terminals of the given ac drive
- practice on setting of parameters in the given ac drive
- start, run, change the direction of rotation and control the speed of three phase induction motor using different digital and analog inputs of the drive.

Requirements

Tools/Instrument

- Insulated combination pliers 150 mm - 1 No.
- Screw driver 100,150,200mm - 1 No Each.
- D.E. spanner set 5mm - 30mm - 1 Set.
- Side cutting plier 150 mm - 1 No.
- Screw driver 150 mm - 1 No.
- Connector screw driver 100 mm - 1 No.
- Neon tester 0 - 500V - 1 No.
- Wire stripper 75 mm - 1 No.

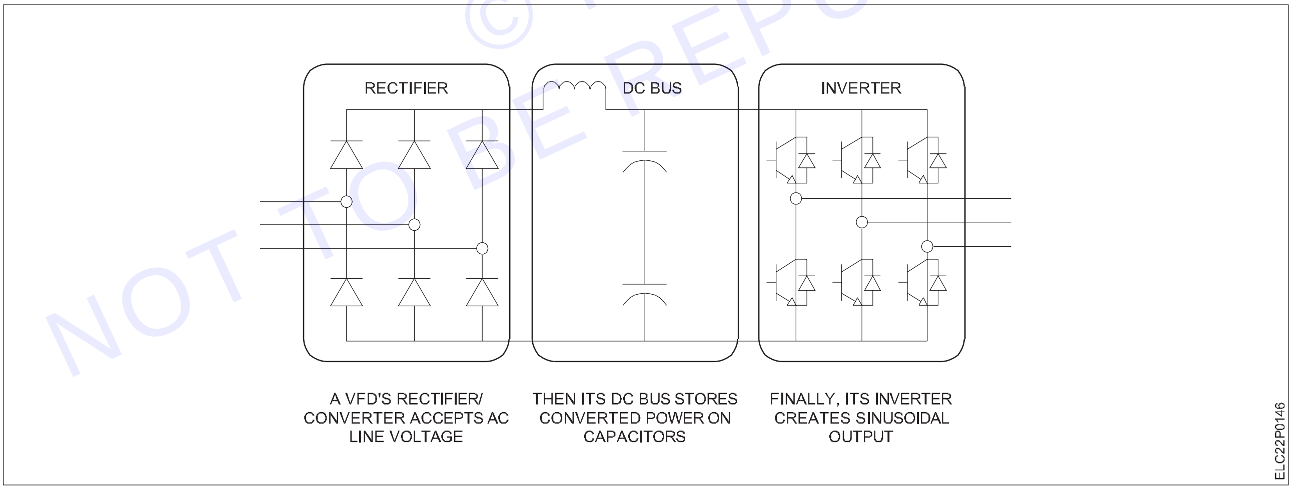
.Tools/Instrument

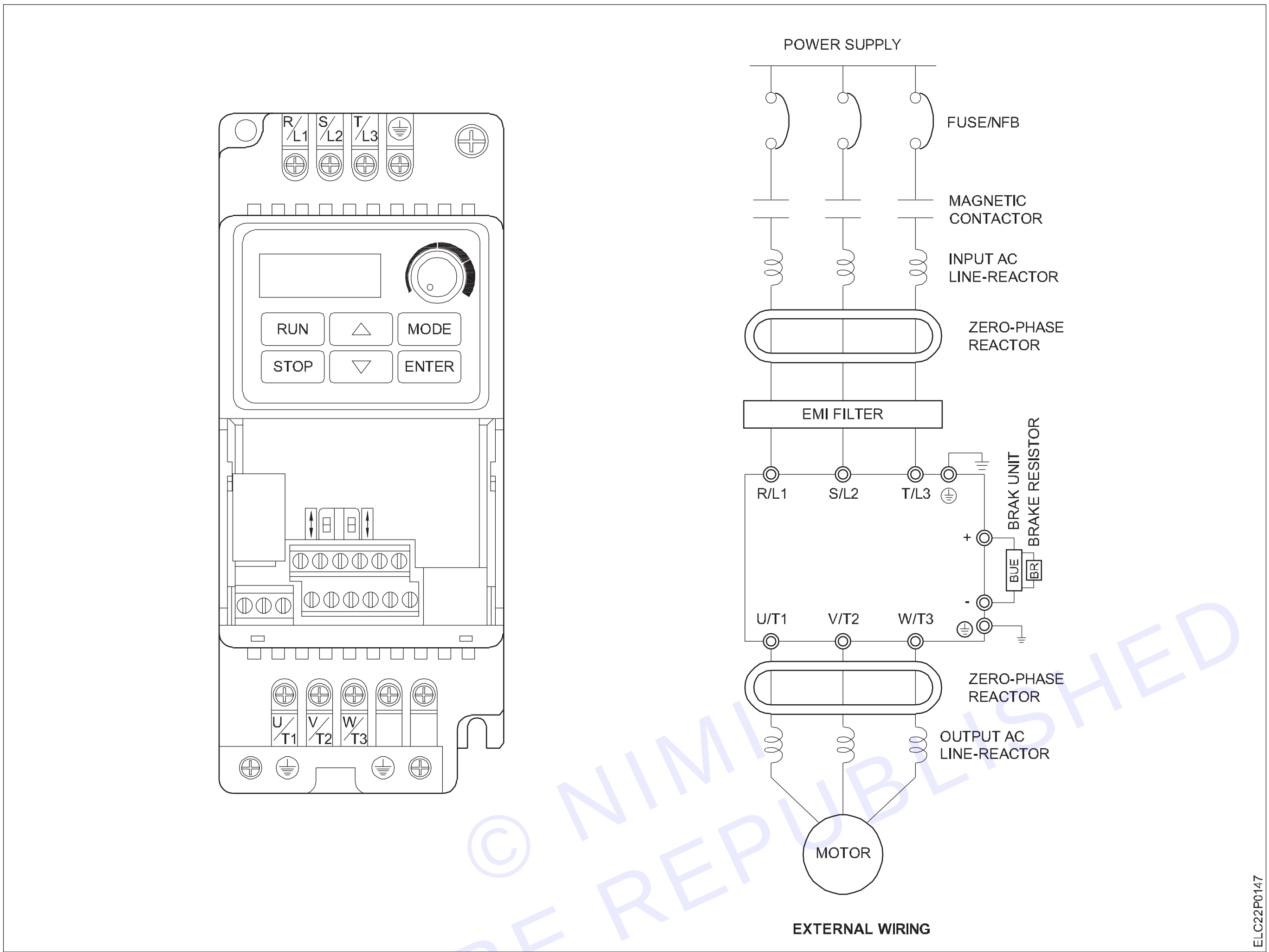
- AC drive ,3 phase,415 V,2HP 415 V, 2HP- 1 No.
- 3 ph induction motor 2HP,1440rpm - 1 No.

Materials

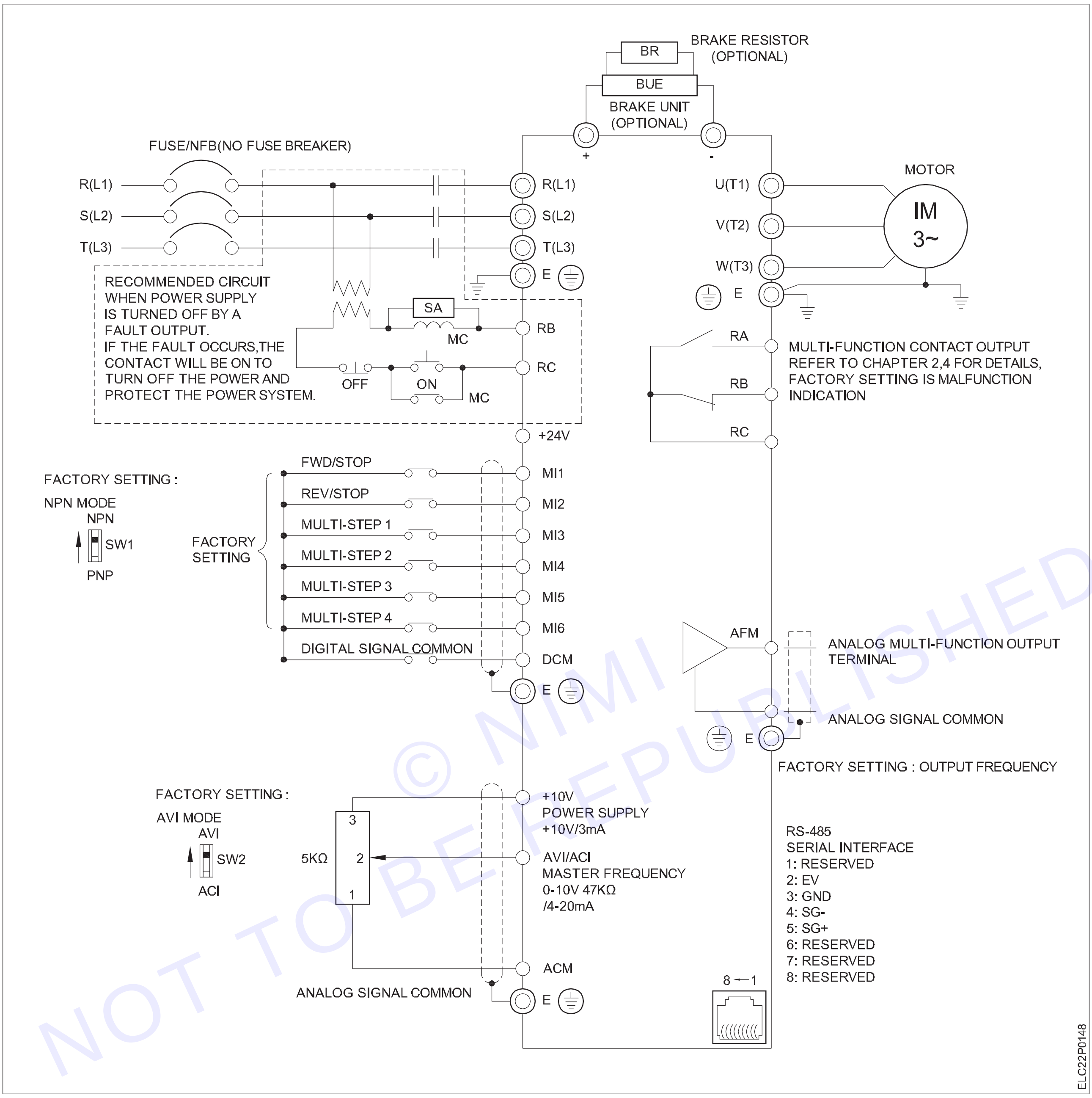
- Insulated wire 1mm^2 ,1100V - 4m.
- PVC stranded copper cable. 1.5 mm^2 - 15m.
- Insulated tape - 1 No.

Procedure





R/L1
S/L2
T/L3
RUN
MODE
STOP
ENTER
U/T1
V/T2
W/T3
POWER SUPPLY
FUSE/NFB
MAGNETIC CONTACTOR
INPUT AC LINE-REACTOR
ZERO-PHASE REACTOR
EMI FILTER
BRAK UNIT
BRAKE RESISTOR
BUE
BR
ZERO-PHASE REACTOR
OUTPUT AC LINE-REACTOR
MOTOR
EXTERNAL WIRING
ELC22P0147



A guideline diagram is given for reference, which indicates input and output terminals of VFD

Parameter setting depends on the type and the manufacturer.A sample of delta vfd-el is provided. Generic controls of keyboard level and external controls are accordingly to be set

TASK 1 :

1. Read and interpret and note down the name plate details of the given AC drive.
2. Remove the cover plate for power terminal if fitted.

Note : Do not open the cover if power to the drive is ON

3.Identify the input/output power terminal and control terminals and note down in Table1

Table 1

Terminal symbol	Terminal function (for reference)	Identify corresponding / similar terminals available to VFD at your institute
(R/L1, S/L2, T/L3)	Mains power terminals	
(U, V, W)	Output terminals for main circuit	
MI1	Forward/ stop command	
MI2	Reverse/ stop command	
MI3	Multifunction digital input 3	
MI4	Multifunction digital input 4	
MI5	Multifunction digital input 5	
MI6	Multifunction digital input 6	
+24 V	DC source voltage	
DCM	Digital signal common	
RA	Multi-function relay output NO	
RB	Multi-function relay output NC	
RC	Relay common	
+ 10 V	Potentiometer power supply	
AVI	Analog voltage input	
ACM	Analog common	
AFM	Analog output	

— — — — —

TASK 2 :

To set the basic parameters.

Parameter	Function	Setting	Factory Setting
01.00	Maximum Output Frequency (Fmax)	50.00 to 599.0 Hz	60.00
01.01	Maximum Voltage Frequency (Fbase)	0.10 to 599.0 Hz	60.00
01.02	Maximum Output Voltage (Vmax)	115V/230Vseries : 0.1V to 255.0V 460V series : 0.1V to 510.0V	220.0 440.0

Parameter	Explanation	Setting	Factory Setting
07.00	Motor Rated Current	30 % FLA to 120% FLA	FLA
07.01	Motor No-Load Current	0 % FLA to 99% FLA	0.4° FLA

1 Identify the ac drive basic parameter setting code from the manual.(reference in pic above)

2 Turn ON the ac drive.

3 Press ENTER key displays parameter entry option

4 Press enter key to display the default value of parameters

5 Reset all parameters (eg set 00-02 to 9)

6 Set the basic parameters of voltage, frequency, and currents in the VFD.

— — — — —

TASK 3 :

1 Connect the 3-phase motor to U, V, W output terminals on the front panel on the unit.

2 Connect 440 V 3 phase AC main supply &ground to the unit

3 Switch on the power supply mains.

4 Switch on the MCB then the indicator will be ON.

5 Press the ON/OFF switch.

6 Measure the speed of the motor by using tachometer record it.

7 Vary the speed keypad potentiometer and check the speed of the motor.

8 Increase and decrease the frequency and check the speed of the motor and note down the output voltage, output current

9 Press stop button and turn off main power supply disconnect the supply.

Note : Improper connection of ac drive results shock and material damage.

10 Then set the parameters for reverse direction.

Parameter	Function	Setting	Factory Setting
02.04	Motor Direction Control	0 : Enable Forward/reverse operation 1 : Disable reverse operation 2 : Disabled Forward operation	0

11 Press the RUN /STOP button key, the motor will run in reverse direction.

12 Press stop button and turn off main power supply disconnect the supply.

EXERCISE 96 : Demonstrate maintenance of AC/DC machines, voltage stabilizer, UPS, Inverter & Drives

Objectives

At the end of this exercise you shall be able to

- list out the trouble shooting procedure
- assess the symptoms
- test the parts
- service and maintain the appliances.

Requirements

Tools/Instruments

- Electrician tool kit - 1 Set
- Insulated cutting pliers 200mm - 1 No.
- Soldering iron 25W, 125W, 240 V - 1 No.
- Tray 200 mm x 200 mm x 50 mm - 1 No.
- Tweezer 100mm - 1 No.

Equipments/Machines

- Voltage Stabiliser – 1kva - 1 No.
- Meggar 500V - 1 No.
- AC / DC machines - A/r
- AC Drive, 2HP - 1 No.

Materials

Collect the circuits already constructed in experiment 93

- Spare components - as reqd.
- Solder 60/40 - as reqd.
- Soldering flux - as reqd.
- Connecting wires - as reqd.

Procedure

AC/DC machines

1 Record the name plate data.

Sl.No	Description	Value	Remark
1	Name of the machine		
2	Make		
3	Model		
4	Rated Voltage		
5	Rated capacity		
6	Rated current		

2 Draw scheme of the equipment

3 Inspect the terminals for rust and replace rusted parts

4 Measure the winding resistance

5 Measure the insulation resistance between winding

6 Assess the insulation resistance value with manufacturer specified value

7 Inspect the bearings for noise and wear out.

8 Lubricate the bearings

voltage stabilizer

1 Record the name plate data

2 Draw scheme of the equipment

Sl.No	Description	Value	Remark
1	Name of the machine		
2	Make		
3	Model		
4	Rated Voltage		
5	Rated capacity		
6	Rated current		

3 Inspect the terminals for rust and replace rusted parts

4 Measure the winding resistance

5 Measure the insulation resistance between winding

6 Assess the insulation resistance value with manufacturer specified value

7 Test the input fuse

8 Check the terminations for rust

9 inspect the relay

UPS /inverter

1 Record the name plate data

Sl.No	Description	Value	Remark
1	Name of the machine		
2	Make		
3	Model		
4	Rated Voltage		
5	Rated capacity		
6	Rated current		

2 Draw scheme of the equipment

3 Inspect the terminals for rust and replace rusted parts

4 Measure the winding resistance

5 Measure the insulation resistance between winding

6 Assess the insulation resistance value with manufacturer specified value

7 Test the input fuse

8 Check the terminations for rust

9 Test the battery with high rate discharge cell tester

Drives

1 Record the name plate data

Sl.No	Description	Value	Remark
1	Name of the machine		
2	Make		
3	Model		
4	Rated Voltage		
5	Rated capacity		
6	Rated current		

2 Draw scheme of the equipment

3 Inspect the input power supply

4 Refer the instruction manual and set the basic parameters

5 Check for any error codes and refer the manual to reset

6 Inspect electrical interlocks if provided

— — — — —

EXERCISE 97 : Demonstrate Wiring of Motors

Objectives

At the end of this exercise you shall be able to

- read name plate data and estimate wiring accessories for motor
- draw the wiring diagram of motor
- demonstrate the wiring of motor.

Requirements

Tools/Instrument

- Insulated combination pliers 150 mm - 1 No.
- Screw driver 100,150,200mm - 1 No Each.
- D.E. spanner set 5mm - 30mm - 1 Set.
- Side cutting plier 150 mm - 1 No.
- Screw driver 150 mm - 1 No.
- Connector screw driver 100 mm - 1 No.
- Measuring tape steel 3 m - 1 No.
- Electric hand drill machine 1 - 16 mm - 1 No.
- Drill bit 1 - 10 mm - 1 No Each.

Tools/Instrument

- AC induction machine 3ϕ,0.5 Hp,415 V - 1 No.
- DOL starter 1-2A,415 V - 1 No.

Materials

- IThree core flexible cable 1.5 mm^2 - 5 m.

Procedure

TASK 1:

1 Record the name plate data

Sl.No	Description	Value	Remark
1	Name of the machine		
2	Make		
3	Model		
4	Rated Voltage		
5	Rated frequency		
6	Rated speed		
7	Rated capacity		
8	Rated current		
9	Insulation class		
10	Type of connection		

— — — — —

TASK 2:

1 Calculate the current of the motor by multiplying with a factor of 3 for three phase squirrel cage induction motor full voltage start motor.

I = HP X 735.5/(1.73 X 415 X 0.85 X.8) assuming efficiency of 85% and pf 0.8

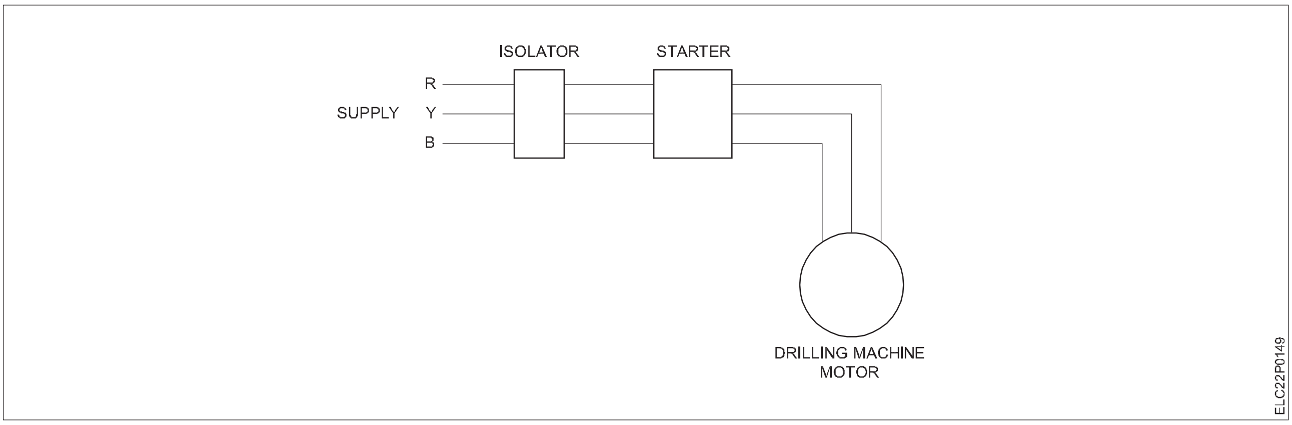
2 Select cable for connections.

3 Select starter suiTable for the motor.

4 Assess the selected Starter for its contactor rating and set Over load relay.

5 Prepare the layout with room dimensions

6 Draw the circuit diagram. (Fig 1)



TASK 3:

1 Identify the terminals of motor.

2 Connect the mains to the input of TP switch using conduit and fix.

3 Connect the output of TP switch to the input of DOL starter using conduit and fix.

4 Connect the starter output to the motor using flexible metal conduit and earth metal conduit.

5 Connect the ON and OFF indicators.

6 Connect the motor to earth.

7 Test continuity of earth to body.

8 Test insulation resistance between body and earth, between conductors.

9 Trace the wiring of the motor as per circuit.

10 Get the wiring checked by instructor.

11 Switch On and run the motor

12 Switch OFF the motor.

EXERCISE 98 : Test and service protective devices, control panel etc

Objectives

At the end of this exercise you shall be able to

- list the control panel components
- test the control panel components.

Requirements

Tools/Instruments

- Trainees kit - 1 Set
- Scriber 100 mm - 1 No.
- Hacksaw frame with blade- 300 mm - 1 No.
- Hand drilling machine 6mm capacity - 1 No.
- HSS Drill bit 6mm & 4mm - 1 No.each
- Round nose plier 150 mm - 1 No.
- Crimping tool 200 mm - 1 No.

Instruments/Equipments

- Digital multimeter - 1 No.
- Megger 500V - 1 No.
- Contactor 4 pole, 16A,240V - 1 No.
- Thermal overload relay 10A, 415V - 1 No.
- Remote station - 1 No.
- Over load relay 15A, 415V - 1 No.

Materials

- Push button red /green - 1 each
- Indicator lamp with holder (red, yellow, blue) - 1 each
- MCB 4 Pole 16A , 415V - 1 No.
- Race ways - 1 m
- DIN rail - 1 m
- G - channel - 2 m
- Wire clips - as reqd.
- Terminal connectors - as reqd.
- Wire ferrule - as reqd.
- Grommets - as reqd.
- Lug/thimble - as reqd.
- Cable binding straps and buttons - 10 m
- Nylon cable ties - 15 Nos.
- PVC 1.5 sq mm copper cable 660V - as reqd. (red, black, yellow, blue, green)
- Assorted size bolt & nut - as reqd.

Procedure

TASK 1:

1 Note the specification of various panel board accessories (refer Table 1 for guidance)

2 Identify the power circuit accessories

3 Identify the control circuit accessories

4 Identify the indicating circuit accessories.

Table 1

Sl No.	ITEMS	SPECIFICATION
1	MCB	1P,2P,3P,4POLE
2	Push button	Red, green
3	Push button element	NO & NC type
4	Selector switch	Maintained type, Momentary (2 position, 3 position)
5	Indicator lamp	LED type & filament lamp type (Green, red, yellow, blue, amber)
6	Slotted wire duct	50 mm X 35 mm
7	Din rail (Making material cold rolled carbon steel with zinc plated	35 mm
8	Cable Tie	80 mm,100mm,150mm,200mm etc

9	Elmex connector nylon	Universal rail mounting type 2.5mm2, 4 mm2 etc
10	End plate for connector	2.5mm2,4 mm2 etc
11	Marking tag for connector	
12	Cable lug	Pin, palm, ring, U type etc (1mm2, 2.5mm2etc copper or aluminium)
13	Ferrule	Alphabet A-Z & Number 0-9
14	PVC insulated copper wire	1 mm2 ,1.5 mm2,2.5 mm2 etc
15	PVC sleeve	1 mm2 ,1.5 mm2,2.5 mm2 etc
16	bus bar	Aluminium, copper
17	Isolator	32A,63A,125A etc (240V or 415V)
18	Current transformer	100/5,150/5,200/5etc (15VA, Class-1, class PS etc)
19	Small type exhaust fan	4"X4",220/240VA,0.125/0.14A 2600/2800RPM
20	ELCB + MCB (RCBO)	C25 ,30mA, 2 pole (1+N) 240 V, 50 Hz
21	Glass type relay (Generator control)	contact:10A (NO) 250V AC /28VDC 5A(NC)RES 250V AC 7A, GEN, cos φ=0-4
22	Spreader	Making aluminium
23	Commutator change over switch	32A,63A,125A etc (240V or 415V)
24	Insulators	Bush type, L type, finger support
25	Earthing copper strip	20x3mm,25x3mm,25x6mm etc
26	Grommet	½ inch,3/4-inch etc
27	Timer	On delay, OFF delay, Sequence, Star/Delta etc

— — — — —

TASK 2:

1 Draw a neat sketch of various panel boards accessories
2 Test the NC and NC switches in OLR
3 Test the contactor with rated voltage and check the change in main and auxiliary contact changes
4 Test the connection and continuity of circuit breaker. If test button is available, check function
5 Measure with voltmeter
6 Test ammeter
7 Test frequency meter
8 Check for connection of revolution counter and power on status
9 Test the indicators
10 Check input and output of control transformer
11 Test insulation resistance of component and enter result in Table 2

Table 2

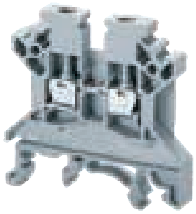
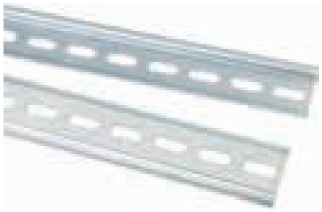
Sl.No	Description of the items	Megger value in M Ω between body and terminal	Condition OK / not OK
1	Overload relay		
2	Contactor		
3	Circuit breaker		
4	Voltmeter		
5	Ammeter		
6	Frequency meter		
7	Temperature indicator		
8	Tachometer/ revolution counter		
9	Indicators		
10	Control transformer		

TASK 3

1 Identify control panel available at shop floor and match column given below

Sl.No	Item name	Shuffled Picture	Write the correct name of the component
1	Busbar Support		
2	Push Button		
3	Indication Lamp		

4	MCB		
5	Contactor	 	
6	Electro Mechanical Relay		
7	Overload Relay		
8	Timers		
9	Star Delta Timer		
10	Slotted Wire Duct/Pvc Channel/ Race Ways		

11	Din Rail		
12	Terminal Connector		
13	Wire Ferrule		

EXERCISE 99 : Check wiring on UPS & Inverter

Objectives

At the end of this exercise you shall be able to

- record the details of UPS
- check wiring of the UPS
- record the details of UPS
- check the wiring of inverter.

Requirements

Tools/Instruments

- Trainees kit - 1 Set
- Portable electric drilling machine 6mm - 1 No
- Star head screw driver set (set of 6mm) - 1 No.
- Rawl jumper No.8 - 1 No.
- Cutting plier 150mm - 1 No.
- D.E spanner set 6mm-25mm - 1 Set
- Ballpein hammer 0.75 kg - 1 No.
- Single phase energy meter 250V/15A - 1 No
- Multi pin socket 3/5 pin 250V/6A - 1 No.

Equipments/Machinery

- 200W/250V/6A -inverter - 1 No.
- Battery 12V/120AH - 1 No.

Materials/Components

- 4 way MCB -20A - 1 No.
- 1.5mm2 P.V.C. copper (1/18)wires - as reqd.
- Auto wires (stranded) - as reqd.
- I.C.D.P switch 16A/250V - 1 No.
- 4 way MCB/ICDP20 A switch - 1 No.
- Power socket 250 V/16A - 1 No.
- Multi pin wall socket 250V/6A (2 in one) with switch - 1 No.
- Grease/Vaseline - as reqd.

Procedure

t

TASK 1: **Record the details of UPS**

1 Record name plate details

Sl.No	Description	Value	Remarks
1	Name of manufacturer		
2	Model No		
3	Sl.No		
4	Capacity	KVA	
5	Type	Online / offline /Line interactive	
6	Type of battery	VRLA / SMF / Ni-Cd/Li-ion	
7	No of batteries		
8	Voltage of battery bank		
9	Combination of battery bank		
10	Capacity of 1 battery		

— — — — —

TASK 2:

1 Trace wiring of UPS and verify with instruction manual of manufacturer.

2 Test the insulation resistance between conductor and body of UPS.

3 Test earth continuity.

4 Check tightness of connections of battery and UPS terminals.

5 Verify the combination of battery bank to match name plate data

6 Verify the input supply MCB type and current rating to suit the inrush charging current after power failure.

Sl.No	Description	Value	Remarks
1	Name of manufacturer		
2	Model No		
3	Sl.No		
4	Capacity	KVA	
5	Is UPS mode available	Yes / No	
6	Type of battery	VRLA / SMF / Ni-Cd/Li-ion	
7	No of batteries		
8	Voltage of battery bank		
9	Combination of battery bank		
10	Capacity of 1 battery		

7 Assess the load circuits and verify to be less than the manufacturer recommended limit.

— — — — —

TASK 3: **Record the details of inverter**

1 Record name plate details. — — — — —

TASK 4: **Check wiring of the inverter**

1 Trace wiring of inverter and verify with instruction manual of manufacturer Fig 1

2 Test the insulation resistance between conductor and body of inverter

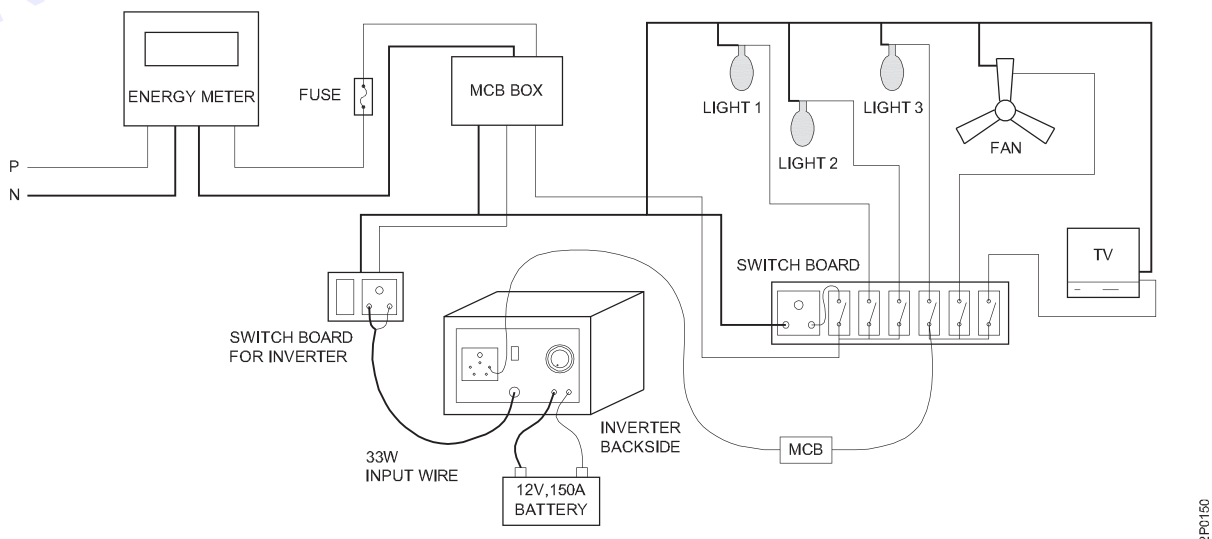
3 Test earth continuity

4 Check tightness of connections of battery and inverter terminals

5 Verify the combination of battery bank to match name plate data

6 Verify the input supply MCB type and current rating to suit the inrush charging current after power failure.

7 Assess the load circuits and verify to be less than the manufacturer recommended limit.



INVERTER WIRING DIAGRAM FOR HOME

EXERCISE 100 : Demonstrate control cabinet/ control panel assembly, wiring, checking / buzzing & testing for the following exercises on 3 Ø induction motor

Objectives

At the end of this exercise you shall be able to

- design and draw the power and control circuit
- fix all the accessories required for the starter wiring
- wire up and check the circuit.

Requirements

Tools/Instrument

- Combination pliers 150 mm - 1 No.
- Screw driver 100,150,200mm - 1 No Each.
- D.E. spanner set 5mm - 30mm - 1 Set.
- Side cutting plier 150 mm - 1 No.
- Screw driver 150 mm - 1 No.
- Connector screw driver 100 mm - 1 No.
- Neon tester 0 - 500V - 1 No.
- Wire stripper 75 mm - 1 No.
- Measuring tape steel 3 m - 1 No.
- Steel rule 300 mm - 1 No.
- Electric hand drill machine 1 - 16 mm - 1 No.
- Drill bit 1 - 10 mm - 1 No Each.
- Tap set 4mm , 5mm,6mm - 1 Set Each.
- Crimping tool 0.5 - 6 mm - 1 No.

Tools/Instrument

- 3 ph induction motor 5HP,1440rpm - 1 No.

Materials

- CRCA sheet steel powder coated control panel 1.6 mm thick IP 55, with mounting plate and gland plate, hinged door (size 700 m(h)X500 mm(w)X 250mm(d)) - 1 No.
- 3 pole MCB 32 A - 1 No.
- 2 pole MCB 4 A - 1 No.
- Power contactor 415V, AC3,9A - 1 No.
- Over load relay 5-8A, class 10 - 1 No.
- Push button red with 1 NC - 1 No.
- Push button green with 1 NO - 1 No.
- Indicator lamp LED green 220 V AC - 1 No.
- Indicator lamp LED red 220 V AC - 3 Nos.
- Indicator lamp LED yellow 220 V AC - 1 No.
- Indicator lamp LED blue 220 V AC - 1 No.
- Indicator lamp LED amber 220 V AC - 1 No.
- PVC insulated copper wire 1 mm^2 - 25m.
- PVC insulated copper wire 2.5 mm^2 - 6m.
- Slotted wire duct 50 mm(h) X35mm (w) - 2m.
- Din rail 35mm(W)x7.5mm(D) - 1m.
- Cable tie 80 mm - 1 Pack.
- Elmex connector nylon (universal rail mounting type) 2.5 mm^2 - 10 Nos.
- Elmex connector nylon (universal rail mounting) 4 mm^2 - 10 Nos.
- Pin lug copper 1 mm^2 - 30 Nos.
- Pin lug copper 2.5 mm^2 - 15 Nos.
- Alphabet ferrule A-Z 1.5 mm^2 - 1 Set.
- Number ferrule 0-9 1.5 mm^2 - 1 Set.
- Screw round headed M4 X 12 mm - 24 Nos.
- Cotton waste - 100gm.

Procedure

TASK 1 :

1 Design the circuit as per required logic.

2 Draw the circuit diagram.

3 Prepare the wiring Table.

Note : Use standard symbols while preparing the power and control circuit, the design should meet all the requirements.

— — — — —

TASK 2 :

1 Remove the detachable plate from the control panel.

2 Place the accessories on the plate as per layout.

Note : Ensure sufficient spacing between components while preparing layout. The minimum spacing between components and race ways should be 100 mm for 415 V and 50 to 75 mm for less than 415 V system

3 Fix the accessories on the plate by making necessary marking, drilling and tapping.

Note : Make sure that the marking is correct and use only suiTable size drill bit and tap

— — — — —

TASK 3 :

1 Take the measurement of control and power cable as per lay out.

2 Cut the required length of control and power cable.

3 Insert identification ferrule in each end of wire as per wiring diagram and wiring Table.

Note : Insert all the strand of the cable in the copper lug while crimping

1 Lay the cable through the slotted wire duct and dress it properly.

2 Refit the detachable plate to the control panel.

3 Bunch the control cables up to the push buttons and indication lamps which are fixed in panel door using nylon cable tie.

4 Strip the insulation and crimp the copper lug on each end of wire using crimping tool.

Note : Remove only sufficient length of cable insulation and use proper sized lugs

5 Connect the cable to the accessories as per diagram.

Note : Over tightening of screw have to be avoided otherwise this can crush the strand and give a poor contact

6 Connect suiTable size of earth wire to the cabinet and door.

7 Connect 3 phase supply with neutral to the control panel.

8 Check the circuit and test the DOL starter.

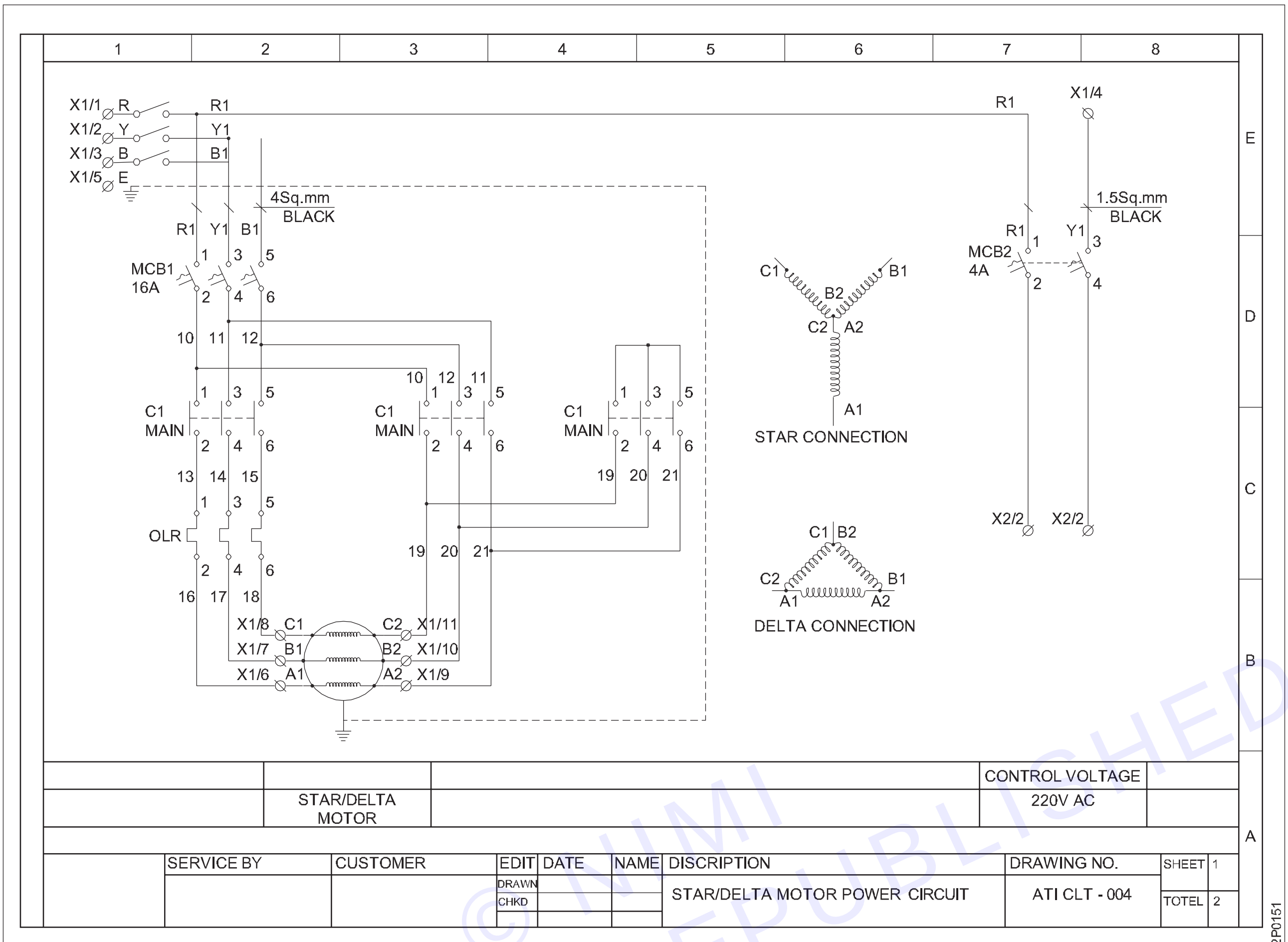
RESULT

Wired up and tested the DOL starter.

WIRING Table

DIRECT ON LINE STARTER - POWER CIRCUIT

WIRING FROM			FERRULE No.	WIRING TO		REMARKS
SL No.	ITEM	TERMINAL No.		ITEM	TERMINAL No.	
1	X1	1(TOP)	R	1Q1	R	X1-ELMEX TERMINALS
2	X1	2(TOP)	Y	1Q1	Y	1Q1-3 PHASE ISOLATOR
3	X1	3(TOP)	B	1Q1	B	MCB1- 3 POLE MCB
4	X1	4(TOP)	N1	MCB2	3	MCB2- 2 POLE MCB
5	X1	5(TOP)	E	CABINET/ PANEL	EARTH POINT	C1- MAIN CONTACTOR
6	1Q1	U	R1	MCB1	1	OLR- OVER LOAD RELAY
7	1Q1	V	Y1	MCB1	3	
8	1Q1	W	B1	MCB1	5	
9	MCB1	2	10	C1	1	
10	MCB1	4	11	C1	3	
11	MCB1	6	12	C1	5	
12	C1	2	13	OLR	1	
13	C1	4	14	OLR	3	
14	C1	6	15	OLR	5	
15	OLR	2	16	X1	6(TOP)	
16	OLR	4	17	X1	7(TOP)	
17	OLR	6	18	X1	8(TOP)	
18	MCB1	1	R1	MCB2	1	
19	X1	1(BOTTOM)	R	POWER SUPPLY	R	
20	X1	2(BOTTOM)	Y		Y	
21	X1	3(BOTTOM)	B		B	
22	X1	4(BOTTOM)	N		N	
23	X1	5(BOTTOM)	E	EARTH	EARTH POINT	
24	X1	6(BOTTOM)	A1	MOTOR	A1	
25	X1	7(BOTTOM)	B1		B1	
26	X1	8(BOTTOM)	C1		C1	
27	X1	9(BOTTOM)	EARTH		EARTH POINT	



WIRED UP AND TESTED THE DOL TEATER

MODULE 16 : Domestic Appliances

EXERCISE 101 : Repair and test various domestic appliances and equipment

Hot plate

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

- to carry out test, repair and maintenance work on hot plate
- to carry out test, repair and maintenance work on electric iron
- to carry out test, repair and maintenance work on storage type water heater
- to carry out test, repair and maintenance work on room air cooler
- to carry out test, repair and maintenance work on pedestal fan
- to carry out test, repair and maintenance work on table fan
- to carry out test, repair and maintenance work on ceiling fan
- to carry out test, repair and maintenance work on electric mixie
- to carry out test, repair and maintenance work on semi-. automatic washing machine.

Requirements

Tools/Instruments

- Combination pliers 150 mm - 1 No.
- Screw driver 100 mm - 1 No.
- D.E. spanner set 5 – 20 mm - 1 Set.
- Electrician knife 75 mm - 1 No.
- Side cutter 150 mm - 1 No.
- Connector screw driver 100 mm - 1 No.
- Multimeter Digital - 1 No.
- Megger 500 V - 1 No.

Equipment/Machines

- Hot plate 1500 W, 250 V - 1 No.
- Test lamp 60W, 250 V - 1 No.
- Electric iron 750W/230V - 1 No.
- Heating element - Electric iron 750W/230V - 1 No.
- Geyser 1500 W,230 V - 1 No.
- Room air cooler 170W / 230V - 1 No.
- Pedestal fan 60W, 240V - 1 No.
- Table fan 60w,240V - 1 No.
- Ceiling fan 60w,240V - 1 No.
- Mixer 750 W/250 V - 1 No.
- Rotary switch 6A/250V - 1 No.
- External growler 230V - 1 No.
- semi-automatic washing machine 5kg, 230V - 1 No.

Materials

- PVC Copper wire 1.5mm2 - 6 m.
- 3 core cable 1100V - 6 m.
- Heating element 1500 W, 250 V - 1 No.
- Capacitor 2µf, 440V - 1 No.
- Rotary switch 5A, 230V - 1 No.
- Regulator 240V - 1 No.

Procedure

TASK 1:

1 Disconnect the cable from the socket.

2 Remove the two screws and remove the plate from the base.

3 Disconnect the cable from the heating element.

4 Remove the heating element.

5 After inspection and necessary repair re assemble the heater in the reverse order

6 Visually inspect the heating element for any burn indication.

7 Replace the heating element if found defective, with heating element of same specifications.

8 If found good in visual inspection, check the element with multimeter for continuity.

9 Replace the heating element if found no continuity.

10 Check the cable for continuity and insulation.

11 Check the cable near the entry points of the plugs for breakage or sign of overheating.

Too rigid of cable insulation will indicate overheating. Too much flexibility is an indication of breakage of conductor.

12 Check for overheated terminals of socket and plugs.

13 Check the body for rust, particularly at the socket inner surface and at the fixing holes.

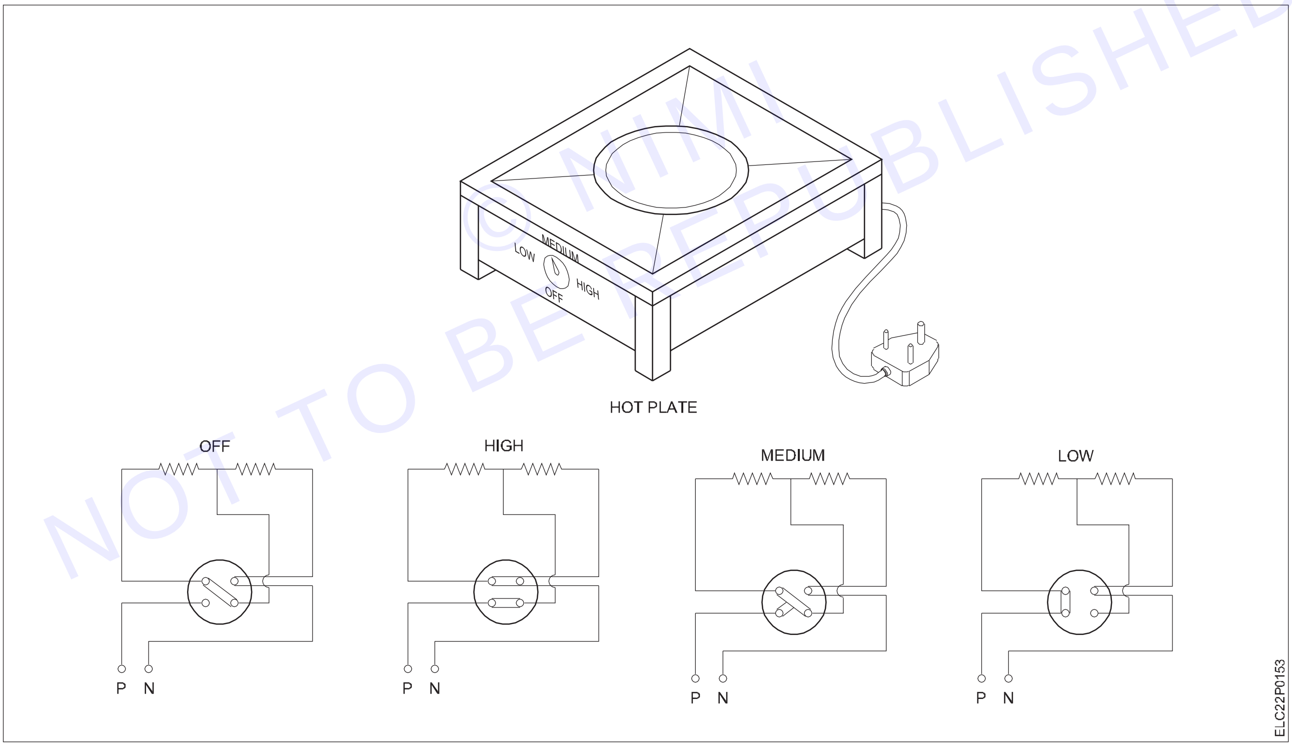
Rusted sockets or earth clips of plugs should be replaced. Never paint them. But the rust in the fixing holes may be removed and repainted. If necessary, replace the screws of bigger size.

14 Replace the heavily pitted, welded terminals of socket and plug. Replaced plug should be checked for proper tight fitting in the socket.

15 Check the hot plate for breakage. Broken plates need to be replaced.

16 Check the earth continuity of body and grill plate.

Insulation resistance between the live parts and body should not be less than one mega ohm.



TASK 2:

1 Dismantle the electric iron.

2 Identify the parts

3 Trace the internal connection of iron.

4 Draw the free hand sketch of electric iron parts.

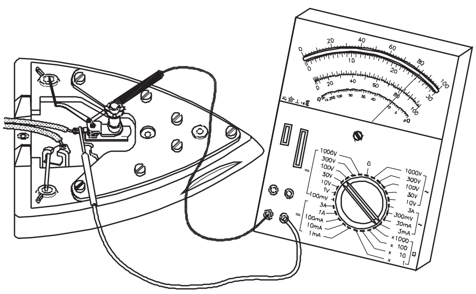
5 Draw the circuit diagram of electric iron.

6 Conduct preliminary test for short circuit, continuity & insulation, earth fault, defective element circuit

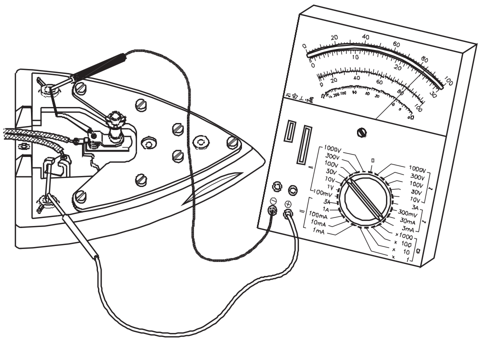
7 Check the continuity of heating element using test lamp or multimeter Fig 2

8 Check the earth continuity of body and grill plate.

8 If there is no continuity, replace by new one.



(A) TESTING THE THERMOSTAT FOR CONTINUITY



(B) TESTING THE HEATING ELEMENT FOR CONTINUITY

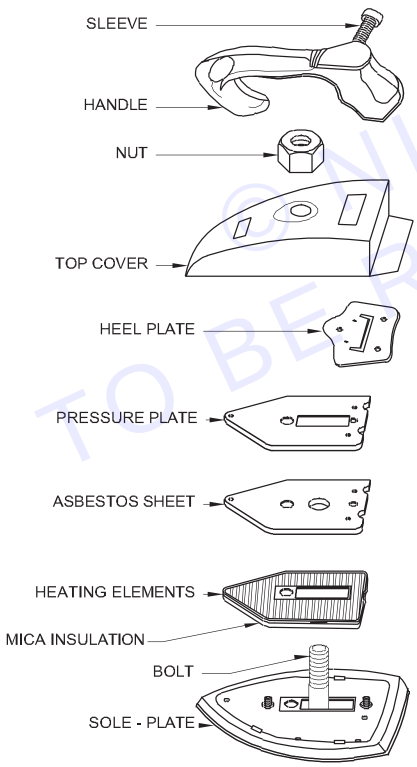
ELC22P0240

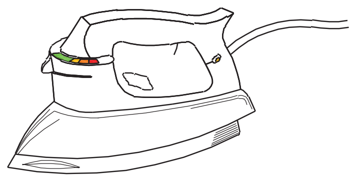
9 Measure the insulation resistance of the heating element between the terminals and the body before and after connecting the cord.

10 Replace the parts if the insulation resistance value is less than 1.0 MΩ.

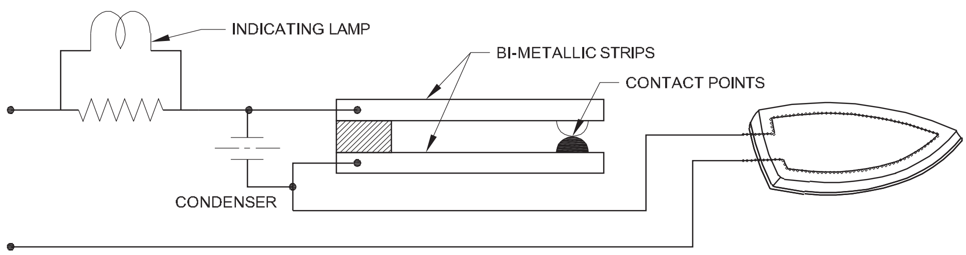
11 Replace the cord, if necessary

12 Check for the insulation resistance between line terminal of the iron and the body of the iron





AUTOMATIC ELECTRIC IRON



THERMOSTATIC CONTROL OF AN ELECTRIC IRON

ELC22P0155

TASK 3:

1 Dismantle the geyser.

2 Study the internal structure of the geyser.

Check and ensure that switch is off before removing the power plug.

3 Trace the connections of geyser.

4 Draw the complete connection diagram of the geyser.

5 Draw the sketch of the geyser.

6 Conduct the insulation test on the cord between the leads and lead and earth.

7 Measure the insulation resistance between the element and earth.

8 The minimum value of insulation resistance should be 1.0 MΩ.

9 Connect the geyser to the supply and switch ON the appliances, keeping the inspection/bottom cover of the connections open.

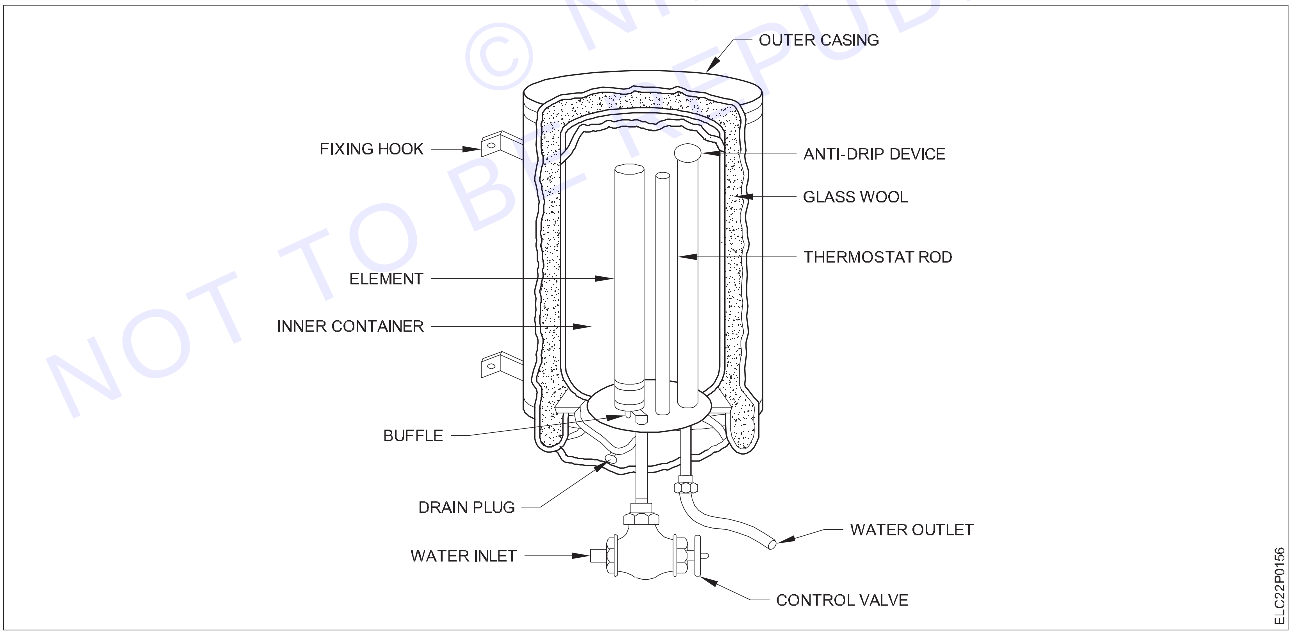
10 Observe the actuation of the thermostat after heated to a preset value.

11 Switch off the supply and measure the insulation resistance between terminal and body of the heater while it is hot.

12 Replace the thermostat unit if the insulation value is less than 1 MΩ.

13 Reassemble the geyser and check the working condition.

The geyser should be switched ON only with water in the container.



TASK 4:

1 Draw the connection diagram of the room air cooler.

2 Note down the name plate details of the room air cooler.

3 Put a mark on the outer cover and remove it.

4 Remove the parts one by one and identify them.

Proper tools are to be used for dismantling and assembling.

5 Check the power cord for short circuit and open circuit.

6 Check the switches for proper operation.

7 Check water pump for working.

8 Check the pipelines for leakage and blockage.

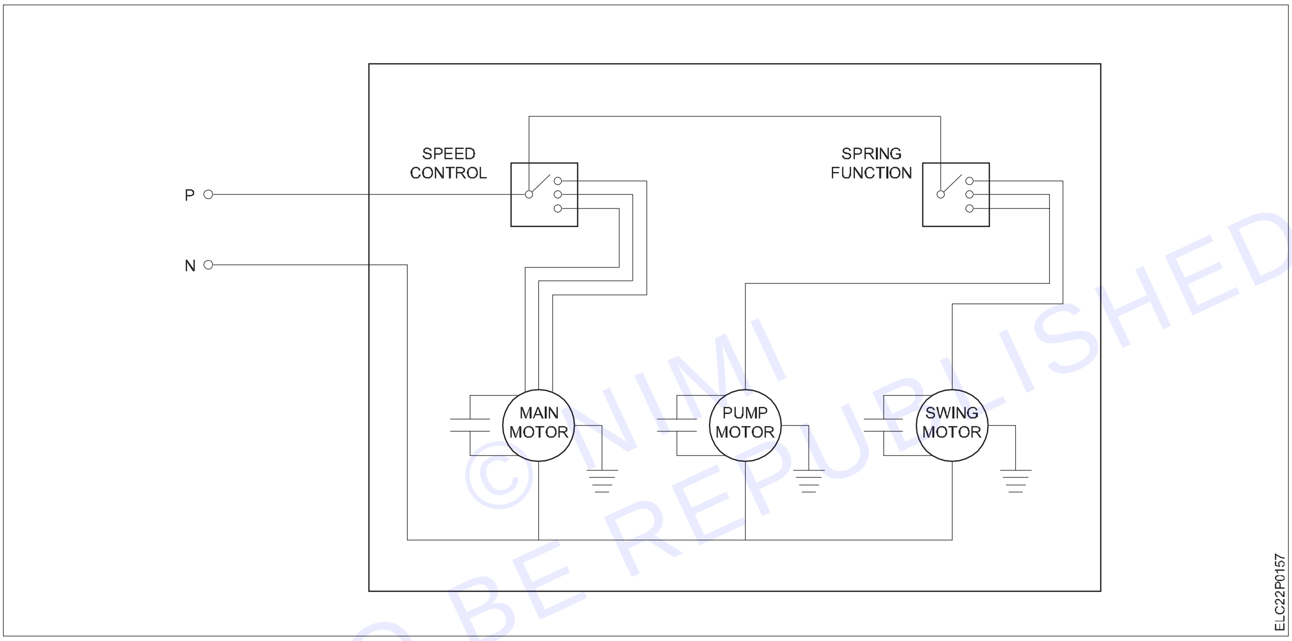
9 Check the fan for its operation.

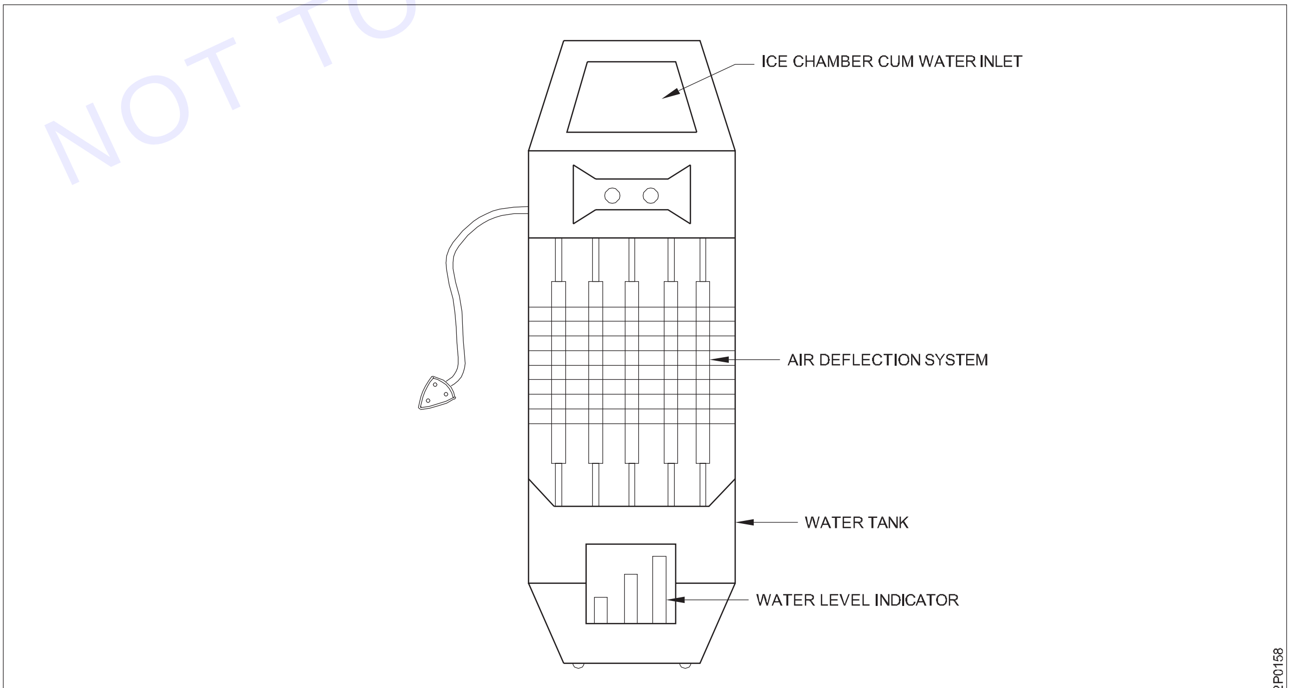
10 Check the tank.

11 Clean the parts or replace if required.

12 Re-assemble the parts in the reverse order.

The dismantled part is to be kept properly, in the sequential order.





ROOM AIR COOLAR

TASK 5:

1 Dismantle the pedestal fan

2 Specify parts of the fan

3 Draw the sketch of the fan

4 Draw the circuit diagram

5 Check the windings of the fan with multimeter.

6 Measure the resistance of the windings.

7 Identify the starting and running winding.

The starting winding is having comparatively higher resistance.

8 Study the internal connections of pedestal fan.

Fan is noisy

- Collect the history and nature of the noise of the fan from the user.
- Run the fan and observe the noise.
- Identify whether the noise is due to one or a combination of the following.

a Slack canopy/cover - touching the rotating body.

b Worn out/partly out shackle.

c Loose element of the blade.

d Loose or missing screws.

e Capacitor housing slack.

f Broken or worn-out split pin at the top and bottom.

g Lack of lubrication, or dirt in bearing.

h. Worn out bearing/bush.

i Blade distortion/breakage.

j Alignment of blades.

Fan wobbles excessively

- Check to be sure that the screws which attach the fan blade flanges to the motor hub are tight.
- Check to be sure that the fan blade flanges seat firmly and uniformly to the surface of the motor hub.
- Tighten the hanger bracket screws to the junction box, secure the hook.
- Interchange the adjacent (side by side) pair of blades.

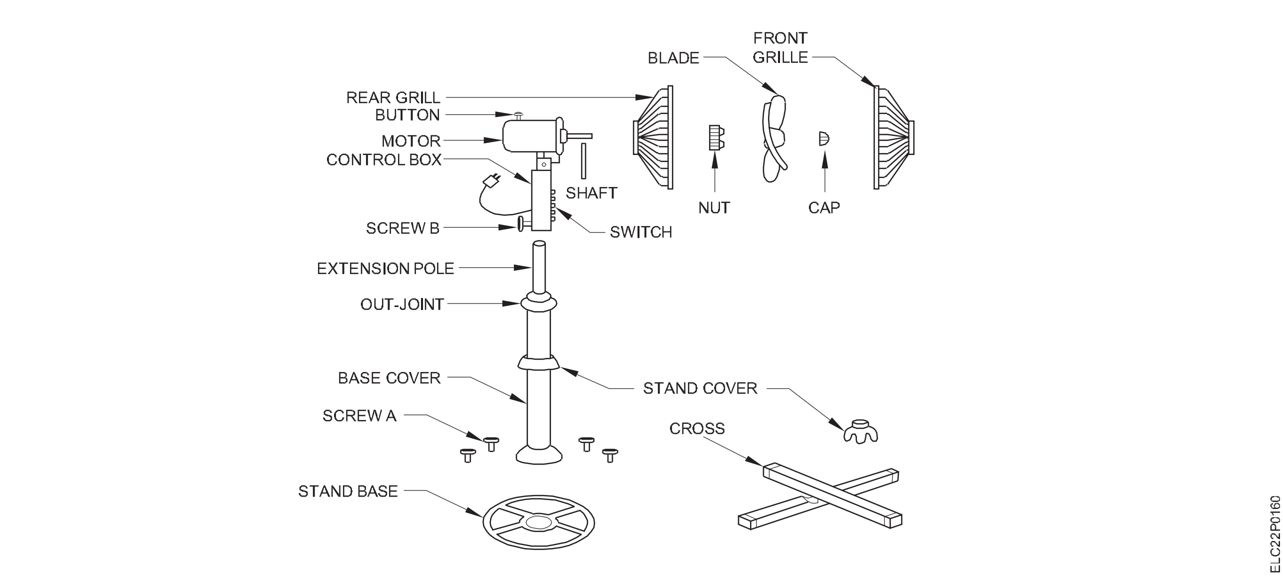
Motor runs hot

- Check for partial short circuit in winding. If defective, send it for rewinding
- Check for tight bearing, if it is defective, replace it with good bearing

9 Rectify the fault of the fan, if any.

10 Reassemble the fan.

11 Check the working of fan.



TASK 6:

1 Dismantle the Table fan.

2 Identify and specify the parts of the fan.

3 Draw the circuit diagram and neat sketch of the fan.

4 Check the windings of the fan with multimeter.

5 Measure the resistance of the windings.

6 Identify the starting and running winding.

7 The starting winding is having comparatively higher resistance.

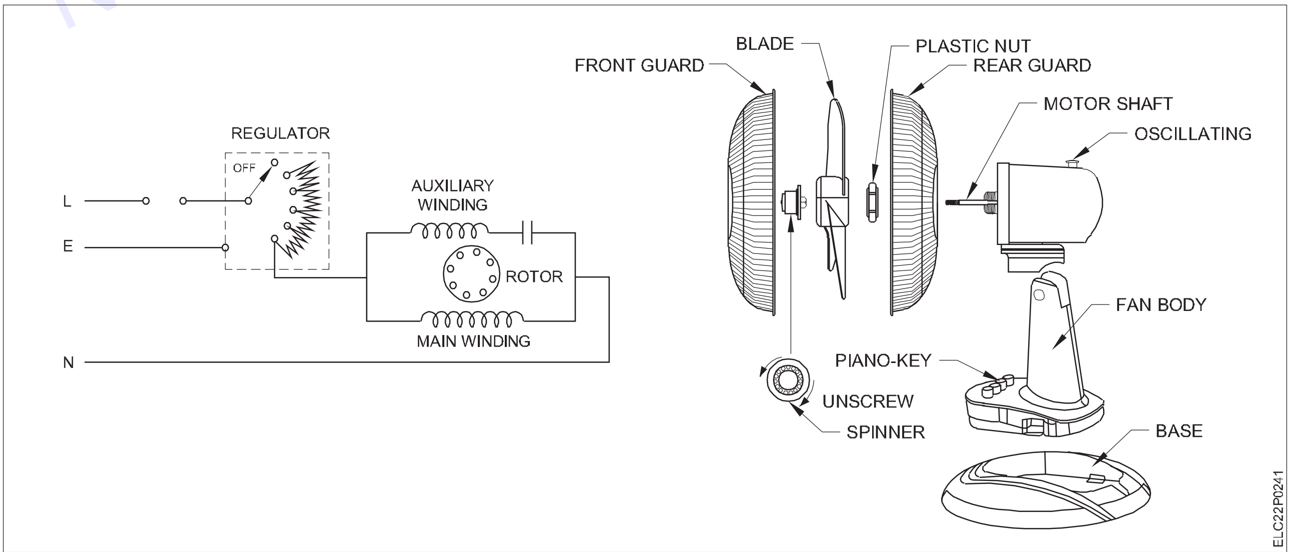
8 Trace the internal connections of the Table fan.

9 Rectify the fault of the fan, if any. Refer pedestal fan trouble shooting points.

10 Replace the capacitor with an identical good capacitor, if the fan is not running.

11 Re assemble the fan properly.

12 Check the operation of the fan.



TASK 7:

1 Dismantle the ceiling fan.

2 Identify the parts.

3 Draw the circuit diagram.

4 Draw the neat sketch of the fan.

5 Check the windings of the fan with multimeter.

6 Measure the resistance of the windings.

7 Identify the starting and running winding.

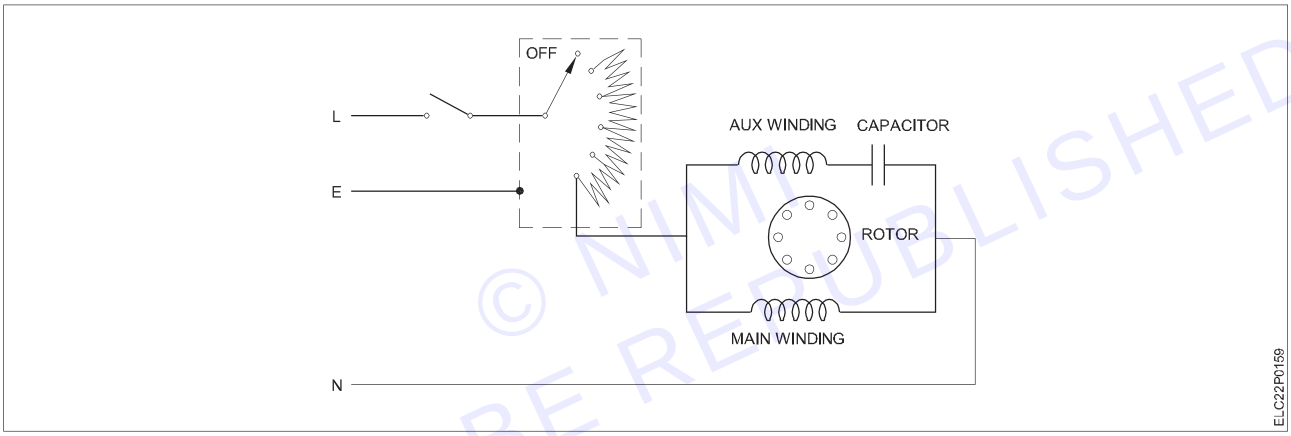
The starting winding is having comparatively higher resistance.

8 Trace the internal connections of the ceiling fan.

9 Rectify the fault of the fan, if any. Refer pedestal fan trouble shooting points.

10 Re assemble the fan.

11 Check the working of the fan.



TASK 8:

1 Draw the circuit diagram.

2 Draw a neat sketch of mixer.

3 Specify the mixer.

4 Test the mixer with series test lamp.

5 Dismantle the mixer if not working.

6 Check the armature by using growler.

7 Check the field winding with test lamp.

8 Check the insulation resistance between windings and body.

9 Improve the insulation value by heating or varnishing, if the insulation value is less than one megohm after cleaning thoroughly the stator and armature and bush bearings.

10 Rectify the faults and repair it if necessary.

11 Check the brushes for its condition.

12 Replace if required.

13 Check the brushes for sufficient pressure.

14 Check the bush for any play.

15 Reassemble the mixer properly.

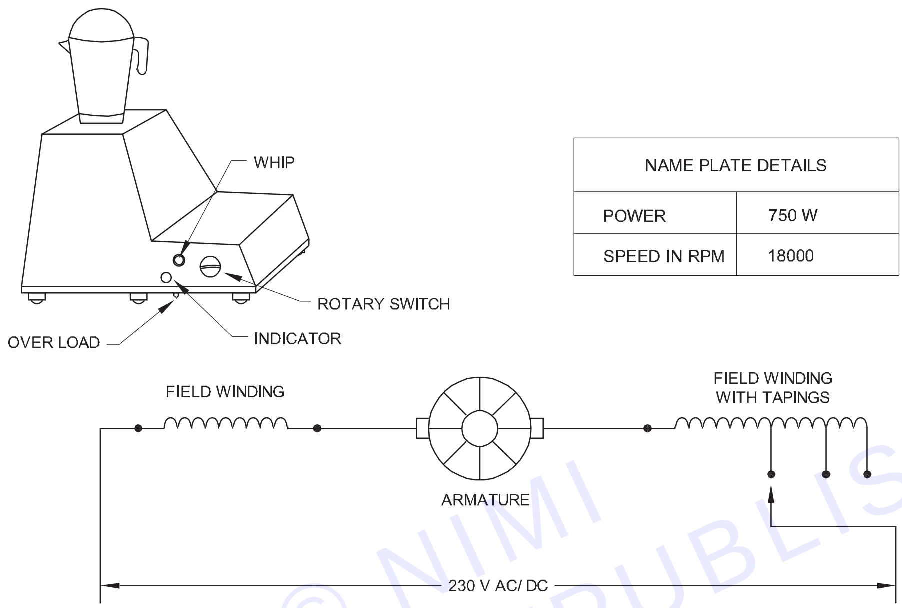
16 Connect the leads of field windings

17 Switch ON the supply and run the mixer.

Observe the DOR, if it is reverse interchange the brush terminals

18 Observe for any sparking.

19 Switch OFF the supply and remove the cables.



NAME PLATE DETAILS	
POWER	750 W
SPEED IN RPM	18000

TASK 9:

1 Note down the name plate details of the semi-automatic washing machine.

2 Dismantle the washing machine

Ensure supply is OFF before dismantling

3 Trace the circuit.

4 Identify each part of washing machine.

5 Draw the circuit diagram and neat sketch

Handle the parts carefully

6 Check the washing machine.

7 Find the fault of washing machine.

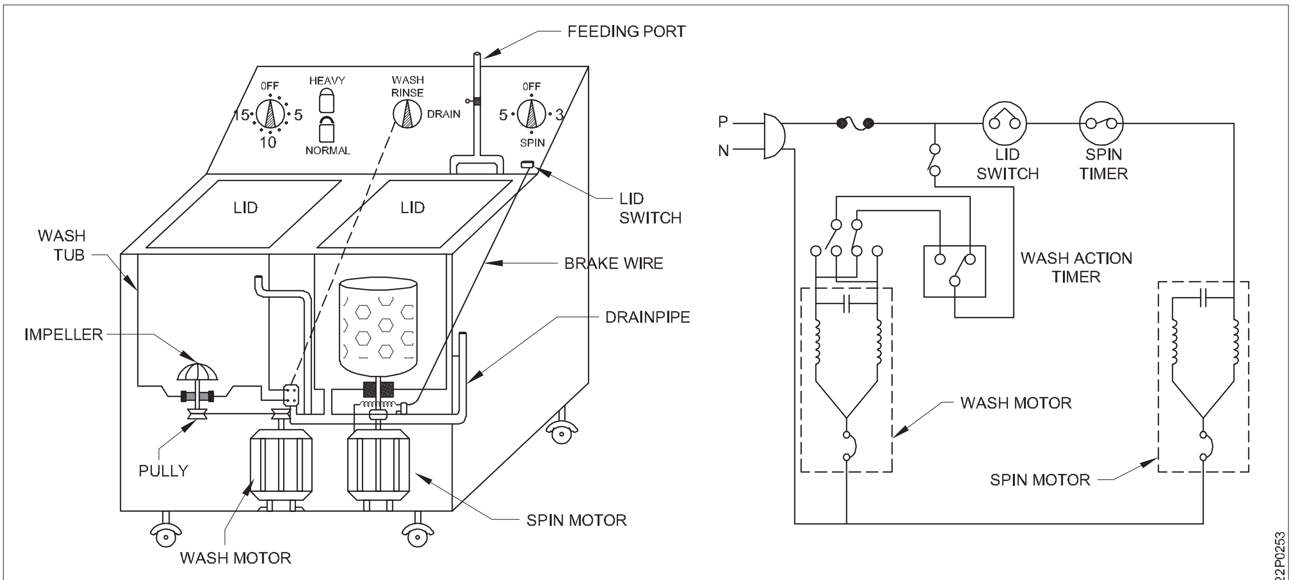
8 Rectify the fault, if any

9 Reassemble the washing machine.

While reassembling connection should be tight and neat

10 Check its working condition

Sl.No.	Complaints	Causes and remedies
1	Machine not Swiching “ON”	I Check for open connection and rectify the same I Check the incoming supply III Check the fuse on the machine IV Check the motor windings and repair of minor repairs can be carried out, if needed send it for repairs/rewinding for internal open circuit. V Check the speed governing starting switch, repair or replace with a new switch.
2	Water not filling up in the washing drum	I The inlet pipe is chocked. Open the inlet valve, clean it and reconnect it using water proofing teflon tape I Check incoming water supply and replace the same.
3	Water does not drain out of the wash drum	I Check the timer working. The timing mechanism at pre-deter- mined times set on the timer have been closed or clogged - if possible, repair it.Otherwise replace the timer with a new one. I The timer may be okay but the switch may be stuck -replace the switch.
4	Machine does not switch ‘OFF’ after	I Check the timer working. The timing mechanism at pre-deter- mined times set on the timer have been closed or clogged - if possible, repair it.Otherwise replace the timer with a new one. II The timer may be okay but the switch may be stuck -replace the switch.
5	Machine becomes ‘ON only for a very short duration and then switches off	I The timer setting may be incorrect;set the timer properly. II The speed governor switch may be faulty; dismantle the motor and repair the same, If possible, or replace the starting speed governor swivel mechanism. III The running winding impedance could have increased due to open circuit and insulation failure. Check the running winding impedance and rewind the motor, if necessary.
6	The machine is noisy	I Check the balancing of the drum and correct the same if found off balance. I The motor shaft pulley/drum driver pulley may be loose,tighten the same. III The belt of the machine drive might have loosened thus giving play. IV Check the bearings of the motor, replace the worn out or grease the same using the recommended grease. V Check all rubber bushings that are used in the machine for absorbing mechanical vibration, and replace, if found spoilt or missing.
7	The machine gives shock	I Isolate the machine from the spply and carry out megger test I If there is an insulation failure found in the plug, isolate the motor and check the winding with body. III If winding insulation failure is detected, send the motor for rewinding. IV If insulation failure is detected, trace the complete wiring of the machine and locate the faulty or leaky insulation area. V Replace the complete wire that is found faulty



AUTOMATIC WASHING MACHINE

TASK 10 : **Service and repair of induction heater**

1 Note the name plate details of the induction heater and record them in the Table.

Name Plate Details	
SL No. __________ Make __________ Voltage __________V Current __________A	Power ____________KW 1f / 3f

2 Disconnect the power supply from the induction heater.

3 Check the power cord for continuity of the cable

If found defective, replace the power cord

4 Open the induction heater.

5 Do a thorough cleaning of PCB and other parts.

6 Remove the main board for visual inspection and trouble shooting.

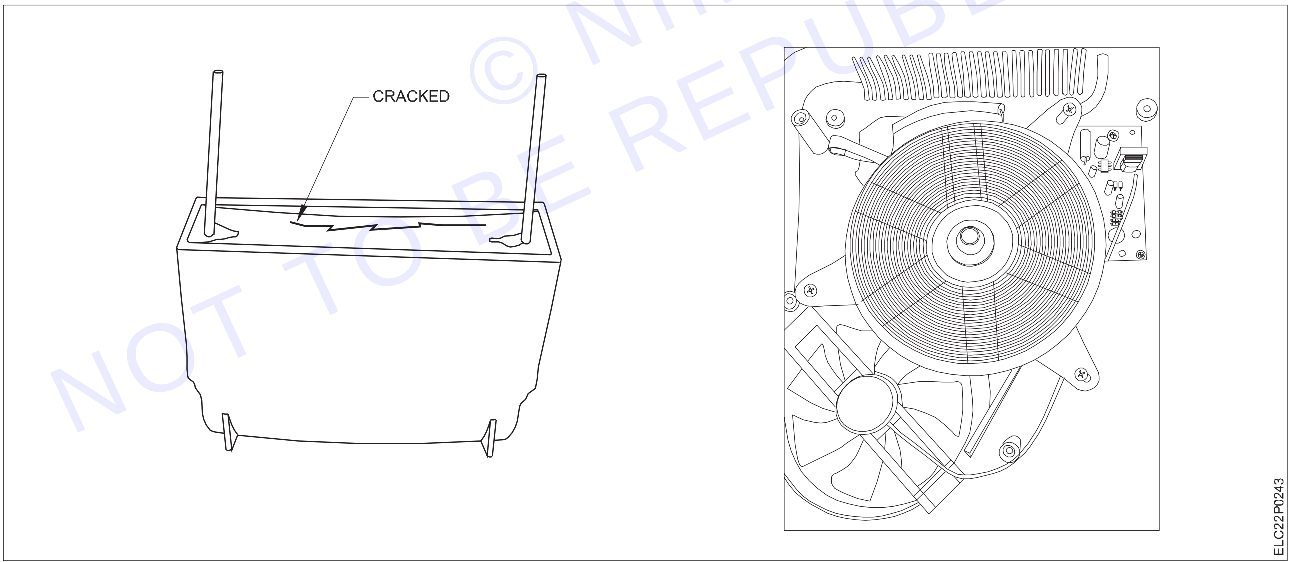
7 Check whether PCB is covered by varnish.

8 Apply thinner and rub with metal brush and scrap with a knife and expose the dry solder points. (Fig 1)

9 Retouch all the points with fresh solder.

10 Check whether any capacitor cracked in the PCB (Fig 2). If so remove it from the PCB with the help of tile cutter (Fig 4) .

11 Check the electrolytic capacitors on the board and replace with a new one if they are found at the brim.



12 Press the switches on the control board and if they show resistance, it may be due to improper contact.

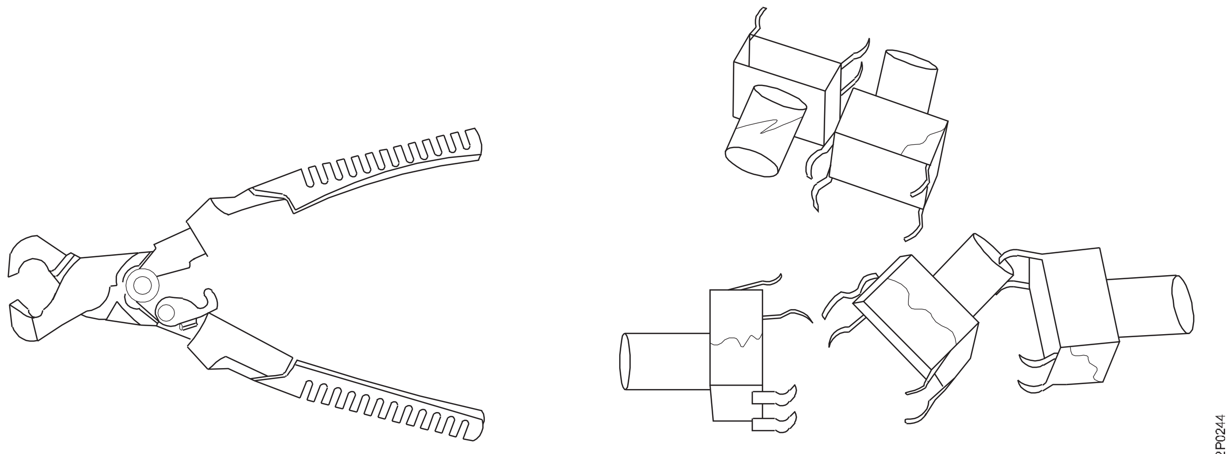
13 Replace all the Press-to-on button switches.

If buttons are slightly longer than the one on the board, nip the extra length with tile cutter tool

14 Defective switche is shown below (Fig 5)

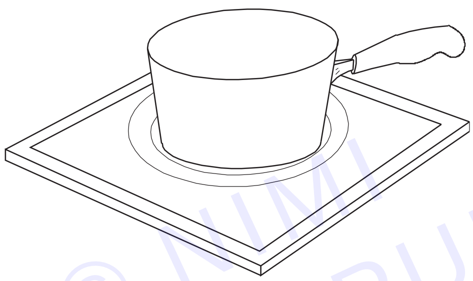
15 After completing the work put the PCB and other parts back into the cabinet, (Fig 3). Fig 6 shows the cook top of induction heater.

16 Test the appliances with supply for its working.



TILE CUTTER

DEFECTIVE SWITCH



INDUCTION COOK TOP

TASK 11: **Service and repair of oven**

1 Identify the oven model number or part number on the element

The package (Fig 8b) of the new element will list the manfacturers, model numbers and part numbers for which it serves as a replacement.

2 Turn off the power to the oven at the breaker box and unplug the oven

3 Remove the screws that secure the element to the oven

4 Pull the element 10 to 12.5 cms away from the back wall of the oven (Fig 7)

5 Remove the screws that hold the wires of element

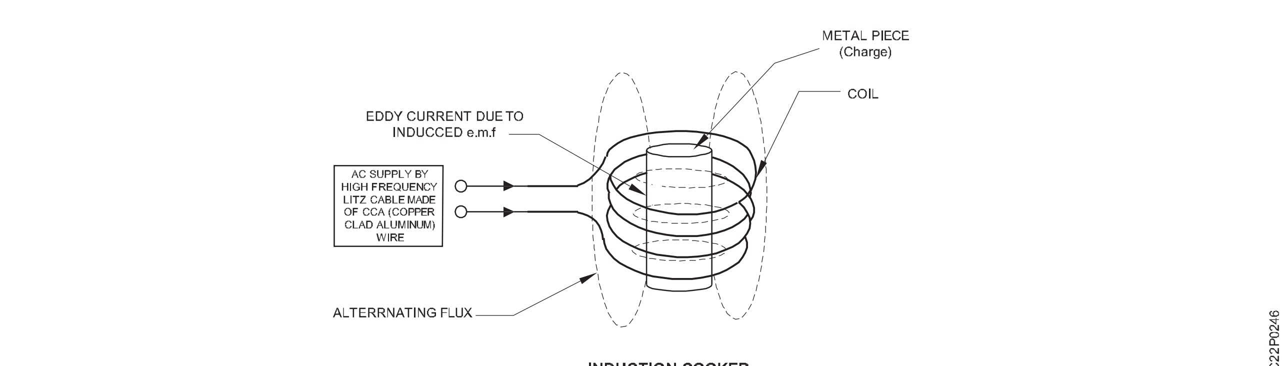
6 Install the new oven element attaching the wires as they were before

7 Secure the new element to the back wall of the oven (Fig 8a) shows element.

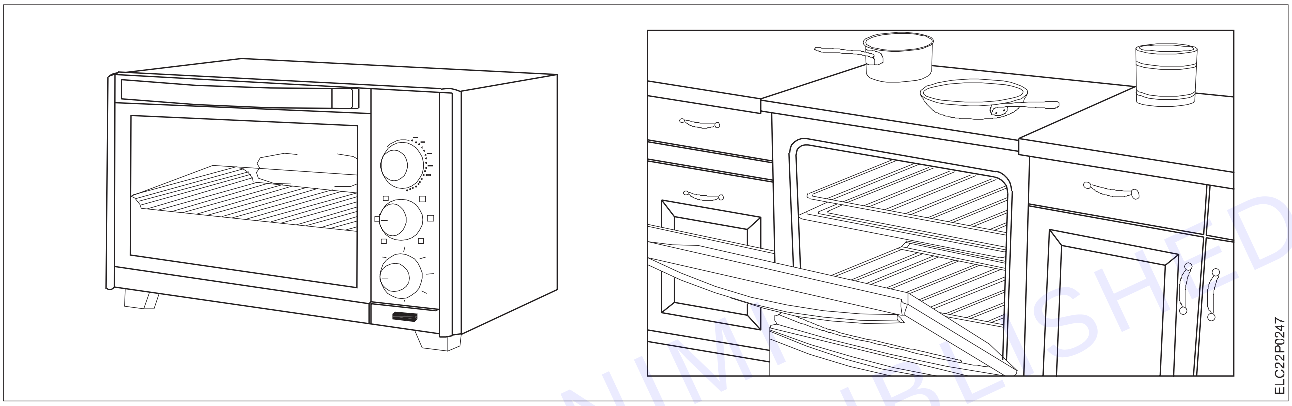
8 Plug the oven back in and return the breaker back to the “ON” position

9 Test the oven with supply for its working..

There may be little smoke when the new element heats up it’s likely just the factory coating burning off.



INDUCTION COOKER



EXERCISE 102 : Demonstrate dismantling, servicing, re-assembling &testing of domestic appliance

Objectives

At the end of this exercise you shall be able to:

- list out the dismantling procedure for domestic appliances
- list out the servicing procedure for domestic appliances
- reassemble the domestic appliance
- test the domestic appliance

Procedure

TASK 1: **List out the dismantling procedure for domestic appliance**s

1 List the space requirements, required tools and parts, power supply availability for dismantling

2 Trace the serial and model number of the appliance and service manual and if unavailable from the appliance.

3 Follow the instructions from manual to dismantle appliance if available.

4 Kee the parts in sequence when disassembled and do the reverse, starting with the last part, for reassembly.

5 Put the disassembled parts in clean containers when disassembled to avoid any missing

— — — — —

TASK 2: **list out the servicing procedure for domestic appliances**

1 Test the component of dismantled appliance as referred in service manual

2 Clean the dust and moisture in the appliance.

3 Inspect for decoloring or rusting of parts.

4 Replace the aged components as required

— — — — —

TASK 3: **Reassemble the domestic appliance**

1 Record the works done in service report.

2 Follow the appliance service manual for reassembly.

3 Tighten the electrical and mechanical connections

— — — — —

TASK 4: **Test the domestic appliance**

1 Operated the appliance as per user manual instructions

2 Test for insulation resistance between supply terminals and body

3 Reconnect all earth connections of the appliance

4 Use series test lamp to energise the appliance.

— — — — —

EXERCISE 103 : Demonstrate Care & Maintenance of Domestic appliances

Objectives

At the end of this exercise you shall be able to:

- list out the general care and maintenance for domestic appliance
- list out the specific care and maintenance for domestic appliance.

Procedure

General

1 Measure and verify the appliance is operated at specified voltage level.

2 Clean the appliance

3 Remove dust and dirt.

4 Do not overload the appliance.

5 Explain the consequence of using the appliance continuously more than the time mentioned my manufacturer.

6 Check for proper ventilation for the domestic appliances

7 Explain the need not to pull the power cable to remove the electric connection

8 Verify the earth connections inside and outside the appliance.

9 Verify the service and maintenance log

Specific

Inverter - UPS

1 Check the level of electrolyte in Battey of inverter / UPS

2 Demonstrate to Discharge the capacitors using power resistors or test lamps before handling

3 Switch off the inverter before connecting the battery.

4 Test the battery using battery tester in charged conditions to prevent back up issues

5 Demonstrate and under rated MCB of lesser causing trip for inrush charging current

6 leads of battery / battery bank should never be short circuited

7 demonstrate and adhere to lift handling guidelines

8 wear protection / insulation gloves during electrolyte preparation

9 apply petroleum jelly to the battery terminals to prevent corrosion

10 Keep battery always charged

Heating appliances

1 Mount with clearances as in instruction manual with easy access

2 Ensure the heat consuming load is always available

3 Demonstrate the Testing of the thermostat setting.

4 Tighten the terminal connection to avoid loose due to heat

5 Verify the use heat insulators for electrical insulation

6 Ensure proper ventilation to avoid any CO suffocation

7 Demonstrate the replacing of self-sacrificing corrosion preventing rods in regular intervals

8 Check for water leakages / aged gaskets / loose screws and rectify

9 Remove any sediment collection

10 check for noises in operation/discoloration of water / foul smell

11 Replace any worn power cables.

Motorized domestic appliance

1 Check for proper direction of rotation after a maintenance

2 Keep the terminal and body properly insulated to avoid unwanted RCCB tripping

3 Check for any noises, from fan and bearings or other parts

4 Keep the motor always dry

5 Replace the loose belts/ adjust the tightness

6 Lubricate the bearings.

7 Check for error code in service manual for digital control appliances

Micro wave oven

1 Do not operate or allow the oven to be operated with the door open.

2 check the magnetron, wave guide or transmission line, and cavity for proper alignment, integrity, and connections before turning on microwave power for any service test or inspection within the microwave generating compartments

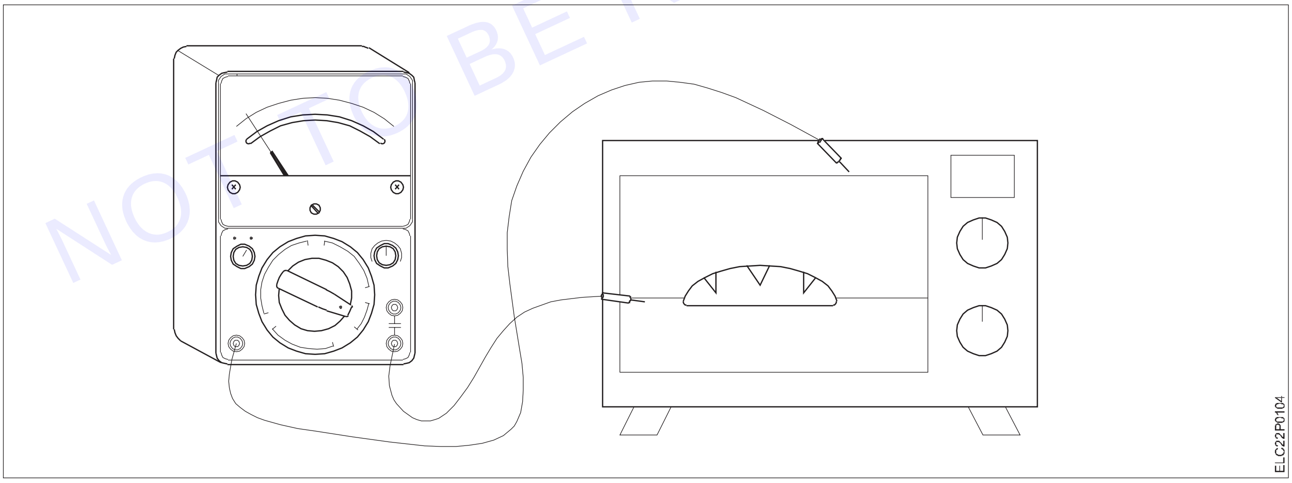
3 DO NOT operate on a 2-wire extension cord during repair

4 Do not put iron tools on the magnetron

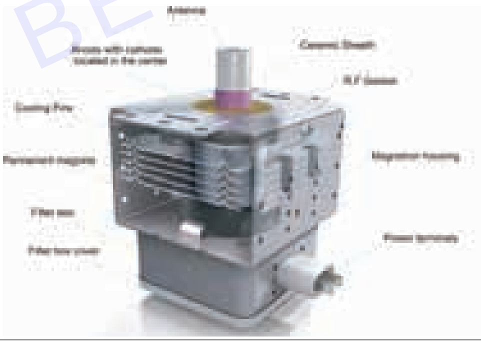
5 Do not put anything into the latch hole and the interlock switches area

6 Check for microwave energy leakage after every servicing. The power density of the microwave radiation leakage emitted by the microwave oven should not exceed 1mW/cm2.sq

7 Refer the Table for troubleshooting guidelines. Normal values are mentioned in Table. Replace component if the test result value is not normal.



Test procedures

Components	Test	Results
Transformer	1 Remove wire leads. 2 Measure resistance. (ohm meter scale: Rx1) • Primary winding • Secondary winding • Filament winding 3 Measure resistance. (ohm meter scale: Rx1000) • Primary winding to ground • Filament winding to ground 	Approx. 0.3 to 0.5 ohms Approx. 65 to 120 ohms 0 ohm Normal: Infinite Normal: Infinite
Magnetron	1 Remove wire leads. Install the magnetron seal in the correct position. Check that the seal is in good condition. 2 Measure resistance. (ohm meter scale: Rx1) • Filament terminal 3 Measure resistance. (ohm meter scale: Rx1000) • Filament to chassis 	Normal: Less than 1 ohm Normal: Infinite
Capacitor	1 Remove wire leads. 2 Measure resistance. (ohm meter scale: Rx1000) • Terminal to terminal  • Terminal to case	Normal Momentarily Infinite and then soon reach 10 mega. ohms Normal: Infinite.

<table>
<tr><th>Components</th><th>Test</th><th>Results</th></tr>
<tr><td>Diode

Some inexpensive ohm meters may indicate infinite resistance in both directions</td><td>1 Measure continuity. Forward. (ohm meter scale: Rx1000)
2 Measure continuity. Reverse. (ohm meter scale: Rx1000)
</td><td>Normal: Below 100 ohms

Abnormal infinite

Normal:Infinite.

Abnormal: Below 100 ohmss</td></tr>
<tr><td>Relay 2</td><td>1 Measure continuity. (ohm meter scale: Rx1)

2 Remove the lead wires and operate oven at power level 1 through power level 10.
</td><td>
<table>
<tr><th>Power leavel</th><th>Open</th><th>Close</th></tr>
<tr><td>1</td><td>4 Sec</td><td>18 Sec</td></tr>
<tr><td>2</td><td>6 Sec</td><td>16 Sec</td></tr>
<tr><td>3</td><td>8 Sec</td><td>14 Sec</td></tr>
<tr><td>4</td><td>10 Sec</td><td>12 Sec</td></tr>
<tr><td>5</td><td>12 Sec</td><td>10 Sec</td></tr>
<tr><td>6</td><td>14 Sec</td><td>8 Sec</td></tr>
<tr><td>7</td><td>16 Sec</td><td>6 Sec</td></tr>
<tr><td>8</td><td>18 Sec</td><td>4 Sec</td></tr>
<tr><td>9</td><td>20 Sec</td><td>2 Sec</td></tr>
<tr><td>10</td><td>22 Sec</td><td>0 Sec</td></tr>
</table>
</td></tr>
<tr><td>Ventilation motor</td><td>1 Remove lead wires.

2 Measure resistance. (ohm meter scale: Rx1)

Turbo speed: White and Brown

High speed: White and Blue

Low speed: White and Violet

Slow speed: white and Yellow
</td><td>Normal:

Turbo speed: Approximately 20-25ohms

High speed: Approximately 40-45ohms

Low speed: Approximately 50-55ohms

Slow speed: Approximately 60-65ohms</td></tr>
<tr><td>TurnTable motor</td><td>1 Remove wire leads.

2 Measure resistance. (ohm meter scale: Rx1000)
</td><td>Normal:

Approximately 2.5 to 3.5 Kohms

Abnormal:

Infinite or several</td></tr>
</table>

Components	Test	Results
Noise filter	1 Unplug microwave oven or disconnect power. 2 Remove wire 3 Measure resistance (ohmmeter scale:Rx1). 	Nmomal: L(1)-L(2)(coil):Less than 1 ohm N(1)-N(2)(coil):Less than 1 ohm Abnormal:infinite Normal: L(1) or L(2)-N(1) or N(2) (resistor: 1.5M ohms Abnormal: 0 ohms
High voltage fuse	1 Depart from other components. 2 Measure Resistance. (ohm meter scale Rx1) 	Normal: under 100hm Abnormal: infinite.

MODULE 17: Estimating and Costing

EXERCISE 104 : Plan and carry out Domestic, Commercial, Industrial and Multi-storeyed building Workshop

Objectives

At the end of this exercise you shall be able to:
- draw and construct the circuit of domestic wiring
- draw and construct the circuit of industrial wiring
- draw and construct the circuit multi storied commercial building wiring.

Requirements

Tools/Instruments

- Insulated combination pliers 150 mm - 1 No
- Side cutting pliers 150 mm - 1 No
- Screw driver set 100 mm - 1 No
- Poker 250 mm - 1 No
- Hacksaw 300 mm - 1 No
- Measuring tape 15 mtr - 1 No
- Ballpeen hammer 100 gm - 1 No
- Electrician's knife 75 mm - 1 No
- Multimeter digital - 1 No

Materials

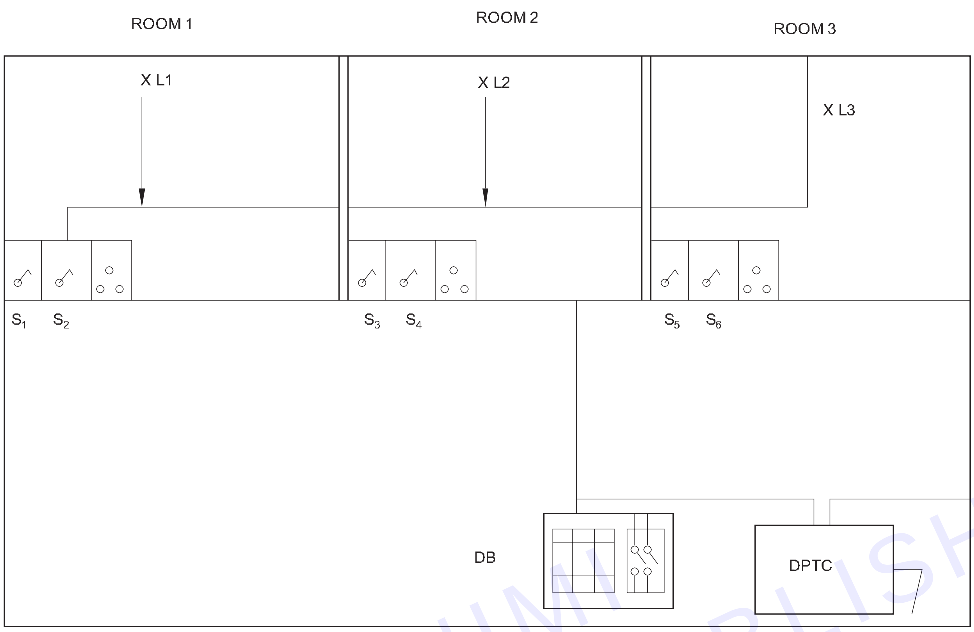
- PVC Insulated flexible copper wire 1.5 mm² - 11 mtr.
- PVC conduit pipe 19 mm - 3 mtr.
- PVC junction box 3 way 19 mm - 1 No.
- PVC junction box 4 way 19 mm - 2 Nos.
- PVC round box 80*25 mm - 3 Nos.
- PVC gang box 2"*2" - 3 Nos.
- Distribution board 12"*10" - 1 No.
- SPST switch 6A, 250V - 6 Nos.
- Three pin socket 15A, 250V - 3 Nos.
- DPIC switch 6A, 250V - 1 No.
- MCB 6A, 250V - 3 Nos.
- ELCB 25A, 30mA,250V - 1 No.
- Steady batten holder 6A, 250V - 3 Nos.
- Lamp 100W, 250V - 3 Nos.
- Elbow 20 mm - 2 Nos.
- Saddle 20 mm - 20 Nos.
- Wood screw
  - 12mm - 40 Nos
  - 18mm - 20 Nos
  - 32mm - 26 Nos
- ICTP main switch 3-phase 60A, 415V - 1 No
- Main bus bar chamber 3-phase 60A 415V - 1 No
- ICTP main switch 3-phase 16A 415V - 1 No
- Phase change over switch 3-phase 16amps 415V - 1 No
- ELCB/RCCB 100mA 16amp 240V/400V - 1 No
- PVC copper cable 1.5 sqmm cable 600V - 0.3 coil
- MCB 6amp 240V - 4 Nos.
- Sheet metal box for fixing the MCB,ELCB & phase change over switch with indicator - 1 No
- PVC channel 25mm x 12 - 4 Length
- PVC channel 25mm elbow inner & outer - as reqd
- SPT switch, flush type 6A, 240V - 12 Nos
- Fibre plugs - as reqd.
- Metal screws for plug 20mm, 25mm, 35mm x No.6 - as reqd.
- PVC round block - 25 x 75 mm - 8 Nos.
- Two plate ceiling rose - 6A 240V - 6 No
- Insulation tape 5m 20mm - 1 Roll
- Bare copper wire 10SWG & 16SWG - as reqd

Procedure

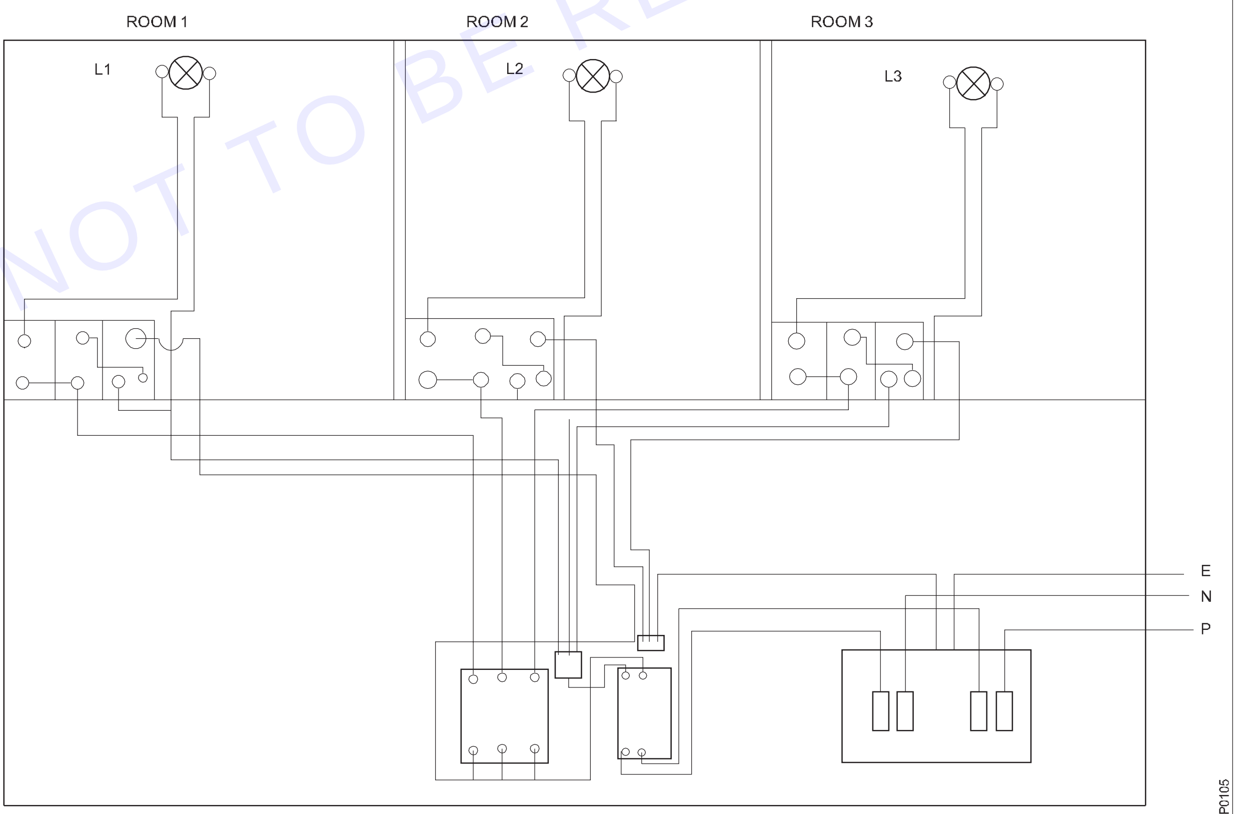
TASK 1:

1 Draw the layout diagram of domestic wiring. Refer Fig 1

2 Read and interpret the schematic diagram (Fig 1) and the layout diagram (Fig 2)



LAYOUT DIAGRAM



CIRCUIT DIAGRAM

3 Estimate the material required for wiring installation referring to the layout as well as the wiring diagrams.

4 Draw the circuit diagram as per layout diagram.

5 Cut the conduits to required length.

6 Lay the conduit and accessories as per layout.

7 Fix them with saddle and screw.

8 Cut the wire to required length.

9 Draw the wire through the conduit.

10 Connect the cables to the electrical to the electrical accessories as per circuit diagram and fix them.

11 Test the circuit after getting the approval of the instructor.

Avoid twisting, bending and crowding of cables inside the conduits.

Stripped portion of wires should not be exposed inside the terminals of accessories after connection.

— — — — —

TASK 2:

1 Obtain the floor plan of the work shop (Fig 1).

2 Mark the position of motors on the floor plan with the consultation of the customer. A Sample requirement is given below for trainee's reference

1 One 5 HP, 415V 3 phase motor.

2 One 3 HP, 415V 3 phase motor.

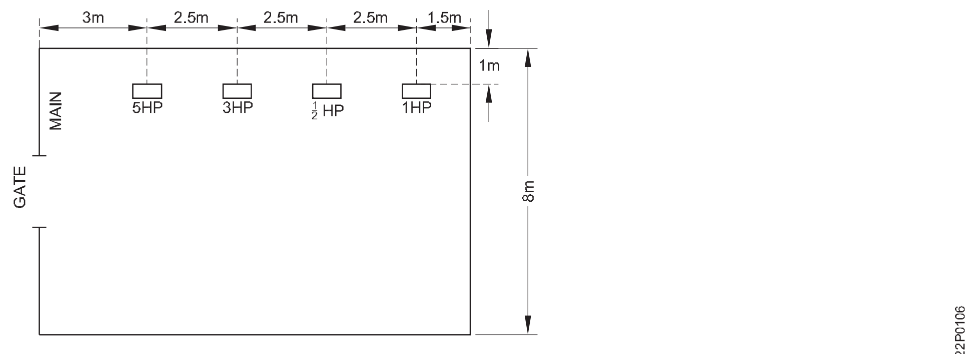
3 One 1/2 HP; 240V, 1 Phase moor

4 One 1 HP, 240V, 1 Phase motor

The motors are to be arranged as shown in Fig 3.

3 Draw the wiring diagram based on Fig 3.

The mainswitch, motor switch and starter are assumed to be mounted at a height of 1.5 m from the ground level. Height of horizotal run from ground level will be 2.5 m



FLOOR PLAN

4 Mark the layout based on Fig 4.

5 Prepare the PVC conduit frame as per layout.

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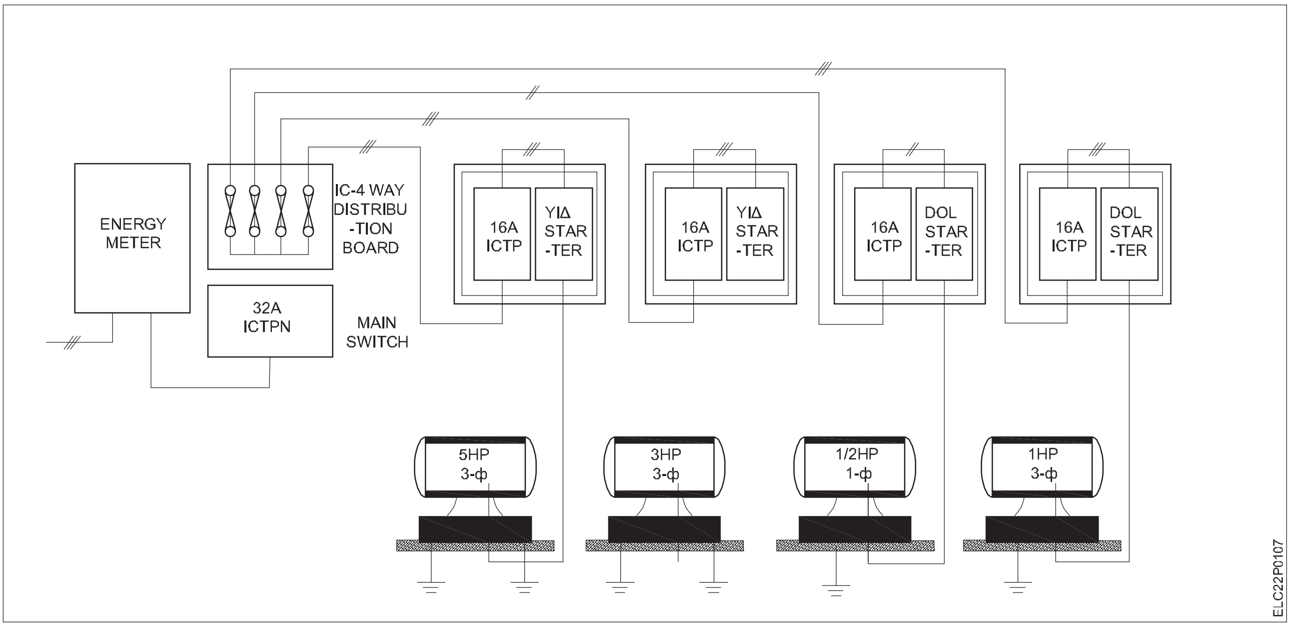

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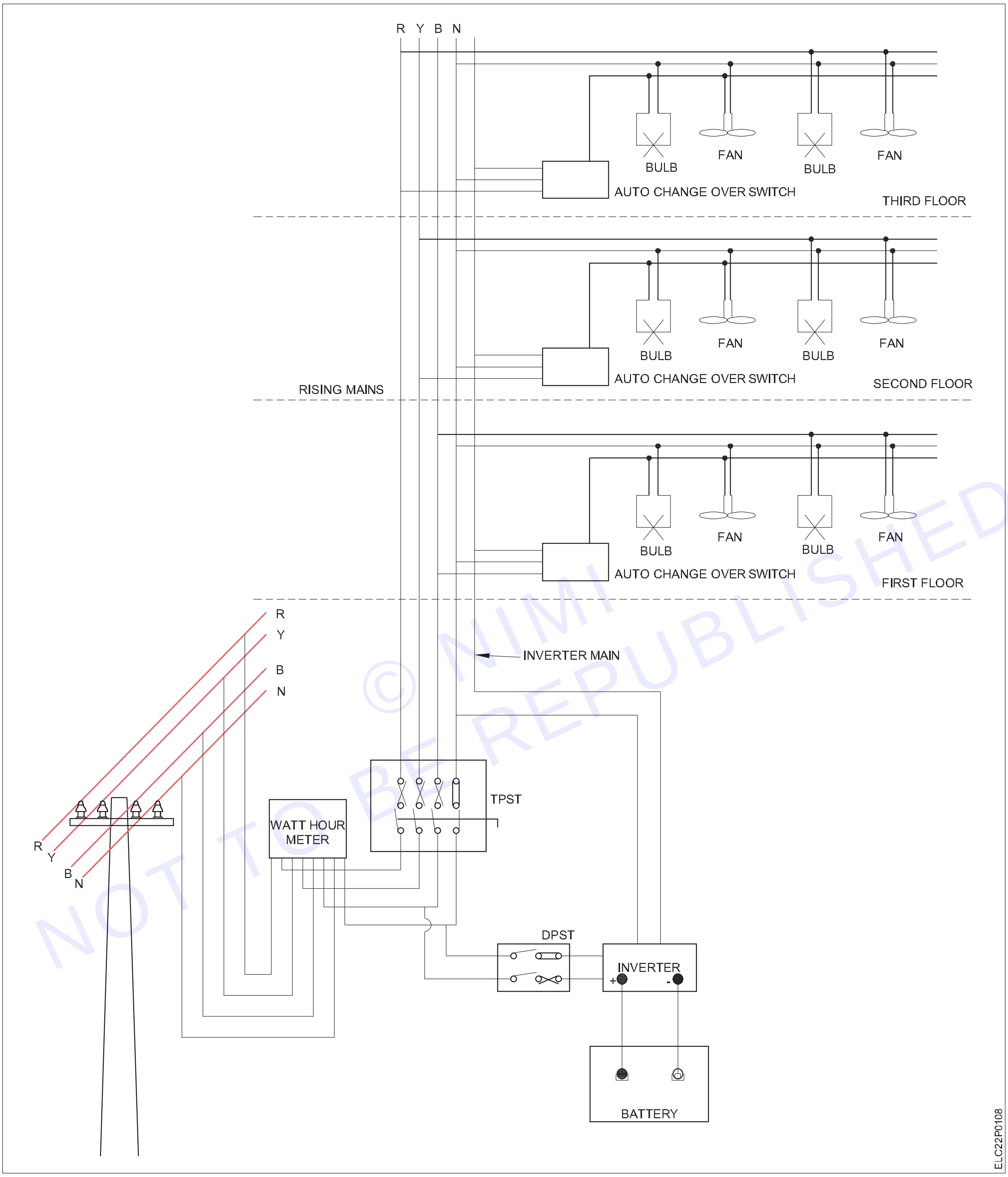
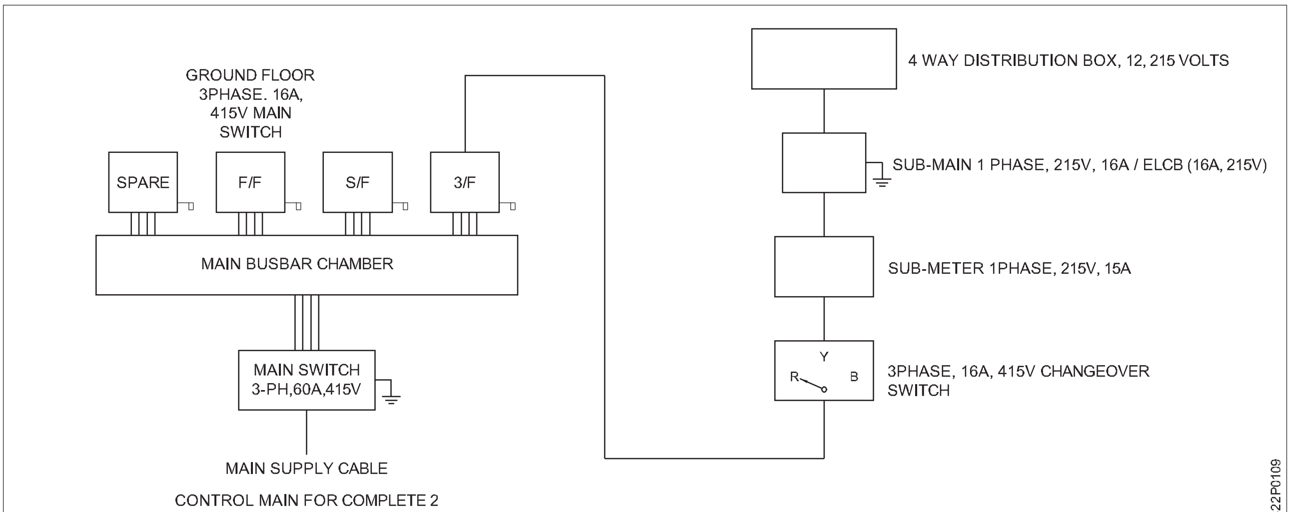
TASK 3: **Multi-storeyed (3 floor) building wiring, with 3 phase supply**

1 Draw the plan of the complete multi story building in given Fig 1.



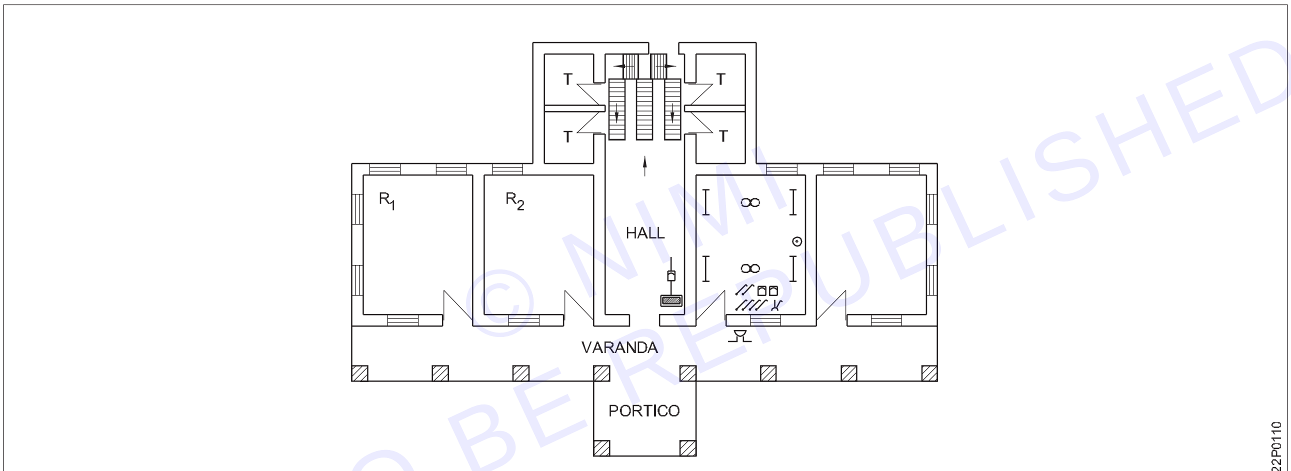
2 Position the electrical fittings for one floor.

3 Prepare Installation layout of mains and sub mains in Fig 3.



INSTALLATION IN THIRD FLOOR

4 Position the accessories in third floor as Fig 2



ACCESSORIES POSITION LAYOUT

It may not be possible to get a building for wiring as per the Fig 1. Hence the trainees may be asked to do the wiring in a wiring board/ cubicle

5 Distribute the load each phase per floor, as load per floor are equal

6 Select the suiTable size channel according to the type, size and no. of cables and also estimate the respective length.

7 Determine the size & type of cables for each run according to the load and their respective length

8 List out materials for PVC channel wiring. Looping system with proper protective devices (ELCB, MCB's & earth)

9 Mark on the cubicle as per the installation layout given in Fig 2.

10 Cut the PVC channel as per layout given in Fig 2.

11 Drill holes in the PVC channel for fixing at end distance using drilling machine

12 Place the channel on the marked route & mark holes for fixing.

13 Prepare the joints on the PVC channel.

14 Fix the channel as per the layout.

15 Wire the accessories as per diagram

16 Test the wiring installation as per IE rules.

— — — — —

EXERCISE 105 : Demonstrate estimation and costing labour / Materials-accessories as per layout

Objectives

At the end of this exercise you shall be able to:

- calculate the total load in sub-circuit
- select the size of cable in the sub circuits
- estimate the quantity of materials
- estimate the cost of wiring.

Requirements

Tools/Instruments

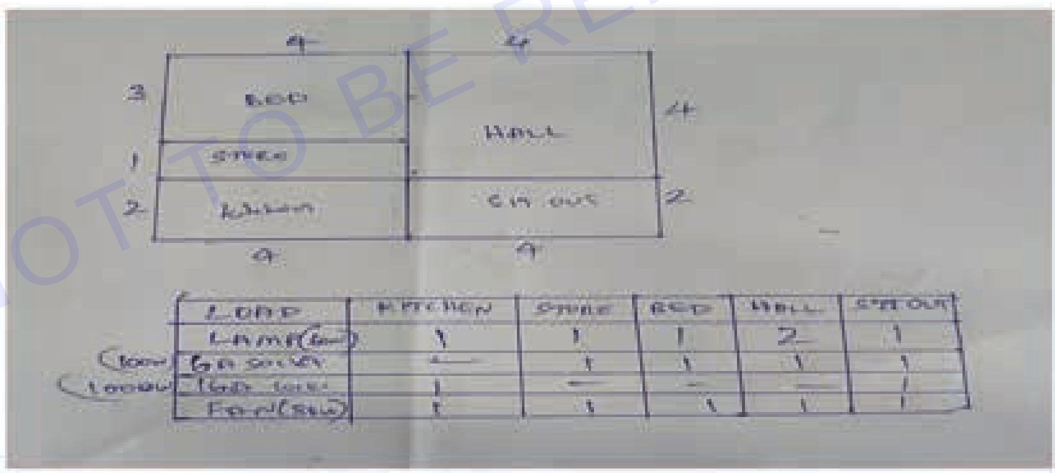
- Measuring tape 0-25 m - 1 No
- SWG - 1 No
- Steel rule 300 mm - 1 No
- Micrometer 0-25 mm - 1 No

Materials

- A-4 Paper - as reqd
- Pencil/HP - 1 No
- Eraser - 1 No

Procedure

TASK 1: **Estimate the cost/bill of material for wiring of Domestic /Commercial building /multi storied building**



1 Calculate the number of sub circuits required for the above load as per IE rules.

Total wattage of light points = 6 x 60=360

Total wattage of fan points = 5 x 80=400

Total wattage of (6A) sockets = 4 x 100=400

Total wattage of (16A) sockets = 2 x 1000=2000

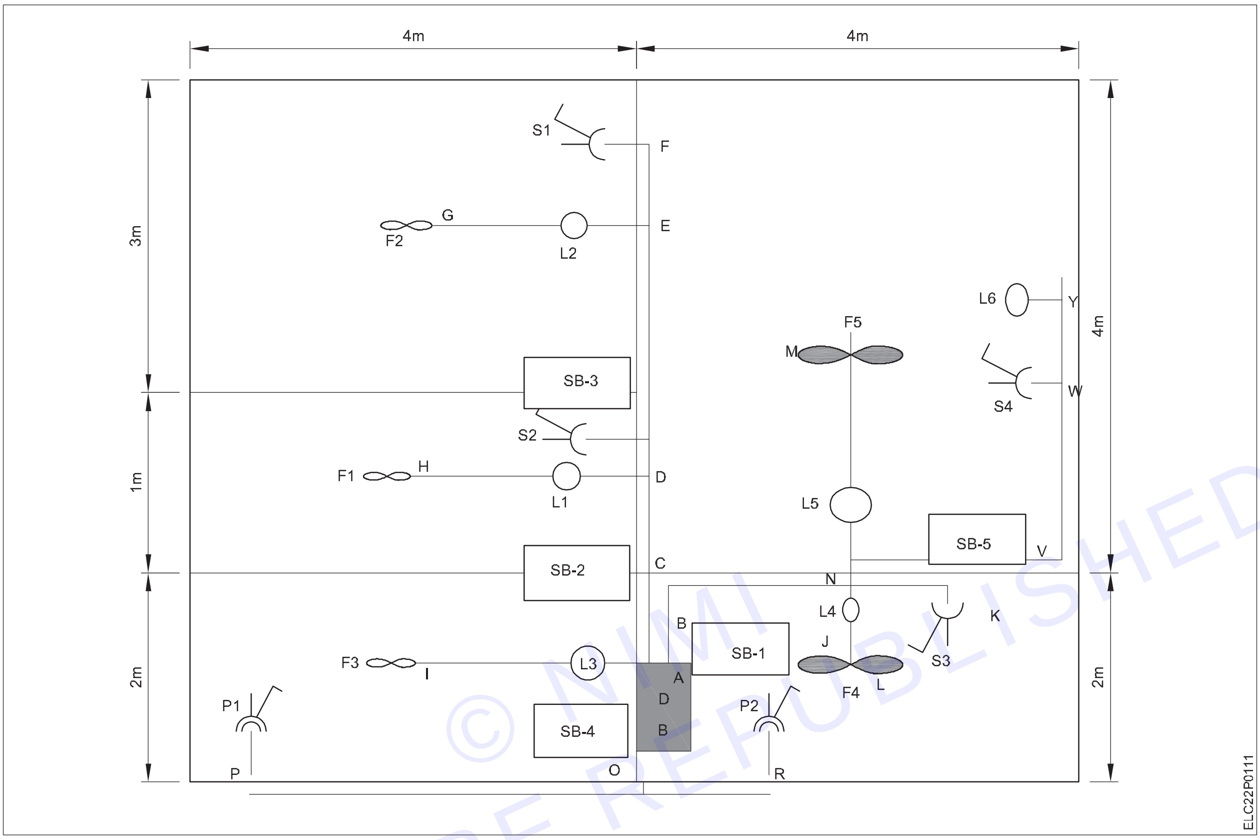
Total 16 Nos = 3160W

2 Assign number of subcircuits to for the load given in the plan

DISTRIBUTION BOARD →

- SUB CIRCUIT = L1, L2, F1, F2, S1, S2
- SUB CIRCUIT = L3, L4, L5, L6, F3, F5, F6, S3, S4
- SUB CIRCUIT = P1,P2

3 Prepare wiring layout diagram for customer approval



i current through subcircuit-1

(2 x 60) +(2 x 80) + (2 x 100)/230

=120+160+200=480

480/230=2.08Amp.

ii Current through subcircuit -2

(4 x 60) + (3 x 80) + (2 x 100)

= 240+240+200=680

680/230=2.95Amp.

iii Current through sub circuit 3

= 2000/230=8.696Amp.

Total current =2.08+2.95+8.696=13.726Amp.

16Amp,250V flush type DP main switch is sufficient

Length of conduit and cable

19 mm conduit can be used up to ABC length and for remaining length,12mm conduit in sufficient

Horizontal Runs

19mm conduit for length ABC = 1 m

19mm conduit for length at C (wall thickness) = 0.4 m

Total = 1.4 m

12 mm Conduit

Length CDEF (1 + 1.5+0.5)	= 3 m
Length Dh	= 2.0+0.4 m
Length EG	= 2.0+0.4 m
Length BJK	= (2+1) = 3.0 m
Length JNVWY (0.4+2+2+1)	= 5.4 m
Length JL	= 2.0 m
Length JN	= 0.4 m
Length NM	= 2.0 m
Length YL6	= 0.5 m
Length POR	= 4.0+1+0.4m
Total	**= 26.5 m**

Vertical down drops (horizontal run to SB's) :

19 mm conduit

Length A to SB-4	= 1.5M
Length D to SB-2	= 1.5M
Length E to SB-3	= 1.5M
Length J to SB-1	= 1.5M
Length N to SB-5	= 1.5M
Length A to roof	= 0.5M
Length D to roof	= 0.5M
Length E to roof	= 0.5M
Length N to roof	= 0.5M
Length J to roof	= 0.5M
Total	**= 10 M**

Total 19 mm conduit required	= 1.4+10=11.4 m
Total 12mm conduit required	= 26.5M
Wastage10%	= 2.65M
Total	= 29.15 Take (30 M)

Cable for (power) sub circuit -3 (1/1.8mAl) = 3 x (4+1+1.5+1.5) = 21M

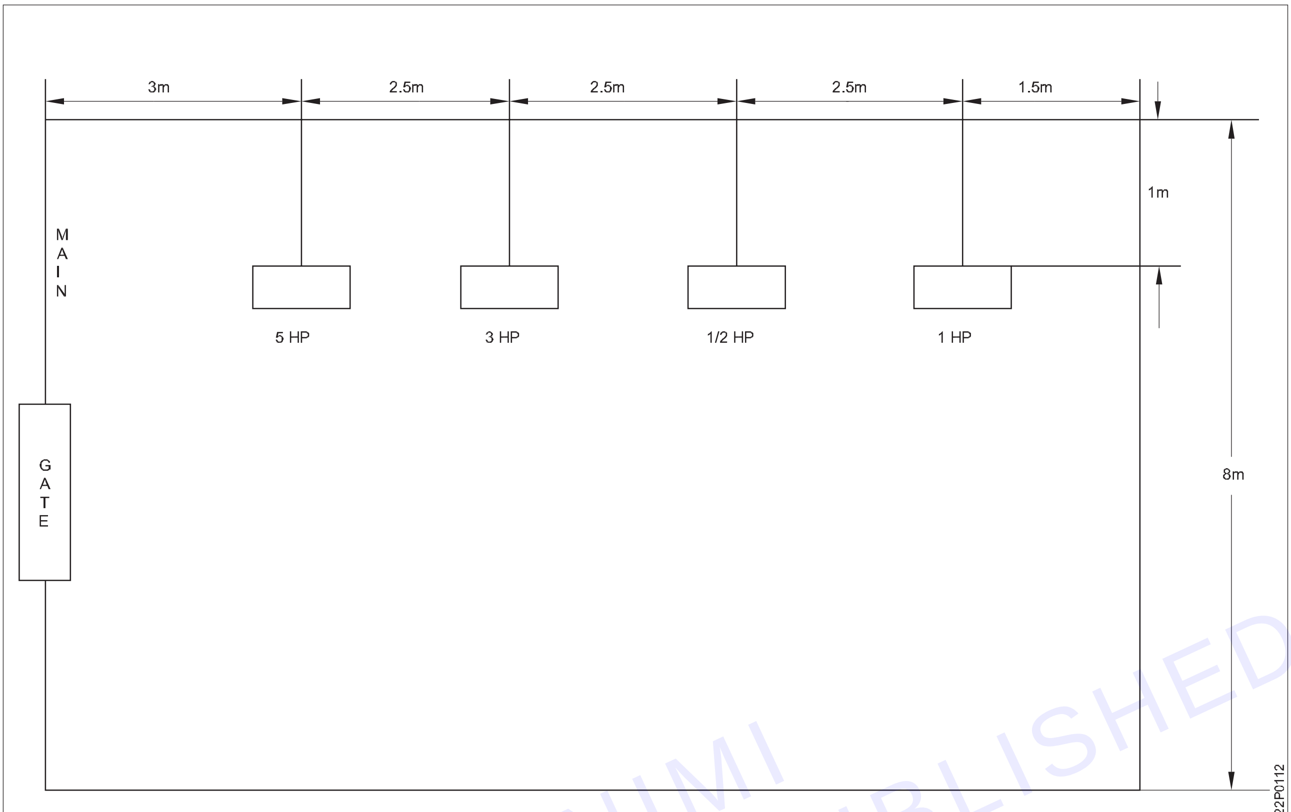
Cable for Subcircuit 1&2 (1.0sq mm copper)

3 x (6+10+26.5) = 127.5M

Meter Board	= 2 points
Distribution board	= 2 points
Light/Fan	= 15 Points
Power	= 2 Points
Total	**= 21 points**

Sl.No	Material specification	Quantity	Rs.ps.	Per	Rs.Ps.
1	D.P main switch 10 A, 240 v flush type	1 No	………	Each	………
2	I.C cut out 16A,240 v	1 No	………	Each	……..
3	Flush type fuse unit16 A	1No	………	Each	……..
4	Flush type fuse unit 6 A	2 Nos	……..	Each	……..
5	PVC conduit 19 mm(heavy guage)	2m	………	Length	……..
6	PVC conduite 12mm (Heavy guage)	27m	………	Length	……..
7	1.0 Sq.mm multistrand copper, VIR cable	128m	………	100m	……..
8	1/1.8mm aluminium VIR cable	21m	………	100m	……..
9	1/1.8mm copper VIR cable	2m	………	100m	……..
10	switches 6A,240 V with switch and neon	15Nos	………	Each	……..
11	2-Pin sockets 6A,240 V	4Nos	………	Each	………
12	3-Pin socket 16 A. 240 V with switch And Neon	2Nos	………	Each	………
13	Ceiling Rose 2-plate 6A 240 V	5Nos	……..	Each	……..
14	Lamp Holders brass batten type	6Nos	……..	Each	……..
15	PVC junction boxes 25 mm 4 way	2Nos	……..	Each	……..
	PVC junction boxes 12 mm 3 way	5Nos	……..	Each	……..
	PVC junction boxes 12 mm 2- way	2Nos	……..	Each	……..
16	PVC bend 12 mm	2Nos	……..	Each	……..
17	PVC reducer(25mm To 12 mm)	1No	……..	Each	……..
18	Saddles 25 mm	24Nos	……..	Doz	……..
	Saddles 12 mm	144Nos	……..	Doz	……..
19	wooden Board (a)30*30cm	2Nos	……..	Each	……..
	Wooden Board (b)18+10cm	7Nos	……..	Each	……..
20	Round Blocks	5Nos	……..	Each	……..
21	Wooden Gutties /plugs 9cm*4cm*50 cm	3Doz	……..	Doz	……..
22	Nails 25mm	1Kg	……..	Kg	……..
23	Wooden Screw 60mm	25 Nos	……..		……..
	Wooden Screw 12 mm	25 Nos	……..		……..
24	Copper wire (16 SWG) For Earth (GI WIRE 14 SWG)	1Kg	……..	Kg	……..
25	Earth set (Pipe, Salt, Coal	1Kg	……..	Kg	……..
26	Cement	2Kg	……..	Kg	……..
27	Labour Cost		……..		……..
	Total				
	Contingency 10%				
	Grand Total				

TASK 2: **Estimate the cost / bill of materials for wiring of industrial installation / workshop**



FLOOR PLAN

The main switch, motor switch and starters are assumed to be mounted at a height of 1.5m from the ground level.

Height of horizontal run from the ground level will be 2.5m

The cost of motors and starters are not included in the estimate

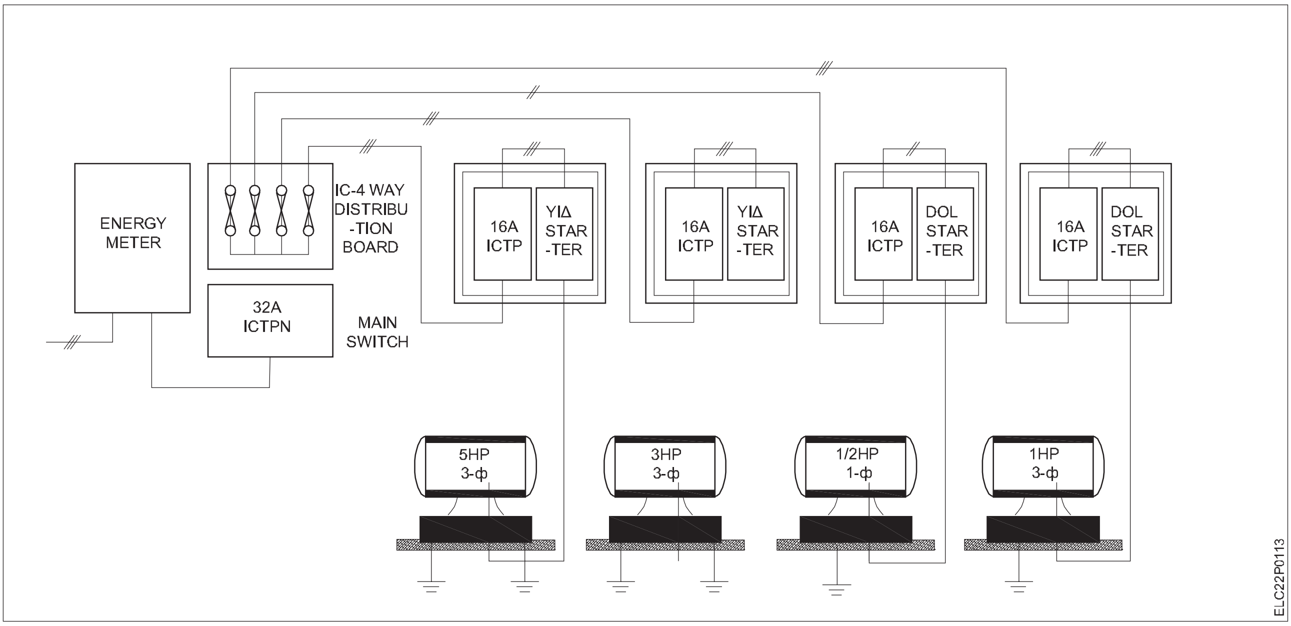
SL. No.	Motor	FL current IL(A)	Starting current I8=2IL(A)	Recommended Cable size
1	5HP Motor	7.5	15	2.0 Sq mm copper conductor cable (17A) or 2.5Sq mm Aluminium Conductor Cable (16)A
2	3 HP Motor	4.68	9.36	2.0Sq mm Copper conductor cable (17A)
3	1/2 HP Motor	2.25	4.5	1.0Sq mm Copper conductor cable (11A) Minimum recommended Cable
4	1 HP Motor	1.56	3.12	1.0Sq mm Copper conductor cable (11A) Minimum recommended Cable

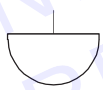
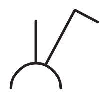
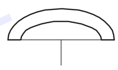
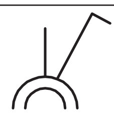
Select the suiTable switches and distribution board

- 32 A,415V ICTP switch with fuse cab be used as main switch
- 16A, 415V ICTP switches with fuses can be used form 5HP , 3HP , & 1HP motors
- 16 A , 240V ICDP Switches with fuses can be used for ½ HP motor
- 415V, 4 Way,16A per way ic distribution board with Natural link can be used for power distribution.

Draw the single line diagram of power wiring

Calculate the size and length of conduit.



Name	Present Symbol	Correct
F1, F2,F3,F4 F5		
S1 TO S4		
P1 , P2		

19 mm heavy guage conduit should be used for 3 cable runs and 25mm heavy guage conduits should be used for 6 cables runs.

- 19mm heavy gauge conduit

  Length from main board of 5HP motor starter = 1+1+3+1 = 6.0m

  Length from main board to 3HP motor starter = 1+1+5.5+1=8.5m

  Length from main board to ½ HP motor base = 1+1+8+1+1.5+1.5=14m

  Length from main board to 1HP motor base = 1+1+10.5+1+1.5+1.5=16.5

  Total = 45.0m

  10% wastages = 4.5m

  Total length = 49.5m,(Take 50M)

- 25.4mm heavy gauge conduit.

  Length from meter to main switch = 0.75

  Length from 5 HP motor starter to 5HP motor base(1.5+1.5) = 3.0 m

  Length from 3HP motor Starter to motor base = 3.0m

  Total = 6.75m

10%Wastage = 0.67m

Total = 7.45m, (Take 8.0m)

- 25mm flexible conduit for 5HP&3HP motor (0.75+0.75) =1.5(Take 2M)

Calculate the length of cables

2.0Sq mm copper conductor from main board to 5HP motor terminals = 3(1+1+3+1)+6(1.5+1.5+0.75)40.5m

15%Wastages&end connections = 7.2m

Total = 55.2m, (Take=56.0m)

1.0Sqmm copper conductor from main board to ½ HP motor terminals =2(1+1+8+1+1.5+1.5+0.75)=29.5M

15% wastages & end connections = 7.76m

Total 59.51m, (Take=60.0m)

Calculate the labour cost as per the local rare and rules for calculating number of points.

Prepare Schedule of material and cost as shown in Table

Sl.No	Specification of materials	Quantity	Rs.ps.	Per	Rs.Ps
1	32A,415V-Iron-clad triple-pole(ICTPN) witch with fuse	1No	……..	Each	……..
2	16A,415V,Iron-clad triple-pole Switch with fuses	3 Nos	……..	Each	……..
3	16A,415V,Iron-clad double-pole Switch with fuses	1 No	……..	Each	……..
4	4-way Distribution box,415v,16A	1 No	……..	Each	……..
5	Conduit heavy gauge …………..19mm	50m	……..	m	……..
6	Conduit heavy gauge ………..….25mm	8m	……..	m	……..
7	Flexible conduit………………..…..19mm	2m	……..	m	……..
8	Flexible conduit………………..…..25mm	2m	……..	m	……..
9	2.0Sq mm copper conductor single core(17A)	47m	……..	100m	……..
10	1.0Sq mm copper conductor single core(11A)	56m	……..	100m	……..
11	1.0Sq mm copper conductor single core(11A)	34m	……..	100m	……..
12	1.0Sq mm copper conductor single core(11A)	60m	……..	100m	……..
13	Angle Iron Frame50*30m	5 Nos.	……..	Each	……..
14	Conduit bends……….…..…19mm	10Nos.	……..	Each	……..
15	Conduit bends…………….....25mm	2Nos.	……..	Each	……..
16	Saddles………………………….19mm	150 Nos.	……..	100	……..
17	Saddles……………………..……25mm	25 Nos.	……..	100	……..
18	Conduit couples…………….19mm	6Nos.	……..	Each	……..
19	Conduit couples…………….25mm	1 No	……..	Each	……..
20	wooden gutties	120 Nos.	……..	doz	……..
21	Earth wire,GI,8 SWG	40m	……..	Kg	……..
22	Lugs For Connecting Leads to motors	17 No.	……..	Each	……..
23	Earthing Pipe perforated 25.4mmDia	2.5 m	……..	m	……..
24	Coal	40 Kg	……..	Kg.	……..
25	Salt	40 Kg	……..	Kg.	……..

26	Funnel With wire mesh	1 No	……..	Each	……..
27	Lavour charge For Earthing (Civil Work)	2 Nos.	……..	Pit	……..
28	Caution plate	1 No	……..	Each	……..
29	Nails 25.4 mm	2		Kg.	……..
30	Shock treatment chart	1	……..	Each	……..
31	Labour cost	-	……..	Point	……..
	Total	…….	……..	……	……..
	Contingency 10%	…….	……..	……	……..
	Grand Total	…….	……..	……	……..
	Say	…….	……..	……	……..

MODULE 16: Generation Transmission and Distribution

EXERCISE 106 : Visit and Prepare layout plan/ single line diagram of the Thermal /Hydro /Nuclear power plant

Objectives

At the end of this exercise you shall be able to:

- visit and prepare layout plan of thermal power plant and identify the various stages in the plant
- visit and prepare layout plan of hydel power plant and identify the various stages in the plant
- visit and prepare layout plan of nuclear power plant and identify the various stages in the plant.

Procedure

1 Visit the stages of a thermal power plant i.e.

a Coal and ash handling arrangement

b Steam generating plant

c Steam turbine

d Alternator

e Feed water supply

f Cooling arrangement

2 Identify the following constituents of a steam generating plant and write down their functions in Table 1.

Table 1

Constituents	Type	Function
Boiler		
Super heater		
Economizer		
Air pre-heater		
Turbine		
Condenser		
Cooling tower		
Water treatment chamber		

3 Trace the various parts of alternator and note down the name plate details in Table 2.

Table 2

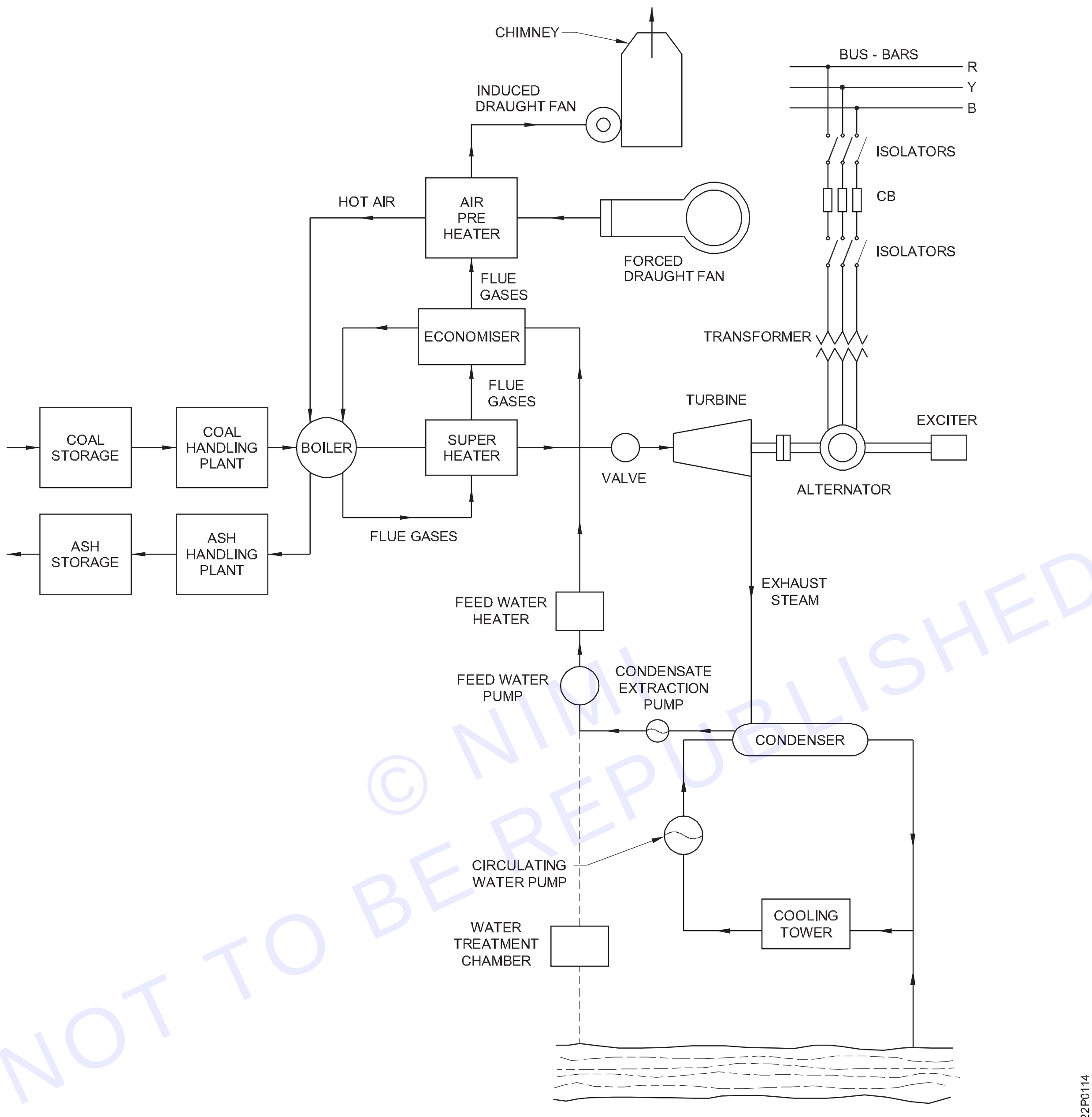
No.of phase ________________	Single / three
Capacity __________________	KVA / MVA
Speed ________________________	RPM
Output voltage ________________	Volt
Current ________________________	Amp.
Frequency ____________________	Hz
Excitation current ______________	Amp.
Sl.No__________________________	
Year of Manufacturing____________	
Model No ______________________	

4 Draw the schematic diagram of thermal power station you visited in your record and get checked by your instructor.

Model schematic diagram of a thermal plant given in Fig 1 for general guidance to trainees. The trainees have to prepare and draw the schematic diagram of the plant they visited.

5 Note down the main step-up transformer specification and the type of cooling arrangements

6 Draw the schematic diagram of thermal power station



SCHEMATIC ARRANGEMENT OF STEAM POWER STATION

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TASK 2:

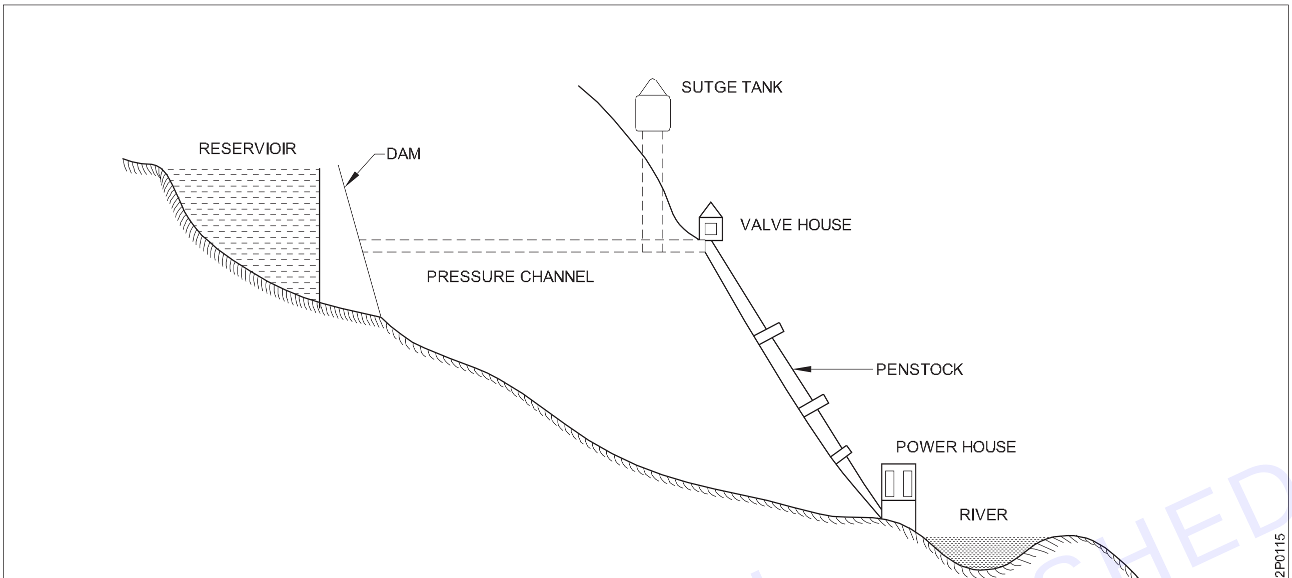
1 Visit the stages of a hydro-electric power plant i.e. (1) Hydraulic structures (2) Water turbines (3) Electrical equipment.

2 Identify the following stages of a hydro-electric plant and write down their functions.

Table 1

Constituents	Type	Function
Dam		
Spill ways		
Head works		
Surge tank		

Pen stocks		
Tail race		
Draft tube		
Turbine		



SCHEMATIC ARRANGEMENT OF A HYDRO-ELECTRIC PLANT

3 Trace the various parts of alternator and note down the name plate details in Table 2

4 Draw layout of hydro-electric power plant visited. refer Fig 2 for guidance.

Table 2

No.of phase ________________ Single / three

Capacity __________________ KVA / MVA

Speed ______________________ RPM

Output voltage ______________ Volt

Current ____________________ Amp.

Frequency __________________ Hz

Excitation current _____________ Amp.

Sl.No_______________________

Year of Manufacturing__________

Model No ____________________

TASK 3:

1 Visit the stages of a nuclear power plant.

2 Identify the following stages of a nuclear power plant and write down their functions in Table 3.

Table 3

Constituents	Function
Containment building/ Nuclear reactor	
Heat exchanger	
Steam turbine	

Condenser	
Cooling tower	
Containment structure	
Steam generator	
Generator transformer	
Feed water pumps	
Alternator	

3 Trace the various parts of alternator and note down the name plate details in Table 4.

Table 4

No.of phase ________________ Single / three

Capacity __________________ KVA / MVA

Speed _____________________ RPM

Output voltage ______________ Volt

Current ____________________ Amp.

Frequency __________________ Hz

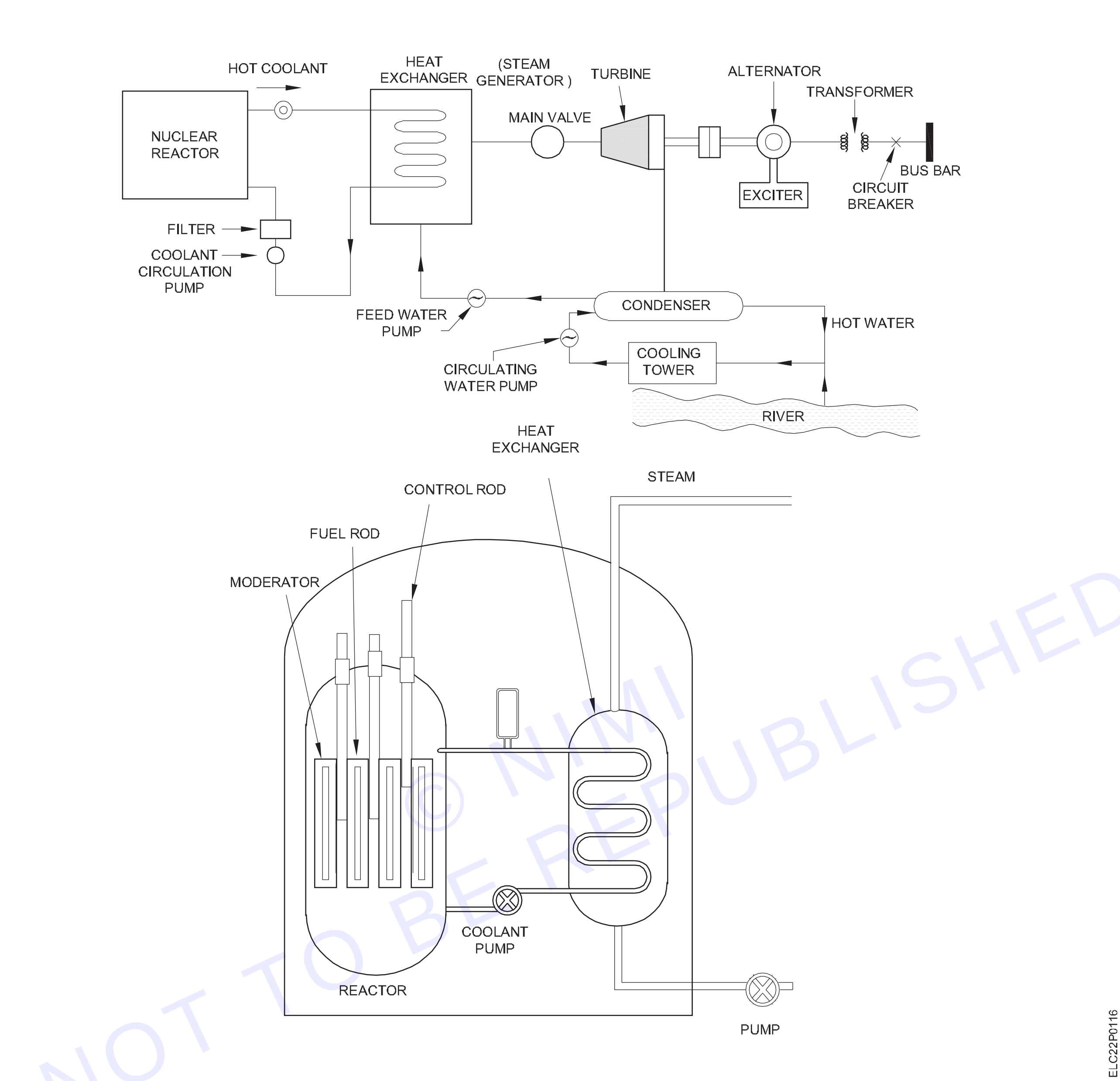
Excitation current _____________ Amp.

Sl.No______________________

Year of Manufacturing__________

Model No ___________________

4 Draw layout plan of nuclear power plant and the reactor. (typical scheme is given below for directions Fig 3a and Fig 3b)


HOT COOLANT
HEAT EXCHANGER
(STEAM GENERATOR)
TURBINE
ALTERNATOR
TRANSFORMER
NUCLEAR REACTOR
MAIN VALVE
BUS BAR
EXCITER
CIRCUIT BREAKER
FILTER
COOLANT CIRCULATION PUMP
CONDENSER
FEED WATER PUMP
HOT WATER
COOLING TOWER
CIRCULATING WATER PUMP
RIVER
HEAT EXCHANGER
STEAM
CONTROL ROD
FUEL ROD
MODERATOR
COOLANT PUMP
REACTOR
PUMP
ELC22P0116

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EXERCISE 107 : Prepare layout plan for non-conventional power plant

Objectives

At the end of this exercise you shall be able to:

- prepare lay out of wind power plant
- prepare layout of biomass power plant
- prepare layout of small hydro power plant.

Requirements

Materials

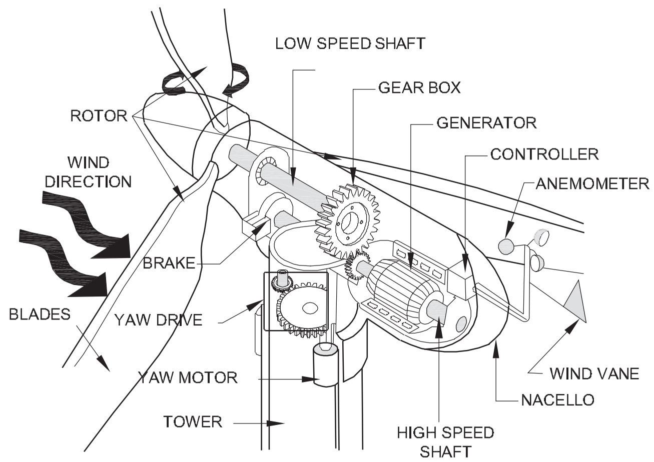
- Drawing sheet - 1 No.
- Pencil HB - 1 No.
- Eraser - 1 No.
- Scale - 300 mm - 1 No.

Procedure

TASK 1:

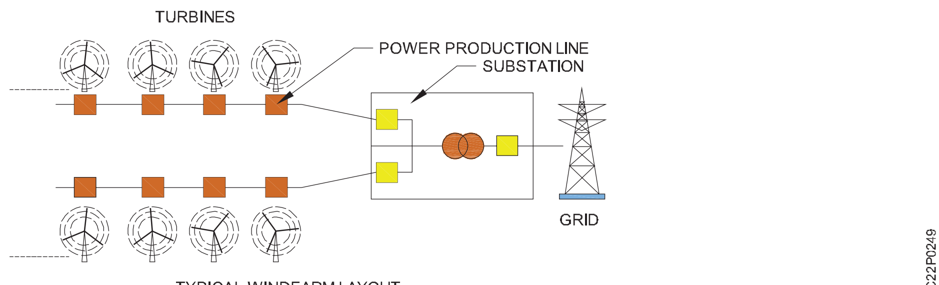
Location name / state	
Installed capacity od plant	
No of wind turbines	
No of blades	
Capacity of wind turbine	
Type of mounting of turbine	
Generation voltage	
Capacity of generator transformer	
Rated rpm	
Length in meter of base dia, height, blade length	
Wind speed range in operation	
Blade material	

1 Record the power plant details



COMPONENTS OF A HORIZONTAL AXIS WIND TURBINE

ELC22P0117



TYPICAL WINDFARM LAYOUT

2 Prepare layout of wind power plant. (picture of wind machine I given in Fig1)

SL.No	Description	Function / spec
1	Gear box	
2	Wind vane	
3	High speed shaft	
4	Low speed shaft	
5	Yaw motor	
6	Nacelle	
7	Anemometer	
8	Blade	
9	Pitch	
10	Type of generator (Synchronous/Asynchronous)	
11	Brakes (types)	

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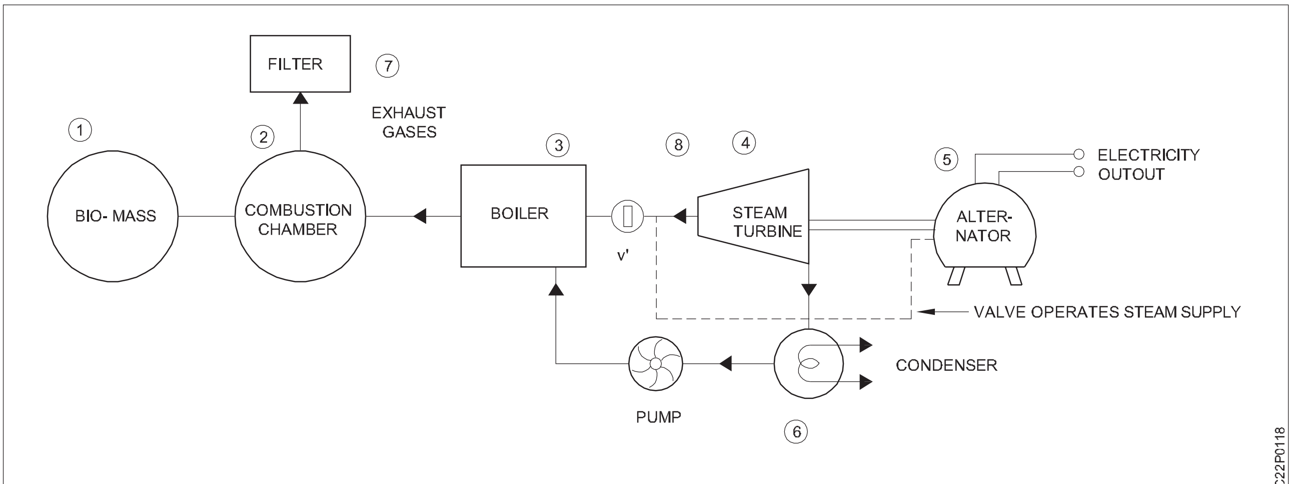
Write the function of the following components in wind power plant

TASK 2:

Location name / state	
Installed capacity of plant	
Type of biomass plant	
No of boilers	
Capacity of generator transformer	
Capacity of fuel feeder	
Emission control methods	
Ash handling details	
Cooling unit	

1 Record the biomass power plant details



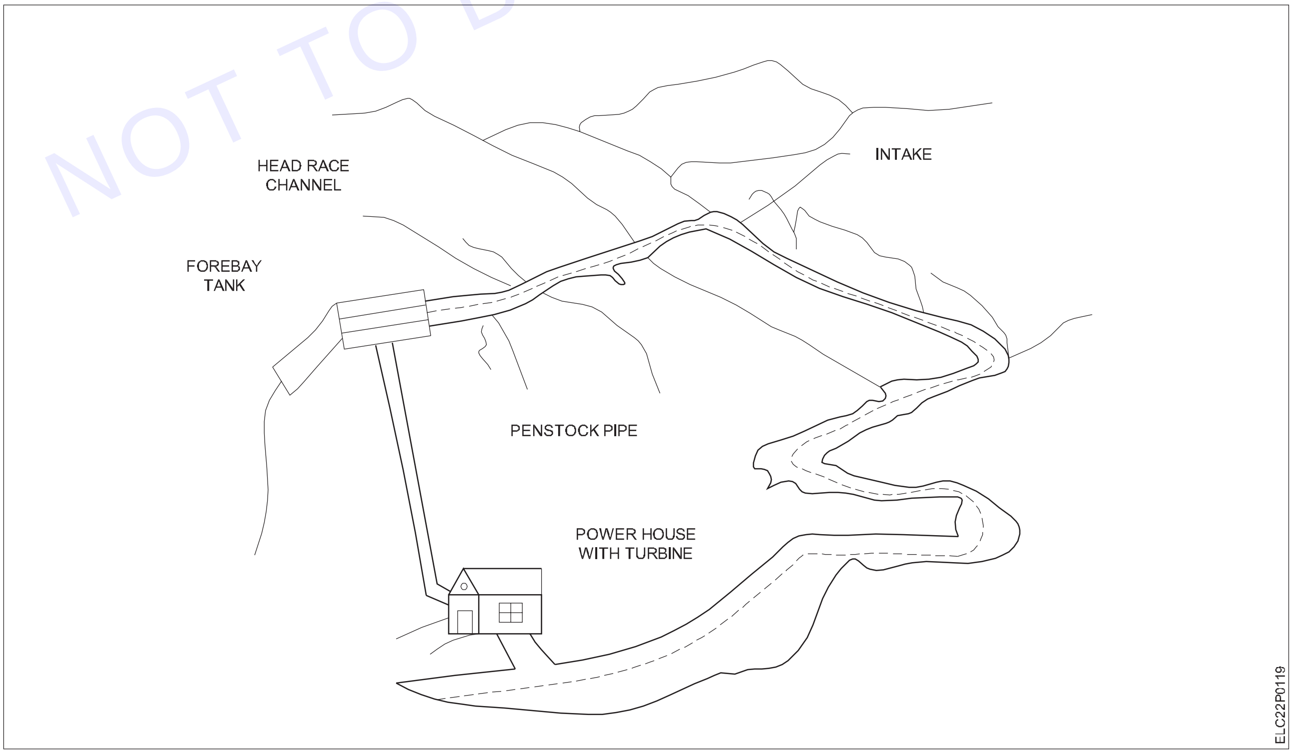
BLOCK DIAGRAM OF BIO-CHEMICAL BASED (BIO-GAS) POWER PLANT

2 Draw the block diagram of visited biomass power plant.

SL.No	Description	Function / spec
1.	Types of biomas material	
2.	Combustion chamber	
3.	Boiler	
4.	Steam turbine	
5.	Condenser	
6.	Alternator	

3 Write the function of the following components in wind power plant

TASK 3;



1 Draw layout of small hydro power plant

2 Record the power plant details

Location name / state	
Installed capacity of plant	
Capacity of generator transformer	
Height above MSL	
Type of turbine	
No of alternators available	

3 Record the biomass power plant details

4 Write the function of the following components in wind power plant

SL. No	Description	Function / spec
1	Penstock	
2	Head	
3	Reaction turbine	
4	Generator transformer	

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EXERCISE 108 : Prepare layout plan and identify different elements of solar power system

Objectives

At the end of this exercise you shall be able to:
- prepare layout plan of off grid solar power plant.
- identify different elements of off grid solar power plant.
- prepare layout plan of on grid solar power plant.
- identify different elements of on grid solar power plant

Requirements

Materials

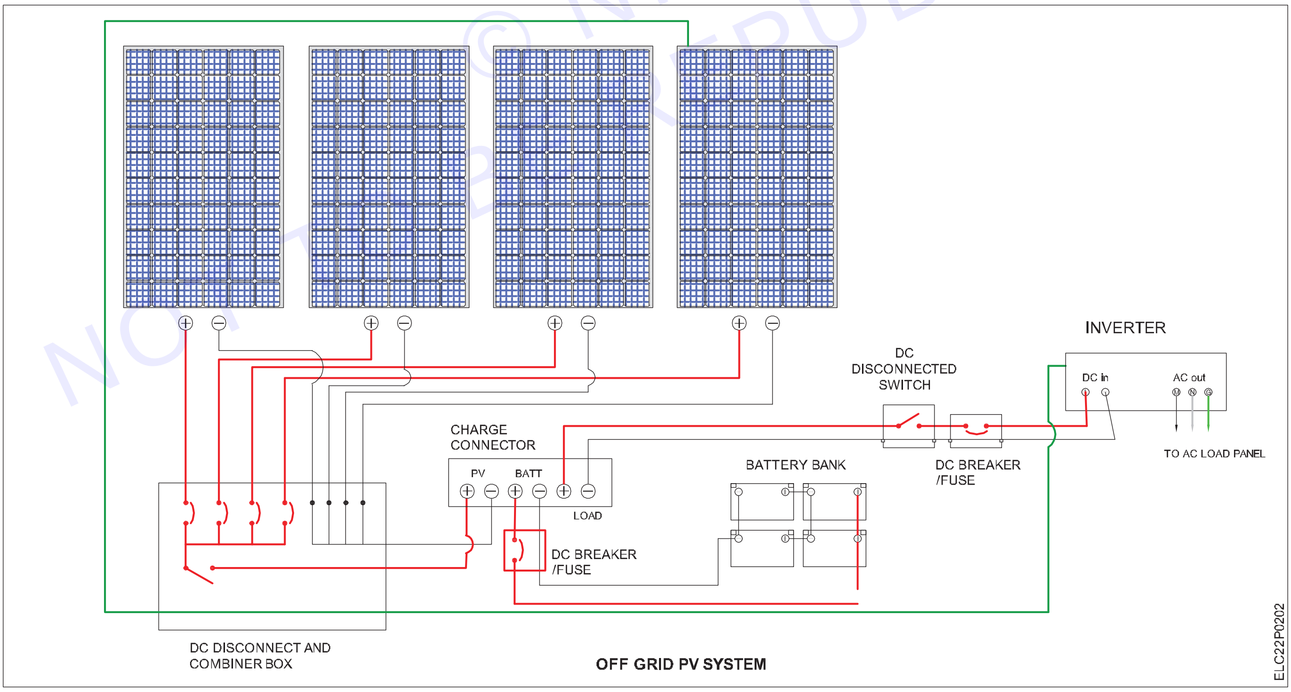
- Drawing sheet - 1 No.
- Pencil HB - 1 No.
- Eraser - 1 No.
- Scale - 300 mm - 1 No.

Procedure

TASK 1: **Prepare layout plan and identify the components of an off grid solar power plant and prepare layout**

1 Prepare the layout of the off grid solar power plant. (A guideline picture is given in Fig 1)

2 Write the specifications of the following components



Component	Specification
Solar panels	
Inverter	
Charge controller	
Battery bank	

— — — — — —

TASK 2:

Identify the following Balance Of Systems of solar power plant fill the following Table

Table 1

Components	Specification	Function
DC cable		
AC Cable		
Connectors		
DC Disconnects		
AC Disconnects		
DC combiner box / AJB		
Surge Protection Device AC		
Surge Protection Device AC		
Fuses		
AC Circuit breaker		
DC circuit breaker		
Lightning arrester		
Earthing		
Energy meter		
mounting structure		

— — — — — —

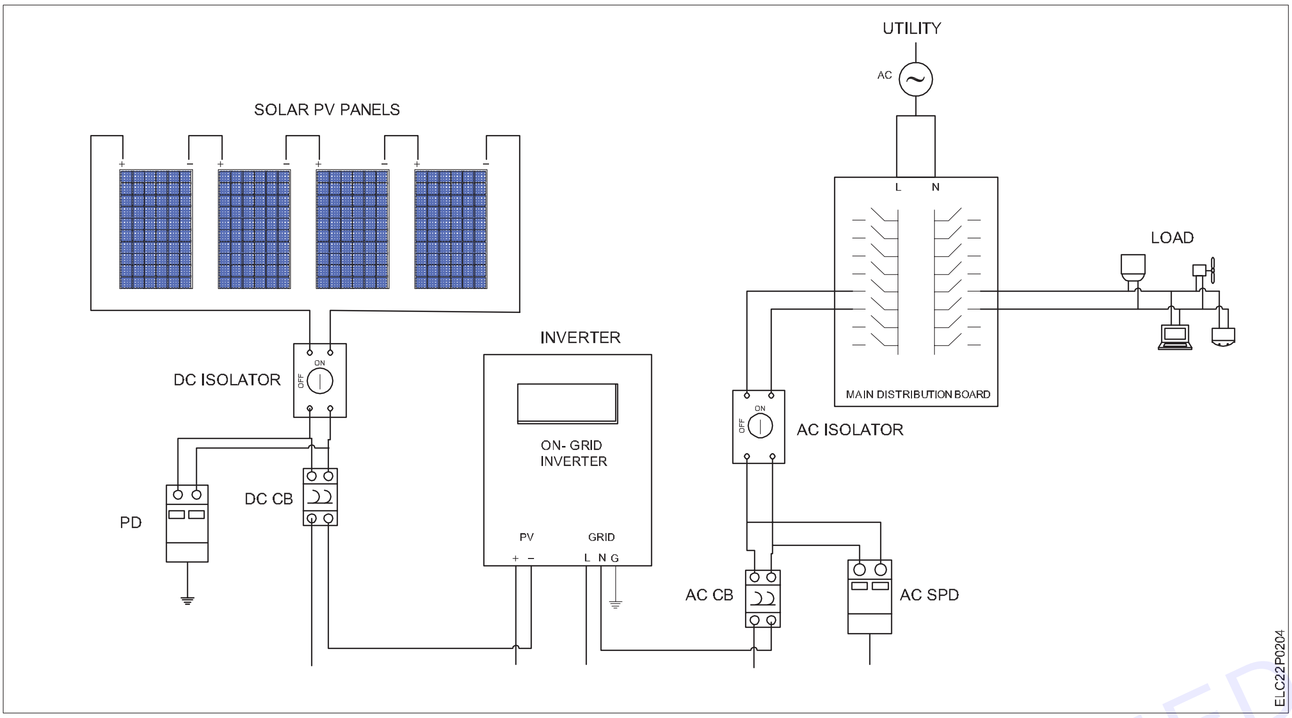
TASK 3:

Identify the components of an on grid solar power plant and prepare layout

1 Write the specifications of the following components

Typical layout of ongrid Solar plants

Component	Specification
Solar panels	
Inverter(Power Conditioning Unit)	
Bi Directional Meter (Net meter)	
Battery bank	



TASK 4:

Identify the following Balance Of Systems of solar power plant fill the following Table

Table 1

Components	Specification	Function
DC cable		
AC Cable		
Connectors		
DC Disconnects		
AC Disconnects		
DC combiner box / AJB		
Surge Protection Device AC		
Surge Protection Device AC		
Fuses		
AC Circuit breaker		
DC circuit breaker		
Lightning arrester		
Earthing		
Energy meter		
mounting structure		

EXERCISE 109 : Assemble and connect solar panel for illumination

Objectives

At the end of this exercise you shall be able to:

- draw the connection diagram
- connect the components as per the diagram
- record the charging current and voltage.

Requirements

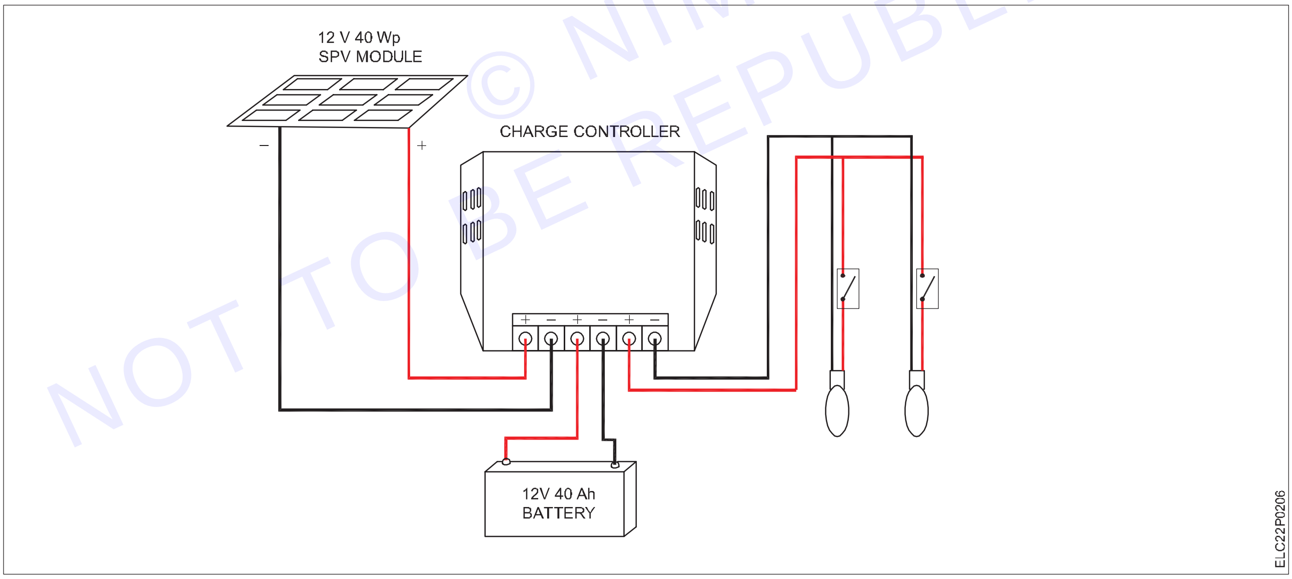
Tools/Equipments/Instruments

- PWM charge controller rated (12V, 5 A)
- Battery (12V, 40 Ah)
- Solar panel (40WpW)
- Wired illumination load DC, 12V lamps of 5W – 3nos
- DC cable 4mm2 – 10m

Procedure

TASK 1:

1 Draw the block diagram Fig 1.



2 Record the name plate details of the PWM charge controller, Battery, Solar panel and Load.

Sl. No	Description	Value
Charge controller		
1.	Make	
2.	Maximum Current Output	
3.	Nominal Battery Voltage	
4.	PV Open Voltage	
5.	Maximum PV Array Power under STC	
6.	Technology: PWM / MPPT	
7.	MPPT Voltage Range (For MPPT Controllers)	
Battery		
1.	Make	
2.	Battery Type: Lithium-ion / Lead-acid/Lithium iron phosphate (LiFePO4)	
3.	Capacity (Ah)**:	
4.	Voltage	
5.	C rating	
Solar panel		
1.	Make	
2.	Type: Mono /Poly /PERC	
3.	Voltage at Maximum Power Point (Vmpp):	
4.	Current at Maximum Power Point (Impp):	
5.	Dimensions and Weight	
6.	Open circuit voltage Voc	
7.	Short Circuit current Isc	

— — — — — —

TASK 2:

1 Mount the solar panels with orientation to south and with inclination angle equivalent to latitude of the location

2 Wire the charge controller to battery first and then the solar panel through disconnect switch as per the terminals provided in charge controller

3 Keep the switch in OFF position.

4 Inspect the connections.

— — — — — —

TASK 3:

1 Switch On the circuit.

2 Demonstrate illumination of the load.

3 Note the voltage and currents at panel side and load side of charge controller with different load conditions in Table 1

4 Observe the variation of current with variation of panel mounting angle.

9 Observe the variation of current with variation of panel mounting angle

Table 1

Sl.No	Current at panel side	Panel voltage	Battery charging current	Tilt angle	Load current

— — — — — —

EXERCISE 110 : Identify different types of insulators and binding insulators, fix jumper by crimping tool

Objectives

At the end of this exercise you shall be able to:

- identify the type of HT/LT line insulators
- install insulator and bind it
- fix jumper using crimping tool.

Requirements

Tools/Equipments/Instruments

- Insulated combination plier 200 mm -1No.
- DE spanner set 6mm to 25 mm -1Set.
- AdjusTable spanner 6mm to 25 mm -1Set.
- Safety belt -1No.
- Wooden or nylon mallet 1/2 kg -1No.
- Ladder 6m long -1No.
- Jute rope of 25 mm dia and 15 m length -1No.
- Wire stretcher 25 mm -1No.
- Megger 500 V -1No.

Materials/Components

- Shackle insulator, porcelain 1kV -4No's.
- Pin insulator, porcelain 1kV -4No's.
- Suspension insulator -1No.
- Strain insulator -1No.
- Ring insulator -1No.
- Stay/egg insulator -1No.
- Cotton waste -as reqd.
- Binding wire 14 SWG aluminium -as reqd.
- Scrap piece of ACSR conductor of length 1m (for bow) -3 Pieces.
- Sandpaper or emery sheet -as reqd.
- Flat aluminium tape -as reqd.
- Protective grease suiTable to apply over the ACSR line conductor -as reqd.
- Line accessories -as reqd.

Procedure

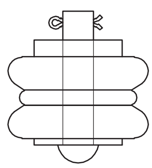
TASK 1: **Identify the LT and HT types of insulators**

1 Identify the LT and HT type line insulators from Figures 1 to 6.

Fig 1

PIN INSULATOR

Fig 2



SHACKLE INSULATOR

Fig 3

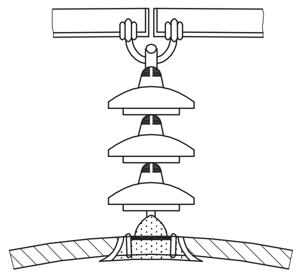


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Fig 4a

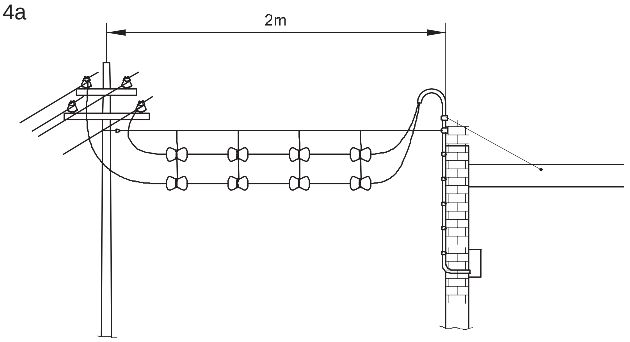

Fig 4b

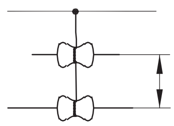

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Fig 5

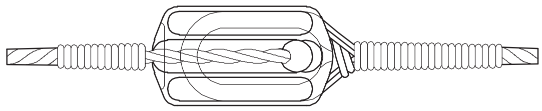
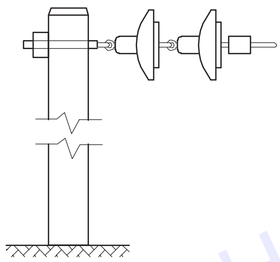


Fig 6



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2 Write their names with voltage range and purpose in Table 1.

3 Get it checked with your instructor.

Table 1

Sl.No	Name of the Insulator	Voltage range	Purpose of insulator
1			
2			
3			
4			
5			
6			

— — — — — —

TASK 2: **Install the shackle insulator in HT**

Shutdown if the nearest lines are energised. Use a safety belt while working on a pole.

Before starting the work check the ladder, safety belt and all the connected accessories.

1 Fasten the safety belt, lay the ladder on the pole.

2 Release the conductor from the reel, measure the actual span plus sag and binding. Keep two lengths of conductor. (Length of span + 1ft. Sag)

3 Check the shackle insulator for its damage and select a good one. (Clean and carbonize etc.)

4 Check the assembly of the shackle insulator for its proper fitting.

5 Ask the helper to hold the ladder, climb up the ladder with the guide rope and spanner set.

While working on the ladder, the ladder should be held by a helper to avoid slipping.

6 Position yourself conveniently on the cross-arm, tie the safety belt end to the cross-arm. Send one end of guide rope to the helper and ask him to tie to the shackle assembly and lift it to the top.

7 Fix the shackle insulator to the cross-arm by ‘C’ clamps. (Fig 1)

8 Get the draw pulley from the ground and secure it on the cross-arm. Interlace the rope through the pulley and send the other end to the helper.

9 Ask the helper to properly tie the O.H. conductor to the rope and lift the conductor to the cross- arm position.

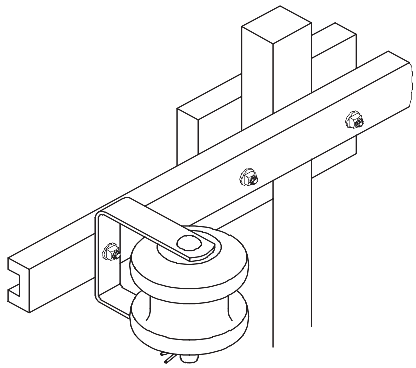
While lifting the conductor both the end conductors should be lifted at a time first, and then middle conductors to avoid the fitting of the cross-arm.

While tying, the conductor to the rope the helper should leave atleast 1 metre length of conductor free at the end from binding.

10 Twist the end portion of the conductor over the main line conductor. (Fig 2)

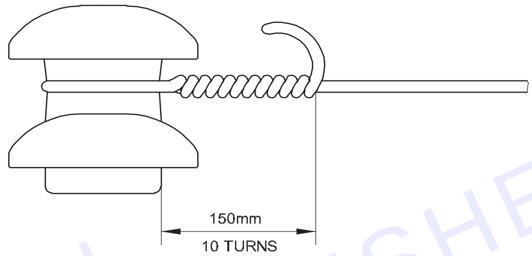
11 Bind the shackle insulators with the one fixed at the last cross - arm

Fig 1



SHAKLE INSULATOR MOUNTED IN A "C" CLAMP

Fig 2



BINDING OF A SHACKLE INSULATOR

ELC22P0210

Ground clearance of overhead conductor should not be less than 4.572 m for low and medium voltage.

12 Get down from the pole after checking the binding.

— — — — — —

TASK 3: **Install the pin type insulator in LT**

1 Climb the next pole following the previous procedure

2 Lift the conductor and keep it on the pin insulator. Ask the other helper to lift and stretch the conductor with wire stretcher.

3 Fix the pin insulator to the cross - arm of the existing pole.

If the span is less, there is no need to use a draw pulley, pulling with the help of a rope is sufficient.

4 Bind the pin insulators as per procedure.

The binding wire must be of the same metal as the line wire.

Binding should be mechanically strong.

Bind the free ends of the binding conductor over the line conductor tightly in the opposite direction. (Fig 3)

Alternatively the conductor can be placed in the side groove for binding the conductor with the pin insulator as in Fig 4.

Binding should be tight without any gap.

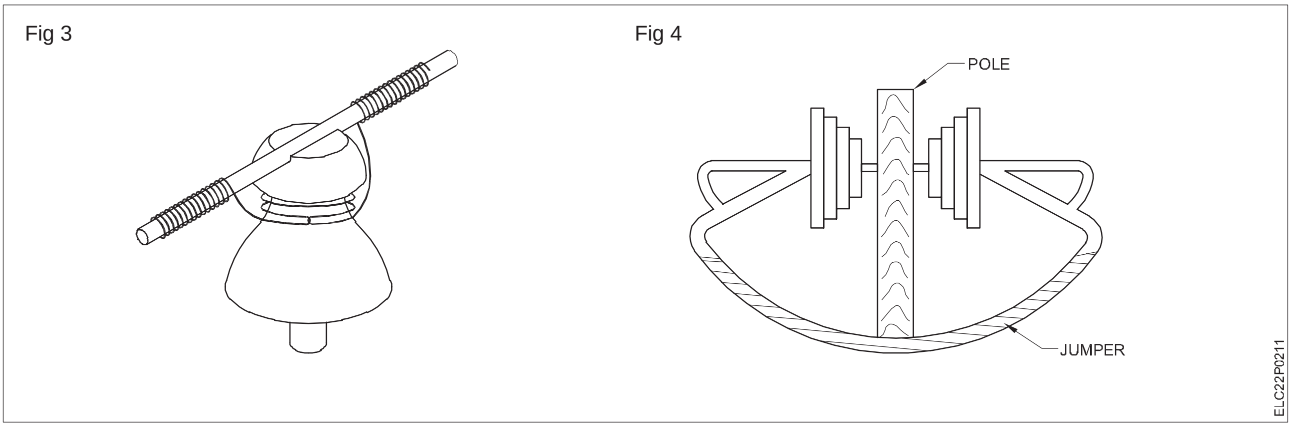
6 Complete the binding by giving about 15 turns on both sides.

7 Cut the extra binding wire and round off the raised ends.

8 Repeat the procedure for the other pin insulator by the side of the same cross arm.

Check the bindings before getting down. No tool and wire should be left on the cross-arm.

9 Test by a Megger of 500 Volt for insulation between conductors and insulation resistance between conductors and earth.



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TASK 4: **Fasten the jumper in pin insulator**

1 Keep the ladder on the pole and ask the helper to hold the ladder. climb up the ladder with the guide rope and spanner set.

2 Fix the pin type insulator to the cross-arm of the existing pole.

3 Tape the neck of the pin insulator with flat aluminium tape.

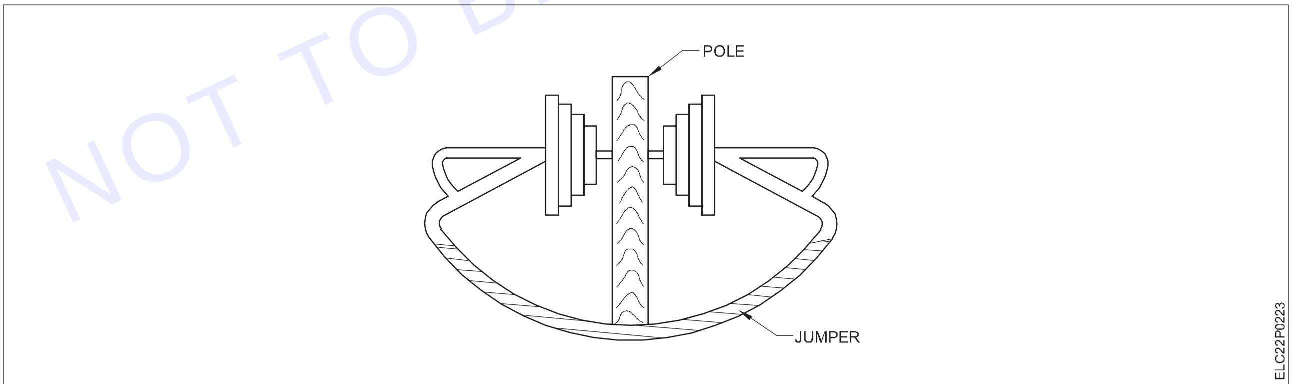
4 Lift the Aluminium Conductor Steel Reinforced (ACSR) conductor and keep it in between pole and the pin insulator.

5 Lay the ACSR wire on the slot of the pin insulator and ask the other helper to stretch the conductor with a wire stripper.

6 Take the binding wire of about 2 metres length, leaving equal length on both sides. Bind two turns on the insulation (Fig 1a) around the neck of the pin insulator.

7 Make a knot of the binding wire with the free ends tightly. (Fig 1b)

8 Bind the free ends of the binding conductor over the line conductor tightly in the opposite direction. (Fig 2)



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EXERCISE 111 : Check various joints in UG cables

Objectives

At the end of this exercise you shall be able to

- list the components for heat shrink cable joint of 440V 3 core cable
- Identify types of cable joints
- carry out cable joint in XLPE cable
- carry out end termination of XLPE cable.

Requirements

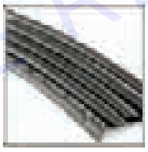
Tools/Equipments/Instruments

- Trainees tool kit - 1 No.
- Multimeter/ohm meter - 1 No.
- Knife - 1 No.
- Hack saw - 1 No.
- Heavy duty crimping tool - 2 Nos.
- 11kv XLPE cable armoured - 1 No.
- Cable joining kit for 11kV cable - 1 No.
  - Crimping type jointing ferrule.
  - Self-amalgamating insulating tapes.
  - Self-amalgamating semiconducting tapes.
  - Non-linear stress grading pads.
  - Earthing connector and clamps.
  - Plastic mould and jointing compound etc.

Procedure

TASK 1 :

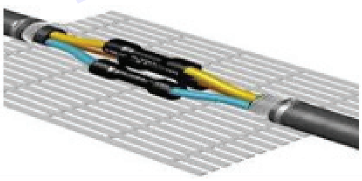
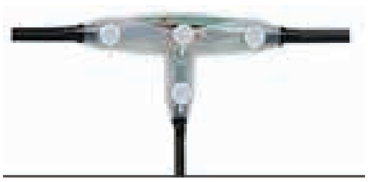
1 Identify the items and write the functions of components

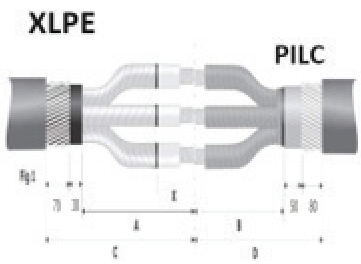
Sl.No	Item		Function
1	Heat shrink outer insulating tubes		
2	Canister		
3	Anti-tracking/ lug sealing tubes		
4	Stress Control Tubes		

5	Lugs / ferrule		
6	Cleaning solvent		
7	Worm clip		
8	Tinned copper braid		
9	Stress control mastic		
10	PVC insulation tape		
11	Black sealing mastic		

TASK 2 :

1 Match the Cable joint picture to Name of Joint

Sl.No	Cable joint	Name of joint
1		Tee/ branch joint
2		Simple straight through
3		Transition joint

4		Termination joint

TASK 3: **Join 11 kV XLPE cable**

1 Identify the accessories

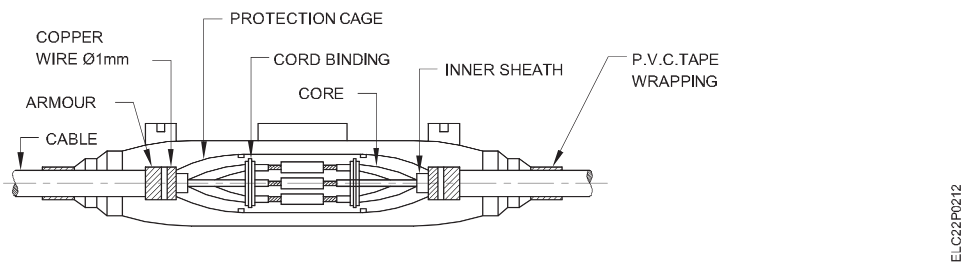
- Crimping type jointing ferrule.
- Self amalgamating insulating tapes.
- Self amalgamating semiconducting tapes.
- Non-linear stress grading pads.
- Earthing connector and clamps.
- Plastic mould and jointing compound etc.

2 Cut the given cable to half, Strip the outer sheath, armour and inner sheath, insulation screen, core insulation and conductor screen.

3 Joint all the conductor cores shall be joint with the help of jointing ferrule and its crimping by suiTable crimping tool.

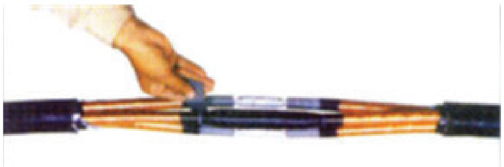
4 Fill up the space between the ferrule and the core insulation and the crimped portion in ferrule with semi conducting tape, so that it forms a smooth and round profile with 2 mm. Overlap on the insulation on each side of the ferrule as shown in Figure given below.

5 Apply stress grading pad of 30mm on both sides of the semiconducting for a distance of 20 mm tape.



6 Wrap the self-amalgamating insulating tape to build up insulation thickness keeping a gap of 5mm from the semi conducting layer of core, with a tapered profile of the tape towards the semi conducting layer of the insulation.

7 Wrap stress grading pad of 30mm width between the self-amalgamating insulating tape and semi conducting layer of core by about 5mm as shown in Figure given below.

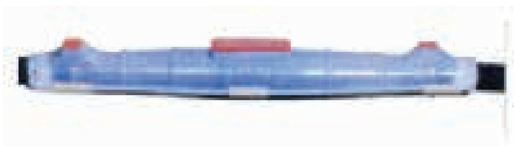


8 Apply semi conducting tape one layer half over lapped about 10mm on one side of metallic shielding to the other end in the same manner as shown in Figure given below.

9 Wrap 2 layers of self -amalgamating insulating tape-each half overlapped to cover the semi conducting tape. Stretch the tape 2/3rds of width while applying as shown in Figure given below.

10 Wrap one layer of copper wire mesh on the core to connect the copper tape from end to another over the tapes as shown in Figure given below.

11 Connect connector wire with clamps, place the mould & fill it with cable jointing compound as shown in Figure given below.

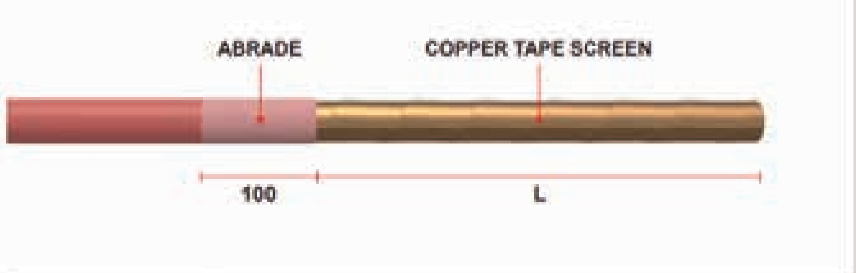


TASK 4: **End termination of XLPE cable**

1 Prepare the cable and cut the exceeding length

2 Remove the outer sheath for the length “L” (“L” see the Table).

3 Abrade the outer sheath for 100 mm and clean with solvent.



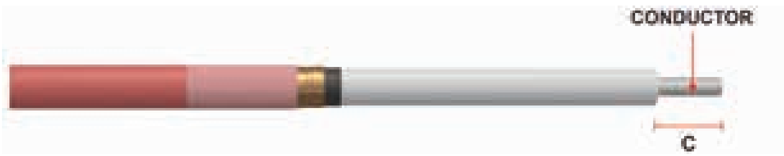
TYPE	INDOOR TYPE							
SECTION RANGE (mm^2)	25 - 95	70 - 240	95 - 300	185 - 400	400 - 630	630 - 1000	800 - 1200	1200 - 1600
L (mm)	300	300	300	300	300	330	350	400

TYPE	OUTDOOR TYPE							
SECTION RANGE (mm^2)	25 - 95	70 - 240	95 - 300	185 - 400	400 - 630	630 - 1000	800 - 1200	1200 - 1600
L (mm)	450	450	450	450	450	450	450	500

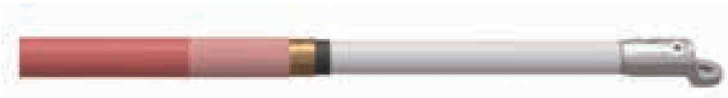
4 Remove the copper tape screen leaving 25 mm out of the outer sheath.

5 Remove the semi-conductive layer leaving 15 mm out of the copper tape screen taking care not to damage the insulation.

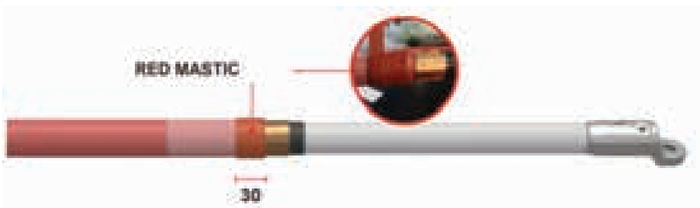
6 Bare the conductor for the length “C” (“C”= inside depth of lug) for bolted lug or “C+5mm” in case of compression lug.



7 Position the lug and crimp it



8 Apply a layer of red mastic tape (20% overlap) on the outer sheath for 30 mm.



9 Position the earthing braid over the copper tape screen.

10 Connect the braid to the copper tape screen with the roll force spring.

11 Fill the cavities of the lug with red mastic tape

12 Wrap around the exposed conductor the red mastic tape stretching it, till reaching the lug barrel diameter and wrap mastic tape around the lug barrel.

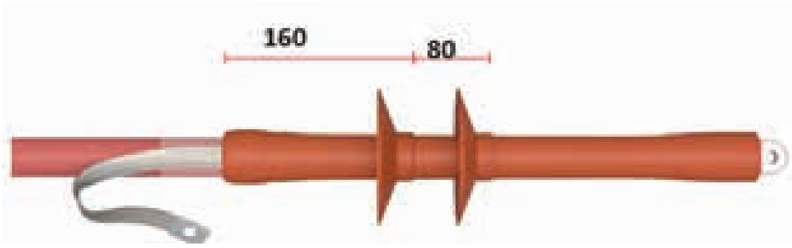
13 Apply a layer of red mastic tape starting from cut outer sheath till covering the previous applied layer of mastic tape.

14 Apply the stress relief mastic pad, lightly stretched, starting from the cut outer sheath.

15 Slide the outer heat shrinkable red tube (stress control + insulation) till the TOP edge of red mastic tape applied over the cable lug.

16 Start heat shrinking from the top downwards as below for indoor termination

17 Slide and set the first antitracking shed at 160 mm from the bottom edge of shrunk tube and heatshrink it. Slide the remaining shed and heatshrink.



EXERCISE 112 : Visit HT/LT substation, identify various parts of relay and ascertain the operation

Objectives

At the end of this exercise you shall be able to

- identify the external controls and parts of electromagnetic relay
- identify the internal parts of the single pole over current relay.

Requirements

Tools/Equipments/Instruments

- Trainees tool kit - 1 No.
- Single pole over current/earth fault relay with instruction manual - 1 No.

Procedure

TASK 1 : **Identify external controls and parts of a electromagnetic relay**

1 Locate the relay parts provided in front of the relay (Fig 1) and identify the parts and fill in Table 1.

2 Note down the tap setting of current ranges at Table 2.

3 Note down in Table 2 the Indication displayed in the dial, multiplier along with percentage of fault current tripping time.

4 Locate the tripping. Flag indicator resetting level provided in front panel.

Note: Once the relay tripped the flag will indicate a red line once it is tripped needs manual resetting by operating the lever.

SINGLE POLE OVER CURRENT RELAY

Table 1

Sl.No.	Part No.	Name of the external part	Function
1	1	Tripping flag indicator	Display tripping condition
2	2		
3	3		
4	4		
5	5		

Table 2

Sl.No.	Current range	Multiplier of fault current	Time in seconds
1	Tap setting - 0.25A	Tripping flag indicator	Display tripping condition

— — — —

TASK 2 : **Identify internal parts of a single pole over current relay**

Note: Instructor has to explain how to locate the internal parts and function of the circuit breaker and ask the trainees to tabulate the identified part of the available circuit breaker in your section.

1 Remove the front cover by loosening the four knobs provided in the corner of relay and preserve the cover with knobs carefully. (Fig 1)

Note: Don't touch (or) try to operate any projected parts inside the relay.

2 Locate the aluminium disc fitted in the bottom of the spindle. (Fig 2)

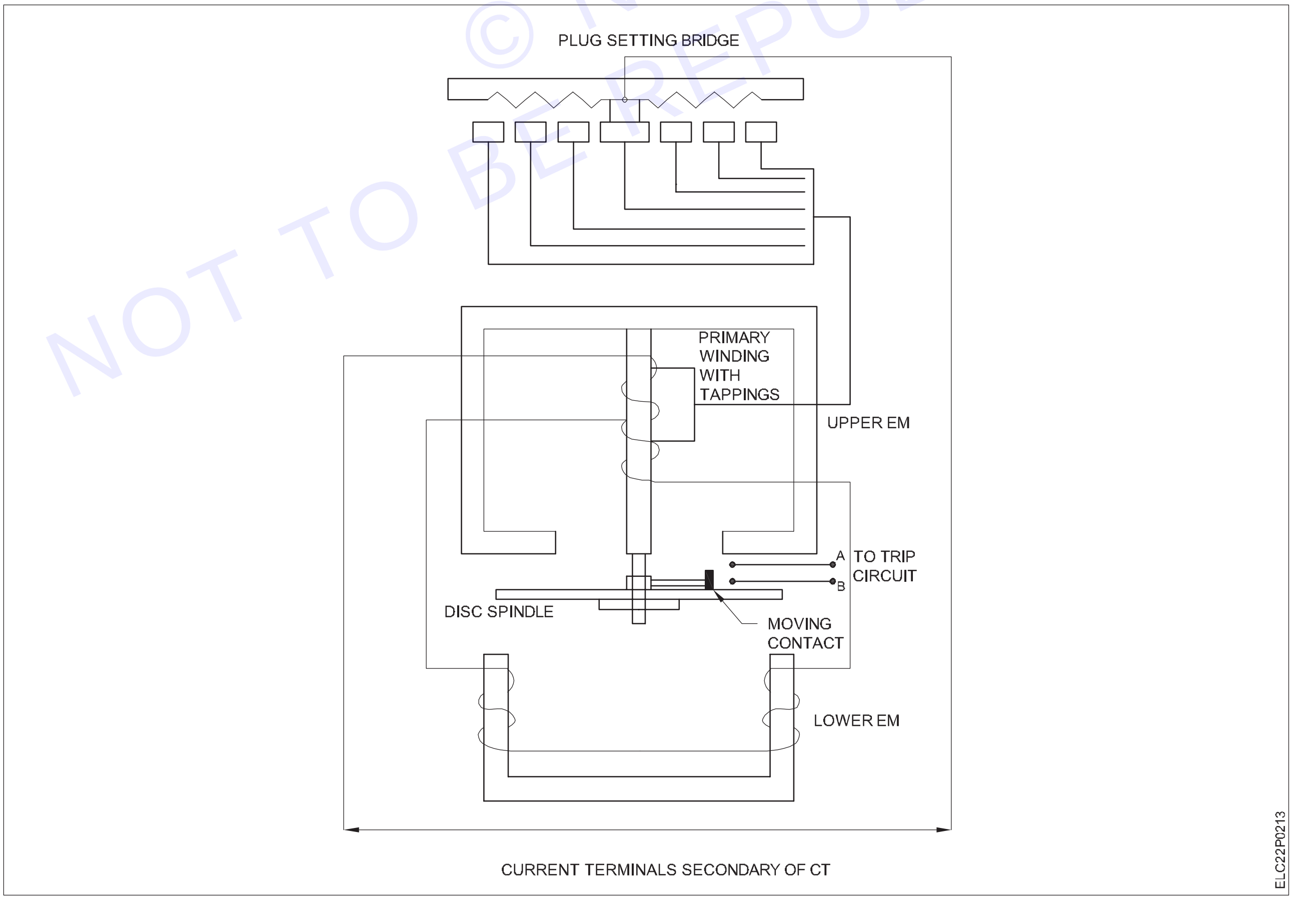
3 Locate the Time Multiplier Setting (TMS) fitted in the top of the spindle.

4 Check the divisions marked on the TMS disc used for time setting.

5 Locate the spiral spring mounted on the top of spindle to bring back the disc top its original position after tripping.

6 Locate the moving contact fitted along with the spindle on the top of disc enabling tripping circuit.

7 Locate the two terminals contact points acting as a switch to trip the circuit.



Note: Do not allow any dust or tiny particles enter inside. Dust will deposit in the pinion and effect the disc movement.

8 Close the front panel and show the findings to your instructor.

9 Note down the identified parts in Table 3.

Table 3

Sl.No.	Part No.	Name of the external part	Function
1	1	Tripping flag indicator	Display tripping condition
2	2		
3	3		
4	4		
5	5		

— — — —

EXERCISE 113 : Practice setting of pick up current and time setting multiplier for relay operation

Objectives

At the end of this exercise you shall be able to

- calculate the fault current in different percentage
- set up current in injector unit for different fault current
- set the pick up current of a 50% fault current
- set the time multiplier for time setting under various fault condition.

Requirements

Tools/Equipments/Instruments

- Trainees tool kit - 1 No.
- Over current relay with manual - 1 No.
- Current injection unit with manual - 1 No.

Procedure

TASK 1 : **Identify of pickup current and trip the relay for different fault current**

1 Identify the supply voltage required for operating over current relay to its tripping coil.

2 Identify the current input terminals of relay.

3 Identify the shorting pins of NC/NO relay contacts.

Note: The current Injector unit is required to provide different fault current levels. The fault current settings is done in tap setting provided in the relay along with percentage of fault current with time.

4 Connect the tripping coil voltage and fault current connections from current injector to relay as per the manual instruction. Keep all the controls at zero position in current injector unit.

Note: Some coils requires DC supply that can be taken from current injector unit.

5 Set the tap on relay for one amp. Calculate the multiplier from the dial and set the current in current injector unit. Record the values in Table 1.

Note : A sample reading is recorded in Table 1 on the tap setting at 1A; and multiplies value-2. Trip time displayed in dial an 10 seconds

Select multiplier 2, so that the total fault current is 2 amp. ensure the time multiplier disc kept at position 1.

6 Note down the corresponding time displayed on the dial for multiplier 2.

Note: The current injection unit have different makes and specifications . Energise the relay using manual supplied along with current injection unit.

7 Switch on the current injector unit ensure that relay is energised.

8 Increase slowly the current which is the input of relay to pickup.

Table 1

Sl. No.	TMS Position	Tap set current (A)	Multiplier value	Time in seconds	Total fault current	Pickup current	Actual trip time
1	1	0.5	2 x 0.5 = 1A	10 Sec	1A	<1A	
2	1	1.0					
3	1	1.5					
4	1	2.0					

9 Increase the current slowly, the disc of relay start to move that is the pickup current. Note down the value in Table 1.

10 Change the tap set current to some other current value and repeat the step 5 to 9.

11 Change the tap set for other value and repeat the steps 6 to 10 and record the readings.

12 Try few more tap set values and check the pickup current.

Note: TMS position should not be changed while doing the exercise.

— — — —

TASK 2 : **Reduce the tripping time by setting time multiplier setting**

1 Keep all the controls knobs at zero position.

2 Set the TMS disc at 0.5 position by rotating TMS disc fitted on the main spindle.

3 Repeat the steps 5 to 10 for the new TMS value of 0.5. Enter all the readings in Table

Note : It may be noted that when TMS set for 0.5 the actual trip time reduced by 50% of the trip time actual in Task 1.

Table 2

Sl. No.	TMS Position	Tap set current (A)	Multiplier value	Time in seconds	Total fault current	Pickup current	Actual trip time
1	0.5	0.5 A	2 x 0.5 = 1A	10 Sec	1A	<1A	
2	0.5	1.0 A					
3	0.5	1.5 A					
4	0.5	2 A					

— — — —

EXERCISE 114 : Identify the parts of circuit breaker, check its operation

Objectives

At the end of this exercise you shall be able to
- identify the external parts of air circuit breaker
- identify the internal parts of air circuit breaker
- test the manual tripping of air circuit breaker.

Requirements

Tools/Equipments/Instruments

• Trainees tool kit	- 1 No.
• Multimeter/ohm meter	- 1 No.
• Air circuit breaker 3 phase 415V maximum capacity 400 KA with instruction manual	- 1 No.

Procedure

TASK 1 : **Identify the external parts and control switches of air circuit breaker**

1 Verify the specifications of air circuit breaker with instructions manual. (Fig 1)

Note: Different makes of circuit breakers are available in the market. The air circuit breaker mentioned here is only a sample model for your guidance. The instructor may arrange the available model with necessary instructions if necessary.

2 Identify the label numbers of the external part mentioned in Fig 1.

AIR CIRCUIT BREAKER

3 Write the corresponding label numbers against the corresponding external parts names only given in Table 1.

Table 1

Sl.No.	Parts label no	Name of the part
1	1	
2	2	
3	3	
4	5	
5	6	
6	7	
7	9	
8	13	
9	17	

4 Get it checked with your instructor.

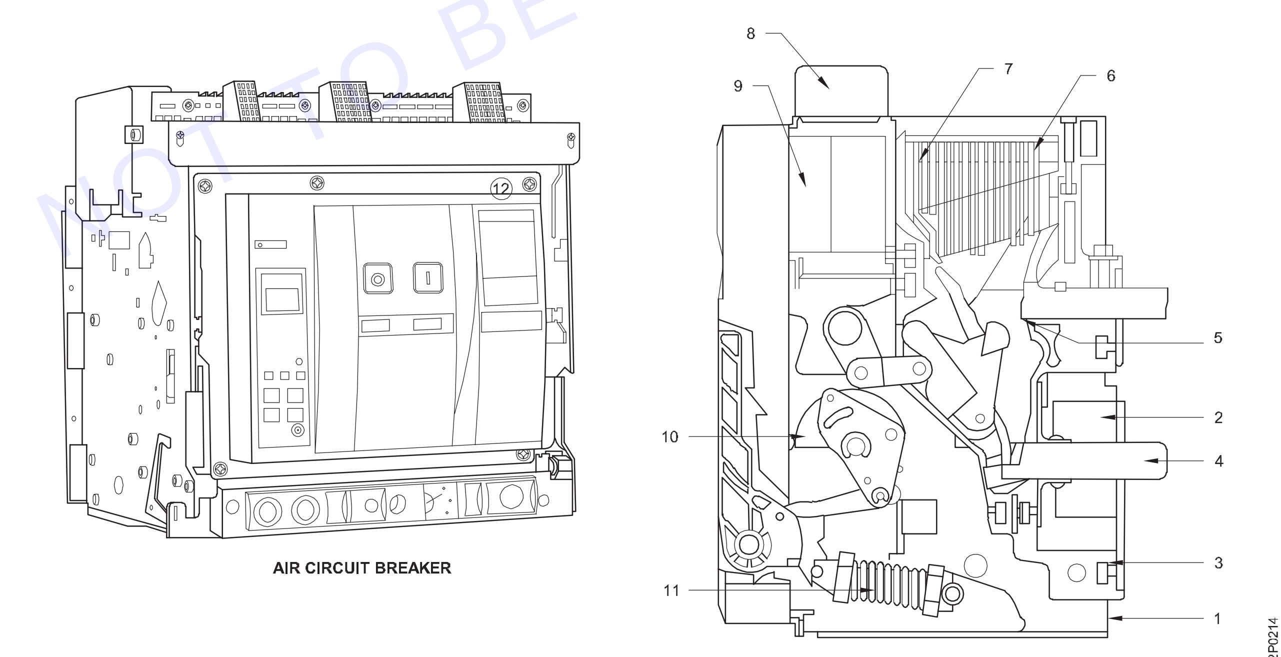
— — — —

TASK 2 : **Identify the internal parts of air circuit breaker**

1 Remove the front cover carefully.

Note: Do not remove any permanent parts of the breaker.

2 Identify the main internal parts (Fig 2) fitted in the breaker and note down in Table 2.



AIR CIRCUIT BREAKER

INTERNAL PARTS OF THE AIR CIRCUIT BREAKER

3 Locate the fixed main contact and movable main contacts.

4 Check the continuity of the contacts.

5 Locate the tripping coil terminals.

6 Remove the arcing chamber unit and test the arc chutes and diverters.

7 Locate the manual tripping lever to trip manually.

8 Connect the ACB to the main supply and switch ON.

9 Check the condition of indicating and tripping lamps.

10 Charge the breaker manually by operating handle.

11 Check the engaged main contact and confirm by checking its continuity.

12 Press the manual tripping switch and confirm its disengagement of the contacts.

13 Charge again the breaker and confirm the engagement of the main contacts.

14 Switch 'OFF' the AC mains, the arcing chamber and close the removed covers.

15 Submit the reports to your Instructor and get it approved.

Table 2

Sl. No	Parts no	Name of the part	Function
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			

EXERCISE 115 : Test tripping characteristic of circuit breaker for over current and short circuit current

Objectives

At the end of this exercise you shall be able to

- connect relay and circuit breaker for test tripping
- set the current injection unit for tripping current
- set the tripping current for definite time lag (over current)
- set the current for extreme inverse characteristic (short circuit current).

Requirements

Tools/Equipments/Instruments

- Trainees tool kit - 1 No.
- Air circuit breaker 400 KA 415V with manual - 1 No.
- Over current relay with manual - 1 No.
- Current injection unit with manual - 1 No.

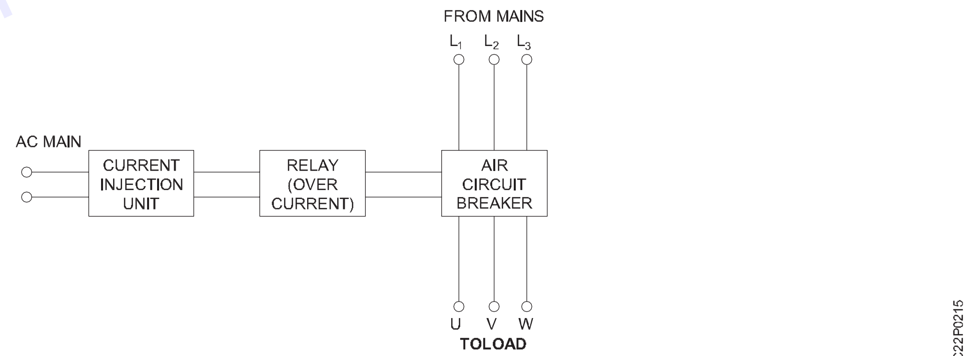
Procedure

TASK 1 : **Tripping of circuit breaker for definite time with set fault current**

This exercise is prepared to set the relay in definite time tripping in over current conditions and extreme inverse tripping in short circuit situations. This model relay is not having the facility of various tripping characteristics.

However short circuit current situation can be provided to trip the relay in short time by setting time Multiplier Setting (TMS) to trip the relay instantly at high fault current situation.

1 Connect the relay, circuit breaker with the current injection unit by referring in block diagram. (Fig 1)



BLOCK DIAGRAM

2 Check all the connections as per the instruction manual.

3 Set the tap setting current in 1 amp and note down the multiplier, time in seconds in Table 1.

4 Set the TMS at position 1 marked in the dial.

5 Check the pick up current of the set value of tap setting current and note down values in Table 1.

6 Set the fault current by selecting multiplier from the dial and note corresponding time in seconds and note the values in Table 1.

Note: Now the fault current set value is 2 Amp and the relay should trip in the time as per the dial indication.

7 Switch 'ON' the current injection and note down the tripping indicated by the timer fitted on the current injection unit.

8 Reduce the time by setting TMS by 0.5

Note: Since the short circuit current cannot be generated practically the tripping time is reduced by taking the short circuit current is present now.

9 Ensure the rotating aluminium disc returns to its original position.

10 Switch ON the injection unit and note down the tripping time in seconds.

Note: This time will be half time of the first reading.

11 Change the tap setting at 2 amps slot in the relay and repeat the steps 4 to 9.

12 Record the readings in the Table and get it approved by your instructor.

Table 1

Test tripping of circuit breaker definite time charts

Sl. No	Tap setting current	TMS value	Time	Multiplier	Total fault current	Actual tripping current	Error in %
1							
2							
3							
4							

TASK 2 : **Tripping circuit breaker in extreme inverse characteristic condition**

1 Repeat the step 1 to 3 in Task 1.

2 Set the TMS at 0.2 position.

3 Set the tap setting plug into maximum current input on the dial.

4 Select the maximum multiplier value in the dial record the fault current (plug set value 'X' multiplier) and the tripping time in Table 2.

5 Check the pickup current for the tap set value.

6 Set the fault current in the current injector unit

7 Switch 'ON' and note down the actual tripping time in Table 2.

8 Try to some higher value of fault current and repeat the step 5 to 7. Record the values in Table 2.

Table 2

Sl. No	Tap setting current	TMS value	Time	Multiplier	Total fault current	Actual tripping current	Error in %
1							
2							
3							
4							

EXERCISE 116 : Practice on repair and maintenance of circuit breaker

Objectives

At the end of this exercise you shall be able to

- follow the shutdown procedure
- refer to service and operating manuals of a given circuit breaker to identify the parts and their functions (R)
- refer to previous maintenance records for carrying out routine maintenance checks
- locate the faulty part and replace it
- follow the general maintenance procedure on the circuit breaker.

Requirements

Tools/Equipments/Instruments

- Insulated cutting pliers 150 mm - 1 No.
- Screwdriver 150 mm - 1 No.
- Heavy duty screwdriver 300 mm - 1 No.
- Neon tester 150 mm 600V - 1 No.
- D.E. spanner set of 9 Nos. 5 mm to 20 mm - 1 Set.
- Box spanner set of 9 Nos. 5 mm to 20 mm - 1 Set.
- Megger 500V - 1 No.
- Multimeter 20 kilo ohm/volt - 1 No.
- Cleaning brush round 2.5 cm - 1 No.
- Plumb bob with thread - 1 No.
- Spirit level 300 mm - 1 No.
- Flat file bastard 250 mm - 1 No.

Equipment/Machines

- Circuit breaker of higher voltage and current rating - 1 No.

Materials

- Rubber or cork gasket as specified and reqd.
- Sand paper Grade "0" - 1 Sheet.
- Grease - 10 g.
- Flexible cable 14/0.2 - 5 mts.
- Dash pot oil of specific grade - 200 ml.
- Contact cleaner oil - CRC 2-26 - 1 bottle.
- Electro tube - 25 g.

Procedure

As it is impracticable to get a switch gear of high voltage and current rating in a vocational institute, it is recommended that the trouble shooting procedure is followed in a circuit breaker, having similar facilities like the rotor resistance starter used in a slip ring induction motor. However, the manufacturers instruction for the trouble-shooting should be followed for larger circuit breakers when the trainee is employed in an industry. The working steps given there are of a generalized nature and could be used with slight modification for any circuit breaker.

Caution: Before taking up the maintenance work on any circuit breaker which is in operation, it is utmost necessary to take permission from the engineer in-charge. He only decides whether alternative arrangement is required to maintain supply to the consumer or a shut down is to be effected.

Permission for shut down is given by the engineer in the approval forms. Follow all the instructions contained in the shut down form before taking up the maintenance work on the circuit breaker. The concerned control switch of the circuit breaker should be switched OFF and locked and caution boards should be displayed in the control panel. The key should be kept in the custody of the engineer in-charge. A caution board should also be displayed predominantly near the circuit breaker which is under maintenance.

1 Collect the service and operating manuals of the circuit breaker and read them carefully.

2 Collect the maintenance record sheet of the circuit breaker.

Note: It is desirable that you read the service and operating manuals carefully and thoroughly before starting the actual maintenance work.

3 Note the name-plate details of the circuit breaker in Table 1.

Note: Example of work permit and shut down

4 Switch 'OFF' the incoming and outgoing bus bars, and then disconnect the circuit breaker from the bus bars.

5 Follow the instructions contained in the service manual to open the top covers of the circuit breaker.

6 Identify the parts and compare with the service manual.

7 Identify and trace the tripping circuits.

8 Carefully inspect the parts for burnt smell, visible indication of burns, pittings and discolouring.

9 Interpolate your finding with the maintenance record sheet information to pin point the faulty part.

10 Identify the part number from the service manual and collect the parts from the stores.

11 Check the correctness of the part received from the stores and then replace the part in the circuit breaker.

General maintenance procedure

12 Check the mounting bolts/studs for correct tightness.

13 Check the verticality of the circuit breaker with the help of a plumb bob, and horizontality with the help of spirit level.

Note: If necessary correct them by mounting bolts.

Table 1

Technical data of the circuit breaker

i	Type of the circuit breaker	......
ii	Type designation	......
iii	No. of phases/poles	......
iv	Rated voltage	......
v	Maximum voltage	......
vi	Rated frequency	......
vii	Rated current	......
viii	Rated symmetrical breaking capacity	......
ix	Rated making current	......
x	Rated short time current	......
xi	Quantity of oil per pole	......
xii	One minute try withstand voltage	......
xiii	Impulse withstand voltage	......
xiv	Type of closing device	......
xv	Trip free/fixed trip	......
xvi	Weight of the oil	......
xvii	Quantity of oil in litres	......

xviii Nett weight of the circuit breaker with oil in kg	......
xix Overall dimensions of OCB mounted on frame	......
xx Ambient temperature for which OCB is designed	......
xxi Auxiliary voltage for shunt trip coils	......
xxii Auxiliary voltage for under-voltage release	......
xxiii Auxiliary supply voltage for motor drive	......

14 Check the stationary, fixed, arcing, intermediate and main contacts. Clean them with a steel wire brush or sandpaper grade ‘0’ to remove any deposit due to oxidation. Figs 1 and 2 are given for your guidance.

Note: If pittings are heavy, use a flat file to remove the pittings. If the surface area is reduced more than ten percent due to pittings it will be better to replace the contact points.

15 Clean the contact by using CTC solution.

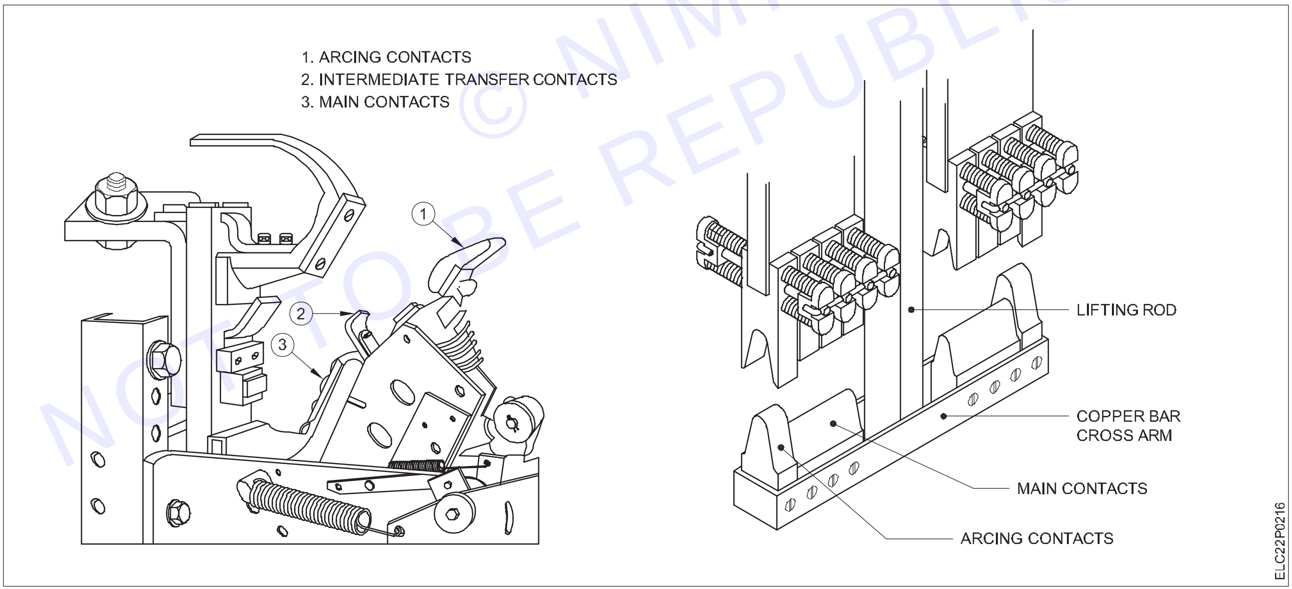
16 Check the internal control wiring along with the given wiring diagram of the manual.

17 Use a continuity tester to test the continuity of each wire from point to point.

Note: If the internal wiring cables are damaged replace them. Check for loose terminations and tighten them.

18 Measure the trip coil resistance and compare with the earlier measurement.

Note: There should not be any change in coil resistance.



19 Check that the tripping rod and the armatures of the tripping releases, move freely without blocking or friction.

20 Circuit breaker regular maintenance record sheet model given in Table 2.

Note: If the releases are found to be under friction clean the relevant part thoroughly.

Table 2

Maintenance record sheet for circuit breaker

Sl.No.	Date	Particulars	Complained by	Attended by	Description of fault	Particulars of replacement	Signature of the engineer in-charge
1							
2							
3							
4							
5							

1 Run-time maintenance

(a) Ensure the load current is within the normal range.

(b) Ensure the relevant indicators conform to the normal circuit indicators.

(c) Look out for any abnormal sound, like chatter, humming, or buzzing during operation and as noise is an indication of poor contact or under-voltage.

(d) Ensure no discolouration at the contact points and the coil is not burned out.

(e) Keep the contactor clean, both inside and outside. Refrain from having a poor operating state in the surrounding environment, which includes keeping away from the moisture, dust, oil, physical obstruction that affects the full closure of the contactor and limit the degree of vibration.

2 Inactive maintenance

(a) Ensure the cable is secure, the wire insulation is not damaged, and refrain from having any loose ends. If the contact is loose, look out for any traces of burns.

(b) Ensure strict measurement of the interphase insulation resistance of AC contactors, and the resistance value is not less than 10M.

(c) Clean the contactors regularly.

(d) For the maintenance of the contact system, Ensure the reliability of the contact, the endurance of the coil, and the function of the middle spring. Check if the contactor coil is open weld, burnt, and/or discoloured.

(e) For the maintenance of the iron core Ensure the iron core is removed when conducting power failure inspection. General inspection includes,

(i) Look out for any abnormal sound.

(ii) Check if the short circuit ring is damaged and replace any damaged rings timely if necessary

MODULE 19 : EV Charging

EXERCISE 117 : Demonstrate installation of EV charging Station for Public places

Objectives

At the end of this exercise you shall be able to

- identify the EV charging connectors
- prepare the lay out and power requirements for charging station
- install the EV charging station.

Requirements

Tools/Equipments

- Trainees kit -1 No.
- Multimeter -1 No.
- EV charger for public station with instruction manual) -1 No.

Procedure

TASK 1: **Identify the EV charging connectors**

1 Identify the connectors in picture.

S.No.	Picture	Name	Country	Capacity kw
AC Connectors				
1		SAEJ1772	Not in india , in US	
2		IEC62196 Or Type-2 With Communication Pwm)	India	3.3,7,22(3P)
3		IEC60309, Bharat AC-001 , No Communication Ev & Evse,	India	3.3KW

DC Connectors				
1		Combined Charging System	CCS2 Communication Plc	
2		CHAdeMOv	Communication Controller Area Network(CAN) 400kw	
3		GB/T	Controller Area Network(CAN)	180KW

TASK 2: **Prepare the lay out and power requirements for charging statiom**

1 Calculate the space needed for an EVCS which needs to have the capability of charging two 2 wheelers, two 3 wheelers and one 4 wheelers.

S.No.	Vehicle type	No of vehicle	Guide line Space per vehicle(sq.ft)	Total space required
1	2 wheeler	2	60	
2	3 wheeler	2	120	
3	4 wheeler	4	170	
4	Additional space recommended for movement		100	
			Total	

2 Guideline to select the type of charger for the from sample charging station specifications.

S. No.	Type of charger	Typical maximum output	No. of max outlets	Type of connector	Type of charging	
1	Bharat AC-001 (LOW VOKTAGE EVs)	3.3kW/ outlet or 10kW in total	3	IEC 60309 three-pin connector	Slow	
2	IEC 62196 / TYPE-2 CHARGING STATION	3.3/7/11/22 kw	1 / 2	IEC 62196	Fast	
3	Bharat DC-001	15 KW (72 V DC, 200 A).	1 / 2	GB/T 20234.3	Slow	
4	CCS2	60kW	1/2	CCS2 / CHAdeMO	Fast	

3 Note the EVSE specifications.

S.No.	Description	Rating
1	Make	
2	Model	
3	No of phases input	
4	Input Voltage	
5	Input Current	
6	Capacity(kW)	
7	No. Output connectors	
8	Output voltage range	
9	Output current	
10	Connector types	
11	Communication between EV&EVSE Protocol	
12	Communication with network (Wi-Fi /GSM/ Blue tooth/ Ethernet)	
13	Safety available (like Overvoltage, Overcurrent, Short circuit detection, Power fail detection, Reverse polarity, Temperature Monitoring	
14	Authorization (QR, NFC, RFID)	

4 Verify the permission from landlords / local authority for use of space

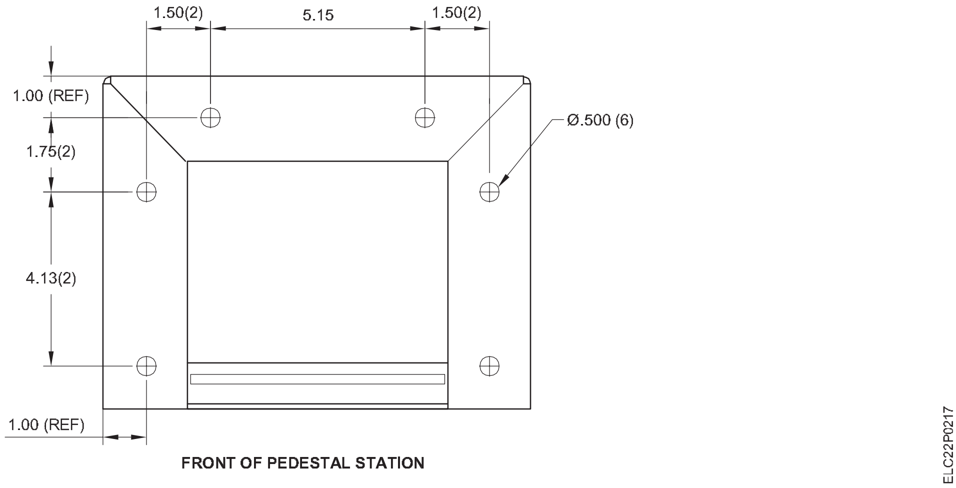
5 Verify the sanctioned load availability from DISCOM for power with connected and maximum demand. Allowance of approx. 1.5 times the charging load need to be given for load fluctuations and future expansion

6 Verify the received model and brand and check the mounting type for wall mounting or pedestal mounting

7 Assess the accessibility of the location is optimal for installation for EV charging and ensure location is protected from natural hazards.

TASK 3: **Install the EV charging station**

1 Build the civil infrastructure for installing charging stations, taking care of movement of vehicles, roofing, dimensional and mounting requirements with weight of the unit. Typical installation in Fig 1



FRONT OF PEDESTAL STATION

2 Install the power cable, with conduit or racking or by UG Cabling

3 Install the charging stations as per the OEMs instructions.

4 Install Circuit breaker

5 Install RCCB, surge protection devices as recommended by manufacturer

6 Do permanent copper wire earthing

7 Verify electrical wiring.

8 Test Supply voltage

9 Test voltage between neutral and earth and verify it to be less than 2volts

10 Test insulation resistance between conductors and earth.

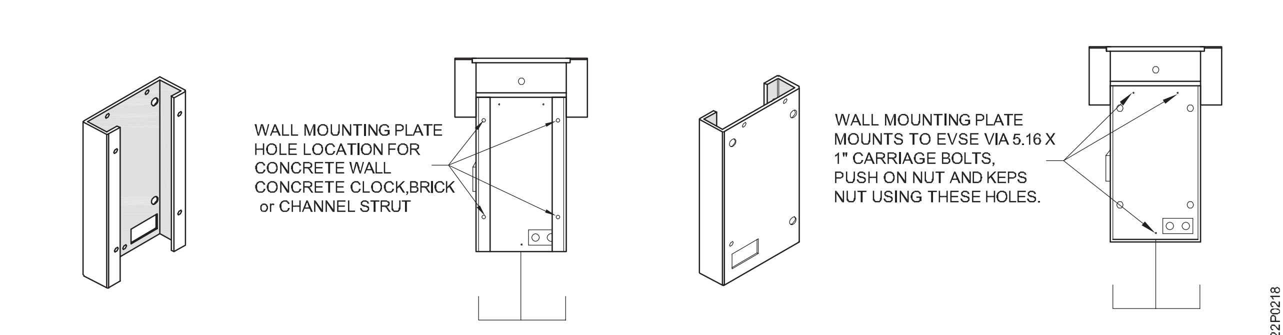
11 Connect charging stations to communication management system platform and verify the firmware update

12 Verify indicator for Switch ON/OFF, Stand-by/charging, Availability status (operational/non-operational), safety lights, charging completion indication

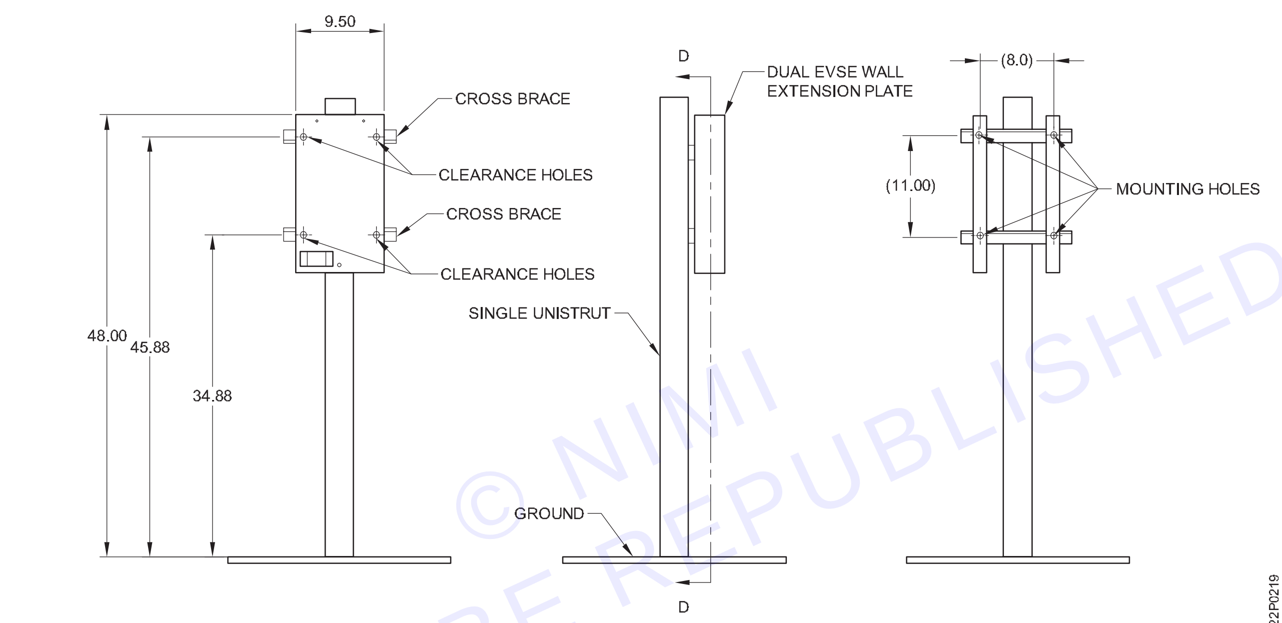
13 Ensure availability of safety and traffic guidelines signage for customers

14 Clean the site and dispose the garbage.

15 Prepare a detailed installation report.



TYPICAL WALL MOUNTING



DIMENSIONAL DETAILS FOR MOUNTING

EXERCISE 118 : Demonstrate installation of Home EV charging stations

Objectives

At the end of this exercise you shall be able to:
- collect the data of EV charger
- verify the power requirements for the input available at site
- install the EV charging station
- test the installation.

Requirements

Tools/Equipments/Instruments

- Trainees kit - 1 No.
- Multimeter - 1 No.
- Home EV charger with instruction manual - 1 No.

Procedure

TASK 1: **Collect the data EV charger**

1 Collect the EVSE details and record in Table 1

Sl. No	Description	Value	Remark
1	Make		
2	Model		
3	Capacity(kW)		
4	No of phases input		
5	Input Voltage		
6	Input Current		
7	No. Output connectors		
8	Output connector type		
9	Output voltage range		
10	Output current		
11	Length of cable available with EVSE manufacturer		
12	Communication between EV&EVSE Protocol		
13	Communication with network (Wi-Fi /GSM/Blue tooth/ Ethernet)		
14	Safety available (like Overvoltage, Overcurrent, Short circuit detection, Power fail detection, Reverse polarity, Temperature Monitoring		

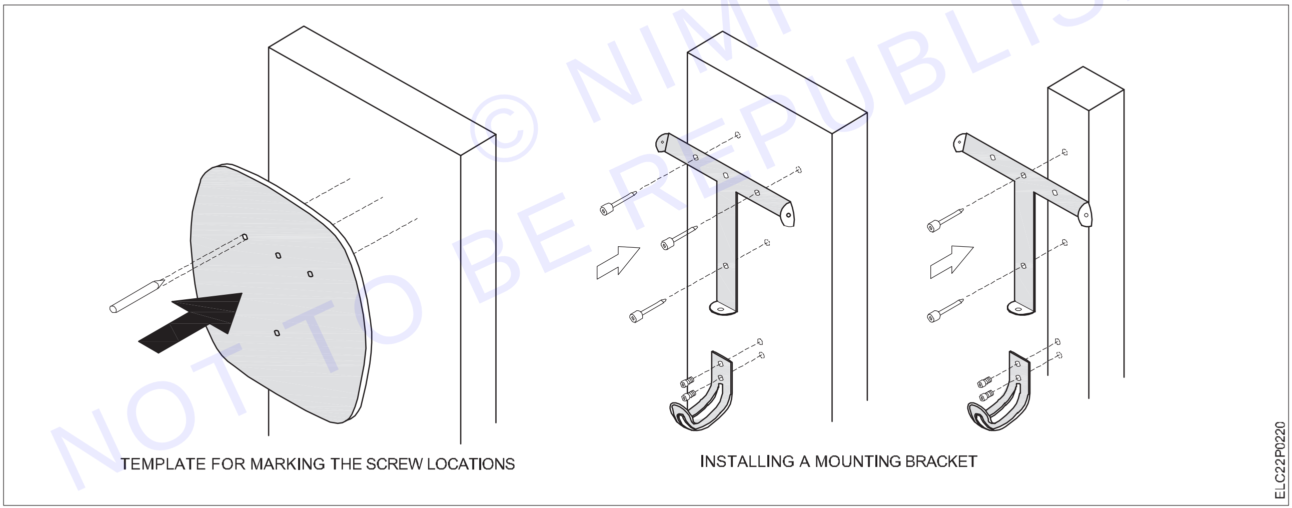
TASK 2: **Verify the power requirements for the input available at site**

1 Check the Connected load, maximum demand allotted by DISCOM
2 Calculate the input power and current from DISCOM with efficiency factor of 0.8
3 Asses to comply to DISCOM rule for ceiling use of power in Kw, if needed apply for upgradation. (Depending on state / DISCOM , three phase power connection will be required
5 Assess the main service line power cale size match to the new charger load.
6 Select the power cable size from MCB/MCCB to the charger installation location
7 Check the existing rating of Main and DB components for the addition of EV charger
8 Replace if the fuses (use of HRC fuse is recommended), MCBs of existing installation if found to be under rated
9 Test the voltage between Phase and neutral to be less than 2 volts.
10 Install RCCB and wire up with power cable to RCCB input with required current rating.

Install 16A,230V socket for slow charger provided by the manufacturer

TASK 3: **Install the EV charging station**

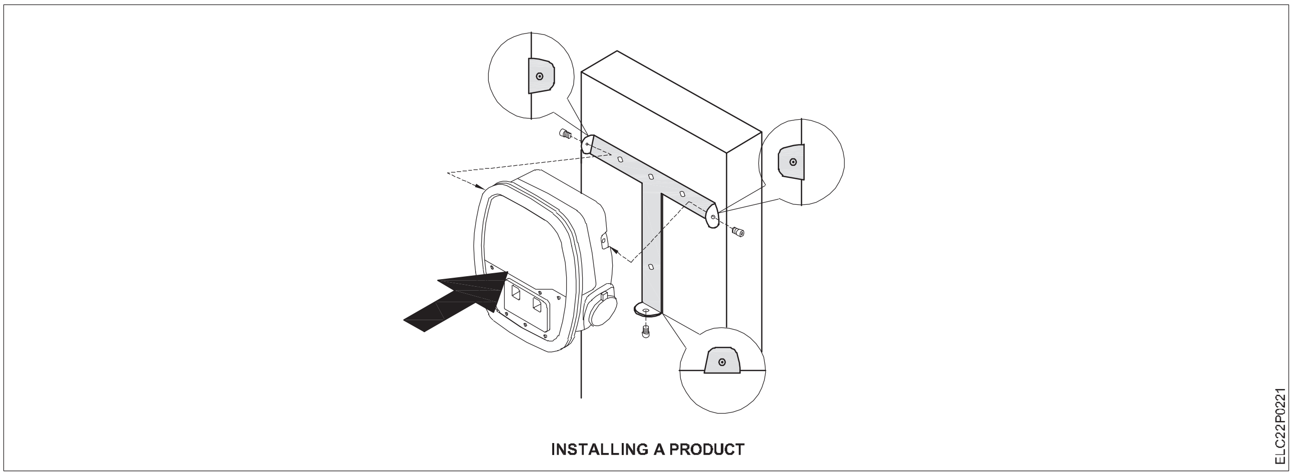
1 Install the EV charger at site, with minimum ground clearance specified by OEM and check the site suitability for preventing dust and moisture. Use template supplied by OEM in manual for drilling holes in wall. (Fig 1)
2 Mount the brackets on the holes drilled. (Fig 2)



TEMPLATE FOR MARKING THE SCREW LOCATIONS

INSTALLING A MOUNTING BRACKET

3 Install the EV charger on mounting brackets. (Fig 3)



INSTALLING A PRODUCT

The new EV 4-wheelers in India is as per the IEC standard with an IEC 62196 / Type-2 connector. These charging stations can have 1 or 2 outputs or a 1 three-phase output.

Typical spec

INPUT	single-phase (230 V AC) or three-phase 415 V AC
Maximum Current	32 A(per phase)
Maximum Power	UPTO 7 KW for single-phase and 22K KW for three-phase
OUTPUT	1
	2(Single phase)
Output Connector	IEC 62196
Voltage per Output	230 V AC, single-phase; 415 V AC three-phase
Current per Output	15 A / 32 A
Power per Output	3.3 KW / 7.4 KW / 11 KW / 22 KW
Protection Communication	PWM / Control Pilot with EV

TASK 4: **Test the installation**

1 Test insulation resistance between conductors and earth.

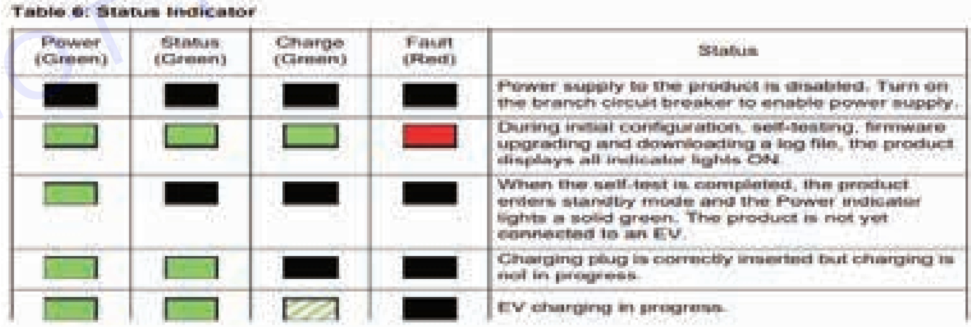
2 Install the SIM /Wifi module/ethernet wire if available with product model.

3 Appropriately set the current setting of the EVSE as per user manual for safe operation

4 Switch on and verify the status indicators. (guideline Fig 1)

Figure 20. Identifying the LED Panel

Table 6: Status indicator



Power (Green)	Status (Green)	Charge (Green)	Fault (Red)	Status
				Power supply to the product is disabled. Turn on the branch circuit breaker to enable power supply.
				During initial configuration, self-testing, firmware upgrading and downloading a log file, the product displays all indicator lights ON
				When the self-test is completed, the product enters standby mode and the Power indicator lights a solid green. The product is not yet connected to an EV.
				Charging plug is correctly inserted but charging is not in progress.
				EV charging in progress.

5 Switch the MCB on (depending on the model, on the charger will start indication flashing). Plug in the charger gun to the car's charging port. Lock the car and place the RFID Tag on the charger icon

6 Check the charging status

7 Record charging voltage, Status of battery, Time and current from the display

8 Switch OFF when the charging done as per requirement

9 Remove charging gun only after 10 seconds or time recommended by manufacturer.

EXERCISE 119 : Demonstrate troubleshooting of EV charging stations

Objectives

At the end of this exercise you shall be able to:

- identify the symptoms of the trouble
- test various sections of EV installation.

Requirements

Tools/Equipments/Instruments

- Trainees kit - 1 No.
- Digital multimeter - 1 No.
- Instruction manual of charger - 1 No.

Procedure

TASK 1: **Identify the symptoms of the trouble**

1 Check for Input MCCB to EV charger, in case of charging failure.

2 Check the service / user manual for EVCS Notification, Warning, Alarm and Error Codes. A guide of errors is summarized in Table1

General EV Charging Station Error Codes

Sl. No	Error type	Reason	Remedy
1	High Battery Voltage Error	battery voltage is too high to start charging	check the battery voltage and cable connections
2	Low Battery Voltage Error	battery voltage is too low to start a charge.	check the battery voltage and cable connections
3	Charge Timeout	does not reach the required voltage within a safe time limit	improve the cooling air flow, check for low AC voltage
4	Battery Defective	the battery could not be charged to the minimum voltage	replace the battery pack
5	Charge Amp-Hour Limit Exceeded	deeply discharged battery, poor battery connection,	replace the battery pack, check DC connections
6	Battery Temperature Out of Range	Check temperature / temperature sensor of battery.	check the temperature sensor and connections
7	Charger Output Reverse Polarity	Improper connection	checking the battery connections

TASK 2: **Test various sections of EV installation**

1 Calibrate pilot signal CP(control pilot – Type 2 charging), in case of failure of communication between EV and EVSE , for correct performance.

2 Test for continuity in the pilot wires, which are located on the connector.

3 Examine EV charging cable, and charging station for issues.

4 Check the charger screen or LED for fault indicators.

5 Verify the station is online if networked and is updated with the latest firmware.

6 Update the firmware over the air without opening EVSE, If firmware or network related issue arise.

7 Check the on-board charger intake current rating and that of EV charger for slow charging issues.

8 Check communication to CMS (Charging Management System), mobile app if any.

9 Check wires are fitted properly.

10 Check if all connectors are mounted properly.

11 In case of overheating switch OFF the charger.

12 Check pre-conFigured load balancing setting of EV charger, in case of slow charging problem with fast charger

13 EV Chargers which is coming with mobile app / digital interface will show the cause of failure / error code in user interface area. Refer the use manual for error codes.