ELECTRICIAN

NSQF LEVEL - 4

2nd Year

TRADE PRACTICAL

SECTOR : POWER

(As per revised syllabus July 2022 - 1200 hrs)

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

Sector : Power

Duration : 2 - Years

Trade : Electrician 2nd Year - Trade Practical - NSQF Level - 4 (Revised 2022)

Developed & Published by

National Instructional Media Institute
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Guindy, Chennai - 600 032
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First Edition : March 2023 Copies: 1000

Rs.315/-

FOREWORD

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

The National Instructional Media Institute (NIMI), Chennai, an autonomous body under Ministry of Skill Development & Entrepreneurship is entrusted with developing producing and disseminating Instructional Media Packages (IMPs) required for ITIs and other related institutions.

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

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

Jai Hind

Director General (Training),
Ministry of Skill Development & Entrepreneurship,
Government of India.

New Delhi - 110 001

PREFACE

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

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

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

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

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

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

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

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

Chennai - 600 032 **EXECUTIVE DIRECTOR**

ACKNOWLEDGEMENT

National Instructional Media Institute (NIMI) sincerely acknowledges with thanks for the co-operation and contribution extended by the following Media Developers and their sponsoring organisations to bring out this Instructional Material **(Trade Practical)** for the trade of **Electrician NSQF Level - 4 (Revised 2022)** under **Power** Sector for ITIs.

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

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

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

INTRODUCTION

This manual for trade practical is intended for use in the ITI workshop. It consists of a series of practical exercises that are to be completed by the trainees during the first year of course is the **Electrician trade under Power Sector. It is National Skills Qualifications Framework NSQF Level - 4 (Revised 2022),** supplemented and supported by instructions/information to assist the trainees in performing the exercise. The exercises are designed to ensure that all the skills prescribed in the syllabus are covered including the allied trades.The syllabus for the1st Year **Electrician** Trade under **Power Sector** Trade Practical is divided into Fourteen Modules.The allocation of time for the various modules is given below:

Module 1	-	DC Generator
Module 2	-	DC Motor
Module 3	-	AC Three Phase Motor
Module 4	-	AC Single Phase Motor
Module 5	-	Alternator
Module 6	-	Synchronous Motor and MG Set
Module 7	-	Electronic Practice
Module 8	-	Control Panel Wiring
Module 9	-	AC/DC Motor Drives
Module 10	-	Inverter and UPS
Module 11	-	Power Generation and Substation
Module 12	-	Transmission and Distribution
Module 13	-	Circuit Breakers and Relays
Module 14	-	Electric Vehicle

The syllabus and the content in the modules are interlinked. As the number of workstations available in the electrical section is limited by the machinery and equipment, it is necessary to interpolate the exercises in the modules to form a proper teaching and learning sequence. The sequence of instruction is given in the schedule of instruction which is incorporated in the Instructor's Guide. With 25 practical hours a week of 5 working days 100 hours of practical per month is available.

Contents of Trade Practical

The procedure for working through the 106 exercises for the 1st Year with the specific objectives as the learning out comes at the end of each exercise is given is this book.

The skill objectives and tools/instruments, equipment/machines and materials required to perform the exercise are given in the beginning of each exercise.Skill training in the shop floor is planned through a series of practical exercises/experiments to support the related theory to make the trainees get hands on trainning in the Electrician trade along with the relevant cognitive skills appropriate for the level. A minimum number of projects have been included to make the training more effective and develop attitude to work in a team. Pictorial, schematic, wiring and circuit diagrams have been included in the exercises, wherever necessary, to assist the trainees broaden their views. The symbols used in the diagrams comply with the Bureau of Indian Standards (BIS) specifications.

Illustrations in this manual, help trainess visual perspective of the ideas and concepts.The procedures to be followed for completing the exercises is also given. Different forms of intermediate test questions have been included in the exercises, to enhance the trainee to trainee and trainee to instructor interactions.

Skill Information

Skill areas which are repetitive in nature are given as separate skill information sheets. Skills which are to be developed in specific areas are included in the exercises itself. Some subexercises are developed to fulfill the sequence of exercises in keeping with the syllabus.

This manual on trade practical forms part of the Written Instructional Material (WIM). Which includes manual on trade theory and assignment/test.

CONTENTS

LEARNING / ASSESSABLE OUTCOME

On completion of this book you shall be able to

Sl.No.	Learning Outcome	Exercise No.
1	Plan, execute commissioning and evaluate performance of DC machines. (NOS: PSS/N4402)	2.1.107 - 2.1.113
2	Execute testing, and maintenance of DC machines and motor starters. (NOS: PSS/N4402)	2.2.111 - 2.2.122
3	Plan, execute commissioning and evaluate performance of AC motors. (NOS: PSS/N1709)	2.2.111 - 2.2.122
4	Distinguish, organise and perform motor winding (Mapped NOS: PSS/N4402)	2.3.123 - 2.3.133
5	Plan, Execute commissioning and evaluate performance of AC motors. (Mapped NOS: PSS/N1709)	2.3.123 - 2.3.133
6	Execute testing, and maintenance of AC motors and starters. (NOS: PSS/N1709)	2.3.123 - 2.3.133
7	Plan, execute testing, evaluate performance and carry out maintenance of Alternator / MG set. (NOS: PSS/PSS/N9405)	2.4.134 - 2.4.142
8	Execute parallel operation of alternators. (NOS: PSS/N9405)	2.4.134 - 2.4.142
9	Distinguish, organise and perform motor winding. (NOS: PSS/N4402)	2.4.134 - 2.4.142
10	Assemble simple electronic circuits and test for functioning. (NOS: PSS/N9406)	2.5.143 - 2.6.151
11	Assemble accessories and carry out wiring of control cabinets and equipment. (NOS: PSS/N9407)	2.7.152 - 2.7.166
12	Perform speed control of AC and DC motors by using solid state devices. (NOS: PSS/N9408)	2.8.167 - 2.8.171
13	Detect the faults and troubleshoot inverter, stabilizer, battery charger, emergency light and UPS etc. (NOS: PSS/N6002)	2.9.172 - 2.9.174
14	Plan, assemble and install solar panel. (NOS: PSS/N9409)	2.10.175 - 2.10.180
15	Erect overhead domestic service line, outline various power plant layout and explain smart distribution grid and its components. (NOS: PSS/N0106)	2.11.181 - 2.11.187
16	Examine the faults and carry out repairing of circuit breakers. (NOS: PSS/N7001)	2.11.181 - 2.11.187
17	Install and troubleshoot Electric Vehicle charging stations. (NOS: PSS/N9410)	2.12.188 - 2.12.194
18	Read and apply engineering drawing for different application in the field of work. (NOS: PSS/N9401)	2.13.195 - 2.13.199
19	Demonstrate basic mathematical concept and principles to perform practical operations. Understand and explain basic science in the field of study. (NOS: PSS/N9402)	2.14.200 - 2.14.202

NOTE :

- **ITI students can obtain certificate of competency (Trade license) from respective Labour/ Industries department under State/ UT Govt.**
- **Refer to notification available in public domain for concern states/ UT. Principal & Trade Instructors to facilitate trainees**.

QR CODE

MODULE 1

Ex.No. 2.1.110

MODULE 2

Ex.No. 2.2.119

Ex.No. 2.2.122

MODULE 3

Ex.No. 2.3.125

Ex.No. 2.3.130

MODULE 13

Ex.No. 2.13.195

Ex.No. 2.13.197

SYLLABUS

Duration	Reference Learning Outcome	Professional Skills (Trade Practical) With Indicative Hours	Professional Knowledge (Trade Theory)
Professional Skill 35 Hrs.; Professional Knowledge 09 Hrs.	Plan, execute commissioning and evaluate performance of DC machines. **(Mapped NOS: PSS/N4402)**	107. Identify terminals, parts and connections of different types of DC machines. (05 Hrs.) 108. Measure field and armature resistance of DC machines. (05 Hrs.) 109. Determine build up voltage of DC shunt generator with varying field excitation and performance analysis on load. (10 Hrs.) 110. Test for continuity and insulation resistance of DC machine. (5 Hrs.) 111. Start, run and reverse direction of rotation of DC series, shunt and compound motors. (10 Hrs.)	General concept of rotating electrical machines. Principle of DC generator. Use of Armature, Field Coil, Polarity, Yoke, Cooling Fan, Commutator, slip ring and Brushes, Laminated core etc. E.M.F. equation Separately excited and self-excited generators. Series, shunt and compound generators. (09 Hrs.)
Professional Skill 77 Hrs.; Professional Knowledge 24 Hrs.	Execute testing, and maintenance of DC machines and motor starters. **(Mapped NOS: PSS/N4402)**	112. Perform no load and load test and determine characteristics of series and shunt generators. (08 Hrs.) 113. Perform no load and load test and determine characteristics of compound generators (cumulative and differential). (07 Hrs.) 114. Practice dismantling and assembling in DC shunt motor. (10 Hrs.) 115. Practice dismantling and assembling in DC compound generator. (10 Hrs.)	Principle and types of DC motor. Relation between applied voltage back e.m.f., armature voltage drop, speed and flux of DC motor. DC motor Starters, relation between torque, flux and armature current. Changing the direction of rotation. Characteristics, Losses & Efficiency of DC motors. Routine and maintenance. (12 Hrs.)
		116. Conduct performance analysis of DC series, shunt and compound motors. (14 Hrs.) 117. Dismantle and identify parts of three point and four-point DC motor starters. (06 Hrs.) 118. Assemble, Service and repair three point and four-point DC motor starters. (10 Hrs.) 119. Practice maintenance of carbon brushes, brush holders, Commutator and sliprings. (12 Hrs.)	
Professional Skill 35 Hrs.; Professional Knowledge 09 Hrs.	Distinguish, organise and perform motor winding. **(Mapped NOS: PSS/N4402)**	120. Perform speed control of DC motors - field and armature control method. (10 Hrs.) 121. Carry out overhauling of DC machines. (10 Hrs.) 122. Perform DC machine winding by developing connection diagram, test on growler and assemble. (15 Hrs.)	Methods of speed control of DC motors. Lap and wave winding and related terms. (09 Hrs.)

Professional Skill 80 Hrs.; Professional Knowledge 26 Hrs.	Plan, Execute commissioning and evaluate performance of AC motors. **(Mapped NOS: PSS/N1709)** Execute testing, and maintenance of AC motors and starters. **(Mapped NOS: PSS/N1709)**	123. Identify parts and terminals of three phase AC motors. (5 Hrs.) 124. Make an internal connection of automatic star-delta starter with three contactors. (10 Hrs.) 125. Connect, start and run three phase induction motors by using DOL, star-delta and auto-transformer starters. (17 Hrs.) 126. Connect, start, run and reverse direction of rotation of slip-ring motor through rotor resistance starter and determine performance characteristic. (13 Hrs.)	Working principle of three phase induction motor. Squirrel Cage Induction motor, Slip-ring induction motor; construction, characteristics, Slip and Torque. Different types of starters for three phase induction motors, its necessity, basic contactor circuit, parts and their functions. (13 Hrs.)
		127. Determine the efficiency of squirrel cage induction motor by brake test. (05 Hrs.) 128. Determine the efficiency of three phase squirrel cage induction motor by no load test and blocked rotor test. (05 Hrs.) 129. Measure slip and power factor to draw speed-torque (slip/torque) characteristics. (10 Hrs.) 130. Test for continuity and insulation resistance of three phase induction motors. (5 Hrs.) 131. Perform speed control of three phase induction motors by various methods like rheostatic control, autotransformer etc. (10 Hrs.)	Single phasing prevention. No load test and blocked rotor test of induction motor. Losses & efficiency. Various methods of speed control. Braking system of motor. Maintenance and repair. (13 Hrs.)
Professional Skill 23 Hrs.; Professional Knowledge 09 Hrs.	Distinguish, organise and perform motor winding. **(Mapped NOS: PSS/N4402)**	132. Perform winding of three phase AC motor by developing connection diagram, test and assemble. (18 Hrs.) 133. Maintain, service and troubleshoot the AC motor starter. (05 Hrs.)	Concentric/ distributed, single/ double layer winding and related terms.
Professional Skill 39 Hrs.; Professional Knowledge 12 Hrs.	Plan, Execute commissioning and evaluate performance of AC motors. **(Mapped NOS: PSS/N1709)** Execute testing, and maintenance of AC motors and starters. **(Mapped NOS: PSS/N1709)**	134. Identify parts and terminals of different types of single-phase AC motors. (5 Hrs.) 135. Install, connect and determine performance of single-phase AC motors. (10 Hrs.) 136. Start, run and reverse the direction of rotation of single-phase AC motors. (08 Hrs.) 137. Practice on speed control of single-phase AC motors. (08 Hrs.) 138. Compare starting and running winding currents of a capacitor run motor at various loads and measure the speed. (08 Hrs.)	Working principle, different method of starting and running of various single-phase AC motors. Domestic and industrial applications of different single-phase AC motors. Characteristics, losses and efficiency. (12 hrs.)

Professional Skill 50 Hrs.; Professional Knowledge 12 Hrs.	Distinguish, organise and perform motor winding. **(Mapped NOS: PSS/N4402)**	139. Carry out maintenance, service and repair of single-phase AC motors. (10 Hrs.) 140. Practice on single/double layer and concentric winding for AC motors, testing and assembling. (25 Hrs.) 141. Connect, start, run and reverse the direction of rotation of universal motor. (10 Hrs.) 142. Carry out maintenance and servicing of universal motor. (05 Hrs.)	Concentric/ distributed, single/ double layer winding and related terms. Troubleshooting of single-phase AC induction motors and universal motor. (12 hrs.)
Professional Skill 75 Hrs.; Professional Knowledge 22 Hrs.	Plan, execute testing, evaluate performance and carry out maintenance of Alternator / MG set. Execute parallel operation of alternators.	143. Install an alternator, identify parts and terminals of alternator. (5 Hrs.) 144. Test for continuity and insulation resistance of alternator. (5 Hrs.) 145. Connect, start and run an alternator and build up the voltage. (5 Hrs.) 146. Determine the load performance and voltage regulation of three phase alternator. (5 Hrs.) 147. Parallel operation and synchronization of three phase alternators. (15 Hrs.)	Principle of alternator, e.m.f. equation, relation between poles, speed and frequency. Types and construction. Efficiency, characteristics, regulation, phase sequence and parallel operation. Effect of changing the field excitation and power factor correction. (10 Hrs.)
		148. Install a synchronous motor, identify its parts and terminals. (10 Hrs.) 149. Connect, start and plot V-curves for synchronous motor under different excitation and load conditions. (10 Hrs.)	Working principle of synchronous motor. Effect of change of excitation and load. V and anti V curve. Power factor improvement. (06 Hrs.)
		150. Identify parts and terminals of MG set. (5 Hrs.) 151. Start and load MG set with 3 phase induction motor coupled to DC shunt generator. (15 Hrs.)	Rotary Converter, MG Set description and Maintenance. (06 Hrs.)
Professional Skill 99 Hrs.; Professional Knowledge 31 Hrs.	Assemble simple electronic circuits and test for functioning.	152. Determine the value of resistance by colour code and identify types. (03 Hrs.) 153. Test active and passive electronic components and its applications. (05 Hrs.)	Resistors – colour code, types and characteristics. Active and passive components. Atomic structure and semiconductor theory. (04 Hrs.)
		154. Determine V-I characteristics of semiconductor diode. (05 Hrs.) 155. Construct half wave, full wave and bridge rectifiers using semiconductor diode. (08 Hrs.) 156. Check transistors for their functioning by identifying its type and terminals. (10 Hrs.)	P-N junction, classification, specifications, biasing and characteristics of diodes. Rectifier circuit - half wave, full wave, bridge rectifiers and filters. Principle of operation, types, characteristics and various configuration of transistor. Application of transistor as a switch, voltage regulator and amplifier. (12 Hrs.)

		157. Bias the transistor and determine its characteristics. (05Hrs.) 158. Use transistor as an electronic switch and series voltage regulator. (05Hrs.)	
		159. Operate and set the required frequency using function generator. (05Hrs.) 160. Make a printed circuit board for power supply. (09 Hrs.) 161. Construct simple circuits containing UJT for triggering and FET as an amplifier. (05 Hrs.) 162. Troubleshoot defects in simple power supplies. (09 Hrs.)	Basic concept of power electronics devices. IC voltage regulators Digital Electronics - Binary numbers, logic gates and combinational circuits. (06 hrs.)
		163. Construct power control circuit by SCR, Diac, Triac and IGBT. (12 Hrs.) 164. Construct variable DC stabilized power supply using IC. (08 Hrs.) 165. Practice on various logics by use of logic gates and circuits. (05 Hrs.) 166. Generate and demonstrate wave shapes for voltage and current of rectifier, single stage amplifier and oscillator using CRO. (05 Hrs.)	Working principle and uses of oscilloscope. Construction and working of SCR, DIAC, TRIAC and IGBT. (09 Hrs.)
Professional Skill 82 Hrs.; Professional Knowledge 24 Hrs.	Assemble accessories and carry out wiring of control cabinets and equipment.	167. Design layout of control cabinet, assemble control elements and wiring accessories for: (i) Local and remote control of induction motor. (09 Hrs.) (ii) Forward and reverse operation of induction motor. (09 Hrs.) (iii) Automatic star-delta starter with change of direction of rotation. (12 Hrs.) (iv) Sequential control of three motors. (09 Hrs.)	Study and understand Layout drawing of control cabinet, power and control circuits. Various control elements: Isolators, pushbuttons, switches, indicators, MCB, fuses, relays, timers and limit switches etc. (12 Hrs.)
		168. Carry out wiring of control cabinet as per wiring diagram, bunching of XLPE cables, channeling, tying and checking etc. (13 Hrs.) 169. Mount various control elements e.g. circuit breakers, relays, contactors and timers etc. (09 Hrs.) 170. Identify and install required measuring instruments and sensors in control panel. (09 Hrs.) 171. Test the control panel for its performance. (12 Hrs.)	Wiring accessories: Race ways/ cable channel, DIN rail, terminal connectors, thimbles, lugs, ferrules, cable binding strap, buttons, cable ties, sleeves, gromats and clips etc. Testing of various control elements and circuits. (12 Hrs.)
Professional Skill 50 Hrs.;	Perform speed control of AC and	172. Perform speed control of DC motor using thyristors / DC drive. (18 Hrs.)	Working, parameters and applications of AC / DC drive.

Professional Knowledge 11 Hrs.	DC motors by using solid state devices.	173. Perform speed control and reversing the direction of rotation of AC motors by using thyristors / AC drive. (18 Hrs.) 174. Construct and test a universal motor speed controller using SCR. (14 Hrs.)	Speed control of 3 phase induction motor by using VVVF/ AC Drive. (11 Hrs.)
Professional Skill 50 Hrs.; Professional Knowledge 10 Hrs.	Detect the faults and troubleshoot inverter, stabilizer, battery charger, emergency light and UPS etc. **(Mapped NOS: PSS/N6002)**	175. Assemble circuits of voltage stabilizer and UPS. (10 Hrs.) 176. Prepare an emergency light. (10 Hrs.) 177. Assemble circuits of battery charger and inverter. (10Hrs.) 178. Test, analyze defects and repair voltage stabilizer, emergency light and UPS. (05Hrs.) 179. Maintain, service and troubleshoot battery charger and inverter. (07Hrs.) 180. Install an Inverter with battery and connect it in domestic wiring for operation. (08Hrs.)	Basic concept, block diagram and working of voltage stabilizer, battery charger, emergency light, inverter and UPS. Preventive and breakdown maintenance. (10 Hrs.)
Professional Skill 23 Hrs.; Professional Knowledge 04 Hrs.	Erect overhead domestic service line, outline various power plant layout and explain smart distribution grid and its components. **(Mapped NOS: PSS/N0106)**	181. Draw layout of thermal power plant and identify function of different layout elements. (5 Hrs.) 182. Draw layout of hydel power plant and identify functions of different layout elements. (5 Hrs.) 183. Visit to transmission / distribution substation. (08 Hrs.) 184. Draw actual circuit diagram of substation visited and indicate various components. (5 Hrs.)	Conventional and non-conventional sources of energy and their comparison. Power generation by thermal and hydel power plants. (04 Hrs.)
Professional Skill 25 Hrs.; Professional Knowledge 07 Hrs.	Plan, assemble and install solar panel	185. Prepare layout plan and Identify different elements of solar power system. (05 Hrs.) 186. Prepare layout plan and Identify different elements of wind power system. (05 Hrs.) 187. Assemble and connect solar panel for illumination. (15 Hrs.)	Various ways of electrical power generation by non-conventional methods. Power generation by solar and wind energy. Principle and operation of solar panel. (07 Hrs.)
Professional Skill 50 Hrs.; Professional Knowledge 10 Hrs.	Erect overhead domestic service line, outline various power plant layout and explain smart distribution grid and its components. **(Mapped NOS: PSS/N0106)**	188. Practice installation of insulators used in HT/LT line for a given voltage range. (04hrs.) 189. Draw single line diagram of transmission and distribution system. (04Hrs.) 190. Measure current carrying capacity of conductor for given power supply. (04hrs.) 191. Fasten jumper in pin, shackle and suspension type insulators. (07Hrs.)	Transmission and distribution networks. Line insulators, overhead poles and method of joining aluminum conductors. (05 Hrs.)
		192. Erect an overhead service line pole for single phase 230V distribution system in open space. (10 Hrs.) 193. Practice on laying of domestic service line. (10 Hrs.)	Safety precautions and IE rules pertaining to domestic service connections. Various substations. Various terms like – maximum demand, average demand, load

		194. Install bus bar and bus coupler on LT line. (5 Hrs.)	factor, diversity factor, plant utility factor etc. (05 Hrs.)
Professional Skill 25 Hrs.; Professional Knowledge 04 Hrs.	Examine the faults and carry out repairing of circuit breakers. **(Mapped NOS: PSS/N7001)**	195. Identify various parts of relay and ascertain the operation. (5 Hrs.) 196. Practice setting of pick up current and time setting multiplier for relay operation. (5 hrs.) 197. Identify the parts of circuit breaker, check its operation. (5Hrs.) 198. Test tripping characteristic of circuit breaker for over current and short circuit current. (5 hrs.) 199. Practice on repair and maintenance of circuit breaker. (5 hrs.)	Types of relays and its operation. Types of circuit breakers, their applications and functioning. Production of arc and quenching. (04 Hrs)
Professional Skill 22 Hrs.; Professional Knowledge 04 Hrs.	Install and troubleshoot Electric Vehicle charging stations.	200. Demonstrate different charger specifications. (05 hrs) 201. Perform installation of EV charging Station for Public places. (10 hrs) 202. Perform installation of Home EV charging stations. (10 hrs)	EV scenario in India and EV Charging basic theory. EV Charging safety requirements (04 Hrs)

Project work / Industrial visit:

a) Battery charger/Emergency light

b) Control of motor pump with tank level

c) DC voltage converter using SCRs

d) Logic control circuits using relays e) Alarm/indicator circuits using sensors

Identify terminals, parts and DC connections of different types of DC machines

Objectives: At the end of this Exercise you shall be able to
- **read and interpret the name-plate details of the given DC machine**
- **determine the pairs of terminals of the windings of the DC machine by the test lamp method**
- **test and identify the field and armature terminals of DC machine by the test lamp method**
- **Identify the parts of DC machines**
- **connect different types of DC machines.**

Requirements

Tools/Instruments

- Insulated combination pliers 200mm - 1 No.
- Screwdriver 150mm - 1 No.
- D.E. spanner set 5mm to 20mm (For a group of seven) - 1 No.

Equipment/Machines

- DC compound machine 220V or 440V rating - 1 No.
- Dismantled DC machine - 1 No.

Materials

- P.V.C. Insulated cable 3/20 of 660 V grade - 5 m
- Kit-kat fuse unit 250V, 16A - 1 Set
- Pendent lamp-holder 240V, 6A - 1 No.
- S.P.T. switch 240V, 6A - 1 No.
- B.C. lamp 25/40 watt, 240V - 1 No.
- Fuse wire 5A - as reqd.
- Cleaning cloth - as reqd.

PROCEDURE

TASK 1: **Read and interpret the name plate details and identify the terminals of a DC compound machine**

1 Read the name-plate details of the given DC compound machine and record them in Table.

2 Remove the terminal box cover and sketch the layout of the terminals by yourself.

Do not spoil screw heads or nuts nor lose them while removing the terminal cover.

As there is no marking on the terminals, give your own marking.

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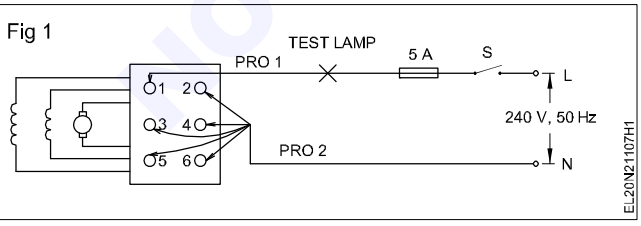
TASK 2: **Test and identify the pairs of terminals of a DC compound machine**

1 Prepare a test lamp for 240V 25W.

2 Connect Probe 1 of the test lamp to terminal 1 and touch the other Probe 2 to the rest of the terminals, one by one. (Fig 1)

Fig 1



3 Check the condition of the lamp.

If the lamp glows (Fig 1) while touching any one of the other terminals, then the terminal connected to Probe 1 and Probe 2 form pairs of the same circuit. Record the observations in Table 1.

4 Connect Probe 1 of the test lamp to another terminal as shown in Fig 1 and repeat the procedure of steps 2 and 3 to find the second pair of terminals and write the results in Table 1.

Table 1

Sl. No.	Pairs of terminals	Condition of lamps	Identification
1	1 and 2		
2	1 and 3		

The test lamp glows bright in both armature and series field terminals as the respective inductive reactance are of low value, whereas in the shunt field circuit the light may glow dim, or probes when touched, may give some spark only due to high inductive reactance therein.

Conclusion

Armature terminals _____ and _____
(Mark them as A_1 & A_2.)

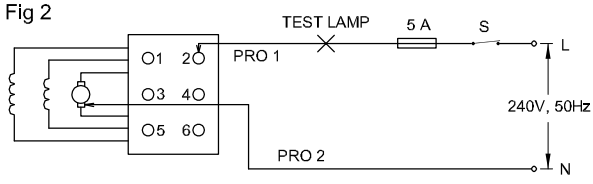
Shunt field terminals_____and _____.
(Mark them as E_1 & E_2.)

Series field terminals _____.and_____
(Mark them as D_1 & D_2.)

5 Check the other two left out terminals, to ascertain whether they belong to the same pairs of terminals.

The pairs of terminals in which the lamp either glow dim or the prod contact point gives spark as shown in Fig 2 form the shunt field terminals.

Fig 2



IDENTIFYING THE TERMINALS OF A DC MACHINE

Note: You might have observed in this experiment the lamp glows rather brightly at two sets or pairs of terminals. They belong to the armature and series fields. To distinguish the pair of armature terminals out of the two pairs, follow the steps as given in Task 3.

— — — — — — — —

TASK 3: **Identify the armature terminals pair out of 2 pairs of low resistive terminals**

1 Connect probe 1 to any one of the identified low resistive (where lamp was glows bright) pairs. (Fig 2)

2 Touch probe 2 to any one of the brushes. (Fig 2)

Take care that the probe does not touch the body/frame of the machine or any other metal part except the brush.

3 If the test lamp glows, then that pair belongs to the armature terminals. If not, try the other pairs. Mark the terminals as A_1 and A_2 in and also enter in Table 1.

4 The remaining two terminals will be of series field terminals. Mark them as D_1 and D_2 and also enter in Table 1.

5 Show the results to your instructor.

— — — — — — — —

TASK 4: **Identify the parts of DC machines**

1 Read and interpret the name plate details of the DC machine.

2 Identify the parts of the DC machine.

3 Put the label on each parts with numbers. (Fig 1)

4 Record the name of the parts and draw the sketches of each parts in your notebook

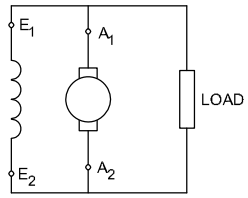
— — — — — — — —

TASK 5 : **Identify terminals and connect DC shunt generator**

1 Connect the machine as per the connection diagram. (Fig 1)

2 Connect field winding to the armature terminal in parallel. (Fig 1)

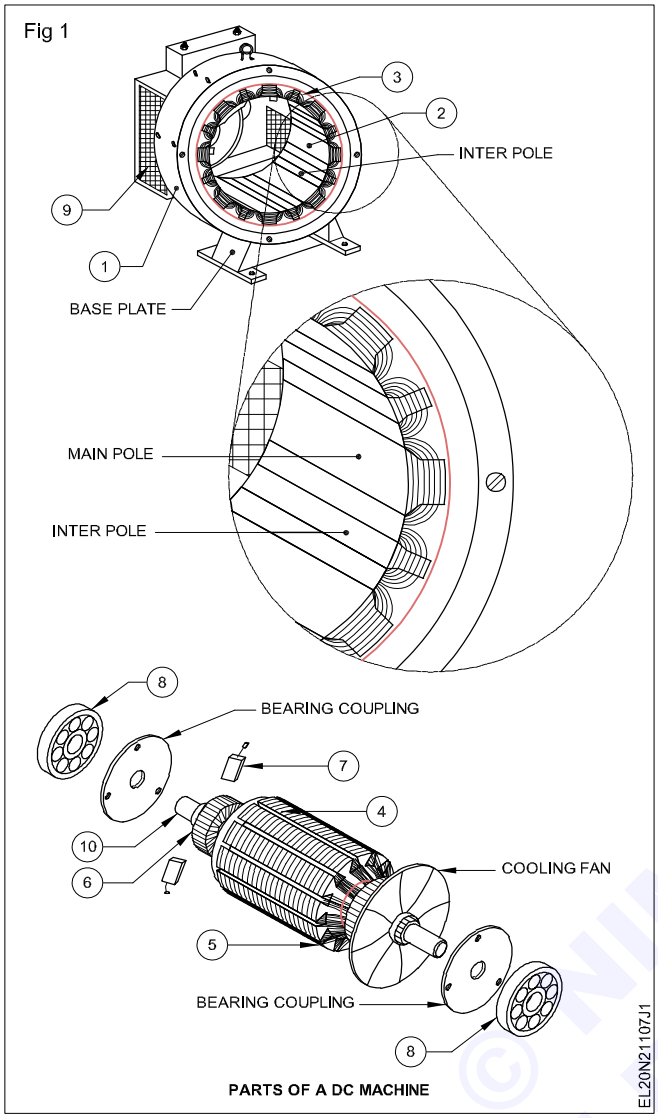
Fig 1



SHUNT GENERATOR

— — — — — — — —

Fig 1



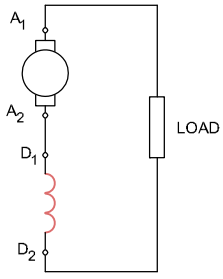
PARTS OF A DC MACHINE

TASK 6 : **Identify terminals and connect DC series generator**

1 Connect the machine as per the connection diagram. (Fig 1)

2 Connect field winding in series with the armature. (Fig 1)

Fig 1



SERIES GENERATOR

TASK 7 : **Identify terminals and connect various DC compound generator**

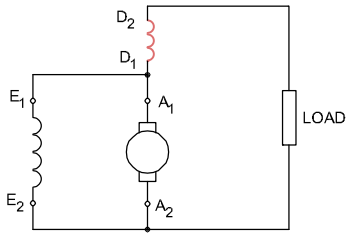
1 Connect the machine as per the connection diagram (Fig 1).

2 Provide the field excitation by a combination of shunt and series field windings.

3 Connect the shunt field directly across the armature (Fig 1).

4 The shunt field is connected in parallel with the series combination of armature and series field. (Fig 2)

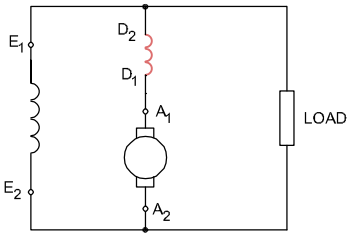
Fig 1



SHORT SHUNT COMPOUND GENERATOR

EL20N2110TZ1

Fig 2



LONG SHUNT COMPOUND GENERATOR

EL20N2110TZ2

5 Connect the machine as per the connection diagram. for short shunt cumulative compound and short shunt differential compound generator.

6 Connect the machine as per the connection diagram for differential long shunt cumulative compound and long shunt differential compound generator.

Measure field and armature resistance of DC machines

Objectives: At the end of this Exercise you shall be able to
- **measure the shunt field resistance of a DC machine by the voltmeter and ammeter method**
- **measure the shunt field resistance of a DC machine by the ohmmeter method and compare the results**
- **measure the armature resistance using a voltmeter and ammeter**
- **measure and verify armature resistance by the ohmmeter method.**

Requirements

Tools/Instruments

- Screwdriver 150 mm - 1 No.
- Insulated combination pliers 150 mm - 1 No.
- D.E. spanner set 5mm to 18mm - 1 Set
- M.C. voltmeter 0 to 25V - 1 No.
- M.C. ammeter 0 to 100 milli-amperes - 1 No.
- Series/ shunt type ohmmeter 0-50 ohms - 1 No.
- M.C. ammeter 0 to 5A - 1 No.
- M.C. voltmeter 0 to 500V - 1 No.

Equipment/Machines

- Car battery 24V, 100 AH - 1 No.
- Rheostat 250 ohms, 1 ampere - 1 No.
- DC compound machine 220V/ 3KW - 1 No.
- Rheostat 10 ohm 5 A - 1 No.

Materials

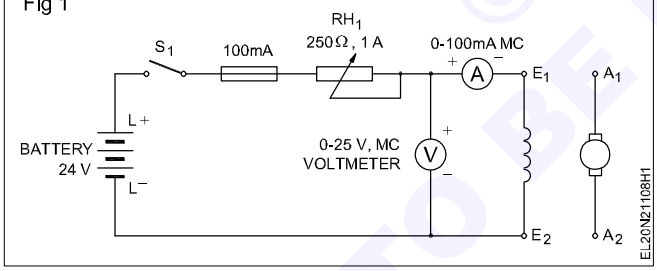
- PVC Insulated copper cable 1.5 sq mm - 5 m
- Crocodile clips 16A - 4 Nos.
- Test lamp - 1 No.

PROCEDURE

TASK 1: **Measure the shunt field resistance by the voltmeter and ammeter method**

1 Connect the circuit as per Fig 1 and get the approval of the instructor.

Fig 1



2 Switch 'on' the circuit and adjust the rheostat to get 20 mA.

3 Read and record the voltmeter and milli-ammeter readings in Table 1.

4 Repeat steps 2 and 3 for 40, 60, 80 and 100 mA current ratings.

5 Switch off the circuit and complete the tabular columns.

6 Calculate the average value of the field resistance and show it to the instructor.

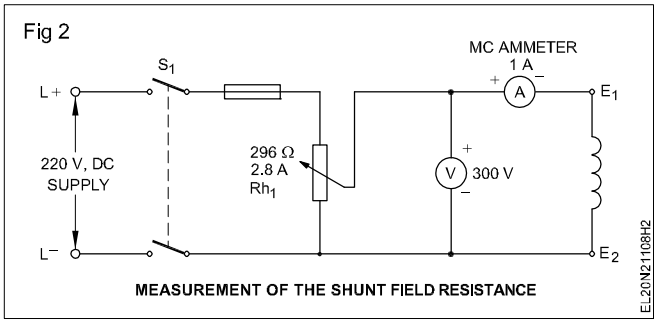
7 Disconnect the circuit after getting the approval by the instructor.

Table 1

Sl. No.	mA	Volts	R_{sh} = V/mA K ohms (R = V/I)	Average value shunt field resistance in ohms
1	20			
2	40			
3	60			
4	80			
5	100			

If the specified range of meters or supply is not available, it can be carried out, as shown in Fig 2, by using suitable meters and 220V DC.

Fig 2

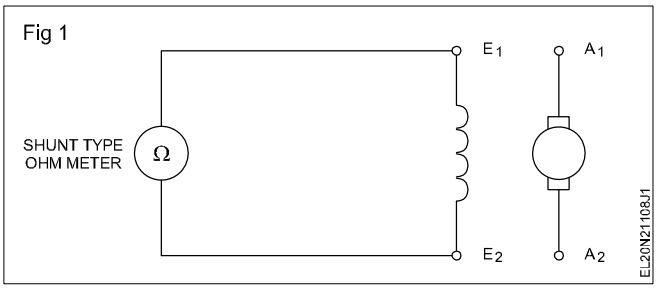


TASK 2**: Measure shunt field resistance by an ohmmeter**

1 Take a series type ohmmeter or multimeter; select a proper ohmic range and set its value to zero by shorting the prods.

Use a series type ohmmeter to measure high value resistance.

Fig 1



2 Connect the meter leads to the shunt field terminals of the machine as per the Fig 3.

3 Read, and record the value of the shunt field resistance below. The value of the shunt field resistance is _____ohms.

4 Refix the terminal cover.

5 Compare the readings obtained in Tasks 1 and 2. If there is any difference write the reasons in the space given below.

_____

_____

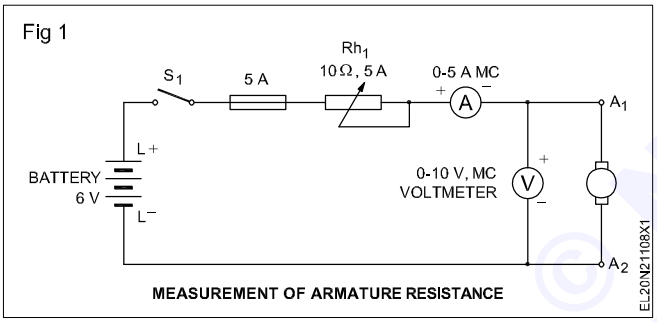
_____

— — — — — — — —

TASK 3: **Measure the armature resistance using a voltmeter and ammeter**

1 Connect the armature terminals to the ammeter, voltmeter, fuses, rheostat Rh_1 and the battery. (Fig 4)

Fig 1



MEASUREMENT OF ARMATURE RESISTANCE

2 Keep the rheostat Rh_1 in cut 'in' position. Then switch 'on' the circuit.

Sometimes the armature starts rotating slowly during the experiment. In such cases hold the armature in a steady position by hand to avoid erroneous reading.

3 Adjust the reading of the ammeter to 0.5 amperes by adjusting Rh_1.

Move the armature to different positions by hand and see that the reading remains constant.

4 Read and record the volt and ammeter readings in Table 2.

Table 2

Sl. No.	Amps.	Volts	R =V/I	Average Value of armature resistance
1	0.5			
2	1			
3	1.5			
4	80			
5	100			

5 Repeat steps 3 and 4 for 1, 1.5, 2 and 2.5 amperes current ratings.

6 Switch 'OFF' the circuit.

7 Complete the remaining columns of the table, find the average value of the armature resistance and show the results to the instructor.

8 Disconnect the circuit after getting by the approval of the instructor.

— — — — — — — —

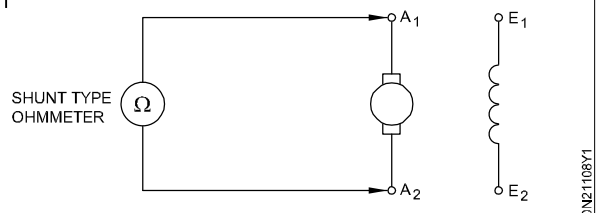
TASK 4: **Measure armature resistance using an ohmmeter**

1 Adjust ohms 'Zero' and ohms 'Infinity' of the ohmmeter.

Use a shunt type ohmmeter to measure the low value resistance of the armature.

2 Connect the ohmmeter across the armature terminals (Fig 5) and measure the resistance.

Fig 1



MEASUREMENT OF ARMATURE RESISTANCE

Move the armature to different positions by hand and see that the reading remains constant.

3 Note down the meter reading and record it below.

Armature resistance value is_____ ohms.

4 Replace the terminal cover and keep all tools, equipment and meters at their places.

5 Compare the readings of Task 2 & 3. If there is any difference, find the reasons for that and write your conclusions in the space below.

6 Conclusion

_____

_____

_____

Determine build up voltage of DC shunt generator with varying field excitation and performance analysis on load

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

- **measure the voltage due to residual magnetism or create residual magnetism, if necessary**
- **measure the speed of a DC shunt generator with the help of a revolution counter and stopwatch**
- **build up voltage in a self-excited DC shunt generator**
- **determine the relation between field current and induced emf (magnetisation characteristic) in a DC shunt generator when the speed is constant**
- **connect a DC shunt generator and build up the voltage**
- **load the DC shunt generator**
- **determine the load performance characteristic of the DC shunt generator at different loads.**

Requirements

Tools/Instruments

• Combination pliers 200mm	- 1 No.
• Screwdriver 150mm	- 1 No.
• Electrician's knife 100mm	- 1 No.
• Revolution counter 4 digits	- 1 No.
• Stopwatch	- 1 No.
• Ammeter MC 0-1A	- 1 No.
• Voltmeter MC 0-300V	- 1 No.
• M.C ammeter o-20A	- 1 No.

Equipment/Machines

• DC shunt generator 2 or 4 KW 220V	- 1 No.
• Rheostat 296 ohms 2.8 Amps	- 1 No.
• Knife switch D.P.S.T. 16A	- 1 No.
• Knife switch S.P.S.T. 16A	- 1 No.
• Lamp load 220v/5kw	- 1 No.

Materials

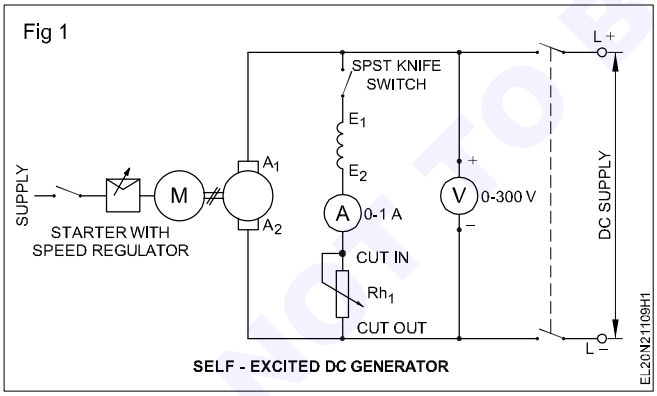
• P.V.C. Insulated cable 2.5 sq.mm	- 5 m
• Fuse wire 10 A	- 0.2 m
• P.V C Insulated flexible cable 14/0.2	- 2 m

PROCEDURE

TASK 1: **Build up voltage of a DC shunt generator**

1 Connect the circuit as per Fig 1.

Fig 1



SELF - EXCITED DC GENERATOR

2 Keep the field switch open and the field rheostat in the cut `in' position. Get the approval of the instructor.

3 Start the prime mover coupled to the DC shunt generator.

The direction of rotation must be according to the direction marked on the DC generator. If not, change the direction of the rotation of the prime mover.

4 Measure the speed of the generator with the help of the revolution counter and stopwatch.

The number of revolutions made by a machine in a minute gives the r.p.m.

5 Adjust the prime mover speed such that the generator runs at its rated speed.

Keep the speed constant throughout the experiment.

6 Measure the voltage induced across the armature and note down the measured value in Table 1.

This induced voltage is due to the residual magnetism as the field current is zero. If the residual magnetism is absent in the field poles, then there will be no residual voltage. In such a case the residual magnetism could be recreated by connecting the field winding to a DC source such as a battery for a short time.

7 Close the field circuit switch and gradually increase the field current to 0.1 ampere by reducing the resistance of the field rheostat.

If the generator is not able to build up voltage even though it is running in the marked direction, switch off the prime mover and then

interchange the field terminals of the generator. While varying the field rheostat/regulator it should be done positively and slowly in the forward direction. Reverse movement should be avoided.

8 Increase the field current slowly in steps of 0.1 ampere, and for each step, note down the field current and the corresponding induced voltage. Record them in Table 1.

Increase the field current only till the induced voltage reaches just above 125% of the rated value. Check the speed of the generator at intervals. If necessary, adjust it to the rated value.

9 Switch 'OFF' the DC generator and the prime mover.

10 Draw the graph keeping the induced voltage in the 'Y' axis and the field current in the X axis.

The graph shows the magnetisation / no-load characteristic of the DC shunt generator.

11 Show your readings and graph to your instructor.

Table 1

Sl. No.	Field current in amps	Induced voltage in volts	Speed (held at constant rated value throughout the experiment)

— — — — — — —

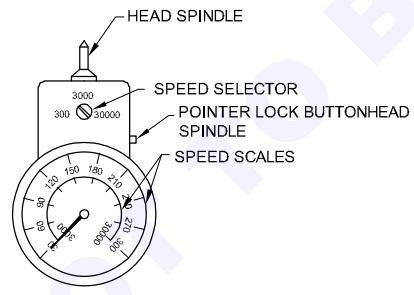
Skill Sequence

Method of using a tachometer

Objective: This shall help you to
• measure speed using a tachometer.

A hand tachometer (Fig 1) is a portable instrument and is used for measuring the speed of the rotating machinery.

Fig 1



To use a hand tachometer (Fig 2)

- Select and fit the correct head
- Select the highest speed range on the tachometer if the speed is not known.
- Hold the tachometer gently against the shaft.
- Depress the pointer lock button when the pointer has settled. (Fig 3)
- Remove the tachometer from the shaft to take a reading.
- Take a reading using the correct scale for the speed range.

If the reading is within a lower speed range, use the next lower range to take a new reading for a more accurate result.

Fig 2

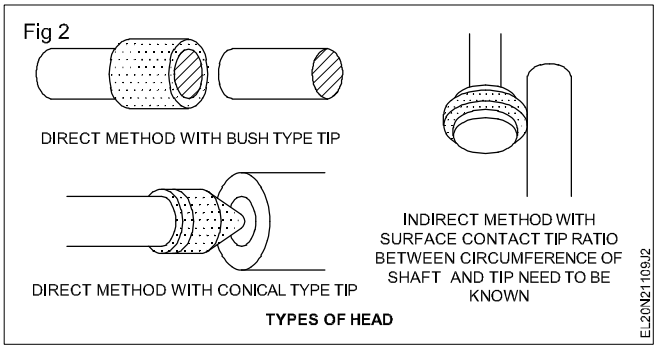
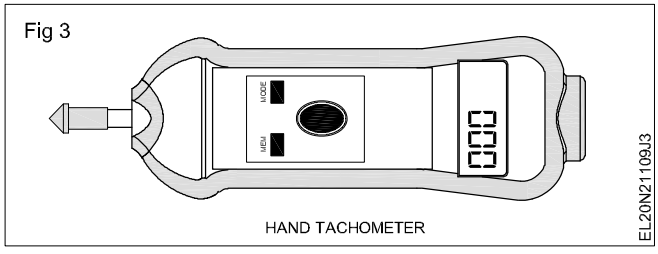


Fig 3



TASK 2 : **Determine performance analysis of DC shunt generator on different loads**

1 Measure the armature resistance and enter the value in Table 1.

2 Select appropriate cables, switch, load and meters, according to the capacity of the given DC shunt generator.

3 Connect the meters, rheostat and lamp load with the terminals of the DC shunt generator (Fig 1). (If a lamp load is not available, a water load can be used.)

4 Keep the load switch open and also switch `off' all the circuit switches in the lamp load.

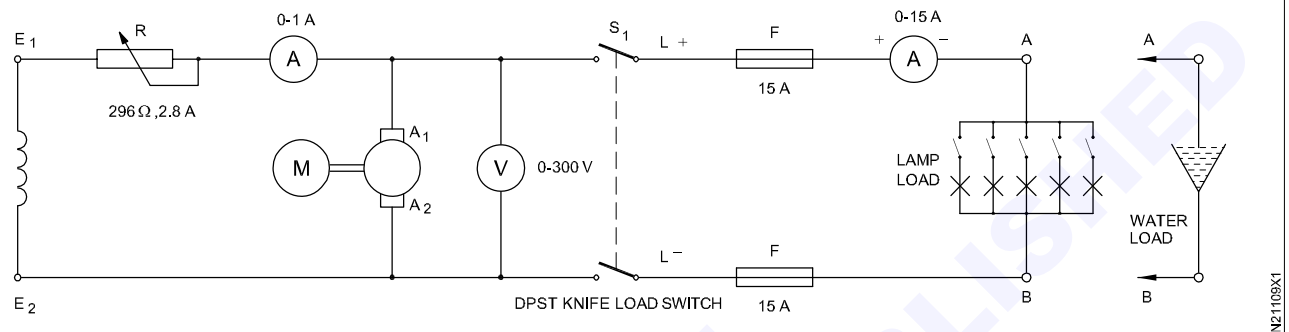
5 Keep the field regulator resistance in `cut-in' position.

Make yourself clear about the method of starting the prime mover and the procedure of adjusting its speed.

6 Start the prime mover and bring it to the rated speed of the generator.

7 By adjusting the field rheostat, build up the voltage of the generator to its rated value. Enter the value of the open circuit voltage in Table 1.

Fig 1



LOADING OF DC SHUNT GENERATOR

Table 1

Sl.No.	Terminal voltage `V'(Volts)	Load current I_L	Shunt field current (I_{sh}) kept constant	Armature current $I_a=I_L+I_{sh}$	Induced emf $E=V+I_aR_a$	Remarks
						Armature resistance = ohms

Remember

8 Determine open circuit voltage $V = E - I_a . R_a$
where E is the induced emf
I_a is the armature current
R_a is the armature resistance.

9 Determine the armature current $I_a = I_L + I_{sh}$
where I_L is the load current
Ish is the field current.

In the case of no load $I_L = 0$
hence $I_a = I_{sh}$.

Therefore, at no load, the terminal voltage comes to
$V = E - (0 + I_{sh}) . R_a$.

10 Close the load switch and gradually load the generator by switching `ON' a few lamps.

11 Read the corresponding terminal voltage, shunt field current, load current, and record them in Table 1.

Check the speed of the generator at intervals, and adjust it to the rated value.

12 Increase the load current up to 125% of its rated value in 6 or 8 equal steps.

13 Note down the corresponding terminal voltage and field current for each step of load current in Table 1.

14 Gradually reduce the load current to zero and switch 'OFF' the load circuit and the prime mover.

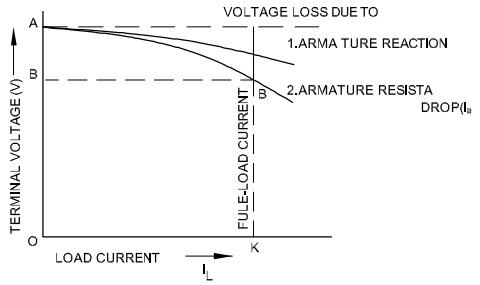
15 Show the record of your readings to the instructor and get his approval.

16 Draw the graph of the external characteristic of a DC shunt generator by keeping the terminal voltage in the Y-axis and the load current in the X-axis. (Fig 2)

17 Show the graph to your instructor and get his approval.

18 Disconnect the circuit.

Fig 2



EXTERNAL CHARACTERISTICS CURVE OF DC SHUNT GENERATOR

Test for continuity and insulation resistance of DC machine

Objectives: At the end of this Exercise you shall be able to
- **test a DC machine for continuity with a megger**
- **test a DC machine for insulation resistance between windings with a megger**
- **test a DC machine for insulation resistance between windings and body with a megger.**

Requirements

Tools/Instruments

- Insulated cutting pliers 150 mm - 1 No.
- Megger 500V - 1 No.
- Screwdriver 150 mm - 1 No.
- D/E spanner set 5 to 18mm - 1 Set

Equipment/Machines

- DC compound machine of any rating - 1 No.

Materials

- PVC Insulated flexible copper cable 24/0.2 mm - 4 m
- Crocodile clips 16 amps - 2 Nos.

PROCEDURE

TASK 1: **Test a DC machine for continuity**

1 Switch off the designated main switch of the DC machine and remove the fuse-carriers.

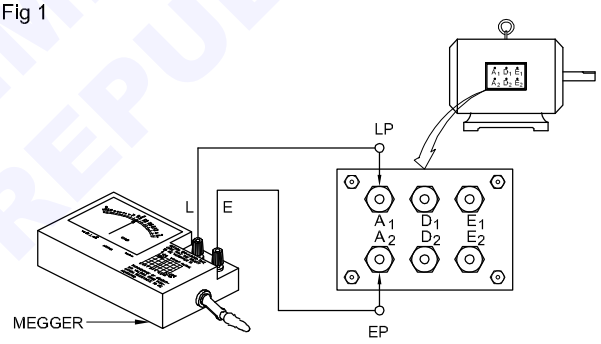
2 Identify the pairs of the terminals from the marking.

3 Test the continuity of the armature terminals A_1 and A_2. (Fig 1)

4 Test the continuity of the series field terminals D_1 and D_2 using a Megger.

5 Test the continuity of the shunt field terminals E_1 and E_2 using a Megger.

Fig 1



CONTINUITY TEST ON DC MACHINE

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TASK 2: **Test a DC machine for insulation resistance between windings**

1 Fill up the columns 1 to 4 in Table 1.

2 Connect the Megger between armature and shunt field terminals.

3 Rotate the Megger at its rated speed, and note down the reading in Table 1.

4 Repeat step 3 for testing the insulation between the shunt field and series field after connecting the Megger terminals.

5 Connect the Megger to measure the insulation resistance between the armature and series field.

The measured value should not be less than 1 megohm.

Table 1

Insulation resistance test between windings of a DC machine

Date	Time	Weather condition	Duty cycle	Test between terminals	Insulation resistance in megohms	Remarks
1	2	3	4	5	6	7
				Armature and shunt field		
				Shunt and series field		
				Series field and armature		

— — — — — — — —

TASK 3: **Test a DC machine for insulation resistance between armature/winding and body**

1 Fill up the columns 1 to 4 in Table 2

2 Connect the Megger between the armature and body and repeat step 3 of Task 2, and note down the reading in Table 2.

3 Connect the Megger between the series winding and body and repeat step 3 of Task 2, and note down the reading in Table 2.

4 Connect the Megger between the shunt winding and body and repeat step 3 of Task 2, and note down the reading in Table 2.

If any reading is zero ohms, it shows a short circuit of that winding to the body.

If the reading is less than one megohm, it shows that the insulation is weak. If the value is less than one megohm, inform your instructor immediately so that the necessary remedial steps could be taken to improve the insulation resistance.

5 Show the results to your instructor and get his approval.

Table 2

Insulation resistance test between armature/field windings and the body of a DC machine

Date	Time	Weather condition	Duty cycle	Test between terminals	Insulation resistance in megohms	Remarks
1	2	3	4	5	6	7
				Armature and the body		
				Series field and the body		
				Shunt field and the body		

— — — — — — — —

Start, run and reverse direction of rotation of DC series, shunt and compound motors

Objectives: At the end of this Exercise you shall be able to
- **connect a 2 point starter and start the motor**
- **reverse the direction of rotation of a DC series motor**
  - **by changing the armature terminals.**
  - **by changing the field terminals.**
- **connect a 3 point starter to a DC shunt motor, start and run the motor**
- **reverse the direction of rotation of a DC shunt motor**
  - **by changing the armature terminals**
  - **by changing the field terminals**
- **connect, start and run a DC compound motor through a 4 point starter**
- **reverse the direction of rotation of a DC compound motor**
  - **by changing the armature connections (method 1)**
  - **by changing the shunt field and series field connections (method 2).**

Requirements

Tools/Instruments

- Insulated cutting pliers 150mm - 1 No.
- Megger 500 V - 1 No.
- Screwdriver 150mm - 1 No.
- D.E. spanner set 5mm to 20mm - 1 Set
- Shunt type ohmmeter 0-2K or multi meter - 1 No.
- Test lamp with 220V 25W lamp - 1 No.
- Revolution counter cyclometer 4 digits - 1 No.
- Stop watch 30 minutes - 1 No.

Equipments/Machines

- DC series motor 220V 3 H.P - 1 No.
- 2-point starter for 220V 3 H.P. DC series motor - 1 No.
- Loading arrangement or complete brake test arrangement - 1 Set
- D.C shunt motor 220V 3HP - 1 No.
- ICDP switch 250V/16A - 1 No.
- 3 Point starter suitable for 220V 3HP D.C shunt motor - 1 No.
- Motor compound DC 220Volts and 2 to 3HP - 1 No.
- 4 Point starter 220V 16A - 1 No.

Materials

- 2.5sq mm P.V.C. copper multi-strand cable - 18 m
- Fuse wire 15 amps - as reqd.

PROCEDURE

TASK 1: **Connect, start and run a DC series motor**

1 Fix and arrange a suitable load for the series motor.

The series motor should not start or run without a load. A flat belt drive, which might slip, while running should not be used. Fig 1 shows the loading through brake arrangement. The belt over the pulley should be marginally tightened to apply a certain load on the motor.

2 Select a proper rating of the I.C.D.P. switch, cables, fuse wire and 2-point starter, according to the rating of the given DC series motor.

The rating of the switch, fuse, cable and 2-point starter given here is for a 220 V 3 HP DC series motor.

3 Open the 2-point starter, identify the parts, trace the connection and draw the connection diagram.

4 Connect the motor as per a circuit diagram (Fig 1) and get it approved by the instructor.

Check whether the belt is in position for loading the pulley.

5 Switch `ON' the I.C.D.P.and move the 2-point starter gradually in the clockwise direction, till the `ON' position is reached and observe the direction of rotation.

6 Record the direction of rotation in Table 1.

7 Measure the speed with a tachometer and enter the value in Table 1.

Table 1

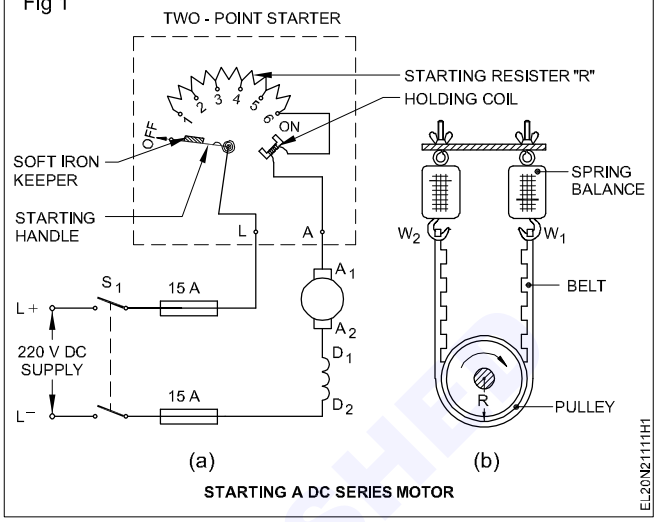
Sl. No.	Figure	Direction of rotation	Speed in r.p.m.
1	Fig 1		
2	Fig 2		
3	Fig 3		
4	Fig 4		

8 Stop the motor by switching off the I.C.D.P. and wait till the starter handle comes to the `OFF' position. Remove the fuse.

If the 2-point starter provided to you is without the hold on coil and spring-loaded handle, then the starter handle needs to be brought to the `OFF' position manually after switching `OFF' the supply.

When reversing any motor, we should allow it to come to a dead stop and then operate it in the opposite direction.

Fig 1

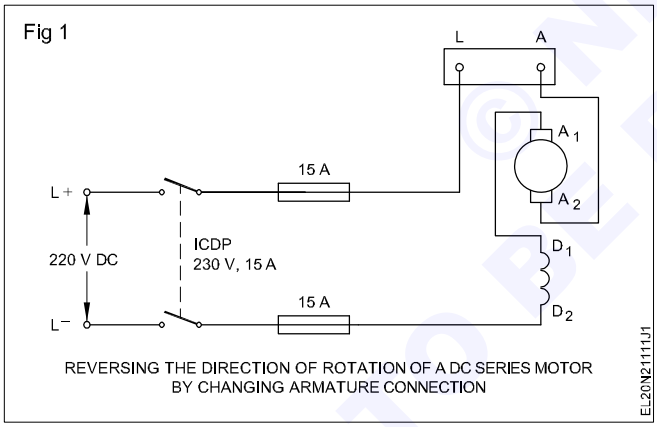


TASK 2 : **Reverse the direction of rotation of a DC series motor**

METHOD 1 : **Reverse the direction of rotation by changing the armature terminals**

1 Repeat steps 5 to 8 of Task 1. (Fig 1)

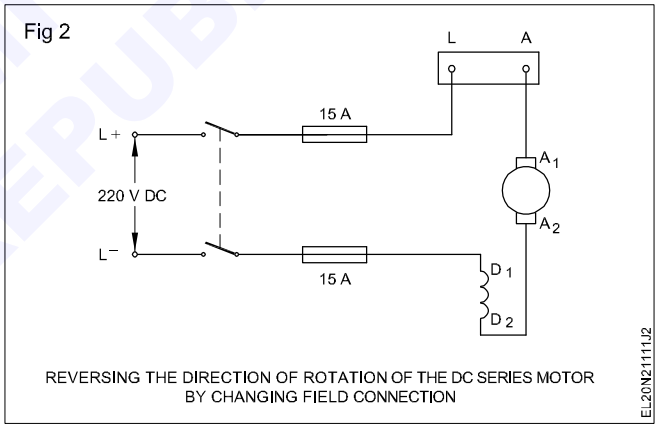
Fig 1



METHOD 2 : **Reverse the direction of rotation by changing the field terminals.**

1 Repeat steps 5 to 8 of Task 1. (Fig 2)

Fig 2



2 Change the supply terminals as per circuit diagram and the loading arrangements for correctness. Repeat steps 5 to 8 of Task 1.

3 Compare the connections. Check the direction of rotation in both the cases.

4 Write the conclusion based on this experiment in the space given below.

Conclusion

TASK 3: **Connect, start and run a DC shunt motor**

1 Select the ICDP switch, 3-point starter, fuse wire and cable according to the given specification.

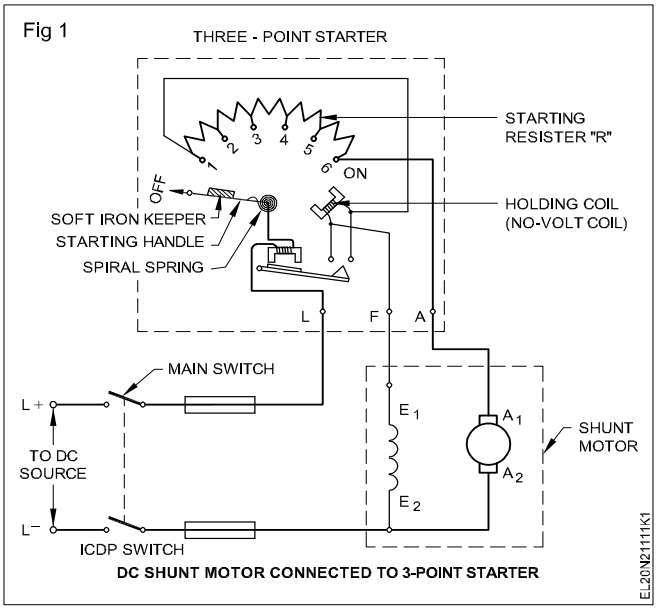
The specification here is for DC shunt motor 220v, 3HP rating. If the available DC shunt motor in the shop floor is not of the same rating, the specification will have to be changed.

2 Open the 3-point starter, trace the connections and sketch the internal parts.

3 Measure the resistance of the series resistor and the no-volt coil of the starter. Enter these values in Table 2.

4 Connect the DC shunt motor as per circuit diagram. (Fig 1)

Fig 1



DC SHUNT MOTOR CONNECTED TO 3-POINT STARTER

5 Check the supply voltage and confirm by verifying with the data given in the name-plate.

6 Check the rating of the fuses in the main switch. If required, change it in accordance with the motor rating.

7 Switch `ON' the ICDP and gradually move the starter handle to the `ON' position.

8 Check the direction of rotation and enter it in Table 3.

9 Stop the motor by switching `OFF' the ICDP. Wait until the shaft comes to a standstill position.

10 Remove the fuse-carriers from the ICDP.

Table 2

Resistance of the series resistor (in ohms)	Resistance of the no-volt coil(in ohms)

Table 3

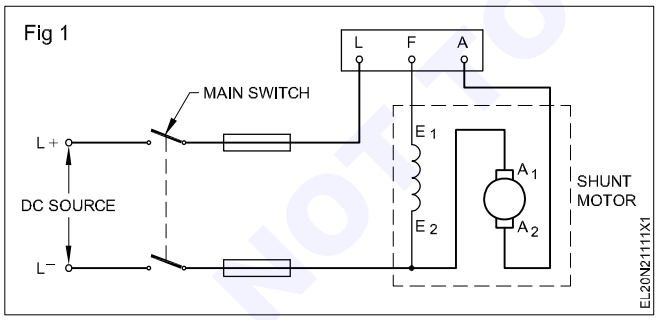
Sl.No	Description	Direction of rotation
1	Normal connection	
2	By changing armature terminals	
3	By changing shunt field terminals	

TASK 4: **Reverse the direction of rotation of a DC shunt motor**

METHOD 1: **Change the direction of rotation by changing the armature terminals.**

1 Reconnect the DC shunt motor as per circuit diagram. (Fig 1)

Fig 1



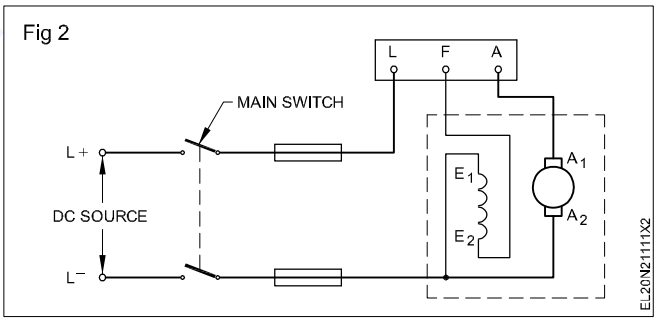
2 Replace the fuse-carriers.

3 Repeat the working steps 7 to 10 of Task 3.

METHOD 2: **Change the direction of rotation by changing the shunt field terminals.**

1 Reconnect the DC shunt motor as per circuit diagram. (Fig 2)

Fig 2



2 Replace the fuse-carriers.

3 Repeat the working steps 7 to 10 of Task 3.

Only one pair of terminals, either armature or shunt field, should be changed. If both the armature and shunt field terminals are changed, the direction of rotation will not change.

Write the conclusion:

a Necessity of starter

b Method of changing the direction of rotation in a DC shunt motor based on Fleming's left hand rule.

TASK 5: **Connect, start and run a DC compound motor**

1 Read and interpret the name-plate details of the given DC compound motor and record it.

2 Identify the terminals, and test for the insulation resistance of the given DC compound motor.

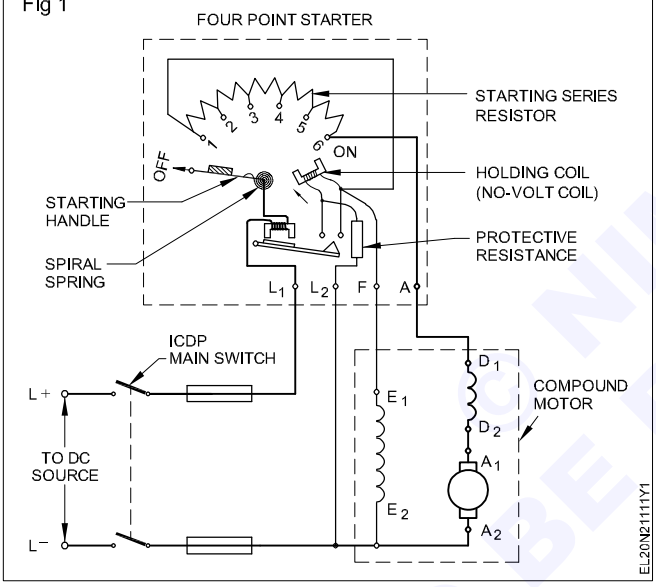
3 Select proper sizes of switch, starter and cables according to the rating of the given DC compound motor.

The ratings of the switch, starter, cables etc. given here are for a DC compound motor of 220V 3 HP rating. If the motor rating changes, the rating of the switch, starter, cable etc. should also be changed.

4 Select and insert a suitable fuse wire in the main ICDP switch according to the rating of the given motor.

5 Give the connections as per circuit diagram. (Fig 1)

Fig 1



6 Connect the ICDP switch to the rated DC supply voltage of the motor.

7 Switch on and move the 4-point starter handle slowly until the `ON' position is reached.

8 Observe the direction of rotation of the motor. The direction of rotation of the motor is _____

9 Take the revolution counter, set the readings to zero, and fix the rubber tip.

10 Take the stopwatch and set its reading to zero.

The rubber tip of the revolution counter should be engaged to the shaft centre of the motor. The revolution counter and the stopwatch need to be started at the same time and stopped at the same time.

11 Hold the revolution counter in the right hand and the stopwatch in the left hand.

12 Engage the rubber tip of the revolution counter in the centre of the shaft of the motor.

Stand away but in front of the shaft and engage the rubber tip slowly in the small countersink position of the rotating shaft.

13 Press the start-button of the revolution counter and the stopwatch simultaneously.

14 Press the 'off' button of the stopwatch just when the stopwatch reads one minute and the revolution counter simultaneously. Read the revolution per minute. Speed of the motor in revolution per minute is_____

If you are not able to stop the stopwatch exactly in one minute, follow the procedure given below. (However the stopwatch and the revolution counter ought to have been stopped at the same time)

'N' Number of revolutions recorded in counter for a time of 'X' minutes as recorded by the stopwatch.

Revolution per minute =

$$\frac{\text{'N' Number of revolutions in counter}}{\text{Stopwatch time in 'X' minutes}} = \text{r.p.m.}$$

15 Stop the motor by switching off the ICDP switch, wait till the shaft comes to rest.

— — — — — — — —

TASK 6: **Reverse the direction of rotation of a DC compound motor**

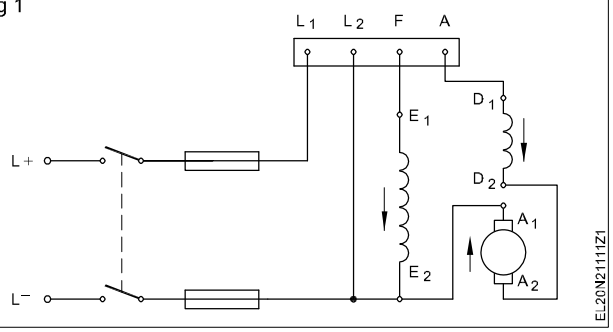
METHOD 1 : **Reverse the direction of rotation of the DC compound motor by changing the armature connection**

1 Interchange the terminal of the armature. (Fig 1)

2 Switch `ON' and start the motor by the starter; observe the direction of rotation. The direction of rotation of the motor is _____.

3 Stop the motor by switching off the I.C.D.P; wait until the motor stops completely.

Fig 1

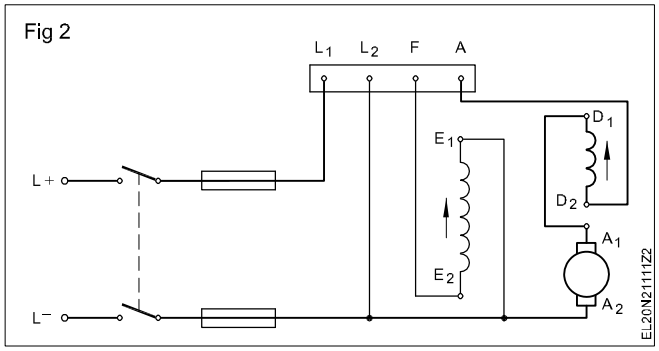


METHOD 2 : **Reverse the direction of rotation of the DC compound motor by changing the shunt field terminals and series field terminals.**

As explained, the series field terminals also need to be changed in this case, to retain the earlier characteristics of the compound motor.

1 Interchange the field terminals. (Fig 2).

Fig 2



2 Switch `ON' and start the motor by the starter and observe the direction of rotation. The direction of rotation of the motor is _____

3 Switch off the supply. Write your observation regarding the method of changing the direction of rotation of the DC compound motor in the space given below.

4 Show your observations to your instructor.

5 Disconnect the connections and keep the tools, equipment and materials in their proper places.

— — — — — — — —

Perform no load and load test and determine characteristics of series and shunt generators

Objectives: At the end of this Exercise you shall be able to
- **conduct no load test of a DC series generator**
- **conduct load test and characteristics of a series generator**
- **conduct no load test of a DC shunt generator**
- **perform load test and characteristics of the shunt generator.**

Requirements

Tools/Instruments

• Combination pliers 200mm	- 1 No.
• Screw driver 150 mm	- 1 No.
• Electricians knife 100mm	- 1 No.
• Revolution counter 4 digits	- 1 No.
• Stop watch	- 1 No.
• M.C ammeter 0 to 5A 250V	- 1 No.
• M.C voltmeter 0-300V	- 1 No.
• M.C ammeter 15A 250V	- 1 No

Equipment/Machines

• DC series generator 2 or 4 KW 220V	- 1 No.
• DC shunt generator 2 or 4KW 220V	- 1 No.
• Rheostat 480Ω 1A	- 1 No.
• Knife switch DPST 20A/250V	- 1 No.
• Knife switch SPST 16A/250V	- 1 No.
• Lamp load 220V/5KW	- 1 No.

Materials

• P.V.C. Insulated cable 2.5 sq.mm	- 6 m
• Fuse wire 16A	- 0.5m
• P.V.C Insulated flexible cable 14/0.2	- 2 m

PROCEDURE

TASK 1: **Conduct no load test of a DC series generator**

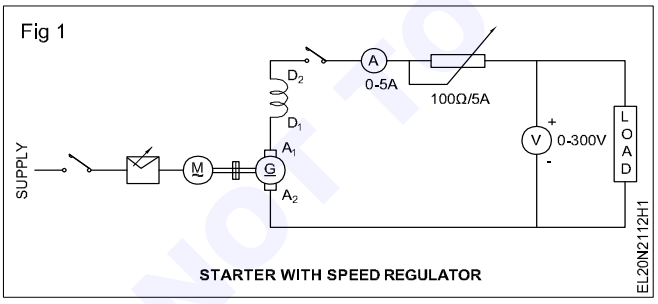
1 Place all the materials and tools on the work bench.

2 Read and interpret the name plate details of the given generator.

3 Identify the terminals of the given DC series generator.

4 Connect the circuit as per Fig 1.

Fig 1



5 Start the generator and note down readings.

6 Measure the speed of the generator with the help of the revolution counter and stop watch.

7 Adjust the prime mover speed such that the generator runs at its rated speed.

8 Measure the voltage induced across the armature and note down the measured value in Table 1.

9 Increase the field current slowly in steps of 0.1 amperes and for each step note down the field current and the corresponding induced voltage and record them in Table 1.

10 Switch off the DC generator and the prime mover.

11 Draw the graph keeping the induced voltage in the 'Y' axis and the field current in the x axis.

12 Show your readings and graph to your Instructor.

Table 1

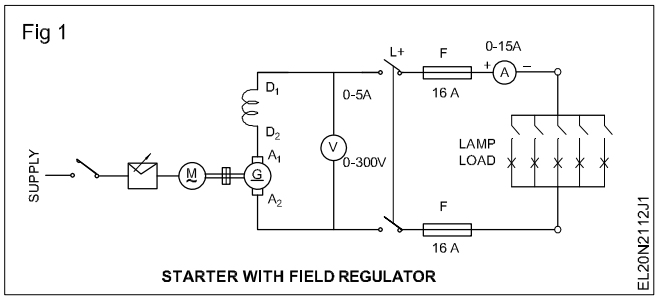
Sl. No.	Field current in amps	Induced voltage in volts	Speed (held at constant rated value throughout the experiment)

TASK 2 : **Conduct load test and analyse characteristics of DC series generator**

1 Place all the materials and tools on the work bench.

2 Connect the circuit as per Fig 1.

Fig 1



STARTER WITH FIELD REGULATOR

3 Keep the main switch at off position.

4 Rotate the armature using a prime mover at the rated speed.

5 Operate the main switch in ON position.

6 Now operate the load switch in ON position

7 Note down the ammeter and voltmeter readings in the Table 2.

8 Change the speed of generator and note the different values of ammeter and voltmeter

9 Plot the graph between terminal voltage and load current.(Fig 2)

Fig 2

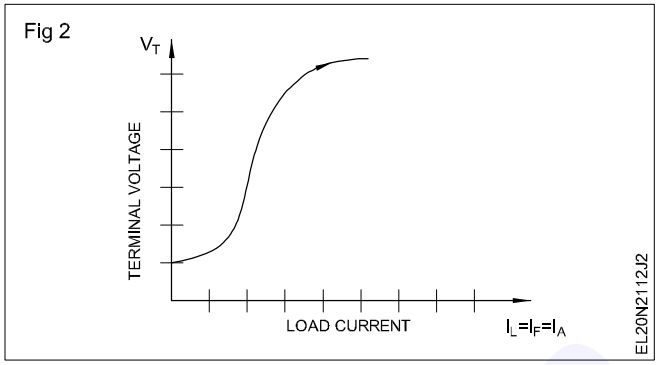


Table 2

Sl No	Load current I_L (in amps)	Terminal Voltage V_T (involts)
1		
2		
3		

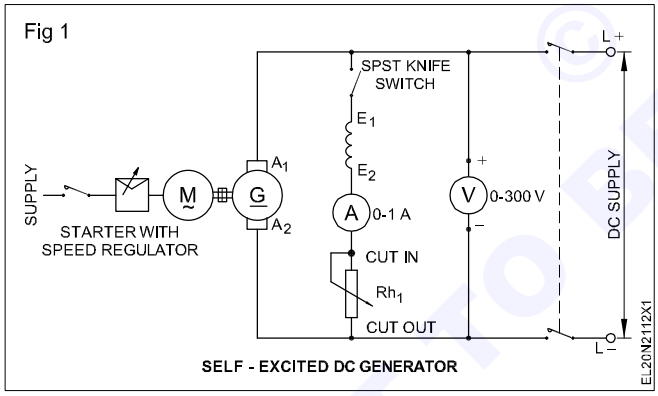
— — — — — — —

TASK 3: **Perform conduct no load test of a shunt generator**

1 Identify the terminals of the given DC shunt generator.

2 Connect the circuit as per Fig 1,

Fig 1



SELF - EXCITED DC GENERATOR

3 Keep the field switch open and the field rheostat in the cut `in' position. Get the approval of the instructor.

4 Start the prime mover coupled to the DC shunt generator.

The direction of rotation must be according to the direction marked on the DC generator. If not, change the direction of the rotation of the prime mover.

5 Measure the speed of the generator with the help of the revolution counter and stopwatch.

The number of revolutions made by a machine in a minute gives the r.p.m.

6 Adjust the prime mover speed such that the generator runs at its rated speed.

Keep the speed constant throughout the experiment.

7 Measure the voltage induced across the armature and note down the measured value in Table 3.

8 Close the field circuit switch and gradually increase the field current to 0.1 ampere by reducing the resistance of the field rheostat.

Table 3

Sl.No.	**Field current in amps**	**Induced voltage in volts**	**Speed** (held at constant rated value throughout the experiment)

If the generator is not able to build up voltage even though it is running in the marked direction, switch off the prime mover and then interchange the field terminals of the generator. While varying the field rheostat/regulator it should be done positively and slowly in the forward direction. Reverse movement should be avoided.

9 Increase the field current slowly in steps of 0.1 ampere, and for each step, note down the field current and the corresponding induced voltage. Record them in Table 3.

10 Switch `OFF' the DC generator and the prime mover.

11 Draw the graph keeping the induced voltage in the `Y' axis and the field current in the X axis.

The graph shows the magnetisation / no-load characteristic of the DC shunt generator.

12 Show your readings and graph to your instructor.

13 Answer the following questions.

a The magnitude of the residual voltage is

_____

b When there is no current in the field, how is the residual magnetism available in the poles?

c What are the reasons for the disappearance of residual magnetism in a DC generator?

d What is the reason for the magnetisation characteristic curve to have a straight line relationship between the field current and the induced voltage?

e What is the reason for the magnetisation characteristic curve to have a flat portion in the end?

f Could you remember the shape of the magnetisation characteristic as a part of a certain other curve which you studied earlier? If yes, write where and how the two curves are related to each other.

— — — — — — — —

TASK 4: **Conduct load test and analyse characteristics of a DC shunt generator**

1 Measure the armature resistance and enter the value in Table 4.

2 Connect the meters, rheostat and lamp load with the terminals of the DC shunt generator.(Fig 1a) (If a lamp load is not available, a water load (Fig 1b) can be used.)

3 Keep the load switch open and also switch `off' all the circuit switches in the lamp load.

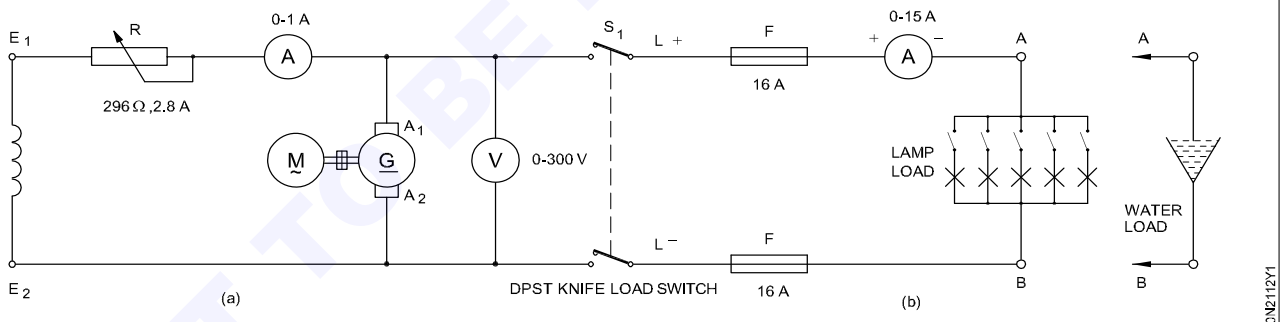
4 Keep the field regulator resistance in `cut-in' position.

Make yourself clear about the method of starting the prime mover and the procedure of adjusting its speed.

5 Start the prime mover and bring it to the rated speed of the generator.

6 Build up the voltage of the generator to its rated value, by adjusting the field rheostat. Enter the value of the open circuit voltage in Table 4.

Fig 1



LOADING OF DC SHUNT GENERATOR

Table 4

Sl.No.	Terminal voltage `V'(Volts)	Load current I_L	Shunt field current (I_{sh}) kept constant	Armature current $I_a=I_L+I_{sh}$	Induced emf $E=V+I_aR_a$	Remarks
						Armature resistance = ohms

Remember

Therefore, at no load, the terminal voltage comes to

$$V = E - (0 + I_{sh}) \cdot R_a.$$

7 Close the load switch and gradually load the generator by switching `ON' a few lamps.

8 Read the corresponding terminal voltage, shunt field current, load current, and record them in Table 4.

Check the speed of the generator at intervals, and adjust it to the rated value.

9 Increase the load current up to 125% of its rated value in 6 or 8 equal steps.

10 Note down the corresponding terminal voltage and field current for each step of load current in Table 4.

11 Gradually reduce the load current to zero and switch 'OFF' the load circuit and the prime mover.

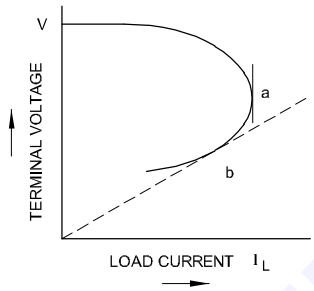
12 Show the record of your readings to the instructor and get his approval.

13 Draw the graph of the external characteristic of a DC shunt generator by keeping the terminal voltage in the Y-axis and the load current in the X-axis. (Fig 2)

14 Show the graph to your instructor and get his approval.

15 Disconnect the circuit.

Fig 2



LOAD CHARACTERISTIC CURVE OF DC SHUNT GENERATOR

EL20N2112Y2

Perform no load and load test and determine characteristics of compound generators (cumulative and differential)

Objectives: At the end of this Exercise you shall be able to
- **connect the DC compound generator as long shunt and then as short shunt**
- **build up voltage and load the compound generator**
- **determine the load performance characteristic of a DC compound generator (cumulative and differential).**

Requirements

Tools/Instruments

• Combination pliers 200mm	- 1 No.
• M.C. voltmeter 0-250V	- 1 No.
• Screwdriver 150mm	- 1 No.
• M.C. ammeter 0-20A	- 1 No.
• Electrician's knife	- 1 No.
• Rheostat 296 ohms 2.8 amp	- 1 No.

Equipment/Machines

• DC compound generator 220V 4KW	- 1 No.
• Lamp load/resistance load/water load of capacity 220V 5KW	- 1 No.

Materials

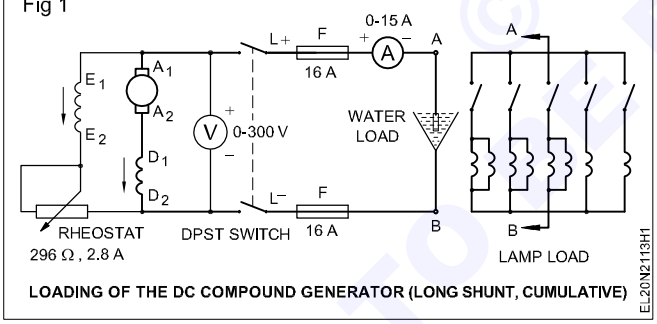
• PVC Insulated copper cable 4 sq mm	- 5 m
• DPST knife switch 16A 240V	- 1 No.

PROCEDURE

TASK 1: **Connect, build up and determine the load performance characteristic of a DC long shunt compound generator : (a) cumulative (b) differential.**

1 Connect the machine as per the connection diagram. (Fig 1)

Fig 1



LOADING OF THE DC COMPOUND GENERATOR (LONG SHUNT, CUMULATIVE)

To check whether the compound generator is connected for cumulatively compound or differentially compound which will not be easy at this stage. But this could be determined after loading.

2 Provide a suitable fuse according to the rating of the DC compound generator.

Keep the load switch and all the load sub-circuit switches open.

Keep the field rheostat sliding arm in such a position that the maximum value of resistance is included in the field circuit.

3 Start the prime mover coupled to the DC compound generator, and build up the voltage of the DC compound generator to its rated value.

4 Switch `ON' the load.

5 Increase the load step by step, note the values of the terminal voltage and load current for each step, and enter them in Table 1.

Table 1
Long shunt compound generator

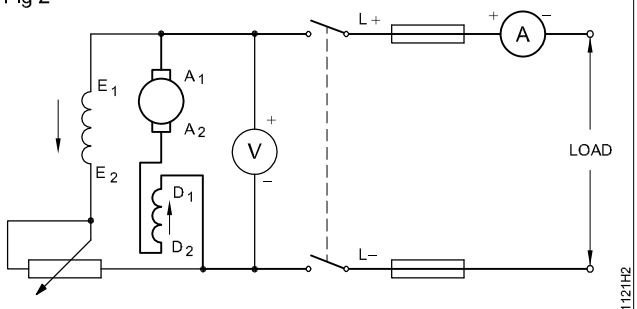
I EXERCISE			II EXERCISE		
Sl.No	**Load current**	**TPD**	**Sl.No**	**Load current**	**TPD**
Type of connection			**Type of connection**		

6 Draw the external characteristic curve keeping the load current in the `X'-axis and the terminal voltage of the generator in the `Y'-axis.

7 Open the load switch and stop the prime mover.

8 Interchange the connections of the series field. (Fig 2)

Fig 2



LOADING OF THE DC COMPOUND GENERATOR (LONG SHUNT, DIFFERENTIAL)

9 Repeat the working steps 6 to 9 and draw the external characteristic curve for the second set of readings in the same graph sheet.

10 Write clearly which one of the graph is for the cumulatively compounded generator, and which one is for the differentially compounded generator.

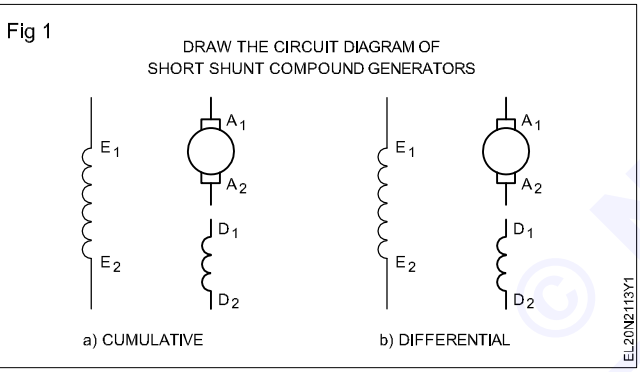
— — — — — — — —

TASK 2: **Determine the load performance of DC short shunt compound generator : a) Cumulative b) Differential**

1 Check connections (Fig 1&2 from Task 1) are for a long shunt compound generator.

Complete the connection diagrams shown in Figs 1a and 1b for the short shunt cumulative, and differential compound generator, and get it approved by the instructor.

Fig 1



2 Repeat the experiment for the short shunt cumulative and differential compound generators following steps 5 to 13 of Task 1, and enter the values in Table 2.

3 Draw the external characteristic curves on a separate graph sheet in the same scale as in the earlier graphs, and compare with them.

Table 2

Short shunt compound generator

I EXERCISE			II EXERCISE		
Sl.No	**Load current (Amps)**	**TPD Volt**	**Sl.No**	**Load current (Amps)**	**TPD volt**
1					
2					
3					
4					
Type of connection			**Type of connection**		

— — — — — — — —

Practice dismantling and assembling in DC shunt motor

Objectives: At the end of this Exercise you shall be able to
- **read and interpret the name-plate details of a DC shunt motor**
- **conduct visual inspection of the Power machine**
- **dismantle the DC shunt motor**
- **remove, inspect and install the bearings**
- **clean the parts of DC shunt motor**
- **reassemble the DC shunt motor**
- **adjust the brush tension and bedding of brushes, and correct the rocker arm position**
- **check the performance of DC shunt motor.**

Requirements

Tools/Instruments

• Pulley puller 6"	- 1 No.
• Hammer 500 gms	- 1 No.
• Cutting pliers 200mm	- 1 No.
• Centre punch 100mm. length	- 1 No.
• Spanner set 5mm to 20mm	- 1 Set.
• Screwdriver, heavy duty	- 200 mm
• Tray 300 x 300 mm x 50 mm	- 1 No.
• Mallet, hardwood 60mm dia.	- 1 No.
• "Man on line" board	- 1 No.
• Electric blower - 250V 50HZ	- 1 No.

Equipment/Machines

• DC Shunt motor	- 1 No.

Materials

• Kerosene	- 1 litre
• Cotton cloth	- 1/4 sq.m.
• Carbon tetrachloride	- 100 ml.
• Round brush for cleaning 2cm	- 1 No.
• Petrol	- 200 mil.
• Sand paper No.1	- 1 Sheet
• Hacksaw blade 300 mm	- 3 Nos.
• Sand paper `oo' smooth	- 1 Sheet
• Mobile oil S.A 40	- 1/2 litre
• Cotton waste	- 100 gms
• Shell alvania 3 grease or equivalent	- 100 gms
• Hardwood 3cm sq. 20cm long	- 2 Pieces

PROCEDURE

1 Read the manufacturer's instruction booklet, and particularly take into account any special instructions regarding dismantling procedures.

2 Remove the fuse-carriers from the main switch, disconnect the DC machine from the supply and display the "Man-on-line board" on the main switch.

3 Remove the foundation bolts of the machine, shift the machine to the workbench and note the name-plate details in Table 1 as shown is Exercise 2.1.107

4 Conduct a visual inspection.

5 Clean the outside surface of the motor. Remove all dirt and grease with a dry cloth soaked in petrol/kerosene.

Do not use water.

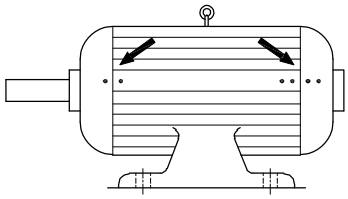
6 Make punch marks on both the end plates and yoke. (Fig 1)

7 Mark the rocker arm position with respect to the end plate.

8 Remove the brushes from the brush-holder.

9 Check pulley tightness and adjust. Remove pulley it with a pulley puller if the pulley is found tightly fitted.

Fig 1

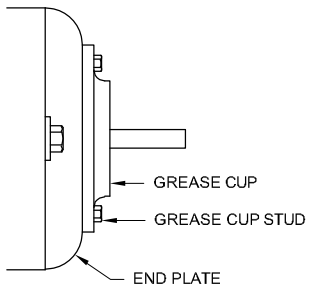


IDENTIFICATION PUNCH MARKS

EL20N2114H1

10 Remove the grease cup stud and open the grease cup. (Fig 2)

Fig 2



REMOVAL OF THE GREASE CUP

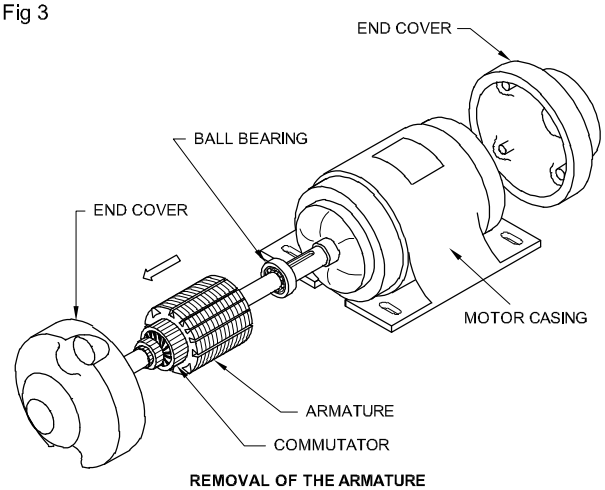
EL20N2114H2

11 Loosen the studs of both the end plates and then remove the end plate of the shaft side.

Open one end of the end plate slowly by holding the armature shaft by hand or pulley block so that the weight of the armature does not damage the pole faces or field windings.

12 Remove the armature from the body of the machine. (Fig 3)

Fig 3

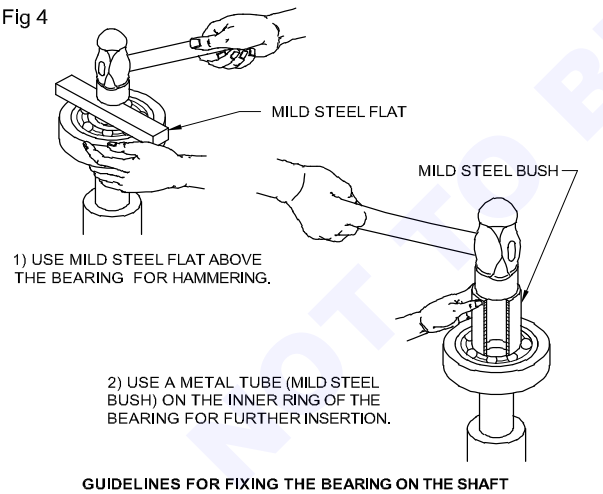


REMOVAL OF THE ARMATURE

13 Remove the bearings using a bearing puller.

New bearings need no cleaning. Do not remove the new bearings from the package until needed. Before opening the new bearing, keep the workbench clean and tidy. For fixing the bearing in the shaft, follow the guidelines (Fig 4).

Fig 4



GUIDELINES FOR FIXING THE BEARING ON THE SHAFT

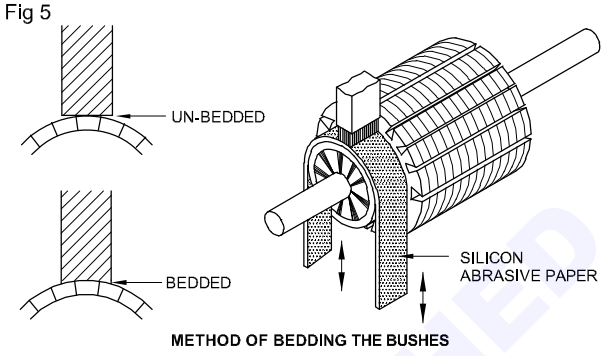
14 Reassemble the yoke, armature and end plates.

15 Check the freeness of the shaft by rotating the shaft by hand.

If found tight (not free) loosen the end-plate studs and tighten the crosswise studs gradually in the proper sequence, and at the same time feeling the shaft for free rotation.

16 Insert the brush in the holder, adjust the brush tension, and bed the brushes following the procedure shown in Fig 5.

Fig 5



METHOD OF BEDDING THE BUSHES

17 Position the rocker-arm in the end plates as per original marking.

18 Re-install the machine in the foundation and tighten the foundation bolts and connect the motor to the supply.

19 Check whether the motor is operating smoothly without any vibration. A check-list for mechanical functions is given in Table 1. Fill up all the possible columns after checking the motor operation.

Table 1

Sl. No.	Check-list (Mechanical)	Remarks
1	Noise	
2	End-play	
3	Rotor running free	
4	Bearing fits	
5	Lubrication, grease, nipples oil supply	
6	Temperature bearings	
7	Temperature motor frame	
8	Condition of shaft, keyway, pulley, bearing seals	
9	Bolts, nuts tightened	
10	Test run 30 min	

Practice dismantling and assembling in DC compound generator

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

- **read and interpret the name-plate details of a DC compound generator**
- **conduct visual inspection of the Power machine**
- **dismantle the DC compound generator**
- **remove, inspect and install the bearings**
- **clean the parts of the DC generator**
- **reassemble the DC compound generator**
- **adjust the brush tension and bedding of brushes and correct the rocker arm position**
- **check the performance of DC compound generator.**

Requirements

Tools/Instruments

• Pulley puller 6"	- 1 No.
• Hammer 500 gms	- 1 No.
• Cutting pliers 200mm	- 1 No.
• Centre punch 100mm. length	- 1 No.
• Spanner set 5mm to 20mm	- 1 set
• Screwdriver, heavy duty	- 200 mm
• Tray 300 x 300 mm	- 1 No.
• Mallet, hardwood 60mm dia.	- 1 No.
• "Man on line" board	- 1 No.
• Electric blower 240V 50HZ	- 1 No.

Equipment/Machines

• DC compound generator	- 1 No.

Materials

• Kerosene	- 1 litre
• Cotton cloth	- 1/4 sq. m.
• Carbon tetrachloride	- 100 ml.
• Round brush for cleaning 2cm	- 1 No.
• Petrol	- 200 mil.
• Sandpaper No.1	- 1 sheet
• Hacksaw blade 300 mm	- 3 Nos.
• Sandpaper `oo' smooth	- 1 sheet
• Mobile oil S.A 40	- 1/2 litre
• Cotton waste	- 100 gms
• Shell alvania 3 grease or equivalent	- 100 gms
• Hardwood 3cm sq. 20cm long	- 2 pieces

PROCEDURE

TASK 1: **Dismantle, inspect and reassemble DC compound generator**

1 Read the manufacturer's instruction booklet, and particularly take into account any special instructions regarding dismantling procedures.

2 Remove the foundation bolts of the machine and shift the machine to the workbench.

3 Conduct a visual inspection.

Do not use water.

4 Make punch marks on both the end plates and yoke.

5 Mark the rocker arm position with respect to the end plate.

6 Remove the brushes from the brush-holder.

7 Check pulley tight and adjust.

8 Remove the grease cup stud and open the grease cup.

9 Loosen the studs of both the end plates and then remove the end plate of the shaft side.

Open one end of the end plate slowly by holding the armature shaft by hand or pulley block so that the weight of the armature does not damage the pole faces or field windings.

10 Remove the armature from the body of the machine.

11 Remove the bearings using a bearing puller.

12 Reassemble the yoke, armature and end plates.

13 Check the freeness of the shaft by rotating the shaft by hand.

If found tight (not free) loosen the end-plate studs and tighten the crosswise studs gradually in the proper sequence, and at the same time feeling the shaft for free rotation.

14 Insert the brush in the holder, adjust the brush tension, and bed the brushes.

15 Position the rocker-arm in the end plates as per original marking.

16 Re-install the machine in the foundation and tighten the foundation bolts and connect the generator.

17 Check whether the generator is operating smoothly without any vibration. A check-list for mechanical functions is given in Table 1. Fill up all the possible columns after checking the generator operation.

Table 1

Sl. No.	**Check-list** (Mechanical)	**Remarks**
1	Noise	
2	End-play	
3	Rotor running free	
4	Bearing fits	
5	Lubrication, grease, nipples oil supply	
6	Temperature bearings	
7	Temperature motor frame	
8	Condition of shaft, keyway, pulley, bearing seals	
9	Bolts, nuts tightened	
10	Test run 30 min	

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Conduct performance analysis of DC series shunt and compound motors

Objectives: At the end of this Exercise you shall be able to
- **measure the armature resistance**
- **measure the series field resistance**
- **connect the two-point starter for series and 3 point & 4 point starter for shunt and compound motor**
- **measure the speed of the motors**
- **vary the load of a DC series motor**
- **determine the performance characteristic of a DC series motor shunt motor and compound motor and draw the following curves**
  - speed versus load
  - torque versus load
  - speed versus torque.
- **determine the efficiency of the DC shunt motor at different loads.**

Requirements

Tools/Instruments

- Insulated cutting pliers 150mm - 1 No.
- Screwdriver 150mm - 1 No.
- D.E. spanner set 5mm to 20mm - 1 No.
- 500V Megger - 1 No.
- Multimeter/ohmmeter 0 to 2 K ohms - 1 No.
- M.C.ammeter 0-15A - 1 No.
- M.C. voltmeter 0-300V - 1 No.
- Tachometer 300-3000 r.p.m - 1 No.

Equipment/Machines

- D.C. series motor 220V 3 H.P - 1 No.
- ICDP switch 250V 16A - 1 No.
- 2- Point starter - 1 No.
- Dial type spring balance 25kg capacity - 1 No.
- Prony brake system complete - 1 No.
- DC shunt motor 220V 2/3 HP - 1 No.
- 220V 4 - point starter - 1 No.
- Rheostat 100 ohms 2 amps - 1 No.
- Brake test arrangement with two spring balances of 25 and 50 kg rating - 1 Set
- 220V DC compound motor 2 or 3 with prony brake loading arrangement - 1 Set

Materials

- 2.5 sqmm PVC insulated multi-strand copper cable - 6 m.
- Fuse wire 5A &10A. - as reqd.
- Test lamp - 1 No.

PROCEDURE

TASK 1: **Conduct the load performance test on a DC series motor**

1 Note down the name-plate details.

2 Identify the terminals of the given DC series motor and test for insulation and ground.

3 Select and collect the required equipment, apparatus and cables, and connect the motor as per the circuit diagram. (Fig 1)

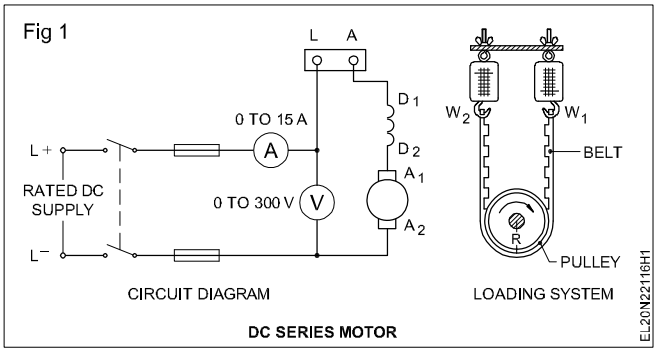
The DC series motor should not be started or made to run without load.

4 Start the DC series motor slowly by moving the starter handle to the 'ON' position.

5 Check the speed, load current and input voltage. Adjust the load current to 1/4th of the F.L. value by adjusting the load.

6 Measure the speed, load current, voltage and read the spring balance and record in Table 1.

Fig 1



7 Slowly increase the load in steps up to full load. Record the measurement for 1/2, 3/4 and full load.

8 Tabulate all the readings in the tabular columns provided in Table 1.

9 Stop the motor by switching it off after taking all the readings.

Do not remove the mechanical load before switching off.

10 Measure the radius of the pulley and calculate the torque, horsepower and efficiency.

11 Draw the following characteristic curves.

- Speed versus load
- Torque versus load
- Speed versus torque

12 Write your conclusion about the relationship between speed and load, torque and load, speed and torque and efficiency and load.

CONCLUSION

Input voltage = Voltage x Current

T = 9.81 x f x r

f = W1 - W2 r = Pulley radius

Table 1

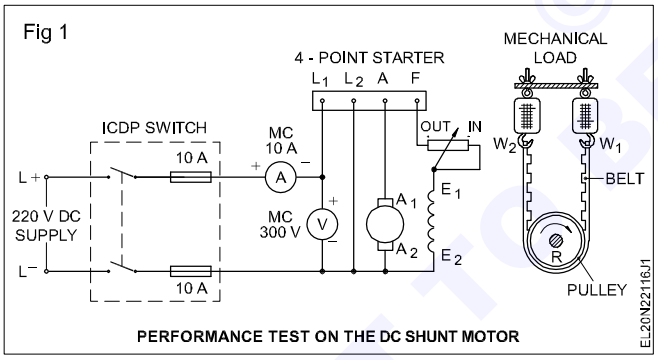
Sl. No.	Load	Applied voltage (volts)	Line current (amps)	Spring balance W_1 kg	Spring balance W_2 kg	Radius of pulley (metre)	T_1 Torque in Kilogram metre	T Torque in N.M NM= 1 kg mx9.81	N Speed in r.p.m.	OP = $\frac{(2\pi NT)}{60}$ (where N is the speed in r.p.m. & T is the torque in newton metre)	Efficiency = $\frac{(OP \times 100)}{IP}$
	1/2 3/4 Full load										

— — — — — — — —

TASK 2: **Conduct the load performance test on a DC shunt motor**

1 Connect the DC shunt motor as per the circuit diagram.(Fig 1) Keep the shunt regulator rheostat in the cut out position, and the mechanical load applied through the brake to zero value.

Fig 1



2 Switch on and move the 4-point starter handle, gradually up to `ON' position.

3 Measure the speed, and if necessary, adjust the speed to the rated value by adjusting the shunt regulator rheostat and note down the reading in Table 2.

4 Increase the load step by step by tightening the wing-nut.

5 Measure the speed each step read the meters and the spring balances and record them in Table 2. Load the motor up to its full load value.

6 Reduce the load gradually and switch `OFF' the motor.

7 Measure the radius of the pulley in metres and calculate the torque in kg. metres.

Torque in kg.m = ($W_1 - W_2$)kg x radius of pulley in meters where W_1 is the reading of the tight side spring balance and W_2 is the reading of the slack side of the spring balance in kilograms.

8 Draw the speed load characteristic curve, keeping the load (line) current in the X-axis and the speed in the Y-axis.

9 Draw the torque-load characteristic in the same graph sheet, keeping the load (line) current in the X-axis and torque in the Y-axis.

10 Draw the torque-speed characteristic in the same graph sheet, keeping the torque in the X-axis and the speed in the Y-axis.

Use different colours for each curve.

11 Write the conclusion by highlighting the relation between

- speed and load
- torque and load
- torque and speed.

11 Calculate the efficiency of the given DC shunt motor by applying the following formula and record it in Table 2.

$$= \frac{2\pi NT \times 100}{60 \times VI} \text{ percentage.}$$

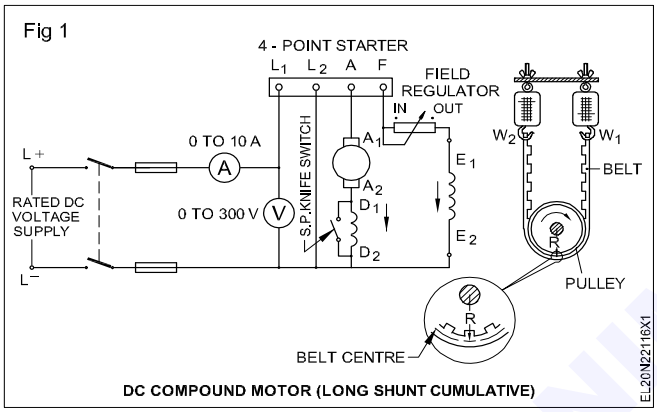
Table 2

Sl. No.	Applied voltage (volts)	Line current (amps)	Spring balance W_1 (kg)	Spring balance W_2 (kg)	Radius of pulley (metre)	T_1 Torque in Kilogram metre	T Torque in N.M NM= 1 kg mx9.81	N Speed in r.p.m.	OP = $\frac{2\pi NT}{60}$ (where N is the speed in r.p.m. & T is the torque in newton metre)	Efficiency = $\frac{OP \times 100}{IP}$

TASK 3: **Conduct the load performance test of a DC compound motor**

1 Connect the machine as a long shunt (cumulative) compound motor with the switches, fuses and meters and starter.(Fig 1)

Fig 1



DC COMPOUND MOTOR (LONG SHUNT CUMULATIVE)

2 Arrange the prony brake for loading the motor.

3 Keep the series field shorted by the S.P.S.T. knife switch.

This will enable the motor to start normally, even if it is connected as a differential compound motor.

4 Keep the field regulator in the `cut out' position. Switch on the supply and move the 4-point starter handle gradually up to the `ON' position.

5 Open the series field shorting switch.

6 Measure the speed and adjust it to the rated value and note down the readings in Table 3.

7 Increase the load step by step up to the full load following the instructions contained in step 8.

When applying the load, the speed may increase, if it is differential. Then stop the motor and interchange the connections of the series field for cumulative compounding Accordingly modify the connection diagram. (Fig 3)

8 Measure the speed for each step read the meters and spring balances and record them in Table 3. Increase the load up to the full load value.

9 Reduce the load gradually, switch off the motor.

10 Draw the torque-load characteristic in the same graph sheet, keeping the load current in the X-axis and the torque in the Y-axis. Use different colours.

11 Draw the torque-speed characteristic in the same graph sheet, using a different colour and keeping the torque in the X-axis, and the speed in the Y-axis.

12 Write your conclusion by highlighting the relation between – speed vs load

- torque vs load
- speed vs torque.

CONCLUSION:

18 Draw the curve showing the relation between load and efficiency of the DC compound motor in a separate graph sheet keeping the load in the `X' axis and the efficiency in the 'Y' axis.

Table 3

Sl. No.	Applied voltage (volts)	Line current (amps)	Spring balance W_1 (kg)	Spring balance W_2 (kg)	Radius of pulley (metre)	T_1 Torque in Kilogram metre	T Torque in N.M NM= 1 kg mx9.81	NSpeed in r.p.m.	OP= $\frac{2\pi NT}{60}$ (where N is the speed in r.p.m. & T is the torque in newton metre)	Efficiency = (OP x 100) / IP
1										
2										
3										
4										
5										

Dismantle and identify parts of three point and four point - DC motor starters

Objectives : At the end of this Exercise you shall be able to
- **dismantle the 3 points & 4 point starter**
- **identify the parts of three point starter**
- **identify the parts of four point starter.**

Requirements

Tools/Instruments

- Combination pliers 200mm - 1 No.
- Screw driver 200mm - 1 No.
- Multimeter - 1 No.

Equipment/machines

- 3 point starter 3HP 240V - 1 No.
- 4 point starter 3Hp 240V - 1 No.
- Series testing board - 1 No.

Materials

- PVC Insulated stranded Copper cable 4 sq mm - 10 m
- DPST main switch 250V 32A - 1 No.
- Insulated tape - 0.2m
- Fuse wire of required amps rating. - as reqd.

PROCEDURE

TASK 1: **Identify the parts and terminals of 3 point starter**

1 Write down the name plate details of the given DC 3 point in Table 1.

Table 1

DC starter	_____ 3 point
Volts	_____
Amps	_____
Serial No.	_____
Make	_____

2 Identify the different parts of the starter and draw the starter diagram and label the parts in your record.

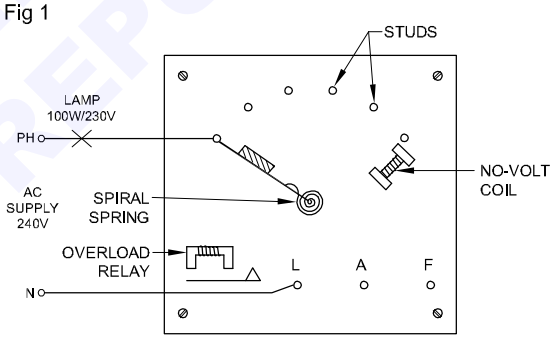
3 Connect one lead of series testing board with the 'handle' of the starter and connect second lead with the other terminals of the starter. Keep checking the other terminals with the second lead till the lamp glows. When the lamp glows brightly with any one of the terminals, that shows terminal is 'L' (Fig 1).

4 Connect one lead of the series testing board with any stud of the resistance and another one with remaining two terminals respectively. The terminal on which the lamp glows dim is terminal 'F'. Connect the remaining third terminal and check lamp glow bright. (Fig 2)

Testing should be done carefully.

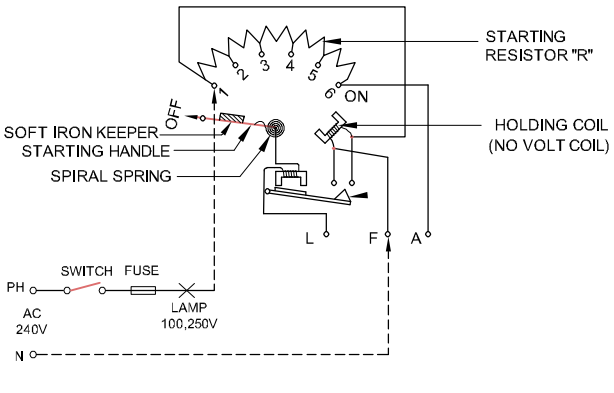
While identifying terminals, power supply should not be switched ON in the starter.

Fig 1



FACE PLATE ARRANGEMENT

Fig 2



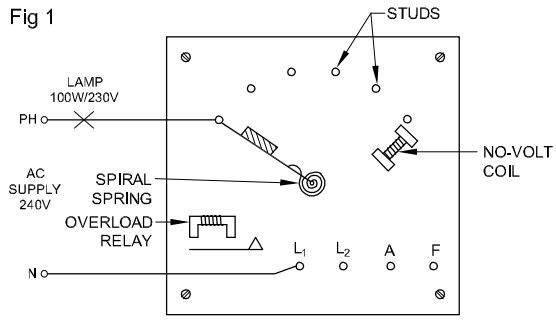
TASK 2 : **Identify the parts and terminals of 4 point starter**

1 Write down the name plate details of given DC 4 point starter in Table 2.

Table 2

DC starter	_____ 4 point
Volts	_____
Amps	_____
Serial No.	_____
Make	_____

Fig 1



FACE PLATE ARRANGEMENT

2 Identify the different parts of the starter and draw the starter diagram and label the parts in your record.

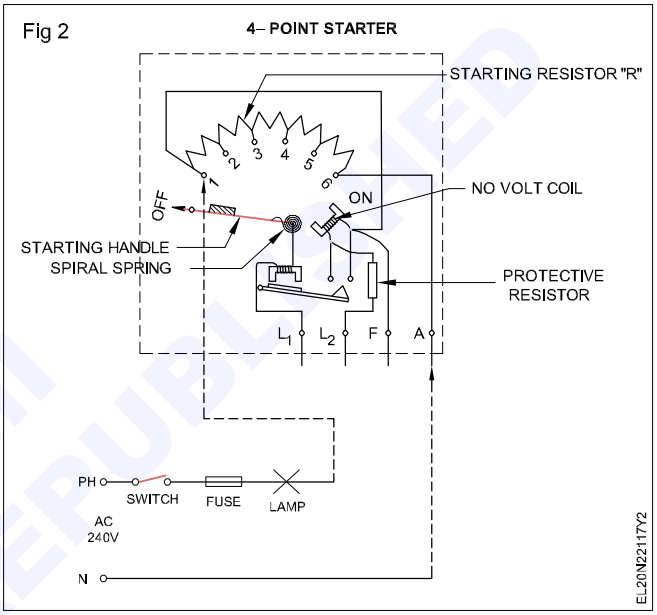
3 Connect one lead of series testing board with the 'handle' of the starter and connect second lead with the other terminals of the starter. Keep checking the other terminals with the second lead till the lamp glows. When the lamp glows brightly with any one of the terminals, that shows terminal is 'L_1' (Fig 1).

4 Connect one lead of the series testing board with any stud of the resistance and another one of the three terminals respectively. The terminal on which lamp glows more dim (or) spark on the terminals, that shows terminal is L_2. (Fig 2)

5 Connect one lead of the series testing board with any stud of the resistance and another one with remaining two terminals respectively. The terminal on which the lamp glows more bright is terminal 'F'.

6 The remaining fourth terminal is that of the terminal 'A'.

Fig 2



Assemble, service and repair three point and four point DC motor starters

Objectives: At the end of this Exercise you shall be able to
- **assemble, service repair three point starter and four point starter.**

Requirements

Tools/Instruments

- Combination pliers 200 mm - 1 No.
- Screw driver 200 mm - 1 No.
- Multimeter - 1 No.
- Flat file Bastard 150 mm - 1 No.
- Flat file smooth 150 mm - 1 No.
- Ammeter DC 0-30A - 1 No.
- Voltmeter DC 0 - 300 V - 1 No.
- Megger 500 V - 1 No.

Equipment/Machines

- 3 point starter 3 HP 250 V DC - 1 No.
- 4 point starter 3 HP 250 V DC - 1 No.
- DC compound motor 230 V 3HP 10 A - 1 No.

Materials

- DPST main switch 250 V 32 A - 1 No.
- PVC Insulated stranded copper cable 4 sq mm. - 10 m
- Insulation tape - 0.2 m
- Fuse wire of required amps rating - as reqd.
- Carbon tetra chloride - 50 ml.
- Sandal paper No. 1 - as reqd.
- Petroleum jelly - as reqd.

PROCEDURE

General maintenance and servicing

1 Write down the Name-plate details of the given DC motor starter in Table 1.

Table 1

DC starter

DC starter _____	3 point / 4 point
Amps _____	Volts _____
Make _____	Serial No._____

2 Identify the different parts of the starter and draw the starter diagram and label the parts in your record.

3 Trace the internal connections of the starter and draw the schematic diagrams. Fig 1 and 2 are given for your guidance.

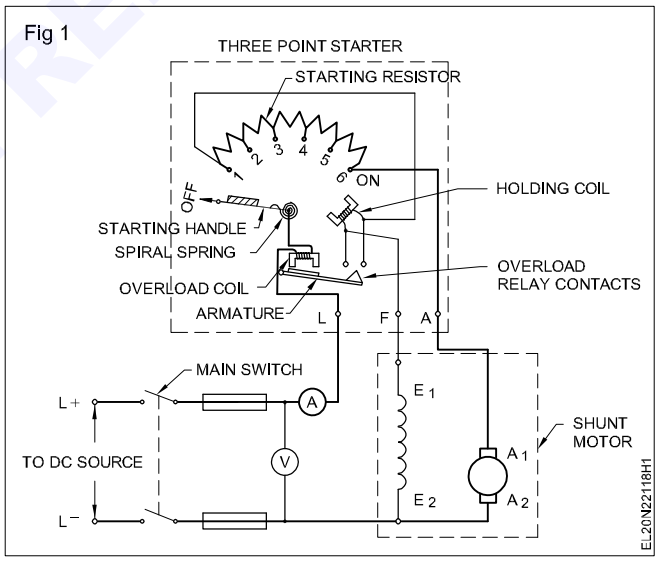
4 Check the contact studs (movable in handle and stationary in face plate of starters) and the starter resistance. Follow the procedure given in chart 1 to rectify the defects.

5 Visually inspect the colour and condition of the no volt coil and enter the details in Table 2.

6 Measure the resistance value of the holding (no-volt) coil as well as that of protective resistance and note the readings in the Table 2.

7 Measure the insulation resistance of the coil with respect to the core. Enter the value in Table 2.

Fig 1



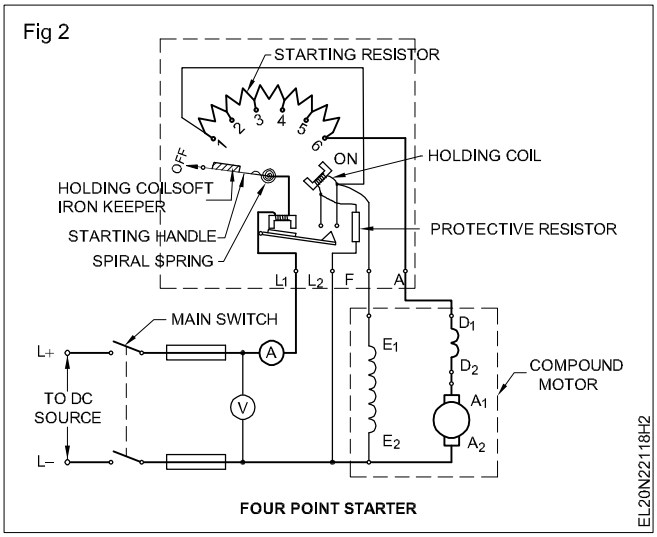
If there is any change in the present condition with respect to values obtained at the time of installation, discuss with your instructor. If necessary replace the NVC with a new one having same specification.

8 Set the overload relay for the same current rating as of the motor.

9 Connect the DC motor with the starter.

10 Make necessary loading arrangement for the DC motor.

Fig 2



FOUR POINT STARTER

11 Start the DC motor and load it to the rated current.

The starter should not trip at this settings. If it trips, increase the current setting of the overload relay to the next higher value by a small increment. In case the overload relay current setting is much higher, then also starter will not trip.

To find the correct setting reduce the current setting till the starter trips and then slightly increase the current setting till the starter holds. Accordingly recalibrate the overload current rating. Normal setting of the overload relay will be 1.5 times the rated current of the motor.

12 Check the starter operation in load condition. In case of any trouble follow the trouble shooting chart and rectify the defect.

Chart 1

General maintenance procedure for DC starters

Trouble area	Cause	Remedy
1 Check the stationary and movable contact studs for burns and pitting.	a) Loosely fitted studs	a) Tighten the nuts in the rear of the contact studs
	b) Over load	b) Reduce the load.
	c) Insufficient pressure on contact studs due to loosely fitted handle.	c) Add a washer or two over the handle and tighten the handle studs
	d) Improper operation.	d) Smoothly manipulate the handle from start to run condition.
		e) Light burns over the contacts could be cleaned with CTC (Carbon tetra chloride) Heavy burns and pitting need to be dressed with a sand paper or a flat file.
		f) Apply petroleum jelly over the movable and stationary contact points.
2 Check the starter resistance for open or shorts	a) open resistance are due to excessive heating resulted from: i) wrong starting method ii) excessive load	a) Do not keep the starter handle in starting position for a long time. i) Reduce the over load. ii) Replace the opened resistance with the equivalent material size and length.
	b) Shorted resistance due to: i) excessive vibration of the panel ii) loose mounting of the resistance	i) Reduce the vibration of the panel by proper mounting. ii) Properly mount the resistance.

Table 2

No volt coil

Sl. No.	Description	Initial condition at the time of installation		Present condition		Remarks
		Date of installation	Condition	Date	Condition	
1	Colour of the no volt coil (visual inspection)	1.8.2000	Yellow			
2	Resistance value of the no volt coil	1.8.2000	2500 ohms			
3	Insulation resistance between the no volt coil and the core	1.8.2000	5.5 Megohms			
4	Protective resistance of the 4 point starter	1.8.2000	1000 ohms			

Chart 2

Trouble shooting chart for DC Starters

Trouble	Cause	Remedy
1 Intermittent current flow in the motor through starter.	1 Loose connections. 2 Stud may not be firm. 3 Insufficient pressure of the handle 4 Formation of dirt.	1 Tighten all terminals / connections. 2 Tighten the studs. 3 Adjust the pressure 4 Clean the studs with contact cleaner.
2 Handle is not coming to off position when NVC is demagnetised	1 Insufficient spring tension. 2 Gummy material sticking to the faces of the magnet.	1 Replace the spring with a good one. 2 Clean the magnet faces.
3 Noisy magnet	1 Loose core. 2 Magnetic pole surfaces not making proper contact. 3 Dirt or dust on magnetic faces.	1 Fix the core firmly 2 Replace the magnetic assembly. 3 Clean with suitable solvent.
4 Failure to pick up handle in 'on' position.	1 Low voltage for no volt coil. 2 Coil open or short . 3 Mechanical obstructions. 4 Soft iron piece on the handle missing.	1 Check the supply voltage and rectify. 2 Replace the coil. 3 Clean and check up contacts. 4 Fix the soft iron piece on the handle properly such that it is attracted firmly on the magnetic pole face of the no volt coil.
5 Starter is tripping often	1 Incorrect setting of overload relay. 2 Sustained overload.	1 Set the overload relay properly. 2 Reduce the load.

Practice maintenance of carbon brushes, brush holders, commutator and slip rings

Objectives: At the end of this Exercise you shall be able to
- **inspect the DC machine and pre-test it to locate the fault**
- **dismantle the DC machine, overhaul it**
- **maintain and service the parts of the DC machine like carbon brushes, brush holders, commutator and slip rings.**

Requirements

Tools/Instruments

• Electrician tool kit	- 1 No.
• Bearing puller	- 1 No.
• DE spanner set 2 mm to 20 mm	- 1 Set
• MC ammeter 0-500 mA	- 1 No.
• MC voltmeter 0-500 mV	- 1 No.
• MC voltmeter 0-250V	- 1 No.
• Growler external with ammeter	- 1 No.
• Megger 0-50 meg ohms, 500 V	- 1 No.
• Multimeter	- 1 No.
• Wooden mallet 8 cm dia	- 1 No.
• Electric air blower 240 V, 50 Hz	- 1 No.
• Under cutting tool	- 1 No.
• Soldering iron 60W 240V	- 1 No.

Equipment/Machines

• Faulty DC machine 220 V, 3 HP	- 1 No.
• Arbor press	- 1 No.
• Dial test indicator	- 1 No.

Materials

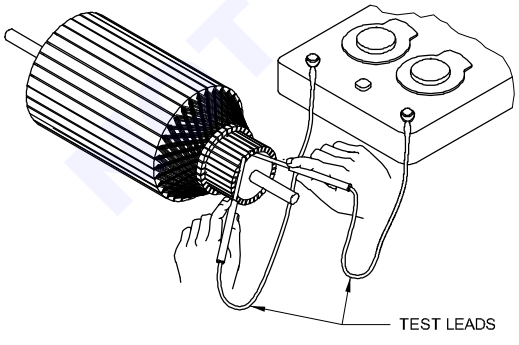
• PVC Insulated copper wire 2.5 sq mm, 250V grade	- as reqd.
• Cleaning brush 3 cm dia	- 1 No.
• Carbon tetra chloride (CTC)	- 5 0 ml.
• Grease type and quantity	- as reqd.
• Kerosene - 1 litre	
• Lurbrication oil type and quantity	- as reqd.
• Cotton cloth	- as reqd.
• Sand paper/sand cloth-grade and quantity	- as reqd.
• Solder 60/40	- as reqd.
• Soldering flux	- as reqd.

PROCEDURE

TASK 1: **Service the parts of the DC machine as stated below**

1 Test the armature for short or open circuits by connecting the ohmmeter test leads to two adjacent commutator bars (Fig 1).

Fig 1

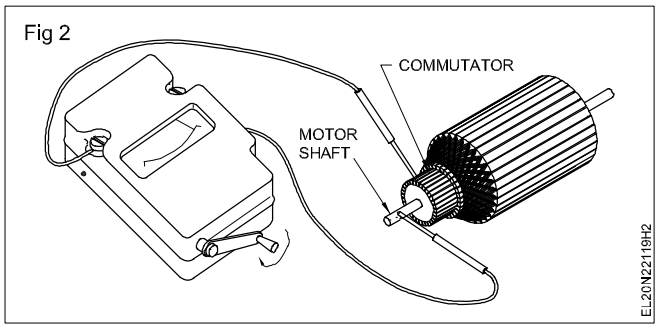


2 Set the meter range to get a reading as near mid- scale as possible.

3 Check that the meter reading is the same for all adjacent commutator segments. If not a) a high resistance indicates an open circuit b) a low resistance indicates a short circuit.

4 Test the armature/commutator for earth fault by connecting one lead of the Megger to the shaft and the other lead of the Megger to the commutator bar. (Fig 2) Enter the defect and the action taken to rectify the defect.

Fig 2



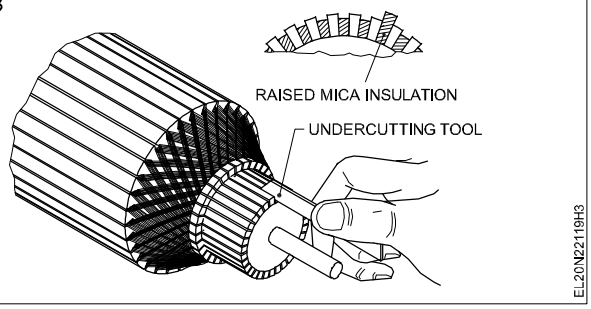
As the commutator is also a part of the armature winding a short or open shown by the above tests involves commutation. Hence check the commutator as explained here before suspecting a coil defect.

Alternatively the armature can be tested for short, open or grounded coils by a growler.

In case a single open or short or ground coil is detected in the above tests, the coil could be replaced with a similar coil; on the other hand if a number of coils are found to be defective, the armature needs to be rewound.

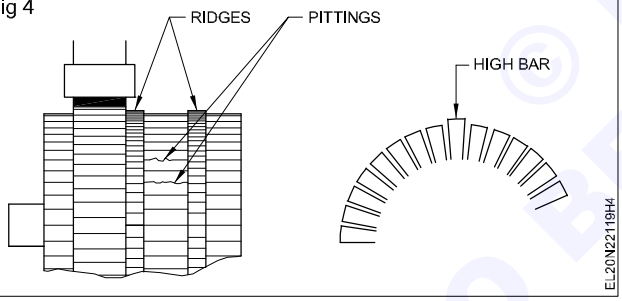
5 Check the commutator for raised mica insulation. If found, under cut the mica. (Fig 3)

Fig 3



6 Check the commutator for pitting, ridges and high bars. (Fig 4). If found, they could be removed by skinning the commutator. (Turning in a lathe)

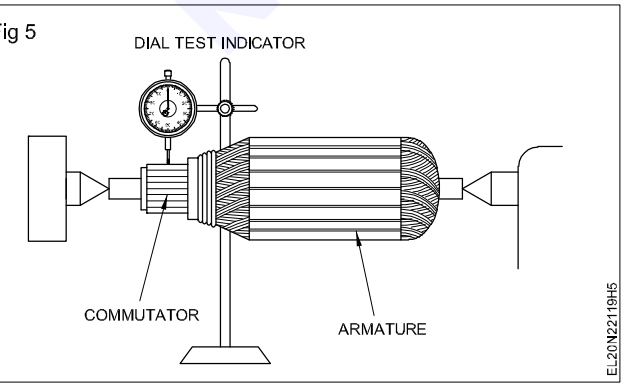
Fig 4



The commutator can only be turned to a minimum diameter specified by the manufacturer.

7 Verify before skinning (turning) check with a dial test indicator that the shaft centre is the true commutator centre. (Fig 5)

Fig 5



8 Get the help of a good turner and remove minimum copper from the surface of the commutator till the pitting, ridges and high bars are rectified.

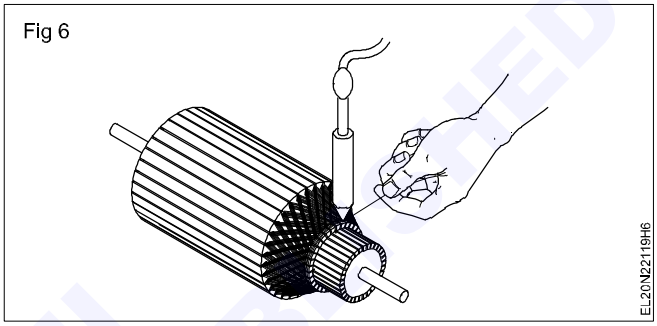
9 Clean by using the sandpaper/sand cloth to give fine finish to the commutator surface.

After finishing, check again for raised mica if necessary undercut the mica.

Badly damaged commutator needs to be replaced by a new one having the same specification.

10 Check the commutator connections in the raisers. If necessary, resolder the suspected soldering spots. (Fig 6)

Fig 6



11 Clean away the dust, dirt and carbon deposits from the brush holder and assembly using Carbon Tetra Chloride. (CTC)

12 Check the length of the brushes using scale.

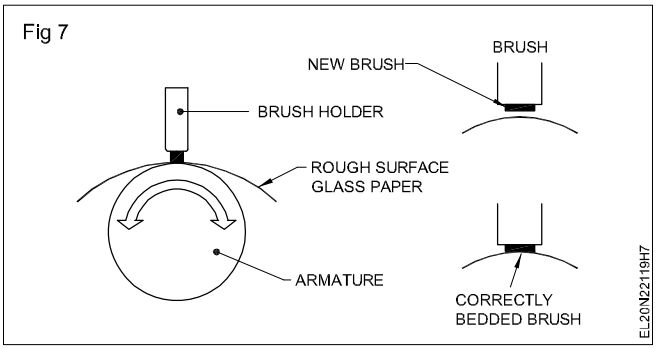
If the length of the brush is reduced to 1/3rd of the original length, the brush should be replaced.

In case a new brush is to be replaced in place of the old one, the new brush should have the specification as recommended by the manufacturer.

13 Check new brush whether it slides freely in the holder without undue side play. If necessary fit with a smooth file. Keeping the brush sides parallel.

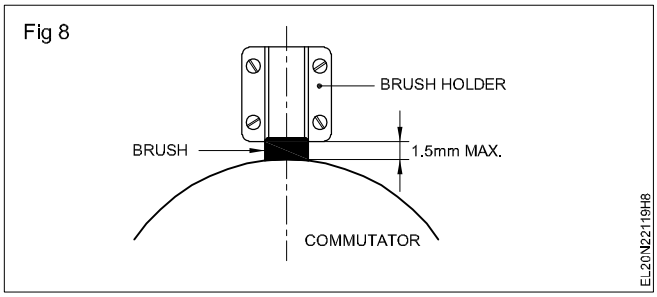
14 Insert the new brush and shape the end of the curve of the commutator, using glass-paper wrapped around the commutator and light pressure in the brush. (Fig 7)

Fig 7



15 Assemble the brush in the brush holder check that the brush holders are not more than 1.5 mm (1/16 in.) away from the commutator surface. If necessary adjust, keeping them square to the commutator. (Fig 8)

Fig 8

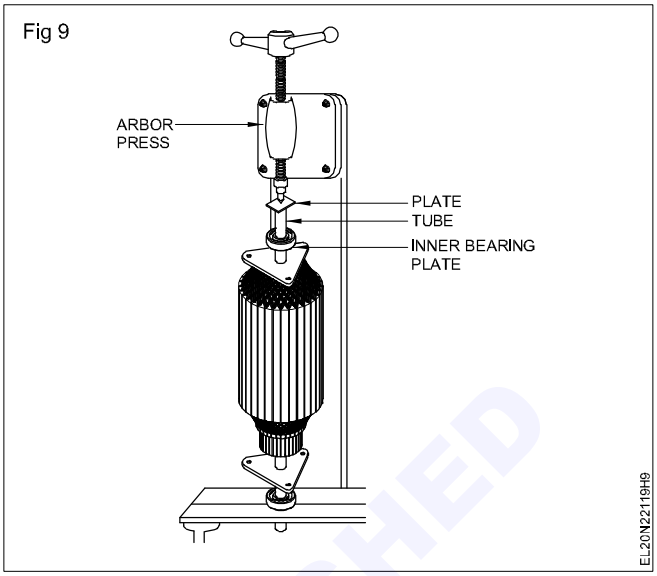


16 Check the spring tension. If it is adjustable, set it to the minimum pressure that will prevent sparking or follow the directions given by the manufacturer.

17 Identify the bearing which is found defective, remove the defective one with the help of a bearing puller and replace it with a bearing having the same specification.

18 Refit the inner bearing plate and then press the bearing on to the shaft in an arbor press, using a tube and a plate to apply pressure to the inner ring of the bearing. (Fig 9)

Fig 9



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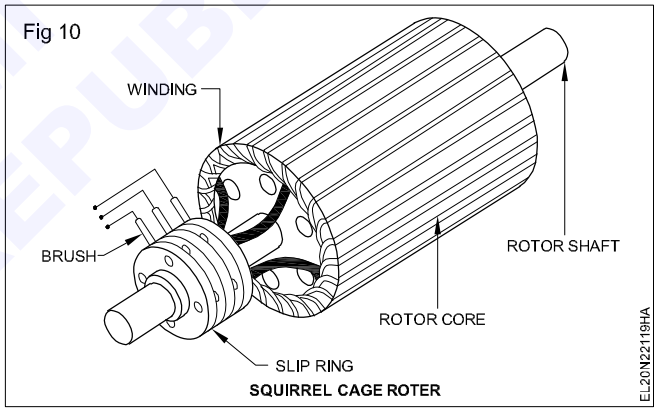
TASK 2: **Practice maintenance of slip rings**

1 Wipe the slip rings with the rag to get ride of any dirt.

2 To get rid of the residue wipe the rings with denatured alcohol.

3 This procedure will completely, clean the dust and debris off of the electrical slip rings. (Fig 1)

Fig 10



Perform speed control of DC motors field and armature control method

Objectives: At the end of this Exercise you shall be able to
- **vary the speed of a DC motor using the shunt field control regulator, and find the relationship between the field current and speed**
- **vary the speed of a DC motor using armature circuit resistance and find the relationship between armature voltage and speed.**

Requirements

Tools/Instruments

• Insulated cutting pliers 200mm	- 1 No.
• Screwdriver 200mm	- 1 No.
• Electrician's knife (100 mm)	- 1 No.
• M.C. ammeter 0-1A	- 1 No.
• M.C. voltmeter 0-300V	- 1 No.
• Tachometer 300-3000 r.p.m.	- 1 No.
• Megger - 500V	- 1 No.
• Test lamp	- 1 No.
• M.C. ammeter 0 to 15A	- 1 No.

Equipment/Machines

• DC shunt motor 220V 3HP	- 1 No.
• Rheostat 220 ohms 1 amp	- 1 No.
• 4-point starter 15A 220V	- 1 No.
• Rheostat 20 ohms 15 amps	- 1 No.
• 3 point starter 15A 220V	- 1 No.

Materials

• P.V.C. Insulated multi-strand copper cable 2.5 sq mm 600V grade	- 10 m
• Fuse wire 15 Amps	- as reqd.

PROCEDURE

TASK 1: **Control the speed of a DC shunt motor by the field control method**

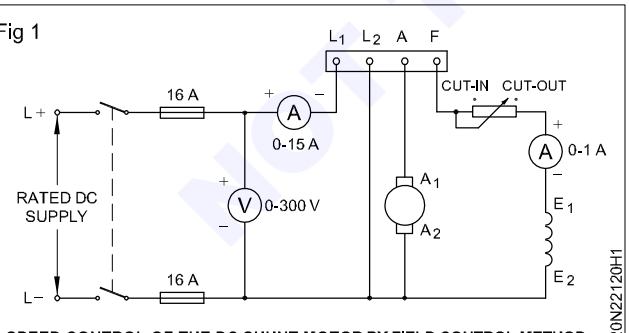
1 Note the name-plate details of the given DC shunt motor and record then in your note book.

2 Identify the terminals of the given DC shunt motor and test for insulation and ground.

3 Select a suitable range of rheostat, ammeter, voltmeter, switch and fuse according to the specification of the given DC shunt motor.

4 Make the connections as per the circuit diagram. (Fig 1) .

Fig 1



SPEED CONTROL OF THE DC SHUNT MOTOR BY FIELD CONTROL METHOD

5 Keep the field rheostat in the cut out position to have minimum resistance in the shunt field circuit.

The rheostat position must be in the cut out position at the time of starting to have a low starting speed.

6 Apply the rated supply voltage through the switch and start the motor by the 4-point starter.

7 Measure the speed, field current, voltage and enter them in Table 1.

8 Decrease the field current by increasing the field control resistance in steps.

Calculate 130% of the speed value from the name-plate details. The speed should not be more than 30% of the rated value.

9 Measure the speed, field current and the applied voltage for each step and enter these values in Table 2.

10 Switch OFF the supply of motor.

11 Draw the speed versus field current curve in a graph sheet, keeping the field current in the X-axis and the speed in the Y-axis.

12 Write your observation highlighting the relation between speed, field current and field flux.

Observation

Table 1

Sl.No.	Voltage	Line current (I_L)	Field current (I_{SL})	Speed rpm
1				
2				

— — — — — — — —

TASK 2: **Control the speed of a DC shunt motor by the armature resistance method**

1 Note the name-plate details of the given shunt motor and record it.

2 Identify the terminals of the given DC shunt motor and test for insulation and ground.

3 Select the 3-point starter, rheostat, ammeter and voltmeter according to the rating of the given DC shunt motor.

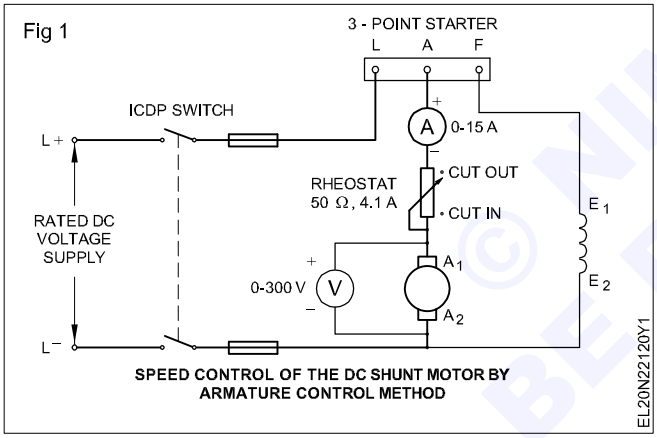
4 Make the connections as per the circuit diagram. (Fig 1)

5 Keep the armature circuit rheostat in the cut out position.

6 Apply the rated voltage and start the motor by using the 3- point starter.

7 Measure the speed, armature current & voltage across the armature and enter them in Table 2.

Fig 1



8 Increase the armature circuit resistance gradually and check the speed and corresponding armature current and voltage across the armature.

9 Repeat step No 7 for each variation .

10 Switch `OFF' the supply to the motor.

11 Draw the speed and armature voltage characteristic curve in the graph sheet, keeping voltage in the X-axis and speed in the Y-axis.

12 Write your conclusion highlighting the relationship between the voltage across the armature and speed.

Note: Back emf =

E_b = Applied voltage – Total armature circuit voltage drop

$= E - I_a R_T$

$= E - I_a (R_a + R_{ar})$

E_b = Applied voltage – (Internal armature resistance drop + External armature rheostat drop)

Assuming the internal armature resistance drop is negligible, we can also assume voltage across the armature = back emf E_b.

Conclusion

Table 2

S.No.	Armature current (I_a)	Voltage across armature	Speed r.p.m.	Remarks

— — — — — — — —

Perform DC machine winding by developing connecting diagram, test on growler and assemble

Objectives: At the end of this Exercise you shall be able to
- **dismantle the armature from the body**
- **collect and record the armature datas**
- **perform winding of armature**
- **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

• 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

• Growler external with hacksaw blade	- 1 No.
• Burnt out armature	- 1 No.
• Rotor balancing machine for small armature	- 1 No.
• Multimeter 0 1000 ohm 2.5 to 500V	- 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

PROCEDURE

TASK 1: **Dismantle of armature from the body**

Assumption: To facilitate easy approach, the procedural steps are for a mixer similar to Sumeet make. However NIMI does not take any responsibility for the correctness of the specification given in this information as the specifications are bound to change by the manufacturer from time to time.

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 Dismantle 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.

Fig 1

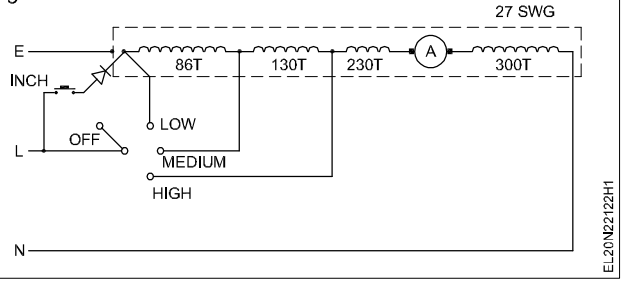


Table 1

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

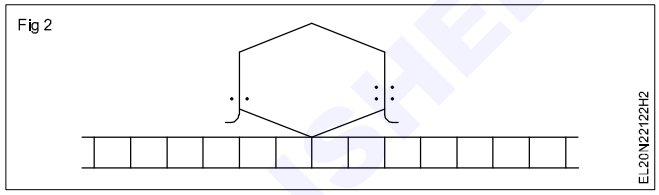
Centre of slots.

to

Centre of bars

Centre of mica

Fig 2



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 data's**

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 1, the ring diagram is shown in Fig 2 and the developed diagram is shown in Fig 3.

5 Identify one slot and mark a dot each on the side of slot with the help of a centre punch. (Fig 4)

6 Trace the end connection from the slot to the commutator segment.

Fig 1

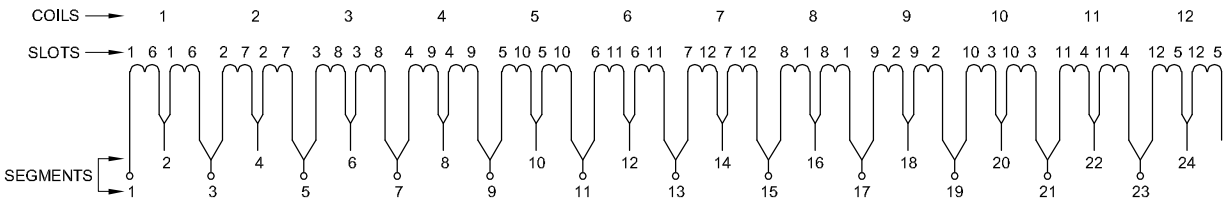


Fig 2

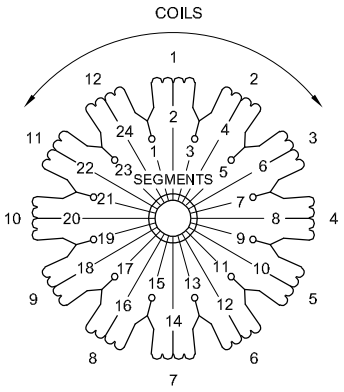


Fig 4

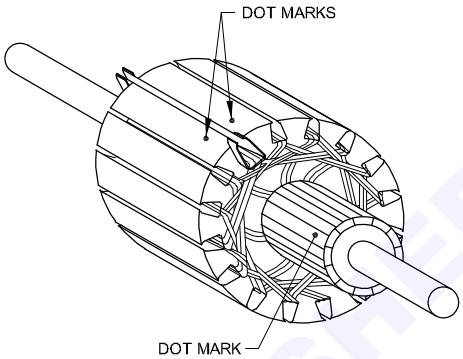
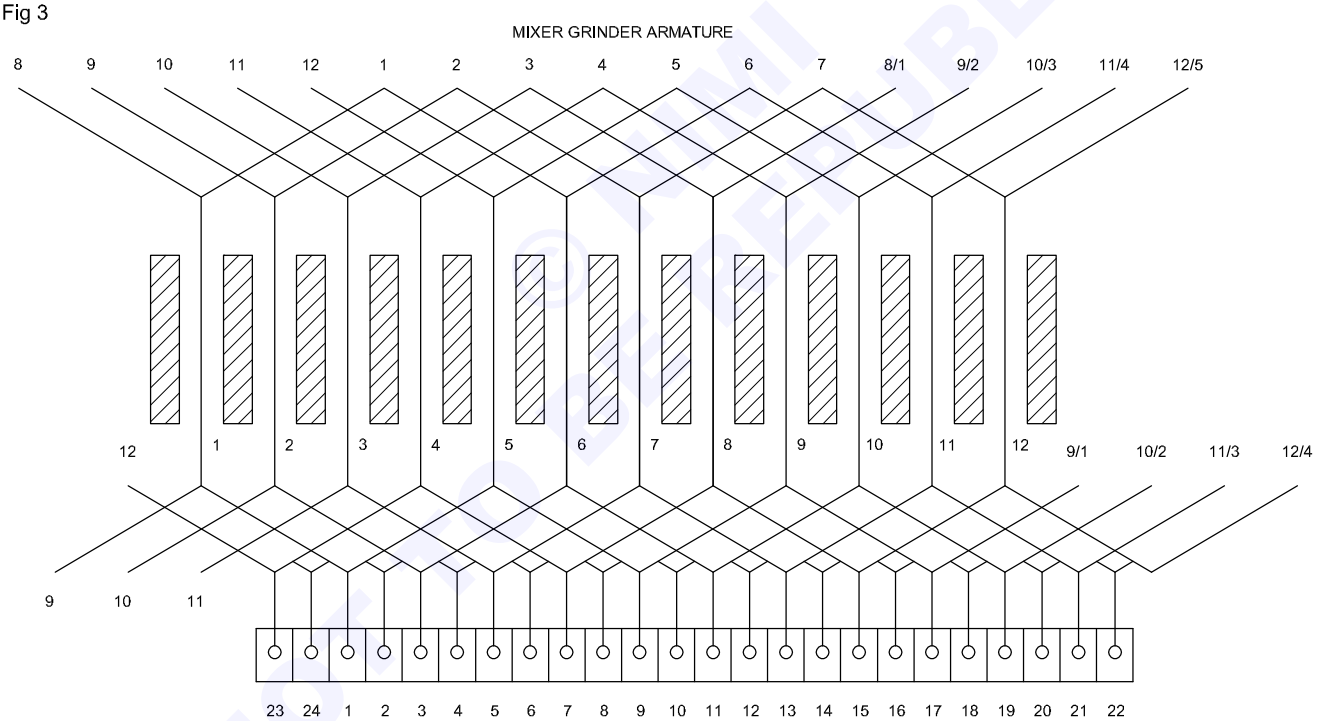


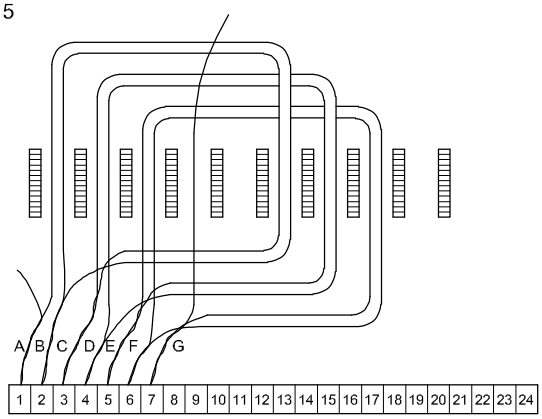
Fig 3



7 Mark one dot on the lightly ends of the identified commutator segment by using a centre punch. (Fig 4)

Fig 5 shows the lead swing as found in the mixer taken as the example

Fig 5



8 Record the findings in Table. 1

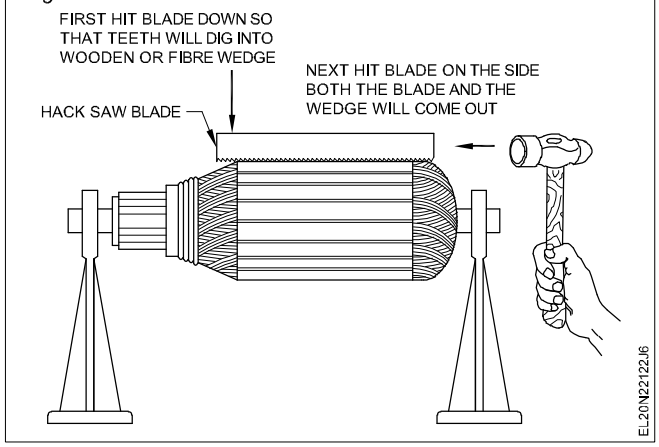
9 Cut the armature leads from the commutator raisers.

10 Apply a thinner to the armature slots and winding.

11 Remove the fibre/Hylam wedges from the armature slots (Fig 6).

12 Count the coil pitch and record it in Table. 1

Fig 6



13 Remove the armature coil one by one from the slots

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.

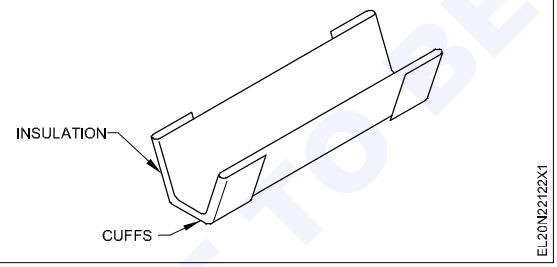
TASK 3: **Perform winding of armature**

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 1)

Fig 1



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**

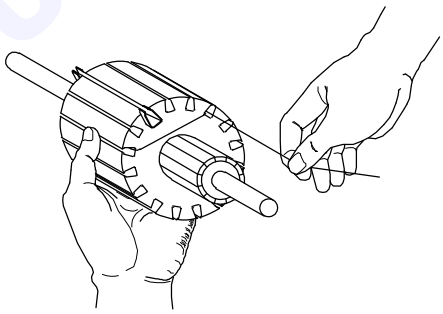
(2 coil sides are looped together and the loops are connected to the segments)

Number of turns in each coil = 36 turns identified slot pitch 1-6.

3 Place a guide paper in slots 1 and 6. (Fig 1)

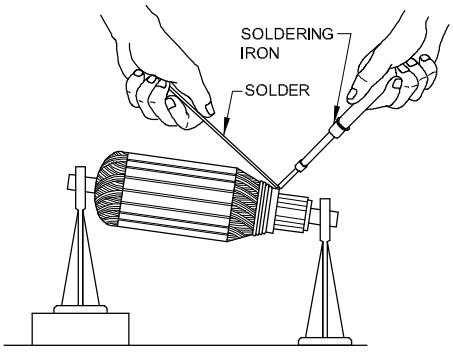
4 Hold the armature in hand. (Fig 2)

Fig 2



Large size armatures are to be supported by stands (horses during winding). (Fig 3)

Fig 3



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 tons 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 slots (1 and 6) by holding the loop with your fingers of the hand.

8 Make a short loop at the end of the second coil and start winding the next coil in slot numbers 2 and 7.

9 Make a long loop at the end of 36 turns and wind the same number (36) of turns in the same slots (2 and 7).

— — — — — — — —

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 (Fig 3 from Task 3).

5 Remove the excess solder from the raisers.

6 Check the connections and then bind the end connections with the armature. (Fig 1)

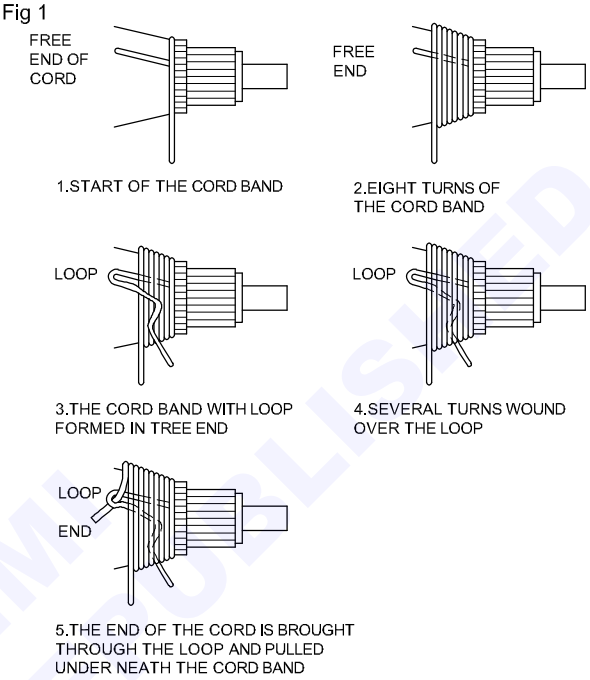
7 Test the armature with an external growler for shorts, open and grounding.

8 Varnish the armature after no fault in armature.

9 Remove the excess varnish after drying and check the rotor for balance in a dynamic balancing machine.

10 Assemble the mixer/liquidizer and test run the mixer with load.

Fig 1



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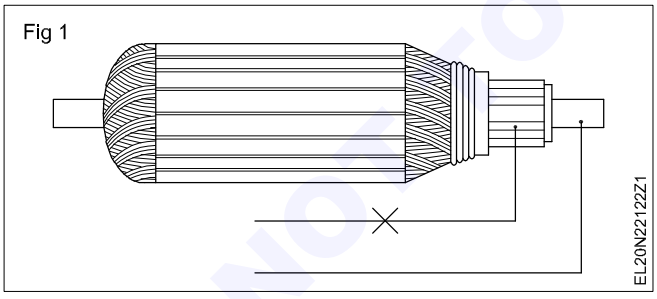
TASK 5: **Test the armature**

1 Test the armature winding for ground with a test lamp between the commutator segments and shaft. (Fig 1)

Fig 1



In case of grounding, trace the grounding by sequential de-soldering of the commutator connections and remove the grounding.

2 Place the armature on the external growler. (Fig 2)

3 Switch 'ON' the growler.

4 Hold the hacksaw blade over the top of the slot and along the length of it. (Fig 3)

Fig 2

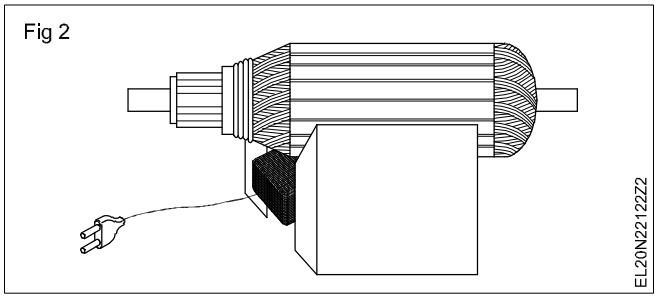
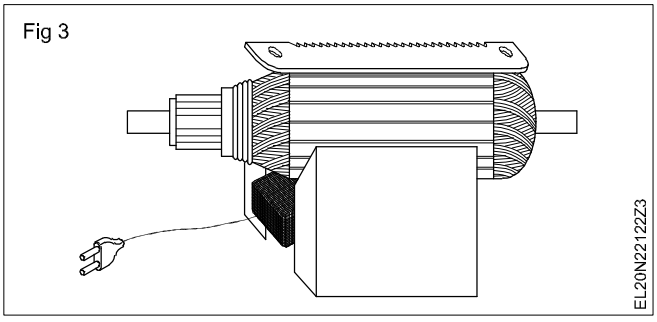


Fig 3



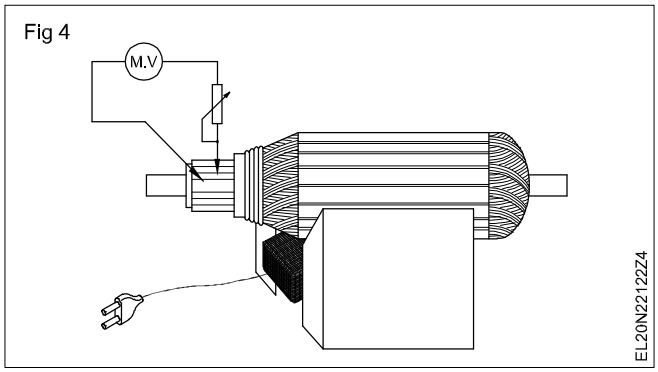
5 Rotate the armature slowly and observe the hacksaw blade vibration and the growling noise.

- The blade does not vibrate-it is an indication of 'NO' short in the armature coils.
- Vibration of the blade and a growling noise indicate short in the coil.

In case of a fault, rectify the same.

6 Connect the AC milli-volmeter/ammeter (normally provided with the growler) leads to the top two adjacent segments (Fig 4) by keeping the growler switches 'ON'.

Fig 4



7 Rotate the armature and continue testing all the adjacent bars.

While rotating the armature, the geometrical position of the test-leads should not be changed for subsequent testing's.

- Equal meter reading show correctness of winding.
- Any higher value of reading shows open in-between the armature coil/coils

8 Consult the instructor in case of fault in the armature winding.

9 Pre-heat and varnish the armature.

Care should be taken while varnishing the armature to ensure that the commutator is not exposed to the varnish.

10 Repeat the Exercise for four or five armatures.

Identify parts and terminals of three phase AC motors

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

- **read and interpret the name plate details of the given 3 phase squirrel cage induction motor and slip ring induction motor**
- **identify their parts and write their names**
- **test the 3 phase squirrel cage induction motor for continuity test**
- **identify the terminals of 3-phase squirrel cage and slip ring induction motors.**

Requirements

Tools/Instruments

- Insulated combination plier 200mm - 1 No.
- Insulated screw driver 200mm with 4mm blade - 1 No.
- DE spanner set 5 mm to 20mm - 1 Set
- MI volt meter 0-300 V - 1 No.
- MI volt meter 0-500 V - 1 No.
- Test lamp 240V, 60 Watts - 2 Nos.

Equipments/Machinery

- AC 3 phase squirrel cage induction motor - 5HP, 3-Phase, 415V, 50Hz - 1 No.
- AC 3 phase slip ring induction motor - 5HP, 3-Phase, 415V, 50Hz - 1 No.

Materials

- PVC Insulated copper cable 1.5 sq mm - 4 m
- Pendent lamp-holder 240V 6A - 2 No.

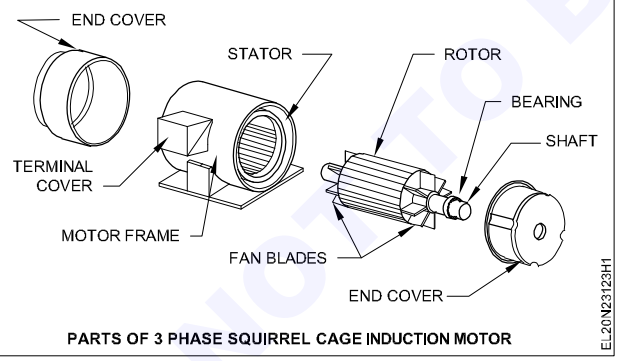
PROCEDURE

TASK 1: **Identify the parts of 3 phase squirrel cage induction motor**

1 Read and interpret the name plate details of the 3 phase squirrel cage induction motor.

2 Identify the parts of the AC squirrel cage induction motor from the real objects or from the exploded view chart (Fig 1)

Fig 1



PARTS OF 3 PHASE SQUIRREL CAGE INDUCTION MOTOR

3 Label the each identified parts with number tags.

4 Write the name of the parts of each labelled number tag in Table 1.

Table 1

S. No.	Label Number	Name of the parts of squirrel cage induction motor
1		
2		
3		
4		
5		
6		
7		

5 Get it checked with your instructor.

— — — — — — — —

TASK 2: **Identify the parts of AC 3 Phase slip ring induction motor**

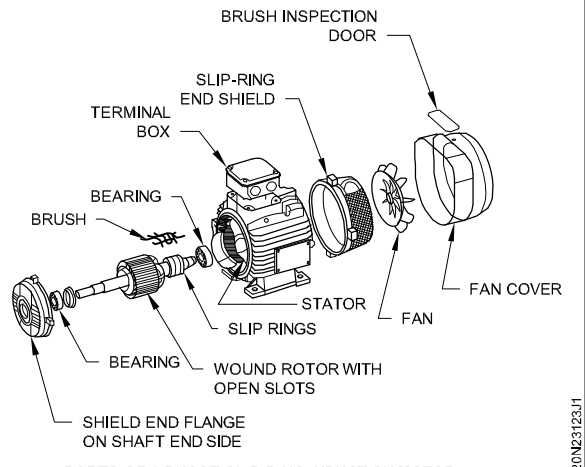
1 Read and interpret the name plate details of the 3 Phase slip ring induction motor.

2 Identify the parts of the AC 3 Phase slip ring induction motor from the real objects (or) from the exploded view chart (Fig 1).

3 Label the each identified parts with number tags

4 Write the name of the parts of each labelled number tags in Table 1.

Fig 1



PARTS OF 3 PHASE SLIP RING INDUCTION MOTOR

Table 1

S. No.	Label No.	Name of the part
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

5 Get it checked with your instructor.

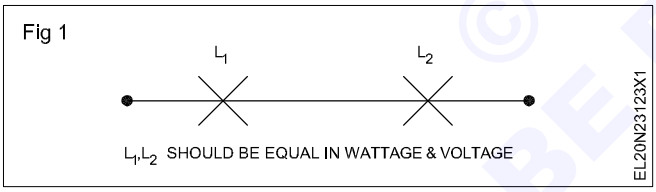
— — — — — — — —

TASK 3: **Identify the terminal of a 3 phase squirrel cage induction motor**

METHOD 1: Identifying the terminals of a 3-phase induction motor with the help of two lamps in series

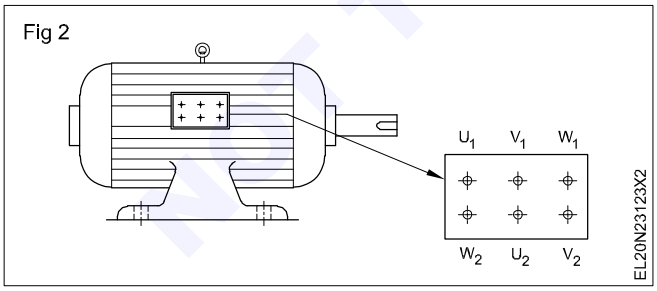
Lamps should be equally rated both in voltage and wattage. (Fig 1)

Fig 1



2 Test for continuity with the help of a test lamp and find the 3 pairs out of six terminals of the induction motor. (Fig 2)

Fig 2

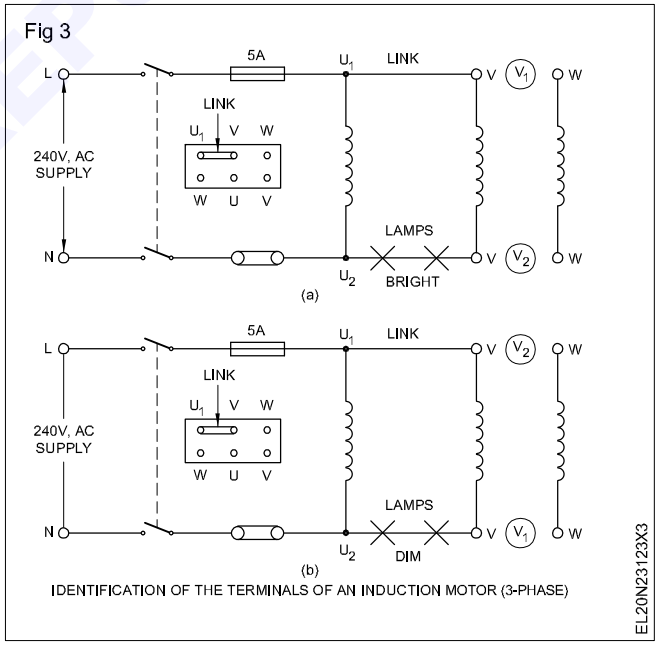


3 Identify the 3 pairs of terminals, name them as 'U' coil, 'V' coil and 'W' coil.

4 Tag U_1 and U_2 for 'U' coil only. For other coils tag V_1 and V_2 for 'V' coil and W_1 and W_2 for 'W' coil as shown in Fig 1.

5 Connect the terminals U_1 to V and then connect the series combination of the lamps to the winding ends U_2 and V as shown in Fig 3a and give 250 AC voltage across U_1 and U_2.

Fig 3



IDENTIFICATION OF THE TERMINALS OF AN INDUCTION MOTOR (3-PHASE)

If the lamps glow bright as shown in Fig 3a then the linked ends are similar ends. For example, the linked ends are U_1 and V_1.

If the lamps glows dim as shown in Fig 3b, then the linked ends are dissimilar ends. For example, the linked ends are U_1 and V_2.

6 Check to the test result in step 6 or 7, mark the name of V coil terminals as V_1 and V_2.

When the current flows through the coils they produce magnetic fields. If similar ends are connected, the magnetic fields help each other and produce high voltage across the lamp terminals making them to glow bright. In the case of dissimilar connections the voltage at lamp terminals will be low and the lamps will give dim light.

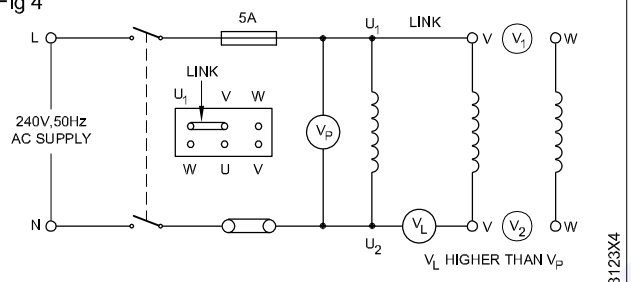
7 Test in the same way for the remaining terminals of coil 'W' and mark them as W_1W_2.

METHOD 2: Identifying the terminals of a 3-phase induction motor with the help of a voltmeter

1 Repeat the steps 1 to 4 of Method 1.

2 Connect the terminals U_1 and V with a link, connect a voltmeter V_L of 500V range between U_2 and V and a voltmeter V_P of 300V range between U_1 and U_2 as shown in Fig 4.

Fig 4



IDENTIFYING THE TERMINALS OF A 3-PHASE INDUCTION MOTOR

3 Switch 'on' the supply, if the voltmeter V_L reads more than V_P, then the linked terminals are similar as shown in Fig 2 (i.e U_1V_1).

4 Check the voltmeter V_L reads less than V_P, then the linked terminals are dissimilar (i.e U_1V_2). Mark them as U_1V_2.

5 Test in the same way the remaining terminals of coil 'W' and mark them as W_1 and W_2.

METHOD 3: Identifying the terminals of a 3-phase induction motor with the help of single lamp method

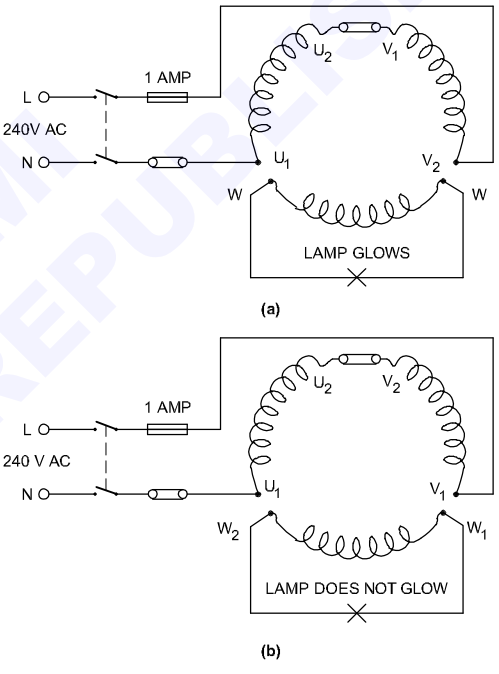
1 Connect the terminals as shown in Fig 5a. Connect it to a 240V AC supply and switch on the supply.

2 Check the lamp glows, the linked terminals are dissimilar. i.e U_2V_1. Mark them as U_2V_1.

If the lamp does not glow, the linked terminals are similar (i.e U_2V_2). (Fig 5b) Mark them as U_2 and V_2.

When current flows through the coils they produce magnetic fields. If dissimilar ends are shorted (linked) they assist each other and voltage induces in the third coil and the lamp glows. If similar ends are linked, the magnetic fields oppose each other and no voltage will be induced in the third coil. Hence the lamp does not glow.

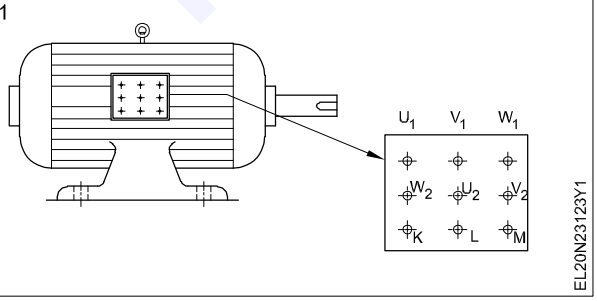
Fig 5



TASK 4: **Identify the terminal of a slip ring induction motor**

1 Remove the terminal box cover and sketch the lay out of the terminals. (Fig 1)

Fig 1



2 Test for continuity with the help of a test lamp and find out rotor's three terminals out of nine terminals of the slip ring induction motor

3 Connect probe - 1 to any one of the 3 slip rings or brush

4 Touch probe - 2 to terminals of motor one by one.

5 Check the test lamp burns then that terminals are rotor terminal.

6 Put name them as KLM and remaining six terminals are stator terminals.

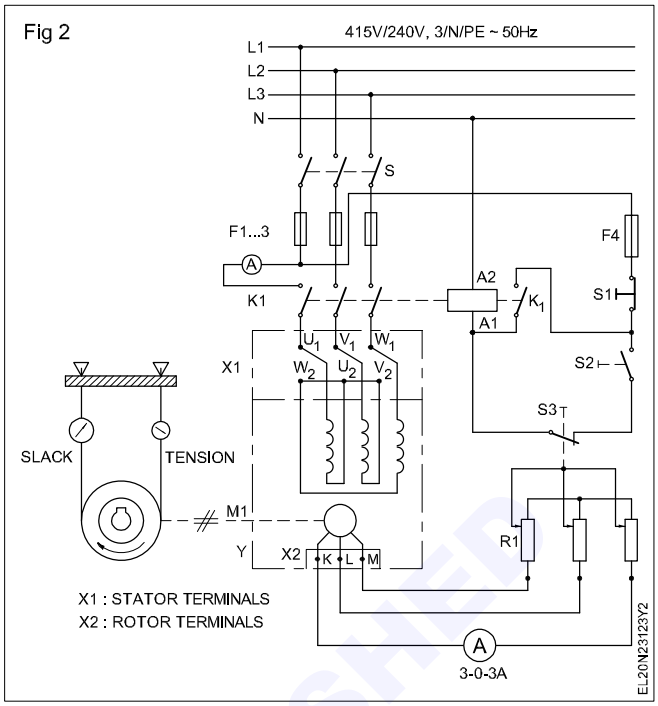
The above test will not be valid until and unless the following conditions are observed.

Condition 1: Check and ensure that the earth continuity conductor (E.C.C) connected to them main earth electrode is in perfect continuity, having a resistance of less than 1 Ohm.

Condition 2: The resistance of the earth electrode should be less than 5 ohms unless otherwise stated.

8 Draw connection diagram for the 3 phase slip ring induction motor (Fig 2).

Fig 2



Make an internal connection of automatic star-delta starter with three contactors

Objectives : At the end of this exercise you shall be able to
- **identify the major parts of automatic star delta starter**
- **read and trace the internal circuit diagram of the starter.**

Requirements

Tools/Instruments

- Connector /Screw driver 100 mm - 1 No.
- Spanner Set (6mm -25mm) - 1 Set
- Multimeter - 1 No.

Equipment/Machines

- Semi automatic star-delta starter 10A 415v,50Hz - 1 No.
- Automatic star-delta starter 10 A 415v to 50 Hz - 1 No.
- 3 Phase 415V 3 Hp/5 Hp squirrel cage induction motor with 6 terminals - 1 No.

Materials

- PVC insulated copper wire 2.5 sq mm, 250V grade - as reqd.
- Cleaning brush 3 cm dia - 1 No.
- Carbon tetra chloride (CTC) - 5 0 ml.
- Grease type and quantity - as reqd.
- Kerosene - 1 litre
- Lurbrication oil type and quantity - as reqd.
- Cotton cloth - as reqd.
- Sand paper/sand cloth-grade and quantity - as reqd.
- Solder 60/40 - as reqd.
- Soldering flux - as reqd.

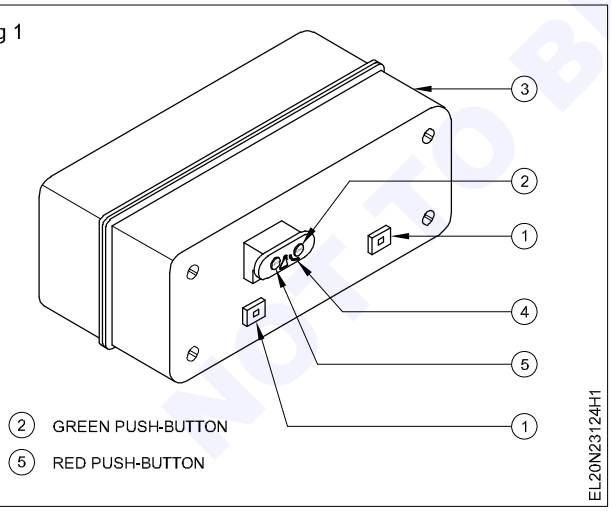
PROCEDURE

TASK 1 : **Make internal connections of automatic star-delta starter with three contactors**

1 Collect the automatic star-delta starter without inter connections from the instructor.

2 Name the external parts indicated by the numbers in Fig 1.

Fig 1



3 Name the internal parts of an automatic star-delta starter indicated in Fig 2.

4 Read the power and control diagrams (schematic) in Fig 3.

5 Draw and complete the connections for power circuit only conforming to Fig 3 (i.e connection between supply, contactors, overload relay and motor terminals).

6 Draw the connections of the control circuit on the diagram for automatic star-delta operation. Observe the sequence indicated in the schematic diagram. (Fig 3)

7 Open the cover of the automatic starter and read the circuit diagram given with it.

8 Check the working of the contactors with a multimeter by manually actuating the contactor.

9 Mount the contactors, overload relay, stop and start push-buttons on the T.W board.

10 Wire up the control circuit with the help of connecting wires.

Use single strand conductors only. Make proper termination.

11 When separate contactors and other parts for an automatic star-delta starter are not available, remove the contactors, overload relay and the timer with the starter and mount on a plain vertical board for easy interconnections.

The space available within the starter is very limited and making connection consumes more time, and is a special skill of panel wiring.

12 Label the contactors, star, delta and main.

13 Give supply control circuit and check for the logical sequence of closing and opening contactors.

Fig 2

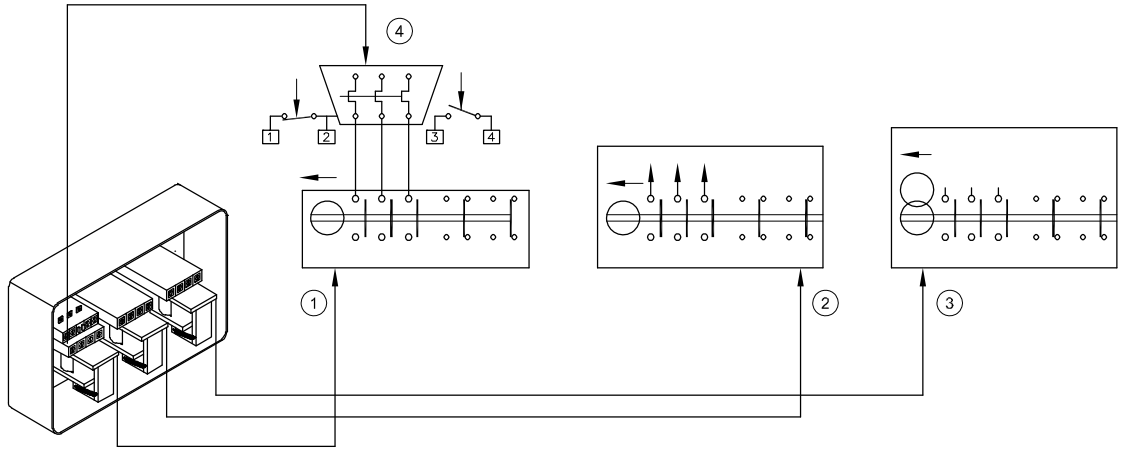
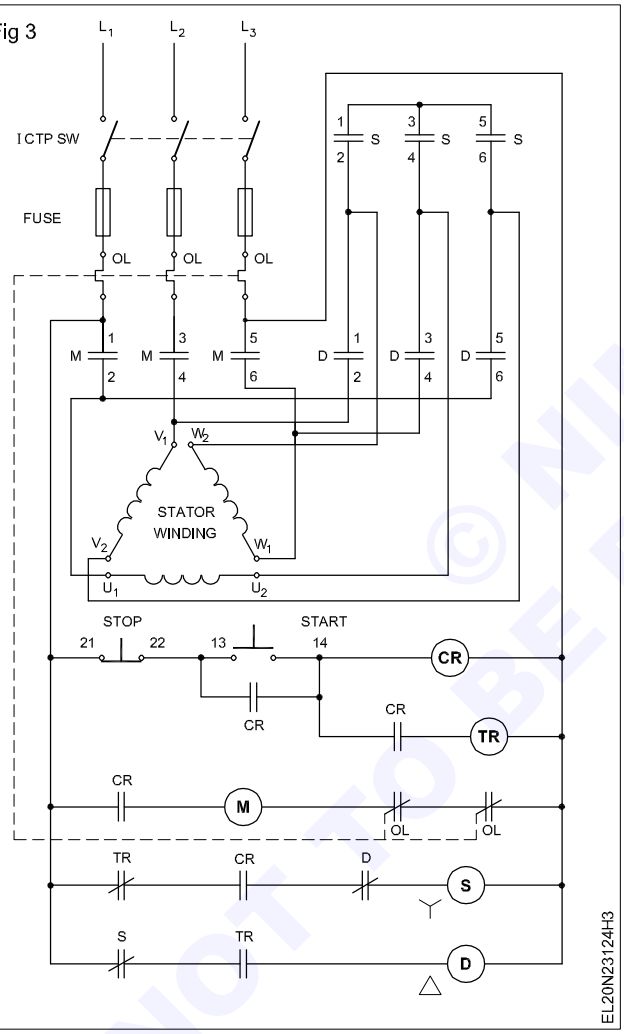


Fig 3



14 Call the instructor and get his approval to make the power circuit connections of the star-delta starter.

15 Wire up the power circuit on the star-delta starter according to the circuit diagram.

16 Read the name-plate details of the motor. Check the suitability of the fuse for the motor to be connected.

17 Connect the motor to the 3-phase supply through the starter.

18 Start the motor and observe the starting. Check what speed the starter switches over from the star to delta.

19 Answer the statement.

At what speed the switching over from star-y connection to Delta connection happens?

a) above 70% of normal speed

b) below 70% of normal speed

The turning of the set screw increases or decreases the gap between normal strip of timer relay causing more or less time to actuate contact mechanism.

20 Press the start-button again and check. There should not be any effect in the motor running.

21 Disconnect the motor from the supply after opening the ICTP isolating switch.

Connect, start and run three phase induction motor by using DOL, star-delta and auto transformer starters

Objectives: At the end of this exercise you shall be able to
- **identify and collect the parts of a DOL starter**
- **assemble the DOL starter and make control circuit connection**
- **connect ICTP switch and DOL starter with 3 phase motor**
- **set the overload relay and replace correct capacity fuse**
- **start and stop the 3 phase motor through DOL starter**
- **Identity the parts of a manual star-delta starter and trace the connection**
- **connect the manual star delta starter with 3 phase squirrel cage motor**
- **adjust the over load relay according to the motor current rating**
- **start and stop the motor through the star delta starter**
- **reverse the direction of rotation of the motor**
- **connect a 3 phase induction motor with an auto transformer and contactor as starter**
- **start and run a 3 phase induction motor using auto transformer and contactor.**

Requirements

Tools/Instruments

- Combination pliers 200 mm -1 No.
- Screw driver 200 mm, 300 mm - 2 Nos.
- Connector screw driver 100 mm - 1 No.
- Wire stripper 150 mm - 1 No.
- MI Ammeter 20A, 10A - 2 Nos.
- MI Volt meter 0-500V - 1 No.
- Tachometer 0-3000rpm - 1 No.

Equipment/Machines

- Contactors 415V AC with 240V operating coil having 16A - 3 power circuit contacts 2A - 4 auxiliary change over contacts - 4 Nos.
- Delay time relay, 24V AC operating coil with 1 or 2 normally open contacts - 3 No.
- 3-phase Squirrel cage motor 415V, 50 Hz, 3HP, 5 HP - 2 Nos.
- DOL starter 10 Amp 415V - 1 No.
- Manual star-delta starter 16A,415V - 1 No.
- TPIC switch 16A 415V - 1 No.

Materials

- PVC Insulated single strand copper cable 16 SWG, 18 SWG - 0.5 m
- Machine screw 2BA.30mm long with two washers and one nut - as reqd.
- Power cable single strand 2.5 mm^2 - as reqd.
- GI wire 145WG - 8 m

PROCEDURE

TASK 1: **Identify the parts of a DOL starter connect, start and run the 3 phase induction motor**

1 Collect the contactor unit, overload relay unit, start/ stop push-button unit, the necessary fixing screws, hookup cables, I.C.T.P switch and D.O.L starter base and cover.

2 Record the name plate details of the contactor and overload relay in your record respectively.

3 Identify the connecting terminals for interconnecting no-volt coil, main supply to control circuit, normally open auxiliary contacts.

Refer and recapitulate the connection diagram

4 Draw the complete circuit diagram for the given D.O.L starter with overload relay, no-volt coil, 'ON' and 'OFF' push-buttons.

For your guidance following diagrams are given for a starter of a particular make.

Fig 1 shows Overload relay package with push-button strips in the foreground which will get actuated when the push-buttons are pushed.

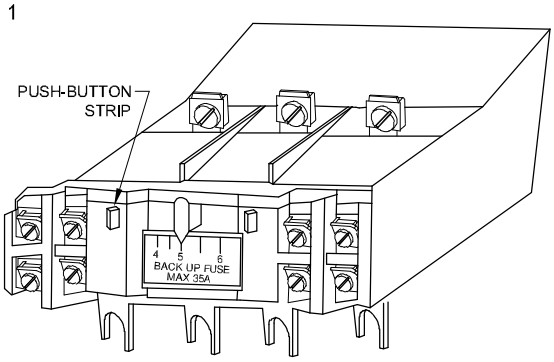
Fig 2 shows Contactor with no-volt coil.

5 Get the approval instructor for diagram.

6 Mount the accessories in the starter base box with the help of mounting screws.

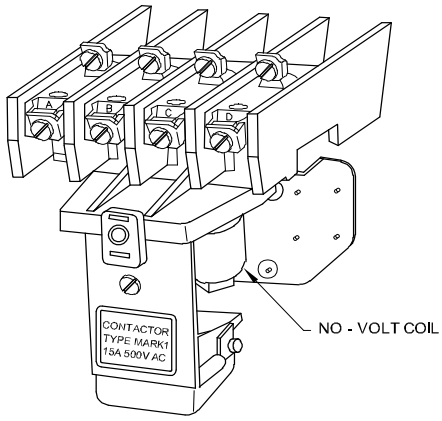
Do not tighten the screws more than necessary as too much tightening of screws will break the PVC casing of the contactor and OL relay.

Fig 1



OVERLOAD RELAY

Fig 2



CONTACTOR

7 Connect the hook-up cables according to the approved diagram.

8 Check up once again the complete connection of the D.O.L starter internal wiring.

9 Get the wiring approved by your instructor.

10 Identify the holes in the starter base box for mounting the starter on the wall/frame.

11 Mount the starter vertically on the wall/frame.

The position of the starter should be such that the no-volt coil mechanism works properly, taking advantage of the gravitational pull while disengaging.

Use a plumb bob or spirit level to check the verticality.

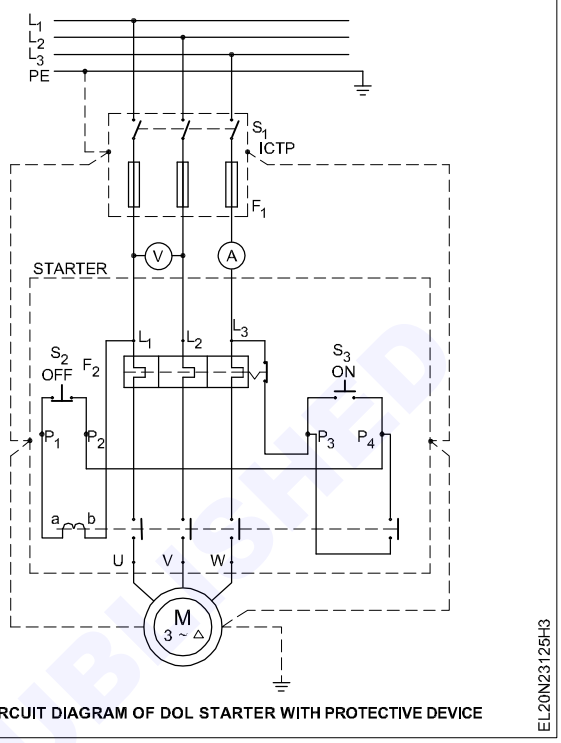
12 Connect the main supply to the starter incoming terminals through the I.C.T.P switch. (Fig 3)

13 Connect the starter outgoing terminals to the 3-phase squirrel cage induction motor along with the ammeter and voltmeter. (Fig 1)

Before connecting the 3-phase squirrel cage motor, test it for continuity and insulation.

14 Connect the protective earthing continuity conductors (two separate PE connections) to the motor and starter case, ICTP switch, and connect securely the PE continuity conductors to the main earth. (Fig 1)

Fig 3



CIRCUIT DIAGRAM OF DOL STARTER WITH PROTECTIVE DEVICE

15 Investigate the full load current of the motor and set the overload relay of the starter to that rating.

16 Provide a backup fuse as recommended by the manufacturer of the starter considering the horse-power rating of the motor.

17 Get the main connections, earth connections, overload setting and the backup fuse rating approved by your instructor.

18 Switch on the ICTP.

19 Start the motor by the start (S_3) button of the starter.

20 Read the ammeter for the starting current at the time of starting.

21 Read the voltmeter and ammeter values when the motor shows normal running.

22 Measure the actual speed of the rotor with the help of a tachometer.

23 Switch OFF the motor using stop (S_2) button of the starter.

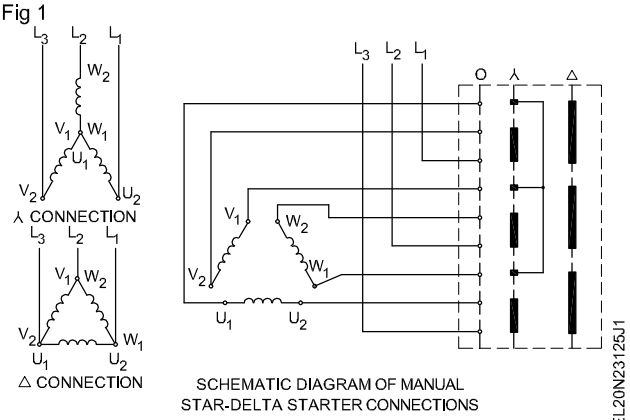
24 Show the readings to your instructor.

TASK 2 : **Start, run and reverse a AC 3 phase squirrel cage induction motor by manual star/delta starter**

1 Read and interpret the name-plate details of the starter.

2 Identify the parts of the given star-delta starter, trace the connections and verify its operation. Draw the traced out circuit and get it approved by the instructor. (Fig 2)

Fig 1



SCHEMATIC DIAGRAM OF MANUAL STAR-DELTA STARTER CONNECTIONS

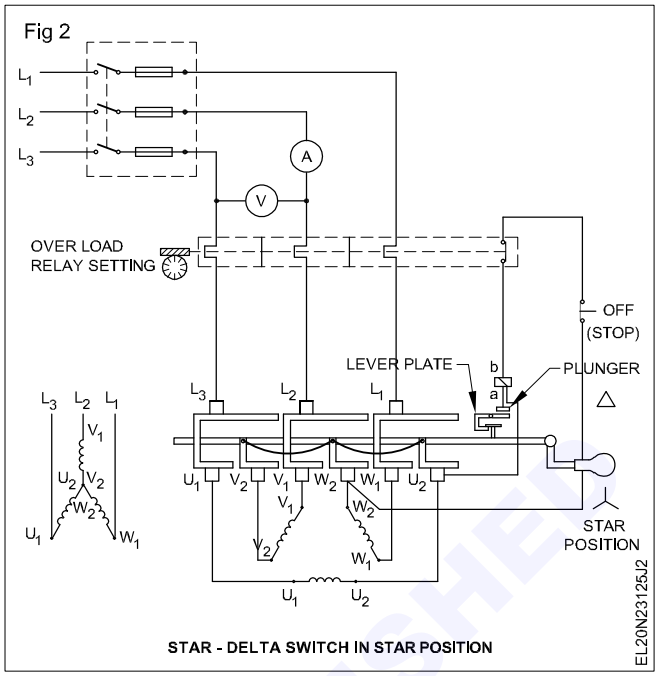
EL20N23125J1

3 Make the connections of the motor, starter and the ICTP switch as per the approved diagram.

4 Connect three cables from supply $L_1 L_2$ & L_3 to the main switch. (Fig 3)

5 Insert the ammeter in series with one of the line cables from the main switch and a voltmeter across two line cables. (Fig 3)

Fig 2



STAR - DELTA SWITCH IN STAR POSITION

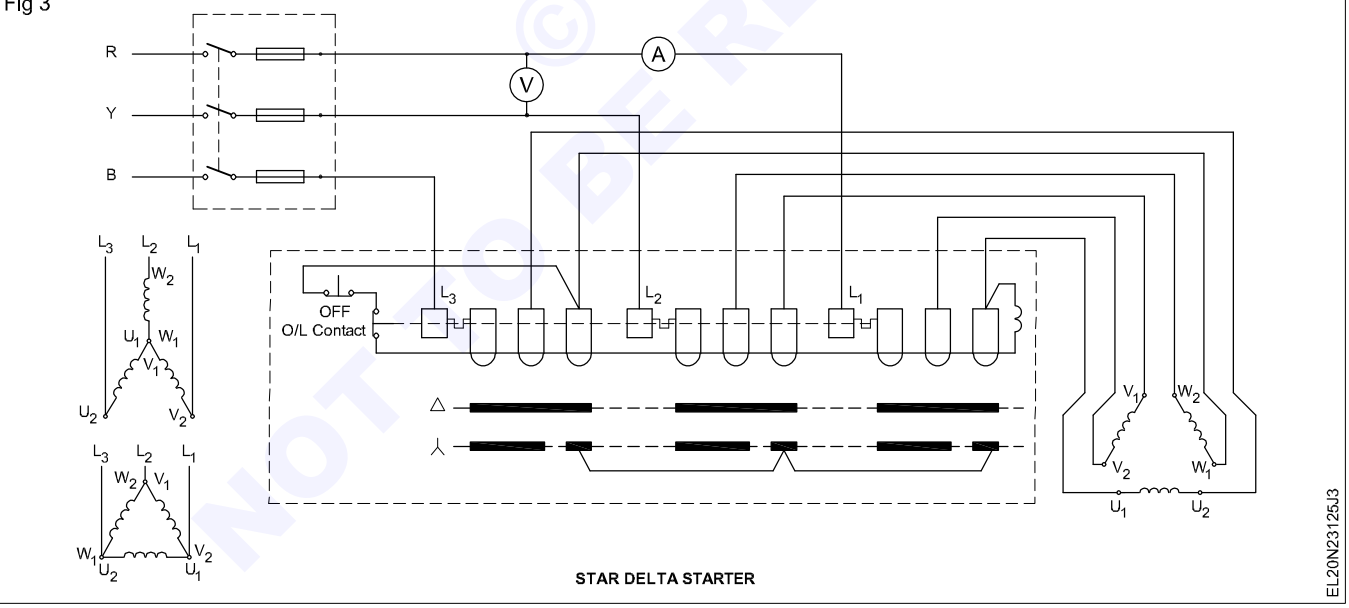
EL20N23125J2

6 Wire the proper fuse element according to the given motor rating in the fuse-carrier and insert the carriers in the main switch.

7 Set the overload relay according to the full load current rating of the motor.

8 Provide double earth to the metal body of the main switch, starter and the motor frame.

Fig 3



STAR DELTA STARTER

EL20N23125J3

ASSUMPTION : Check the connections for correctness and tightness. Get it approved by the instructor.

9 Switch 'on' the main, observe the voltmeter reading and move the handle to the star position positively and at the same time observe the starting current and enter it in Table 1.

10 Allow the motor to start, race initially and let the sound of the rotating shaft come to a steady state; then move the handle to the delta position positively.

11 Note down the direction of rotation and enter it in Table 1.

Table 1

Sl. No.	Description	1st Start	2nd Start	3rd Start	Unit
1	Supply voltage				Volts
2	Starting current (Star position)				Amps
3	Running current (Delta position)				Amps

12 Note down the current taken by the motor in running condition and enter the value of the current in Table 2.

Table 2

S.No.	Description	Direction of rotation
1	1st start Connection R to L_1 Y to L_2 B to L_3	
2	2nd start Connection R to L_2 Y to L_1 B to L_3	
3	3rd start Connection R to L_2 Y to L_3 B to L_1	

13 Stop the motor by pressing the stop-button of the starter.

14 Switch 'OFF' the main switch and remove the fuses.

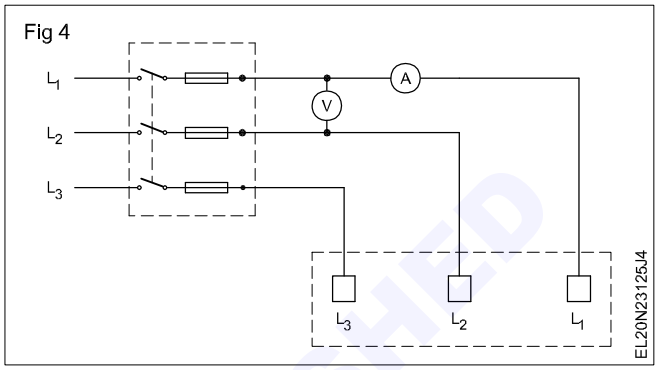
15 Interchange the two line cables R' and Y' to terminals L_2 and L_1 respectively as shown in Fig 1.

16 Insert the fuse-carriers in the main switch.

17 Repeat steps No.9 to 12 and record the information in Tables 1 and 2.

18 Stop the motor, switch off the supply and remove the fuse; then interchange the line cables Y' and B' terminals L_3 and L_1 respectively. (Fig 2)

Fig 4



19 Insert the fuse-carriers in the main switch.

20 Repeat steps Nos.13 to 16 and record the information in your notebook.

21 Stop the motor and write your observations about the method of changing the direction of rotation.

_____

_____

22 Switch 'off' the mains, remove the fuse-carriers and remove all connections.

— — — — — — — —

TASK 3 : **Connect and run 3-phase induction motor through auto-transformer starter operated by contactors**

1 Check the insulation and continuity of three-phase induction motor.

2 Check the earthing connection for its effectiveness.

3 Examine the diagrams. (Fig 1 and 2) What the following symbols in the diagram indicate? Write your response in the space provided).

4 Draw the power lines connecting the contactors, auto-transformer and motor for sequential operation.

5 Mark the different terminals of contactors corresponding to the actual panel provided.

6 Draw the control circuit connections including timer and overload trip for sequential operation.

Get the circuit checked by the instructor before proceeding.

7 Make connections as per diagram.

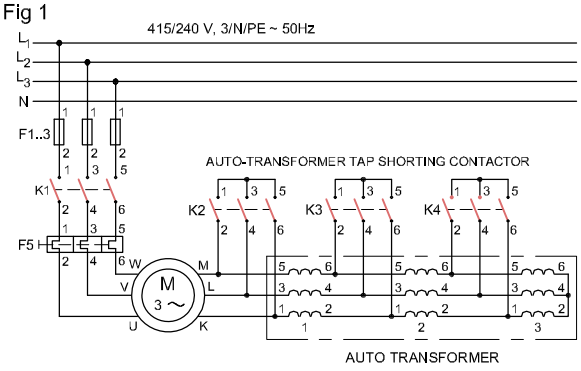
8 Switch on S1. Switch on the contactor.

9 Check when the full voltage to the induction motor is given by the auto-transformer.

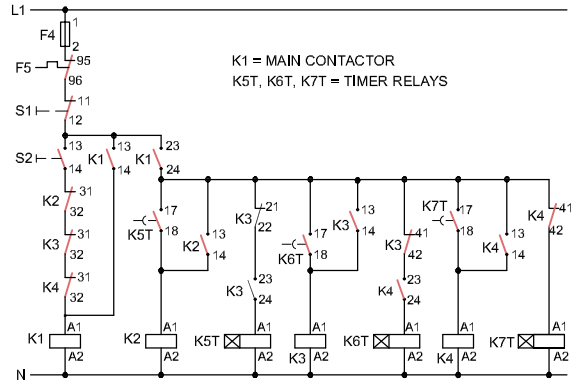
10 Measure rpm of the induction motor.

11 Switch 'OFF' the contactor and then the S_1.

Fig 1



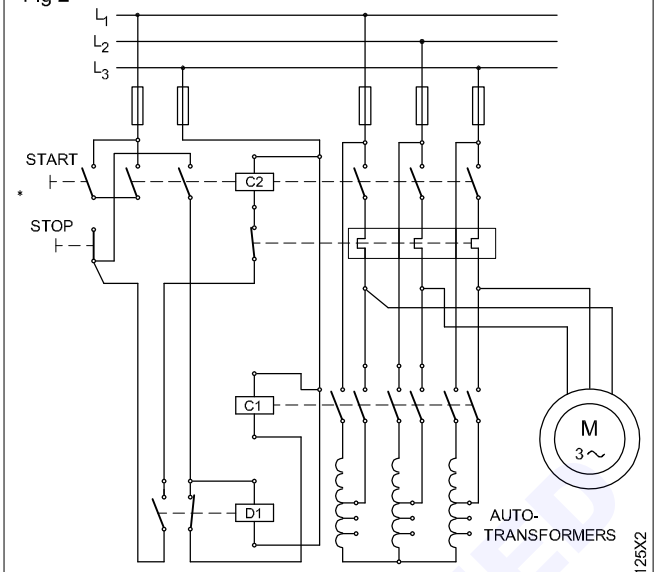
a) POWER CIRCUIT



b) CONTROL CIRCUIT

EL20N23125X1

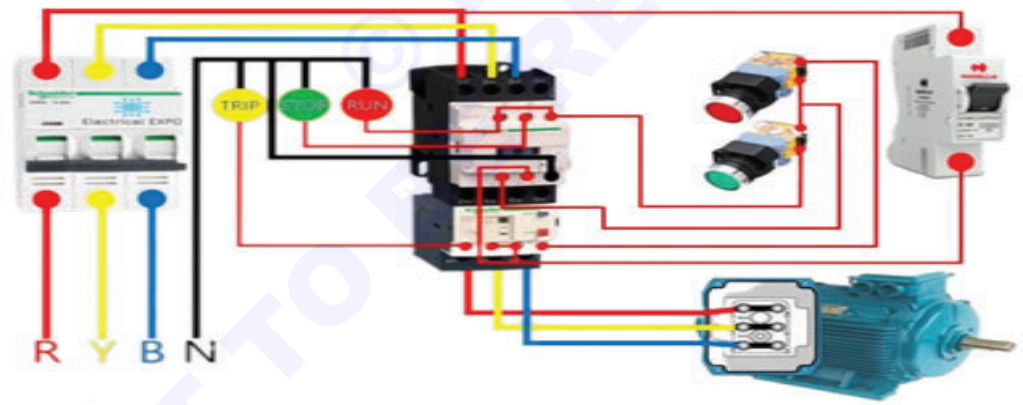
Fig 2



EL20N23125X2

A New type of starter s given below for trainees reference.

Fig 3



Connect, start, run and reverse direction of rotation of slip-ring motor through rotor resistance starter and determine performance characteristic

Objectives: At the end of this exercise you shall be able to
- **read and interpret the name-plate details of a 3-phase slip-ring induction motor**
- **identify the parts of a rotor resistance starter, trace the circuit and investigate the operation**
- **connect the 3-phase, slip-ring induction motor through the rotor resistance starter, start and run the motor**
- **measure the starting and running current and speed**
- **reverse the direction of rotation**
- **load a 3 phase slip ring induction motor and measure the slip.**

Requirements

Tools/Instruments

- Insulated cutting pliers 200mm - 1 No.
- Connector screwdriver 100mm - 1 No.
- Electrician's knife 100mm - 1 No.
- Screwdriver 200mm - 1 No.
- MI Voltmeter 0-500V - 1 No.
- Tachometer 300 r.p.m to 3000 r.p.m - 1 No.
- MI Ammeter 0-20A, 0-10A - 1 each
- Megger 500V - 1 No.
- MI Ammeter centre zero 5-0-5A -1 No.

Equipment/Machines

- AC 3-phase, slip-ring induction motor 415V, 5HP, 50Hz - 1 No.
- Rotor resistance starter, complete set, suitable for 5HP 415V 3-phase slip-ring induction motor - 1 Set
- Mechanical loading arrangement complete set - 1 Set

Materials

- PVC insulated, stranded aluminum cable 2.5 sq.mm -15 m
- PVC insulated, flexible cable 14/0.2mm - 2 m
- Black insulation tape - 0.2m
- G.I. wire 8 SWG - 10 m

PROCEDURE

TASK 1: **Connect start, run and reverse the slip- ring induction motor through rotor resistance starter**

1 Record the name-plate details of the given motor and the starter.

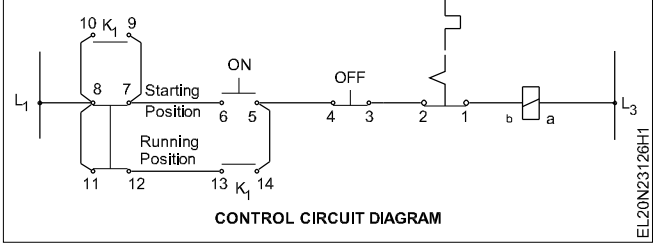
2 Identify the terminals of the 3-phase, slip-ring induction motor.

Slip-ring terminals can be identified by checking the continuity from terminals to the slip-ring.

3 Open, identify and trace the internal connections of the rotor resistance starter, draw the diagram and get it approved by the instructor.

4 Draw the circuit diagram connecting the ICTP, starter, rotor-resistance and the motor, and get it approved by the instructor.

Fig 1



CONTROL CIRCUIT DIAGRAM

5 Connect double earth independently for the main switch starter and the motor. (Use G.I wire No.8 SWG as earth wire)

6 Connect the motor, starter, main switch meters as per the approved diagram (Fig 2) and get it checked by the instructor.

To start and run the motor

7 Keep the rotor resistance starter handle in the starting position (cut in) of the rotor resistance.

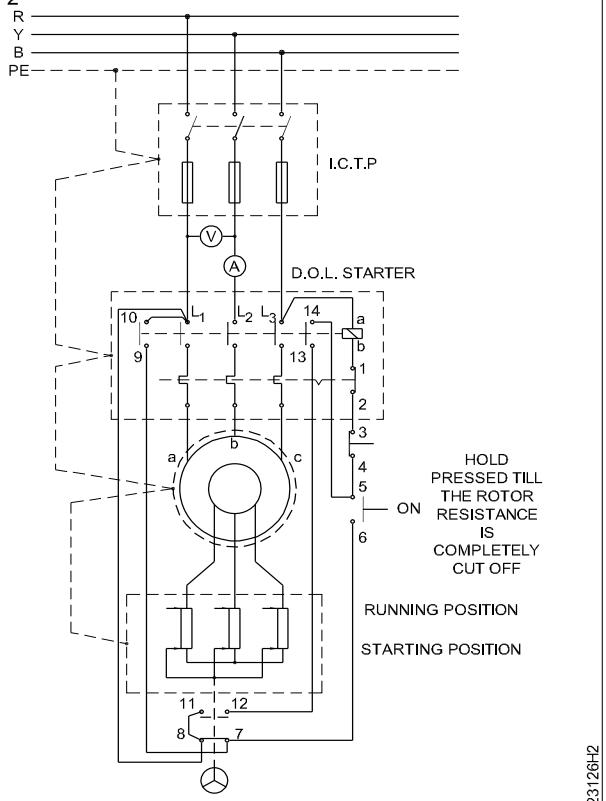
8 Press the start-push button of the starter. While pressing the start-push button, slowly move the handle of the rotor resistance from the starting position towards the running position till it settles down at 'run' position.

9 Note down the reading of the voltmeter, ammeter at the time of just starting and normal running positions. Record them in Table 1.

10 Release the pressure from the start-push button.

11 Note down the direction of rotation. The direction of rotation is .....

Fig 2



CIRCUIT DIAGRAM OF THE ROTOR RESISTANCE STARTER WITH I.C.T.P. SWITCH & MOTOR

12 Measure the speed and enter in Table 1.

13 Press the 'OFF' button of the starter to stop the motor.

14 Do not start the motor when the rotor-resistance handle is in the running position. The motor starts only when the rotor-resistance handle is in the starting position. (Fig 2) The motor will not start in any intermediate position or in the running position.

Investigate the following:

- Whether the motor could be started when the rotor resistance handle is at the running position.
- Whether the motor could be started when the rotor resistance handle is at an intermediate position between the starting and running positions.
- Whether the motor could be started when the rotor resistance handle is at the starting position.

Write your conclusion.

_____

_____

Table 1

(L-with air gap)

Measured resistance = ...ohms

Sl. No	Line voltage in volts	Starting current in amp	Running current in amp	Full load current as shown in the name plate in amps	Speed rpm

Change DOR

15 Switch OFF the ICTP switch and make sure the supply is disconnected, and the fuses are removed and kept in safe custody.

16 Interchange any two of the line wires, either in the starter terminal or in the motor terminals.

Change either the outgoing cable of switch ICTP or the incoming cables of the starter, whichever is easier.

17 Replace the fuses, switch 'ON' the mains and run the motor, observe and record the direction of rotation. The direction of rotation is .....

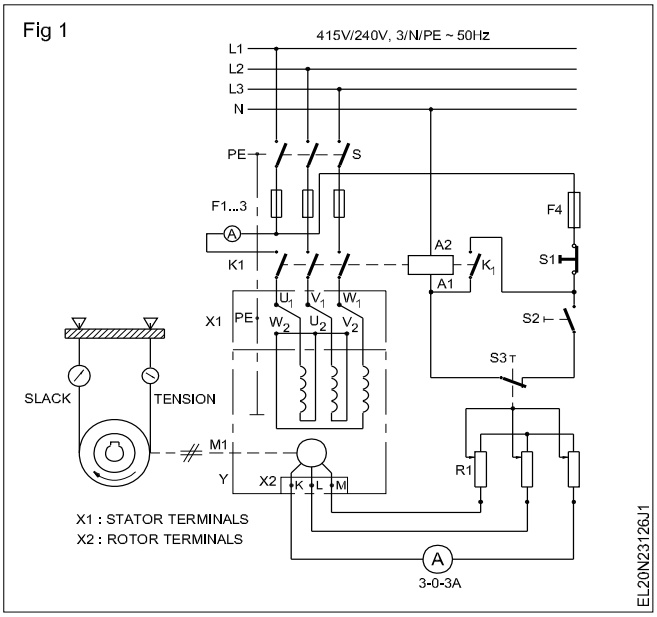
18 Stop the motor, switch 'off' the mains, remove the fuses and disconnect the cables.

TASK 2 : **Determine the performance characteristics of a slip ring induction motor**

1 Make the connections as per diagrams shown in Fig 1 & 2.

2 Check and ensure the control circuit wiring of the starter panel is same as Fig 4.

Fig 1



3 Check the supply voltage for the rated value and switch on the ICTP switch.

4 Start the motor on no-load.

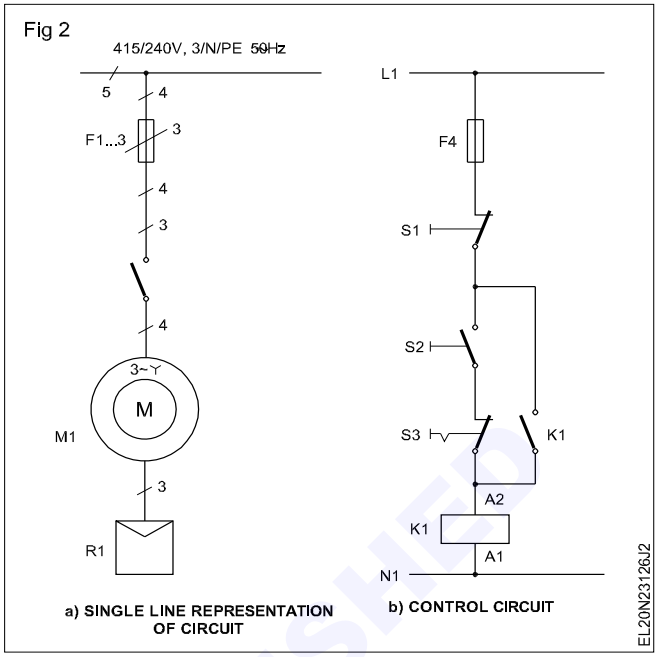
Make sure the rotor resistance starter handle is in the starting position. Otherwise the motor will not start.

5 Cut down the rotor's circuit resistance to zero gradually observing the increasing speed of the motor.

6 Watch the deflections of the ammeter pointer in the rotor circuit and note that it oscillates on either side.

7 Start the stop watch and measure the oscillations of the ammeter pointer for one minute and record in Table 2.

Fig 2



8 Load the motor with a brake load to about 25%, 50%, 75% & 100% and record the number of oscillations of the ammeter per minute in each case. (Table 2)

The load on motor is determined by the current taken by it from supply.

9 Determine the rotor current frequency at standstill is equal to the supply frequency to the stator.

Rotor current frequency (f_r) while running is supply frequency $f_r = s \times f$

10 Apply the formula

$$\text{Slip} = \frac{\text{rotor frequency } f_r}{\text{supply (stator) frequency } f}$$

Table 2

Load current in Ampere	Ammeter Oscillation	Oscillation per second	Slip ($S = f_r/f$)
No load			
About 1/4 FL			
About 1/2 FL			
About 3/4 FL			
Full load			

Determine the efficiency of squirrel cage induction motor by brake test

Objectives: At the end of this exercise you shall be able to
- **connect and conduct the test for actual loading with brake**
- **calculate the output from the readings of the spring balance**
- **calculate the efficiency of the motor**
- **draw the graph of load versus efficiency.**

Requirements

Tools/Instruments

- Tachometer: multi-range 300 to 3000 r.p.m - 1 No.
- MI Voltmeter (0 - 500V) - 1 No.
- MI Ammeter (0 - 10A) - 1 No.
- Wattmeter dynamometer type 500V, 10A, 3000W - 2 Nos.
- Spring balance 10 kg - 1 No

Equipment/Machines

- 3-phase squirrel cage induction motor 415V, 3 HP 50Hz - 1 No.
- Brake loading arrangement DOL starter 415V AC 3-phase,50Hz, 10A - 1 No.
- Connecting cables - as reqd.
- ICTP switch 16A, 415V - 1 No.
- Graph sheet (A4 Size) - 1 No.

PROCEDURE

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. Make connection as per circuit diagram. (Fig 1)

Check the mounting of the motor to the base is firm. Check the brake drum is properly keyed to the shaft.

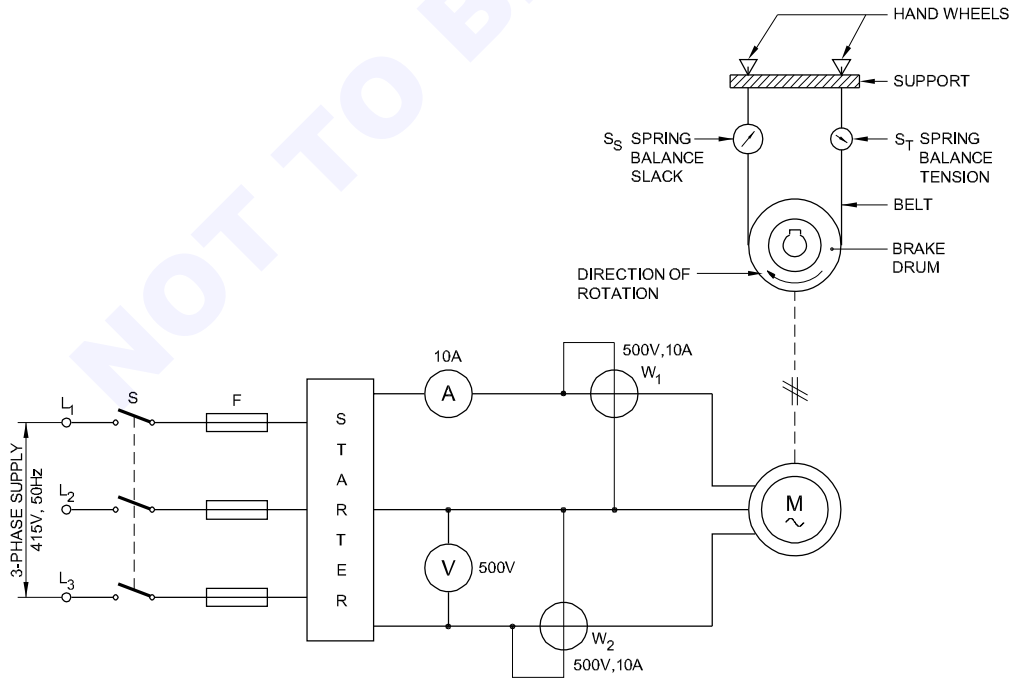
3 Fix the brake drum's rope or belt with the spring balances in slack condition.

4 Switch 'ON' ICTP switch 'S' and start the motor at no-load.

5 Measure the speed and record in Table 1.

6 Tighten the belt to apply brake action on the brake drum, until the motor takes 1/4 full load current.

Fig 1



Apply and regulate the required amount of cooling water to the brake drum.

7 Read the spring balances (Tension side S_T, slack side S_S) and record in Table 1.

8 Record the voltmeter, ammeter and wattmeter readings in Table 1.

9 Measure the speed of the motor at this loaded condition and record in Table 1.

10 Repeat the steps 6 to 9 for different load currents, say about 1/4 , 1/2, 3/4 and full load.

11 Measure the diameter of the brake drum and the thickness of the rope/belt.

12 Drum radius 'R' = _____m.

Rope/belt thickness 't' _____m

13 Calculate the torque

Torque, $T = (S_T - S_S) \times (R + t)$ Kg m

where (R + t) is in metre, $(S_T - S_S)$ is in Kg.

Record the torque and output in Table 2.

14 Calculate the output applying the formula,

Output = 1.027 NT watt

where N - revolutions per minute, T - torque in Kg m

15 Calculate the motor input and record in Table 2.

Input = $(W_1 + W_2)$ watt

16 Calculate the efficiency of the motor and record.

(Efficiency = Output/Input)

17 Plot the graph for the relationship - load in KW versus efficiency in %.

Conclusion

Efficiency of induction motor. _____

_____

Table 1

S No.	Speed in rpm	Reading of spring balance tension		Volt meter reading	Ammeter reading	Wattmeter reading
		S_T	S_s			

Table 2

S No.	Speed	Torque T	Output	Input $(W_1 + W_2)$	Efficiency
1					
2					
3					
4					
5					

— — — — — — — —

Determine the efficiency of 3 phase squirrel cage induction motor by no-load test and blocked rotor test

Objectives: At the end of this exercise you shall be able to
- **conduct a no-load test for a given 3-phase squirrel cage induction motor**
- **conduct blocked rotor test for the above 3-phase squirrel cage induction motor**
- **determine the constant losses and copper loss at full load.**

Requirements

Tools/Instruments

- MC Voltmeter (0-30V) - 1 No.
- MI Ammeter 0-2.5A - 1 No.
- MI Ammeter 0-2A - 1 No.
- MI Ammeter 0-10A - 1 No.
- Wattmeter 500V, 1A/2.5A low power factor - 2 Nos.
- Wattmeter 125/250V, 10/15A multi range - 2 Nos.
- Voltmeter MI 0-500V - 1 No.
- Voltmeter MI 0-75, 150, 300V multi range - 1 No.

Equipment/Machines

- 3-phase induction motor 500V, AC, 50Hz, 3 HP - 1 No.
- DOL starter 500V, AC, 50Hz, 3 HP - 1 No.
- 3-phase auto-transformer input 415V, output 0-500V 3 KVA - 1 No.
- Lock bar/locking arrangement - 1 No.

Materials

- Connecting cables - as reqd.
- ICTP switch 16A, 500V - 1 No.

PROCEDURE

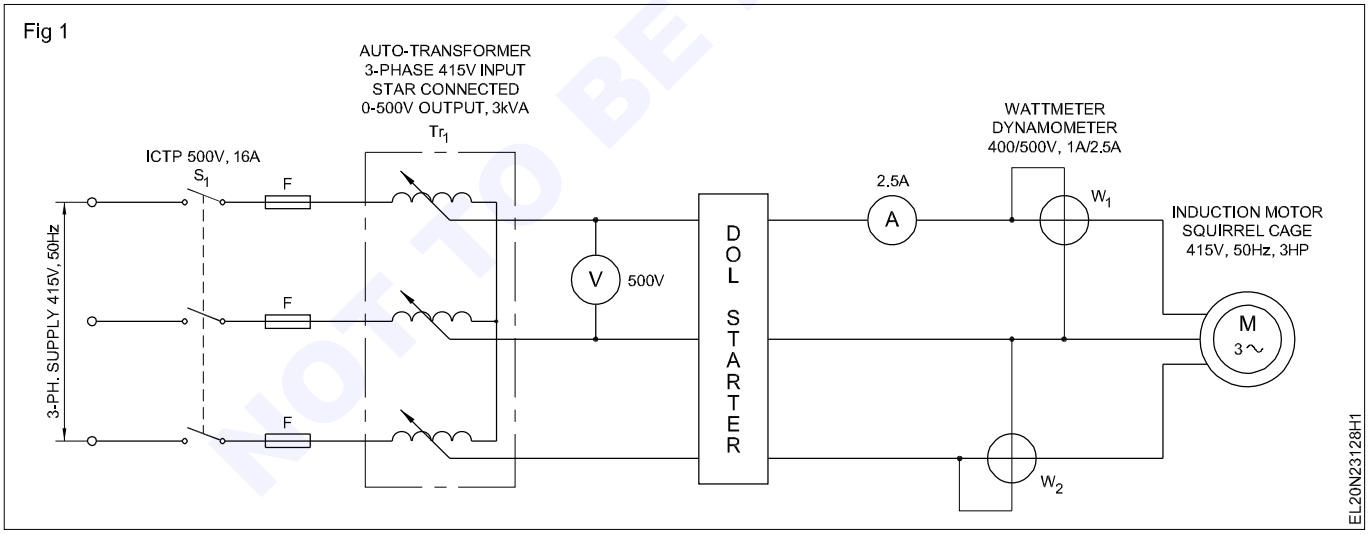
TASK 1 : **Conduct No-load test**

1 Record the name-plate details of the induction motor.

2 Collect all the required instruments for the circuit. (Fig 1)

3 Make the connections as per circuit diagram. (Fig 1)

Fig 1



4 Check the supply for the rated value and switch 'ON' the ICTP switch (S_1) (If the value is not correct adjust by auto transformer)

5 Start the motor without any load.

6 Read and record the wattmeter, ammeter and voltmeter readings in Table 1.

7 Switch 'OFF' the supply and disconnect all connections of the meters, and the motor.

Table 1

Input voltage	Power input $W_o = (W_1 + W_2)$	No-load current I_o

8 Check the connections of the 3-phase supply leads to the motor terminals. If six terminals are available identify each phase winding.

9 Measure the resistance of the stator using DC low voltage supply, ammeter and voltmeter. Record the reading in Table 2.

Table 2

DC supply voltage	Ammeter reading	Resistance of stator (one phase)

10 If the motor has only 3 terminals, and the internal connections are marked on the name plate, make calculations as below.

For star connection

Resistance per phase $R_P = \frac{V}{I} \times \frac{1}{2}$

Therefore $R_P = \frac{R}{2}$

For Delta connection

Resistance between two terminals $R = \frac{V}{I}$

Let the resistance per phase = R_P

$R = R_P$ II $2R_P$ (R_P parallel to $2R_P$)

i.e $\frac{1}{R} = \frac{1}{2R_P} + \frac{1}{R_P}$

Resistance measured $= \frac{2}{3}R_P$

Therefore R_p (resistance per phase of stator) is = $\frac{2}{3}R$

Calculations

The no-load input: W_o = No load copper loss

$= (I^2_{oph}R_P) \times 3$

(I_{oph} = no load phase current)

For star connected motor $I_O = I_{oph}$

For delta connected motor $I^2_{oph} = \frac{I_0}{\sqrt{3}}$

The losses at no load are

- I^2R loss in the stator winding
- Core losses in the stator and rotor
- friction and windage losses

Core losses and friction and windage losses practically remains constant in induction motor

Constant losses = $W_o - (I_{oph})^2 R.3)$

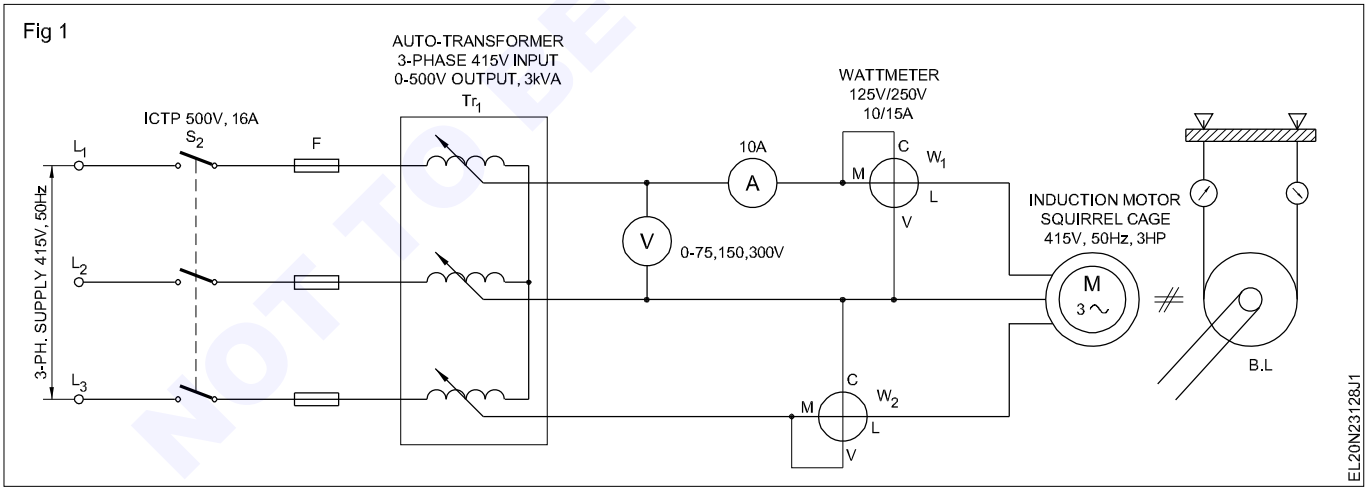
— — — — — — — —

TASK 2 : **Conduct blocked rotor test**

1 Collect the instruments to form circuit as per diagram. (Fig 1)

2 Make the connections as per circuit diagram. (Fig 1)

Fig 1



Keep the auto-transformer at zero output voltage position.

3 Switch on ICTP switch 'S_2'.

4 Increase the output of the auto-transformer voltage gradually, watching the ammeter, till the current is equal to full load current.

5 Read and record the wattmeter, voltmeter and ammeter readings in Table 3.

Table 3

Input voltage V	Power input W	Blocked current I

Calculation

Wattmeter reading = full load I^2R loss.

$= 3I^2_PR_e$,

where R_e = Resistance of stator winding per phase

Wattmeter reading= $3I_P^2R_e$,

I^2R at no load = $3I_o^2R_e$

Magnetic losses = No load input – copper loss.

Total loss = full load I^2R loss + Magnetic losses

= Block rotor wattmeter reading + Magnetic losses

$$\text{Efficiency} = \frac{\text{Output}}{\text{Input}} = \frac{\text{Input - Losses}}{\text{Output} + \text{Losses}}$$

Determine the efficiency of the motor at full load.

Constant losses

= Copper loss at full load = $3I^2_pR_e$ watts

where R_e – equivalent resistance/phase

I_P – full load current/phase

Copper loss at full load = _____ watts.

Input

= $\sqrt{3}$ x v x I x pf = _____ watt.

Total losses = constant losses + copper loss

Therefore, efficiency = _____

6 Determine the efficiency when the input current is 0.7 full load and p.f is 0.8.

Conclusion

_____

_____

_____

_____

_____

— — — — — — — —

Measure slip and power factor to draw speed torque (slip/ torque) characteristics

Objectives: At the end of this exercise you shall be able to
- **wire up and connect resistance starter**
- **start, run the slip ring induction motor**
- **plot the graph of speed torque characteristic of slip ring induction motor.**

Requirements

Tools/Instruments

- MI Ammeter 5/10A multirange - 1 No.
- MI Voltmeter 250/500V multirange - 1 No.
- Tachometer multi-range 300, 1000, 3000 rpm - 1 No.

Equipment/Machines

- 3-phase auto-transformer input 415V star connected, output 0-500V, 3kVA - 1 No.
- 3-phase slip ring induction motor, 3HP, 415V, 50 Hz with rotor resistance starter - 1 No.

Materials

- ICTP switch 16A 415V - 2 Nos.
- Connecting cables - as reqd.
- Graph sheet (A4 Size) - 1 No.

PROCEDURE

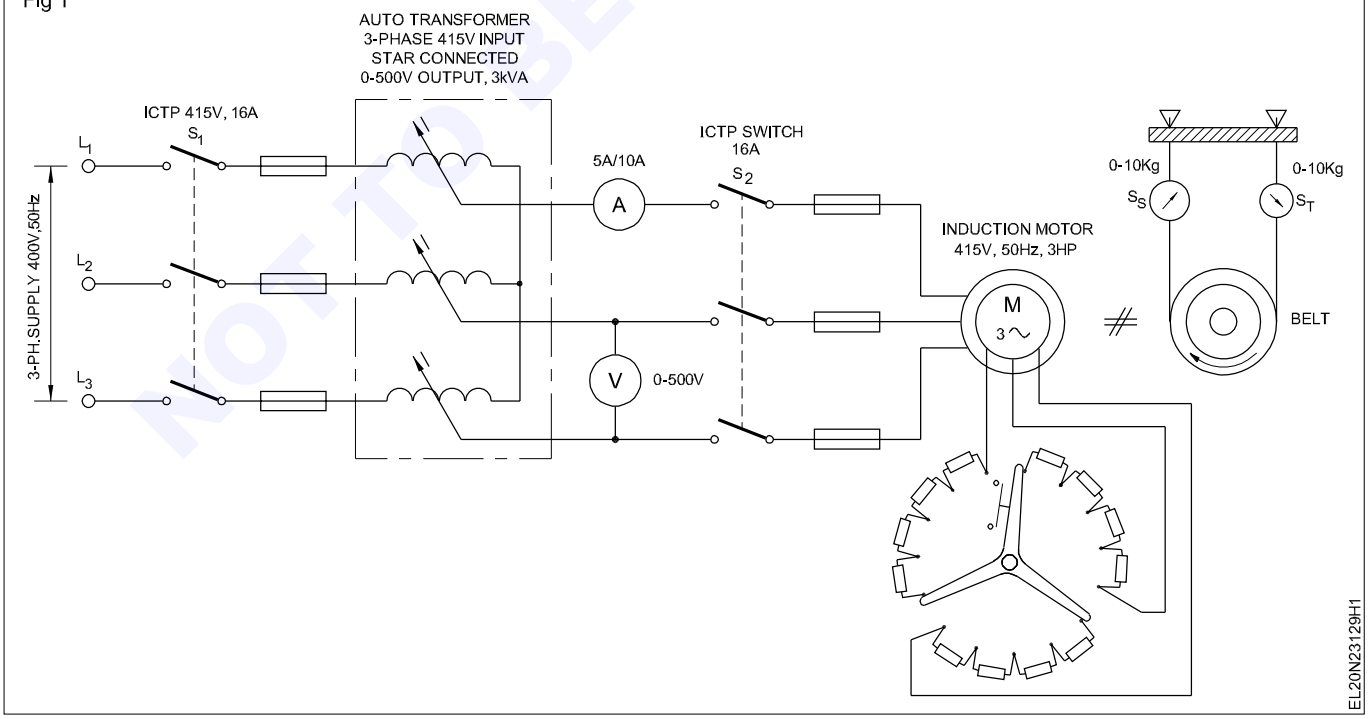
1 Read the name-plate details of slip ring induction motor.

Select the instruments of suitable range to form the circuit as per diagram. (Fig 1)

2 Make the connections as per circuit diagram (Fig 1) and Set the output of three-phase auto-transformer to minimum.

3 Switch on ICTP 'S_1' and adjust the output of the 3-phase varies to 40% of the rated input voltage of the motor.

Fig 1



4 Check the load on the brake drum which is totally removed.

5 Set the rotor resistance starter not to include any resistance in the rotor circuit (i.e rotor terminals are shorted by the starter).

6 Close the switch S_2 and start the motor.

7 Measure the speed, current and record in Table 1

Table 1

	Stator input voltage	**Stator current**	**Speed**	**Slip**	**S_T**	**S_S**	**Motor output torque**
Without extra resistance in rotor circuit							
With additional resistance in rotor circuit							
-do-							
-do-							

8 Load the motor by adjusting the spring tension of the belt on the brake drum/pulley until the speed falls to a very low value.

9 Check the speed, stator current, voltage for each setting of a load and record in Table 1.

10 Remove the load on the motor and allow it to run in no load condition.

11 Increase the resistance in the rotor circuit by adjusting the rotor starter handle in two or three steps and repeat steps 7 to 10.

12 Apply the formula and calculate the torque.

Torque (T) = $(S_T - S_S)(R + t)$

where

S_T - spring balance reading on tension side in kg

S_S - spring balance reading and slack side of belt in kg

R - radius of Drum/pulley in metre

t - thickness of belt in millimetre

13 Record the calculated value of torque and slip in Table 1.

14 Plot the graph of speed/slip - torque for each rotor resistance.

Conclusion

_____

_____

_____

_____

_____

— — — — — — — —

Test for continuity and insulation resistance of three phase induction motors

Objectives: At the end of this exercise you shall be able to
- **perform insulation resistance test between phase windings**
- **perform insulation resistance test between winding and body.**

Requirements

Tools/Instruments

- D.E spanner 5mm to 20m - 1 Set
- Cutting pliers 150mm - 1 No.
- Screwdriver 200mm - 1 No.
- Megger 500V - 1 No.
- Ohmmeter low range 0-10 Ohm - 1 No.
- Test lamp 240V, 60W - 1 No.
- Earth tester with spikes and connecting lead - 1 Set
- Hammer straight peen 1.5kg - 1 No.
- M.C voltmeter 0-10V - 1 No.
- M.C ammeter 0-20A - 1 No.
- Calibrated rheostat 0.1 ohm, 10 amp - 1 No.
- Battery 6V, 60 A - 1 No.
- M.I voltmeter 0-50V - 1 No.
- M.I voltmeter 0-25A - 1 No.

Equipment/Machines

- AC 3-phase, 415V / 3 H.P. squirrel cage induction motor - 1 No.

Materials

- Connecting cables 2.5 mm^2 of length 40m - 1 No.
- Connecting cables 2.5 mm^2 of length 10m - 1 No.
- Testing prods - 1 Pair

PROCEDURE

TASK 1 : **Test the continuity of 3 phase induction motor**

1 Note the name-plate details of the induction motor.

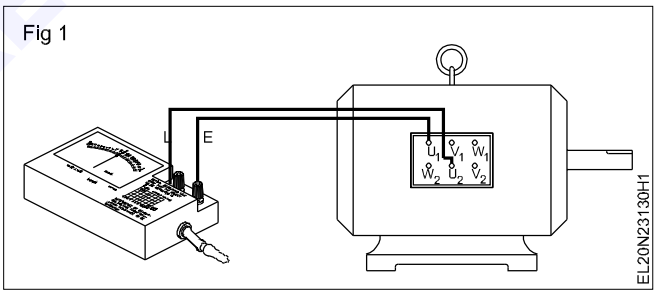
2 Identify the terminals of the given AC induction motor from the markings.

3 Connect the test loads of the megger to the terminals U_1 and U_2. (Fig 1)

4 Rotate the megger at its rated speed and note down the readings in Table 1.

5 Repeat the steps 3 and 4 by connecting the megger terminals between V_1 and V_2 and also between W_1 and W_2. Record the finding in Table 1.

Fig 1



The megger reading should be zero, if the winding of the motor is having continuity.

The megger reading should be high or infinity (∞) if the winding of the motor is open.

Table 1

Continuity test for 3 phase induction motor

Sl.No	Between terminals	Meter reading	Remarks
1	U_1 and U_2		
2	V_1 and V_2		
3	W_1 and W_2		

TASK 2: **Measure the insulation resistance value between the windings**

1 Connect the test leads of the megger to the terminals U_1 and V_1. (Fig 1)

2 Rotate the Megger at its rated speed and note down the readings in Table 1.

Fig 1

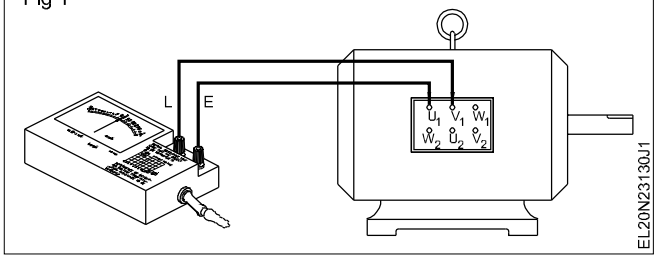


Table 1

Insulation resistance of 3-phase induction motor

Sl. No	Between terminals	Insulation resistance	Remarks
1	U_1 and V_1		
2	U_1 and W_1		
3	V_1 and W_1		
4	U_1 and frame		
5	V_1 and frame		
6	W_1 and frame		

3 Repeat the steps 1 and 2 by connecting the Megger terminals between U_1 and W_1, and also between V_1 and W_1. Record the findings in Table 2.

Recommended standard insulation resistance

$$R_1 = \frac{20 \times E\eta}{1000 + 2P} \text{ in megohm .}$$

where

R_1 = insulation resistance in megohms at 25^0C.

E_n = rated phase-to-phase voltage

P = Rated power in kW.

If the resistance is measured at a temperature different from 25°C, the value shall be corrected to 25°C.

The equation given here is used to calculate the insulation resistance as a standard value. However the accepted insulation value should not be less than 1 megaohms.

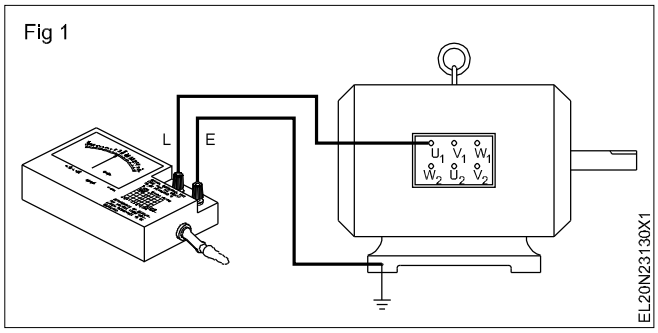
— — — — — — —

TASK 3 : **Measure the insulation resistance between each winding and body or frame**

1 Connect the test leads of the Megger to the frame of the motor and terminal U_1. (Fig 1)

The Megger connection to the frame should be done at the earthing stud of the frame. Before connecting, remove the varnish, dust, dirt and grit thoroughly at the earthing stud.

Fig 1



2 Rotate the Megger at its rated speed and note down the readings.

3 Repeat steps 1 and 2 for the other two windings (V_1 and W_1).

4 Compare the measured value with the standard value.

— — — — — — — —

Perform speed control of 3-phase induction motors by various methods like rheostatic control, auto transformer etc.

Objectives: At the end of this exercise you shall be able to
- **connect the 3 phase slip ring induction motor through rotor resistance starter**
- **control the speed of a 3-phase slip ring motor by rotor resistance starter**
- **connect a 3 phase induction motor to an auto transformer starter**
- **control the speed of a 3 phase induction motor by auto transformer starter.**

Requirements

Tools/Instruments

- Insulated cutting pliers 200mm - 1 No.
- Connector screw driver 100 mm - 1 No.
- Electrician's knife 100 mm - 1 No.
- Screw driver 200mm - 1 No.
- MI Voltmeter - 0-500 V - 1 No.
- Tachometer 300 rpm to 3000 rpm - 1 No.
- Megger 500V - 1 No.

Equipment/Machines

- AC 3 Phase slip ring induction motor 415V 3HP - 1 No.
- Rotor resistance starter complete set suitable for 3HP - 1 No.
- AC 3 phase squirrel cage induction motor 500V, 5 HP - 1 No.
- Auto - transformer starter complete set suitable for 5 HP - 1 No.

Materials

- PVC Insulated flexible cable 2.5 sqmm - 20 m
- IC TP switch 10A 500V - 2 Nos.
- Test Lamp 40 W 250V - 1 No.

PROCEDURE

TASK 1 : **Control the speed of a slip ring Induction motor by a rotor resistance starter**

1 Check the Insulation and continuity of the motor winding.

2 Make the connection as per circuit diagram. (Fig 1)

3 Check the supply and provide proper rating fuses in the main switch according to the motor rating.

4 Keep the rotor resistance starter handle in the starting position (cut in) of the rotor resistance.

> **Cut in position of the rotor resistance is generally indicated in the starter as starting position or off position.**

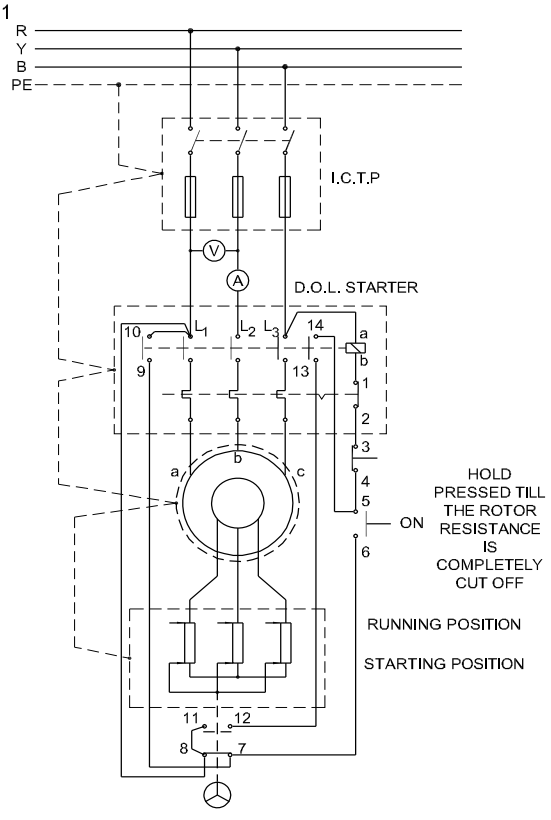
5 Press the start button of the starter, while pressing the start push button, slowly move the handle of the rotor resistance from the starting position towards the running position step by step till it settles down at run position.

6 Measure the speed at every step of rotor resistance and record them in Table 1.

Table 1

Sl No.	Rotor Resistance Handle position	Speed in RPM

Fig 1



CIRCUIT DIAGRAM OF THE ROTOR RESISTANCE STARTER WITH I.C.T.P. SWITCH & MOTOR

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7 Release the pressure from the start push button.

8 Press the off button of the starter to stop the motor.

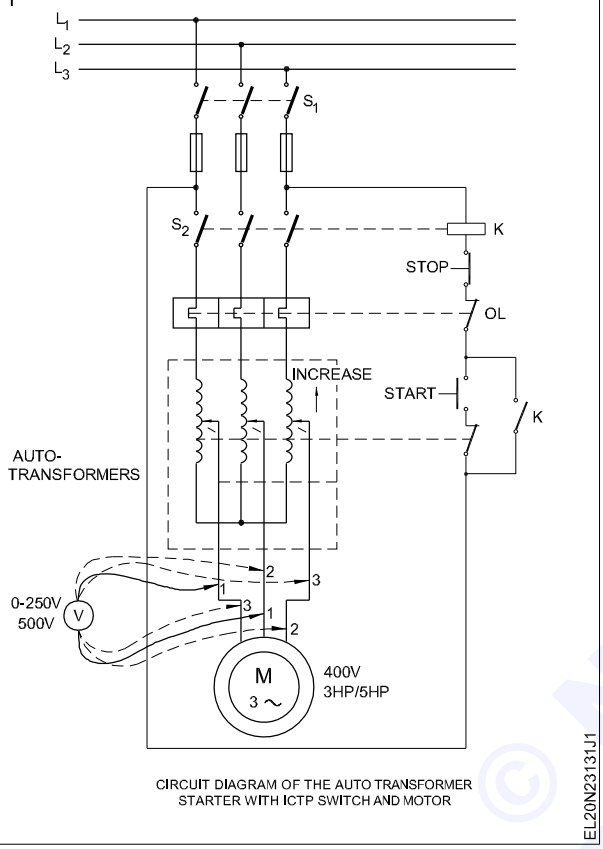
— — — — — — — —

TASK 2 : **Control the speed of 3-phase Induction motor by an auto transformer starter**

1 Check the insulation and continuity of the motor winding.

2 Make connections as per diagram. (Fig 1)

Fig 1



CIRCUIT DIAGRAM OF THE AUTO TRANSFORMER STARTER WITH ICTP SWITCH AND MOTOR

Get the circuit checked by the instructor before proceeding.

3 Switch on the main switch 'S1' and then press start push button. (keep auto-transformer for 100V output)

4 Start moving the auto transformer starter contacts such that the induction motor will start getting more voltage in stages upto full voltage.

5 Note the speed and voltage at every stage.

6 Reduce the applied voltage to the induction motor by resetting the auto-transformer contacts.

7 Measure the rpm of the induction motor at every stage and note in Table 2.

Table 2

Sl.No.	Line voltage (V1)	rpm

8 Switch off by pressing stop button and then switch off the main switch (S1)

Conclusion

State in what proportion the speed changes with respect to applied voltage to induction motor.

— — — — — — — —

Perform winding of three phase AC motor by developing connection diagram, test and assemble

Objectives: At the end of this exercise you shall be able to
- **dismantle the motor**
- **read, record and interpret the winding data for a 3-phase squirrel cage induction motor**
- **strip the old winding from the stator**
- **prepare and provide slot insulation**
- **prepare and lay the coils for the distributed type winding, concentric group of coils**
- **make end connections and terminate the lead wire**
- **insulate, bind and shape the overhangs**
- **assemble the motor**
- **test the motor for performance.**

Requirements

Tools/Instruments

- Screwdriver 100, 150 and 200 mm - 1 No each
- DE spanner 5mm to 30 mm - 1 Set
- Ring spanner 5 mm to 30 mm - 1 Set
- Cold chisel 25 mm x 200 mm - 1 No.
- Ball pein hammer 500 grams - 1 No.
- Nylon mallet 75 mm x 100 mm - 1 No.
- Pulley puller 200 mm with 3 jaws - 1 No.
- Centre punch 10 mm x 150 mm - 1 No.
- Insulated cutting pliers 200 mm - 1 No.
- Side cutter 150 mm - 1 No.
- Micrometer outside 0-25 mm - 1 No.
- Hacksaw frame 300 mm - 1 No.
- Steel rule 300 mm - 1 No.
- Scissors 200 mm - 1 No.
- Fibre or Hylam knife of assorted sizes - 4 Nos.
- Soldering iron 125 W, 250V - 1 No.
- D.B.electrician knife 100 mm - 1 No.
- Multimeter - 1 No.
- Megger (insulation tester) 500V - 1 No.
- Ammeter (or multi-range) M.I. 0-10A - 1 No.
- Voltmeter M.I.Multi-range 0-300V-500V - 1 No.
- Tachometer 0-500-5000 r.p.m. - 1 No.
- Allen key - 1 Set
- Readymade former universal size - 1 Set
- Awl of required length and thickness - 1 No.
- Spatula - 1 No.
- Magnetic compass 15 mm dia. - 1 No.
- Blow lamp - 1 No.
- Electric air blower - 1 No.

Equipment/Machines

- Burnt out 3-phase motor with single layer distributed winding of available capacity & double layer - 1 No.
- Baking oven with temperature control - 1 No.
- Coil winding machine - 1 No.
- Burnt out 3 phase motor with single layer concentric half coil winding - 1 No.

Materials

- Super-enamelled copper wire - as reqd.
- Milinex sheet or triplex paper - as reqd.
- 20 or 25 mm cotton tape - 1 Roll
- Fibre glass sleeves 1 mm, 2 mm, 4 mm, 6 mm - as reqd.
- Bamboo/fibre wedges - as reqd.
- 25 mm painting brush - 1 No.
- Soldering lead 60%, Tin 40%, - 100 g
- Resin flux - 25 g
- Insulating varnish - 1 litre.
- Tray 600 mm x 600 mm x 100 mm - 1 No.
- Thinner - 500 ml
- Hemp thread - 1 Roll
- Used power hacksaw blade - 2 Nos.
- Leatheroid paper - as reqd.
- Empire sleeve - as reqd.

PROCEDURE

Instructor may select a motor having burnt out single layer distributed winding for this exercise.

TASK 1 : **Dismantling of the motor, recording winding data and stripping the winding**

1 Collect the name-plate details and record.

2 Calculate the number of poles from the name-plate details.

Using the formula P =

where P - number of poles

f - frequency in Hertz

N_s - synchronous speed in r.p.m.

(little higher than the rotor speed noted in the name-plate).

3 Enter the number of poles in Table 1.

Table 1

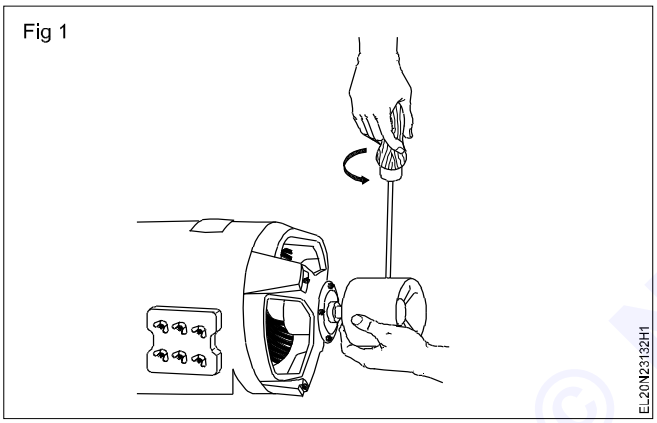
Winding Data

No.of coils	No.of slots.....	Coil pitch .....
No.of Poles		
Overhang projection	a) connection end .....mm	
	b) Non-connection end .....mm	

Alternatively calculate the poles using the rated rotor speed and round off the value to full number.

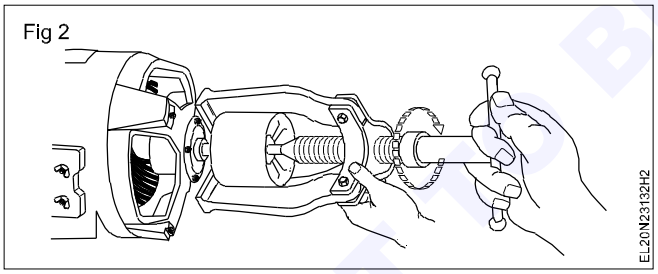
4 Remove the shaft key or the grub screw by holding the pulley. (Fig 1)

Fig 1



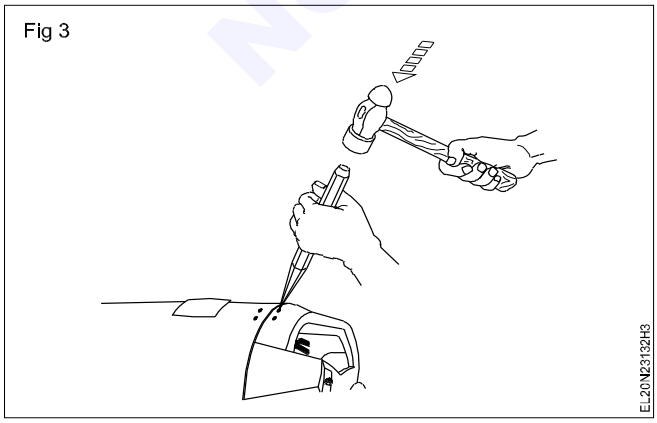
5 Remove the pulley by using a suitable pulley puller. (Fig 2)

Fig 2



6 Make a centre punch alignment mark on the stator and the end shield cover. (Fig 3)

Fig 3

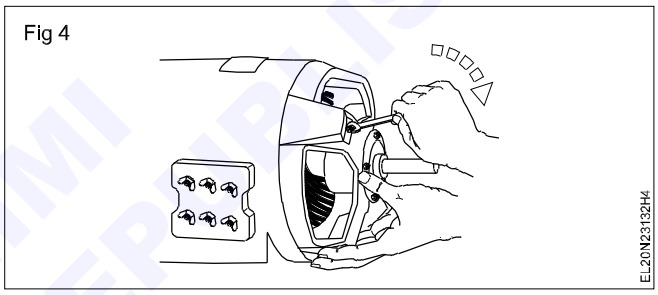


To avoid confusion make a single punch mark on one side and a dual punch mark on the other end of the motor.

7 Remove the grease cup screw.

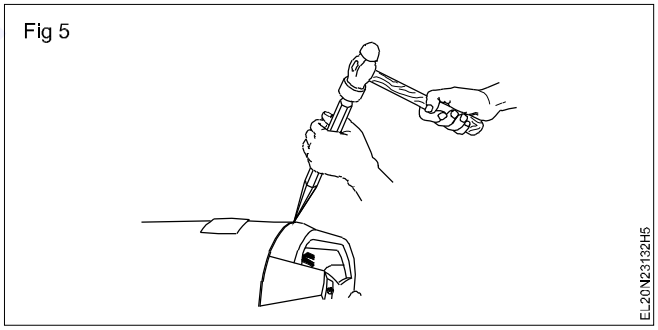
8 Loosen the bolts gradually, switching from side to side till they are removed. (Fig 4)

Fig 4



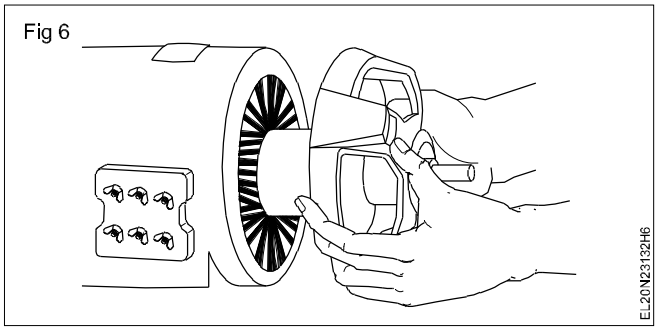
9 Keep the cold chisel tip between the stator and cover and gently tap the chisel with a hammer and separate the stator and the end shield cover. (Fig 5)

Fig 5



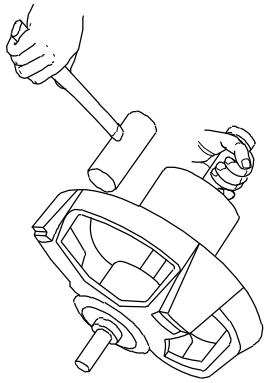
10 Pull off the end shield cover and rotor together, parallel to the motor shaft. (Fig 6)

Fig 6



11 Hold the shaft in one hand, rotate the end cover and tap it lightly with a nylon mallet to remove it from the rotor. (Fig 7)

Fig 7



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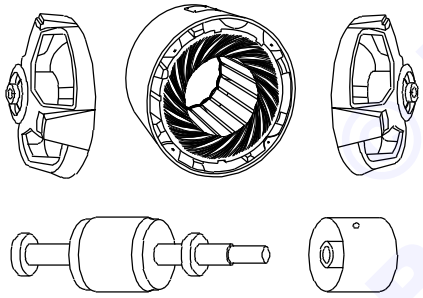
12 Remove the other end shield cover also by gently priming it out.

13 Inspect the rotor for any defect and the bearing for its condition.

If the bearing is worn out replace it with a new one. All fastening devices should be kept in a separate tray. The dismantle parts are shown in Fig 8.

Fig 8



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14 Identify whether the winding is a single layer distributed type.

In a single layer distributed type winding, the number of coils is equal to half the number of slots and the same size of coils are used throughout the winding.

15 Record the number of coils, number of poles, number of slots, pitch and record the overhand projection at both ends of the stator in table 2 and if required prepare templates by cardboard or similar materials for overhang projection. This will help to check the overhangs after rewinding.

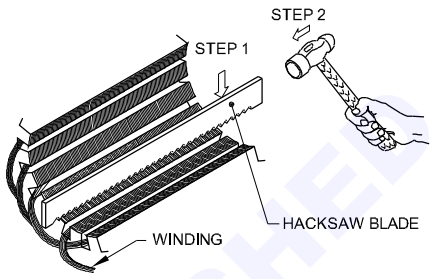
16 Open the end binding of the end and lead connections from the overhang.

17 Trace the group/lead connections and draw the same for reference in your record.

The number of coil groups shall be equal to the number of phase x number of poles in the case of whole coil connection whereas in the case of half coil connection the number of coil groups shall be equal to the number of phases x pair of poles. Hence ascertain the group and connection.

18 Remove the wedges. The wedge can removed by using a power hacksaw blade are shown in Fig 9 or by a wedge remover.

Fig 9



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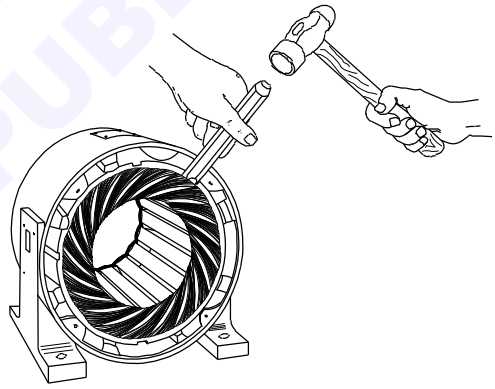
19 Cut off the coils in the non-connection end of the stator with a chisel. (Fig 10)

Fig 10



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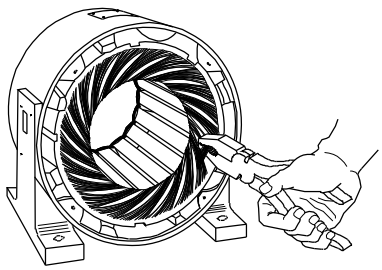
20 Pull out the coils with pincers or pliers. (Fig 11)

Fig 11



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In case the varnish on the winding is hard, heat the winding in an oven to about 200^{0}C for about one hour or heat it by a blowlamp. While heating it is important that the heat should be controlled such that the excess heat will not damage the stampings and warp the frame or core. In the case of loose coils, cutting of the coils may not be required and it can be removed out through the slots.

21 Check, record the total weight of the coils, count the number of turns, measure the size of the wire, and record them in Table 2.

Some manufacturers may use parallel conductors of the same size or different sizes of wires instead of using a single wire. Take care of this while recording and entering the details in Table 2 against 'wire multiple'.

22 Remove all the remaining foreign matter from the slots by scraping with a knife.

23 Clean it by blowing compressed air.

24 Measure the size and shape of the coil. If the full shape of the coil is available record the details in Table 3.

In case the full shape of the coil is not available, prepare a trial coil of single turn and insert it in the slots at the given pitches. Verify the overhang projection, clearance, correct size etc.

Table 2

No. of circuits.....	Turns/Coils.....	Size of the wire.....
Wire multiple.....	Wt.of scrap.....	Wire insulation.....

Table 3

Coil shape: Diamond / Rectangular / Oval

A. Coil length ..... mm

B. Coil width ..... mm

— — — — — — — —

TASK 2 : **Prepare and provide slot insulation**

1 Check the slot dimension and record it in Table 4.

2 Check the core thickness and record the same in Table 4.

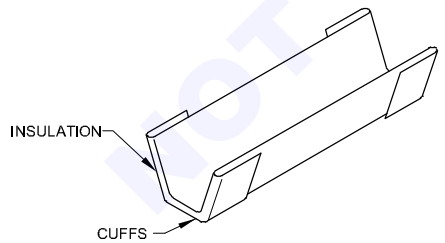
3 Select the slot liner of thickness as in the original.

4 Cut the paper as per slot length/core thickness with an additional length of 10 to 15 mm so as to make the insulation paper to project 5 mm on either side of the slot with cuffed ends.

10 to 15mm on either side is just an approximate requirement. Large motors may require a longer length or vice versa.

5 Cuff either end of the slot liner (Fig 1) and fold the same to the slot size.

Fig 1

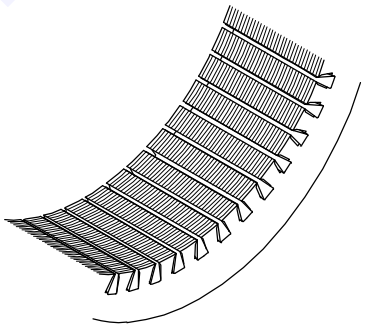


Prepare a sample of the slot liner and try inserting it in the slot to see the correctness.

6 Cut and prepare the necessary number of slot liners as per the correct sample.

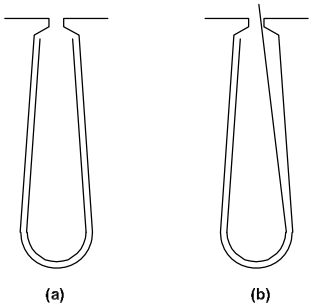
7 Insert the slot liners in all the slots properly and see that the slot liners project evenly on both sides of the core. (Fig 2)

Fig 2



The slot liner should properly adhere to the surface of the slots as shown in Fig 3(a). A wrong method of placing the slot liner. (Fig 3b).

Fig 3



8 Check the group/lead connections drawn in step 17 of Task 1 and also draw the developed diagram of the winding for the given motor.

For your guidance the end connections and the developed diagram are given in Figs 4 and 5 respectively for a certain motor having a single layer distributed type winding with the following data: 24 slots, 12 coils, 4 poles, 3-phase balanced winding.

Fig 4

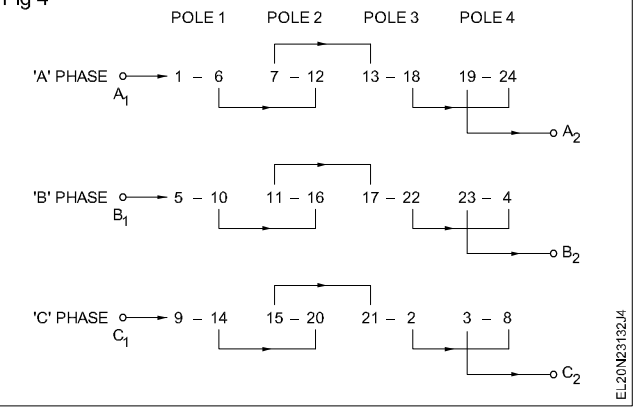
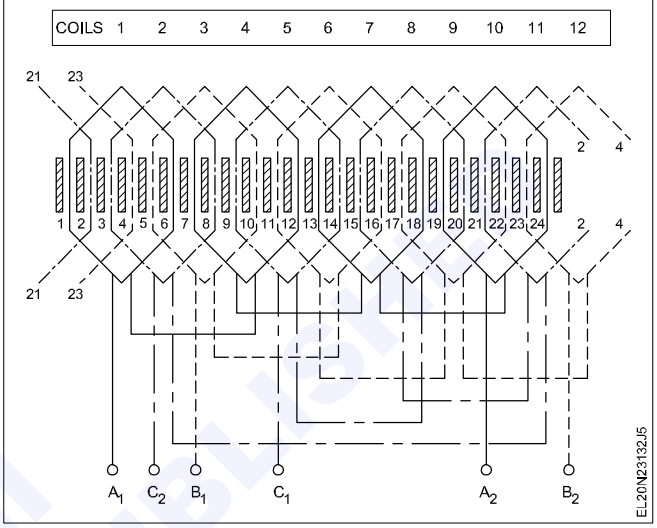


Table 4

Slot dimension

Lower width .....mm
Upper width (W) .....mm
Depth .....mm
Slot length .....mm

Fig 5



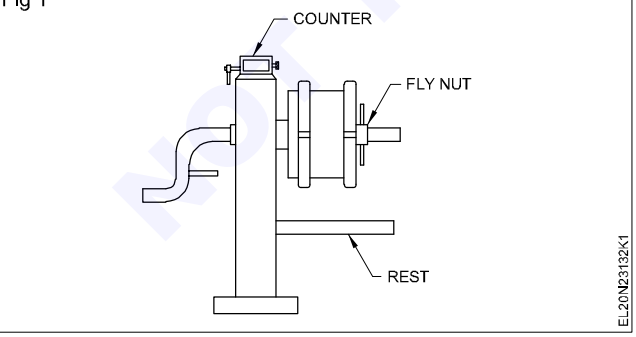
TASK 3 : **Prepare coil winding and forming**

1 Select a suitable size of former according to the dimension recorded in Table 3.

The former is cut with a distinct bevel edge for two reasons: to permit the coil to slip off the former and to allow a longer peripheral length of the coil at the back. Only one size of former is sufficient for the distributed type of winding.

2 Attach the former securely to the winding stand. (Fig 1) .

Fig 1



3 Confirm and select the size of winding wire i.e. given in Table 2.

4 Wind the designated number of turns (Table 3) by leaving 150 mm extension wire.

Make sure the number of turns is small as in the original.

5 Tie the coil tightly with twine thread on either side of the coil, after winding the coil.

6 Cut the remaining length of wire by leaving 150 mm extension.

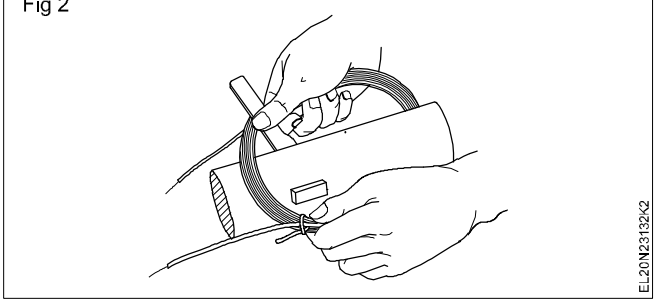
7 Remove the coil from the former and check its correctness by inserting in the slots.

If the size is found OK proceed to step 8. Otherwise make necessary changes in the former till the coil shape is correct.

8 Make the required number of coils.

9 Shape the coils by folding the ends of the straight parts of the coils. (Fig 2)

Fig 2

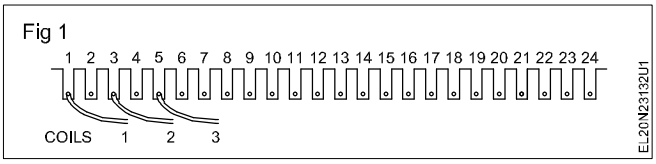


TASK 4 : **Insert the coils in the slots in proper sequence**

Procedure for 24 slots, 12 coils, 4 pole distributed winding is given below. You can adopt the same procedure for other stators of different slots and poles with necessary modification. Observe keenly the developed diagram shown.

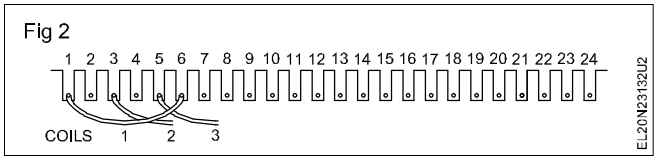
1 Follow the procedure given below. First insert the left coil sides of 1st coil, 2nd coil and 3rd coil in slot 1, 3 and 5 respectively. (Fig 1)

Fig 1



2 Insert the right coil side of the 1st coil in slot number 6. (Fig 2)

Fig 2



3 Insert the left coil side of coil 4 in slot 7 (Fig 3) and then insert the right coil side of coil 2 in slot 8. (Fig 4)

Fig 3

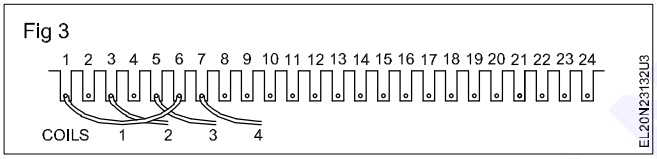
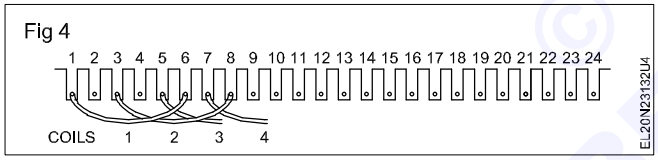
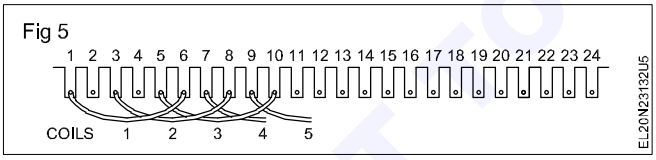


Fig 4



4 Insert left coil side of coil 5 in slot 9 and then insert the right coil side of coil 3 in slot 10. (Fig 5)

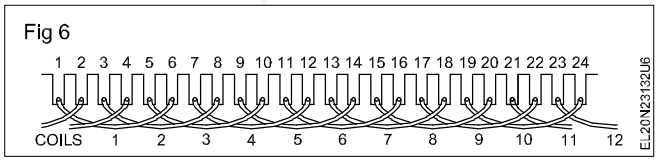
Fig 5



5 Proceed likewise till you are left with the right coil sides of coils 11 and 12.

6 Insert the 11th coil right coil side in slot 2 and then the 12th coil right coil side in slot 4. (Fig 6)

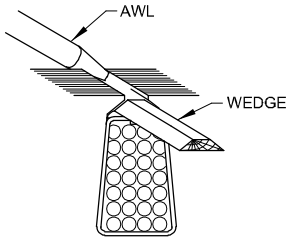
Fig 6



7 Insert the wedges in the slots so that the coil sides are well packed in the slots. (Fig 7)

8 Insert the half moon shaped phase insulation paper between each coil in both sides of the overhang.

Fig 7



9 Follow the developed diagram and connect the end, group and terminal connections.

10 Tie the connections with overhangs and shape the overhang.

11 Test the winding .

12 Measure the resistance between A_1 - A_2 , B_1 - B_2 and C_1 - C_2 and record the values in Table 5.

Table 5

Resistance between A1 - A2 .....ohm
Resistance between B1 - B2 .....ohm
Resistance between C1 - C2 .....ohm

All the three resistances should be equal.

13 Measure the insulation resistance between the windings and the stator core with 500 V Megger and record it in Table 6.

Table 6

Insulation resistance

between core and A phase.....MEGOHM
between core and C phase.....MEGOHM
between core and B phase.....MEGOHM

14 Measure the insulation resistance between the windings with a 500V Megger and record it in Table 7.

The above values should not be less than one megohm in any case.

Table 7

Insulation Resistance

Between A phase and B phase...MEGOHM
Between B phase and C phase...MEGOHM
Between C phase and A phase...MEGOHM

15 Varnish the winding,

16 Assemble the motor and test run the motor with load for 8 hours.

The instructor should select a 3-phase induction motor having a single layer concentric (half coil) winding for this exercise.

TASK 5 : **Record winding data and strip the winding**

1 Collect the name-plate data and record in Table 8.

2 From the name-plate details, calculate the number of poles and write it below.

Number of poles.....

3 Dismantle the given motor. Record the details of the existing winding details before and after removing the coils from the stator in Table 12.

4 Identify the windings of the given motor - whether it is single layer concentric winding.

Table 8

Induction motor

Make .....Frame No. .....Model .....
Phase .....Kilowatt/HP .....r.p.m .....
Volts .....Amperes .....Frequency.....

In single layer winding, the number of coils is equal to half the number of slots. In concentric winding the pitch of coils in the group will be different and will be in concentric form.

5 Record the number of slots, number of coils and the pitch of the coils in Table 9.

Table 9

No. of slots ..... No. of coils .....Coil Pitch
No. of poles..... No. of coils/slot .....
End connections .....(Half coil/whole coil)

6 Trace the group/lead connections and draw the same for reference in the space given.

In whole coil connected winding, the total number of groups shall be equal to the number of phases multiplied by the number of poles, and in the case of half coil connected winding, the total number of groups shall be equal to the number of phases multiplied by the number of pairs of poles. Hence ascertain the number of groups, and, thereby, the type of connection.

7 Record the length of the overhang projection and prepare a template which could be used to check the overhangs after rewinding.

8 Remove the wedges from the slots.

9 Strip all the coils out from the stator except one complete group of coils.

10 Use a thinner in the winding and remove carefully one complete group of coils without damage.

11 Check the total coil weight and record it in Table 10.

Table 10

No. of circuits.....Turns/coil.....
a) .....
b) .....
c) .....
Size of the wire.....Wire multiple.....
Total weight of scraped coils.....Wire insulation.....

12 Clean the stator slots.

13 Using the complete set of coils, measure the s ize and shape of the coils and record the details in Table 11.

Table 11

Shape of the coil.....diamond/Rectangular/Oval		
	Outer coil	**Inner coil**
A	Coil length ..... mm	.....mm
B	Coil width ..... mm	.....mm
C	Coil thickness ..... m	

In case the full shape of a coil is not available, use a single turn of 16 or 18 SWG copper wire and measure the inner dimensions of the coils of the coils of the set, one after the other. Insert it in the slots at the given pitches. Verify the length of overhang projection and clearance etc. taking into account the thickness of the coils. If found satisfactory, use the same for recording the measurement.

— — — — — — — —

TASK 6 : **Prepare slot insulation**

1 Prepare slot liners and insulate the slots.

— — — — — — — —

TASK 7 : **Lay coils in the slots**

The Procedure for 24 slots, 12 coils, 4 poles, single layer concentric winding (half coil) is given below. You can adopt the same procedure for the other stators of different slots and poles with necessary modifications.

The end connection and developed diagrams for the above stated winding are given in Fig 1 and 2 for your guidance.

1 Insert the guide papers in the grooves of slot No.2 (Fig 2) where the winding will begin.

Fig 1

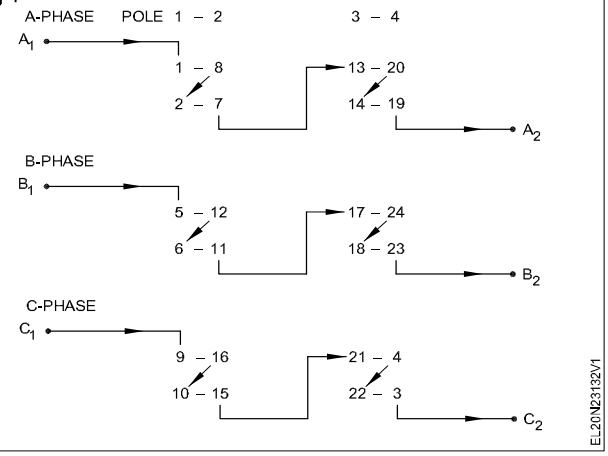
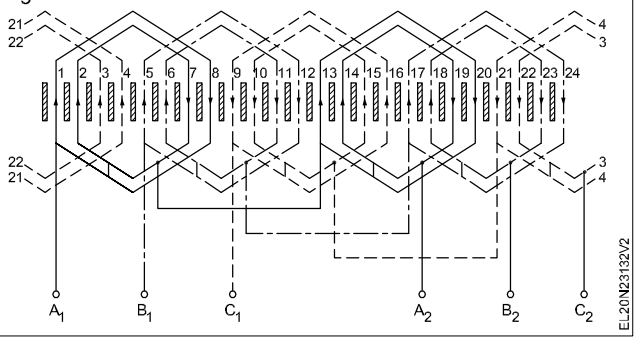


Fig 2



In the concentric type of winding the insertion of coils should start from the inner coil which is having the shortest pitch.

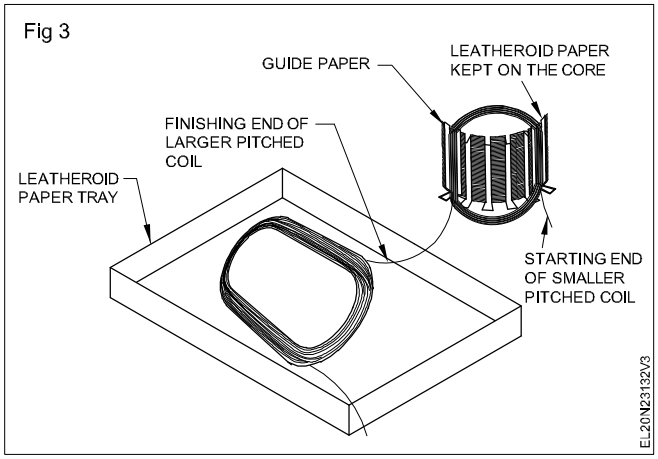
2 Check the connection side of the winding with respect to the stator and hold the connection end of the coil in that side.

3 Place a leatheroid paper of length equal to the width of the core in the right side of the core. (Fig 3).

To avoid insulation damage to the winding wires, check at intervals the position of the leatheroid paper which is kept on the core between the right coil side and the core

4 Separate the inner coil from the group, hold the smaller coil in hand and keep the larger coil in front of the stator in a leatheroid paper tray. (Fig 3)

Fig 3



5 Insert the left coil side of the smaller coil in slot No. 2. (Fig 3)

6 Remove the guide papers and insert them in slot No. 7.

7 Insert the right coil side of the smaller coil in slot No. 7.

8 Remove the guide papers from slot No. 7 and insert them in slot No. 1.

9 Insert the left coil side of the larger coil in slot No. 1

10 Remove the guide papers and insert in slot No. 8 and then insert the right coil side of the larger coil in slot No. 8.

See to it that the current direction in the group is correct according to the developed diagram.

11 Insert the 2nd coil group having smaller and larger coils in slot No. 6, 11, 5 and 12 respectively.

12 Insert likewise 3rd, 4th, 5th and 6th coil groups in the respective slots. (Refer to the developed diagram)

13 Insert a separate paper in all the slots over the inserted coils.

14 Fold the slot liner and insert the wedge in all the slots.

15 Insert a half moon shaped insulation paper as phase insulator between the coils on either side of the overhang.

— — — — — — — —

TASK 8 : **Connect the coil groups**

1 Connect the group connections of the same phase and solder them according to the end connection and developed diagrams (Fig 1 and 2 From Task 7). Sleeve the joints.

2 Connect the phase leads with the coil groups and insert the sleeve over the joints.

3 Use a nylon mallet and shape the overhang to the original size.

Check the size of the overhang with the help of overhang template.

4 Tie the hemp thread to bind the soldered joints along with the overhang.

— — — — — — — —

TASK 9 : **Test the winding**

1 Test the winding by megger continuity, short and insulation resistance test and note down results. (Task : 1, 2, 3 exercise 2.3.130)

— — — — — — — —

TASK 10 : **Varnish the windings**

1 Varnish the winding .

2 Dry the moisture by using lamp loads.

3 Check the varnish dry level.

— — — — — — — —

TASK 11: **Test and assemble the motor**

1 Test and run the motor to ascertain its performance. (Steps 18 to 31 exercise 3.1.33)

— — — — — — — —

TASK 12 : **Calculate winding for the developed diagram**

For easy understanding of the steps a 24 slots, 24 coil, 4-pole, 3-phase motor is considered as an example. For the motor given as an example winding calculations are as under.

1 No. of coils / phase $= \frac{\text{Total No. of coils}}{\text{No. of phases}} = \frac{24}{3}$

= 8 coils/phase.

2 No. of coils / phase / pole =

$$= \frac{\text{Total No. of coils}}{\text{No. of phases x No. of poles}}$$

$$= \frac{24}{4 \times 3} = 2 \text{ coils / phase / pole.}$$

3 Pole pitch = $\frac{\text{No. of slots}}{\text{No. of poles}} = \frac{24}{4} = 6 \text{ slots / pole}$

4 Coil pitch possible A 5 (1 to 6) Short chorded

B 6 (1 to 7) Full pitched

C 7 (1 to 8) Long chorded

5 Coil pitch selected = 5 (1 to 6)

6 Coil pitch selected is short chorded.

7 Total Power degrees = 180^0 x No. of poles

= 180^0 x 4 = 720^0

Slot distance in degrees = $\frac{\text{Total electrical degrees}}{\text{No. of slots}}$

$$= \frac{720}{24} = 30$$

9 Reqd. displacement between phase in terms of slots =

$$\frac{120}{\text{Slot distance in degrees}}$$

$$= \frac{120}{30} = 4 \text{ slots}$$

10 Winding sequence

If 1st phase starts in the 1st slot.

2nd phase starts in the (1+4) i.e in 5th slot.

3rd phase starts in the (5+4) i.e in 9th slot.

11 Arrangement of coils

The coils are to be arranged in the slots in the sequence:

1-6, 2-7, 3-8, 4-9, 5-10, 6-11, 7-12, 8-13, 9-14, 10-15, 11-16, 12-17, 13-18, 14-19, 15-20, 16-21, 17-22, 18-23, 19-24, 20-1, 21-2, 22-3, 23-4, 24-5.

Fig 1 and 2 show the connection diagram and developed diagram for the above motor.

Fig 1

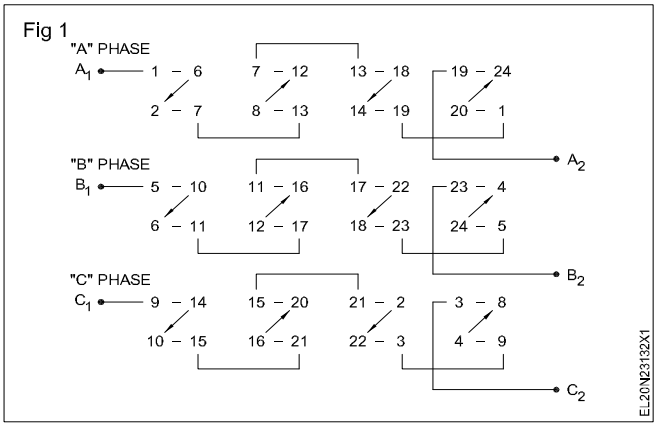


Fig 2

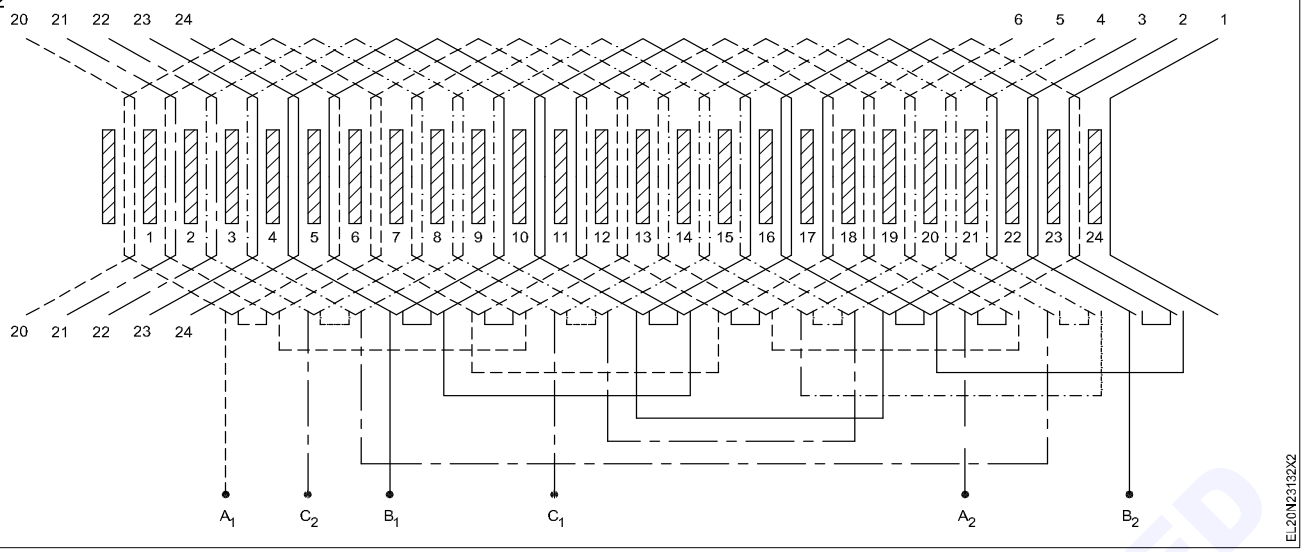


Table 12

Data to be taken from the stator (before removing the coils)

No. of slots .....No. of coils ..... Coils per group .....

Group connectors ..... Wire insulation .....

Coil throw ..... Type of winding .....Distribution/Concentric

Wedge material ..... Size ..... Binding material .....Size .....

Overhang dimension Outer dia. .....mm Inner dia. .....mm

Length .....mm Shape ..... (make template).

Data to be taken (after removing the coils)

Size of wire .....mm No. of parallel wires ..... No. of turns .....

Size of coil length .....mm(inside) width .....mm(inside) Thickness .....mm

Type of sleeve ....size ..... Type of lead ..... size .....

1

2

3

Slot insulation ..... Type ..... Thickness ..... Dimension .....

Type of coil .....Number of coils .....

Weight of single coil .....Weight of the total winding .....

Front end bearing number .....Rear end bearing number .....

Size of connection lead .....

Connection lead side with respect to terminal box .....

With the reference given in the winding calculations fill up the winding data for the motor given to you.

1 No. of coils / phase

= ..... coils/phase

2 No. of coils / phases / poles

$$= \frac{\text{Total No. of Coils}}{\text{No.of phases x No.of poles}}$$

= .....slots/poles

3 Pole pitch = $\frac{\text{No.of slots}}{\text{No.of poles}}$ = ... slots / poles

4 Coil pitch possible A) .....

B) .....

C) .....

5 Coil pitch as per the data collected is .....

6 Coil pitch selected is .....

(short chorded/full pitched/long chorded)

7 Total Power degrees = 180^0 x No. of poles

= 180^0 x ..... = ...

8 Slot distance in degrees = $\frac{\text{Total electrical degrees}}{\text{No. of slots}}$

9 Reqd. displacement between phases in terms of slots

$= \frac{120}{\text{Slot distance in degrees}}$

10 Winding sequence

1st phase starts in the .....

2nd phase starts in the .....

3rd phase starts in the .....

11 Arrangement of coils

The coils are to be arranged in the sequence.

Draw the connection diagram and the developed diagram for the motor given to you, on a separate paper.

— — — — — — — —

TASK 13 : **Prepare the stator to receive the winding**

1 Set the core, if it is mangled (lightly tap with a nylon mallet to correct the core) and clean the slot to remove any old insulation paper.

2 Select the insulation paper of the same grade and thickness or its equivalent as in the original and cut the insulation paper to the same size.

Slot insulation paper must be approximately 10 to 15 mm longer than the slot length and is to be formed according to the shapes of the inner walls of the slot. The ends of the insulation are often cuffed to avoid the insulation paper from sliding off from its position.

— — — — — — — —

TASK 14 : **Prepare coils**

1 Make a ganged former or select a readymade former according the old coil size. (Figs 1 and 2)

Fig 1

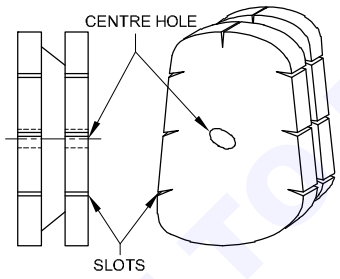
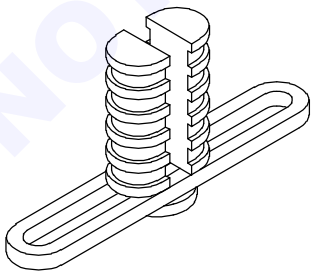


Fig 2



2 Select the correct size of winding wire as per the data taken.

3 Attach the former to the winding machine, wind the designated turns and make one set of ganged coils.

4 Insert the ganged coils in the designated slots and check their correctness.

While checking make sure that the coils are of the correct dimension so that the two coil sides could be accommodated as top and bottom coil sides in the same slot of the double layer winding, and the overhang dimensions are comparable to the template (as in the original).

5 Make necessary sets of ganged coils, if coil dimensions are correct

In the example given, two coils are forming the gang. Choose the former according to the number of gang coils.

— — — — — — — —

TASK 15 : **Lay coils in double layer winding**

Carefully examine the developed diagram in which the slot pitch is given as 1-6 and there will be two coils in a group. The left coil side of coil 1 is in slot 1 as bottom coil and the right coil side of coil 1 is in slot 6 as top coil. In double layer winding the coil sides should be placed in adjacent slots. Modify the procedure to suit the requirement of the given motor winding.

1 Insert the left coil sides of the first set of ganged coils in slots 1 and 2.

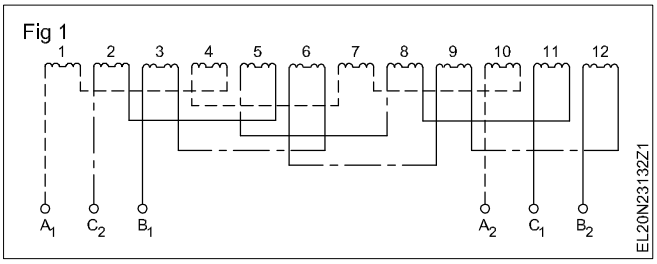
2 Leave the right coil sides of the ganged coils over the stator with a leatheroid insulation paper between the coil sides and core.

— — — — — — — —

TASK 16: **Connect group leads - testing and varnishing**

1 Bring out the group ends, connect, solder and insulate the groups. (Fig 1)

Fig 1



2 Connect the lead cables to the group connections and solder them.

3 Tie the hemp threads in the overhangs, to secure the sleeved joints and phase separator insulations.

4 Shape the overhangs and check with a template.

5 Test the winding for continuity and ground as per Exercise 3.3.138.

6 Assemble the motor if the test results are satisfactory and run it for ten minutes.

7 Dismantle the motor, impregnate the windings and dry them, if the results are O.K.

8 Assemble and test the motor on load.

— — — — — — — —

Maintain, service and troubleshoot the AC motor starter

Objectives: At the end of this exercise you shall be able to
- **identify the parts of the AC starters**
- **trace and draw the schematic diagram of the starters**
- **check volt coil, moving contactors, fixed contactors, NC and NO**
- **set the over load relay and timer.**

Requirements

Tools/Instruments

- Combination pliers 200 mm - 1 No.
- Screw driver 200mm - 1 No.
- Multimeter - 1 No.
- Megger 500V - 1 No.

Equipments/Machines

- D.O.L Starter - 1 No.
- Star Delta starter - 1 No.
- Rotor resistance starter - 1 No.
- Auto transformer starter - 1 No.

Materials

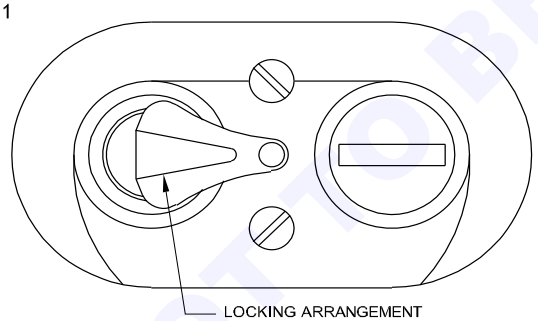
- PVC insulated, stranded aluminium cable 2.5 sq. mm 650V grade - 25 m
- Fuse wire 10 amps - as reqd.
- Black insulation tape - as reqd.
- ICDP switch 16A 500V - 1 No.
- TPIC switch 16A - 500V - 1 No.
- Push button station - 1 No.
- Over load relay - 1 No.
- Contactor - 1 No.
- Time delay relay - 1 No.

PROCEDURE

TASK 1: **Check and service AC motor starters**

1 Identify the parts of AC starters, like contactor unit, overload relay unit, start/stop push button unit, necessary fixing screws, hook up cables, starter base cover and timer. (Fig 1, 2, 3 & 4)

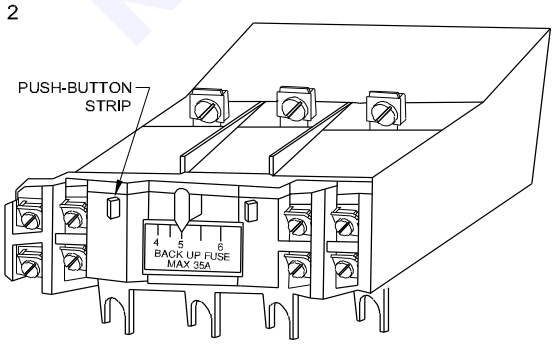
Fig 1



PUSH-BUTTON STATION

EL20N23133H1

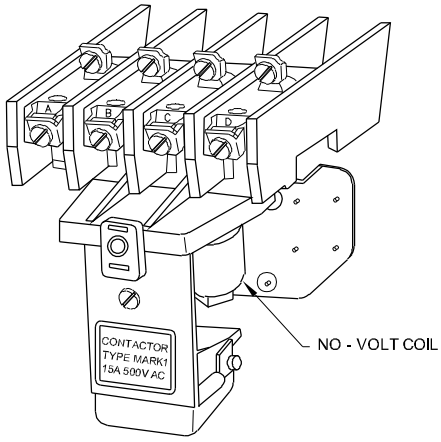
Fig 2



OVERLOAD RELAY

EL20N23133H2

Fig 3



CONTACTOR

EL20N23133H3

2 Investigate and check the contactors input and output terminals, auxiliary and main terminals, movable and fixed contacts, no volt coil, over load relay, their rating, normally closed relay contacts and their operation.

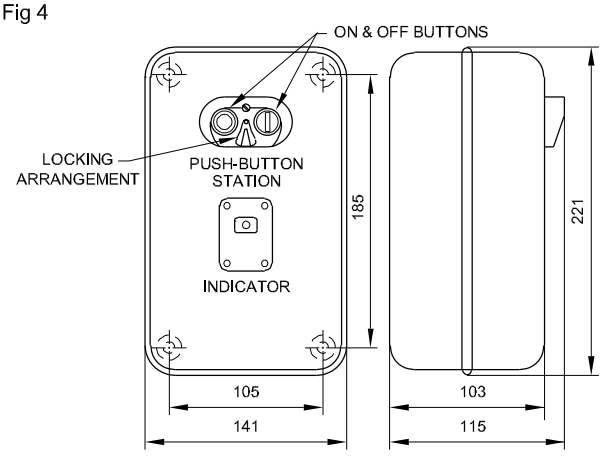
3 Identify the connecting terminals for inter connecting no volt coil, main supply to control circuit, normally open auxiliary contacts.

4 Draw the complete circuit diagram for D.O.L starter, star delta starter, rotor resistance starter and auto transformer starter. (Fig 5, 6, 7 & 8)

5 Get the diagram approved by the instructor.

6 Follow the trouble shoot chart -I.

Fig 4

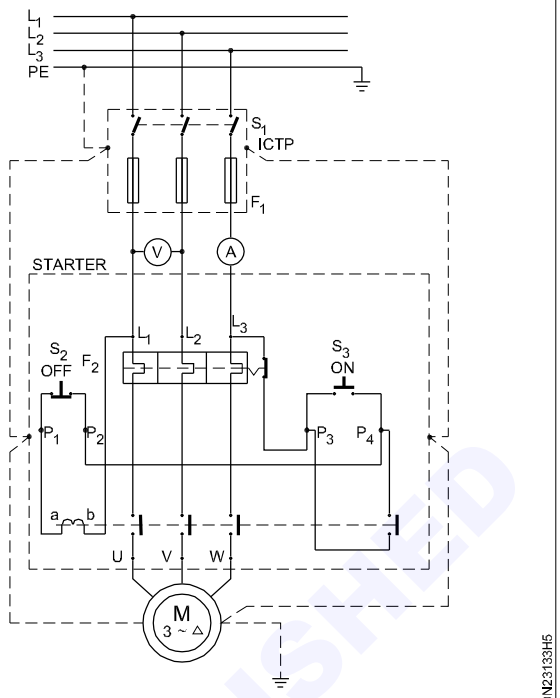


DIMENSIONS OF BASE AND COVER OF DOL STARTER

Do not tighten the screws more than necessary as too much tightening of screws will break the PVC casing of the contactor and OL relay.

A complete diagram showing the internal diagram of a starter of a particular make along with I.C.T.P and motor is given for your guidance. You can replace the internal diagram of the given starter in the place of the starter diagram shown in Fig 5.

Fig 5



CIRCUIT DIAGRAM OF DOL STARTER WITH PROTECTIVE DEVICE

Chart 1

Maintenance of DOL starters

I. **Starter check chart**

Trouble	Cause	Remedy
1 Contacts chatter	Low voltage, coil is not picking up properly, Broken pole shading ring. Poor contact between the pole. Faces of the magnet. Poor contact between fixed and movable contacts.	Correct the voltage condition. In case there is persistent low voltage. Replace Clean the pole faces. Clean contacts and adjust, if necessary.
2 Welding or overheating	Low voltage preventing magnet from sealing. Abnormal in rush current. Short circuit in the motor. Foreign matter preventing contacts from closing. Rapid inching.	Correct the voltage condition. In case of persistent low voltage coil. Check excessive load current or use larger contactor. Remove the fault and check to ensure that the fuse rating is correct. Clean contacts with suitable solvent. Install larger device or caution the operation not to operate the inch button too quickly.
3 Short life of contact points	Weak contact pressure	Adjust or replace contact springs.
4 Noisy magnets	Broken shading coil Magnet faces not mating Dirt or rust on magnet faces.	Replace magnet Align or replace magnet assembly. Clean with suitable solvents.

Trouble	Cause	Remedy
5 Failure to pick up	Low voltage Coil open or short circuited. Mechanical obstruction in the moving parts.	Check system voltage, In case persistent low voltage, change to a lower voltage coil. Replace the coil. Clean and check for free movement of contact assembly.
6 Failure of moving mechanism to drop out.	Worn or rusted parts causing binding. Residual magnetism due to lack of air gap in magnet path. Gummy substance on pole faces causing binding.	Check wiring in the NVC coil circuit. Replace parts. Replace worn out magnet parts. or demagnetise the parts. Clean with suitable solvent.
7 Overheating of coil	Over-voltage Short circuited turns in coils caused by mechanical damage of corrosion High ambient temperature Dirt or rust on pole faces increasing the air gap.	Check and correct terminal voltage. Replace coil. Relocate starter in a more suitable area or use a fan. Clean pole faces.
II Overload relays / release		
1 Starter is tripping often.	Incorrect setting of over load relay Sustained overload	Reset properly. Check for faults/ excessive motor currents.
2 Failure to trip (causing motor burn out).	Wrong setting of O.L relay Mechanical binding due to dirt, corrosion etc	Check O.L relay ratings and set a proper relay, Clean or replace. Incorrect control wiring. Check the circuit and correct it.
III Fuses		
1 Constant blowing of fuses	Short circuit or poor insulation winding / wiring	Check the motor and the circuit for insulation resistance.
2 Fuse not blowing under short circuit condition.	Fuse rating too high	Replace with suitable fuse.
3 Fuse blowing off frequently.	Fuse rating too low. Overloading of feeder.	Replace with suitable fuse. Check for over-current, leakage and short circuit.

Identify parts and terminals of different types of single phase AC motors

Objectives: At the end of this exercise you shall be able to
- **read and interpret the name plate details of the given single phase AC motors**
- **identify their parts and write their names**
- **identify the pairs of two windings of 3 terminals & four terminals of single phase motor**
- **measure the resistance of each winding by an ohmmeter.**

Requirements

Tools/Instruments

- Trainee's tool kit - 1 No.
- ohmmeter/ multimeter - 1 No.

Equipments/Machines

- Induction start induction run motor 1/2 HP, 240V, 50Hz - 1 No.
- Single phase capacitor start induction run motor 1HP,240V,50Hz - 1 No.
- Universal motor 240V, 50Hz,0.5HP - 1 No.

PROCEDURE

TASK 1 : **Identify the parts of single phase induction start motor / split phase motor**

1. Read and interpret the name plate details of the single phase induction start induction run motor and note down in Table 1.

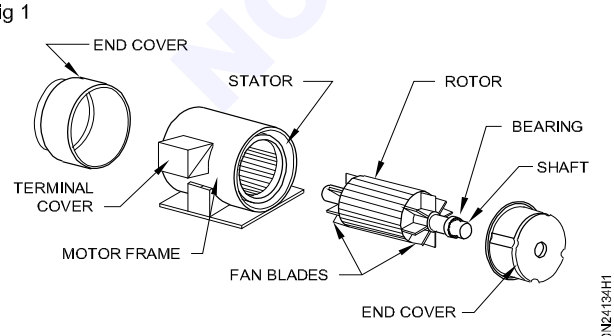
Table 1

Name-plate details

Manufacturer, Trade mark	Rated frequency .....
Type, model or serial number	Rated power .....
Type of current	Rating class .....
Function	Insulation class .....
	Rated current .....amp
	Rated speed .....r.p.m
Rated Voltage .....Volts	Protection class .....

2 Identify the parts of single phase induction start induction run motor from the real objects or from the exploded view chart. (Fig 1).

Fig 1



PARTS OF 3 PHASE SQUIRREL CAGE INDUCTION MOTOR

3 Label the each identified parts with number tags.

4 Write the name of the parts of each labelled numbers tag in Table 2.

Table 2

Sl No.	Label No.	Name of the parts
1		
2		
3		
4		
5		
6		
7		
8		

TASK 2 : **Identify the parts of capacitor start induction run motor**

1 Read and interpret the name details of the capacitor start, induction run motor

2 Identify the parts of the capacitor start, induction run motor from the real objects (or) from the exploded view Fig 1&2 and note down each labelled number in Table 1.

Table 1

Sl No.	Label No.	Name of the parts
1		
2		
3		
4		
5		
6		
7		
8		

Fig 1

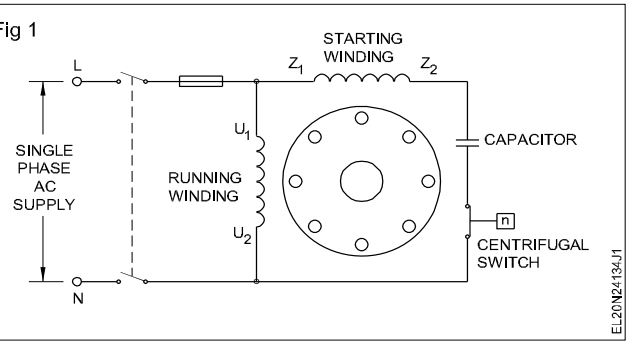
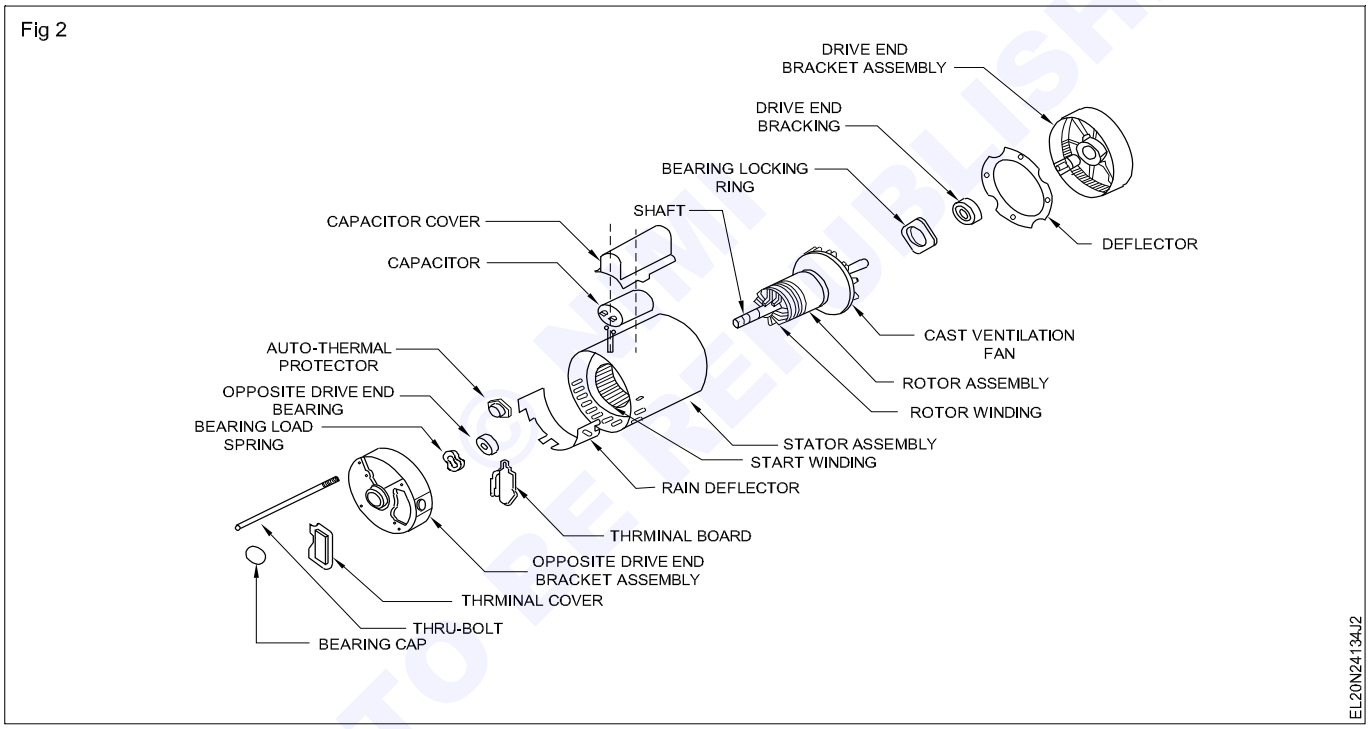


Fig 2



TASK 3 : **Identify the parts of single phase capacitor start capacitor run motor/permanent capacitor motor**

1 Read and interpret the name plate details of permanent capacitor motor.

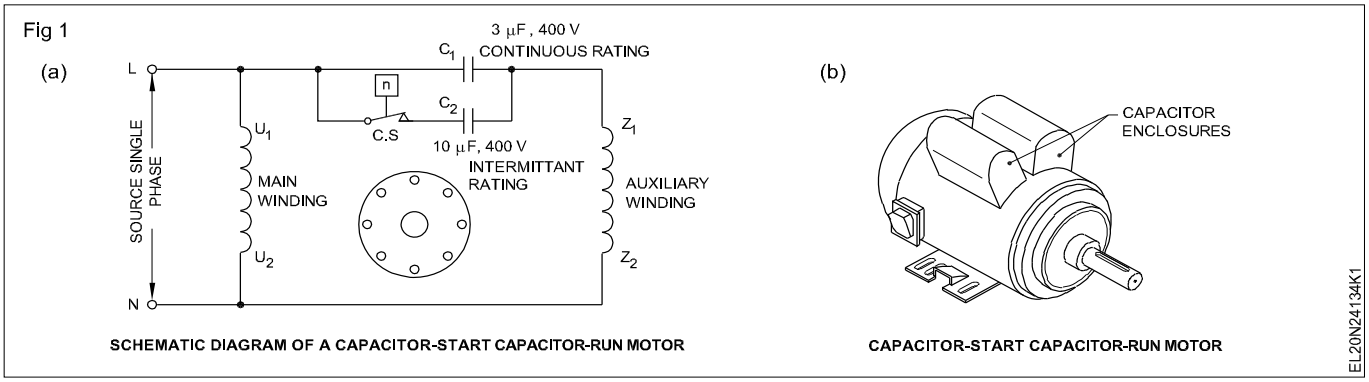
2 Identify the parts of the permanent capacitor motor from the real objects (or) from the exploded view of Fig 1a and 1b and note down each labelled number in Table 1.

3 Get it checked with your instructor.

Table 1

Sl No.	Label No.	Name of the parts
1		
2		
3		
4		
5		
6		
7		
8		

Fig 1



SCHEMATIC DIAGRAM OF A CAPACITOR-START CAPACITOR-RUN MOTOR

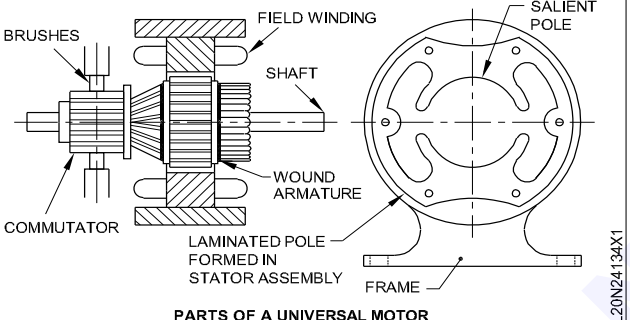
CAPACITOR-START CAPACITOR-RUN MOTOR

TASK 4 : **Identify the parts of universal motor**

1 Read and interpret the name plate details of the universal motor.

2 Identify the parts of the universal motor from the real objects (or) from the exploded view.(Fig 1)

Fig 1



PARTS OF A UNIVERSAL MOTOR

3 Label the each identified parts with number tags.

4 Write the name of the parts of each labelled number tags in Table 1.

Table 1

Sl No.	Label No.	Name of the parts
1		
2		
3		
4		
5		
6		
7		
8		

5 Get it checked with your instructor.

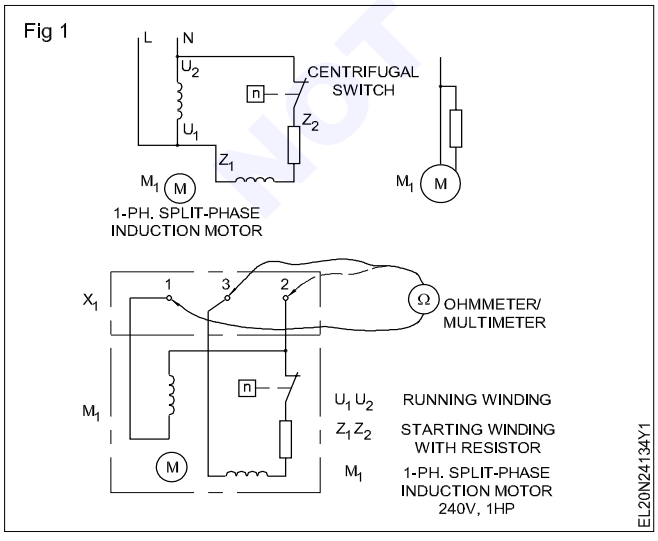
TASK 5 : **Identify 3 terminals of the pair of two windings of single-phase split phase induction motor**

1 Remove the terminal cover. Make connection using a piece of cable and short circuit two terminals at a time to discharge the capacitor.

2 Remove the capacitor if any and test the capaicator for insulation and leakage.

3 Measure the resistance in between pairs of terminals by an ohmmeter. (Fig 1)

Fig 1



4 Mark the terminals between which you get maximum reading as 1 and 3. Mark the unmarked terminal as 2.

5 Record the resistance values in Table 1 according to your terminal marking made.

The reading between the pair of terminals 1 & 2 and 1 & 3, whichever is greater is considered as the terminals of starting winding and the other is considered as terminal of running winding.

Table 1

Resistance between 1 & 2	Resistance between 2 & 3	Resistance between 1 & 3

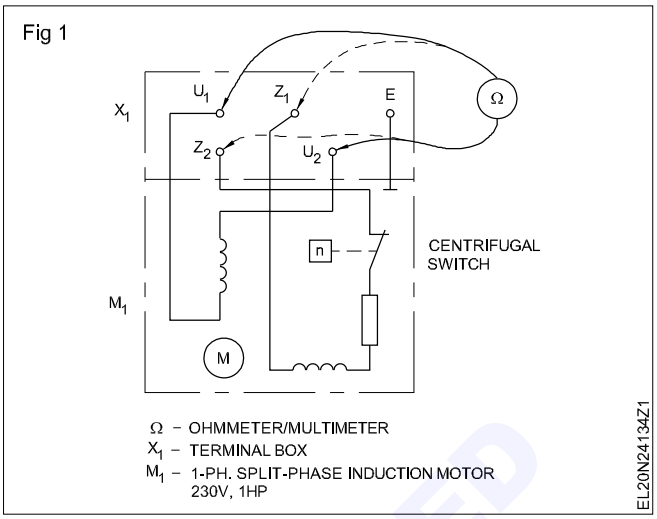
TASK 6 : **Identify 4 terminals of the pair of two windings of single phase split phase induction motor**

1 Repeat the steps 1 and 2 of Task 5.

2 Find out the pairs of terminals and number one pair of terminals as 1 and 2. The other pair is numbered as 3 and 4 (Fig 1)

3 Measure the resistance between U1 and U2 and Z1 and Z2..

Fig 1



Conclusion

1 Higher resistance is between _____ terminals.

2 Lower resistance is between the terminals marked as _____

Therefore the starting winding is connected between _____

Resistance between 1 & 2 = _____ohms

Resistance between 3 & 4 = _____ohms

— — — — — — — —

Install connect and determine performance of single phase AC motor

Objectives: At the end of this exercise you shall be able to
- **read the manufacturer's installation instruction and follow the same**
- **transfer the template measurements to the mounting base**
- **make the template of the base (mounting) of the given motor**
  - **frame (wooden)making**
  - **marking**
  - **drilling**
  - **selecting hole size.**

Requirements

Tools/Instruments

- Masonry tools like travel spirit level etc- 1 Set
- Drilling machine Electric 12.7 mm capacity with drills - 1 No.
- Measuring tape 3 meters - 1 No.
- Electrician hand tool kit - 1 Set
- Spanner set 5 mm to 30 mm - 1 Set
- Ball pein hammer 500 g - 1 No.

Equipments/Machines

- A.C Single phase motor 0.5 HP 240V - 1 No.

Materials

- Connecting cables - as reqd.
- Plywood 8 mm thick 40 x 30 cm - 1 No.
- Nuts, grouting bolts - as reqd.
- GI wire 14 SWG - 6 m

PROCEDURE

TASK 1: **Installation of single phase AC Motors**

1 Read the name plate details and record in the motor maintenance card (Table 1)

Table 1

Name-plate details

Voltage _____Phase _____ Type _____
Rating _____Speed _____
Power factor _____Current _____
SL No. _____

2 Make necessary arrangements at the place where the motor is to be installed as per manufacturer's nuts and bolts or / and R.C.C. foundation etc.

3 Determine the size of the connecting cable and fuse from the rating of the motor. (Table 2)

Fuse current rating will be 3 or 2 times more than running current. If it has the dual function of overload protection also, the rating should be as recommended by the manufacturer or as per I.S recommendations.

4 Cut two straight pieces and two cross pieces of plywood as shown in Fig 1 and mark the holes accordingly to the size of the holes of the base of the motor on the wooden frame planks (Fig 1)

Table 2

Calculating fuse ratings of motors

Motor type	Multiply the running current of the motor by
Single phase	3
Squirrel-cage, full voltage start	3
Squirrel-cage, reduced voltage start or high - reactance type (if motor is rated at 30 ampere's or less)	

5 Select the size of the drill according to the size of the mounting bolt as recommended by the manufacturer.

6 Drill the holes according to the size mentioned.

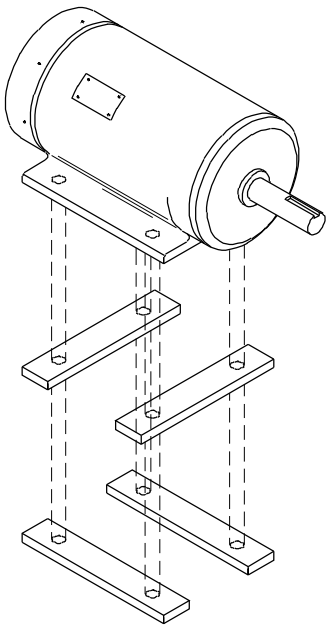
7 Make use of the template measurements on the mounting base and get the base mounting ready for installing the motor. (Fig 2)

a) Fix the planks with a grouting bolt.

b) Check for level using the spirit level.

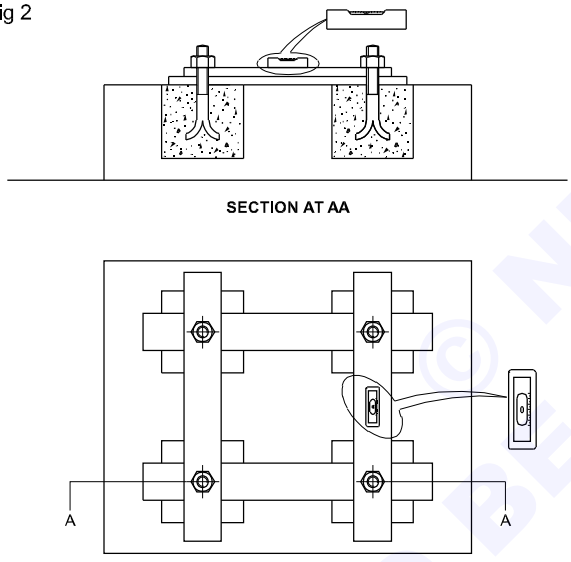
c) Fill the space around the bolts with thin coarse cement mortar.

Fig 1



EL20N24135H1

Fig 2



EL20N24135H2

In the training institute use clay mortar instead of cement to facilitate repetition easily by every trainee in a batch.

d) Allow it to settle down for 8 to 12 hours, then remove the template planks.

e) Cure the cement mortar with water for a minimum of 2 days

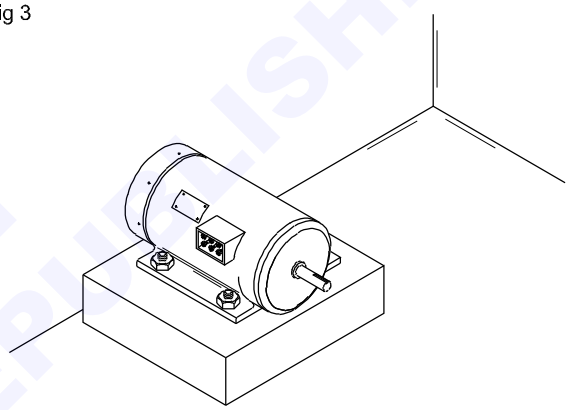
f) Finish the surface by plastering neatly.

Include vibration arresting devices as per the manufacture's instructions such as spring washers etc.

8 Install the motor and fix it with nuts (Fig 3)

9 Make double earthing in accordance with I.E. regulations and I.S. recommendation.

Fig 3



EL20N24135H3

10 Start the motor and observe any mechanical vibrations are there or not.

11 If any mechanical vibrations is there, then stop the motor and tighten nuts properly.

Start run and reverse the direction of rotation of single phase AC motors

Objectives: At the end of this exercise you shall be able to
- **start run and reverse the D.O.R of induction start, induction run motors through DOL starter**
- **start run and reverse the D.O.R of capacitor-start, induction run motors**
- **start run and reverse the D.O.R of capacitors start, capacitor - run motor.**

Requirements

Tools/Instruments

- Trainee's tool kit - 1 No.
- Pulley puller 15 cm - 1 No.
- MI Voltmeter 0-300V - 1 No.
- MI Ammeter0-10 A - 1 No.
- Megger 500 V - 1 No.
- Ohmmeter - 1 No.

Equipment/Machines

- Single phase induction start, induction run motor 1/2HP, 250V, 50Hz - 1 No.
- D.O.L starter for single-phase motor 10A, 250V - 1 No.
- Capacitor start , induction run motor 250v, 50Hz, 1Hp - 1 No.
- Capacitor start, capacitor run motor 250V, 0.5 HP, 50Hz - 1 No.
- Regulated power supply (0.30v) - 1 No.

Materials

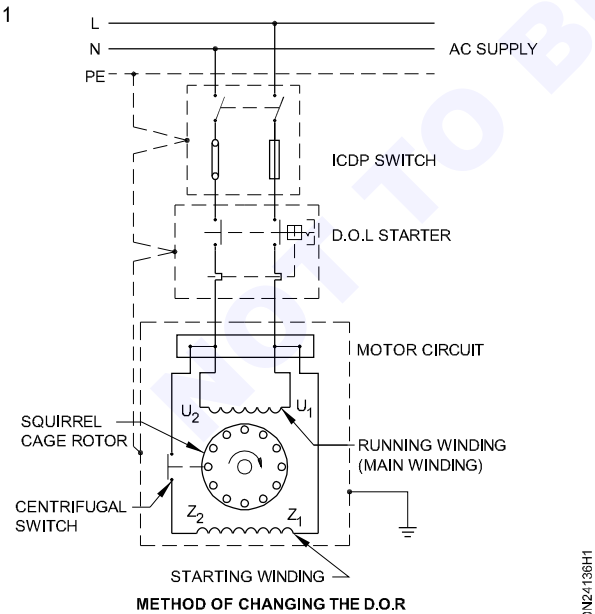
- GI wire 14 SWG - 6 m
- 2.5 sq. mm. PVC copper wire 250 V grade - as reqd.
- I.C.D.P. switch 16 A,250V - 1 No.
- Fuse wire 10A - 10 gm

PROCEDURE

TASK 1 : **Start , run and reverse the D.O.R of Induction start induction run motor through D.O.L Starter**

1 Draw the complete connection diagram of the given motor, starter and I.C.D.P. (Fig 1)

Fig 1



METHOD OF CHANGING THE D.O.R
BY CHANGING THE STARTING WINDING TERMINALS

2 Get the diagram approved by your instructor.

3 Connect the motor through the I.C.D.P. switch and starter as per the approved diagram across the AC rated voltage supply. Provide earth connection to the motor, the starter and the switch.

4 Replace with a fuse of proper capacity according to the motor rating and set the overload relay of the D.O.L. starter to the current rating of the motor.

5 Switch on the I.C.D.P. switch and press the start-button of the starter.

6 Check the direction of rotation and record it below. The direction of rotation is .....

7 Stop the motor by pressing the stop-button; switch `off' the I.C.D.P and remove the fuses.

The I.C.D.P. switch must be switched off and the fuses removed before any modification in the circuit is carried out.

For changing the direction of rotation

8 Change the connection of the starting winding (Fig 2) and record it below. Direction of rotation is .....

9 Stop the motor and interchange the connection of the main field winding.

The D.O.R is .....

10 Stop the motor and switch off the supply.

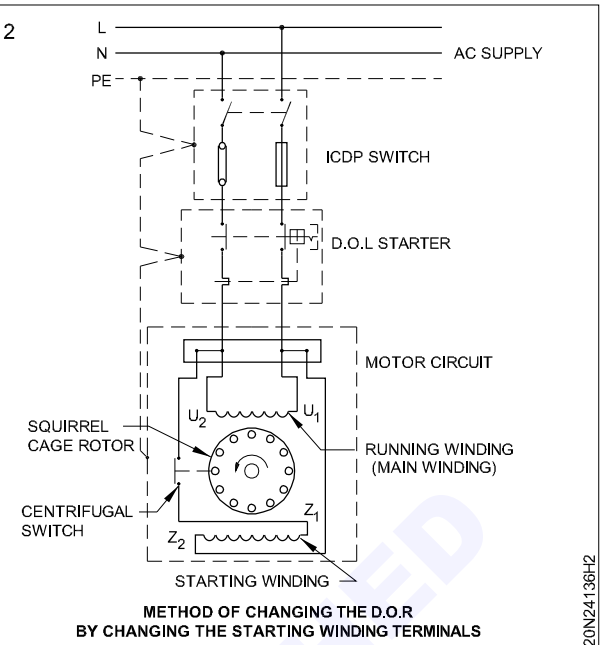
Conclusion

_____

_____

_____

Fig 2



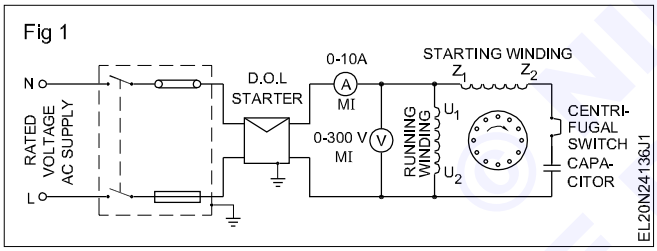
METHOD OF CHANGING THE D.O.R BY CHANGING THE STARTING WINDING TERMINALS

— — — — — — — —

TASK 2 : **Start run and reverse the D.O.R of single phase capacitor start induction run motor**

1 Make the connection as per the circuit diagram. (Fig 1) Earthing the I.C.D.P. switch, starter and motor is most essential.

Fig 1



2 Provide fuse-wire, according to the rating of the motor, in the I.C.D.P. switch and set the overload relay ampere in the D.O.L. starter to the rated value of the motor.

3 Switch `ON' the I.C.D.P.

4 Start the motor with the help of the starter and note the starting current, normal running current and the direction of rotation, and enter the details in Table 1.

Table 1

Sl.No.	Reference circuit diagram	Starting current	Running current	Direction of rotation
1				
2				
3				

For changing the direction of rotation

5 Stop the motor by the starter and switch `off' the I.C.D.P, and remove the fuse-carrier.

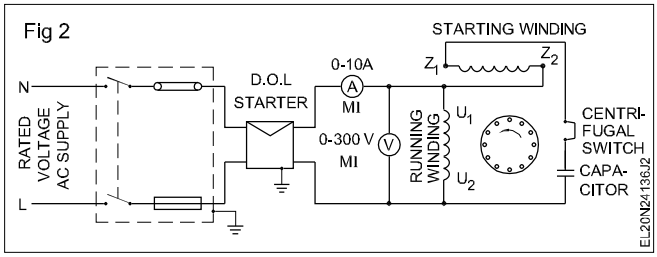
6 Interchange either the starting winding or the running winding terminals for changing the direction of rotation. Fig 4 illustrates the changing of the starting winding.

7 Replace the fuse-carrier, and then switch on and start the motor. Note down the direction of rotation in Table 1.

Effect of changing the supply leads

8 Switch off the motor and reconnect the winding. (Fig 1) Interchange the supply terminals as per circuit diagram. (Fig 2). Switch `ON' the motor. Check the effect on the direction of rotation and record the result in Table 2.

Fig 2



The D.O.R changed / did not change with respect to the condition as per circuit (Fig 3). (Strike out that part of the sentence which is not applicable).

Conclusion

Fig 3

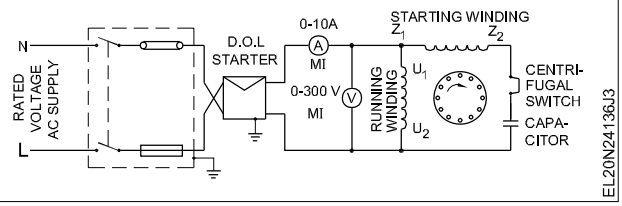


Table 2

Sl.No.	Reference circuit diagram	Starting current	Running current	Direction of rotation
1				
2				
3				

TASK 3 : **Start, run and reverse the direction of rotation of capacitor start capacitor run motors**

1 Identify the starting and running condensers and check their condition and data. Enter them in Table 3. Compare and analyse the data also relating to the starting and running condensers.

2 Show the readings to your instructor and get his approval.

3 Check the condition of the centrifugal switch, and ensure it is working.

Table 3

Sl.No.	Component part	Type	Value in micro-farad	Voltage		Duty Cycle	Condition
				Working	maximum		
1	Running capacitor						
2	Starting capacitor						

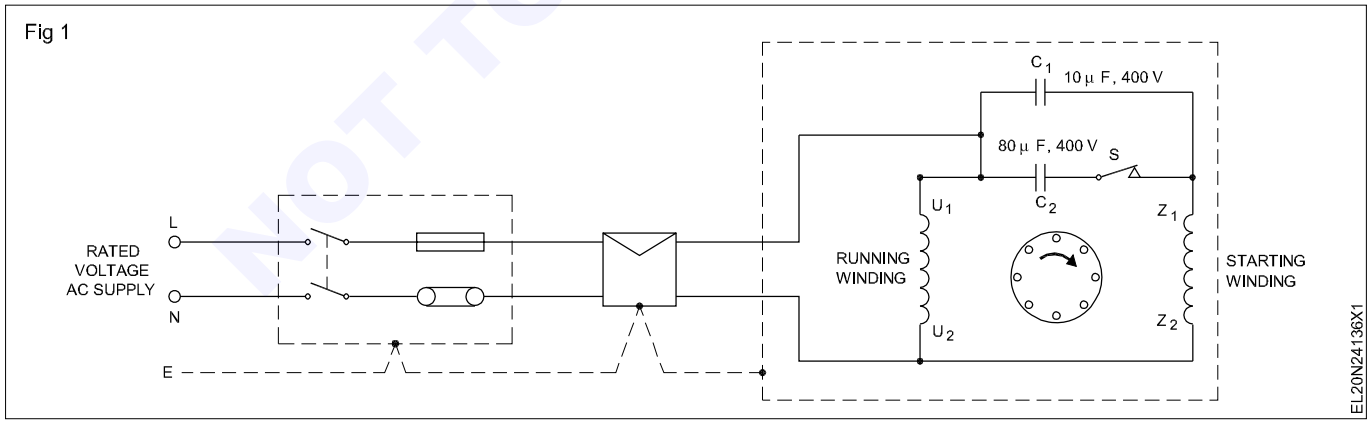
4 Connect the motor to the 240V AC supply through the switch and starter as per the circuit diagram. (Fig 1)

5 Insert a suitable size of fuse in the I.C.D.P switch and set the overload relay according to the rating of the motor.

6 Get the approval of your instructor for starting. Switch on the I.C.D.P and start the motor by pressing the start- button of the starter.

7 Check the direction of rotation and record the D.O.R below. Direction of rotation - clockwise/anticlockwise.

Fig 1

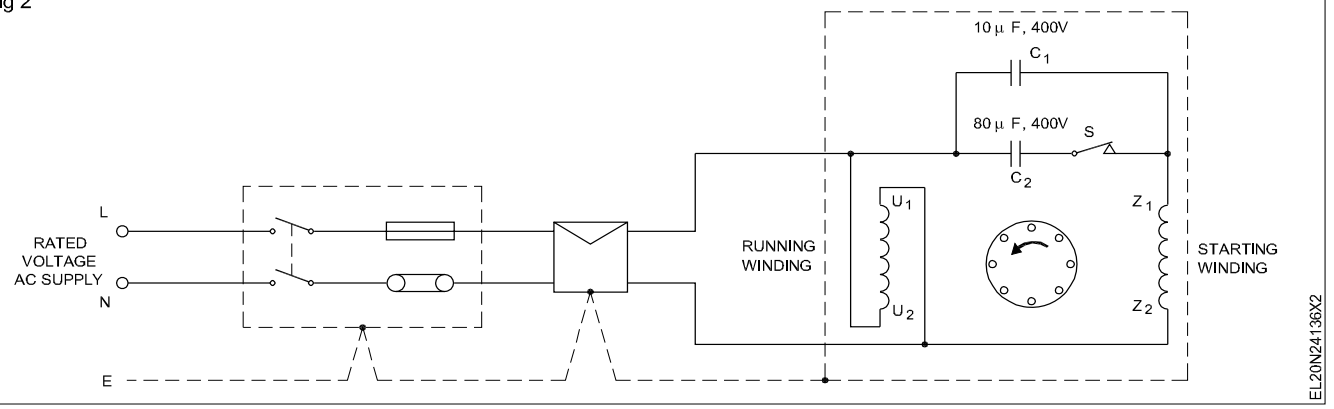


Change the direction of rotation of an AC single -phase capacitor, start capacitor-run motor.

For changing the direction of rotation

8 Stop the motor, switch off the I.C.D.P. Remove the fuse and interchange the running winding terminals. (Fig 2)

Fig 2



9 Repeat the steps 6 and 7 of task 3.

The direction of rotation could be changed either by changing the running winding terminal connections or by changing the starting winding terminal connections whichever is easier. The schematic diagram shown in Fig 8 is for a four terminal machine. For a ten terminal machine only the terminal U_1 and U_2 can be changed easily.

10 Stop the motor, interchange the starting winding terminal connections as shown in Fig 3. Keeping the running winding connection as in Fig 1 and repeat the steps 5 to 6 of task 1.

11 Check the D.O.R is clockwise/ anticlockwise.

12 Stop the motor, reconnect the starting and running winding as in Fig 1. Only interchange the supply terminal connections at the starter outgoing side as shown in Fig 4 and repeat the steps 8 and 9 of Task 1.

13 The D.O.R. is clockwise /anticlockwise.

14 Stop the motor. Switch off the ICDP. Remove the fuses. Disconnect the cables. Write your observation regarding the method of changing the direction of rotation and show to your instructor.

Conclusion

Fig 3

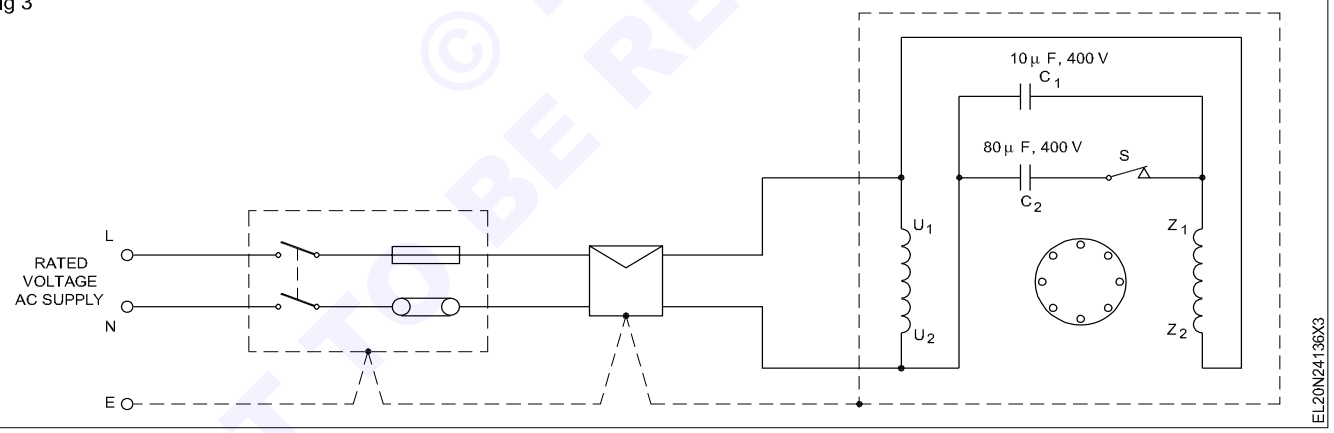
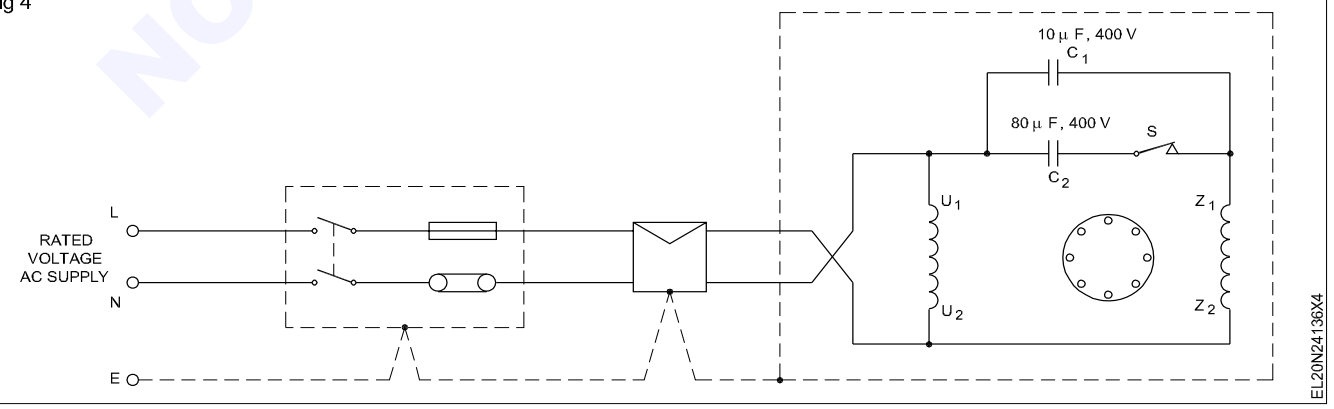


Fig 4



Practice on speed control of a single phase AC motors

Objectives: At the end of this exercise you shall be able to
- **interpret the name-plate details of an ac series motor and determine full load current**
- **select a suitable variable resistor**
- **connect, run and measure the speed for different settings of the resistor.**

Requirements

Tools/Instruments

- Electrician tool Kit - 1 No.
- Voltmeter 0-300 V - 2 Nos.
- Ammeter 0 - 5A - 1 No.
- Tachometer 3000 rpm - 1 No.

Equipments/Machines

- AC series motor 240V 1/2 HP - 1 No.
- Rotary switch 6A, 250.4 position - 1 No.

Materials

- Connecting cable - as reqd.
- ICDP switch 16A 250V - 1 No.
- Wire wound enamel insulated resistor 10 ohms 100 W - 2 Nos.

PROCEDURE

TASK 1 : **Connect, run and control speed at a AC single phase motors**

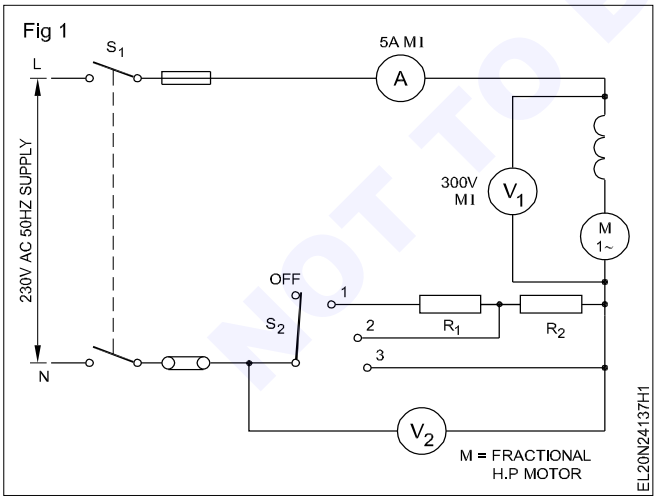
1 Read the name-plate details and record in Table 1.

2 Determine the load current from the name plate

To drop 80 V at position 1 and to drop 40 V at position 2. Calculate the required series resistors R_1 and R_2 and also determine their wattage (see example given)

3 Make the connections as per diagram (Fig 1) and make necessary arrangements to load the motor through prony brake.

Fig 1



4 Close the switch S_1.

5 Set the switch S_2 in position 1 and observe the starting of the motor.

6 Measure the current, voltages V_1 & V_2 and the speed. Record the values in Table 2.

7 Set the switch S_2, in position 2 and repeat the step 6.

8 Set the switch in position 3 and repeat the step 6.

Table 1

Manufacturer's name	
HP/KW	R.P.M.
Current	Voltage
Type	
Sl.No.	Insulation

Table 2

Switch S_2 Position	**Current**	**V_1**	**V_2**	**Speed**

Compare starting and running winding currents of a capacitor run motor at various loads and measure the speed

Objectives: At the end of this exercise you shall be able to
- **measure the current in each winding at a given load condition**
- **load the motor to a specified load.**

Requirements

Tools/Instruments

- MI Ammeter 0-5 A type - 3 Nos.
- Tachometer 3000 rpm - 1 No.

Equipment/Machines

- F.H.P. capacitor run motor 240V - 1 No.
- Brake load arrangement

Materials

- Single pole knife switches 16A - 3 Nos.
- I.C.D.P. Switch 16 A 250V - 1 No.
- Connecting cable - as reqd.

PROCEDURE

TASK 1 : **Connect, run and measure starting and running current, speed of AC single phase capacitor run motor**

1 Identify the terminals of starting winding and running winding.

2 Select the ammeter range suitable to the motor under test. Connect the circuit (Fig 1) with brake load arrangement.

3 Connect the single pole knife switches S_2, S_3 and S_4. (Fig 2)

4 Start the motor on no load and open the switch S_2 after the motor attains the rated speed.

5 Read and record ammeter readings in Table 1. Measure the speed and record in Table 1.

6 Adjust load until A_3 reads 1/2 full load current. Record the currents in each winding in Table 1.

7 Repeat the above step for full load.

Table 1

Load	Speed	Ammeter reading		
		A_1	A_2	A_3
No load				
Half load				
Full load				

Fig 1

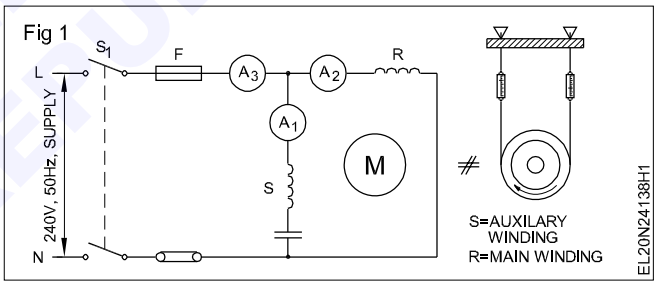
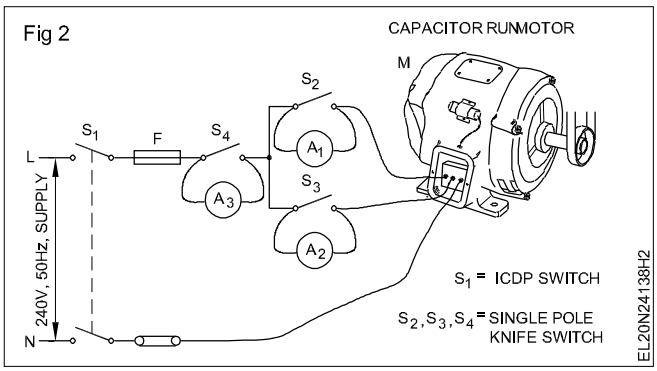


Fig 2



Carry out maintenance service and repair of AC single phase motors

Objectives: At the end of this exercise you shall be able to
- **follow general maintenance and service procedure**
- **identify the general causes of failure and trouble shoot them.**

Requirements

Tools/Instruments

• Electrician kit	- 1 No.
• Set of D.E. spanners 8 to 22 mm	- 1 Set
• Pulley puller 100 mm and 150 mm	- 1 No. each
• Nylon hammer 1/4 kg	- 1 No.
• Ohmmeter 0 - 1 kilo ohms	- 1 No.
• Industrial, thermometer, metric, 0 to 300^0	- 1 No.
• Megger 0-500 V	- 1 No.
• Voltmeter M.I. type 0-300 V	- 1 No.
• Ammeter M.I. type 0-5 amps	- 1 No.

Equipments/Machines

• Fraction horse power AC single phase (split phase) motor	- 1 No.

Materials

• ICDP switch 16A 250V	- 1 No.
• Test lamp	- 1 No.
• Test prods 500V	- 1 Set
• PVC insulated copper cable 2.5 sq mm 250 V grade	- 10 m
• Fuse wire 5 amps capacity	- as reqd.
• PVC insulation tape 20 mm size	- as reqd.
• Bearing - Grease	- 200 gms.
• Kerosene oil	- 1 litre.
• Cotton waste	- 100 gms
• Shellac varnish	- 1/4 litre
• Sandpaper `O'	- as reqd.

PROCEDURE

TASK 1: **Perform maintenance and service as per the following procedure**

1 Read the name-plate details of the motor and record in Table 1.

Table 1

Name-plate details of the motor

Make. ____ Frame____ No. _____ Model _____

Type _____ HP _____ Volts _____

Amperes _____ Phase _____ Cycles _____

2 Switch 'OFF' the respective I.C.D.P. main switch.

3 Remove the fuses and keep in safe custody.

Remove the sub-circuit fuses which supplies power to the ICDP.

4 Clean the main switch with a brush.

5 Check the incoming and outgoing leads of the I.C.D.P. main switch for discolouring.

Discolouring normally indicates loose terminal connection.

6 Check the cable terminal connection screws and tighten them with the help of a screw driver.

7 Open the starter cover and clean the parts with a brush.

8 Check the leads and the terminal screws. Tighten the screws, if found loose.

9 Check the overload setting and if necessary, set it to the rated current of the motor.

10 Check the contact points of the starter for pitting.

If the contact points are lightly pitted, use a sandpaper to clean them. Badly pitted or damaged contacts need to be replaced.

11 Clean the external surface of the single phase motor using brush, a piece of the cloth and a blower.

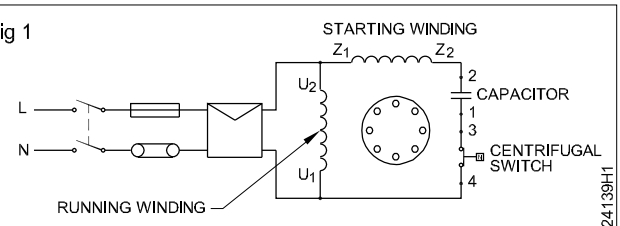
12 Open the terminal cover.

13 Note the incoming, starting winding, running winding, capacitor and centrifugal switch connections and draw a diagram in your record. Indicate the colour of cables in the diagram.

Normally some letter markings are found in the terminal plate. Some manufacturers give the schematic diagram on the back side of the cover. In case no diagram or marking were there wire clearly the colour of the cables

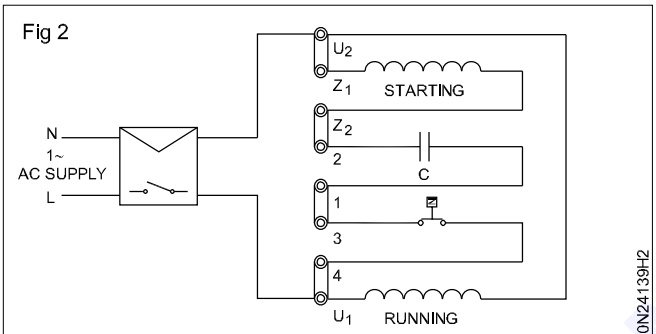
connected to the terminal plate. Fig 1 is the schematic diagram of a particular single phase motor and Fig 2 shows the terminal connections with the simplified internal connections. These diagrams are given for your guidance. Draw the required diagrams to show the connections of the motor for which maintenance is required.

Fig 1



SCHEMATIC DIAGRAM OF THE CAPACITOR START SINGLE PHASE MOTOR

Fig 2



TERMINAL CONNECTION OF A CAPACITOR START SINGLE PHASE MOTOR

14 Open the shorting loops and incoming connections.

15 Check the continuity a) main winding b) starting winding c) centrifugal switch.

16 Measure the resistance value of the windings and contact resistance value of the centrifugal switch with an ohmmeter.

17 Check the capacitor and the centrifugal switch for its condition with an ohmmeter.

A capacitor when tested with a Megger or multimeter, the meter needle will show short indicating the capacitor is charged. When the capacitor terminals are shorted by a cable, a spark will be noticed indicating the capacitor is discharged and in good condition. However whether the capacity is charged or the capacitor able to hold the charge for a specified time cannot be checked by this test.

18 Check the insulation value of the windings with the help of a Megger.

19 Dismantle the motor following the procedural steps.

20 Clean the stator and rotor with a brush and blower.

21 Clean the bearings and grease cups with kerosene and check the bearing.

22 Identify the bearing which is found worn out replace it with a similar type.

23 Check the internal connections and lead insulations.

If necessary reinsulate the leads.

24 Check the rotor bars.

If any loose bar is found, it has to be brazed.

25 Check the rotor and stator surface for rubbing marks.

Rubbing marks indicate either worn out bearing or wrong alignment in assembly. Correct them.

26 Check the centrifugal switch for its tension and perfect contact between the points of contact.

If the switch is in a bad shape it should be replaced with a similar switch. Dressing of contact could be done with the help of sandpaper.

27 Identify the insulation resistance value measured earlier. If found to be less than 1 megohm, dry the winding in an oven or with incandescent lamps and varnish it.

28 Assemble the motor following procedural steps.

The test result should not vary too much. Rather it should show improvement. Discuss with your instructor regarding the test results.

29 Connect the shorting loops and incoming leads as per your diagram.

30 Replace the fuses of correct value in the fuse grip and replace the carrier in the holder of the I.C.D.P. mains.

31 Check the earth connections to the motor starter and switch correct them if necessary.

32 Start the motor and test run for about 30 minutes.

33 Check the frame temperature of the motor and satisfy yourself that the temperature is within the reasonable limits.

34 Check for any undue noise or vibrations.

35 Stop the motor and write your observations in the maintenance card.

If any undue noise or vibrations is found stop the motor and recheck the tightness of the end plate bolts and frame bolts.

— — — — — — — —

TASK 2 : **Trouble shooting procedure**

1 Follow the troubleshooting charts No.1 to 5 to identify the symptom and rectify the fault.

— — — — — — — —

Practice on single /double layer and concentric winding for AC motors, testing and assembling

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

- **record the name plate details of the given single phase having single layer/double layer concentric type winding**
- **dismantle the motor**
- **collect the winding data**
- **draw the connection and developed diagrams**
- **strip the winding and clean the slots**
- **prepare the slot liners and insulate the slots**
- **prepare the stepped former and wind the concentric group of coils**
- **lay the coil groups in the stator slots**
- **connect the coil groups and phase leads**
- **shape the overhang**
- **test the winding**
- **varnish the motor**
- **test and run the newly wound motor.**

Requirements

Tools/Instruments

• Electrician tool kit	- 1 Set.
• Scissors 250mm	- 1 No.
• Nylon hammer 80 mm dia, 120mm long head	- 1 No.
• Soldering iron 125W, 240V	- 1 No.
• Scale and weight 1 to 450 gms	- 1 Set.
• Cold Chisel 100mm dia, 200mm long	- 1 No.
• Multimeter	- 1 No.
• Centre punch 100mm	- 1 No.
• Steel rule 300mm	- 1 No.
• Wood rasp file, half round 200mm	- 1 No.
• Tray 200mm x 200mm x 50mm	- 1 No.
• Megger 500 V	- 1 No.
• DE spanner 5 to 22 mm	- 1 Set
• Outside Micro meter 0 - 25 mm	- 1 No.

Equipment/Machines

• AC split phase motor FHP 250V	- 1 No.

Materials

• Super-enamelled copper wire	- as reqd.
• Millinex (or triplex paper) 10 Mili	- as reqd.
• Empire sleeve 1 mm, 2mm, 3mm, 4mm & 5mm	-1m.each
• Cotton tape 20mm roll of 25 m	-1 Roll
• Bamboo wedge	- as reqd.
• Resin Core solder 60:40	- as reqd.
• Varnish (air dry)	- as reqd.
• Brush 25 mm	- 1 No.
• Fibre sheet	- as reqd.
• PVC insulated copper wire 21/0.2 mm	- 3 m

PROCEDURE

TASK 1: **Rewind a single phase split phase motor (concentric coil winding)**

Collection of data

1 Collect and record the machine data in Table 1.

2 Remove the pulley by using a pulley puller. Remove the fan cover and then remove the cooling fan blade assembly.

3 Mark both the end covers with distinguished markings with a centre punch, and correspondingly mark the body also.

Table 1

Name-plate details

Manufacturer's Name	Serial Number.....
Output.....KW/HP.	Voltage .....V Current .....Amps
Frequency .....Hz	Speed ..... r.p.m. Cycle .....
Insulation	Frame No. .....Starting capacitor ..... Mfd

Table 2

Winding data

1 Terminal marking with colour of the lead cables .....
.....

2 Connection end of the winding with respect to the terminal box .....

3 No. of slots ..... No. of poles ..... Type of winding .....

4 Wedge material ..... size ..... Binding material ..... size .....

5 Overhang dimension	Non-connection end	Connection end
Outer dia.	..... mm	..... mm
Inner dia.	..... mm	..... mm
Length from core	..... mm	..... mm

6 Slot insulation materials 1 ..... Size ..... thickness
2 ..... Size ..... thickness

7. Type of winding	Kind of wire end	No. of coils	Coils/group
1 Running	.....	.....	.....
2 Starting	.....	.....	.....

8 Shaft side rotation CW/ACW

9 Coil size from outer coil	Starting winding	Running winding	Turns	Pitch
	Length .....mm	Length .....mm	.....	
	Breadth .....mm	Breadth .....mm	. .....	

10 Weight of running coils (Total) ..... kg

11 Weight of starting coils (Total) ..... kg

12 Lead wire : Type ..... Size .....
Front bearing No. .....
Rear bearing No. .....

13 Core length .....

14 Coil group connection diagram

15 Any other information

Example: Single phase capacitor motor

No. of poles - 4

No. of slots - 24

No. of coils - 20 (12 for main and 8 for starting winding).

4 Mark and remove the connection leads from the terminal box. Enter the details in Table 2.

5 Loosen the screw bolt/tie rod on both the end shield covers, and also remove the centrifugal switch connections.

6 Remove the rotor from the stator.

7 Inspect the rotor for any defect, and the bearing for its condition.

If any of the rotor bar is open correct the defect by brazing. If bearing is worn out replace it with a new one.

8 Take the possible data before removing the coil and record it in Table 2.

9 Mark the stator for indicating connection lead side with respect to the terminal box. Enter the details in Table 2.

10 Apply a thinner in the connection lead side to loosen the varnish and locate the end connection. Draw the group connection diagram and also prepare the developed diagram in a separate sheet of paper and attach with these sheets.

To avoid imaginary terms while writing the procedure, an example for a single phase capacitor motor having concentric coil winding is given below.

Certain procedural steps are specifically written for the motor given in this example. However, you have to follow the data taken strictly from the given motor, to get the required performance.

Information from collected data

Coil pitches - Main winding 5,3,1

Starting winding 5,3

Coil throw - Main winding 1-6,2-5,3-4

Starting winding 1-6, 2-5

This is the whole coil connection as the end of the 1st coil is connected to the end of the 2nd coil and the starting of the 2nd coil is connected to the starting of 3rd coil etc.

For your guidance, the group connection diagram is given in Fig 1 and the developed diagram is given in Fig 2.

11 Measure the overhang at both sides of the winding. Record it in Table 2 and prepare the template.

12 Collect the possible data like, number of slots, coil pitch etc. and record in Table 2.

Fig 1

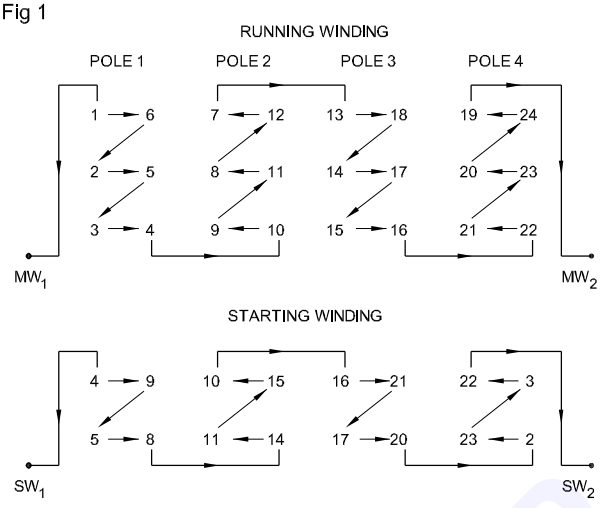
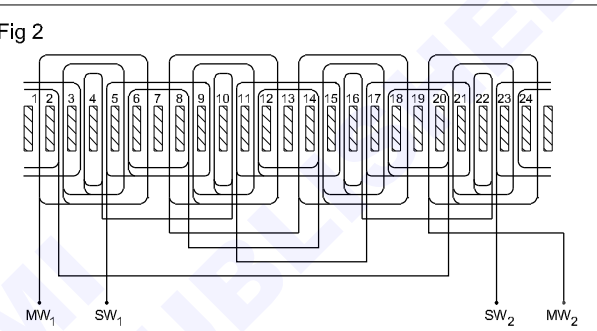


Fig 2



13 Cut the coils except one set of coils each in the starting and main winding with the help of a cold chisel at the non-connection end (i.e. normally load side).

14 Strip the old winding from the stator slot. If it is hard use a blowlamp to heat the winding and pull out the coils.

15 Remove the left out coils in their original shape.

Use a thinner to loosen the coils. Once a thinner is used never use the blowlamp as the coils will catch fire.

16 Measure the size of the wire, size of the coil and collect other details as required and record them in Table 2.

— — — — — — — —

TASK 2 : **Test the winding**

1 Check the winding for short circuit, open circuit and insulation resistance by a multimeter and Megger respectively.

2 Check the condition of the capacitor and centrifugal switch. If there is any fault replace them by new ones.

3 Connect the lead connections, capacitor and centrifugal switch according to the connection diagram and terminate them in the terminal box.

4 Assemble the motor and then run the motor for 15 minutes.

5 Observe the direction of rotation. If necessary change the connections.

6 If test is OK then dismantle the motor.

7 Preheat the stator and impregnate the winding with varnish.

8 Remove the excess varnish in the face of the stator slots after drying.

9 Reassemble the motor and test it on load for 8 hours.

— — — — — — — —

Connect, start, run and reverse the direction of rotation of universal motor

Objectives: At the end of this exercise you shall be able to
- **connect a universal motor to the supply through a D.O.L. starter and start the motor**
- **reverse the direction of rotation of a universal motor.**

Requirements

Tools/Instruments

- Insulated cutting pliers 150 mm - 1 No.
- Screwdriver 150 mm - 1 No.
- D.E. spanner set 5mm to 20 mm - 1 Set
- Megger 500 V - 1 No..
- Test lamp 100W/240V - 1 No.
- Ohmmeter/multimeter - 1 No.
- Tachometer 1500-15000 r.p.m. - 1 No.

Equipments/Machines

- Universal motor 250V, 50 Hz, 0.5 HP - 1 No.

Materials

- 2.5 mm multi-strand PVC copper cable - 10 mts.
- Bare copper wire 14 SWG - 05 mts.
- 250 V 16A, I.C.D.P. switch - 1 No.
- D.O.L. starter 250V suitable for 0.5 HP single phase motor - 1 No.

PROCEDURE

1 Arrange and adjust a suitable load for the given universal motor.

A universal motor has high starting torque. Without load, the motor reaches a dangerously high speed resulting in damage. Normally do not arrange loading through the flat belts which may slip during running. Arrange direct drives or 'V' belt drives as load.

2 Select the proper rating of I.C.D.P. switch, cables, fuse and starter, according to the rating of the given universal motor.

3 Open the starter cover, trace out the connection and set the overload relay to the motor current rating.

4 Connect the motor as per circuit diagram (Fig 1) with proper frame earth connections.

Check for the correct load arrangement before starting the motor.

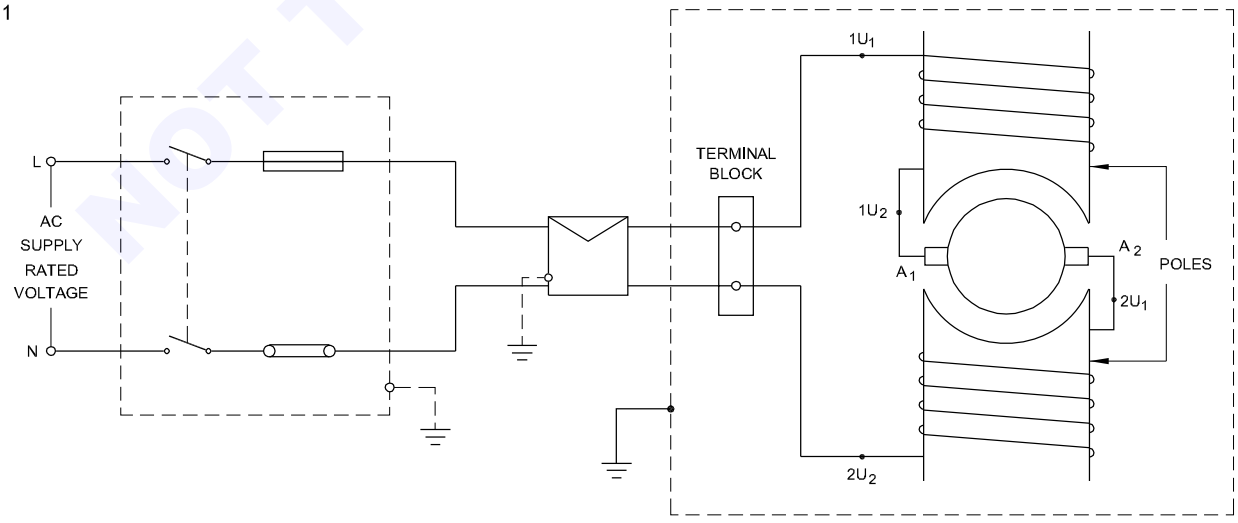
5 Switch on the I.C.D.P. and push the 'ON' button of the starter.

6 Observe the D.O.R. and record it below.

The D.O.R. is _____

7 Measure the speed with a tachometer and record it below. The speed is _____ r.p.m.

Fig 1



CONNECTION OF AN UNIVERSAL MOTOR

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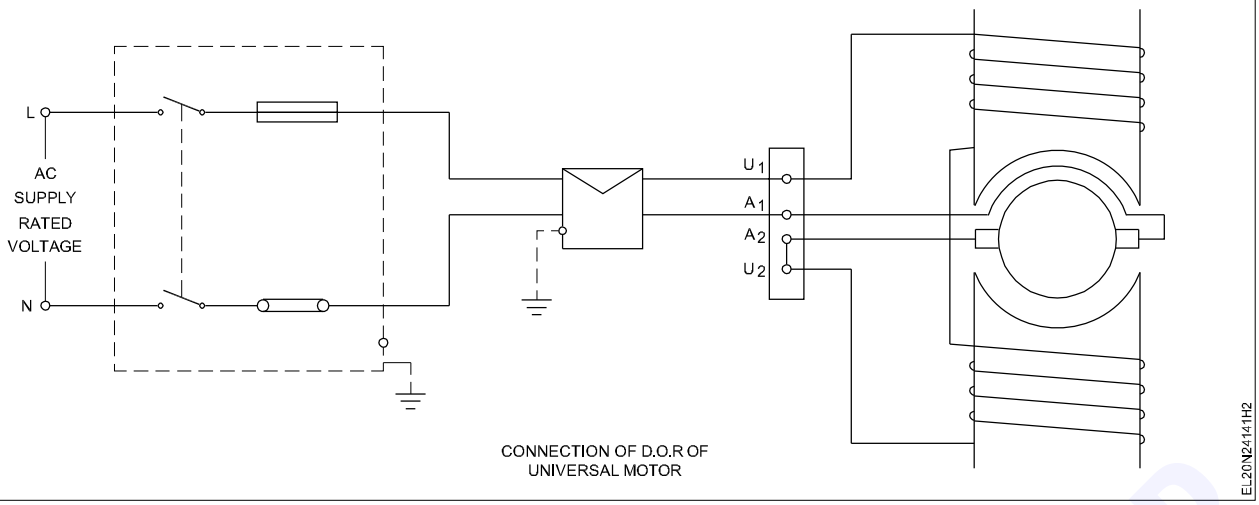
Fig 2



The speed of a universal motor depends upon the load. While setting the range of the tachometer, first set at a high range and then step down the range to a suitable measurable value.

8 Stop the motor by the stop-bottom of the starter. Switch off the I.C.D.P. and remove the fuse.

Change the direction of rotation

Generally the D.O.R of the universal motor is designed in one direction by the manufacturer. Changing the direction of rotation in such cases will result in high sparking, increased heating and failure of the machine.

In case reversing the direction of rotation of the motor is necessary, change either field or armature terminals. While changing the armature terminals of compensated universal motor, change the compensating winding terminals also.

9 Discuss with your instructor the possibility of alternate connections to the one. (Fig 2)

10 Change either the field or the armature terminals.

11 Follow the procedural steps 5 to 8 and record the direction of rotation and speed in the space given below:

The D.O.R. is_____

The speed is_____

Carry out maintenance and servicing of universal motor

Objectives: At the end of this exercise you shall be able to
- **read and interpret the name-plate details of the motor**
- **inspect and ascertain the conditions of the motor**
- **dismantle the universal motor**
- **test and rectify the faults**
- **assemble and test the universal motor**
- **troubleshoot the universal motor.**

Requirements

Tools/Instruments

- Electrician tool kit - 1 Set
- Philips screwdriver 200mm - 1 No.
- Cold chisel 200 mm - 1 No.
- Spanner set double ended set of 8 Nos. 6mm to 25 mm - 1 Set
- Mallet (wooden) 7.5 cm dia - 1 No.
- Bearing puller - 1 No.
- Megger 500 V - 1 No.
- Ohmmeter 0 to 1 kilo ohm - 1 No.
- External and internal growler - 1 Set

Equipments/Machines

- Universal motor as available - 1 No.

Materials

- Test lamp 60W 250V - 1 No.
- Cotton waste - as reqd.
- Bearing grease quality and quantity - as reqd.
- Sandpaper smooth sheet of 300 mm square - as reqd.
- Kerosene oil - 1/2 litre.
- Empire cloth 1 mm - as reqd.
- Carbon tetrachloride - as reqd.
- Empire sleeves 3 mm to 6 mm - as reqd.
- Carbon brushes of suitable grade and size - 2 Nos.
- Lead and tin solder (Resin cored) -20 grams.

PROCEDURE

TASK 1 : **General maintenance and servicing procedure**

1 Note the name-plate details of the motor and enter in complaint card shown in Table 1.

Table 1

Complaint card

Customer _____	Date _____	Job No. _____	Make _____
Frame No. _____	Model _____	Type _____	HP _____

Volts _____ Ampere ___ Phase ___ Cycles

Serial No. _____

Suggestion/Complaint :_____

Signature of Section in-charge

2 Inspect the motor visually and record the defects in Table 2.

3 Read the complaint card and ascertain the area of trouble.

4 Conduct, continuity, open circuit and insulation resistance tests and enter the values in Table 3.

Table 2

Results of visual inspection

Sl.No.	Description of visual inspection	Result of visual inspection

5 Mark the exact position of the end plates with yoke.

6 Dismantle the machine.

7 Clean the internal parts of the motor.

8 Check the following.

a) Test the shorting between commutator segments. (Fig 1)

b) Clean the commutator with carbon tetra chloride.

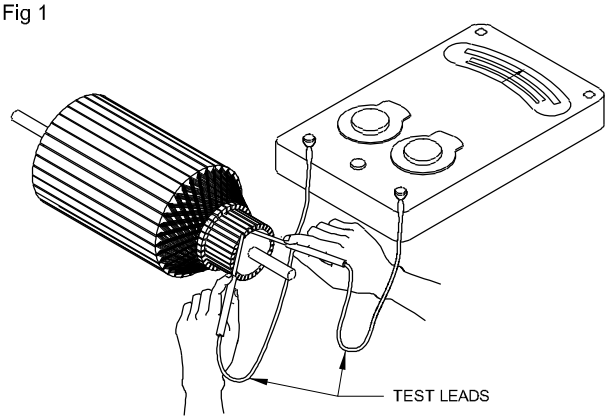
c) Check the mica insulation; if found raised beyond the commutator surface undercut the mica.(Fig 2)

Table 3

Test results

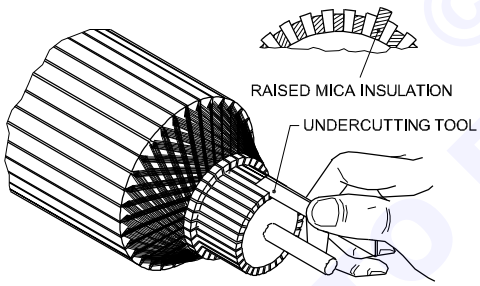
Sl. No.	Description	Continuity Test		Insulation resistance		Resistance Test		Remarks
		Before Dismantling	After Assembling	Before Dismantling	After Assembling	Before Dismantling	After Assembling	
1	Field winding							
2	Armature winding							

Fig 1



ARMATURE RESISTANCE TEST

Fig 2



d) Check the commutator surface for pitting. If necessary use sandpaper to remove the pitting.

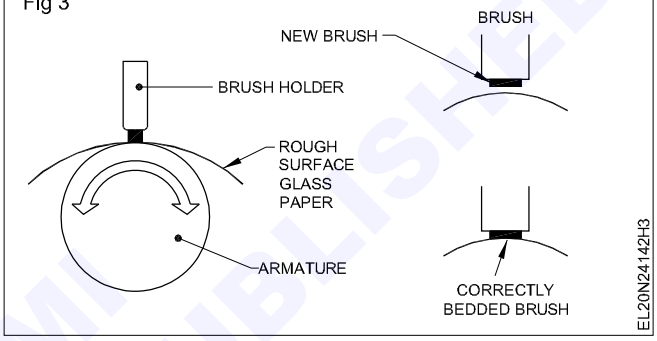
e) Check for overheated spot at raiser and resolder the wires if necessary.

f) Check the length of brushes. If found short, replace them with the same grade of correct size brushes.

g) Check the brushes for proper bedding. If necessary bed the brushes. Refer Fig 3.

Insert the new brush and shape the end to the curve of the commutator using glass paper wrapped around the commutator and light pressure on the brush.

Fig 3



h) Check the bearing for ply or damage.

i) Replace the damaged or defective bearing with the new one having same specification.

If the old bearing is good, then clean the bearing and repack the bearing with grease approved by the manufacturer.

j) Assemble the motor.

k) Check whether the rotor shaft is free to rotate.

In case, the rotor shaft is hard to move or too tight, loosen the end covers and retighten them in a sequence till the rotor is free to rotate.

l) Check the brush tensions and if necessary adjust it.

m) Perform the earlier tests and enter the results in Table 3.

The present test results should be better than earlier ones. If not try to investigate the problem area and rectify.

n) Check the earth connections of the motor, starter and switch and correct them if necessary.

o) Start the motor with partial load and check its performance.

p) Check for undue raise in motor temperature, noise and vibrations.

q) Verify the defect following the trouble shooting chart if necessary.

Install an alternator, identify part and terminals of alternator

Objectives: At the end of this exercise you shall be able to
- **select the location and type of foundation**
- **determine the type of fasteners and prepare the Template**
- **dig pit on the floor and prepare the concrete mixture**
- **place fasteners with a template and grout the fasteners**
- **read and Interpret the name plate details of alternator set**
- **identify their parts and write their names**
- **identify the terminals of alternator.**

Requirements

Tools/Instruments

- Right spanner set 5 mm to 25 mm - 1 Set
- DE spanner set 5mm to 25mm - 1 No.
- Dial gauge - 1 No.
- Feeler gauge - 1 No.
- Ball pein hammer 1 Kg - 1 No.
- Cold chisel 19mm dia 200mm long - 1 No.
- Round file bastard 200mm - 1 No.
- Flat file bastard 200 mm - 1 No.
- Steel rule 300 mm - 1 No.
- Crowbar 1800mm - 1 No.
- Lead hammer 1 Kg - 1 No.
- Screwdriver 300mm with 6 mm blade - 1 No.
- Spirit level 200 mm - 1 No.
- Alignments pins (Fixture pin) - 1 Set

Equipments/Machines

- Electric drilling machine - 1 No.
- 3 Phase Alternator 3KVA 500V 50 Hz coupled to suitable motor - 1 No.
- Ohm meter - 1 No.
- Phase sequence meter - 1 No.

Materials

- PVC insulated copper cable 2.5 sq mm 600V grade - as reqd
- Test lamp 250V - 1 No.
- Bolts and nuts - as reqd
- Cement - as reqd.
- Sand - as reqd.
- Earth wire GI 14 SWG - 3 m

PROCEDURE

TASK 1: **Install an alternator set**

1 Select the Proper place of Installation for the alternator set.

2 Select a suitable type of foundation by referring to the manufacturer's Instructions.

3 Select a suitable fastener by referring to the manufacturers's instructions.

4 Take the measurement of the bed frame as in Fig 1 and enter the data in Table 1.

Fig 1

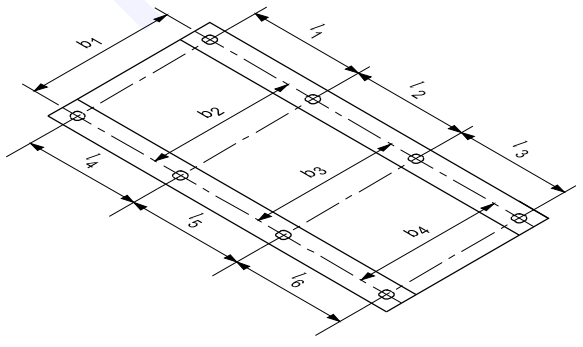


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Table 1

Outside dimensions

Length	.....mm
Breadth	.....mm
Height	.....mm

Table 2

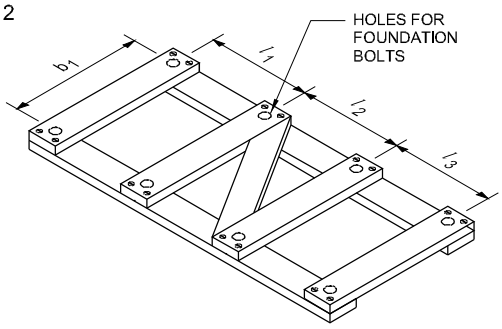
Distance measured from the adjacent holes

$1_{1..}$.....mm	$l_{4..}$.....mm	$b_{1...}$.....mm	b_4.....mm
1_2 .....mm	l_5.....mm	$b_{2.}$... mm	
1_3....mm	l_6 .....mm	$b_{3.}$.....mm	

5 Measure the position and size of foundation bolt holes and enter the data in Table 2.

6 Prepare a template for the bed frame , mark the position of the foundation bolt on the template and drill the frame. (Fig 2)

Fig 2



7 Mark the position of the foundation bolts in the selected space on the floor using the template.

8 Dig the floor at the marked places, such that the depth of holes is 15 cm more than the length of the anchor bolt below the floor surface.

9 Mount the foundation anchor bolts in the template and place the template on the ground surface so that the anchor bolts enter the holes already dig in proper position.

10 Check for level using the spirit level.

11 Fill the space around the bolt with thin coarse cement mortar.

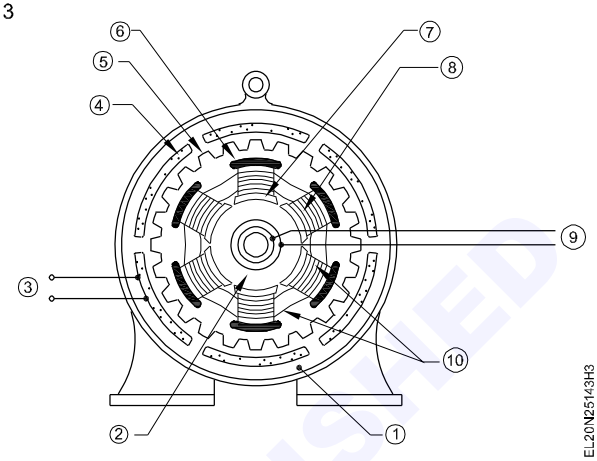
12 Allow it to settle down for 8 to 12 hours, then remove the template.

13 Cure the cement mortar with water for a minimum of two days.

14 Finish the surface by plastering neatly.

15 Install the alternator set and fix with nuts.

Fig 3

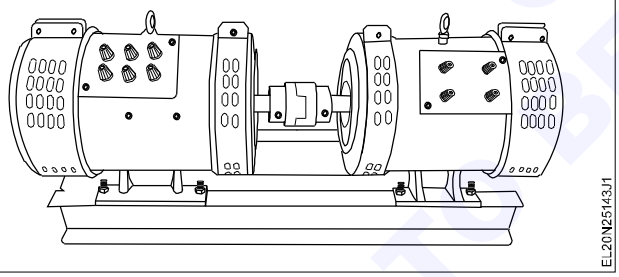


TASK 2 : **Identify the parts of alternator**

1 Read and interpret the name plate details of the given alternator.

2 Identify the parts of the alternator from the real object or form the exploded view chart (Fig 1)

Fig 1 **DC shunt motor coupled with 3 phase alternator**



3 Label the each part with number and write the name of the parts in Table 1.

Table 1

S No.	Label No.	Name of the part
1		
2		
3		
4		
5		
6		
7		

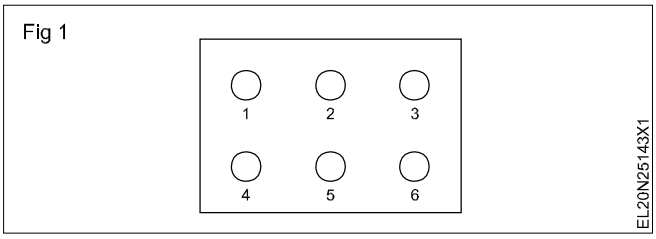
TASK 3 : **Identify the terminals of a 3 phase, star connected alternator**

In a 3-phase, star-connected alternator three windings are internally connected in the star and four terminals are brought out to the terminal block. These four terminals consist of three beginning ends of the 3-phase winding and one neutral.

1 Check there is any marking on the terminals and note it down also. If not, give your own marking as 1,2,3 etc as shown in Fig 1.

2 Identify the terminals which show the internal connection, following the procedure stated in the above working steps and also as shown in Fig 2a. Measure the resistance in between them and record the readings in Table 1.

Fig 1



3 Identify the field winding from the terminal block (Fig 2b)

Fig 2

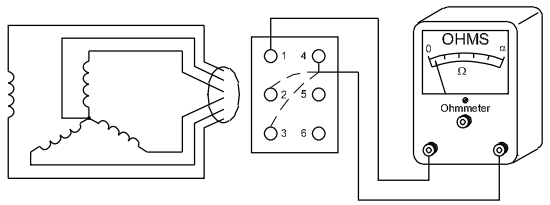


Fig 6(a)

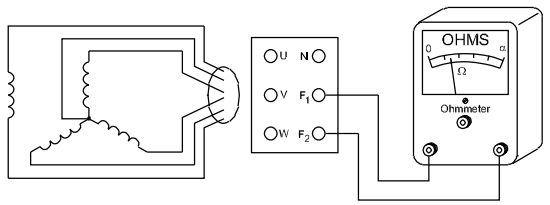


Fig 6(b)

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Only one pair will be independent with marginally high resistance. This pair belongs to the field winding. The other four terminals which show continuity between them belong to the star-connected, main winding terminals.

Out of the four terminals, three terminals will give comparatively high resistances between them. These are the ends of the three coils called UVW terminals. However, the left out terminals out of the four will give half the value of resistance when measured between any one terminal of UVW and that terminal. This terminal is the neutral and has to be marked as 'N'. The marking of the 3-phase terminals as UVW is tentative. The correct phase sequence is to be checked with the help of a phase-sequence meter, then only the terminals could be marked as UVW.

4 Mark the terminals accordingly.

5 Show your making to your instructor and get his approval.

Table 1

Sl No.	Between	Resistance value in ohms	Remarks
1	1 - 2		
2	2 - 3		
3	3 - 4		
4	1 - 3		
5	1 - 4		
6	2 - 4		
7	5 - 6		

Test for continuity and insulation resistance of alternator

Objectives: At the end of this exercise you shall be able to
- **test the alternator windings for continuity**
- **test the insulation resistance between the stator and rotor windings.**

Requirements

Tools/Instruments

- Cutting pliers 200mm - 1 No.
- Spanner set 5mm to 200mm - 1 Set
- Screwdriver 200mm - 1 No.
- Screwdriver 100mm - 1 No.
- Megger 500V - 1 No.

Equipment/Machines

- Alternator, 3-phase, 3 KVA 415V - 1 No.

Materials

- P.V.C. insulated copper wire 23/0.2 mm size - 5 m
- Insulation tape - 1 m.
- Test lamp 60W / 240V - 1 No.

PROCEDURE

TASK 1 : **Read and interpret the name plate details of an alternator**

1 Read and interpret the name-plate details of the 3-phase alternator.

2 Identify the terminals of the alternator as you did in Exercise No.2.5.143. Task : 3.

— — — — — — — —

TASK 2 : **Conduct continuity test by using a lamp**

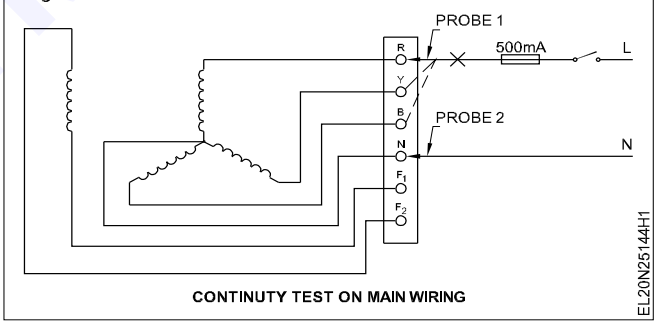
1 Take the test lamp and identify the cable to which the S.P. switch and the fuse are connected in series with the lamp. Use this as Probe 1.

2 Connect Probe 2 to terminal `N' and touch the terminals R, Y and B alternatively by Probe 1. (Fig 1) Observe the lamp condition and enter the same in Table 1.

The phase wire should be identified in the test lamp as Probe 1, and should be connected through the switch and fuse to the test lamp. Care should be taken to see that the phase wire does not touch the body or frame of the alternator. Do not touch any terminal while testing with AC supply.

3 Check the continuity between F_1 and F_2 and enter the finding in Table 1.

Fig 1



CONTINUTY TEST ON MAIN WIRING

Table 1

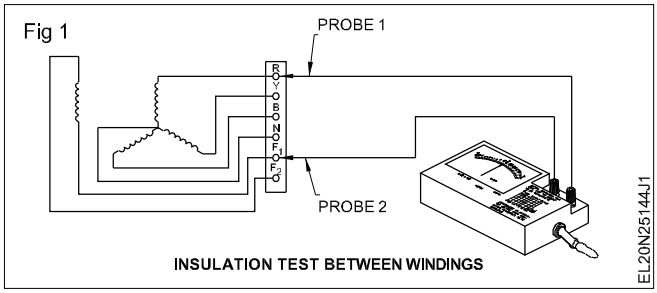
Sl.No.	Connection between	Condition of lamp
1	R and N	
2	Y and N	
3	B and N	
4	F_1 and F_2	

— — — — — — — —

TASK 3 : **Measure insulation resistance between windings**

1 Connect one prod of the Megger to any one of the terminals R,Y,B,N and the other prod to the terminal F1 or F2 as shown in Fig 1.

Fig 1



You can connect to any one of the terminals R, Y, B and N as all of them are having continuity as ascertained earlier.

2 Rotate the Megger at its rated speed and measure the insulation value and record it in Table 2.

The measured value should not be less than 1 megohm.

Table 2

Sl. No.	Insulation resistance between windings	Value in megohms
1	Between RYBN and field winding F_1 & F_2	

— — — — — — — —

TASK 4: **Measure the insulation resistance between the windings and the body**

1 Connect one of the prods of the Megger to any one terminal, RYBN and the other prod to the body/frame of the alternator.

2 Rotate the Megger at its rated speed and measure the insulation resistance. Record it in Table 1.

Table 1

Sl. No.	Insulation resistance between winding and the body	Value in MΩ
1	Between armature winding R/Y/B/N and the body	
2	Between field winding F_1 & F_2 and body	

3 Connect the Megger probe to terminal F_1 or F_2 and the other probe to the body.

Rotate the Megger at its rated speed and measure the insulation resistance value, and record it in Table 1.

The measured insulation value should not be less than 1 megohm.

4 Compare these values of insulation resistance with those entered in the alternator maintenance card available in the section, and discuss the variations in the reading with your instructor.

— — — — — — — —

Connect, start and run an alternator and build up the voltage

Objectives: At the end of this exercise you shall be able to
- **read and interpret the name-plate details of an alternator**
- **test and identify the terminals of an alternator**
- **connect, start, run, adjust the speed and frequency of the alternator**
- **adjust and set the rated voltage of an alternator.**

Requirements

Tools/Instruments

- Insulated cutting pliers 200mm - 1 No.
- Screwdriver 150mm - 1 No.
- Screwdriver 100mm - 1 No.
- Voltmeter AC 0 to 500 volts - 1 No.
- Ammeter DC 0 to 5 amps - 1 No.
- Tachometer 0 to 3000 r.p.m. - 1 No.
- Single phase frequency meter 250V - 45 to 55 Hz. - 1 No.

Equipment/Machines

- 3-phase alternator 3KVA 415V 50 Hz. coupled to a suitable DC motor. - 1 Set
- Rheostat 480 ohms 2 amps - 2 Nos.
- 4-point starter 30 amps 250V - 1 No.

Materials

- PVC insulated copper cable 2.5 sq mm 600 V grade - 10 m.
- Insulation tape - 30 cm.
- Fuse wire 5A, 15A - as reqd.
- T.P.I.C. switch 16 amps 500V - 1 No.
- D.P.I.C. switch 32 amps 250V - 2 Nos.

PROCEDURE

TASK 1: **Connect, start, run, adjust the speed and frequency of an alternator**

1 Read and interpret the name-plate details.

2 Test and identify the terminals of the alternator.

3 Test the alternator for insulation resistance between the windings, the winding and the ground, and record the values separately.

The insulation resistance value should not be less than one megaohm

4 Select a suitable range of rheostats, ammeters, voltmeters, switches and cables according to the specification of the available alternator.

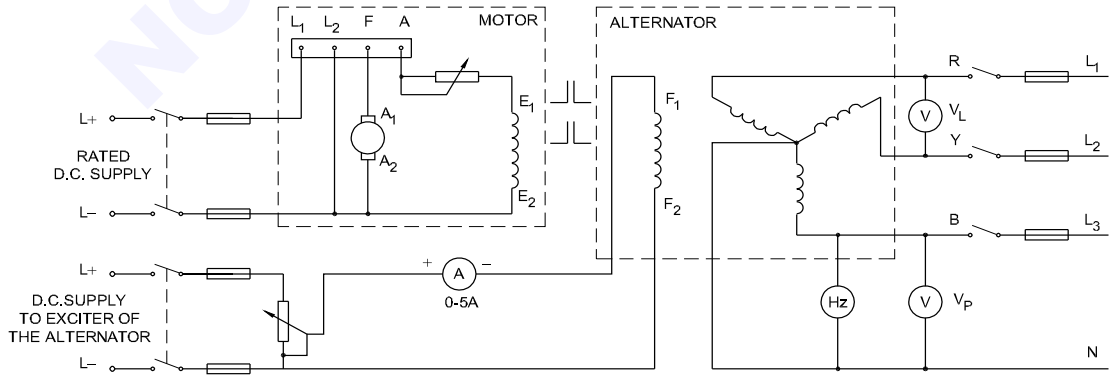
You may have to change the ranges of the meters and rheostat according to the rating of the available alternator with respect to Fig 1.

5 Make the connections as per the circuit diagram.

6 Adjust the field rheostat of the prime mover to cut out position, and the field rheostat of the exciter in the minimum voltage position.

7 Check the couplings.

Fig 1



CONNECTIONS FOR MAGNETISATION CHARACTERISTIC OF THE ALTERNATOR

8 Switch `ON' the DC supply to the prime mover (DC motor) and start the prime mover through the 4-point starter.

9 Adjust the speed of the prime mover through its field rheostat to the rated speed of the alternator.

10 Switch `on' the DC supply to the exciting winding of the alternator. Note down the field current, line voltage and phase voltage of the alternator in Table.

11 Note down the frequency (if possible, for the frequency meter may not read at a low voltage) in Table.

12 Increase the field current in 10 to 12 equal steps. For each step measure the phase voltage, line voltage, frequency and field current and enter the values in Table until the alternator output voltage reaches its rated value.

The field current should be varied gradually in equal steps in the ascending order. Otherwise it will disturb the shape of the plotted curve.

13 Increase the excitation current such that the alternator line voltage is about 10% above the rated value.

14 Draw the curve I_F versus V_P taking I_F on the `X' axis and $V_P$ on the `Y'axis. The curve shows the O.C.C. or the magnetisation characteristic of the alternator.

15 Write your conclusion regarding the relation between the field current and phase voltage as well as the line voltage and phase voltage.

Conclusion

Table

Sl.No.	Field current I_F	Line voltage V_L	Phase voltage V_P	Frequency V_F	Remarks

Determine the load performance and voltage regulation of a 3-phase alternator

Objectives: At the end of this exercise you shall be able to
- **connect, start, run, and build up the voltage of an alternator**
- **determine the voltage regulation of an alternator.**

Requirements

Tools/Instruments

- Combination pliers 200mm - 1 No.
- Round nose pliers 150mm - 1 No.
- Electrician's knife - 1 No.
- M.I. ammeter 0 to 20 amps - 3 Nos.
- M.I. voltmeter 0 to 500 volts - 1 No.
- M.C. voltmeter 0-300V - 1 No.
- M.C. ammeter 0-5A - 1 No.
- Frequency meter 500V, 45 to 50 Hz. - 1 No.
- Power-factor meter 500V, +0.5 to -0.5 P.F. - 1 No.
- Tachometer 300 to 3000 r.p.m. - 1 No.

Equipment/Machines

- 3-phase alternator 500V 5/10 kW coupled with DC shunt motor having facility for speed control - 1 Set
- 3-phase lamp load 415/400V 5 KW - 1 No.
- 3-phase squirrel cage motor 500V 50HZ, 3 HP with DOL starter and switch - 1 No.

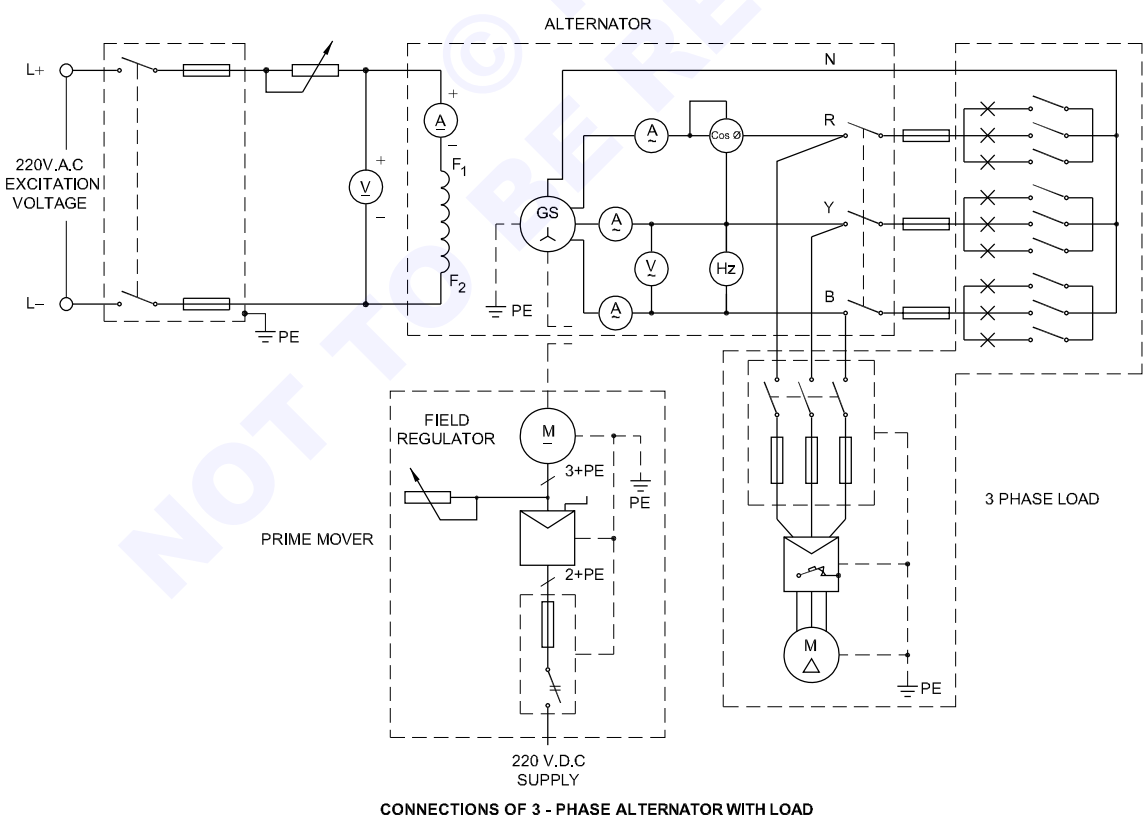
Materials

- P.V.C. insulated stranded aluminium cable -10 m
- T.P.I.C. switch 32 amps 500v - 2 Nos.

PROCEDURE

TASK 1 : **Connect, start, run, and build up the voltage of an alternator**

Fig 1



CONNECTIONS OF 3 - PHASE ALTERNATOR WITH LOAD

1 Note down the name-plate details of the given alternator in Table 1. (As per exercise 2.5.144 Task : 1)

2 Select proper sizes of cables, fuse wires, switches etc., as per the name-plate ratings (rated capacity) of the given 3-phase alternator.

3 Connect the exciter output terminals to the field of the alternator with the rheostat, ammeter and voltmeter. (Fig 1)

The exciter output voltage is shown in Fig 1 as 220V DC. Different manufacturers choose different exciter voltages suitable for their alternators. You may have to select the voltmeter and ammeter ratings according to the voltage rating of the field of the available alternator.

4 Connect the alternator terminals RYB and N to the load as per the circuit diagram (Fig 1). Keep the load switches and also all the lamp switches of the lamp load in the `off' position.

Check the voltage rating of the power factor and frequency meters whether they are for phase voltage or line voltage. Connect accordingly. Do not forget to connect the star point of the lamp load to the neutral point of the alternator. The bulb wattage rating should be equal in all lamps.

5 Show the connection to your instructor and obtain his permission to start the prime mover.

6 Run the alternator at its rated speed. Measure and record the speed. Speed..... r.p.m.

7 Build up its voltage by adjusting the field rheostat to the rated voltage of the alternator. Read and record it. Voltage .....volts.

— — — — — — — —

TASK 2 : **Determine the voltage regulation of an alternator**

1 Close the T.P.I.C. switch of the motor load and start the motor by the D.O.L starter.

2 Close also the T.P.I.C. switch of the lamp load and increase I_L up to the alternator's rated value in steps of one ampere. Read and record the values of I_L, V_L & P.F. frequency in Table 1.

3 Reduce the load and switch off the alternator.

4 Draw the three curves for the 3 sets of reading showing the terminal voltage versus load current. Keep the terminal voltage in the Y axis and load current in the X-axis.

5 Calculate the voltage regulation for the above different loads at 5 and 10 amperes by using the formula:

Percentage voltage regulation ($\%V_R$)

$$\%V_R = \frac{\text{No.load voltage - Full load voltage}}{\text{Full load voltage}} \times 100$$

6 Based on steps 5 and 6 write your conclusion in the space given below.

Conclusion 1

_____

_____

_____

Conclusion 2

_____

_____

_____

Table 1

Sl. No.	Load current equal in all the three phases I_L	Terminal Voltage V_L	Frequency kept constant	Power Factor cos Ø	Power = $\sqrt{3}\ E_L I_L \cos Ø$	Remarks

— — — — — — — —

Parallel operation and synchronization of three phase alternators

Objectives: At the end of this exercise you shall be able to
- **read and interpret the name plate details of the two 3 phase alternators**
- **synchronise the two 3 phase alternators by dark lamp method and test it**
- **synchronise the two 3 phase alternators by dark and bright lamp method and test it**
- **synchronise the two 3 phase alternators by synchroscope method and test it.**

Requirements

Tools/Instruments

- Trainees tool kit - 1 No.
- MI Voltmeter 0-500V - 2 Nos.
- Frequency meter (45 - 50 - 55 Hz) - 1 No.
- Phase sequence indicator - 1 No.
- Synchroscope - 1 No.

Equipments/Machinery

- 3 Phase alternators 5 kVA/500V 50 Hz coupled with prime mover (/adjustable speed control) - 2 Nos.
- Rheostat 150 ohms/1A - 1 No.

Materials

- TPIC switch 16A, 500V - as reqd.
- ICDP / Knife switch 16A, 250V - 1 No.
- ICTP / Knife switches 16A, 500V - 2 Nos.
- 100W/250 V lamps - 6 Nos.
- Connecting wires - as reqd.

PROCEDURE

TASK 1 : **Read and interpret the name plate details of the alternators**

1 Read and interpret the name plate details of the 3 phase alternators.

The voltage rating of two alternators must be same. Rating of alternators (kVA), not necessary must be same. The load can be shared according to the rating of alternators.

— — — — — — — — —

TASK 2 : **Synchronise the two 3 phase alternator by dark lamp method and test it**

For connecting two alternators in parallel they must fulfil the following conditions.

1 Terminal voltage of both the alternators must be same

2 Supply frequency of both alternators must be equal

3 Phase sequence of both the alternators must be ideal

1 Check the phase sequence of the main bus bar line by using phase sequence indicator/meter

2 Connect and set the arrangement of incoming alternator and outgoing alternator with prime mover coupled, TPIC main switch, voltmeters and frequency meters and lamp connection in series. (Fig 1).

While connecting the alternators, care should be taken, that corresponding phase lines must be connected of both alternators. (i.e.) 1st alternator is connected to L1, L2 and L3 then the 2nd alternator must also be connected to same L1, L2 and L3.

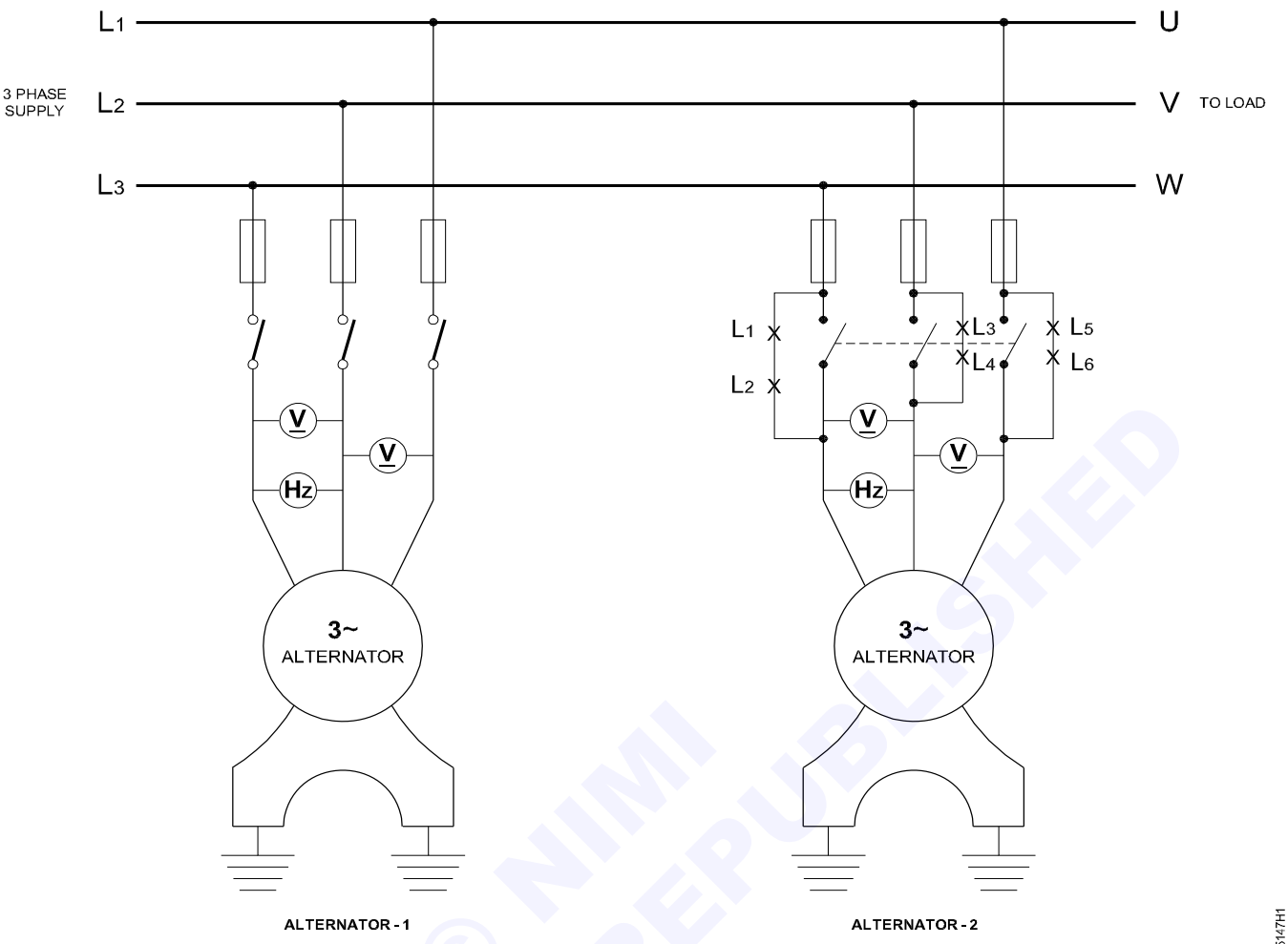
3 Keep the main switch of incoming alternator -1 in closed position after ensuring the phase sequence are correct.

4 Keep the main switch of alternator - 2 in opened position.

5 Start and run the first alternator and build up the rated voltage

6 Measure the line voltage between phases, then measure the frequency of an alternator-1 and note down the readings of voltmeter and frequency meters in Table 1.

Fig 1



PARALLEL OPERATION OF 3 PHASE ALTERNATIVES BY DARK LAMP METHOD

Table 1

Alternator 1

S No.	Voltage reading in Volt	Frequency in Hz
1	L1 - L2	L1 - L2
2	L2 - L3	L2 - L3
3	L3 - L1	L3 - L1

7 Start , run and build up the rated voltage

8 Measure the line voltages and frequency in alternator 2 and note down the readings in Table 2.

Table 2

Alternator 2

S No.	Voltage reading in Volt	Frequency in Hz
1	L1 - L2	L1 - L2
2	L2 - L3	L2 - L3
3	L3 - L1	L3 - L1

9 Check the condition of the two lamp.

If the voltage and frequency are equal the lamps will becomes dark and then becomes bright. If the voltage and frequency of the both alternators are not same, the lamps will flicker.

10 Adjust the field excitation current in the alternator 2 and bring the voltage to the same value of the alternator 2.

11 Check the condition of lamps brightness.

If the lamps are flickering still now, then the frequency may not be equal, it must be brought to same equal frequency value of alternator 1

12 Adjust the speed of the prime mover of alternator 2 and bring the frequency as same as in alternator 1

Now, all the lamps are bright and then become dark at a time, it indicates all the conditions are fulfilled for synchronising.

13 Close the main switch of alternator - 2 when all the lamps are in dark condition.

Now the alternators are synchronised (parallel) and ready for sharing the load.

14 Switch 'ON' common load for both the alternators.

15 Check the loads are shared equally by the two alternators.

16 Get it checked with your instructor.

— — — — — — — —

TASK 3 : **Synchronise the two 3 phase alternators by dark and bright lamp method**

1 Check the phase sequence of the main bus bar lines by using phase sequence indicator

2 Connect and set up the arrangement of the alternator - 1 and alternator - 2 with prime mover, TPIC switch, lamp connection. (2 pairs of lamp are connected across two phases, In one phase, the pair of the lamps are in series with voltmeters and frequency meters. (Fig 2)

3 Repeat the working steps from 3 to 8, in Task - 2

4 Note down the readings in table - 3 & Table - 4

Table 3

Alternator - 1

S. No.	Voltage reading in Volt	Frequency in Hz
1	L1 - L2	L1 - L2
2	L2 - L3	L2 - L3
3	L3 - L1	L3 - L1

Table 4

Alternator - 2

S. No.	Voltage reading in Volt	Frequency in Hz
1	L1 - L2	L1 - L2
2	L2 - L3	L2 - L3
3	L3 - L1	L3 - L1

5 Look at the condition of the lamps

If the voltage and frequency are equal then one pair of the lamp will be dark and other two pair will be bright

If the voltage and frequency of the both the alternators are not same, then the lamp will flicker not giving standstill lighting

6 Check the voltage and frequency are not equal repeat the steps from 10 to 12 of task 2and bring the same value of voltage and frequency as in alternator - 1

If all the condition are fulfilled, then all the lamps will not flicker and one pair of the lamp will be dark and other two pair lamps will be bright at a time.

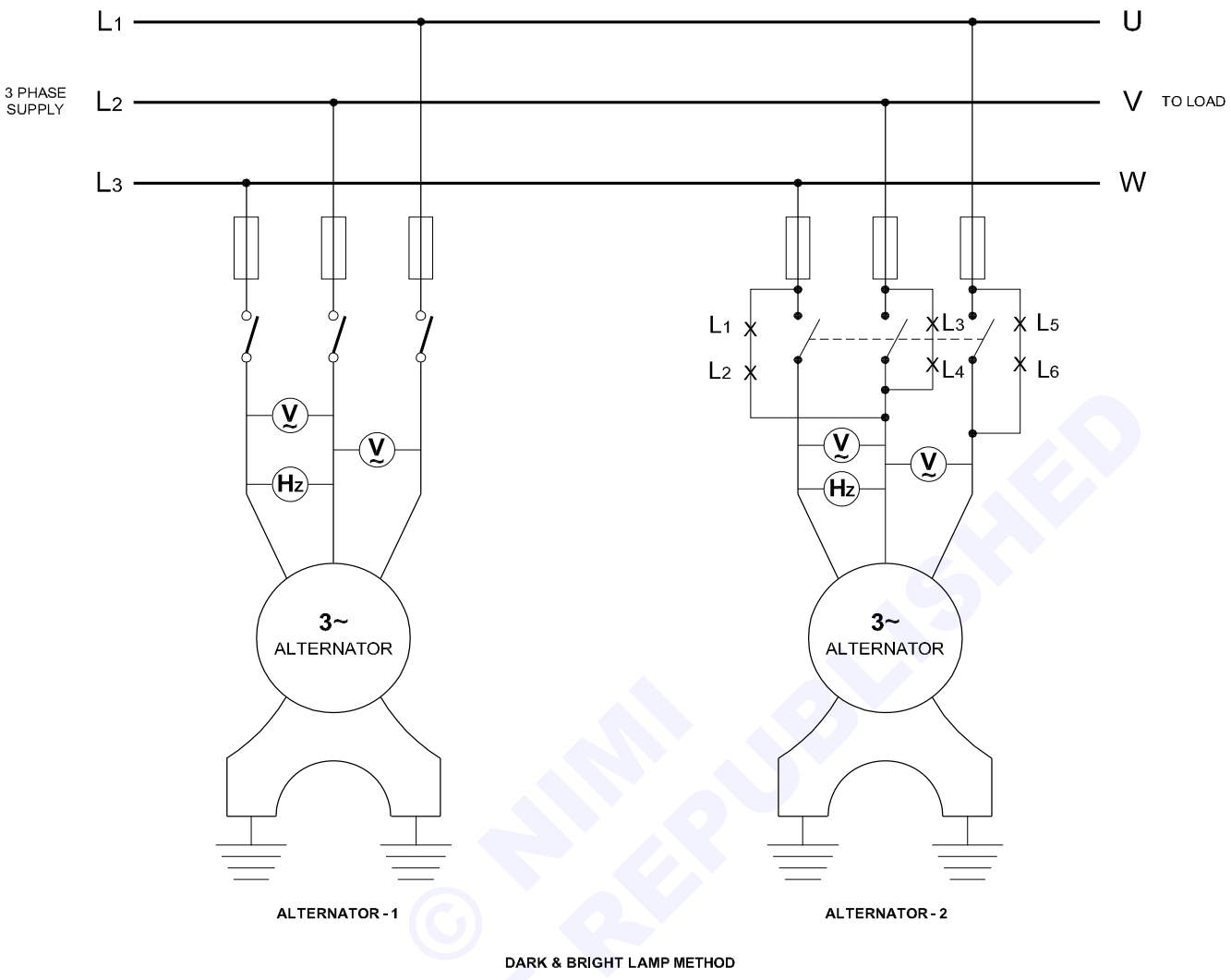
7 Close the main switch of alternator - 2 when the lamps are bright condition

Now the 2 alternators are synchronised (parallel) and ready for sharing the load

8 Switch 'ON' the common load for both alternators

9 Check the loads are shared equally by the two alternators

Fig 1



TASK 4 : **Connect two alternators in parallel by using synchroscope**

1 Collect the instruments as shown. (Fig 3)

2 Connect the equipment and instruments. (Fig 3)

Keep `open' the bus-bar switch S_1 and synchronising switch S_2.

3 Start the incoming alternator (Alternator-2) with low excitation.

4 Close the bus-bar switch S_1.

One alternator (Alternator-1) is connected to the bus-bar that produces the rated V.

5 Observe the bus-bar voltage V_1 and incoming voltage V_2.

6 Adjust the excitation of the incoming alternator till $V_1 = V_2$. The voltage of incoming and exciting machine should be equal.

7 Check the pointer in the synchroscope.

8 Adjust the speed of the alternator. If it is indicating fast, reduce the speed of the incoming machine gradually observing the synchroscope pointer.

If it indicates slow, increase the speed of incoming machine slowly. The result should be slow movement of the pointer to 0.

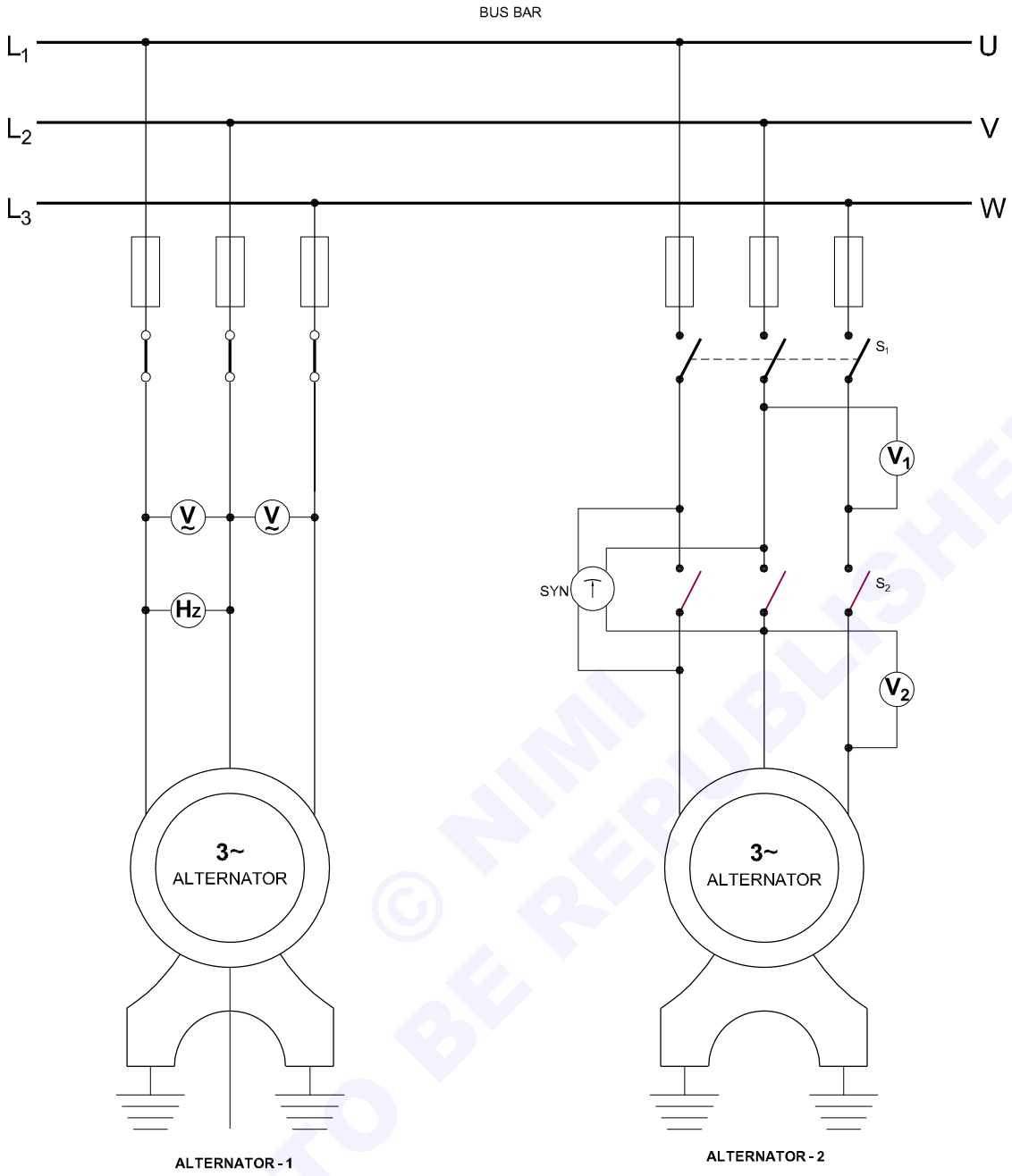
When the pointer comes to zero position very slowly, the bulb behind the dial will glow bright.

9 Adjust the speed of the incoming alternator for minimum oscillation of the synchroscope pointer.

10 Close the synchronising switch `S_2' at zero, and the steady position of the synchronising pointer.

When the two voltages of the incoming and existing machines are the same in magnitude and phase, synchroscope pointer will be at zero.

Fig 1



TWO ALTERNATORS IN PARALLEL BY USING SYNCHROSCOPE

EL20N25147X1

Install a synchronous motor, identify its parts and terminals

Objectives: At the end of this exercise you shall be able to
- **read and interpret the name plate details of given shynchronous motor**
- **read the manufacturers installation instruction and follow the same**
- **transfer the template measurements to the mounting base**
- **make the template of the base frame making (i.e) making drilling, selecting hole size.**

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.

Materials

- Connecting cables - as reqd.
- Nuts grouting bolts - 4 Nos.

PROCEDURE

TASK 1 : **Install a given sychronous motor**

1 Read the name-plate details and record in the motor maintenance card

2 Make the necessary arrangement at the place where the motor to be installed as per manufacture's Instruction, such as drilling holes, position of nuts and bolts or and RCC foundation etc.

3 Determine the size of the connecting cable and fuse from the rating of the motor.

4 Select the size of the drill according to the size the mounting bolt recommended by the manufacturer.

5 Drill the holes according to the size mentioned.

6 Make use of the template measurements on the mounting base and get the base mounting ready for installing the motor. (Fig 1)

a) Fix the planks with a grouting bolt.

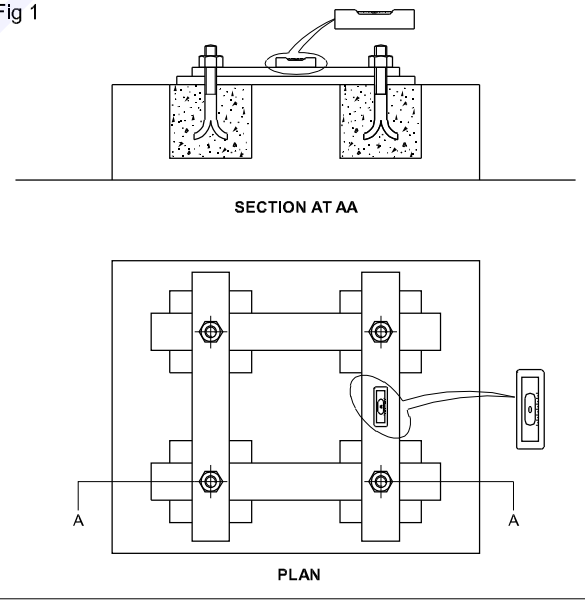
b) Check for level using the spirit level.

c) Fill the space around the bolts with thin coarse cement mortar.

In the training Institute use clay mortar instead of cement to facilitate repetition easily by every trainee in a batch.

d) Allow it to settle down for 8 to 12 hours, then remove the template planks.

Fig 1



e) Cure the cement mortar with water for a minimum of 2 days.

f) Finish the surface by plastering neatly.

Include vibration arresting devices as per the manufacturer's instructions such as spring washers, etc.

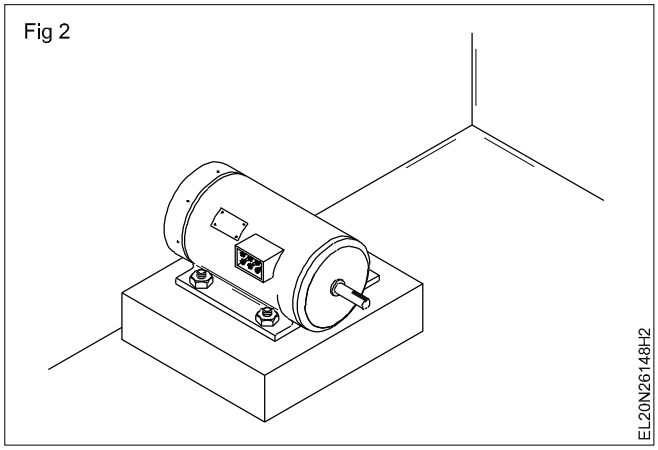
7 Install the motor and fix it with nuts (Fig 2)

8 Make double earthing in accordance with I.E. regulations and I.S. recommendation.

9 Check the continuity of windings. Also check the effectiveness of grounding.

10 Connect the motor with the starter/switch and fuse to the supply temporarily to check smooth running without vibrations.

Fig 2



TASK 2 : **Identify the parts and terminals of synchronous motor**

1 Identify the parts of the synchronous motor from the real object or from the exploded view chart.

2 Label the each identified parts with number tags.

3 Write the name of the parts of each labelled number in the table.

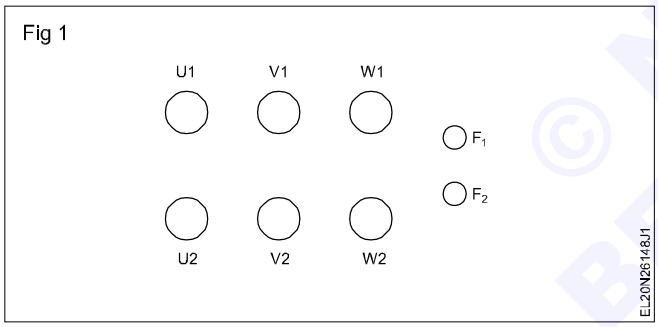
4 Identify the terminals which shown in fig 1. Following the exercise no: 2.5.143 Task 3 for starter terminals.

5 Identify the exciter terminals.

Table

Sl. No.	Label No.	Name of Part

Fig 1



Connect start and plot V-curves for synchronous motor under different excitation and load conditions

Objectives: At the end of this exercise you shall be able to
- **connect the synchronous motor with its starter**
- **start and run the sychronous motor with its starter**
- **plot the 'V' curve.**

Requirements

Tools/Instruments

- Trainees tool kit - 1 No.
- MI Ammeter 0-10 A - 1 No.
- MC Ammeter 0-1 A - 1 No.
- MI Voltmeter 0-500 V - 1 No.
- Frequency meter (45-50-55Hz) - 1 No.
- Tachometer 0-10000 rpm - 1 No.

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.
- Field rheostat suitable for above motor - 1 No.

Materials

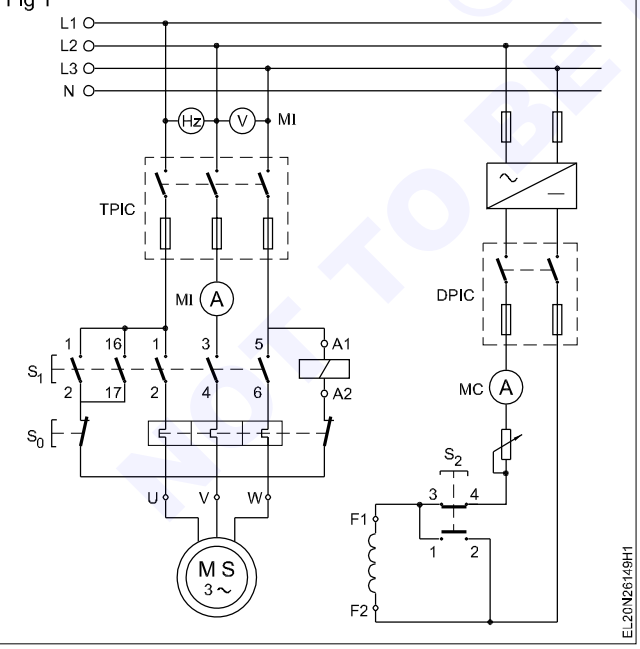
- Connecting leads - as reqd.

PROCEDURE

TASK 1: **Connect the synchronous motor, start, run and test it**

1 Make the connections as per circuit diagram. (Fig 1)

Fig 1



2 Show the connections to your instructor and get his approval.

3 Close TPIC switch and DPIC.

4 Adjust the field current to its rated value as per name plate detail.

5 Hold push button S_2 depressed, and start the motor by operating switch S_1.

Make sure that push button S_2 is pressed before energising the motor at the time of starting.

When S_2 is depressed DC supply to field is disconnected and field winding terminals F1 and F2 are shorted.

6 After the rotor attains maximum speed say 95% of the synchronous speed release push button S_2 i.e. field winding is excited by DC supply.

With field winding excited the motor gets pulled into synchronism and runs at synchronous speed.

7 Measure speed, supply voltage, frequency, line current, and field excitation current and record in Table 2.

Table 2

Line voltage	:	Volt
Line current	:	amp
Excitation current	:	amp
Speed	:	r.p.m
Frequency	:	Hz

8 Calculate the synchronous speed of the motor by using the formula.

$$N_S = \frac{120\,f}{p}$$

Synchronous speed N_s =... rpm.

9 Compare the synchronous speed with the measured speed, and ensure measured speed is equal to synchronous speed.

— — — — — — — —

TASK 2 : **Plot the V-Curve for synchronous motor under different excitation and load condition**

1 Start and run the synchronous motor to its maximum speed without load.

2 Adjust the field current by adjusting the field rheostat (Fig 1) and take the readings of armature current (I_a) and field current (I_f)

3 Note down the readings in Table 1 and plot the 'V' curves for synchronous motor under different excitation and load conditions in a separate graph sheet. The same Procedure has to be repeated for loaded condition.

Table 1

Sl. No.	Without Load		With Load	
	Armature Current (I_a)	Field Current (I_f)	Armature Current (I_a)	Field Current (I_f)

— — — — — — — —

Power Exercise 2.6.150
Electrician - Synchronous Motor and MG Set

Identify the parts and terminals of MG set

Objectives: At the end of this exercise you shall be able to
- **read and interpret the name plate details of the given M.G set**
- **determine the pairs of terminal of the windings of the DC machine by the test lamp method**
- **Identify their parts and write their names.**

TASK 1 : **Identify the parts of a 3-pahse squirrel cage induction motor**

For this Topic Refer Exercise No: 2.3.123 For TASK 1 and TASK 3

— — — — — — — —

TASK 2 : **Identify the terminals of DC generator of the MG set**

1 Read and interpret the name plate details of the given DC generator and note down in Table 2.

For this TASK Refer Exercise No: 2.1.107 - TASK 2

— — — — — — — —

Start, and load a MG set with 3 phase induction motor coupled to DC shunt generator

Objectives: At the end of this exercise you shall be able to
- **connect 3-phase motor with the starter**
- **connect a DC shunt generator, field regulator, ammeter and voltmeter**
- **start the 3-phase AC motor**
- **adjust the field regulator and build up DC voltage**
- **determine combined efficiency of the M.G set.**

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

- 3-phase squirrel cage induction motor 5 HP, 500V, 50 Hz with star-delta starter 500V, 16A - 1 No.
- DC shunt generator - 5 KW 220V with field regulator - 1 No.
- Lamp bank of 5 KW - 250 V - 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.

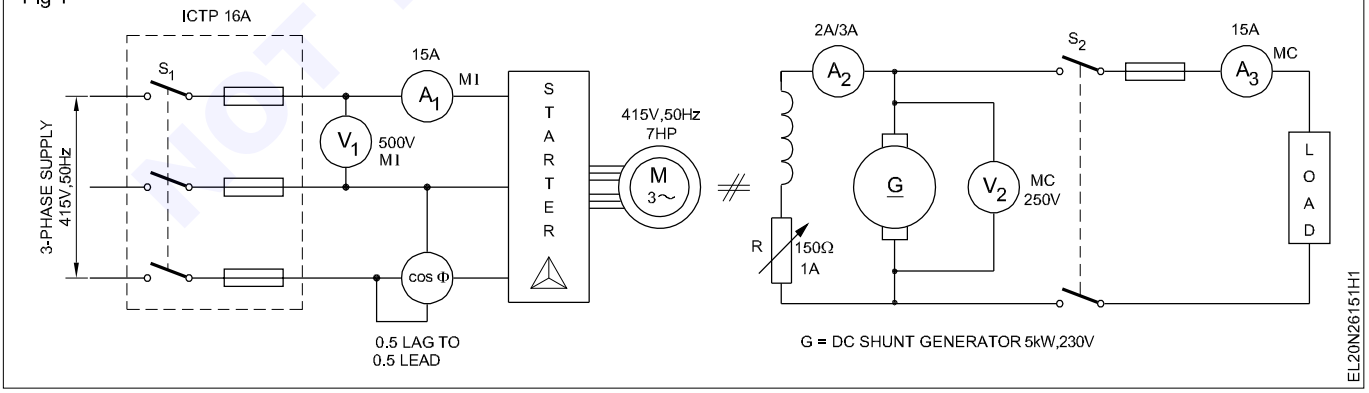
PROCEDURE

TASK 1 : **Start run and load a MG set**

1 Connect the AC motor and generator. (Fig 1)

Keep the field regulator at a position to include zero resistance in the circuit. Keep switch S_1 and S_2 in 'off' position.

Fig 1



2 Start the AC motor. Measure the speed using a tachometer.

3 Build up the DC generator terminal voltage to its rated value and observe the voltmeter (V_2) reading.

4 Switch 'ON' the load switch S_2.

5 Increase the load gradually by switching 'on' the lamps in steps up to the rated capacity of MG set.

6 Measure the speed of the generator for each load condition and record in Table 1.

7 Record input current, voltage and power factor in Table 1. Read and record the load current and terminal voltage of generator in Table 1.

8 Switch 'OFF' the load in steps and open the load switch S_2.

9 Calculate the input power.

10 Calculate the output power.

11 Calculate the total loss and the efficiency at full load.

12 Stop the prime mover of the M.G. set and isolate supply.

Conclusion

Observe from the readings in Table that the terminal voltage drops with increase in load. State your reasons.

Table 1

OUTPUT			INPUT		
Load current (I)	**Terminal voltage (V)**	**Speed in r.p.m**	**Line current (I_L)**	**Line voltage (V_L)**	**Power factor**

Determine the value of resistance by colour code and identify the types

Objectives: At the end of this exercise you shall be able to
- **identify the types of resistors by referring to the pictorial representation**
- **identify the colour bands, and decode the resistance value**
- **calculate the tolerance value by the colour band.**

Requirements

Tools/Instruments

- Multimeter/Ohmmeter - 1 No.

Materials

- Various types of resistors (assorted values) including potentiometers of carbon track and wire-wound type. - as reqd.

PROCEDURE

TASK 1: **Identify the type of resistor from pictorial representation**

1 Identify the resistor's type by referring Fig 1 and write the type in Table 1.

2 Sketch the I.S. symbol for the identified resistor in Table 1.

Fig 1

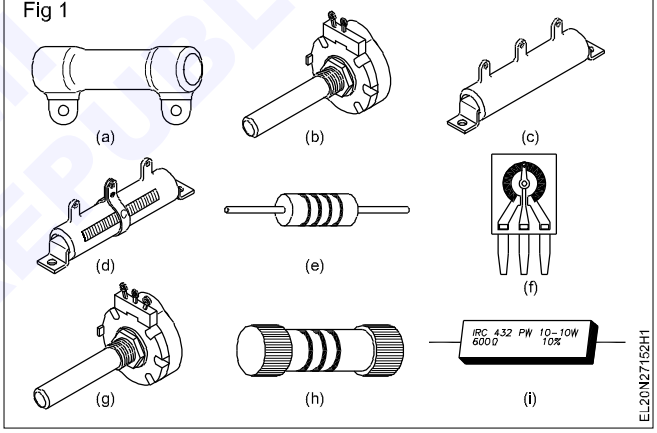


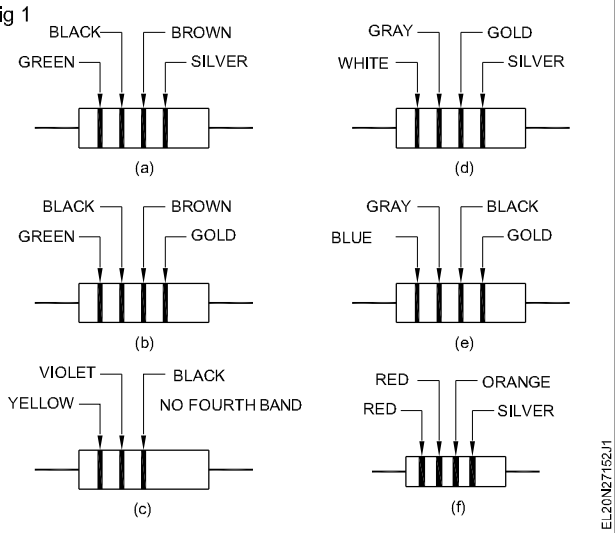
Table 1

Sl. No.	Sketch reference	Type of resistor	Symbol
1	A		
2	B		
3	C		
4	D		
5	E		
6	F		
7	G		
8	H		
9	I		

TASK 2 : **Identify the colour band and decode the resistance value**

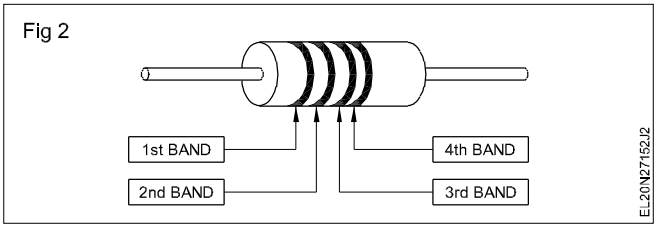
1 Identify the value of resistors shown in Fig 1 from the colour bands and enter Table 1.

Fig 1



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.

Fig 2



3 Write the 1st number and 2nd number in Table 1.

4 Identify the colour of the 3rd band and write the multiplier value in the respective column in Table 1.

5 Compute the value of the resistor and record in Table 1.

6 Identify the 4th band colour and fill up the tolerance in Table 1.

7 Determine the resistance value and the tolerance for the another given resistors and record in Table by repeating the above steps 1 to 6.

8 Measure the value of the resistors by using a multimeter/ohmmeter and enter the values in Table by following the procedure given below.

Table 1

Sl.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										

— — — — — — — —

Test active and passive electronic components and its applications

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

- **identify the electronic components - diode, diode bridge, transistor, SCR, IC by referring to the pictorial representation**
- **identify the given electronic components- diode, diode bridge, selenium bridge, transistor, IC, by visual inspection**
- **identify the passive components by visual inspection**
- **interpret the coding and marking on the components**
- **test the components for its working conditions.**

Requirements

Tools/Instruments

- Multimeters/Ohmmeter - 1 No.

Materials/Components

- Capacitors, inductors, resistors (assorted size, shape and values) - as reqd.
- Assorted components of diodes, transistors, SCRs, DIACs, TRIACs, UJTs, FETs bridge diodes etc of different types with semi-conductor data manual - as reqd.

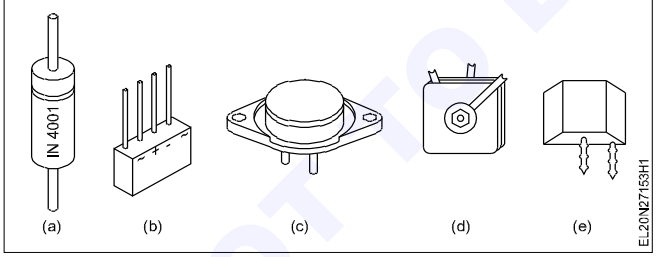
PROCEDURE

TASK 1: **Identify the active components**

Assumption: Given components have their code number, lead identification marks are available in data book

1 Look at the Fig 1. Identify the component from the pictorial representation. Give your response in Table 1.

Fig 1



2 Write the figure Nos. that indicate the components given in Fig 2, in Table 2

Fig 2

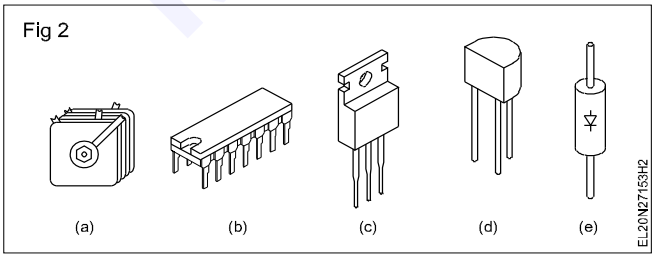


Table 1

Sl.No.	Figure number	Component's name
1	Fig 1 a	
2	Fig 1 b	
3	Fig 1 c	
4	Fig 1 d	
5	Fig 1 e	

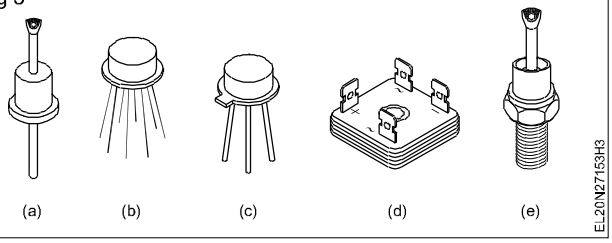
Table 2

Sl. No.	Figure number	Component's name
1		Transistor with heat sink
2		Diode bridge
3		Integrated circuit
4		Diode
5		Transistor

3 Match the names and pictorial representations of the active components (Fig 3).Record your response in the space provided.

4 Collect the electronic (ACTIVE) components from your instructor. Identify the components and record your response in your record book along with sketches of the components. (Refer Fig 3 for guidance)

Fig 3



5 Get it checked by your instructor.

TASK 2 : **Identify and check the passive components**

Instructor shall select the resistors, inductors and capacitors so that, few can be visually identified and other can be identified by coding only.

1 Identify the passive components referring to Fig 1 and write the type of passive component in Table 1.

2 Sketch the appropriate symbol against the corresponding type of passive components in Table 1.

3 Get your result corrected by your instructor.

4 Collect assorted size, shape and type of passive components from your instructor.

5 Divide the passive components into separate groups as resistor, inductor and capacitor by their appearances (or) code references.

6 Interpret, the code references of resistor and list them in Table 2.

7 Measure the value of resistance of each by multimeter and record in Table 2.

8 Interpret the code references of capacitor and list them in Table 3.

9 Check the capacitor for charge and discharge by multimeter, and record the condition in Table 3 by referring Fig 1.

Table 1

Sl. No.	Fig alphabets	Components identified as	Reasons for identifications	Symbols	Remarks
1	A				
2	B				
3	C				
4	D				
5	E				
6	F				
7	G				
8	H				
9	I				
10	J				
11	K				
12	L				
13	M				
14	N				
15	O				
16	P				

Table 2

Sl. No.	Coded reference	Type of resistors and other details	Measured value of resistor
1			
2			
3			
4			
5			
6			

In case of very low value of capacitors, multimeter may not show any deflection during charge or discharge. Anyhow if the multimeter reading is infinity the capacitor has to be considered as good in case of non electrolytic capacitors.

10 Interpret the code references of inductors/ coils / transformers and list them in Table 4.

11 Check the continuity of the coil and its tapping with the multimeter and record the condition in Table 4.

There should not be any continuity between coil and the core

12 Get the above observation approved by your Instructor.

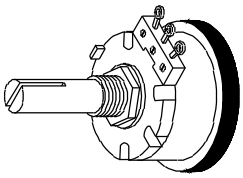
Table 3

Sl. No.	Coded reference	Type of capacitors and other details	Condition of capacitor
1			
2			
3			
4			
5			
6			

Table 4

Sl. No.	Coded reference	Type of inductors /coils transformers and other details	Condition of coil
1			
2			
3			
4			
5			
6			

Fig 1



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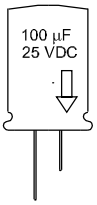

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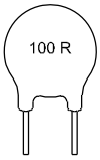

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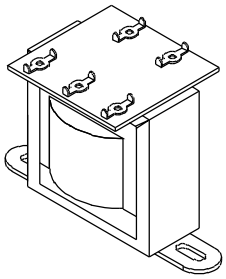

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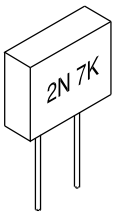

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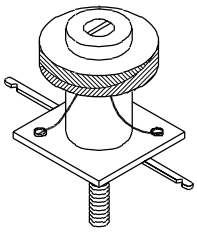

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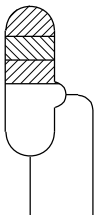
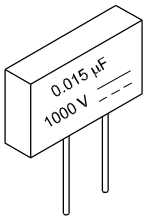


G

H



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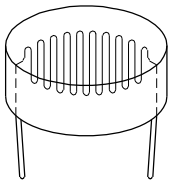

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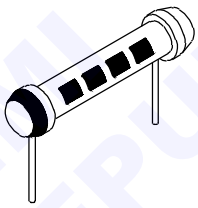

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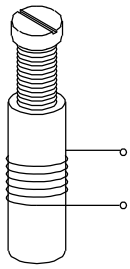

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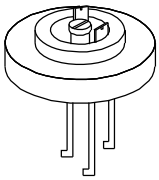

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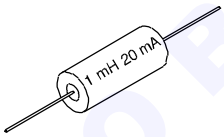

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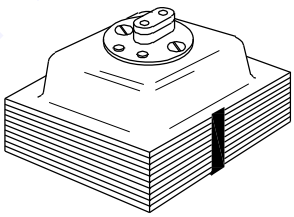
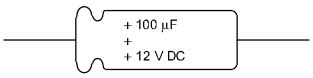


O



P

EL20N27153J1

Determine the V-I characteristics of semi conductor diode

Objectives: At the end of this exercise you shall be able to
- **refer data book and**
  - **a) identify the diode is Ge, Si etc**
  - **b) verify operating voltage and current rating**
  - **c) list the application of the diode**
- **identify the terminals of a diode and test the diode for its condition**
- **plot the forward characteristics, determine the forward resistance of the diode and the barrier potential**
- **plot the reverse characteristics of the diode and determine the minority carrier current.**

Requirements

Tools/Instruments

- Multimeter (Digital) - 1 No.
- Voltmeter MC 0-1 V - 1 No.
- Milliammeter MC 0-25 mA - 1 No.
- Voltmeter MC 0-30 V - 1 No.
- Micro ammeter MC 0-100 Micro Amp - 1 No.
- Semi conductor diode data book - 1 No.

Equipment/Machines

- DC regulated power supply 0- 30 V, 1 A - 1 No.

Materials

- Assorted types of diodes including IN 4001 or IN 4007 - as reqd.
- 570 Ω, 5W potentiometer - 1 No.
- SPST switch 6A 250V - 1 No.
- Bread board 150 x 150 mm - 1 No.
- Suitable connecting wires for bread board - as reqd.
- Patch cords with clips - 2 sets
- 100Ω 1/4 W resistor - 1 No.
- 10 Ω 1/4 W resistor - 1 No.

PROCEDURE

TASK 1: **Refer the diode with data book**

1 Select any one of the given assorted diodes. Record the type number printed on the diode.

2 Refer diode data book and search for the type number of the selected diode.

3 Look in the data book for the column which indicates Rated peak reverse voltage abbreviated as V_R or V_r or PIV against the referred diode. Find and record the indicated value of rated peak reverse voltage.

4 Get as done in step 4 and record the following specifications of the referred diode from the data book:
- I_F of I_f - Maximum average forward current
- V_F of V_f - Forward voltage drop at specified I_F
- I_s - Maximum forward surge current
- I_{VT} - Maximum reverse current at V_R
- Function - Normal use/application of the diode.

The coding used for Function differs from data book to data book. Consult instructor in case of difficulty.

5 Repeat steps 1 to 5 for atleast ten different types of given diodes.

6 Refer diode data book or diode equivalents data book and identify one or two equivalent diode types for each diode. For those diodes you collected the specification.

7 Get your work checked by your instructor.

— — — — — — — —

TASK 2 : **Identify the terminal leads of a given diode**

1 Set the multimeter in ohms range (W x 1). Connect its leads to a M.C. voltmeter (0-3V), to find out the polarity of multimeter output voltage.

In digital multimeter the marked polarity and polarity of output voltage are the same.

2 Check the deflection of the voltmeter, if it indicates the voltage, mark the terminal of the multimeter corresponding to the voltmeter polarity

3 Mark the terminal of the multimeter opposite to voltmeter polarity. If the voltmeter kicks back then.

4 Connect the +ve marked terminal for the multimeter to one terminal of the diode and other to the -ve and observe the reading.

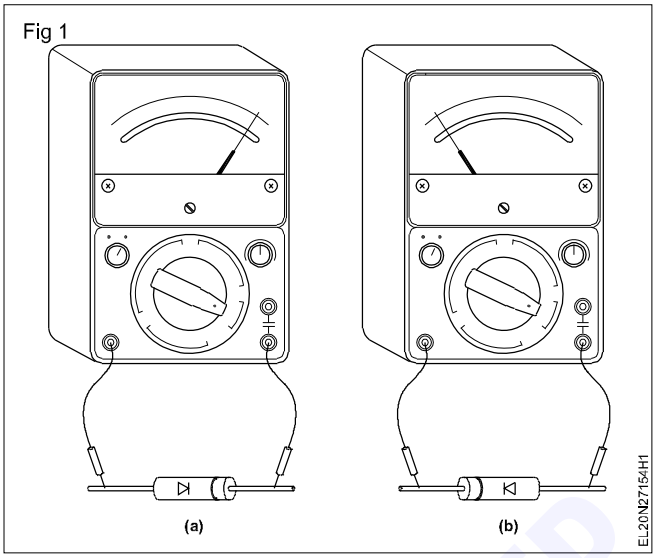
a) If the meter reads low resistance then the lead of the diode connected to +ve marked terminal of the meter is the ANODE and the other is cathode. (Fig 1a)

b) If the meter does not deflect as in Fig 1b then the lead of the diode connected to +ve marked terminal for the multimeter is the cathode and the other is anode.

If the meter reads low resistance for both polarities the diode is short.

If the meter reads high resistance for both polarities the diode is open.

Fig 1



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TASK 3 : **Determine the forward V-I characteristic of the diode**

1 Construct the circuit in the bread board as in Fig 1.

2 Set initially V_B = 0 and switch ON the power supply.

3 Set V_B= 5V, set the potentiometer to minimum position.

4 Close the switch S and adjust potentiometer to increase the voltage across the diode in steps of 0.1 V as per the Table.1

5 Record the corresponding values of current read by the ammeter in the Table.1.

Fig 1

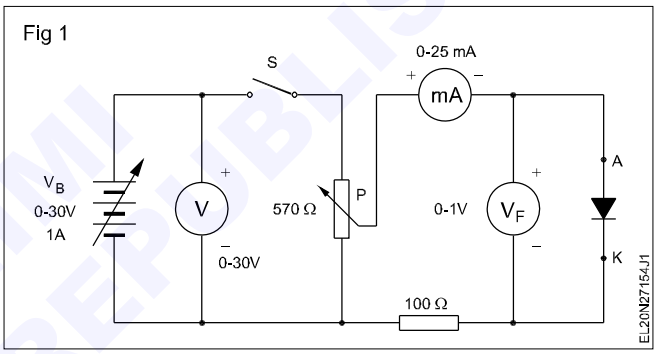


Table 1

V_F Volt	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	2.0
I_FmA	0											

6 Check the value of voltage across the diode at which the current starts increasing and remain constant at later.

7 Switch OFF the supply

8 Plot the graph with V_F on X axis and I_F on Y- axis.

9 Determine the forward resistance.

$$R_F = \frac{V_F}{I_F} \text{ ohms}$$

From the graph determine the knee point voltage at which large quantity of current starts flowing. Enter the value below.

Knee point voltage .... volts If the knee point voltage is around 0.3 V or 0.7V the diode is germanium or silicon respectively.

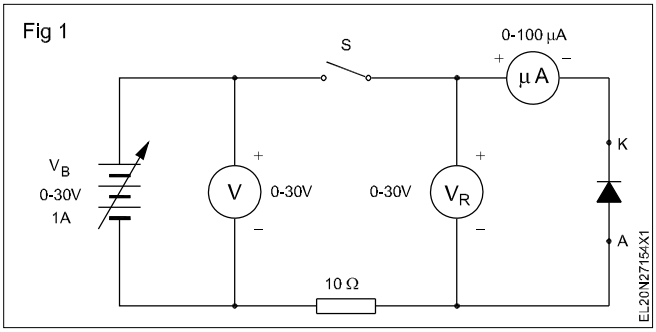
Note : Increase the voltage beyond 2.0V as indicated in case diode is not reached in saturation current.

— — — — — — — —

TASK 4 : **Determine the reverse V-I characteristic of a diode**

1 Construct the circuit in a bread board as in Fig 1. (Reverse the Diode terminals with respect to previous task)

Fig 1



2 Switch on the power supply and close the switch S.

3 Increase the voltage gradually across the diode by operating the power supply as per Table 1 and note down the corresponding current read by the ammeter in Table 1.

4 Switch OFF the power supply.

5 Plot the graph on the same graph sheet (Task 3) with V_R on x-axis and I_R on Y-axis.

6 Determine the minority carrier current from the graph.

If the reverse voltage becomes equal to the PIV of the diode then the diode starts conducting and not to increase the voltage beyond PIV of the diode.

7 Repeat the experiment for different type of diodes.

Table 1

V_R Volts	0	5	10	15	20	30
I_R in Micro camps						

Construct half-wave, full wave and bridge rectifiers using semi conductor diode

Objectives: At the end of this exercise you shall be able to
- **construct a half-wave rectifier and test**
- **construct and test a full-wave rectifiers using two diodes**
- **construct and test bridge type, full wave rectifiers using four diodes.**

Requirements

Tools/Instruments

- Trainees kit - 1 No.
- Voltmeter MC 0-30V - 1 No.
- Multimeter (Digital) - 1 No.

Materials/Components

- Bread board - 1 No.
- Diode IN4007 - 4 Nos.
- Resistor 470Ω (Ohm) - 1 No.
- Step-down transformer, 240V/12.0.12, 500mA - 1 No.
- Multi strand wire, red, blue 23/0.2 of 650V grade - as reqd.
- Mains cord 3 core cable 23/0.2 of 650V grade - 1 No.
- 3 Pin plug 6A 250 V - 1 No.

PROCEDURE

TASK 1: **Construct half-wave rectifier and test it**

1 Test the continuity of the primary and secondary windings of the given transformer. Record the specifications of the given transformer.

2 Follow the order of steps given below by referring Fig 1.
- Mount the rectifier diode on bread board.
- Connect three core power cord to the transformer.

3 Connect AC mains to the board and switch ON mains. Measure and record the mains voltage and transformer secondary voltage $V_{S(rms)}$ (AC input to rectifier) in the Table 1.

4 Calculate and record the calculated DC voltage across load R_L using the formula,

$V_{dc} = 0.45\ V_{S(rms)}$

where, $V_{S(rms)}$ is the AC input to the rectifier.

5 Measure and record the rectified DC voltage V_{dc} across load R_L using multimeter.

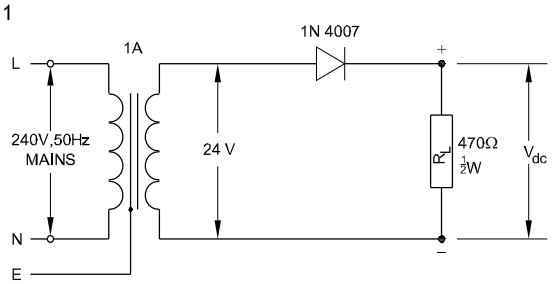
6 Record the difference in the calculated and measured values.

7 Get it checked by your instructor.

Transformer specifications

Rated primary voltage	
Rated secondary voltage	
Secondary current or VA rating of transformer	
Type of transformer step-up/ step down	
No. of windings in secondary	

Fig 1



HALF-WAVE RECTIFIER CIRCUIT DIAGRAM

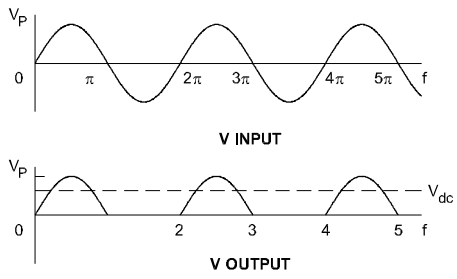


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Table 1

Readings of single diode half wave rectifier

$V_{s(rms)}$ (1)	Calculated V_{dc} volts (2)	Measured V_{dc} volts (3)	Difference of (2) & (3) (4)	Peak value of V_s (5)	Frequency of V_s (6)

TASK 2 : **Construct full wave rectifier with centre tap transformer**

1 Check to confirm good condition of the given components. Record specifications of the transformer.

2 Construct a full wave rectifier circuit as shown in the schematic and layout diagram at Fig 1.

Transformer specifications

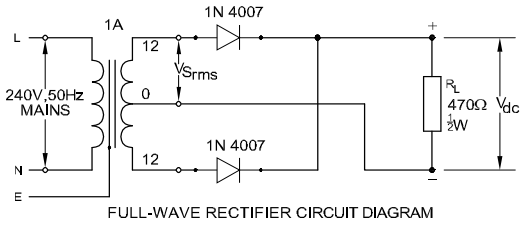
1 Rated primary voltage	-----
2 Rated secondary voltage between centre tape and one end	-----
3 Rated secondary current or VA rating transformer	-----

3 Switch ON the circuit. Measure the AC input voltage $V_{s(rms)}$ to the rectifier across the center-tap and any one end of the transformer and record it in Table 1.

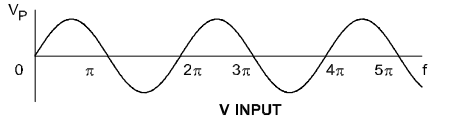
4 Calculate the expected DC voltage V_{dc} across load R_L using the formula given below;

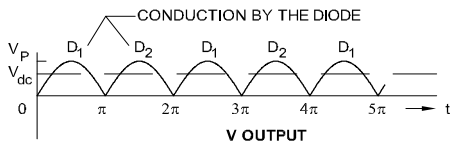
In full wave rectifier, V_{dc} = 0.9 $V_{s(RMS)}$ where, $V_{s(rms)}$ is the voltage across the centre-tap and any one end terminal of secondary. Record the value in Table 1.

Fig 1



FULL-WAVE RECTIFIER CIRCUIT DIAGRAM





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5 Measure the rectified output V_{dc} across load R_L and record it Table 1.

6 Calculate and record the difference in the calculated and measured V_{dc} values. Get it checked by your instructor.

Table 1

Readings of two-diode full-wave rectifier

$V_{s(rms)}$ (1)	Calculated V_{dc} volts (2)	Measured V_{dc} volts (3)	Difference of (2) & (3) (4)	Peak value of V_s (5)	Frequency of V_s (6)

— — — — — — — —

TASK 3 : **Construct bridge rectifier**

1 Modify the two diode full wave rectifier wired in Task 2 to construct a bridge rectifier, referring to the schematic and layout diagrams (Fig 1).

2 Switch On the circuit. Measure and record the AC input $V_{s(rms)}$ to the rectifier in Table 1.

3 Calculate the expected output DC voltage V_{dc} across load R_L using the formula, In a bridge rectifier.

V_{dc} = 0.9 $V_{s(rms)}$ where, $V_{s(rms)}$ is the AC input to the rectifier (refer Fig 1). Record the value in Table 1.

4 Measure the DC output V_{dc} across the load R_L and record it in Table 1.

5 Record the difference in the calculated and measured values in Table 1.

6 Report and get it checked by your instructor.

Fig 1

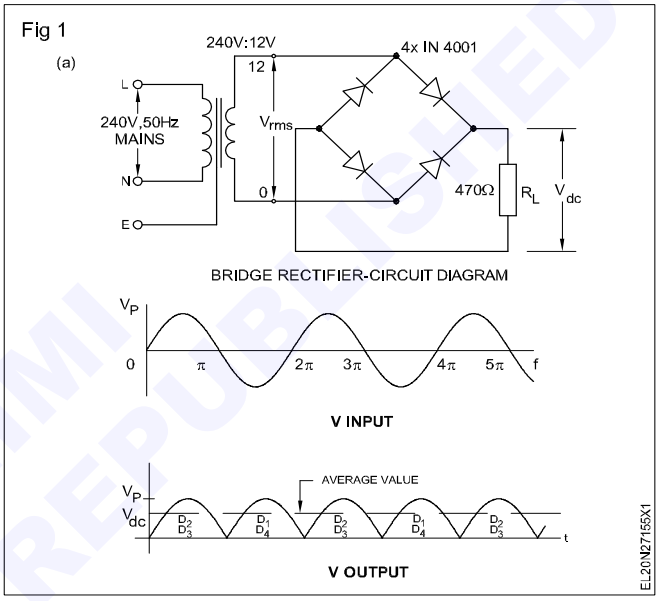

Table 1

Readings of bridge rectifier

$V_{s(rms)}$ (1)	Calculated V_{dc} volts (2)	Measured V_{dc} volts (3)	Difference of (2) & (3) (4)	Peak value of V_s (5)	Frequency of V_s (6)

— — — — — — — —

Check transistors for their functioning by identifying its type and terminals

Objectives: At the end of this exercise you shall be able to
- **identify a transistor from its type-number the following information referring to a data book;**
  a) silicon or germanium
  b) PNP or NPN
  c) package type
  d) base, emitter, collector pins.
- **test the condition of a given transistor using ohmmeter/multimeter.**

Requirements

Tools/Instruments

- Trainees kit - 1 No.
- International transistors data book - 1 No.
- Ohmmeter/multimeter - 1 No.

Materials/Components

- Assorted type of transistors - 10 Nos
- Sleeve wires of red, yellow, blue and black colours 1mm dia - as reqd.

PROCEDURE

TASK 1 : **Identify transistor type and leads, referring to data manual**

1 Take any one transistor from the given assorted lot (Fig 1), enter its label number and transistor type number in Table 1.

2 Refer to transistor data manual, find and record the following details of the transistor in Table 1
- Whether silicon or germanium
- Whether NPN or PNP
- Type of packaging or case outline (Example: TO5, TO7 etc.)

Fig 1

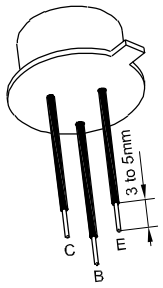

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Table 1 (With sample data)

Label No.	Transistor type No.	Semi-Conductor /type	Type of package	Pin Diagram	E-B Junction resistance B-C	
					in forward bias E-B	in reverse bias (E-B & B-C)
Sample	BC107	Si/NPN	T018		Low	Very High

3 From the type of package recorded, refer to the transistor data manual and draw the pin diagram indicating base, emitter and collector for the transistor in Table 1.

4 Put sleeves of suitable length (Fig 1) to the identified pins of the transistor using the colour scheme given below:

Base : Blue colour sleeve

Emitter : Red colour sleeve

Collector : Yellow colour sleeve

Shield : Black colour sleeve

In power transistors, the metal body itself will be the collector. In such cases, mark 'C' on the metal body using a pencil. All transistors will not have shield pin.

5 Repeat steps 1 to 4 for atleast five transistors of different types in the given lot and get your work checked by your instructor.

— — — — — — — —

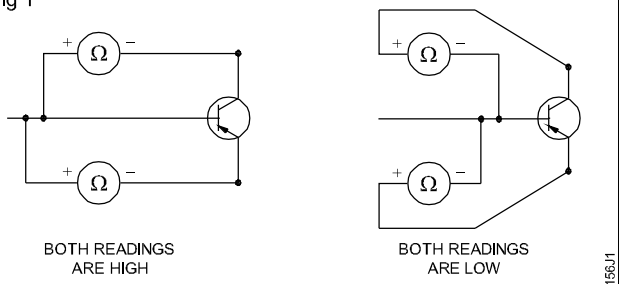
TASK 2 : **Check the transistor for PNP or NPN type**

Referring a data book with respect to transistor number gives the information whether transistor is PNP or NPN. In the absence of data book this test will be useful.

1 Ascertain the +ve and -ve polarity of the ohmmeter leads.

2 Hook the negative lead of the ohmmeter test prod to the base and the positive lead of the ohmmeter to emitter of the transistor.

Fig 1



3 Read the resistance value.

A low reading shows the transistor is PNP and the high reading shows the transistor is NPN provided the condition of the transistor is good. Refer Fig 1 and 2.

4 Record your findings in Table 1 and mark the identified type and condition.

Fig 2

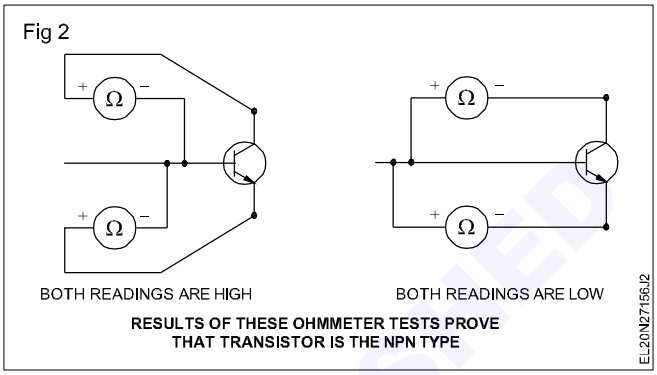


Table 1

Transistor No.	Forward bias		Ohmmeters reading	Reverse bias		Ohmmeters reading	Transistor Type	Remarks
	+Ve	-Ve		+Ve	-Ve			
AC128	E	B	Low	C	B	Low	PNP	Good
	B	E	High	B	C	High		

TASK 3 : **Test transistor for its working condition**

1 Identify which terminal of the ohmmeter being used is connected to the +ve terminal of the internal battery of the meter. Set the meter range to RX100Ω.

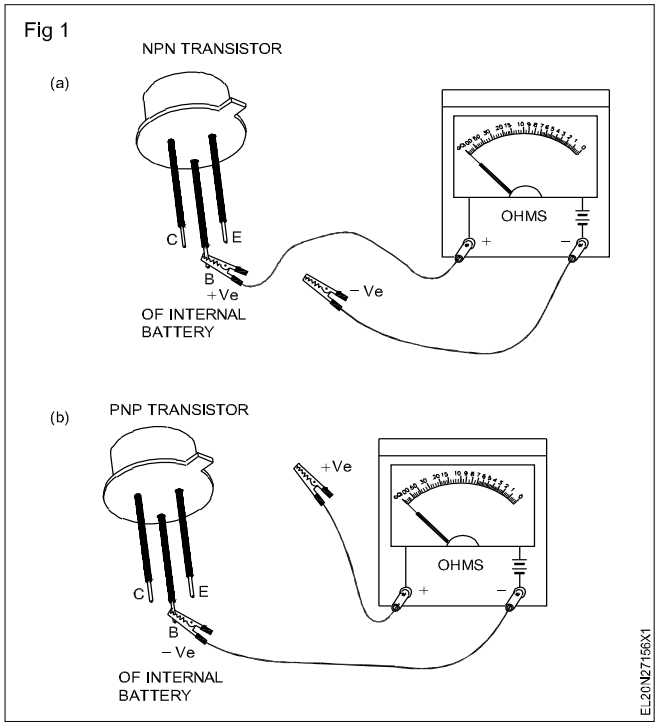
Ohmmeters in very low or very high ohms range can produce excessive current/voltage and may damage low power transistors while testing.

2 Take a transistor whose pins are identified and sleeved at Task 1. Depending on whether the chosen transistor is NPN or PNP, clip/hold the +ve or -ve of the meter prod to the base of the transistor as shown in Fig 1a and 1b.

3 Clip the other meter prod to the emitter. Check if the base-emitter junction diode of transistor shows low resistance (few tens of ohms) or very high resistance (few tens of kilo ohms). Record your observation in Table 1.

4 Reverse the polarity of the prod connected across the base-emitter and check if the base-emitter junction diode of transistor shows low resistance or very high resistance. Record your observation in Table 1.

Fig 1



5 From the recorded observations in steps 3 and 4, and referring to the table given below, conclude and record, the condition of the base-emitter junction diode of the transistor as GOOD, open or shorted in Table 1.

If the resistance of the junction measured in both directions is high, in addition to the condition of the junction given in table, an other possibility is, your identified base pin may be wrong. You may be measuring resistance across emitter-collector. In case of doubt, recheck the identified pins of the transistor and repeat steps 2,3 and 4.

6 Repeat steps 2,3,4, and 5 and check the condition of the base-collector junction diode of the transistor.

7 Measure the resistance across the emitter-collector and record the observation as V-HIGH (> 1MΩ) or LOW (<500Ω).

In a good transistor the resistance between the emitter and collector will be very high. A low resistance indicates that the transistor is leaky.

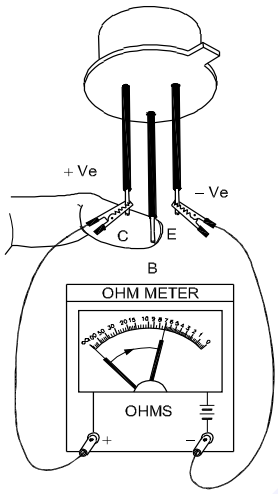
8 Clip the meter across the emitter-collector with correct polarity as in Fig 2. Touch the base-collector with moist finger as in Fig 2 and check if the resistance shown by the meter decreases indicating that the transistor is turning ON. Record your observation as YES or NO in Table 1.

9 From the observations recorded at steps 5,6,7 and 8, give your conclusion on the overall condition of the transistor under test. Refer Table 1.

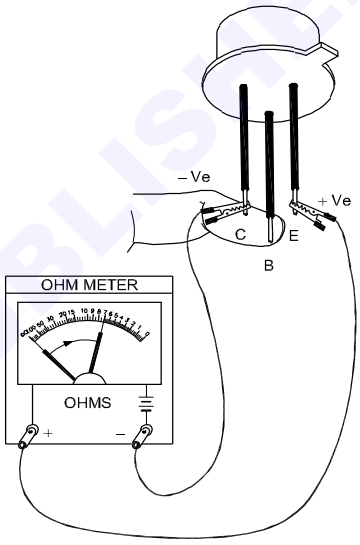
10 Repeat the steps 1 to 9 for at least five more transistors of different types.

11 Report and get your work checked by your instructor.

Fig 2



a) NPN TRANSISTOR



b) PNP TRANSISTOR

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Table 1

Resistance of P - N junction with meter prods in one direction	Resistance of P - N junction with meter in reversed direction	Condition of P - N Junction
Low	Very High	Good
Low	Low	Shorted
Very High	Very High	Open (see Note above)

— — — — — — — —

Bias the transistor and determine its characteristics

Objectives: At the end of this exercise you shall be able to
- **wire up and test a fixed-bias transistor amplifier**
- **wire up and test a emitter-bias transistor amplifier**
- **wire and test a voltage divider-bias transistor amplifier**
- **draw characteristics curve with respect to base current with collector current in all conditions.**

Requirements

Tools/Equipments/Instruments

- Trainees kit - 1 No.
- DC millammeter, 0 - 1 mA - 1 No.
- DC millammeter, 0- 30 mA - 1 No.
- Regulated power supply, 12V, 1A - 1 No.
- DC micro ammeter 0 - 500 µA

Materials/Components

- SL100 or equivalent metal can transistors - 2 Nos.
- Tag board code no.110-03-TB - 1 No.
- Resistors, Carbon, 1/4 W
  - 120 Ω - 1 No.
  - 470 Ω - 1 No.
  - 1K Ω - 2 Nos
  - 5.6K Ω - 1 No.
  - 182K Ω - 1 No.
  - 330K Ω - 1 No.

PROCEDURE

TASK 1: **Wire up and test fixed bias transistor amplifier**

1 Construct the circuit (Fig 1) on the tag board. Identify the type of biasing used in Fig 1 and record in Table 1

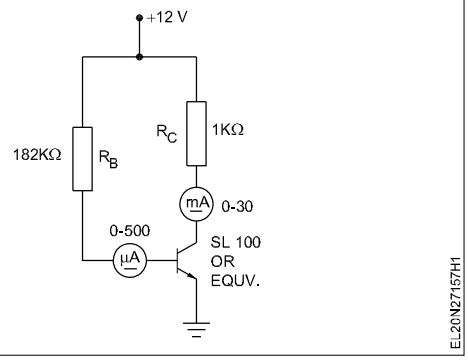
Use the transistor having low β value, (around 100)

2 Switch ON 12V, DC supply to the circuit. Measure and record values of I_B, I_C, V_{BE} and V_{CE} in Table 1.

The readings taken are at normal room temperature.

3 Hold the heated barrel of the soldering iron close to the transistor (but not touching) for 30 sec to 1 min and observe the change in the collector current. Record the changed value of I_B, I_C, V_{BE} and V_{CE} at elevated temperature of the transistor.

Fig 1



The transistor is heated to observe the effect of heat on the set Q point of the transistor.

Table 1

Fixed bias transistor amplifier

Description	I_B µA	I_C mA	V_{BE} volt	V_{CE} volt
Reading taken at room temperature				
Readings taken at elevated temperature				

4 Get your readings checked by your instructor.

5 Switch OFF, power to the circuit. Modify the wired circuit to that in Fig 2. Identify the type of biasing used in Fig 2 and record in Table 2.

6 Switch ON DC supply to the circuit. Measure and record I_B, I_C, V_{BE} and V_{CE} in Table 2.

7 Repeat step 3 and 4.

8 Switch OFF DC supply to the circuit. Modify the wired circuit to that shown in Fig 3. Identify and record the type of biasing used in Fig 3 in Table 3.

Use the transistor having low β value (around 100)

Fig 2

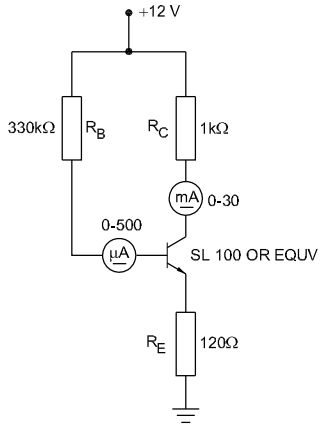


Fig 3

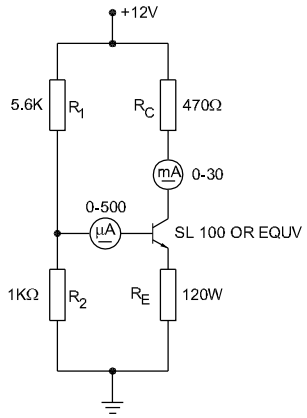


Table 2

Emitter bias transistor amplifier

Description	I_B μA	I_C mA	V_{BE} volt	V_{CE} volt
Reading taken at room temperature				
Readings taken at elevated temperature				

Table 3

Voltage divider bias transistor amplifier

Description	I_B μA	I_C mA	V_{BE} volt	V_{CE} volt
Reading taken at room temperature				
Readings taken at elevated temperature				

9 Repeat steps 2,3, and 4 and record the readings in Table 3

10 Write the conclusion based on the types of bias and stability of current value at collector and base when the circuit is heated.

11 Report and get your readings and graph checked by your instructor.

12 Draw the characteristics curve base current V_S collector current in both cases. (Room temperature and relevant temperature) in the same graph (two curves in one graph).

Use transistor as an electronic switch and series voltage regulator

Objectives: At the end of this exercise you shall be able to
- **determine the minimum forward bias current required to switch the transistor from OFF to ON condition**
- **construct transistorised series voltage regulator and test**
- **measure ripple at input and out put of the regulator and find ripple factor.**

Requirements

Tools/Instruments

- Ammeter MC - (0-100 milliamp) - 1 No.
- Ammeter MC (0-100 microamp) - 1 No.
- Voltmeter MC (0-15 V) - 1 No.
- Trainees Kit
- Unregulated DC power supply 0-30VDC/1A - 1 No.
- CRO, 20 MHz - 1 No./ batch

Equipment/Machines

- DC regulated power supply; 0-30 V 1amp - 1 No.

Materials

- Transistor BC 107 - 1 No.
- Lamp 6V, 150 mA - 1 No.
- Variable resistor 250K 1 W - 1 No.
- Bread board - 1 No.
- Connecting leads - as reqd.
- Dry cell 1.5 V - 1 No.
- Tag board (Code no. 111-01-TB) -1 No.
- Transistor SL 100 or equivalent - 1 No.
- Zener diode, 12V, 1/4W - 1 No.
- 180Ω - 1 No.
- 1KΩ - 2 Nos.
- 220 Ω - 1 No.
- 330 Ω - 1 No.
- Capacitor, 10µF, 25V - 1 No.
- LED, Red colour - 1 No.
- Hook up wires (Red and Black) each - 1 Meter
- Rosin core solder - 20 cms.

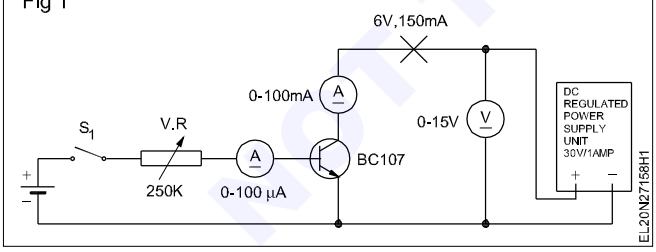
PROCEDURE

TASK 1: **Perform the using of the transistor as an electronic switch**

1 Collect the specifications from the data book for the transistor used in the circuit diagram. (Fig 1)

2 Form the circuit as per the given circuit diagram (Fig 1)

Fig 1



Check for the specific range of instruments and correct polarity.

Keep the supply OFF and the voltage knob of power supply unit at 0V.

3 Switch ON the power and set the collector supply to 10V by operating the voltage knob.

4 Switch ON the battery supply by closing the switch S_1 to the base-emitter circuit.

5 Adjust VR for base current of 5 microamps and note the collector current and record it in Table 1.

6 Change I_b to 90 microamps insteps as in the Table 1.

Table 1

Base current in micro-ampere	5	10	20	30	40	50	60	70	80	90
Collector current in milliampere										
State										

7 Check the value of I_b for which I_c has not changed, (i.e. I_c is saturated).

8 Vary the I_b base current between the two readings to find the exact value of I_b at which I_c reaches saturation.

9 Set the I_b to a value just above minimum to cause I_c saturation and check for 'ON' 'OFF' action by operating switch S_1. Switch OFF power supply.

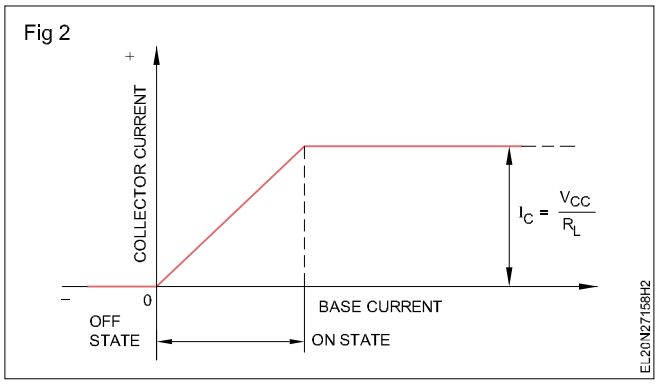
10 Connect a lamp 6V, 150mA in the collector circuit as in Fig 1 and switch 'ON' the power supply.

11 Check lamp glowing; if not slightly adjust the base current to increase till the lamp 'ON'.

12 Confirm the lamp operation by operating base current of Transistor.

13 Draw the base to the collector current graph, and mark the states of the transistor. (Fig 2)

Fig 2



TASK 2 : **Construct transistorised series voltage regulator**

1 Refer data book and record the required details of the given transistor in Table 1.

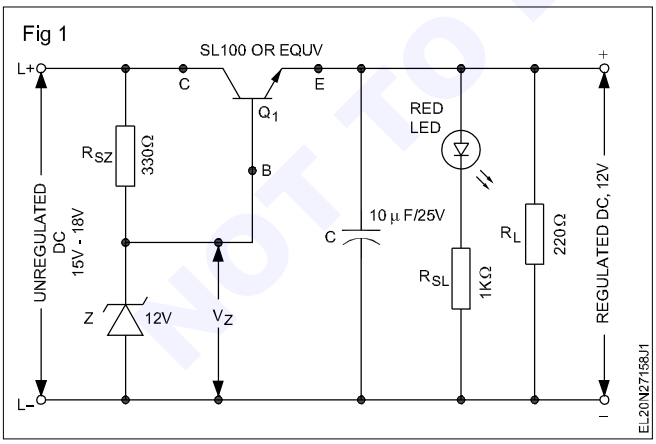
Table 1

Sl.No.	Input P.S voltage in volts	O/P P.S voltage in volts	Remarks
1	6		
2	8		
3	10		
4	12		
5	14		
6	16		

2 Test to confirm the condition of the given components.

3 Solder the components on the given Tag board as per the schematic diagram shown in Fig 1. Get the wired circuit checked by your instructor.

Fig 1



4 Connect an unregulated DC voltage of 0 - 30V to the input terminals of the wired series regulator board.

5 Get the interconnections made checked by your instructor.

6 Switch on the AC mains supply to the unregulated dc supply.

7 Measure and record the input voltage and output voltage of the series regulator.

8 Measure and record the following voltage levels in observation and tabulation sheet .

a) Voltage across zener, V_Z

b) V_{CE} of the transistor Q_1

c) V_{BE} of the transistor Q_1.

9 Keep input P.S Voltage 2V and measure O/P voltage and record in Table 1.

10 Increase the voltage steps of two and record the corresponding O/P voltage in Table 1.

11 Increase the voltage steps up to 16V and record.

Beyond 12V in the output voltage, any increase in input voltage beyond 12V, 14V or 16V will not make any change in output voltage.

12 Switch 'OFF' & Connect to the CRO to the I/P side and O/P side of P.S. (using dual trace CRO) measure and record the ripple presentation the circuit. Record it in Table 1.

13 Calculate the ripple factor in Table 1.

Operate and set the required frequency using function generator

Objectives : At the end of this exercise you shall be able to
- **identify the various controls of the function generator**
- **operate the equipment and set the required frequency and wave form**
- **measure the time and frequency of the set waveform using CRO.**

Requirements

Tools/Instruments

- 10 MHz oscilloscope dual Trace - 1 No.
- Function generator - 1 No.
- AF oscillator 20 kHz - 1 No.

Materials

- Patch cords - 1 Set.

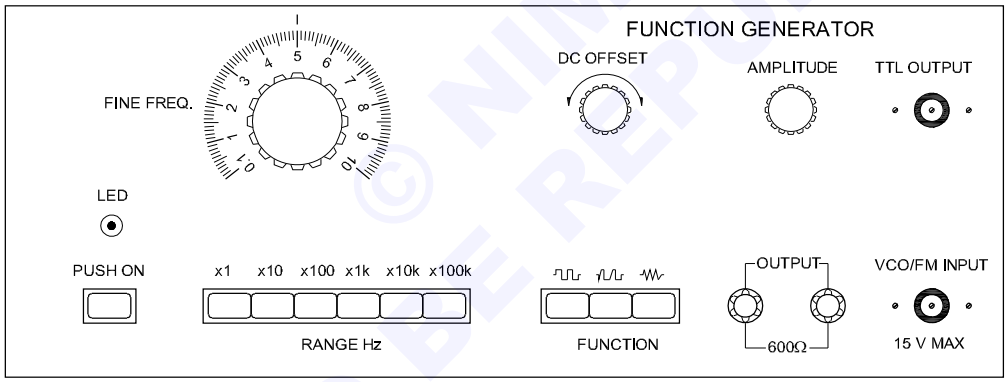
PROCEDURE

TASK 1: **Practice using of a function generator**

1 Locate the various control of the function generator on its front panel which may look like Fig 1. (Some other model have few changes)

2 Keep the amplitude adjustment knob to a minimum position.

Fig 1



FRONT PANEL OF FUNCTION GENERATOR

3 Connect B & C cable to CRO and set CRO working/ measuring conditions.

4 Using patch cords connect the output terminals of the function generator to the input terminals of the CRO. Keep both the instruments in OFF position.

5 Press the function switch to select sine wave.

6 Select 10 Kilo Hertz Range by pressing the range switch marked 'X 10 K'

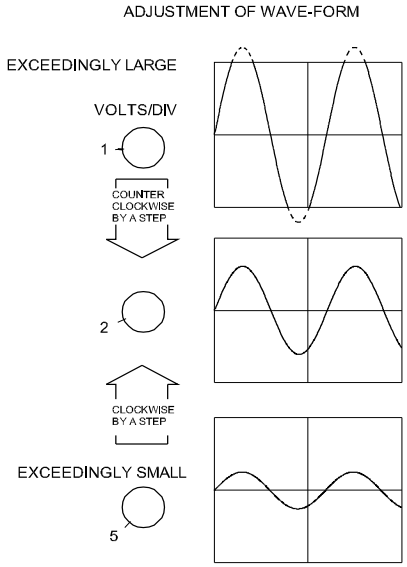
7 Keep the fine frequency dial to position 2 (Fig 1).

8 Set AC-DC switch to AC position (out) in the CRO.

9 Switch 'ON' the power of both function generator and the CRO. Adjust the trace to be on the centre of the screen.

10 Adjust the amplitude knob of the function generator and the Volts/DIV on the CRO To get a clear sine wave on the screen follow the illustration (Fig 2).

Fig 2

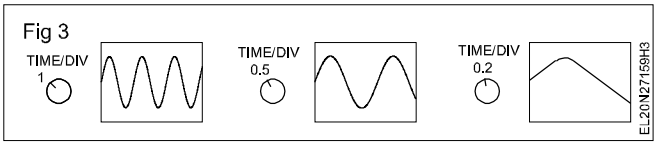


11 Adjust the TIME/DIVISION knob to get adequate number of peaks on the screen.

Relationship between TIME/DIV. (sweep time) and No. of peaks.

When the TIME/DIV. switch is turned clockwise, the time per one period of saw-tooth wave will become small and the wave-form part is stretched. (Fig 3)

Fig 3



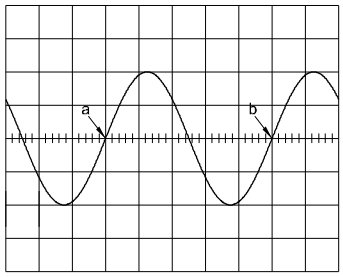
12 Adjust the X-shift control to move the start of the measurement period to a convenient reference point (intersecting point of vertical and horizontal lines). (Fig 4)

13 Check the time period of the wave form. The time between a and b can be determined by counting the no. of horizontal divisions and multiplying it with time base range.

Example

If the time base is set to 0.01 millisecond. There are 5 divisions between 'a' and 'b'.

Fig 4



therefore time period t = 5 x 0.01 = 0.05 ms

therefore frequency of the wave form

$$\text{'f'} = \frac{1}{t} = \frac{1}{0.05 \times 10^{-3}}$$

$$= 20 \text{ kHz.}$$

14 Vary the frequency range settings on the functions generator (follow the Table.1) and verify the output frequency using oscilloscope.

15 Set the function switch to some other wave (e.g. square, triangular etc.,) and repeat the steps 9 to 13 (Note to record the readings in Table 1). Only sine wave entry is needed in Table 1.

Table 1

Trial No.	Range switch position	Fine freq. dial position	Set frequency	Measured frequency using CRO	Remarks
1	x 1	10	10 Hz	—	
2	x 10	5	50 Hz	—	
3	x 100	3.5	350 Hz	—	
4	x 1K	5	5 kHz	—	
5	x 10K	0.1	1 kHz	—	
6	x 100K	2	200 kHz	—	

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Make a printed circuit board for power supply

Objectives: At the end of this exercise you shall be able to
- **transfer the layout on to a copper clad board**
- **punch component mounting holes**
- **paint the pattern using etch-resist ink pen, Indian ink or enamel paint**
- **etch a painted copper clad board**
- **trace the component side pattern and make the components**
- **drill holes on the PCB**
- **rivet tags/terminals at input and output points.**

Requirements

Tools/Equipments/Instruments

- Centre punch, sharp tip - 1 No./batch
- Wooden mallet - 1 No./batch
- Trainee's Kit - 1 No./each
- Hand drill/Push-type drill gun - 1 No./batch
- Drill bit, 0.8 m - 1 No./batch
- Drill bit, 2 mm - 1 No./batch
- Bench vice/Table vice - 1 No./batch
- Wooden block (of PCB size) - 1 No./batch
- Glass rod, 30 cm long - 1 No./batch

Materials/Components

- Detergent soap powder - 10 gms.
- White cotton cloth - 1/4 mt.
- Carbon paper, A4 size - 1 No.
- Adhesive tape - as reqd.
- Etch-resist ink pen, black or Indian ink & fine brush No.6 - 1 No.
- Copper clad, 1 oz, 75 x 60 mm (Phenolic) single side - 1 No.
- Copper clad board - as reqd.
- $FeCl_3$ in liquid or powder form - 50 ml.
- Detergent soap powder - 10 gm.
- Thinner/Alcohol/Petrol - 100 ml.
- Post-type termination tags, riveting type - 4 Nos.
- Turret type termination tags, riveting type - 2 Nos.
- Carbon paper, A4 size - 1 No.
- Plastic tray, 30 cm x 15 cm aprox. - 1 No.
- Plastic hand gloves - 1 pair
- Glass rod, 30 cm - 1 No.
- Plastic table spoon, 10 ml - 1 No.
- Painting brush, fine, No. 6 - 1 No.
- Permanent marker, blue, fine tip - 1 No.

PROCEDURE

TASK 1: **Prepare the tracks on copper clad board**

1 Clean the copper side of the 75 mm x 60 mm single side copper clad board using soap and water. Dry it using a piece of cloth.

Presence of oil or dust on the clad hinders transferring of the layout on the board.

2 Take a fresh carbon paper of 85 x 70mm and fix it on the copper clad board. (Fig 1)

3 Take out the PCB circuit pattern diagram of power supply, prepared for making power supply.

4 Fix the circuit pattern over the carbon paper (fixed on the copper clad board at step-2) as in Fig 2. Get it checked by your instructor.

Use adhesive tapes at several places such that the layout drawing sheet does not slip off while tracing.

Fig 1

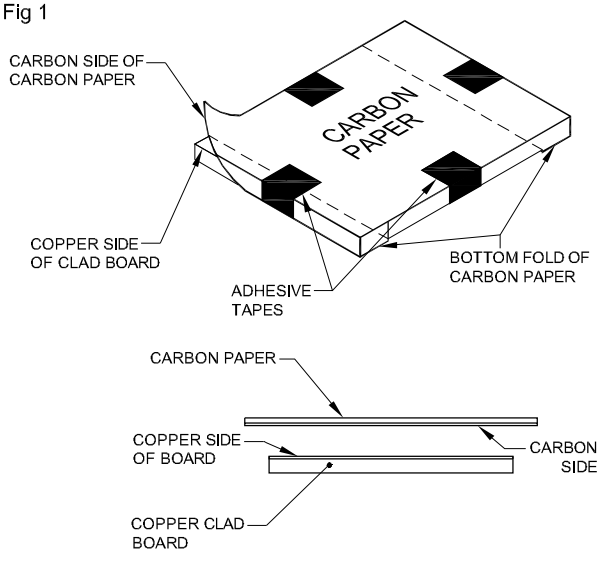
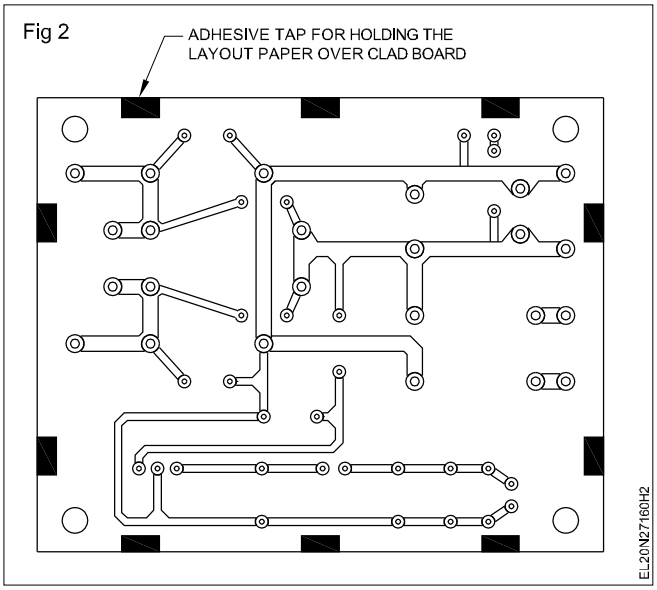


Fig 2



5 Make punch marks using a centre punch, at the centres of all inner circles and the mounting hole circles.

The punching is only to make a mark on the copper clad and not to make a hole on the clad. So, do not hit very hard.

6 Trace all the pads and connecting tracks using a 2H pencil.

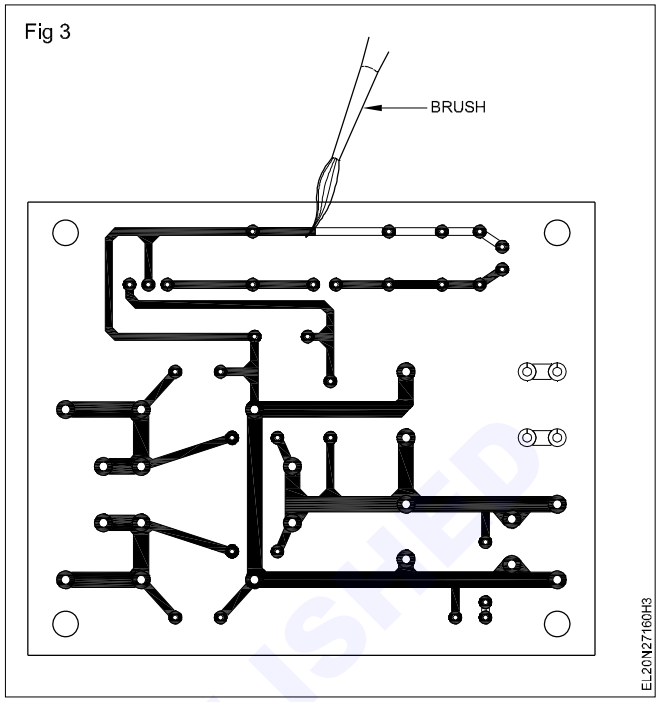
Do not use excessive force while tracing, as this may tear off both the layout and carbon paper. At the same time, do not trace with very little force as this may not transfer the pattern on the copper clad.

7 Take out both the circuit pattern diagram sheet and the carbon paper fixed on the clad.

8 Check if the all traced impression of the pattern on the copper clad is clearly visible. If not touch up using a sharp tip 2B pencil such that the impression is clearly visible.

9 Using etch-resist ink pen or a fine painting brush and Indian ink/ enamel paint, ink the pattern as in Fig 3.

Fig 3



If the ink flows slightly beyond the traced pattern circles and lines, do not try to correct it.

10 Allow the ink to dry for 5 to 10 minutes.

11 Correct the excessive paint flows outside the intended pattern by using a sharp tip knife or half shaving blade. Allow the pattern to dry up in sunlight for atleast 3 to 4 hours.

The drying period depends on the ink/paint used. Consult your instructor.

12 Get your work checked by your instructor.

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TASK 2: **Etch the painted laminate board and drill holes on PCB**

1 Take about half litre of luke warm water in a plastic tray of approximately 30 cm x 15 cm.

Do not take an excessively large tray as you may have to make large quantity of etching solution which has to be thrown once the etching is completed.

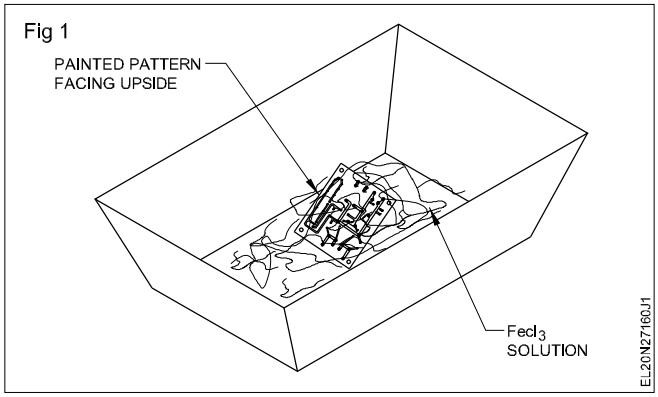
2 Put on hand gloves. Add three spoonful of $FeCl_3$ etchant to water and stir the solution using a glass rod.

$FeCl_3$ solution is injurious to bare skin.

3 Slide the painted copper clad board PCB-1 (made in Task 1) into $FeCl_3$ and water solution with the copper clad side facing upward and visible. (Fig 1)

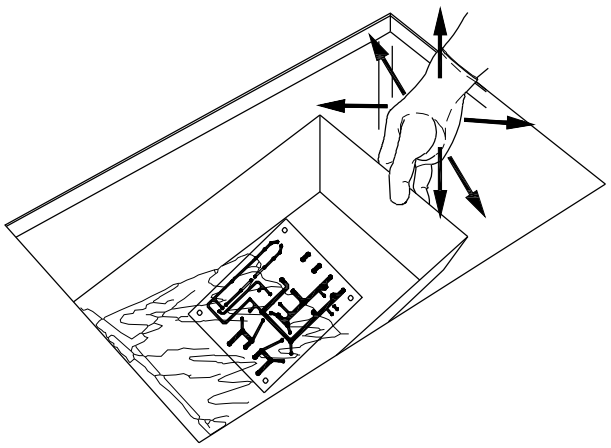
4 Move the tray up and down, left and right (Fig 2) such that the solution is agitated adequately in increasing the etching process.

Fig 1



Do not agitate the solution very fast as this may sometimes peel off the paint and etch the required patterns also.

Fig 2



5 Repeat step 4 for 10-15 minutes and observe the unpainted portion of the copper clad getting etched OFF.

Once the etching is complete the unpainted portion of the board looks brown or the colour of the board.

6 Take out the board from the $FeCl_3$ solution and check visually if the unpainted copper is completely etched. If not, put the board back into solution and allow the board to remain in the solution for 5-10 minutes.

Depending on the concentration of the $FeCl_3$ solution, the etching time may vary from 10 to 30 minutes.

7 Take out the board from the $FeCl_3$ solution and wash the board thoroughly in running water.

8 Apply a small quantity of detergent powder and wash it again in running water.

9 Allow the board to dry in open air or by placing it in front of a fan.

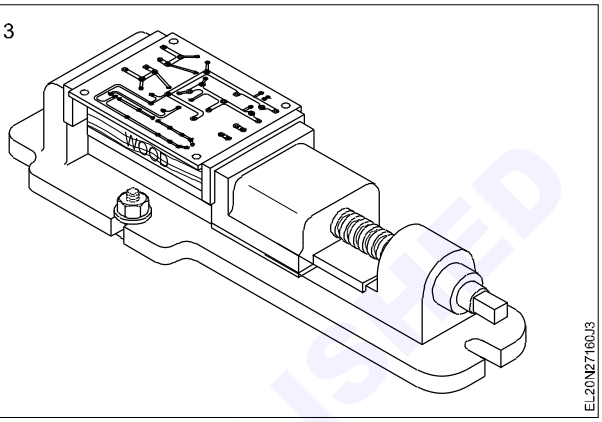
10 Using a thick brush apply thinner or alcohol or petrol on the painted side of the board and remove the ink using a dry cloth.

11 Repeat step 10 till the paint is completely removed and the copper pattern is clearly visible.

12 Wash the printed circuit board with water and dry it using a piece of cloth.

13 Fix the board with a wooden block on a vice as shown in Fig 3.

Fig 3



14 Using a hand-drill/push-drill-gun fitted with a 0.8 mm drill bit, drill holes at the punched points at the centre of circular patterns.

Drill slowly and steadily. Careless drilling may pull the complete circular copper pattern away.

15 Drill holes at the corner mounting points by use a drill bit of 2 mm.

16 Clean the drilled board from burn and other dirt using cloth or a brush.

17 Get your work checked by your instructor.

Construct simple circuits containing UJT for triggering and FET as an amplifier

Objectives: At the end of this exercise you shall be able to
- **construct UJT relaxation oscillator for triggering and test**
- **identify the terminals with specification of JFET and test a N-channel JFET**
- **construct an AC voltage amplifier using JFET and find the gain**
- **plot the graph of gain of the amplifier at different frequencies.**

Requirements

Tools/Equipments/Instruments

- Trainee tool kit - 1 No.
- Dual channel oscilloscope 20 MHZ - 1 No.
- Power supply unit 0-30V 2A variable - 1 No.
- Function generator 2 to 200Hz - 1 No.

Materials/Components

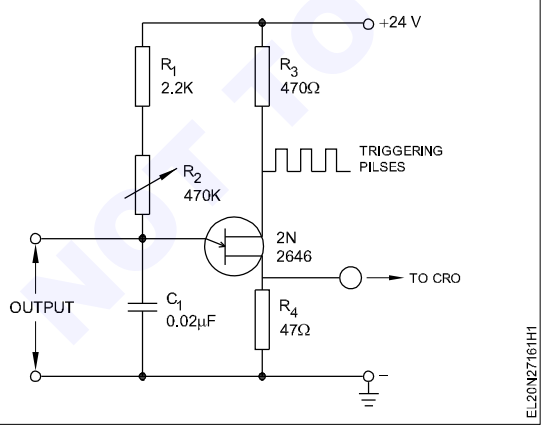
- General purpose PCB (4 x 8)cm - 1 No.
- UJT 2N2646 - 1 No.
- Carbon resistors - 1/4 watt
  47Ω - 1 No.
  470Ω - 1 No.
  2.2 KΩ, 470 KΩ - 1 No.
- Potentiometer 1/2 w, 470 KΩ - 1 No.
- Capacitor 0.02 µf, 25V - 1 No.
- Hookup wires - as reqd.
- Solder - as reqd.
- Assorted types of N-channel, JFET (JFET - BF 245 B/BFW 10) - 4 Nos.
- Sleeves - Red, Green, Yellow, Black (2 cm length each) - 4 Nos.
- Capacitors : 5.6 ηF -Disc type - 1 No.
  270 ηF - 1 No.
  6.8 µF/24V electrolyte - 1 No.
- Resistors - Carbon Film - 1/4 W
  1MΩ, 47KΩ, 10KΩ, 12 KΩ - 1 No. each

PROCEDURE

TASK 1: **Construct UJT relaxation oscillator for triggering and test it**

1 Assemble the relaxation oscillator on the general purpose PCB by referring the circuit diagram (Fig 1)

Fig 1



2 Get the wired oscillator checked by your instructor.

3 Energise the circuit with the stipulated DC.

4 Check the triggering pulses by using CRO between emitter and base and sketch these wave forms in Table 1.

5 Calculate the frequency from the reading taken at Table 1 and apply formulae given below. Keep the potentiometer at minimum, maximum and middle position, record the details of wave forms on Table 1.

Frequency = 1/t where 't' is the time period in seconds.

Time period (Condition 1) t = when C = 0.02 µFD and R_2 is at one extreme end (R_2 = 0)

Time seconds = (R_1 + R_2) x C

where R_1 & R_2 are in ohms

C in Farad

R_1 = 2K2 ohms and R_2 = 470 K ohms variable

Value of R_2 at middle = 235 K ohms

R_2 at other end = 470 K ohms

6 Get the work checked by your instructor.

Table 1

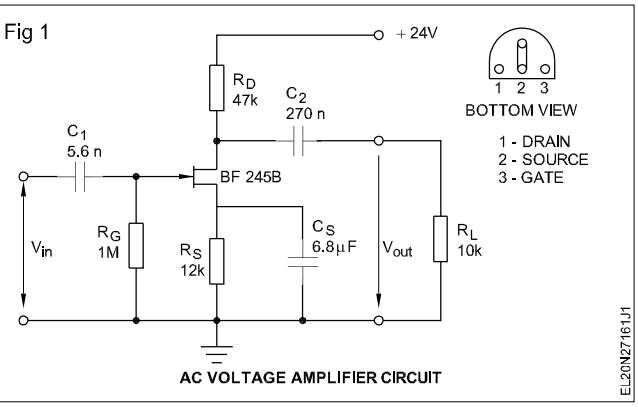
Sl. No.	Waveform at the output terminals	Amplitude	't' time period	Frequency
1	POT at one extreme end			
2	POT at middle position			
3	POT at other extreme end			

— — — — — — — —

TASK 2 : **Construct and test an AC/FET amplifier and plot the graph**

1 Refer Fig 1 and construct an AC voltage amplifier using a N-channel FET.

Fig 1



Construct the circuit on a bread board or on a GPCB. If you are wiring the circuit on a GPCB use base for the FET to ensure that it does not get damaged.

2 Get the wired circuit checked by your instructor.

3 Power ON wired circuit. Feed input, at 10 kHz and level from 1mV to 1V in steps of 100mV. Measure the corresponding output levels by using CRO and record in Table 1.

4 From the recorded readings at step 3, calculate and record gain of the amplifier.

5 Get the recorded readings checked by your instructor.

6 Calculate the gain of the amplifier with an input of 400 mV at frequencies 40 KHz, 80 KHz, 100 KHz, 120 KHz and at 150 KHz in Table 2.

7 Get the work checked by your instructor.

Table 1

Input frequency : 10 KHZ			Gain = Output voltage / Input voltage
Sl. No.	Input voltage	Output voltage	
1	100 mV		
2	200 mV		
3	300 mV		
4	400 mV		
5	500 mV		
6	600 mV		
7	700 mV		
8	800 mV		
9	900 mV		
10	1V		

Table 2

Input volt / Frequency kHz	Gain = Output voltage / Input voltage
40	
80	
100	
120	
150	

8 Plot the graph input/output voltage vs gain as in the first case and frequency vs gain in the second case.

9 Get the graph approved by instructor.

— — — — — — — —

Troubleshoot defects in simple power supplies

Objectives: At the end of this exercise you shall be able to
- **carry out step-by-step troubleshooting of a power supply having bridge rectifier and capacitor filter**
- **carry out a short cut method of troubleshooting of the power supply through problem tree and service flow diagram.**

Requirements

Tools/Equipments/Instruments

- Trainees kit - 1 No.

Materials/Components

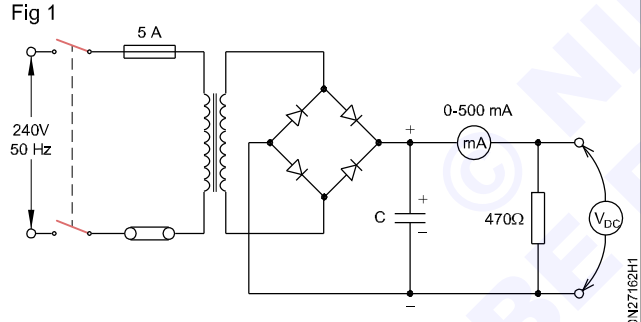
- Bridge rectifier power supply circuit with filter - 1 No.
- Spare components - as reqd.

PROCEDURE

TASK 1 : **Troubleshoot defects in bridge rectifier power supply**

1 In the given power supply board, refer Fig 1. Check for any one of the physical defects listed below; Record the observed defect(s) in Table 1. Service the defect(s).

Fig 1



POWER SUPPLY HAVING BRIDGE RECTIFIER AND FILTER CAPACITOR

– Loose/open wire connections.

– Loose/open component lead connections.

– Dry solder points.

– Shorting of terminals due to solder spray or bad skinning/bending of wire ends or component leads.

2 Trace the circuit wiring and check the correctness of the following.

– Polarity of diodes

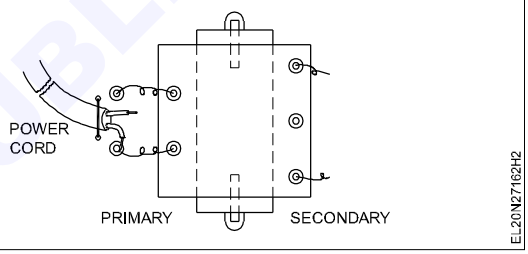
– Polarity of polarized capacitors.

Correct the polarities if found defective and record the defect observed and polarity corrected in Table 1.

3 Open one of the wire ends of the power cord connected to the power supply. (Fig 2)

This will disconnect the transformer primary from the power cord.

Fig 2



4 Using a continuity tester, check the power cord for any one of the following defects and record the defect observed if any;

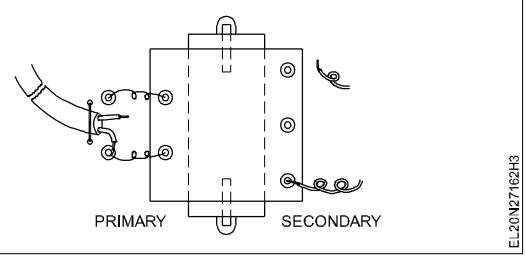
– Open or shorted wires in the plug.

– Open or shorted wires in the 2-core cable.

5 Check the continuity of transformer primary winding. If found open or short the coils record defect.

6 Remove the wires soldered at the secondary winding terminals of the transformer (Fig 3).Check the continuity of the secondary windings. Record your observation.

Fig 3

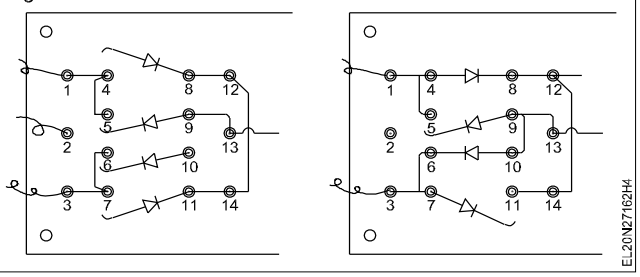


7 Open one lead of each diode (Fig 4). Check the condition of the diodes. Record your observation in Table 1.

Table 1

Sl.No.	Name of the defective component	Nature of defect observed	Specification the component to be replaced	Equivalents, if any, for the components to be replaced	Specification of the component to be replaced
Sample	Soldered point	Dry solder	.....	.....	De-soldered

Fig 4



8 Open one of the leads of the capacitor. Check the condition of the filter capacitor by carrying out the capacitor action test. Record your observation in Table 1.

9 Check the condition of the bleeder/load resistor. Record your observations in Table 1.

10 Get the defects recorded in steps above, checked by your instructor. Get his approval to replace the components found defective.

11 Collect and test the new components to replace the identified defective components.

12 Replace the defective components with the new components and solder back all connections opened while testing.

13 Connect serviced power supply to AC mains and switch ON mains supply. Check and record the output condition in Table 2 under the heading final condition after servicing.

If there is no output from the PSU even after carrying out the laid procedure of servicing, consult your instructor.

The output may have problems other than the one for which it is serviced. Record the problem as it is observed.

14 Get the work checked by your instructor.

Final condition of power supply after servicing

a) Output voltage level

b) Ripple voltage $V_{r(p-p)}$ in output DC

— — — — — — —

TASK 2 : **Troubleshoot defects in power supply using shortcut/logical approach method**

1 Switch 'ON' the given defective power supply unit and record the identified defect in record sheet.

2 Refer the problem tree corresponding to the identified defect.

3 Refer the service flow sequence (SFS-1) or (SFS-2) depending on the identified defect of power supply. Follow the logical sequence to service the defective power supply.

4 Record the identified component defects and remedial measure taken in Table 1 of record sheet.

Whenever any component is found defective, record its type, cause of defect and other details in the Table 1 of record sheet.

Whenever any component is replaced, record the specification of the replaced component in Table 1 of the record sheet.

5 Get your work checked by your instructor.

6 Final condition of power supply after servicing.

a) Output voltage level :

b) Ripple voltage $V_{r(p-p)}$ in output DC :

7 Refer service flow chart 1 & 2 and follow the sequence of approach.

8 Interpret the problem Tree-Chart 1 & 2 (PTC-1 & PTC -2) and locate the exact fault / repair.

Table 1

Sl. No.	Name of the defective component	Nature of defect observed	Possible cause(s) of the defect	Specification of the component to be replaced	Equivalents, if any, for the components replaced	Specification of the component replaced

— — — — — — — —

Construct power control circuit by SCR, DIAC, TRIAC and IGBT

Objectives: At the end of this exercise you shall be able to
- **assemble and test a lamp dimmer-cum-fan speed regulator using TRIAC and DIAC**
- **construct and test a power control circuit using SCR**
- **construct and test a power control circuit using IGBT.**

Requirements

Tools/Instruments/Equipments

- Soldering iron - 25W/240V - 1 No.
- Trainees tool kit - 1 No.
- Lamp load (60 watts 240V) - 1 No.
- Table fan, 80 watts 240V - 1 No.
- Hand drilling machine with bit (8mm) - 1 No.
- Universal motor 500W/240V - 1 No.

Materials

- Triggering pulse module for pulse generator - 1 No.
- Printed circuit board - 1 No.
- Resistors
  – 180 ohms 1w ±5% - 1 No.
  – 4K7 12 w 5% - 1 No.
  – 470 K Ohms 1/4w 5% - 1 No.
- Potentiometer linear 250K, 16 mm plastic shaft - 1 No.
- Capacitor 0.1 μF 415 Volts - 4 Nos.
- Solder (Resin) 60:40 - as reqd.
- Soldering flux (Resin) 60:40 - as reqd.
- IGBT - HGTG 12N 60- (pack) - 1 No.
- General purpose PCB - 1 No.
- TRIAC BT 136 or equivalent - 1 No.
- DIAC D3202 or equivalent - 1 No.
- Inductor (25 SWG, 40 turns on 10mm ferrite rod with former made of leatheroid paper) - 1 No.
- Resistors - 10K, 2W - 1 No.
  470 Ω - 1 No.
  1 KΩ - 2 Nos.
- Pot Meters, 1KΩ, 1W - 1 No.
- Capacitors - 2.2 K PF Disc - 1 No.
  100 PF
- SCR - C 106D or equivalent - 1 No
- Transistor - BD 135 - 1 No.
  BD 136 - 1 No.
- Diode - 1 N 4007 - 6 Nos.
- Connecting cables - 1sq.mm/650V - as reqd.

PROCEDURE

TASK 1: **Construct power control circuit using TRIAC and DIAC**

1 Clean the Printed Circuit Board (PCB). Check the circuit components and confirm their working condition.

2 Assemble the control circuit referring to the circuit schematic diagram shown in Fig 1a & 1b and PCB layout diagram. (Fig 2)

Use multi strand 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.

3 Keep the PCB on any insulated material. Keep the Potentiometer (POT) in mid position. Put AC mains Single Pole Single Throw (SPST) switch mounted on the gang box to 'OFF'.

4 Connect a test lamp at the mains output socket (mounted on the gang box).

5 Connect AC mains supply to the wired circuit. Put the SPST switch mounted on the gang box to ON. Check if the lamp glows.

Fig 1

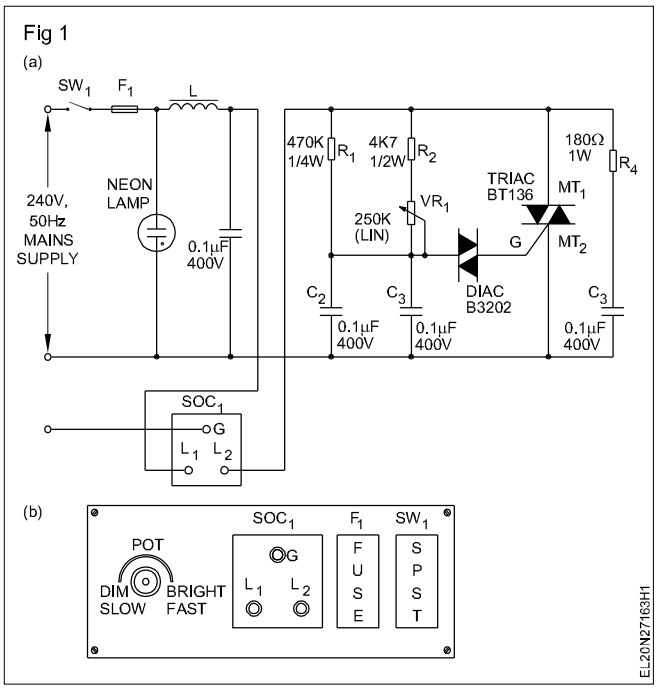
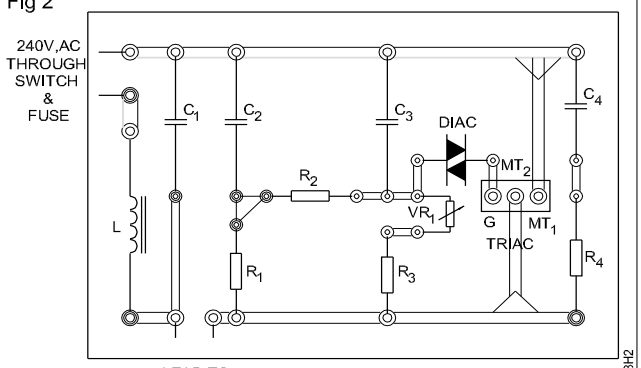


Fig 2



COMPONENT SIDE LAYOUT

EL20N27163H2

If the lamp is not glowing, switch off mains supply and consult your instructor.

6 Vary POT position such that, the light intensity of the output lamp gradually decreases and becomes minimum/zero. Record the status of the lamp intensity at one extreme position of the POT. (Refer Table 1)

Table 1

Status of the lamp intensity when the POT (VR_1) is at one extreme position _____
Light intensity may be recorded as very dim, off or such

7 Increase the intensity of lamp gradually by turning the POT from minimum position to maximum position. Check and record the light intensity at other extreme position of the POT. (Refer Table 2)

Table 2

Status of the lamp intensity when the POT VR,is at other extreme position _____
Light intensity may be recorded as very dim, off or such

8 Repeat steps 6 and 7 a few more times to confirm that the wired lamp dimmer circuit is working satisfactorily. Get it checked by your instructor.

9 Remove the lamp load connected at the controlled output of the lamp dimmer circuit. Connect a table fan to the controlled AC output of the wired circuit.

10 Switch 'ON' AC mains supply to the circuit. Vary the POT from one end to the other. Observe and record the speed of the fan at minimum, middle and maximum position of the POT.

The Lamp dimmer-cum-fan speed controller is a very versatile and very useful gadget. You can make use of this project constructed for any useful purpose and assembled in a suitable box with all mandatory control and protecting devices.

11 Get your work checked by your instructor.

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TASK 2: **Construct power control circuit using Silicon Controlled Rectifier (SCR)**

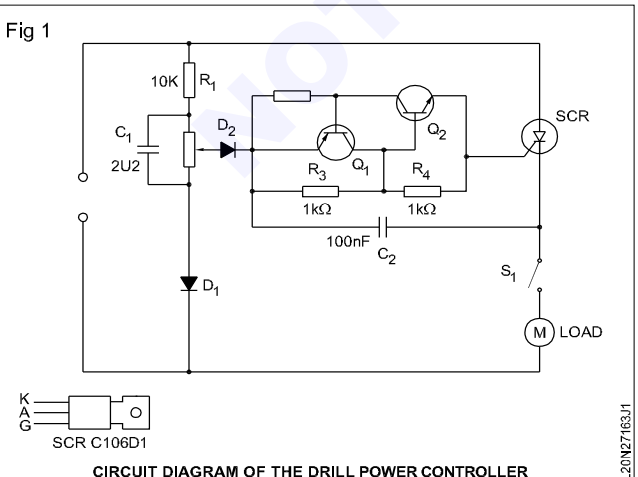
1 Prepare a PCB for the given dimensions. Check the sizes of the components with the soldering position on the PCB. If necessary slightly alter the dimensions of the PCB track.

2 Check the PCB tracks and clean PCB.

3 Test the components to confirm its working condition.

4 Wire the power control circuit on the PCB referring to the circuit schematic (Fig 1) and the PCB layout diagram. Get the wired circuit checked by your instructor.

Fig 1



CIRCUIT DIAGRAM OF THE DRILL POWER CONTROLLER

EL20N27163J1

5 Using suitable wires make connections for the POT, switch, 6A flush type socket, 3 core cable mains 3-pin top with the wired circuit on PCB. Get the wiring checked by your instructor.

The wire connections made is to test the wired power control circuit. Keep sufficient wire lengths in all connections made for the purpose of safety and ease of testing.

6 Test the working of wired circuit by connecting a test lamp load at the output of the speed controller circuit. Find the lamp glow bringing the two extreme positions of the speed.

7 Test the speed controller using table fan as load and record your observation.

8 Assemble the PCB and other associated items, so that the wired speed controller is ready for use. Get it checked by your instructor.

This wired circuit can be effectively used for a control circuit to use for any speed control purpose. Kept in a box with all mandatory controlling and protecting devices.

9 Get your work and recorded readings checked by your instructor.

The wired and tested universal speed controller can be effectively used for any practical applications. So, preserve the project work made and use it whenever required.

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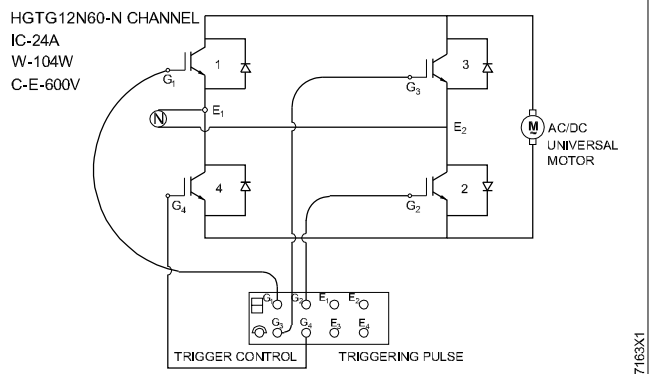
TASK 3: **Construct power control circuit using Insulated Gate Bipolar Transistor (IGBT)**

1 Wire the circuit as per the diagram. (Fig 1)

Fig 1



UNIVERSAL MOTOR CONTROL USING IGBT

Solder the components on a general purpose PCB and connect the cables for connection.

2 Set the input AC single phase supply to 120V and connect to the supply points E_1 & E_2 through a various.

3 Switch 'ON' the triggering pulse generator and set the pulse control minimum position.

4 Switch 'ON' the variac.

5 Increase the triggering pulse control to rotate the AC/DC motor.

Universal motor rotates slowly with abnormal sound.

6 Switch 'OFF' both the control circuit and triggering pulse circuit.

7 Set the variac voltage 240V and switch 'ON' the triggering pulse.

8 Reduce the speed by controlling trigger control knob. If motor rotates with high speed.

Switch OFF both the circuits. Universal motor not allow to run without load.

Ensure the motor rpm varies as per the variation of trigger pulse control.

9 Get it checked with your instructor.

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Construct variable DC stabilized power supply using IC

Objectives: At the end of this exercise you shall be able to
- **construct and test a variable IC regulated power supply**
- **test the voltage regulation at various load and ripple rejection.**

Requirements

Tools/Equipments/Instruments

- Trainees kit - 1 No.
- Soldering iron 25W/250V - 1 No.
- Digital multimeter - 1 No.

Materials

- General purpose PCB - 1 No.
- Step down transformer, 240 V : 24 V, 12-0-12, 24VA - 1 No.
- Diodes, 1N4002 or BY127 or equivalent - 6 Nos.
- Capacitors
  2200 µF, 50V, electrolytic - 1 No.
  25 µF, 50V, electrolytic - 1 No.
  10 µF, 50V, electrolytic - 1 No.
  100 µF, ceramic disc - 1 No.
- LED, Red - 1 No.
- Resistors
  4K7, potentiometer, carbon, rotary - 1 No.
  2K2, carbon, 1/2W - 1 No.
  220W, carbon, 1/4W - 1 No.
- 3-terminal voltage regulator, LM317T, To - 220 package - 1 No.
- 1A, slow blow fuse with fuse holder - 1 No.
- Hook up wires - as reqd.
- Resin cored solder - 20 cms.
- Heat sink for TO-220 package - 1 No.
- Rheostat 100Ω 1 A - 1 No.

PROCEDURE

1 Test all the components to confirm their good working condition. Record the specifications of IC LM317T.

2 Check the given general purpose PCB for the following defects and correct them or take a new board;
- Broken tracks
- Joined tracks
- Closed holes

3 Clean the copper side of the PCB using alcohol or other cleaning agents. Wash, wipe and dry the PCB.

4 Construct a variable regulated output power supply on the given general purpose PCB, referring to the circuit schematic shown in Fig 1.

All components except the transformer to be mounted on GEN-PCB. Use suitable heat sink with IC 317 T.

Note : Solder all components except the fuse and transformer on the given PCB

5 Get the correctness and neatness of wiring checked by your instructor.

6 Connect the secondary of (240:24V) transformer to the wired circuit. Switch ON mains supply.

Switch OFF main supply immediately if burning, smoking overheating, sparks are observed in any of the components, and report to your instructor. Check the IC and ensure that it is not heated-up.

7 Measure and record the unregulated dc input and the minimum, maximum variable voltage of the regulator under no-load condition.

8 Set the output to +15 volts and load the output using a loading rheostat in steps of 200 mA up to 600 mA. In each step measure and record the output voltage and the ripple voltages.

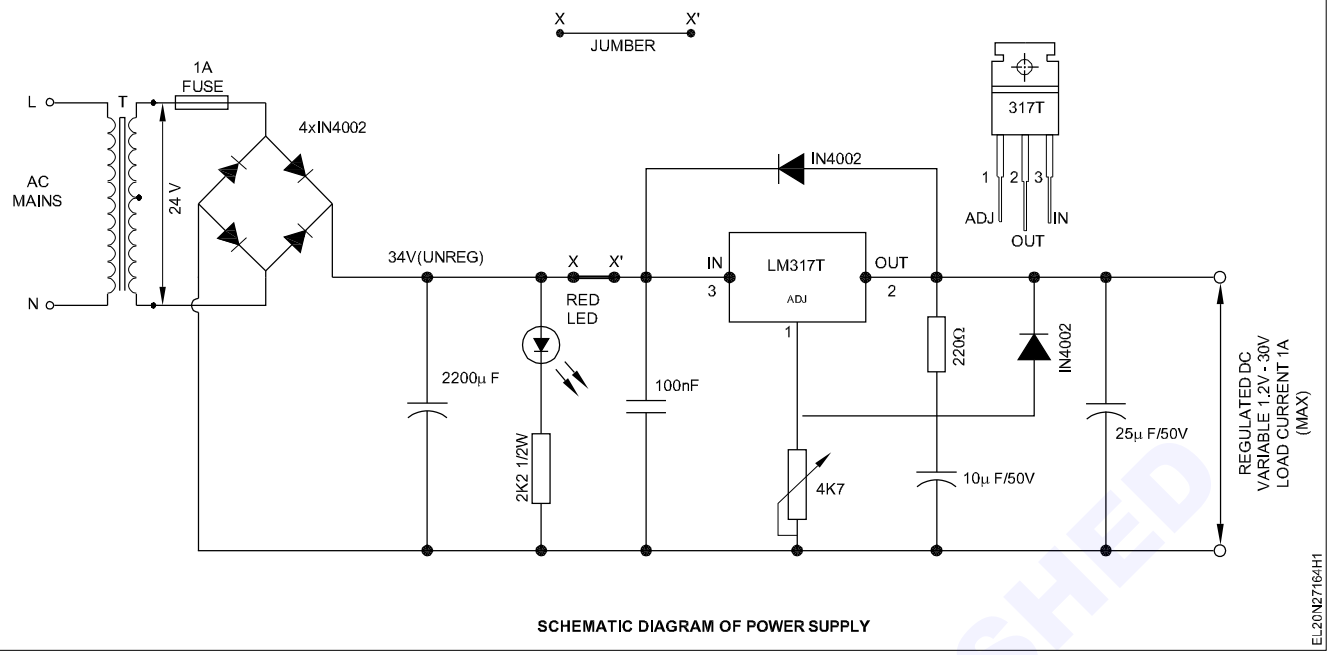
Load current is restricted to 600mA as heat-sink is provided to the IC may not be the ideal one.

9 Calculate and record the output regulation and ripple rejection of the regulator.

10 Short the load terminals momentarily by using a DC current meter (0-1A range) and record the short circuit fold back protection current level.

11 Get the readings checked by your instructor.

Fig 1



SCHEMATIC DIAGRAM OF POWER SUPPLY

Observation & tabulation sheet

1 Specification of the given 3-terminal regulator IC

Type number	Package type	Output voltage		Max. output current
		Min.	Max.	

— — — — — — — —

Practice on various logics by use of logic gates and circuits

Objectives: At the end of this exercise you shall be able to
- **construct an OR gate using lamp and switches and verify its truth table**
- **construct an OR gate using IC-7432 and verify its truth table**
- **construct AND gate using lamps and switches**
- **construct AND gate using IC-7408 and verify its truth table**
- **construct NOT gate and verify truth table using transistor.**
- **construct NOT gate using IC 7404 and verify its truth table.**

Requirements

Tools/Equipments/Instruments/Materials

- Trainees kit - 1 No.
- Regulated DC power supply unit 5V/500mA - 1 No.
- DC voltmeter (MC) 0-10V/multimeter - 1 No.
- Data Manual - 1 No.
- Digital IC tester - 1 No.

Materials/Components

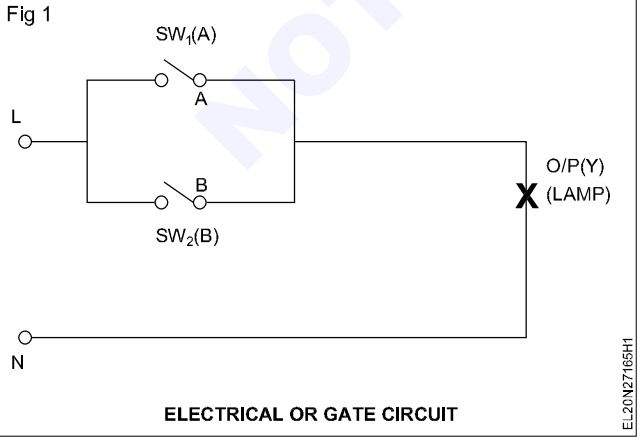
- Single pole switch any type/ Toggle switch 240V/6A - 2 Nos.
- Lamp - 250V/100W - 1 No.
- LED, Red (5mm) - 2 Nos.
- ICs
  7408 QUAD AND gate - 1 No.
  7432 - 1 No.
- Connecting wires - as reqd.
- Solder, flux - as reqd.
- IC base, 14 pin - 2 Nos.
- DC power supply 5V - 1 No.
- SPDT switches (miniature toggle) - 2 Nos.
- General purpose IC test board/Pin Board - 1 No.
- Transistor BC 147 - 1 No.
- Resistors, carbon film, 1/4w
  1KW - 2 Nos.
  330W - 2 Nos.
- LED (t5mm)
  Green - 2 Nos.
- IC 7404 (Hex inverter) - 1 No.
- IC 4049 (Hex inverter) - 1 No.
- IC base 14-pin - 2 Nos.
- Hookup wire
  Red 50cm - as reqd.
  Black 50 as reqd.cm - as reqd.

PROCEDURE

TASK 1: **Construct an OR gate using two switches with lamp and verify its truth table**

1 Refer Fig 1 and wire an OR gate circuit on a test board/pin board.

Fig 1



ELECTRICAL OR GATE CIRCUIT

2 Apply logic level inputs to A and B of the circuit as given in Table 1. Record the output lamp condition in each case and verify its truth table.

3 Get the recorded readings checked by your instructor.

Table 1

Truth table of OR-gate using switches and lamp

Logic input		Logic output
A SW1	**B SW2**	**Y = A + B lamp**
0	0	
0	1	
1	0	
1	1	

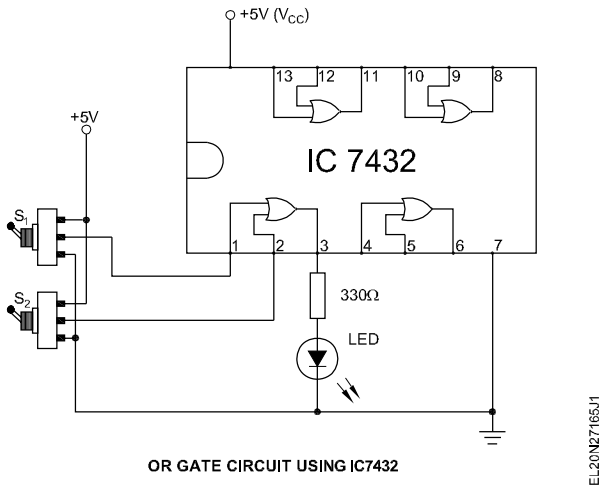
TASK 2 : **Construct a Quad two input OR gate using IC-7432**

1 Record the details of the given IC-7432 in Table 1 of record sheet referring to data manual.

2 Insert the IC-7432 into the IC base of the general purpose IC test board.

3 Make other circuit connections to the IC in Fig 1.

Fig 1



OR GATE CIRCUIT USING IC7432

4 Set switches SW_1 and SW_2 to apply input logic levels as in Table 3 to the first OR gate (Fig 1). Record the output logic level and verify its truth Table 2.

5 Repeat step 4 for the other three OR gates of the IC.

6 Write your conclusion about the condition of each OR gate in Table 3 based on the recorded output of gates.

7 Get the recorded readings checked up by your instructor.

Disconnect connections made at input and output of the gates. Allow the IC 7432 to remain plugged on the board for subsequent tasks.

Table 2

Truth table of OR-gate using IC7432

Logic Input		Output logic at Pin No.			
A	B	3 Gate-1	6 Gate-2	8 Gate-3	11 Gate-4
0	0				
0	1				
1	0				
1	1				
Condition of gate in the IC :					

Table 1

I.C No.	Type of package	Total no. of pins	Input voltage		Output voltage		V_{CC}/V_{DD}		Status	Temperature of IC range
			Logic- 0	Logic- 1	Logic- 0	Logic - 1	max.	min.		
7432										
7402										

— — — — — — — —

TASK 3 : **Construct AND gate using two switches with lamp and verify its truth table**

1 Refer Fig 1 and construct the AND gate circuit using on a board switches and lamp test.

2 Get wired circuit checked by your instructor.

3 Apply different logic levels to the inputs A & B as given in Table 4 . Record the corresponding output logic level and lamp status.

4 Get the work checked by your instructor.

Fig 1

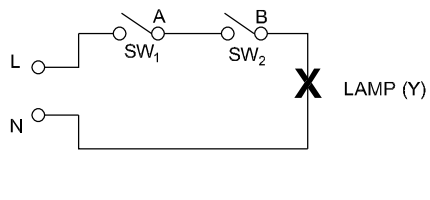


Table 1

Truth table of AND gate using switches and lamp

Input		Output				
Logic level		Equivalent voltage level given as inputs		Logic level	Voltage level	LED status (ON/OFF)
A	B	A	B			
0	0					
0	1					
1	0					
1	1					
open	open					

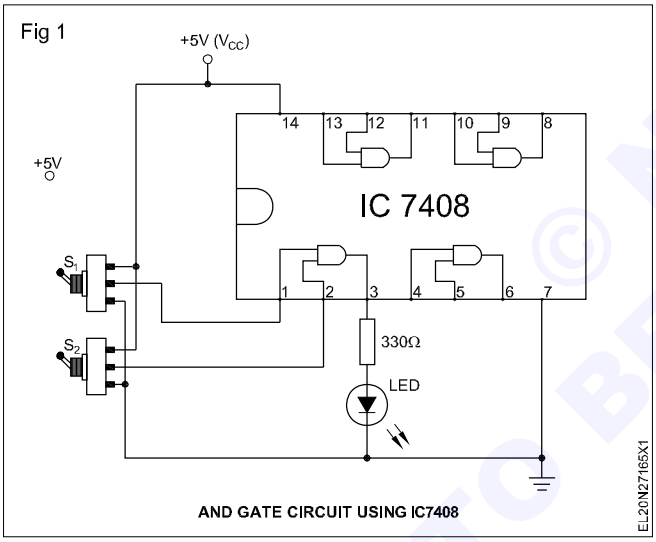
TASK 4 : **Construct and test an AND gate using IC (7408)**

1 Make circuit connections (Fig 1) using IC 7408 (AND).

2 Apply different logic levels to the inputs A and B to gate-1 (between pins 1 & 2) and record output (pin 3).

3 Repeat step 2 for the other AND gates in the IC 7408 by suitably modifying the circuit at input & output.

Fig 1



AND GATE CIRCUIT USING IC7408

4 Conclude the condition of the IC in sheet after verifying truth table at Table 1.

5 Get the work checked by your instructor.

Table 1

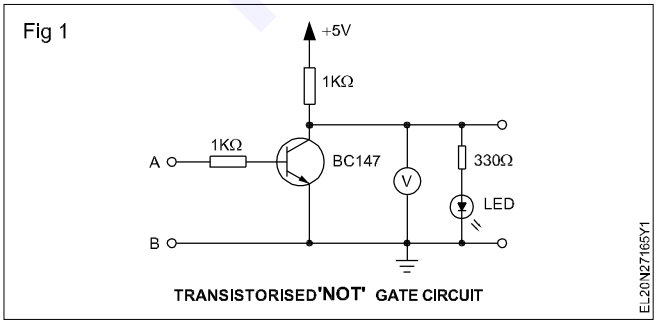
Truth table of AND gate IC-7408

Input		Output Y = A·B			
Logic level A	B	Y_1 (pin 3)	Y_2 (pin 6)	Y_3 (pin 8)	Y_4 (pin 11)
0	0				
0	1				
1	0				
1	1				
Condition of gate					

TASK 5 : **Construct a NOT gate using discrete components and verify its truth table**

1 Construct the NOT gate using discrete components as shown in Fig 1 on the general purpose PCB. Get it checked by your instructor.

Fig 1



TRANSISTORISED 'NOT' GATE CIRCUIT

2 Power ON the circuit, by applying 5V Fig 1. Apply logic level-0 to the input (see note below) and record the voltmeter reading, its equivalent logic level and the status of LED.

When the input terminal of the circuit is grounded, it is equivalent to applying logic 0. Note that keeping input terminals open is not equal to logic 0 level.

3 Apply logic level-1 to the input (see note below) and record the voltmeter reading, its equivalent logic level and the status of LED.

When the input of the circuit is connected to +5V, it is equivalent to applying logic 1.

4 Repeat steps 3 & 4 a few times to confirm the recorded values and to have a clear understanding of the logic levels and concept of inversion logic.

5 Get the working of the NOT gate and confirm the recorded readings (Table 1) checked by your instructor.

Table 1

Input		Output		
Logic level	Voltage level	Logic level	Voltage level	LED status ON/OFF

— — — — — — — —

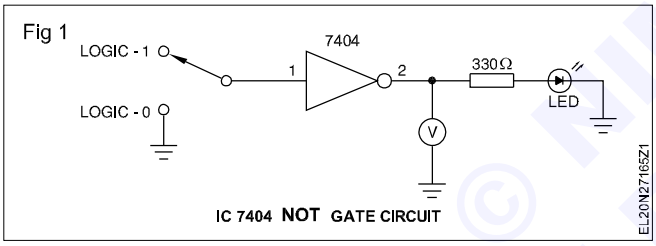
TASK 6 : **Verify the truth table of a Transistor-Transistor Logic (TTL) NOT gate IC 7404**

1 Record the following details for the given IC 7404.

- Manufacturer's name
- IC number
- Type of package
- IC family type
- Internal connection diagram with pin numbers.

Referring to Fig 1 of exercise and IC data book, note down the following readings in Table- 6

Fig 1



IC 7404 NOT GATE CIRCUIT

2 Construct the NOT gate test circuit shown in Fig 1 on the general purpose IC test board/pin board. Get the constructed circuit checked by your instructor.

3 Insert the IC in the IC base of the wired circuit. Make sure IC inserted as per circuit.

4 Switch on the DC supply (+ 5V) to the wired circuit and check if the IC is getting excessively heated-up. If the IC is getting heated up, switch-off power supply and consult your instructor.

5 Measure voltage level at V_{CC} and GND pins at the IC to confirm that supply is reaching the IC.

6 Apply Logic 0 (Low/Ground/ 0 volt) to the input of the inverter 1 of wired IC NOT circuit. Record the output voltage, corresponding logic level and status of LED.

7 Give logic 1 (High/+ 5V) at the input of the same inverter and record the outputs as done in step 8.

8 Get the recorded readings checked by your instructor.

9 Modify the wiring of the circuit to test the next NOT gate between pins 3 & 4. Get it checked by your instructor.

10 Repeat steps 8, 9 and 11 to test other NOT gates of the IC.

If any gate is found to be defective, record it and consult your instructor.

11 Get your work checked by your instructor.

Do not dismantle the circuit. This is required for next exercise.

12 Repeat steps 1 to 11 for the CMOS NOT gate IC, CD4079 following the instructions given below;

- Construct the circuit in a different place on the same board.
- After setting up the circuit get it checked before proceeding further.
- Use 12 volts DC for V_{CC}.
- For CMOS ICs, Logic-1 can be equal to V_{CC}.

  The minimum logic-HIGH input voltage should be = 2/3 V_{CC}. and, maximum logic-LOW input voltage can be = 1/3 V_{CC}.

13 Get the work checked by your instructor.

— — — — — — — —

Generate and demonstrate wave shapes for voltage and current of rectifier, single stage amplifier and oscillator, using CRO

Objectives: At the end of this exercise you shall be able to
- **construct a bridge rectifier test the output wave form**
- **test the wave shape without RC filter and with filter and calculate ripple factor**
- **test the wave shapes of a common smith amplifiers and distinguish with the input & output waves**
- **test the hartley oscillator output wave shape and identify the frequency.**

Requirements

Tools/Instruments

- Trainees kit - 1 No.
- Oscilloscope, 20MHz, dual trace - 1 No.
- Voltmeter MC 0-30V - 1 No.
- Multimeter - 1 No.
- Function generator - 1 No.
- Regulated DC power supply 12V/1A - 1 No.

Materials/Components

- Bread board - 1 No.
- Diode IN4007 - 4 Nos.
- Resistor 470Ω - 1 No.
- Step-down transformer, 240V 24V 500mA - 1 No.
- Multi strand wire, red, blue 19/0.3 of 600V grade - as reqd.
- 3 Pin plug 6A 250V - 1 No.
- Electrolytic capacitor 10 µFD/25V - 1 No.
- Resistor 10K/1W - 1 No.
- Transistor BF 195 - 1 No.
- Capacitors - 0.01and 0.1µfd - 3 Nos.
- Gang capacitor 25-2J - 1 No.
- Resistors - 82K, 18K, 3.9K, 390Ω/1/4W - 1 each
- Medium wave oscillator coil - 1 No.
- Transistor, SL 100 or equivalent - 1 No.
- Diode IN914/OA79
- Capacitor, 100 µF/25 V, electrolytic, axial - 1 No.
- Capacitor, 25 µF/25 V, electrolytic, axial - 2 Nos.
- Resistors 1/4 W, carbon
  - 120 Ω - 1 No.
  - 470 Ω - 1 No.
  - 1.2 KΩ - 1 No.
  - 5.6 kΩ - 1 No.
- Hook-up wires - 20cms.

PROCEDURE

TASK 1:

For TASK 1 Refer Exercise No 2.7.155.

— — — — — — — —

TASK 2: **Measure of ripple and calculate ripple factors in bridge rectifiers with RC filter**

1 Construct the filter circuit in the bridge rectifies already constructed. (Fig 1)

2 Repeat the steps 2 to 6 of task 1. Enter the measured values in Table 1 and 2.

Fig 1

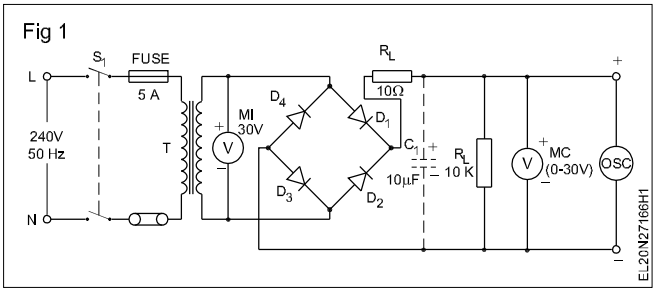


Table 1

Condition	Input AC	Output DC	AC ripple	Ripple factor $= \frac{\text{AC ripple voltage}}{\text{DC voltage}}$
Without RC filter				
With RC filter				

Table 2

Condition		
Output wave form without capacitor		
Output wave form with capacitor		

— — — — — — — —

TASK 3 **: Determine the voltage gain A_2 of CE amplifier and distinguish input and output wave shapes**

1 Construct the circuit of CE amplifier in Fig 1.

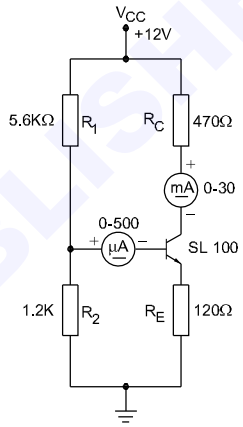
2 Apply V_{cc} measure and record I_c and I_B in Table 1.

3 Apply input sinewave from function generator and measure voltage gain of using CRO. Observe the input and output waves.

4 Record the input and output wave shapes of the CE amplifiers.

5 Get it checked with your instructor.

Fig 1



DC CONDITION OF CE - AMPLIFIER

Table 1

Transistor Number	Collector I_C current	Base current I_B	V gain	Input wave shapes	Output wave shapes	Relation between input & output wave

— — — — — — — —

TASK 4 : **Assemble a hartley oscillator and test the waves, find frequency with different capacitor values**

1 Test the components to confirm their good working condition.

2 Assemble the Hartley oscillator circuit referring to Fig 1.

3 Connect and switch ON + 12V-DC supply to the wired circuit. Check to ensure that the transistor is not getting heated-up.

If the transistor is getting heated-up, switch-OFF supply and consult your instructor.

4 Connect the secondary terminals of the MW OSC coil, to CRO set to measure the frequency.

5 Adjust CRO time-base to get a clear sinusoidal wave on the screen. Measure the amplitude and frequency of oscillations and record the observations below:

i) amplitude of oscillations

ii) Frequency of oscillations

If oscillations are not seen, tune the gang capacitor. If oscillations are still not seen, consult your instructor.

6 Get the working of the oscillator checked by your instructor.

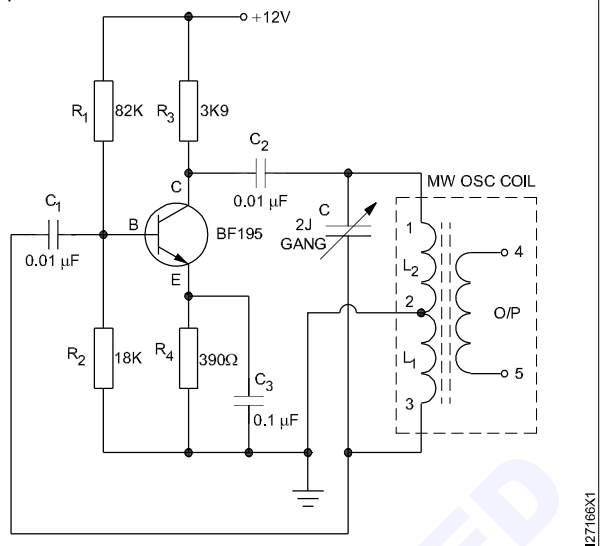
7 Set the gang capacitor to one extreme end. Measure the amplitude and frequency of oscillations and enter in Table 1.

8 Set the gang capacitor to the other extreme end. Measure the amplitude and frequency of oscillations and enter in Table 1.

9 Set the position of the gang capacitor to approximately mid-position. Measure the amplitude and frequency of oscillations and enter in Table 1.

10 Get the recorded reading checked by your instructor.

Fig 1



HARTLEY OSCILLATOR CIRCUIT SCHEMATIC

Table 1

Position of gang capacitor	Amplitude in volts peak to peak	Frequency in Hz
At one extreme end At other extreme end Mid position		

Design layout of control cabinet, assemble control elements and wiring accessories for local and remote control of induction motor

Objectives: At the end of this exercise you shall be able to
- **draw the control and power circuit for remote control**
- **mark the layout on control panel wiring accessories remote control**
- **drill and tap for fixing accessories**
- **mount the DIN rail and accessories**
- **wire up the accessories**
- **arrange the wiring by routing, bunching and tying**
- **test the control panel for local and remote control of induction motor.**

Requirements

Tools/Instruments

• Trainees tool kit	- 1 No.
• 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 (red, black, yellow, blue, green)	- as reqd.
• Assorted size bolt & nut	- as reqd.

PROCEDURE

TASK 1 : **Identify the control accessories and wiring accessories used for control panel wiring**

Instructor must serially arrange the real items of control elements used for control panel wiring, If it is not possible provide the images without their names. He can explain how to identify them with specification and uses / types.

1 Identify the control elements from the real objects (or) from the images.

2 Write the name and type of the control elements against the space provided and also write their specification and purpose / application in Table 1.

3 Check the identified items with your instructor.

Table 1

Sl. No.	Names of control elements and wiring accessories (from real or image)	Types of the elements (whether protective / control etc.)	Specifications	Purpose / Application
1				
2				
3				
4				
5				
6				
7				
8				

— — — — — — — —

TASK 2 : **Develop the layout and mark the layout in control panel**

Note : Instructor has to provide a blank control panel along with power and control circuit of the local and remote control of induction motor.

1 Draw the layout diagram

2 Select and check the accessories required.

3 Mark the layout inside the control panel by using steel rule and scriber.

4 Mark for fixing holes for isolators and control devices etc., as per layout diagram.

5 Mark and cut the DIN rail, 'G' channel and race ways as per layout. Mark the points of drills on it to fix them inside the control panel.

6 Mark the drill holes in the front door of the control panel to fix the indicator lamp and push button switches.

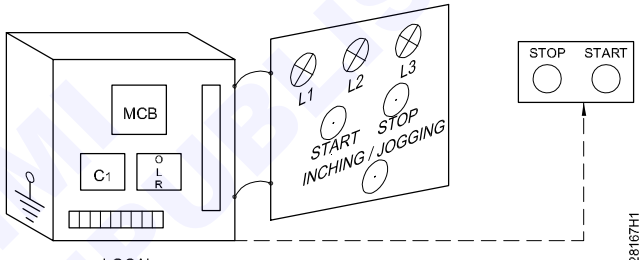
7 Mark the fixing holes for the wire clips in the control panel door to run the wires. (Fig 1)

8 Make the drills in side the control panel to fix control devices, DIN rails, 'G' channel and race ways as per marking.

2 Make the through holes in race ways, DIN rails and G channel.

3 Fix the control accessories race ways, DIN rails and G channel using fixing screw, bolt and nuts.

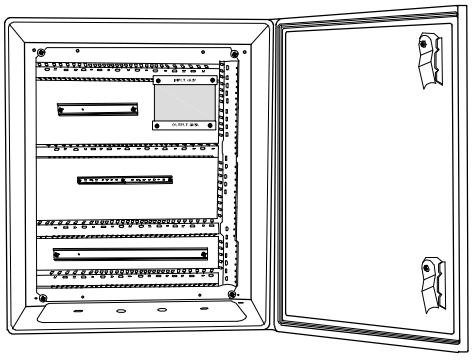
Fig 1



LAYOUT DIAGRAM OF PANEL BOARDS

4 Make the drills on the door of panel for indicator lamp, push button and wire clips as per marking. (Fig 2)

Fig 2



CONTROL PANEL WITH RACEWAYS / DIN RAILS

— — — — — — — —

TASK 3 : **Draw and wire the control and power circuit for local and remote control of induction motor**

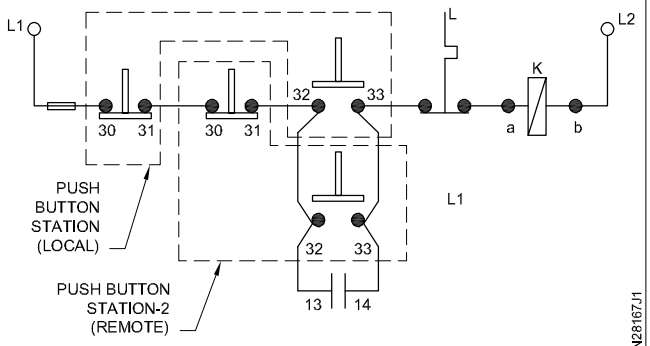
1 Draw the control circuit and power circuit and check and verify with your instructor. (Fig 1 and 2)

2 Label the Terminal number in the control and power circuit.

3 Measure and cut the cable as per layout.

4 Insert the ferrule Nos at the both ends of terminals as per layout and run the wires in the race ways one by one. Avoid the cross over of the wires.

Fig 1



CONTROL CIRCUIT OF LOCAL & REMOTE

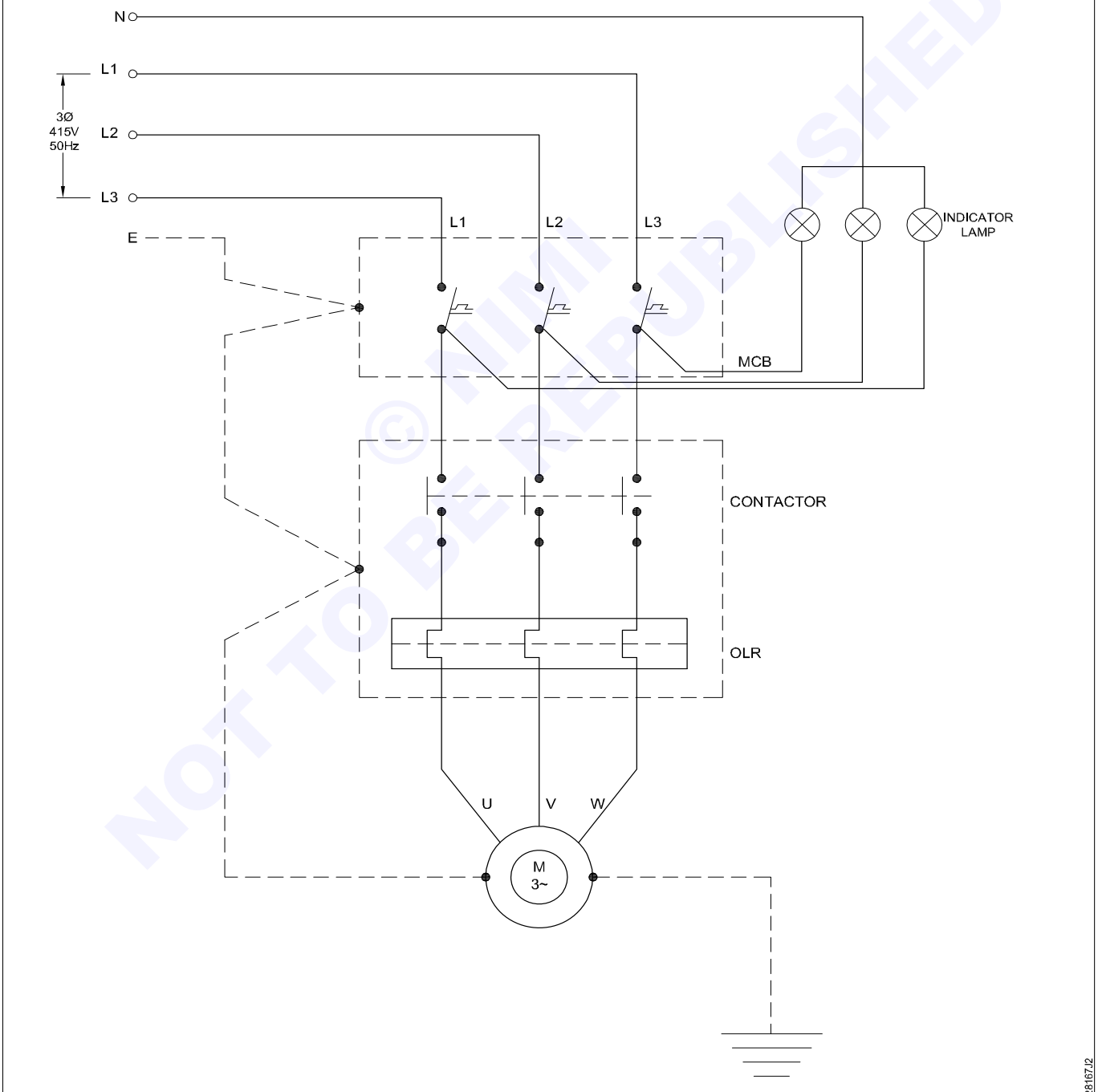
Leave some extra length of wires in the race ways for easy maintenance and repair.

To avoid the cross - over first the vertical wires can be run followed by horizontal run.

5 Skin the wire ends and crimp with suitable lugs/ thimbles.

6 Connect the control circuits wires as per the control circuit and terminals / ferrule table.

Fig 2



POWER CIRCUIT DIAGRAM

7 Connect the power circuit's wires as per the power circuit diagram and terminals / ferrule details.

Avoid the loose connection and over tightness.

8 Route the wires in the race ways. Punch and ties the wires in the race ways using cable binding straps and button.

9 Cover the PVC race ways over the wiring.

Take necessary care to avoid crushing of cable when cover the race ways.

10 Make the "U" loops of wires in the hinged doors. Bunch and tie the cable in the doors.

11 Fix the wire clips at suitable places to hold the cables in the panel door.

U loop should not disturb the movement and closing of the panel door.

12 Connect the incoming and out going terminals as per diagram and terminal details.

Use the grommets to avoid the strain in the cables.

13 Earth the panel and door.

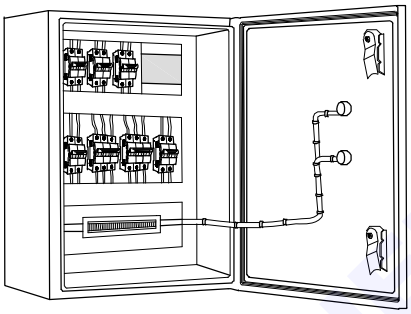
14 Measure the insulation resistance of the panel.

If the IR value is less than 1 Meg ohm, take suitable remedy action.

15 Set the OLR in accordance with the full load current of motor.

A typical control panel with complete wiring is shown in Fig 3.

Fig 3



CONTROL PANEL WITH COMPLETE WIRING

EL.20N28167J3

16 Test the local and remote control of motor.

17 Show and check the control operation with your instructor.

After removing the wiring, get it verified by the instructor and preserve all the fittings for subsequence exercises.

— — — — — — — —

Design layout of control cabinet, assemble control elements and wiring accessories for forward and reverse operation of induction motor

Objectives: At the end of this exercise you shall be able to
- **draw the control and power circuit for forward and reverse operation of motor**
- **mark the layout on control panel**
- **wire up the accessories**
- **arrange the wiring by routing, bunching and tying**
- **test the control panel for forward and reverse of induction motor.**

Requirements

Tools/Instruments

• Trainees tool kit	- 1 No.
• Scriber 100 mm	- 1 No.
• Hacksaw frame with blade- 300 mm	- 1 No.
• Hand drilling machine 6mm capacity	- 1 No.
• HSS Drill bit 6mm & 3mm	- 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.
• Air break contactor 4pole, 16A, 240V	- 2 Nos.
• Overload relay 15A, 415V	- 1 No.

Materials

• Push button red /green/yellow	- 1 each
• Indicator lamp with holder	- 5 Nos.
• MCB 4 Pole 16A	- 1 No.
• Race ways	- 2 m
• Wire clips	- 4 Nos.
• DIN rail /G - channel	- 1 m
• 1.5 sq.mm copper cable 660V (red, black, yellow, blue, green)	- as reqd.
• Terminal connectors	- as reqd.
• Wire ferrule	- as reqd.
• Grommets	- as reqd.
• Lug/thimble	- as reqd.
• Cable binding straps and buttons	- as reqd.
• Nylon cable ties	- 10 Nos.
• Assorted size bolt and nut	- as reqd.

PROCEDURE

The control panel board used in the Ex.2.8.167 (i) has to be retained with accessories fitted to use for this Exercise.

TASK 1 : **Draw the layout and mark the layout in control panel**

1 Draw the layout diagram for the forward and reverse control of induction motor.

2 Select and check the accessories required.

3 Mark the layout inside the control panel by using steel rule and scriber for the additional accessories.

4 Mark holes for fixing control for accessories etc., as per layout diagram. (Fig 1)

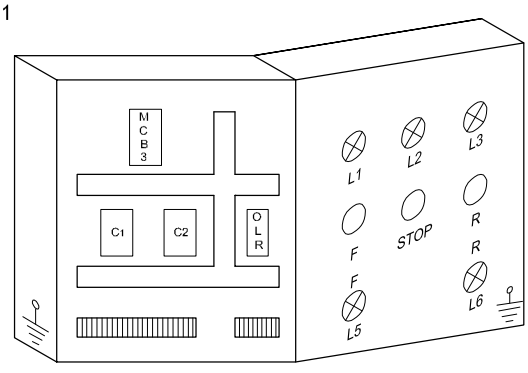
5 Mark and cut the DIN rail, 'G' channel and race ways as per layout. Mark the points of drills on it to fix them inside the control panel.

6 Mark the drill holes in the front door of the control panel to fix the indicator lamp and push button switches.

7 Mark the holes for fixing the wire clips in the control panel door to run the wires. (Fig 1)

8 Fix the control accessories, race ways, DIN rails and 'G' channel using fixing screw and bolt nuts.

Fig 1



TYPICAL LAYOUT FOR CONTROL CABINET

9 Make the drills on the door of panel for indicator lamp, push button and wire clips.

TASK 2 : **Wire the control and power circuit for forward and reverse (F/R) control of induction motor**

1 Draw the control and power circuit and check the correctness. (Fig 1 & 2)

2 Label the Terminal number in the control and power circuit.

3 Measure and cut the cable as per layout.

A typical control panel fitted with race ways, DIN rails, control transformer and isolator etc.

4 Insert the ferrule Nos at the both ends of terminals as per layout.

Leave some extra length of wires in the race ways for easy maintenance and repair.

5 Run the wires in the race ways one by one. Avoid the cross over of the wires.

To avoid the cross-over, run the vertical wire first, followed by horizontal runs.

6 Skin the wire ends and crimp with suitable lugs/ thimbles

7 Connect the control and power circuits as per circuit diagram. (Fig 1 & 2)

8 Route the wires in the race ways. Punch and ties the wires in the race ways using cable binding straps and button.

Leave the excess wires if any in the bends or in the race ways.

9 Cover the PVC race ways over the wiring.

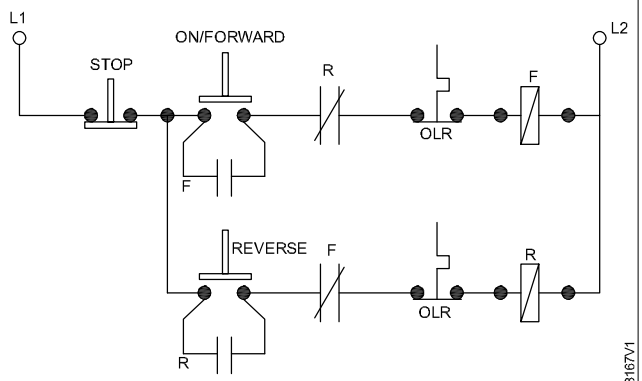
Take the necessary care to avoid the crushing of cable when cover the race ways.

10 Make the "U" loops of wires in the hinged doors. Bunch and tie the cable on the doors.

11 Fix the wire clips at suitable places to hold the cables in the panel door.

Ensure the 'U' loop should not disturb the movement and closing of the panel door.

Fig 1



CONTROL CIRCUIT FOR FORWARD AND REVERSE OPERATION

12 Connect the incoming and out going terminals as per diagram and terminal details.

Use the grommets to avoid the strain in the cables.

13 Earth the panel, door and metal devices.

14 Measure the insulation resistance of the panel.

If the IR value is less than 1 Meg ohm, take suitable remedial action.

15 Set the Over Load Relay (OLR) in accordance with the full load current of motor.

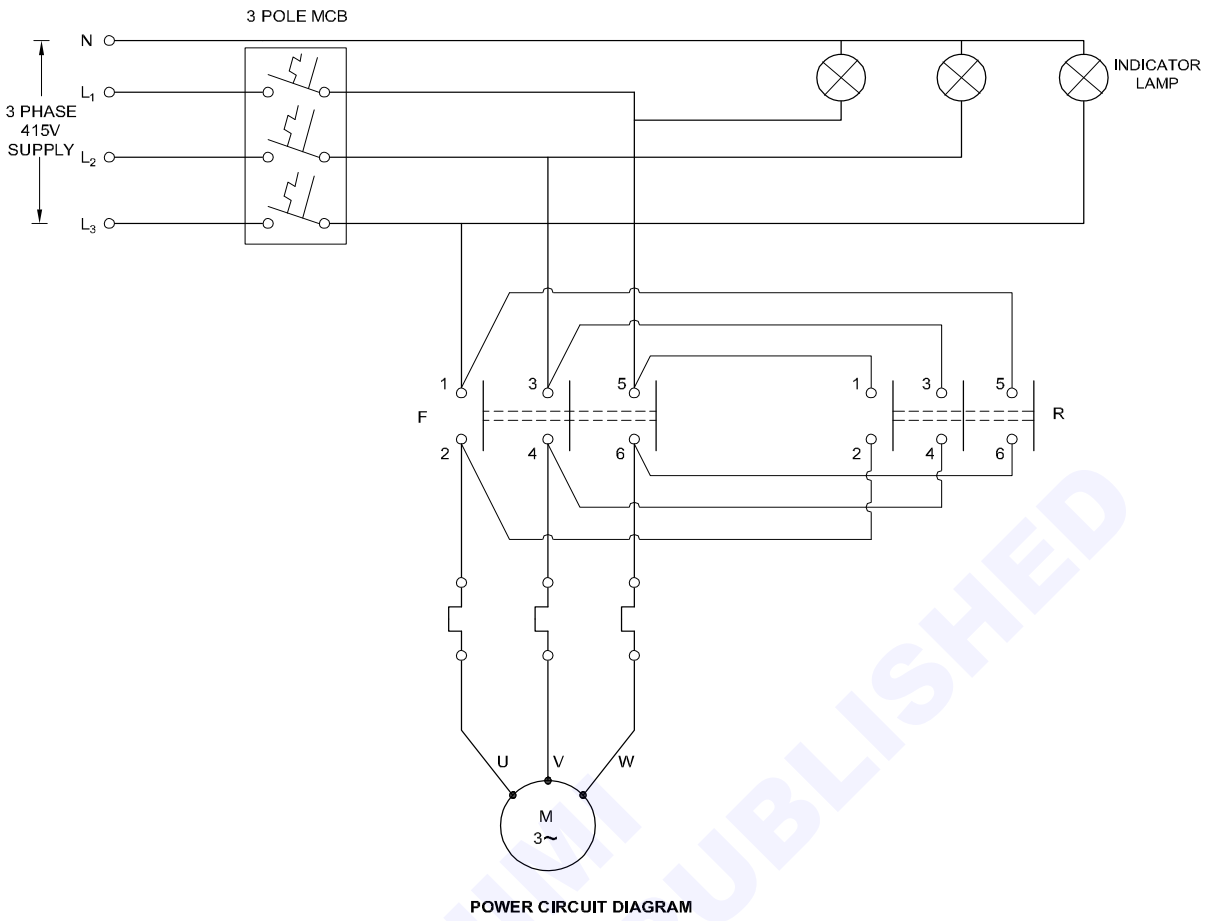
16 Test the control panel for forward and reverse of induction motor operation.

17 Check the proper functioning of indicating lamps when motor is in operations.

18 Show the control panel (F/R) working to your instructor for approval.

Note : Remove the wiring you did in the Ex.2.8.167(i) and preserve the remaining devices fitted for the next Exercise 2.8.167(iii)

Fig 2



POWER CIRCUIT DIAGRAM

Design layout of control cabinet, assemble control elements and wiring accessories for automatic star-delta starter with change of direction of rotation

Objectives: At the end of this exercise you shall be able to
- **draw the control and power circuit of automatic star delta starter with change of direction of rotation**
- **mark the layout on control panel**
- **mount the DIN rail and accessories**
- **wire up the accessories**
- **arrange the wiring by routing, bunching and tying**
- **test the control panel for automatic star-delta starter with change of direction of rotation.**

Requirements

Tools/Instruments

- Trainees tool kit - 1 No.
- Scriber 100 mm - 1 No.
- Hacksaw frame with blade- 300 mm - 1 No.
- Hand drilling machine 6mm capacity - 1 No.
- HSS Drill bit 6mm & 3mm - 1 No.
- 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,2No+2NC - 5 Nos.
- Timer 1 No+ 1 INC relay - 1 No.

Materials

- Push button green/red/green - 1 each
- Indicator lamp with holder - 5 Nos.
- Overload relay 0-15A, 415V - 1 No.
- MCB 3 Pole 25A , 415V - 1 No.
- Race ways - 2 meter
- Wire clips - 4 Nos.
- 1.5 sq.mm copper cable 650V (red, black, yellow, blue, green) - as reqd.
- Terminal connectors - as reqd.
- Wire ferrule - as reqd.
- Grommets - as reqd.
- Lug/thimble - as reqd.
- Cable binding straps and buttons - as reqd.
- Nylon cable ties - 10 Nos.
- Assorted size bolt and nut - as reqd.

PROCEDURE

The control panel board used in the Ex.No. 2.8.167 (ii) has to be retained with accessories fitted to use for this exercise.

TASK 1 : **Draw the layout and mark the layout in control panel**

1 Draw the layout diagram for the automatic star delta starter with change of direction of rotation.

2 Select and check the accessories required.

3 Mark the layout inside the control panel by using steel rule and scriber.

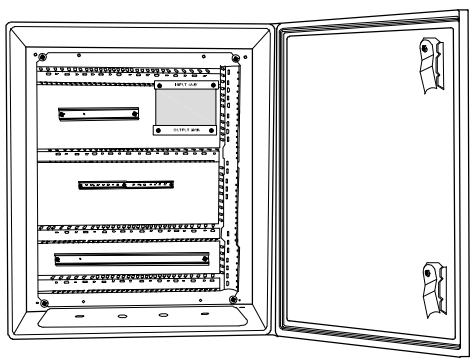
4 Mark for fixing holes for control accessories etc., as per layout diagram. (Fig 1)

5 Mark and cut the DIN rail, 'G' channel and race ways as per layout. Mark the points of drills on it to fix them inside the control panel.

6 Mark the drill holes in the front door of the control panel to fix the indicator lamp and push button switches.

7 Mark the fixing holes for the wire clips in the control panel door to run the wires. (Fig 1)

Fig 1



CONTROL PANEL WITH RACEWAYS / DIN RAILS

EL20N28167W1

8 Make the drills in side the control panel to fix control accessories, DIN rails, 'G' channel and race ways as per marking.

9 Make the through holes in race ways, DIN rails and G channel.

10 Fix the control accessories race ways, DIN rails and G channel using screws and bolt nut.

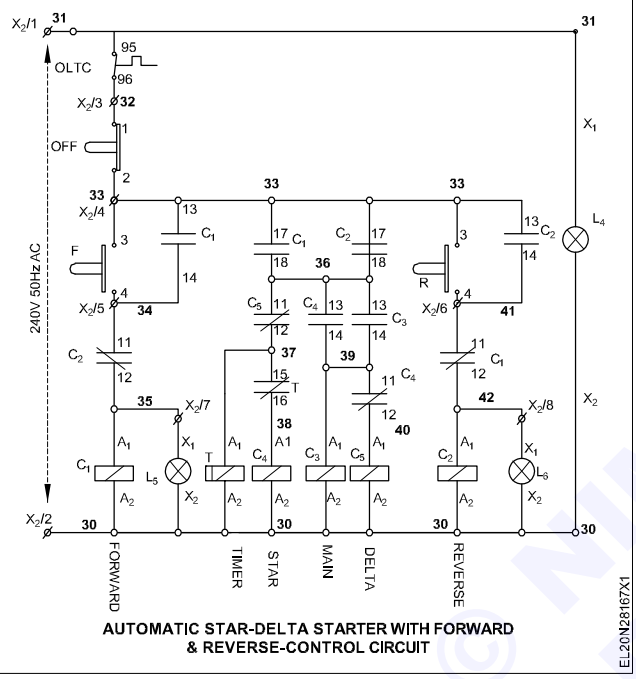
11 Make the drills on the door of panel for indicator lamp, push button and wire clips.

— — — — — — — —

TASK 2 : **Wire the control and Power circuit for automatic star delta starter with change of direction of rotation and test.**

1 Draw the control circuit and power circuit diagram and check with your Instructor. (Fig 1 & 2)

Fig 1



2 Label the Terminal number in the control and power circuit.

3 Measure and cut the cable as per layout.

A typical control panel fitted with race ways, DIN rails, control transformer and isolator.

4 Insert the ferrule Nos at the both ends of terminals as per layout.

Leave some extra length of wires in the race ways for easy maintenance and repair.

5 Run the wires in the race ways one by one. Avoid the cross over of the wires.

To avoid the cross - over first the vertical wires can be run followed by horizontal run.

6 Skin the wire ends and crimp with suitable lugs/ thimbles.

7 Connect the power and control circuits wires as per the control circuit diagram.

8 Route the wires in the race ways. Punch and ties the wires in the race ways using cable binding straps and button.

Leave the excess wires if any in bends or in the race ways.

9 Cover the PVC race ways over the wiring.

Take the necessary care to avoid the crushing of cable when cover the race ways.

10 Make the "U" loops of wires in the hinged doors. Bunch and tie the cable in the doors.

11 Fix the wire clips at suitable places to hold the cables in the panel door.

'U' loop should not disturb the movement and closing of the panel door.

12 Connect the incoming and out going terminals as per diagram and terminal details.

Use the grommets to avoid the strain in the cables.

13 Earth the panel, door, control devices.

14 Measure the insulation resistance of the panel.

If the IR value is less than 1 Meg ohm, take suitable remedial action.

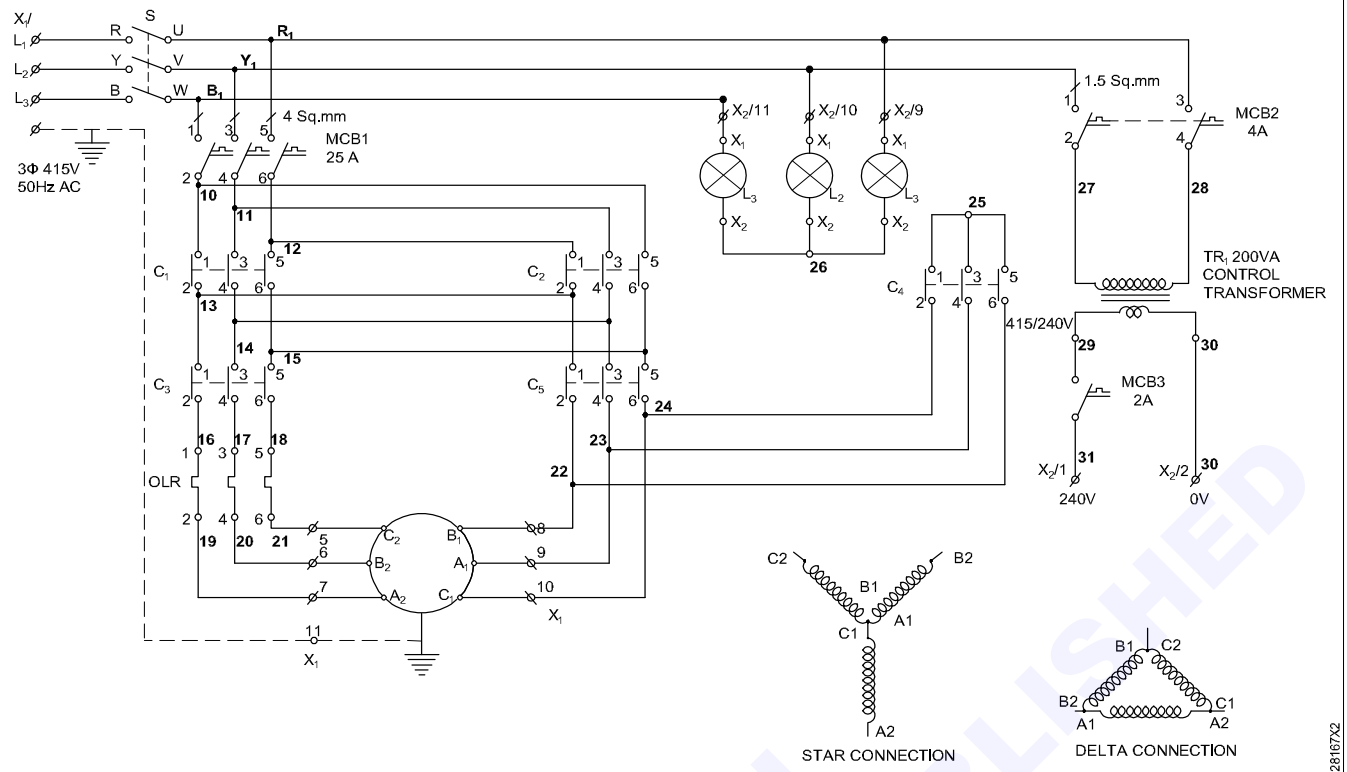
15 Set the OLR in accordance with the full load current of motor.

16 Connect the panel with motor and test the auto star delta starter with change of direction of rotation.

17 Show the control panel working to your instructor and get it approved.

Note: Remove the wiring as you did in the Ex.No.2.8.167(i) and preserve the remaining devices fitted for the next exercise 2.8.167(iv)

Fig 2



AUTOMATIC STAR-DELTA STARTER WITH FORWARD AND REVERSE-POWER CIRCUIT

EL20N28167X2

Design layout of control cabinet, assemble control elements and wiring accessories for sequential control of three motors

Objectives: At the end of this exercise you shall be able to
- **draw the control and power circuit for sequential control of three motors**
- **mark the layout on control panel**
- **mount the DIN rail and accessories**
- **wire up the accessories**
- **arrange the wiring by routing, bunching and tying**
- **test the control panel for sequential control of 3 motors.**

Requirements

Tools/Instruments

• Trainees tool kit	- 1 No.
• Scriber 100 mm	- 1 No.
• Hacksaw frame with blade- 300 mm	- 1 No.
• Hand drilling machine 6mm capacity	- 1 No.
• HSS Drill bit 6mm & 3mm	- 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.
• Air break contactor 4 pole,16A,240V	- 3 No.
• Thermal overload relay 0 -15A, 415V	- 3 Nos.
• Control transformer 415V/240V,200VA	- 1 No.
• Time control transformer 415V, 1 No + 1 NC	- 2 Nos.

Materials

• MCB 4 pole, 415V, 16A	- 1 No.
• Push button Red /Green	- 1 each
• Indicator lamp with holder	- 7 Nos.
• Limit switches 1NO+INC	- 2 Nos.
• Fuse base with carrier	- 9 No.
• MCB 2 Pole 4A	- 1 No
• MCB single pole 2A	- 1 No.
• Race ways	- 2 m
• Wire clips	- 4 Nos.
• DIN rail/ G channel	- 1 m
• 1.5 sq.mm copper cable 660V (red, black, yellow, blue, green)	- as reqd.
• Terminal connectors	- as reqd.
• Wire ferrule	- as reqd.
• Grommets	- as reqd.
• Lug/thimble	- as reqd.
• Cable binding straps and buttons	- as reqd.
• Nylon cable ties	- 10 Nos.
• Assorted size bolt and nut	- as reqd.

PROCEDURE

The control panel board used in the Ex.No.2.8.167 (iii) has to be retained with accessories, fitted, to use for this exercise.

TASK 1 : **Draw the layout and mark the layout in control panel**

Note : Instructors have to provide a blank control panel along with power and control circuit of the local and remote control of induction motor.

1 Draw the layout diagram for the sequential control of three motors.

2 Select and check the accessories required.

3 Mark the layout inside the control panel by using steel rule and scriber.

4 Mark for fixing holes for isolators and control transformer etc., as per layout diagram.

5 Mark and cut the DIN rail, 'G' channel and race ways as per layout. Mark the points of drills on it to fix them inside the control panel.

6 Mark the drill holes in the front door of the control panel to fix the indicator lamp and push button switches.

7 Mark the fixing holes for the wire clips in the control panel door to run the wires. (Fig 1)

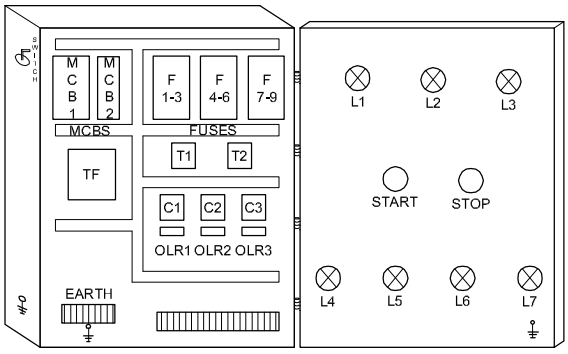
8 Make the drills in side the control panel to fix isolator, control transformer, DIN rails, 'G' channel and race ways as per marking.

9 Make the through holes in race ways, DIN rails and G channel.

10 Fix the race ways, DIN rails and G channel using fixing screw.

11 Make the drills on the door of panel for indicator lamp, push button and wire clips as per marking. (Fig 1)

Fig 1



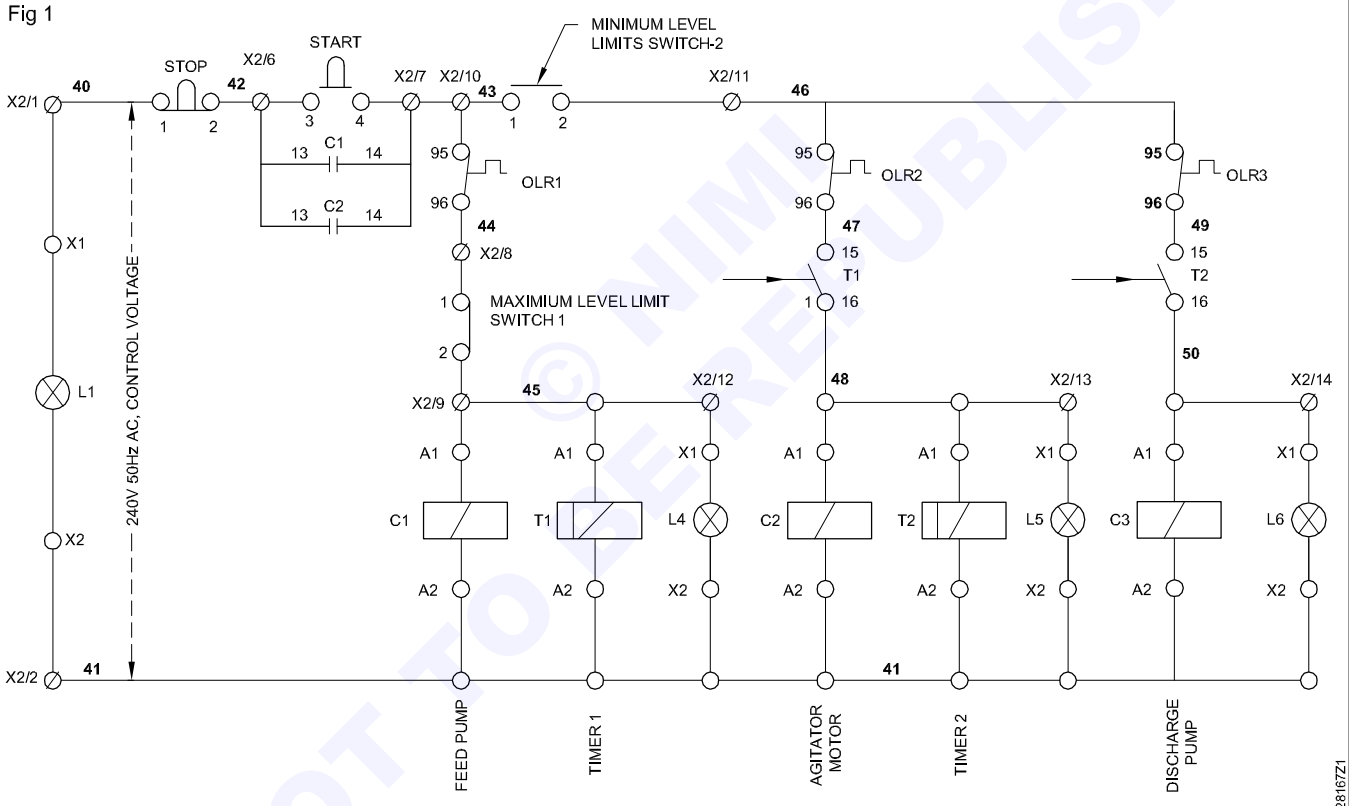
TYPICAL LAYOUT FOR SEQUENTIAL CONTROL PANEL

TASK 2 : **Wire the control and Power circuit for sequential control of three motors and test**

1 Draw the control and power circuit diagram and check with your Instructor. (Fig 1&2)

2 Label the Terminal number in the control and power circuit.

Fig 1



CONTROL CIRCUIT OF SEQUENTIAL CONTROL OF AGITATOR SYSTEM WITH THREE MOTORS

3 Measure and cut the cable as per layout.

4 Insert the ferrule Nos at the both ends of terminals as per layout.

Leave some extra length of wires in the race ways for easy maintenance and repair.

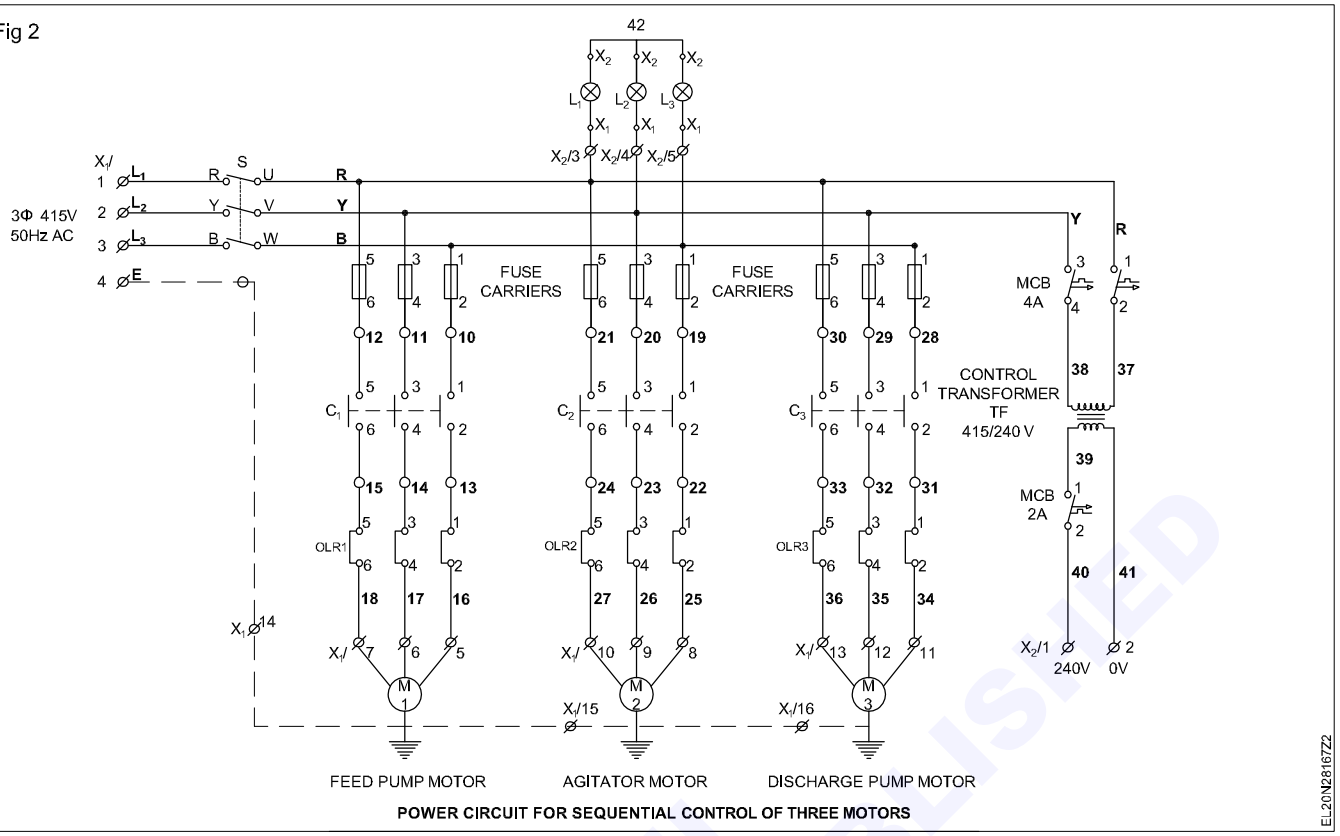
5 Run the wires in the race ways one by one. Avoid the cross over of the wires.

To avoid the cross - over the vertical wires can be run followed by horizontal run.

6 Skin the wire ends and crimp with suitable lugs/ thimbles.

7 Connect the power and control circuits wires as per the circuit diagram.

Fig 2



POWER CIRCUIT FOR SEQUENTIAL CONTROL OF THREE MOTORS

EL20N2816TZ2

8 Route the wires in the race ways. Punch and ties the wires in the race ways using cable binding straps and button.

Leave the excess wires if any in the bends or in the race ways.

9 Cover the PVC race ways over the wiring.

Take the necessary care to avoid the crushing of cable when covering the race ways.

10 Make the "U" loops of wires in the hinged doors. Bunch and tie the cable in the doors.

11 Fix the wire clips at suitable places to hold the cables in the panel door.

'U' loop should not disturb the movement and closing of the panel door.

12 Connect the incoming and out going terminals as per diagram and terminal details.

Use the grommets to avoid the strain in the cables.

13 Earth the panel, door, control transformer and motors.

If the multiple earths are used, use a common earth terminals and strips.

14 Measure the insulation resistance of the panel.

If the IR value is less than 1 Meg ohm, take suitable remedial action.

15 Set the OLR in accordance with the full load current of motor.

15 Test the control panel for sequential operation of 3 motors.

Note: Remove the wiring and preserve the remaining control elements fitted with panel for the next exercise No. 2.8.168.

16 Report and get it checked with your instructor.

Carryout wiring of control cabinet as per wiring diagram, bunching of XLPE cables channeling, tying and checking etc.

Objectives: At the end of this exercise you shall be able to
- **verify the wiring diagram panel board and wire up**
- **bunch the Cross Linked Polyethylene (XLPE) cables**
- **channel and tie the cables**
- **check the wiring.**

Requirements

Tools/Equipments/Instruments

• Trainees tool kit	- 1 No.
• Multimeters	- 1 No.
• Wire cutter/stripper	- 1 No.

Materials

• Panel board - 3'x2'x1' - Metal box with winged front door	- 1 No.
• DIN rails/race ways	- as reqd.
• Screws, nuts and bolts	- as reqd.
• Tying clips	- as reqd.
• Ferrule	- as reqd.
• PVC channel	- as reqd.
• G channel	- as reqd.
• Terminal connector	- as reqd.
• Belt traps	- as reqd.
• XLPE cable 1.5 sq.mm 600V	- as reqd.
• 1 sq.mm cable (copper)	- as reqd.
• Wire sleeves	- as reqd.
• Wire clips	- as reqd.
• Grommets	- as reqd.
• Banana sockets (5 mm)	- 1 No.

PROCEDURE

TASK 1 : **Wire up control cabinet as per diagram with bunching, channeling, typing and checking etc.**

The control panel board used in the Ex.No.2.8.167(iv) has to be retained with control accessories fitted is to used for this exercise. For the wiring XLPE cables to be used.

1 Draw the wiring diagram and wire up as per the diagram.

Follow the colour coding of cables used for line controller, neutral and ground connections.

Inter connections of devices may be used same colour. Supply line, load line should he colour coded and numbered using ferrule.

2 Bunch the XLPE cables by using the tie clips and wire clips.

3 Apply belt traps for excessive bunch of cables.

4 Make a U loop on the bunch of cables when it is connected to front door.

5 Cut excessive tie ends and other excessive parts to make a neat bunching of cables.

Clean the panel board and preserve for next Exercise No.2.8.169.

6 Show the work done on the panel board to your instructor and get approval.

7 Check the wiring for its correctness.

— — — — — — — —

TASK 2 : **Connect the control panel with 3 phase induction motor**

1 Draw the circuit diagram for the control panel with 3 phase induction motor. (Fig 1)

2 Wire up the control panel to the 3 phase motor in conduct wiring.

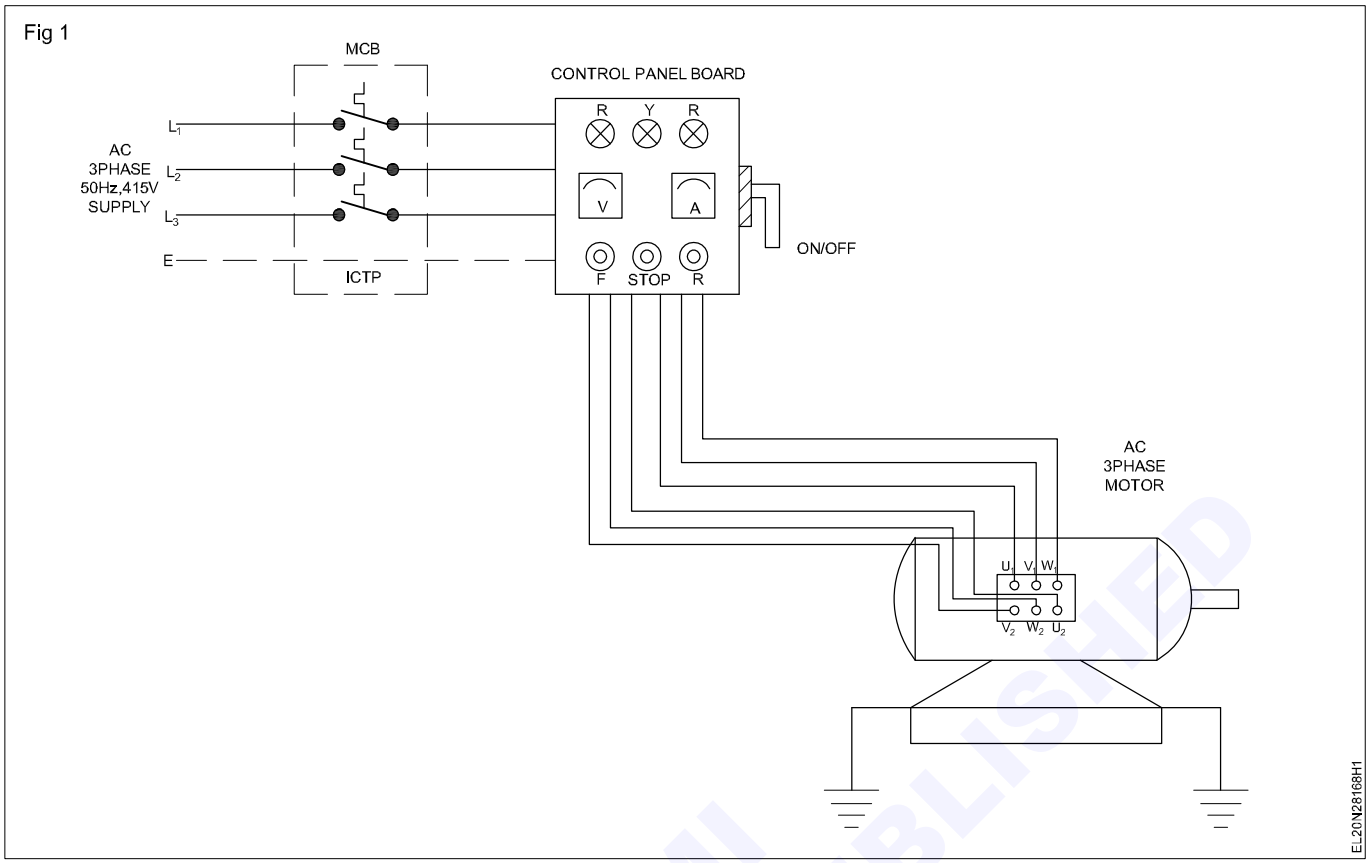
3 Provide double earthing for the motor.

4 Test the wiring for the proper operation of control panel controls with motor.

5 Check the controls of control panel for changing the direction of rotation of motor.

6 Get it checked with your instructor.

Fig 1



Mount various control elements (e.g) circuit breakers, relays, contactors and timers etc.

Objectives: At the end of this exercise you shall be able to
- **drill the holes in the marked places**
- **Mount the circuit breakers, relays, contactors and timer**
- **connect the cables to the control elements.**

Requirements

Tools/Equipments/Machines

• Trainees tool kit	- 1 No.
• Multimeter	- 1 No.
• Wire cutter/striper	- 1 No.
• Needle file set	- 1 Set.
• Round file set	- 1 No.
• Hand drilling machine (electric) 6mm	- 1 No.
• Half round file smooth-150 mm	- 1 No.
• Flat file smooth-150 mm	- 1 No.

Materials

• MCB 4 pole, 415V/16A	- 1 No.
• OLR- 3 phase 415V/0-15A	- 1 No.
• Contactors - 3 phase, 415V/16A 240V coil	- 5 Nos.
• Timer - 1 phase, 10 sec	- 2 Nos.
• Push button - 240V, NC/NO red & green	- 4 Nos
• Indicating lamp with holder RYB	- 3 Nos.
• Limit switch	- 1 No.
• ON-OFF rotary switch 3 phase 32A	- 1 No.

PROCEDURE

The panel board used in the Ex.No.2.8.168 is to be used for this exercise.

TASK 1: **Mark and make holes for mounting devices**

1 Measure the total area of base plate on four panel board, where devices are to be mounted.

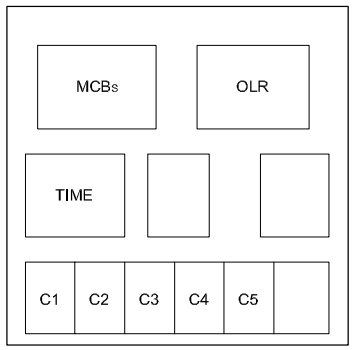
2 Identify and check the area required to mount the devices like circuit breaker, contactor, push button, OLR, ON-OFF rotary switch, Timer, etc: as per the total quantity available.

3 Mark the plates where to fix the DIN rail and race ways to mount circuit breaker, contactors. (Fig 1)

While marking the layout for mounting devices, it is distributed equally to the whole area uniformly. Do not fix all the items in one end. Keep some space for future needs.

4 Make hole by electric drill to the size of nut and bolts. If the bolt is not free in through holes, use needle round file or bigger bits to make the bolt free going.

Fig 1



LAYOUT OF CONTROL DEVICES ON BASE PLATE

5 Fix the devices according to the layout on base plate check each devices for its rigidity and position correctness and get it checked.

— — — — — — — —

TASK 2: **Connect cables to control devices and checking the continuity**

1 Check the XLPE cables for continuity and tighten before connecting to the device.

2 Connect all the cable to the respective terminals and connecting points to the devices, fitted on the base plate.

3 Connect the relay coil, contactor coil, etc to a external source of working voltage and confirm the function especially in the Normally Close (NC) and Normally Open (NO) no contacts of push buttons and contactors.

4 Report to your instructor for approval.

— — — — — — — —

Identify and install required measuring instruments and sensors in control panel

Objectives: At the end of this exercise you shall be able to
- **identify and fix instruments to measure electrical quantities**
- **identify the sensors and fix it on the panel board.**

Requirements

Tools/Equipments/Machines

- Trainees tool kit - 1 No.
- Wire cutter/striper - 1 No.
- Hard drilling machine (electrical) 6mm - 1 No.
- Needle file set (set of 5) - 1 Set.
- Round file smooth - 150 mm - 1 No.
- Flat file smooth - 150 mm - 1 No.
- Tachometer - digital - 3 1/2 digit along with tacho generator set - 1 No.
- Single phase frequency meter digital - 3 1/2 digit - 1 No.
- Temperature indicator - digital 3 1/2 digit - along with thermistor sensor unit - 1 No.
- Voltmeter - 0-600V - digital - 1 No.
- Voltmeter - 0-300V - digital - 1 No.
- Ampere meter 0-30A digital 31/2 digit - 3 Nos.

Materials

- Nut and bolt (Assorted sizes) - as reqd.
- Washer (Ordinary & spring type) difficult sizes - as reqd.
- 1 sq.mm cable - as reqd.

PROCEDURE

The panel board used in the Ex.No.2.8.169 is to be used for this exercise with accessories.

TASK 1: **Fix panel meters and indicators on front panel**

1 Identify and select proper range of instruments (voltmeter, ammeter etc.,) suitable for this control panel.

2 Identify and select the required sensors (for temperature and speed) for this control panel.

The control devices are fitted on base cover and indicators are to be fitted on front panel. Wiring is terminated in respective points to be connected in the instruments. Proper sockets for terminating sensor outputs are to be provided on the front panel.

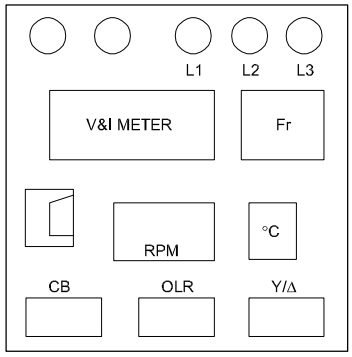
3 Mark the positions to fix the indicators on front panel (Line indicators, tripping indicators etc.)

4 Make holes for fixing the meters and other fixtures on front panel.

5 Fix the meters and indicators on front panel.

Distribution of gadgets on fixing in front panel should be uniform. Proper arrangement and distribution to have a good look on the front panel required. Do not crowed the devices at one places, and indicate devices like line indicator, trip indicator should be at top of the front panel as in Fig 1.

Fig 1



LAYOUT OF DEVICES ON FRONT PANEL

6 Wire the fitting in front panel using suitable cables.

Bunching or typing cables in front panel board is to be done if necessary.

7 Check the continuity of cables wired inside the panel board.

8 Report to your instructor.

Test the control panel for its performance

Objectives: At the end of this exercise you shall be able to
- **test the control panel for any short circuit earthing with fitted devices**
- **test the earthing points connections with connected control devices**
- **energise and test the panel board for its working condition.**

Requirements

Tools/Equipments/Machines

- Trainees tool kit - 1 No.
- Megger 1000V - 1 No.

Materials

- Connecting leads - as reqd.

PROCEDURE

The panel board used for the Ex.No. 2.8.170 is to be used for this Exercise with complete accessories and wiring.

The panel board with accessories and wiring is to be preserved for this Exercise No.2.8.171

1 Check the Insulation Resistance (IR) value of contactors circuit breakers etc, (Fig 1) enter the values in Table 1.

2 Check for any short circuit/open circuit fault.(Fig 1)

If any IR value shows abnormal or very low, consult with your instructor.

3 Switch 'ON' the supply to the panel board and verify the functions of line indicator, meters etc.

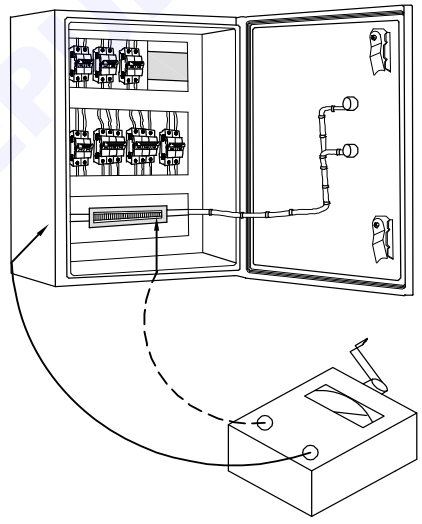
4 Test the contactor, push button switch, timer for its function. Enter the status in Table 1.

5 Switch 'ON' the motor and check the functions of sensors (speed and temperature)

If any control device found faulty replace new control devices and test it.

6 Complete your testing and show to your instructor for approval.

Fig 1



TESTING OF PANEL BY MEGGER

EL20N28171H1

Table 1

Sl.No	Description of the items	Megger value in MΩ	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		

Perform speed control of DC motor using thyristors/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.**

Requirement

Tools/Instruments

- 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.

Equipment/Machines

- 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 standard 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

2 Check and identify terminals of the DC motor and DC drive.

Lamp load

Connect with main switch/MCB, 4 Nos of 500 W clear lamps fitted in a enclosure having individual ON - OFF facility.

Table 1

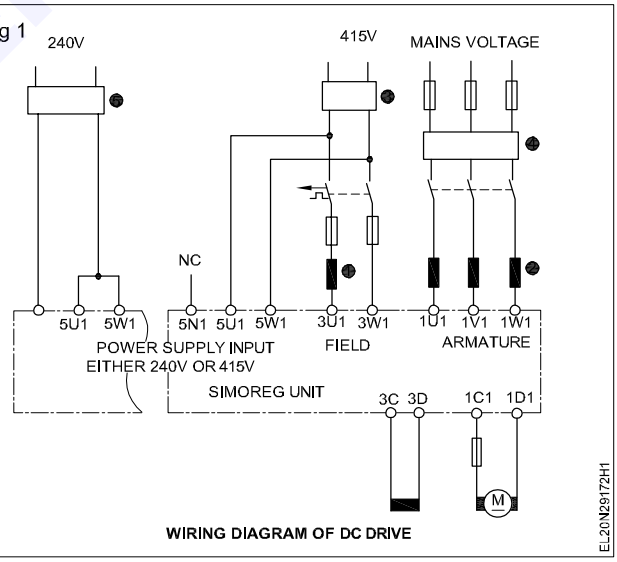
Make & SI.No		
Rated Mains	V	
Rated Power	KW	

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)

Fig 1



WIRING DIAGRAM OF DC DRIVE

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.

Improper connection of DC drives leads to shock and material damage.

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)

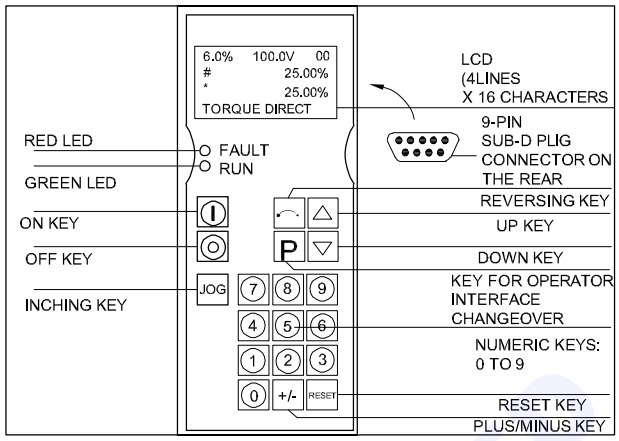
2 Connect MCB, DC drive, M.G set and lamp load. (Fig 2)

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 1.

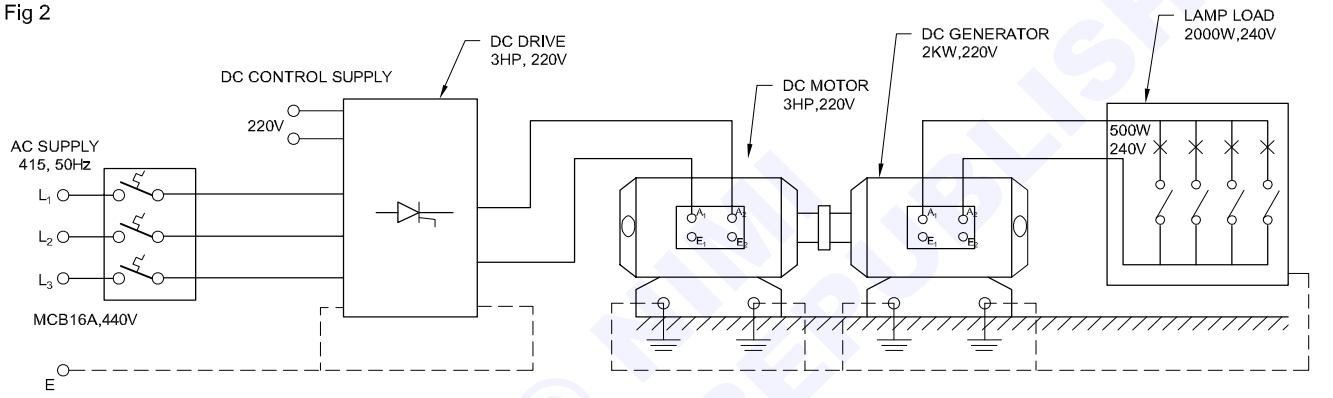
5 Load the motor by 1/4th load; by switching 'ON' one lamp. Record the current , voltage, frequency and voltage in load terminal, vary the speed and observe the readings.

Fig 1



CONTROL PANEL OF DC DRIVE

Fig 2



CONNECTION DIAGRAM SPEED CONTROL OF DC MOTOR USING DC DRIVE

Table 1

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 2. Vary the speed with 1/2th load and observe the readings and record in Table 1.

7 Load further to 3/4th load (500+ 500 + 500=1500W) and repeat step 5 and record the reading in Table 4.

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.

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.

Perform speed control and reversing the direction of rotation of AC motors by using thyristors/AC drive

Objectives: At the end of this exercise you shall be able to
- **read and interpret the name plate details of AC drive**
- **connect the input / output terminals of AC drive through AC motor**
- **identify the operating buttons on AC drive**
- **control the motors speed by using AC drive**
- **reverse the directions of rotation of 3 phase induction motor by using AC drive.**

Requirements

Tools/Instruments

- Insulated combination pliers 150 mm - 1 No.
- Screw driver 200 mm - 1 No.
- Connector 100mm - 1 No.
- Electrician's knife 100mm - 1 No.
- Round nose plier 150 mm - 1 No.

Equipments/Machines

- 3 Phase induction motor 5 H.P/415V - 1 No.
- AC drive 3 phase 415V, 2HP - 1 No.

Materials

- PVC insulated standard copper cable 1.5 sq.mm - 15 m
- PVC insulated flexible cable 14/0.2 mm - 2 m
- Insulated tape - 1 m
- Fuse wire - as reqd.

PROCEDURE

TASK 1 : **Connect the input/output terminals of AC drive through AC motor**

1 Note down the name plate details of the given motor and AC drive and enter them in Table 1 & 2.

2 Identify the terminals of the 3 - phase induction motor.

Table 1

AC motor name plate - details

Manufacturer	_____	Rated frequency	_____ Hz
Model	_____	Speed	_____ RPM
Power	_____ KW/HP	Insulation class	_____
Voltage	_____ Volt	Rated current	_____ A

Table 2

AC drive name plate - details

Manufacturer _____ Model : _____

I/P voltage _____ V

I/P frequency _____ Hz

O/P frequency _____ Hz

Serial Interface type _____

Output voltage _____ V

Power range _____ HP/KW

Control type _____

Braking type _____

3 Identify and trace the internal circuit of AC drive and get it approved by the instructor.

4 Check the switch /MCB , cables and fuse - wire rating and match with motor rating.

5 Draw the connection diagram of ICTP, drive, motor and get it approved by the instructor.

6 Connect the motor, AC drive, main switch as per approved diagram and get it checked the instructor. (Ref. Fig 1)

7 Connect double earth independently for the main switch, AC drive and the motor.

Improper connection of AC drive results shock and material damage.

— — — — — — — —

TASK 2 : **Connect, run the motor and setting the parameter of different speed**

1 Select the suitable type of model AC drive.

2 Connect and wire the AC drive input power supply with terminals R/L1, S/L2, T/L3, when the output terminals U/T1, V/T2, W/T3, are connected to the motor. (Fig.1)

3 Switch ON the power supply main.

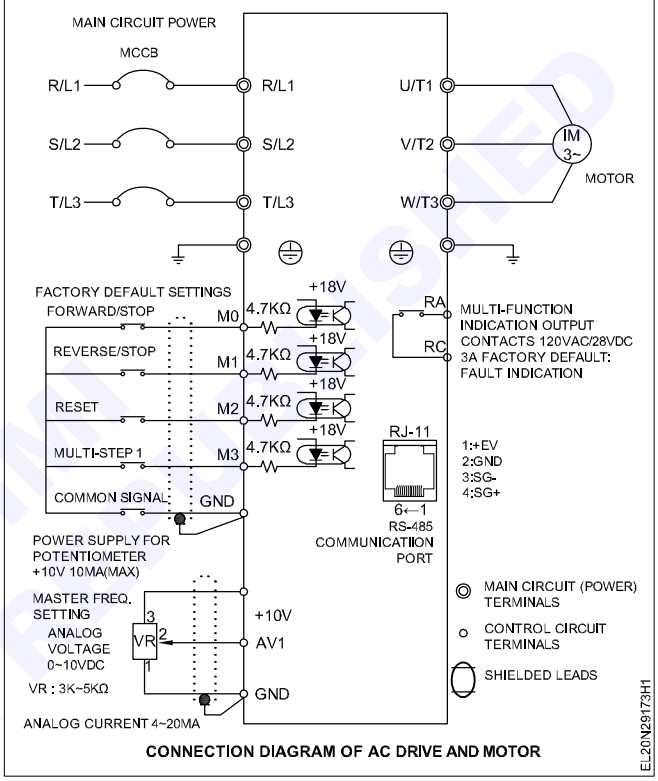
4 Press RUN/STOP button. The motor will run. (Ref. Fig 1 Measure the speed of motor by using the Tachometer and record it_____RPM.

5 Increase and decrease the frequency and check the change in speed of the motor.

6 Press 'STOP' button and turn 'OFF' main power supply to disconnect the supply.

Improper connection of AC drive results shock and material damage.

Fig 1



CONNECTION DIAGRAM OF AC DRIVE AND MOTOR

— — — — — — — —

TASK 3 : **Reverse the direction of rotation in AC motor by setting in AC drive**

1 Switch ON the power supply main.

2 Press key RUN/STOP button (Ref.Fig 1). The motor will run in forward direction.

3 Set the parameter for reverse direction. (Ref.Fig 1)

4 Press RUN / STOP, button key, The motor will run in reverse direction.

5 Press the STOP button to stop the motor.

Improper connection of AC drive results shock and material damage.

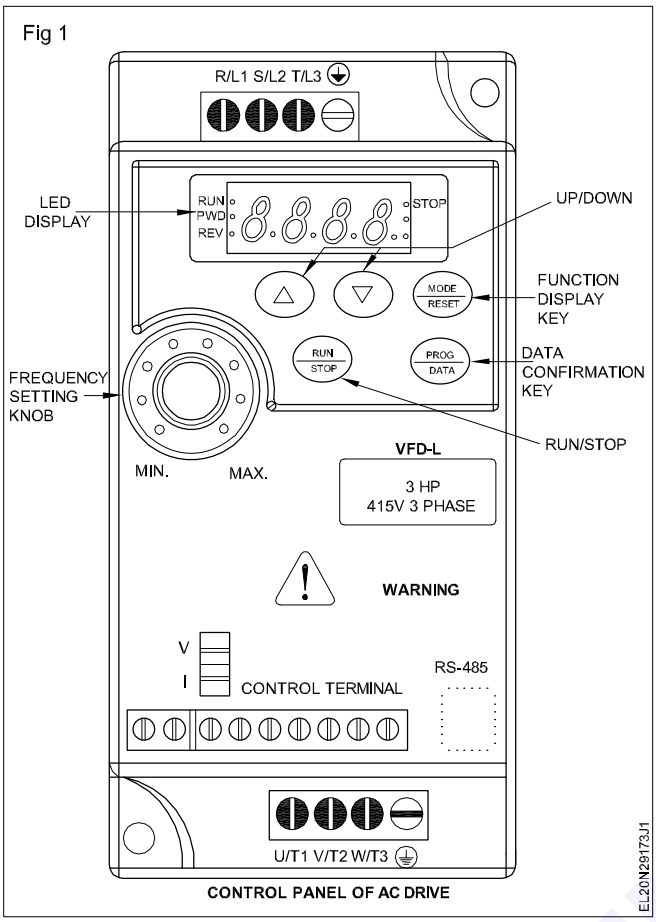
The motor will run as you press the key and will stop as you leave the key

6 Turn 'off' the power supply and disconnect the drive.

Do not run the motor at low speed for longer time. Because the motor cooling will not be effective due to low fan speed. So motor will heat up.

The programming procedure /keys may differ according to the make model of the drive in your institute. Refer to the drive instruction manual and take help of your instructor.

Fig 1



CONTROL PANEL OF AC DRIVE

Construct and test a universal motor speed controller using SCR

Objectives : At the end of this exercise you shall be able to
- **wire an universal motor speed controller circuit on PCB and test it**
- **assemble the wired PCB along with POT and socket in a gang box and test**
- **test the speed controller with lamp, fan, electric drilling machine**
- **check possible minimum and maximum speed adjustment using contact type tachometer.**

Requirements

Tools/Equipments/Instruments

- Trainees tool kit - 1 Set
- Electric hand drilling machine - 1 No.
- Contact type tachometer with necessary attachments - 1 No.
- Wired lamp holder with lamp of 40W or less (Test Lamp) - 1 No.
- Main operated table fan of any make - 1 No.

Materials/Components

- Resistors
  - – R_1 = 10K.5W - 1 No.
  - – R_2 = 470 ohms ± 5%, 1/4W - 1 No.
  - – R_3 & R_4 = 1K ohms ± 5%, 1/4W - 2 Nos.
  - – Potentiometer (RV_1) = 1K, 1W - 1 No.
- Capacitors
  - – C_1 = 2U2, 63V - 1 No.
  - – C_2 = 100 nf (Polyester) - 1 No.
- Semi-conductors
  - – SCR - C106D or equivalent or any SCR of 400V and current rating greater than 3 Amp - 1 No.
  - – Q_1 BD135 or equivalent - 1 No.
  - – Q_2 BD136 or equivalent - 1 No.
  - – (D_1,D_2) IN4004 - 2 Nos.
- Other items
  - – PC board code to be made as in Fig 2 - 1 No.
  - – 100 x 75 mm gang box used for conduit wiring - 1 No.
  - – Hylam sheet 100 x 75mm x 3mm thick - 1 No.
  - – Self threading screw 3mm x 10mm for fixing hylam sheet on gang box - 6 Nos.
  - – 3mm x 20mm screw and nut (to fix PCB inside the gang box) - 4 Nos.
  - – Spacers 3mm x 10mm (to separate PCB from gang box) - 4 Nos.
  - – 5Amps, 3 core cable (Mains cord) - 2 m
  - – 240V, 6 Amps flush type socket - 1 No.
  - – 240V, 6 Amps, flush type SP switch - 1 No.
  - – 240V, 6 Amps, 3 pin plug - 1 No.
  - – Knob suitable for 16 mm plastic shaft pot - 1 No.
  - – Heat sink for SCR (suitable size) - 1 No.
  - – Terminal strip 3 way - 1 No.
  - – Flexible wire, 5 Amps, 240V (Red, Blue, Green) - 0.5 m each
  - – Hookup wire - 1 m
  - – Resin core soldering lead - 20 cms

PROCEDURE

1 Prepare a PCB for the given dimensions (Fig 1). Check the sizes of the components with the soldering position on the PCB. If necessary slightly alter the dimensions of the PCB track.

2 Check the PCB tracks and clean PCB.

3 Test the components to confirm its working condition.

4 Wire the speed controller circuit on the PCB referring to the circuit schematic in Fig 2 and the PCB layout diagram (Fig 3). Get the wired circuit checked by your instructor.

5 Make connections for the POT, switch, 5A flush type socket, mains 3 core cable mains 3-pin top with the wired circuit on PCB by using suitable wires. Get the wiring checked by your instructor.

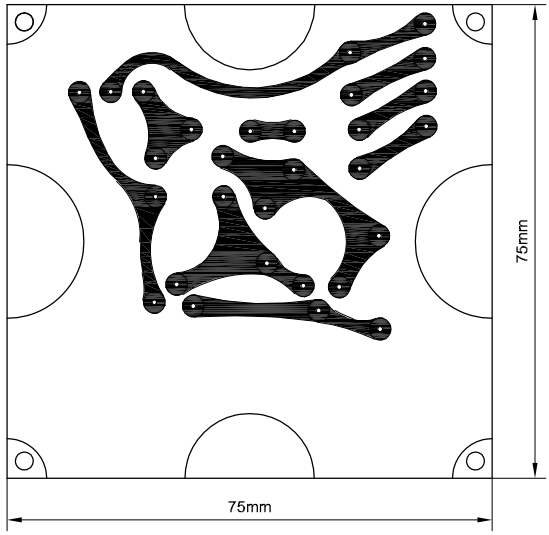
The wire connections are made is to test the wired speed controller circuit before assembling them in the gang box as in Fig 3. Therefore keep sufficient wire lengths in all connections made for the purpose of safety and ease of testing.

6 Test the working of wired circuit by connecting a test lamp load at the output of the speed controller circuit. Check the lamp glow bringing the two extreme positions of the speed.

If the lamp brightness is not varying , vary the position in the wired circuit/connections.

7 Test the speed controller using table fan as load and record your observation.

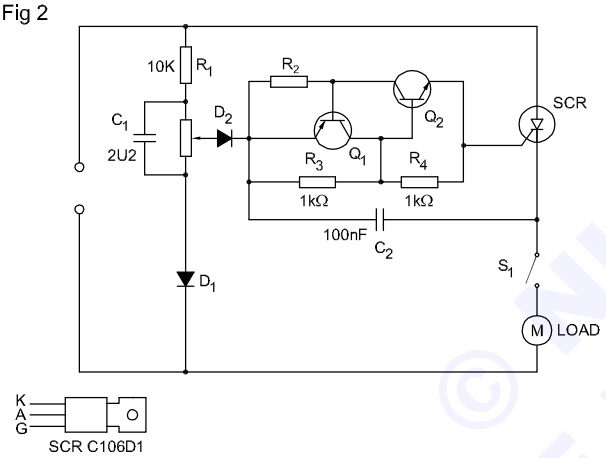
Fig 1



COPPER CLAD SIDE

EL20N29174H1

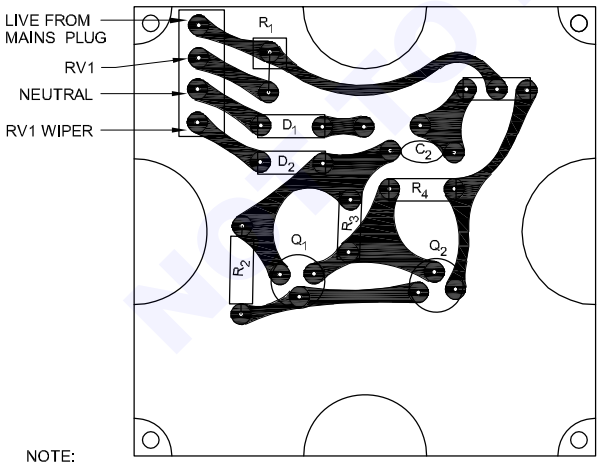
Fig 2



CIRCUIT DIAGRAM OF THE DRILL SPEED CONTROLLER

EL20N29174H2

Fig 3



NOTE:

C1 IS MOUNTED ACROSS RV1 TERMINALS

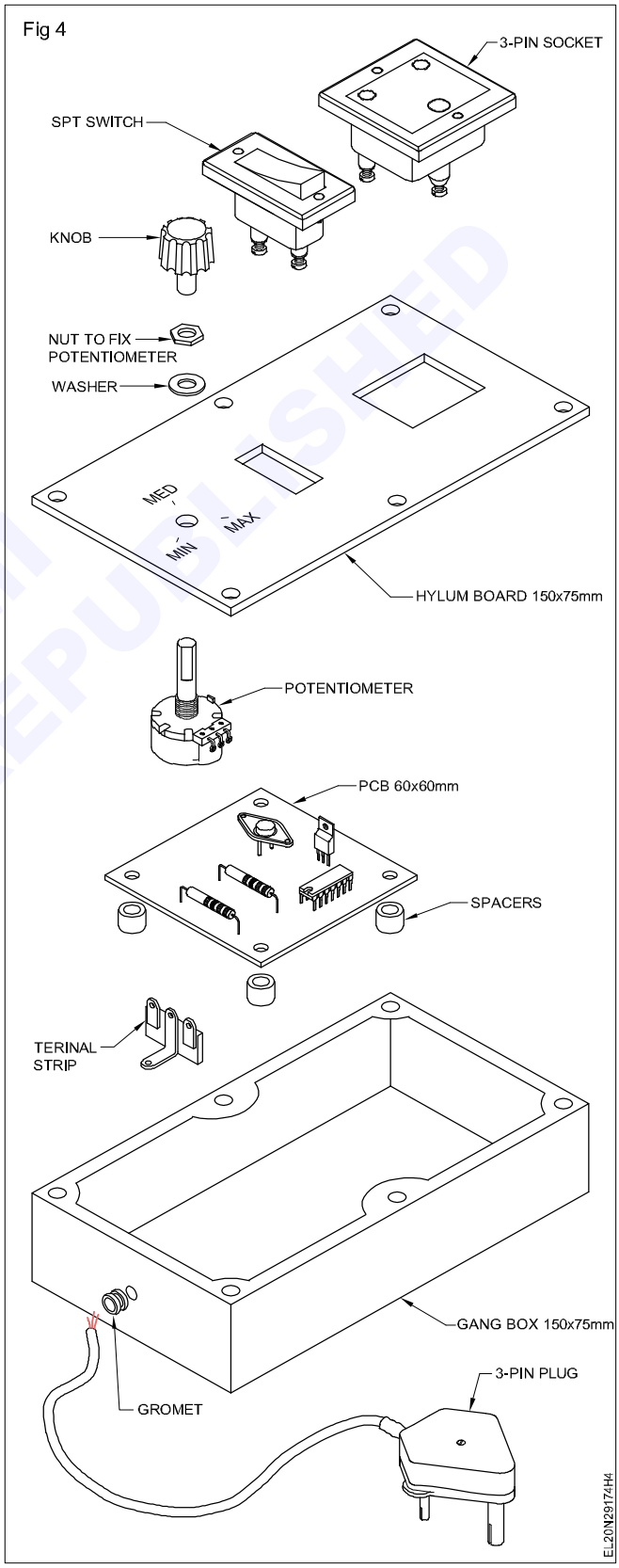
COMPONENT SIDE OF PCB

EL20N29174H3

8 Assemble the PCB and other associated items, so that the wired speed controller is ready for use as shown in Fig 4. Get it checked by your instructor before fixing the top hylam sheet on the gang box.

9 Repeat steps 5 and 6 after making final assembly of the speed controller unit to confirm that no errors are committed during assembly. Record observations made.

Fig 4



EL20N29174H4

10 Test the universal motor speed controller unit for its range of speed control by connecting an electric drill gun as load and measuring the speed of the gun at minimum, middle and maximum positions of the speed control POT.

11 Record the speed in Table 1. Use contact type tachometer to measure the speed of the electric drill gun at different speed control positions of the POT.

12 Get your work and recorded readings checked by your instructor.

Write the specifications of the wired speed controller on a paper and paste it at the back of the gang box in which the circuit is assembled.

13 Get it checked by your instructor.

The wired and tested universal motor speed controller can be effectively used for any practical applications. So preserve the project work made and use it whenever required.

Table 1

Position POT	Speed in RPM
Minimum	
Middle	
Maximum	

— — — — — — — —

Assemble circuits of voltage stabilizer and UPS

Objectives: At the end of this exercise you shall be able to
- **construct voltage stabilizer circuit on PCB**
- **test the stabilizer for its low and high cut-off ranges**
- **assemble 'ON' line UPS with assembled PCB modules/circuit boards**
- **test the 'ON' line UPS for its function.**

Requirement

Tools/Instruments

- Trainees tool kit - 1 No.
- Multimeter - 1 No.
- AC Voltmeter 0-300 V - 1 No.
- Variac 0-300V/1A - 1 No.

Materials

- General purpose PCB - 1 No
- Transistors - BC 147/157 - 2 Nos.
  CL 100 - 2 Nos.
- Diode IN 4007 - 2 Nos.
- Zener diode 6V/0.5A - 1 No.
- LED, red & green - 1 No. each
- Inductor - 21 SWG
  Ferrite core 100 turns - 2 Nos.
- Capacitor - 330 µFd/12V - 3 Nos.
  100 µFd/12V - 4 Nos
- Resistors carbon film 1/2 W
  1K5, 3K3, 1K - 2 Nos. each
  560Ω, 100Ω - 2 Nos. each
  4K7, 47K - 3 Nos. each
  1K Pot - 1 No.
- Electronic relay - 170V - 270 V/6V - 2 Nos. each
  moulded type : 3 pin
  Buck - boost mains transformer
  170V - 270V - 1 KVA
  0-6 A, 0-6 V AC - 1 No.
- Assembled modules or PCBs of a ON line UPS - 1 Set
- Incandescent lamps fitted in pendent holders - 1 No.
- Connecting wires/cables - as reqd.
- Solder; flux etc. - as reqd.

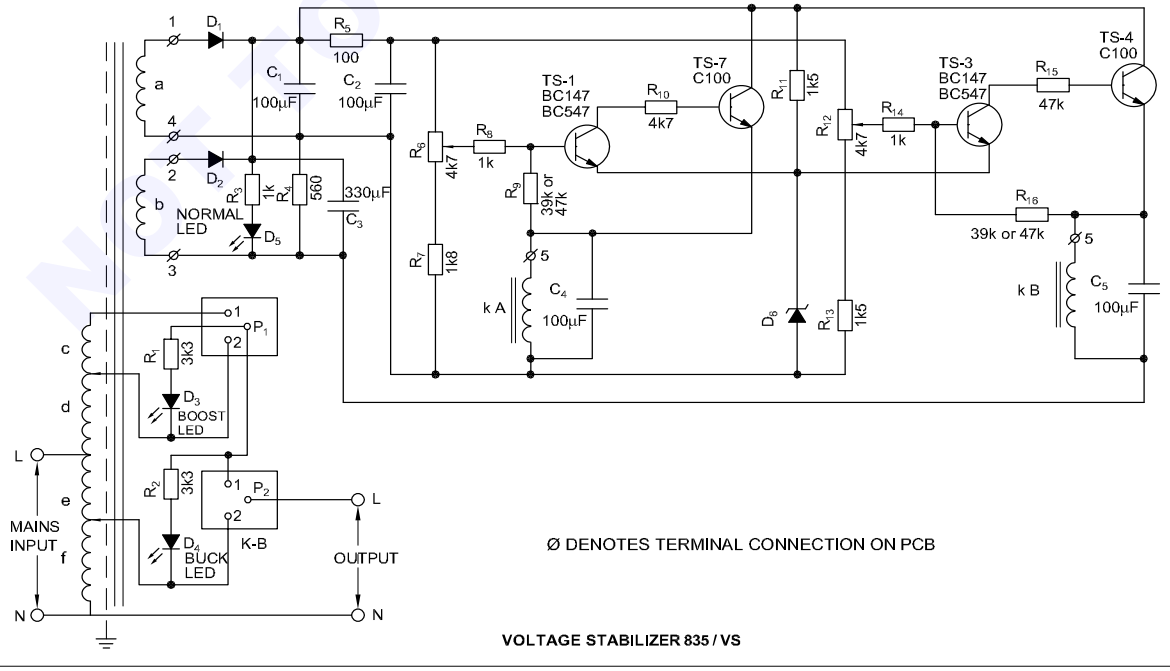
PROCEDURE

TASK 1: **Construct voltage stabilizer circuit on PCB**

1 Solder the components on general purpose PCB as per the circuit (Fig 1). Do not fix the transformer on PCB.

2 Connect the wires or cables from the PCB to connect with transformer winding terminals.

Fig 1



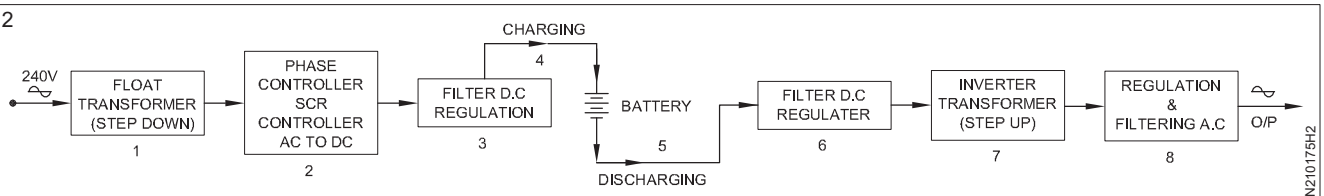
3 Finish the wiring and clean the PCB; check the wiring for its correctness.

4 Connect the transformer input wires to the Variac for testing the circuit. Connect the incandescent lamp in the output of stabilizer. (Fig 2)

5 Switch 'ON' the supply to Variac and slowly increase the voltage till normal LED glow and output lamp glow.

6 Switch 'OFF', remove the lamp and connect the voltmeters. Do not change the variac position.

Fig 2



BLOCK DIAGROM OF 'ON' LINE UPS

7 Switch 'ON' the supply and note down the voltage in Table 1.

8 Test the bulk-boost action by increasing and decreasing of Variac voltage increase the variac voltage.

9 Check the voltmeter, starts to show increase in voltage initially; but drops to normal voltage. Note down both the voltage; Voltage in output and Voltage at Variac terminals. Record in the Table 1.

10 Reduce the voltage of Variac and note the voltmeter reading. The voltmeter voltage will decrease but regains its normal position.

11 Note this time voltage : Voltage at output and variac terminal voltage in the Table 1.

If the voltage is not changing when changing variac volt ; consult your instructor.

12 Remove all connections and get your voltage readings approved by your instructor.

Table 1

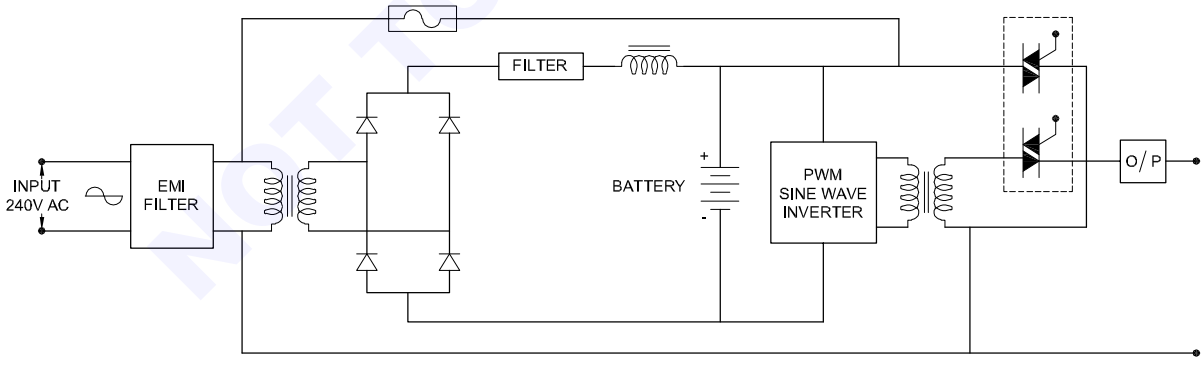
Sl. No.	Variac voltage position	Variac terminal voltage (Volt)	Output voltage (Volt)
1	Variac knob in Middle Position		
2	Increase from Middle Position		
3	Decrease from Middle Position		

TASK 2: **Assemble of 'ON' line UPS using wired PCB modules**

1 Refer the block diagram in Task 1 and arrange the PCB wired modules.

2 Wire the PCB modules as per the block diagram in Fig 2 in Task 1 and check the sequence as per the Fig 1.

Fig 1



ON LINE UPS CIRCUIT

3 Connect the charged battery without shorting the battery terminals. Connect one single pole switches initially with battery circuit.

4 Connect the input to EMI filter. Check for any circuit problems. Switch 'ON' the circuit 240V AC. Check the output with Voltmeters. Record the meter reading in Table 1.

If it is not indicating any voltage and consult with your Instructor.

5 Switch 'ON' the battery. Check the voltage in the output and record the reading in Table 1.

6 Switch 'OFF' the Mains 240V and check the voltage in output, record the voltage in Table 1.

If no voltage consult with your instructor.

7 Connect the incandescent lamp in the output. Repeat steps 4 to 6.

8 Note the lamp brighten while input supply 220V. Switched 'ON' & 'OFF'.

If lamp is not glowing or dim consult with your Instructor.

9 Get your readings approved by your instructor.

Table 1

Sl. No.	Input supply voltage	Output voltage (Volt)
1	'ON'	
2	'OFF'	

Prepare an emergency light

Objectives: At the end of this exercise you shall be able to
- **assemble the components on the PCB and construct charging circuit for emergency light**
- **assemble inverter circuit for emergency light**
- **assemble charging circuit and inverter circuit for emergency light.**

Requirements

Tools/ Instruments

- Soldering iron 10W, 240V - 1 No.
- Wire stripper 150mm - 1 No.
- Tweezer 150mm - 1 No.
- Insulated round nose plier 150mm - 1 No.
- Insulated wire cutter 150mm - 1 No.
- Multimeter - 1 No.

Materials

- Step down transformer centre tapped 240/7.5-0-7.5V, 2A - 1 No.
- Rectifier diode in 5402 - 3 Nos.
- Lead acid battery 6V, 10Ah, maintenance free type - 1 No.
- Toggle switch 2A, 240V SPST - 1 No.
- Toggle switch 2A, 240 DPST - 1 No.
- Relay 6V DC, 5A with one 'NO' and one 'NC' - 1 No.
- Fuse unit with fuse 0.5A (glass type) - 1 No.
- Fuse unit with fuse 2.5A (glass type) - 1 No.
- LED holder 5mm - 2 Nos.
- LED 5mm red - 1 No.
- LED 5mm green - 1 No.
- Resistance 1K, 1/4W - 1 No.
- Resistance 2.2K, 5 W - 2 Nos.
- Resistance 2.2 Ω 1/4 W - 1 No.
- Capacitor 10 μF, 25V - 1 No.
- Capacitor 1000 μF, 25V - 1 No.
- Soldering flux - 10 gms
- Soft solder 60% lead and 40% Tin - 50 gms
- General purpose PCB 150mm x 100mm - 1 No.
- PVC insulated tinned copper cable 14/0.38 mm - as reqd.
- P.V.C. Insulation tape 20mm, 10m - 1 roll
- Screw type incandescent lamp 6V 15W - 1 No.
- Transistor 2N 3055 with the heat sink - 1 No.
- Resistance 50Ω, 5W - 1 No.
- Capacitor 2.2 μF, 250V - 1 No.
- Inverter transformer 6V, 20W - 1 No.
- Complete fluorescent tube light fitting with 20W tube in suitable sheet metal box - 1 Set
- Silicon grease - 5 gms

PROCEDURE

TASK 1 : **Construct charging circuit for emergency light**

1 Draw the circuit diagram (Fig 1) of a simple emergency light circuit.

2 Identify each component in the circuit.

3 Test the collected components for their condition.

4 Arrange the components except the battery on the PCB to meet the technical requirement and aesthetic sense.

5 Draw the layout of the components of the PCB.

6 Mount the components on the PCB in the respective places.

7 Solder the components as per Fig 1.

While soldering the components ascertain correct polarity.

8 Check the connection as per circuit diagram.

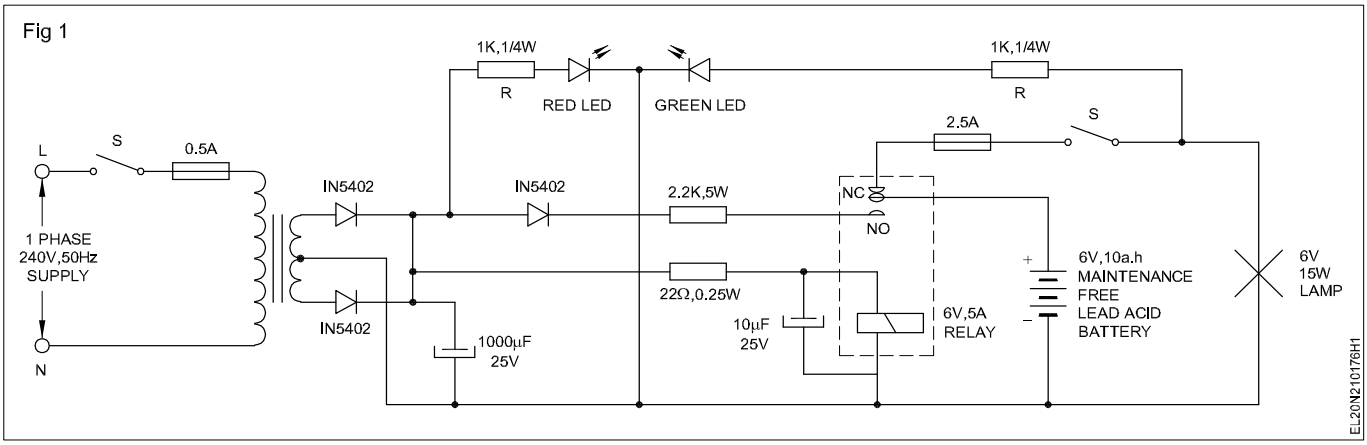
9 Switch 'ON' the AC supply for charging the battery.

10 Check the glow of red LED which is an indication for the presence of AC supply.

11 After charging the battery switch 'OFF' the AC supply, put 'ON' the lamp and observe the functioning of the emergency light and also check the indicator green LED is 'ON'.

Do not allow the emergency light battery to discharge fully.

Fig 1



TASK 2 : **Construct inverter circuit for emergency light**

1 Trace the circuit diagram of an emergency tube light circuit as per diagram. (Fig 1)

2 Identify the each component of the circuit.

3 Solder the components on PCB for making inverter circuit. (Fig 1)

Inverter circuit preferably to be assemble in a separate small PCB

4 Mark the inverter circuit board with charging circuit.

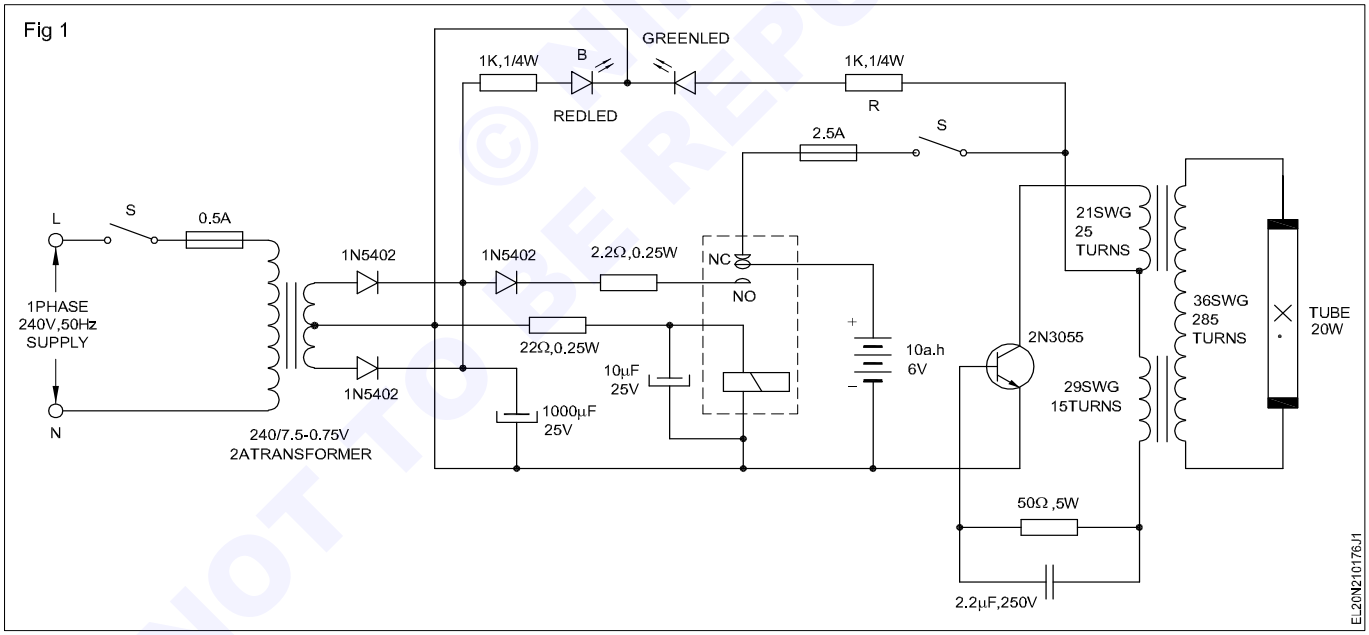
5 Test the emergency light after connecting fluorescent tube light.

6 Fix permanently the charging unit, inverter and fluorescent tube suitably in a box/case.

7 Check the indicating LED Red and Green functioning correctly.

8 Get the work checked and approved by instructor.

Fig 1



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/Instruments

- 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.

Equipments/Machinery

- 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/Components

- 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 -250µf/12V - 1.No.
- Resistors,10Ω, 1W - 1 No.
- Pot 1.5Ω/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 : 2.2Ω, 22Ω, 50Ω, - 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

TASK1 : **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.

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.

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.

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.

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.

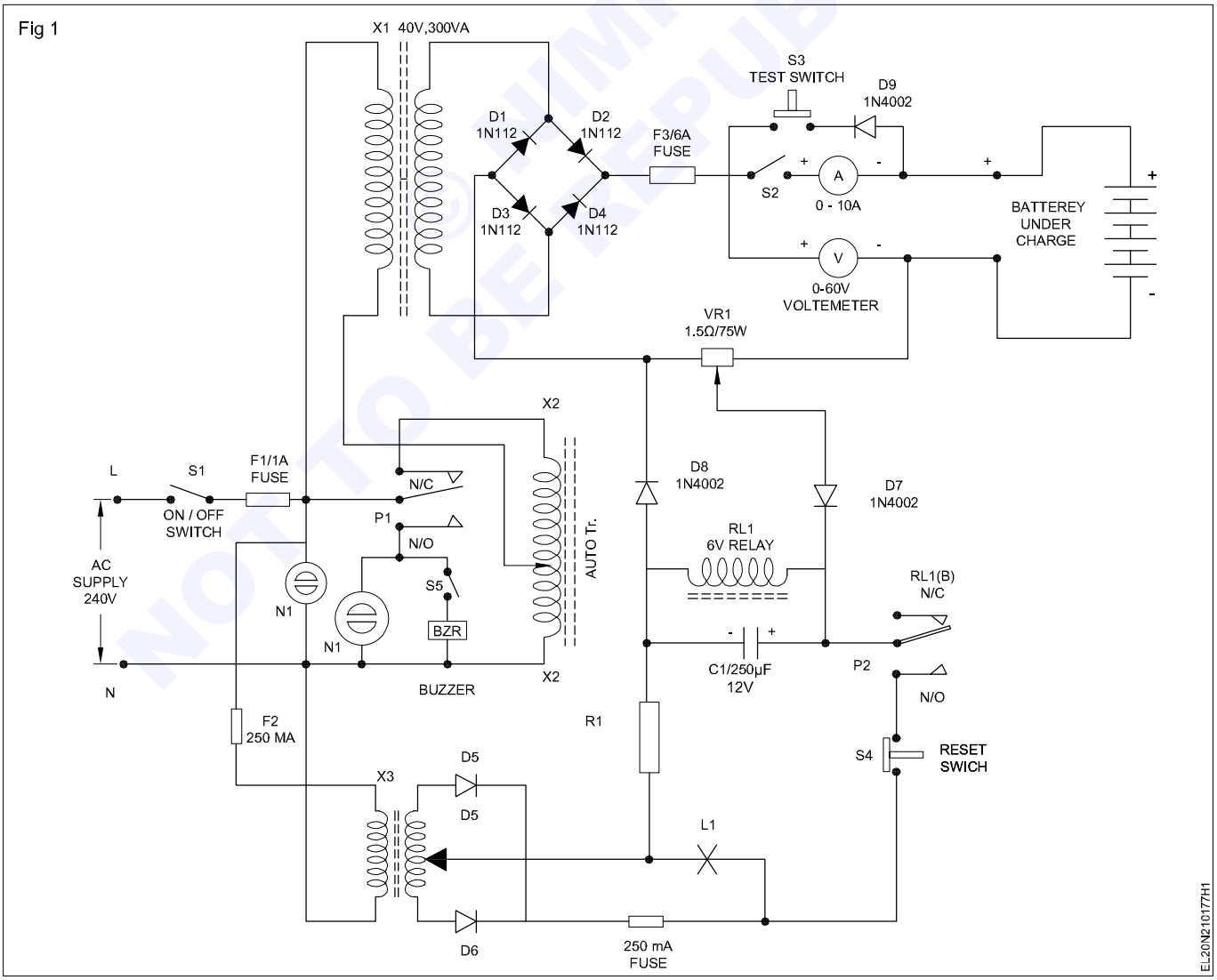
19 Leave the charger on to charge the battery to the required level.

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).

Fig 1



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.

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**

The inverter made for emergency light (Ex. No.2.10.176) can be utilised for this exercise.

1 Collect the inverter circuit assembled in the emergency light. (Fig 1) (Ex. No.2.10.176)

2 Remove the tube light and make the terminals free.

3 Connect the terminals of mains to the supply and switch 'ON'.

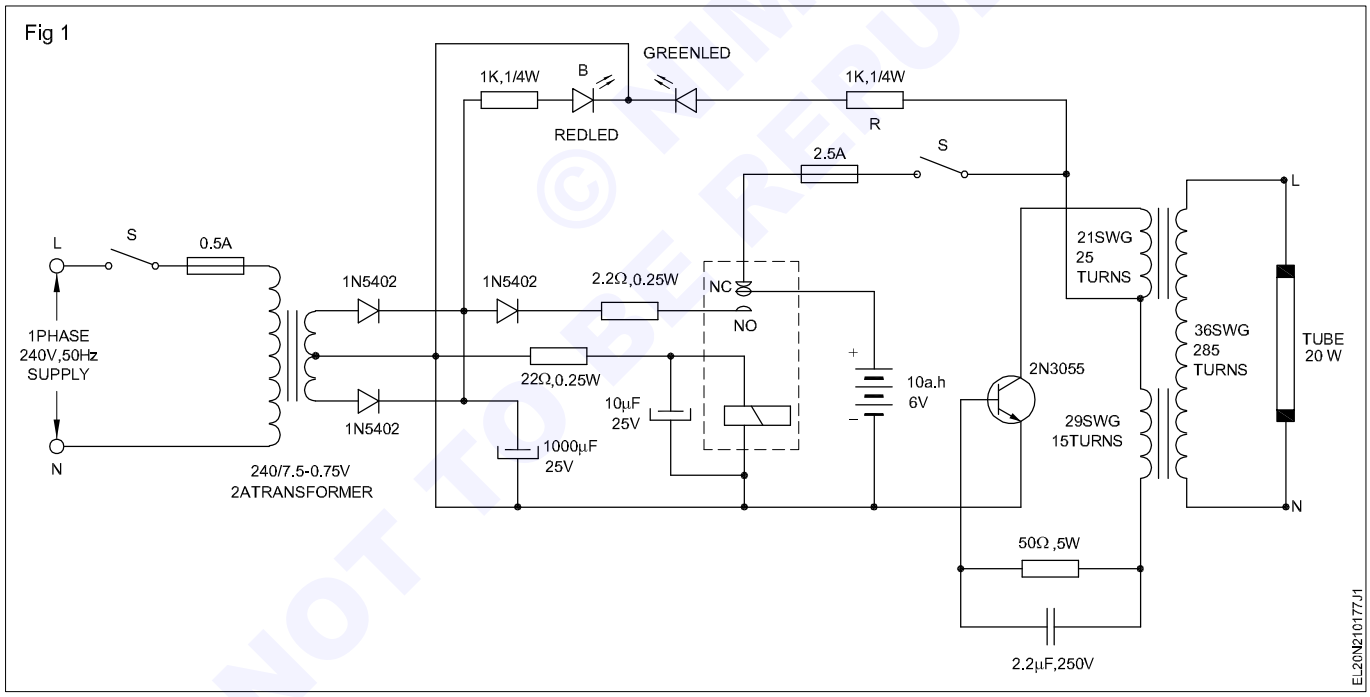
4 Check the corresponding LED's are glowing and measure the output voltage.

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.

Check the backup time of the inverter and verify the same with manufacture's manual.

Fig 1



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Test analyse, defects and repair voltage stabilizer, emergency light and UPS

Objectives: At the end of this exercise you shall be able to
- **analyse the defect and repair voltage stabilizer**
- **repair and maintenance of emergency light**
- **analyse the fault and repair the defects in UPS.**

Requirements

Tools/Instruments

- Trainees Tool kit - 1 Set
- Connector screw driver set - 1 Set
- Line /Neon tester 500 V - 1 No.
- Soldering iron 35 W/250V - 1 No.
- Desoldering gun - 1 No.
- Multimeter (analog (or) digital) - 1 No.
- Clamp on meter - 1 No.

Equipments

- Common UPS 625 VA/12 V - 1 No.
- Sealed lead acid battery with operation manual (maintenance free battery) 12 V/120AH - 1 No.
- CRO 20 MHz/dual trace - 1 No.
- Assembled circuit of voltage stabilizer in Ex. No. 4.4.183
- Assembled circuit of emergency light in Ex. No. 4.4.184
- Assembled circuit of 'ON Line' UPS in Ex. No. 4.4.183

Materials/Components

- Spare components - as reqd.
- Solder 60/40 - as reqd.
- Soldering flux - as reqd.
- Connecting wires - as reqd.

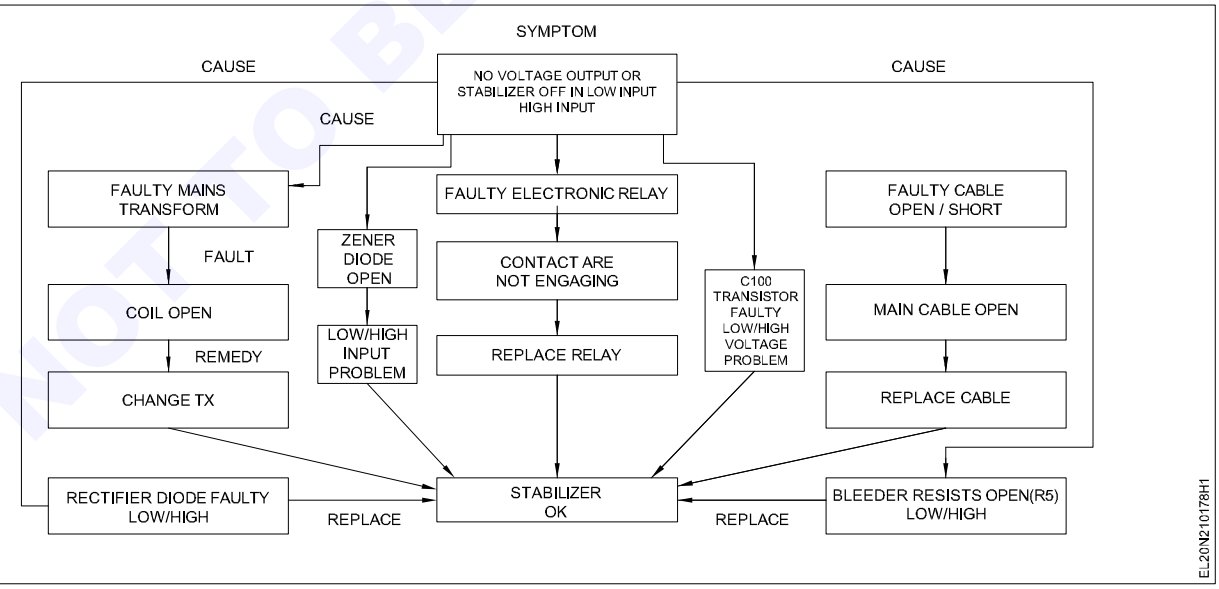
PROCEDURE

TASK 1: **Analyse the fault and repair of voltage stabilizer with the help of a Service Flow Sequence (SFS)**

1 Check the circuit carefully before connecting the supply for any short circuit in the components/parts in the stabilizer.

2 Connect the main supply cable into ohm meter and check the resistance by switch 'ON' the circuit (note to be connect with AC mains)

Fig 1



If it shows '0' resistance, it indicates a dead short. Consult your instructor.

3 Check for any open circuit visually or by ohm meter after testing for short circuit.

If the meter shows infinity i.e. open circuit. Otherwise, if it is a healthy circuit it will show some resistance reading.

4 Analyze the status of the circuit by the meters reading.

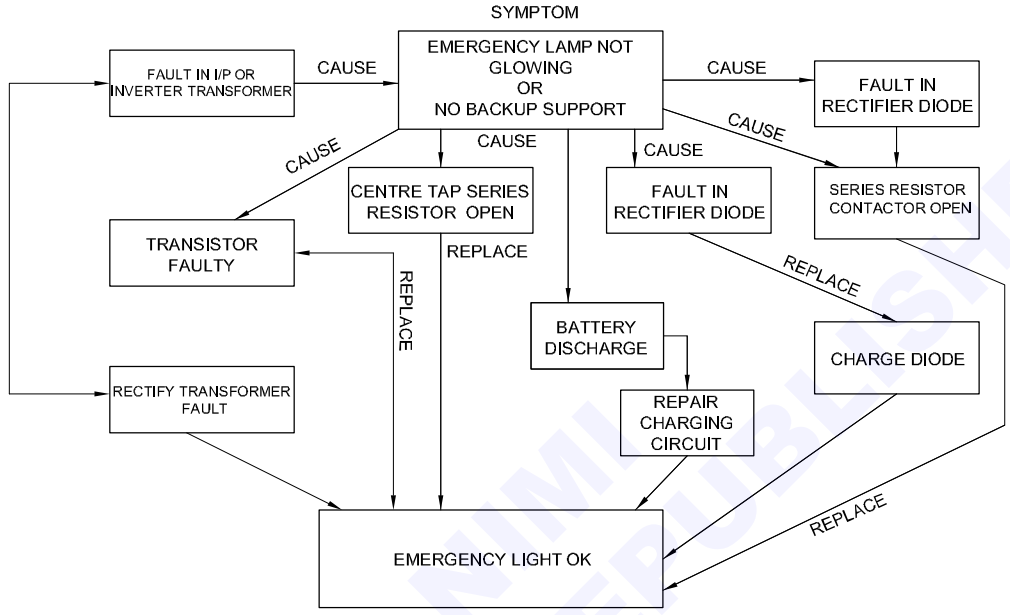
5 If the stabilizer is without short circuit fault, connect it to the supply mains and switch 'ON'. Check the symptoms of the unit, and record the symptoms. Analyze the fault with the help of service flow sequence.

TASK 2: **Repair and maintenance of emergency light with the help of trouble shooting sequence block**

1 Steps 1 to 5 on as same as follow in Task 1 . Refer the service flow sequence diagram and solve it. (Fig 1)

There may be single fault or multi fault involving more components. A visual check will help in to find burning of components, dry soldering, loose connection, etc. A careful visual check is very much essential.

Fig 1



TASK 3 : T**est UPS and identify the faults and rectify**

1 Read and interpret the name plate details of the given UPS

Type of UPS.....ON line/OFF line

Model .....

Power rating .....VA

Change over time .....m sec

Battery rating .....

Back up time .....Hours

2 Switch 'ON' the UPS, with UPS. 'Plugged in'

3 Press and hold the ON/OFF /test /silence button for more than one second until "Line normal 'LED green lights up. (i.e U.P.S .'ON' and ready for use)

If green LED does not light up, the possible causes may be (i) button not pressed (or) pressed to short (ii) voltage of battery less than 10V (iii) PCB - failure and (iv) load may be less than 20 W at battery mode.

4 Identify the problem by self testing UPS., and rectify this fault by referring the trouble shoot sequence block diagram (Fig 1)

5 To switch 'OFF' the UPS press and hold the ON/OFF/ test/ silence button for more than 3 seconds until the "Line normal" or "backup" LED 'OFF'.

6 Check the condition of switch, (or) back up LED (yellow LED) (or) press the switch for more than 3 seconds and rectify the problem, if the UPS not switched 'OFF'.

To de-energise the UPS properly in emergency, the right way is to switch 'OFF' the output switch to 'OFF' position and disconnect the power cord from the main supply.

7 Press the ON/OFF/test/silence switch, more than 3 seconds, to switch 'OFF' the UPS and battery.

8 Check the back up (LED yellow).

If the yellow LED (back up) lights 'OFF', the UPS and battery is on 'OFF' position. If the back LED is not 'OFF', it indicates UPS always at battery mode. The causes for this fault may in power cord, fuse or up normal voltage.

9 Check the condition of power cord, A.C fuse, abnormal voltage and PCB.

10 Rectify problem by referring the trouble shooting sequence block diagram (Fig 1)

11 Press the ON/OFF/TEST silence button less than one second, when A.C mains supply is available observe the operation UPS

If the UPS operates on load on battery mode, then battery LED lights up, it indicates UPS is in 'ON' line operation.

If the UPS does not operate on load on battery mode and immediately returns to 'ON' line operation and lights up the RED-LED ,It indicates that the back up time is too short the battery is to be replaced (or) to be recharged.

12 Recharge the battery immediately for atleast four hours.

13 Check and test UPS with recharged battery and rectify the fault by referring Fig 1,Trouble shooting sequence block diagram.

If the "replace battery" (red LED) is still on, replace the battery.

14 Press the ON/OFF/test/silence button for less than 1 sec in 'Backup' mode ,observe the audible alarm, It should be 'silence.

If does not function under 'Low battery (or) over load conditions.

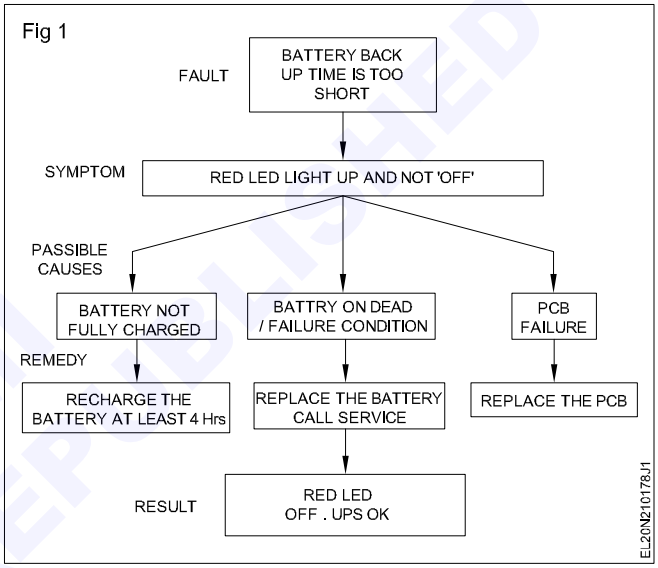
15 Check the beeping alarm ,when pressing the silence button to stop the operation of UPS.

If it is stopped in back up mode it indicates UPS is in normal . But, If the beep sound alarms continuing, It indicates that UPS is over loaded.

16 Press the button (ON/OFF)during alarms to stop the beeping when yellow LED (backup) lights up.

17 Check for the maximum connected load to UPS and rectify this fault by disconnect the excess until the beep alarm is not available.

Fig 1



Maintain service and troubleshoot battery charger and inverter

Objectives: At the end of this exercise you shall be able to
- **carryout service and troubleshoot a battery charger**
- **troubleshoot and repair a inverter.**

Requirements

Tools/Equipments

- Trainees kit - 1 No.
- Multimeter - 1 No.

Material

- Collect the circuits already constructed in Ex.No. 2.10.177

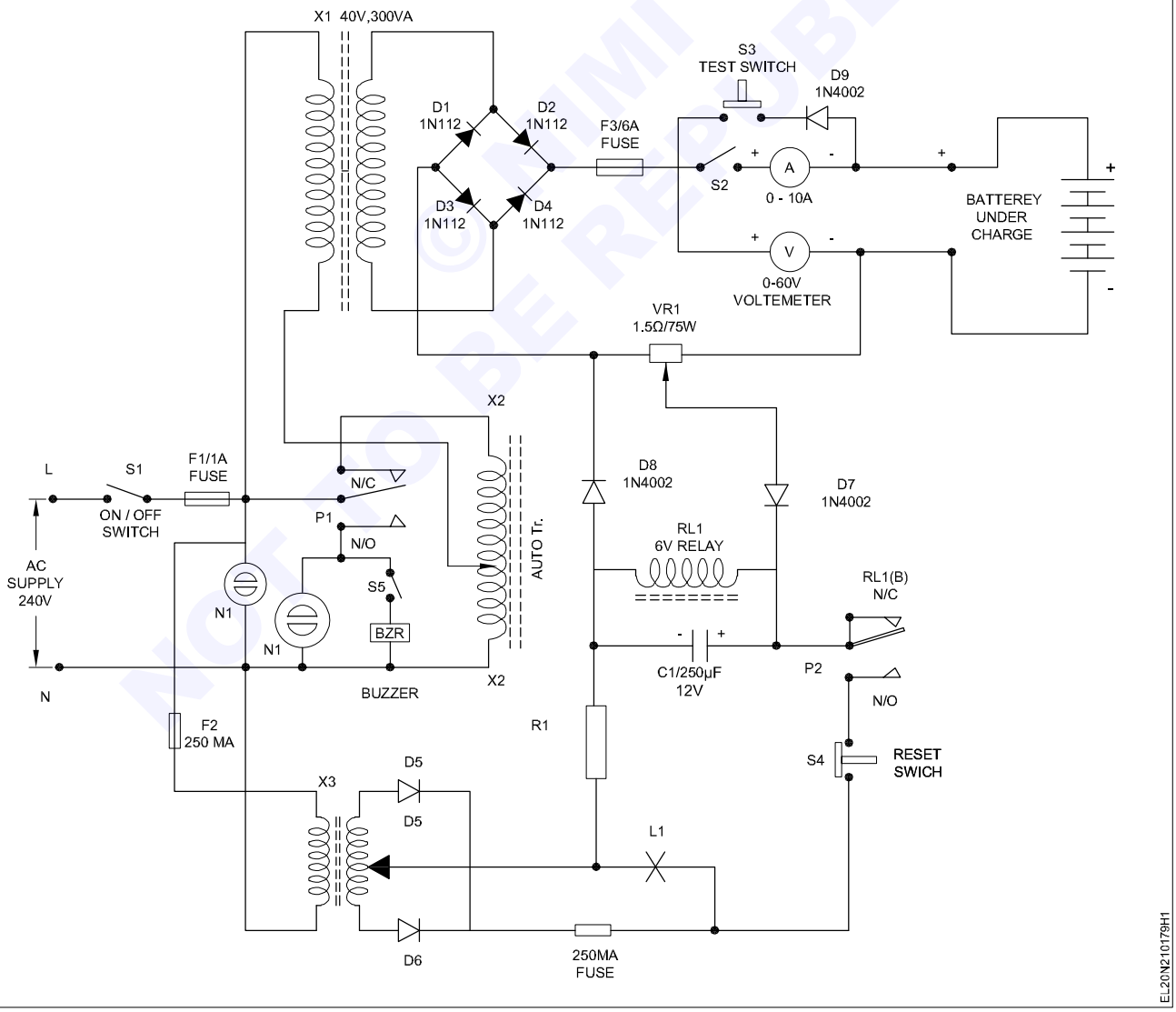
PROCEDURE

TASK 1: **Service and troubleshoot of battery charger**

1 Trace the battery charger circuit made in Ex.2.10.177 as in Fig 1.

2 Check the circuit for an availability of charging volt at battery connecting terminals.

Fig 1



3 Check the fuse provided in the fuse carrier. If the voltage is not available.

4 Test the voltage output at the bridge rectifier output with multimeter.

5 Check the conditions of bridge rectifies diodes if found defective replace. If no voltage available.

6 Check the AC input to Bridge network. If the diodes are OK.

7 Check the relay contacts and; ensure supply is available at primary of the auto transformer. If the AC is not available

8 Check the charging control circuit for normal working after the charging circuit is repaired.

9 Check that auto cut-off of AC Mains is 'OFF' the battery is fully charged.

10 Check the diode connected to potentiometer and voltage at relay terminals, If auto cut-off is not working or functioning, and if the voltage is present at relay terminal (pole) Auto cut-off is OK.

11 Check the conditions of the battery, fully charged battery will show DC Voltage in no load about 20% more than the rated voltage.

Do not allow the battery Voltage (no-load) drop below 70% of the rated voltage. If it is so revival of the battery is difficult.

12 Check while charging battery; ensure that it is topped-up with distilled water and caps are removed for easy gaseous out from the cells.

13 Complete the work and show to your instructor for approval.

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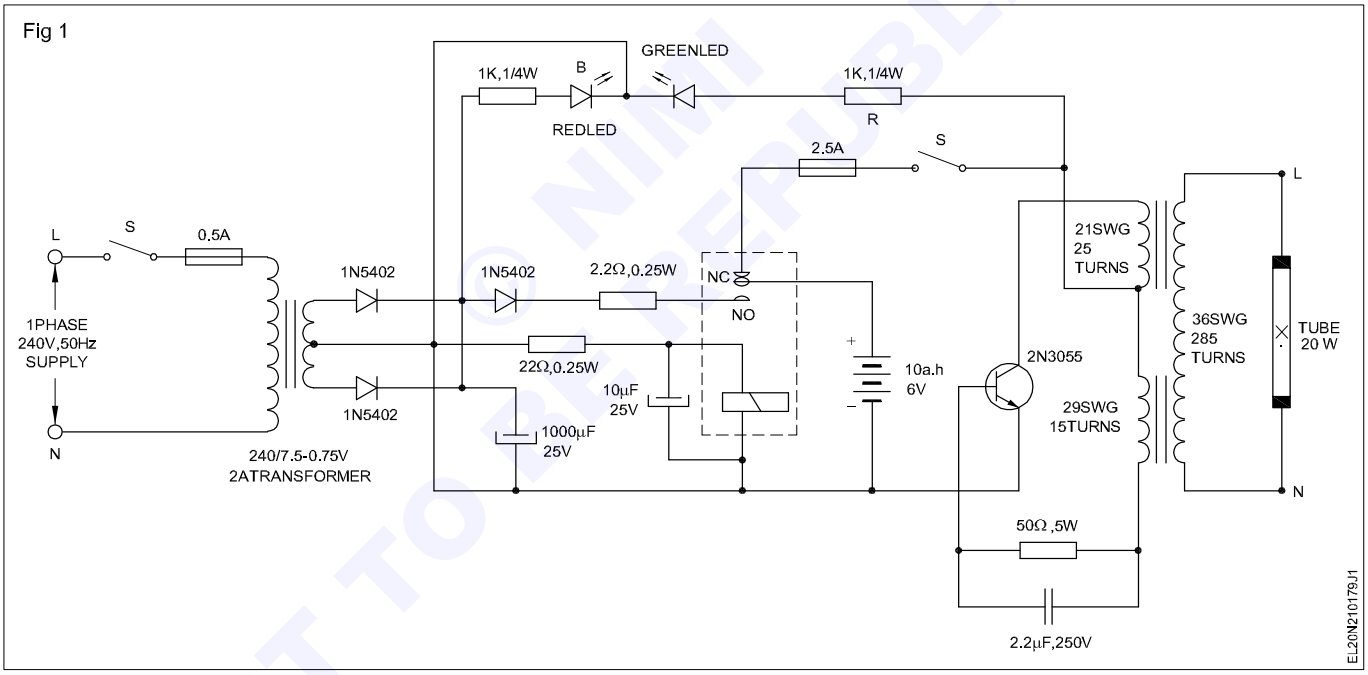
TASK 2: **Service and troubleshoot of inverter circuit**

1 Trace the circuit made in Ex. No.2.10.177 (Inverter circuit) and locate the Active Components. (Fig 1)

2 Carry out short circuit and open circuit test.

Fig 1



3 Remove the battery connect to AC Voltage check the inverter output with mains 'ON'.

4 Check the continuity of inverter transformer primary and secondary windings. If then is no output.

5 Check the transistor 2N3055 and the base supply. If the transformer is OK,

6 Check the fuse provided with NC of relay and check the conditions of relay contacts.

7 Check the rectifier diodes and bleeder resistor connections secondary to the Mains transformer.

8 Check the mains transformer primary and secondary windings. Check the main fuse.

9 Once the repair is completed check the output voltage without battery connections.

10 Connect the charged battery if output is available and operate it and ensure its working. Maintenance of battery is explained in the Task 1 and follow the same.

11 Complete the work and show to your instructor for approval.

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Install an inverter with battery and connect it in domestic wiring for operation

Objectives: At the end of this exercise you shall be able to
- **select the proper rating of inverter to install**
- **select suitable place for the inverter in the house**
- **select a correct rating of battery and the place to keep with inverter**
- **install the inverter and make connection to the load**
- **test the inverter for its good performance in 'OFF' and 'ON' supply mains.**

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.
- 1.5mm^2 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

TASK 1: **Select, install inverter with battery to connect in domestic wiring**

1 Select the suitable rating of the Inverter considering the total connected load in that house, like fan, lamp etc.

The rating of the inverter should not exceed 60% capacity of the inverter key. (for a 100w inverter, total load should not be more than 60W).

2 Select the right place to install the inverter, where good ventilation is available.

The place for installation for inverter should be nearer to the D.P switch and the energy meter position.

3 Select the correct place to install battery, which is nearer to the inverter and to the ventilation.

4 Install the inverter and battery close to each other.

Do not provide the battery away from inverter. If should be closed to the inverter because it helps in reducing the current loss due to resistance of wire.

5 Make wiring connection to the inverter with 1.5 mm^2 wire.

6 Connect the three pin output socket from the mains supply (Fig 1)

7 Connect the positive terminal of the battery (i.e red wire) to the place provided for the positive terminal on the Inverter.

8 Connect the negative terminal of the battery (i.e black wire) to the place provided for the negative terminal of the inverter.

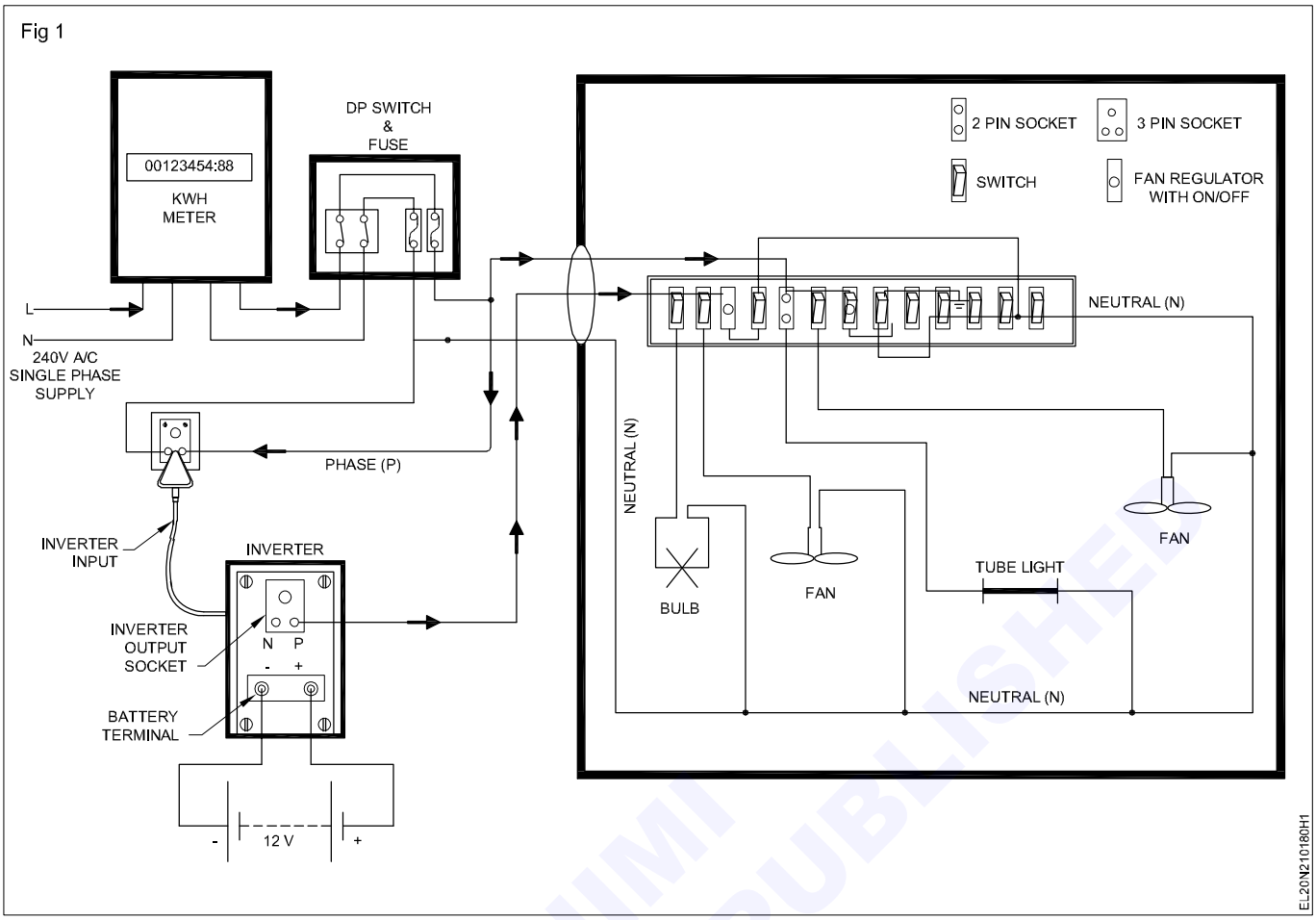
When connecting battery terminals to the inverter use special auto wires, do not use common 3/20 (or)7/20 wires and ensure that the battery is fully charged.

9 Put grease (or) vaseline on the battery terminals for reducing the terminal corrosion.

10 Complete the connection Take the output from the inverter output socket and use it to power the load.

To connect the inverter output to the load use only 1/18 wire, and do not use 3/20 or 7/20 wires.

Fig 1



11 Connect the ON/OFF switch on the wall panel from the phase output pin of inverter output socket (Fig 1)

12 Connect one common Neutral line of both inverter output and mains AC supply.

13 Connect only one wire for the phase line from the inverter output socket to the switches.

14 Give connection to one bulb, one fan (A) and 2 pin socket only to the inverter output as in Fig 1.

15 Connect the other devices in the room i.e the tube light, fan (B) and 3 pin socket directly to the mains AC line.

Low wattage load only to be connected on the two pin socket during the power 'OFF' time. Heavy load should not be connected to this socket., such as heater, geyser, motors in HP etc.

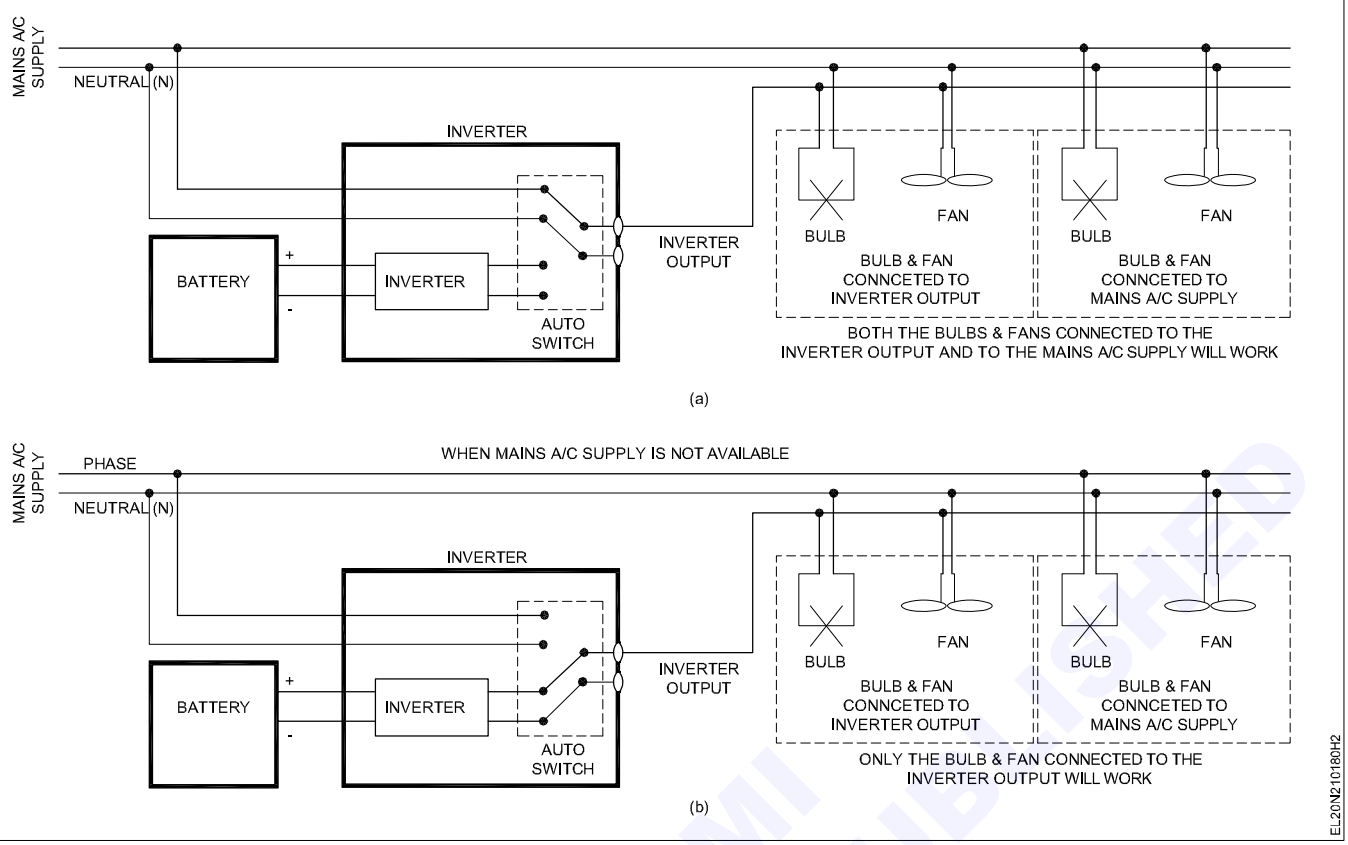
16 Show the connection and get it approved by your instructor.

17 Check the operation of inverter during power 'OFF' and then power returns.

If the main supply is 'ON' the load connected to the inverter will get the main AC supply and the other devices which are directly connected to the mains AC supply will also work on the main supply. (Fig 2a)

During power shut down, the devices which are directly connected to the mains AC will stop functioning and the devices connected to the inverter will keep on working on the inverter output . when the mains AC supply returns the inverter will again connect the load to its output. (Fig 2b)

Fig 2



Draw layout of thermal power plant and identify function of different layout element

Objectives : At the end of this exercise you shall be able to
- **visit the thermal power plant and identify the various stages in the plant**
- **interpret the function of each stage of thermal power plant**
- **prepare and draw the schematic diagram of thermal power plant.**

Requirements

Materials

• Drawing sheet	- 1 No.	• Eraser	- 1 No.
• Pencil (HB)	- 1 No.	• Scale -300mm	- 1 No.

PROCEDURE

Instructor may take the trainees to a nearest thermal power plant to visit the various stages of the power station and explain the functions of each stage.

Before entering the power station the instructor should explain to the trainees all the safety regulations pertaining to the power plant.

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
a	Boiler		
b	Super heater		
c	Economizer		
d	Air pre-heater		
e	Turbine		
f	Condenser		
g	Cooling tower		
h	Water treatment chamber		

3 Note down the details of the steam turbine and enter it in the diary.

4 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 _____

5 Draw the schematic diagram of thermal power station you visited in your record and get checked by your instructor.

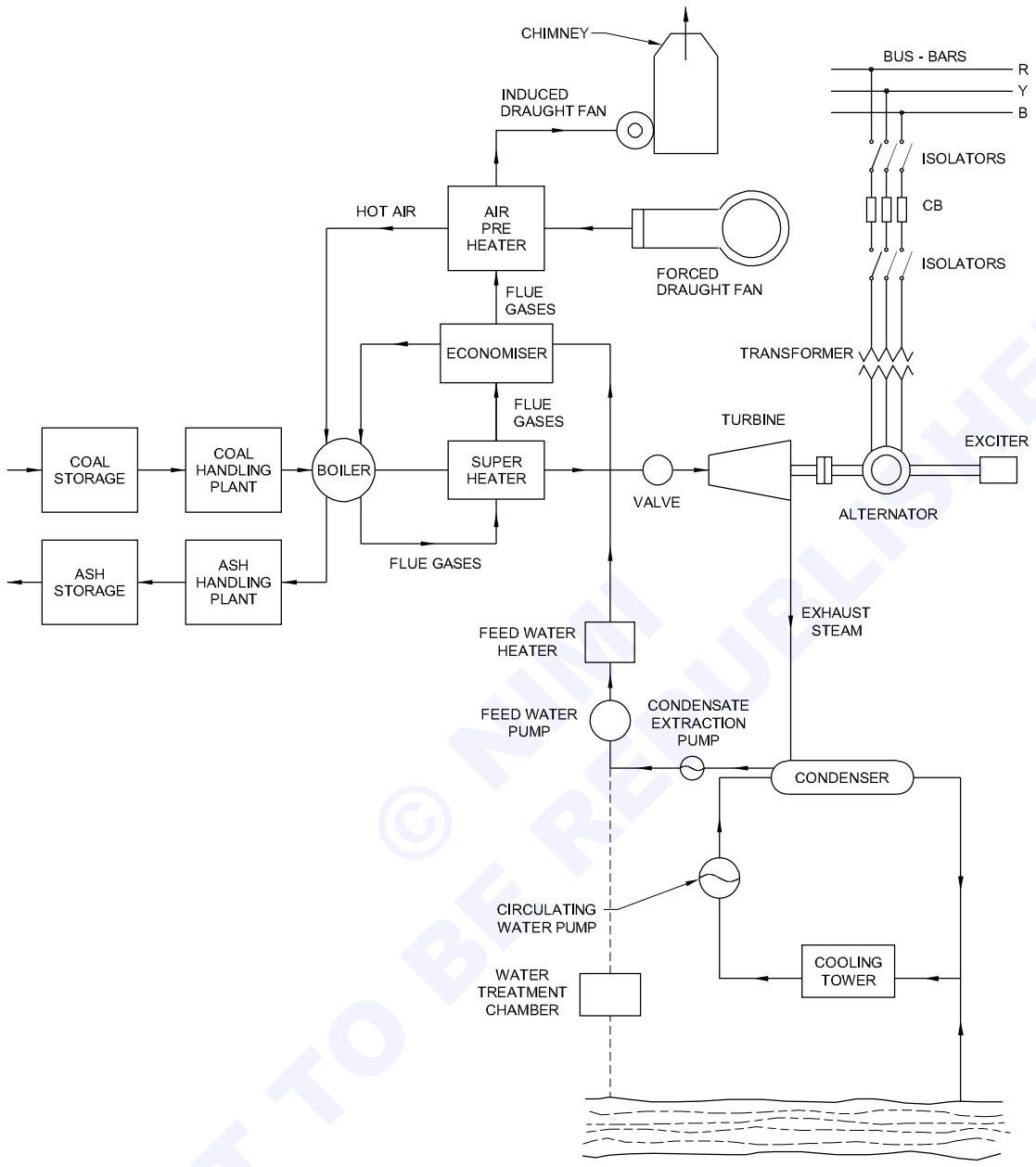
Fig 1 is the model schematic diagram of a thermal plant given for general guidance to trainees. The trainees have to prepare and draw the schematic diagram of the plant they visited.

6 Note down the main step-up transformer specification and the type of cooling arrangements.

7 Note down the voltage ranges transmitting from the power station.

Note down the boiler temperature range and method of temperature controlling and types of thermocouples used in boiler.

Fig 1



SCHEMATIC ARRANGEMENT OF STEAM POWER STATION

Draw layout of hydel power plant and identify functions of different layout elements

Objectives : At the end of this exercise you shall be able to
- **visit the various stages of hydro-electric plant**
- **interpret the functions of each stage of hydro-electric plant**
- **prepare and draw the schematic diagram of hydro plant.**

Requirements

Materials

- Drawing sheet - 1 No.
- Pencil - 1 No.
- Eraser - 1 No.
- Scale -300mm - 1 No.

PROCEDURE

Instructor may take the trainees to a nearest hydro-electric power station to visit the various stages of the power station and explain the functions of each stage.

Before entering the power station the instructor should explain to the trainees all the safety regulations pertaining to the power plant.

1 Visit the stages of a hydro-electric power plant i.e.(1) Hydraulic structures (2) Water turbines (3) Electrical equipments.

2 Identify the following stages of a hydro-electric plant and write down their functions in Table 1.

Table 1

	Constituents	Type	Function
a	Dam		
b	Spill ways		
c	Head works		
d	Surge tank		
e	Pen stocks		
f	Tail race		
g	Draft tube		
h	Turbine		

3 Note down the speed of the water turbine and other details and enter it in the diary.

4 Trace the various parts of alternator and note down the name plate details in Table 2.

5 Draw the schematic arrangement of a hydro-electric power station in your record and get checked by your instructor.

6 Note down the main step-up transformer specifications and the type of cooling arrangements.

7 Ensure that the cooling arrangement of power transformer, is water cooling or any other types.

8 Note the transmitting voltage range and the no. of transmission lines.

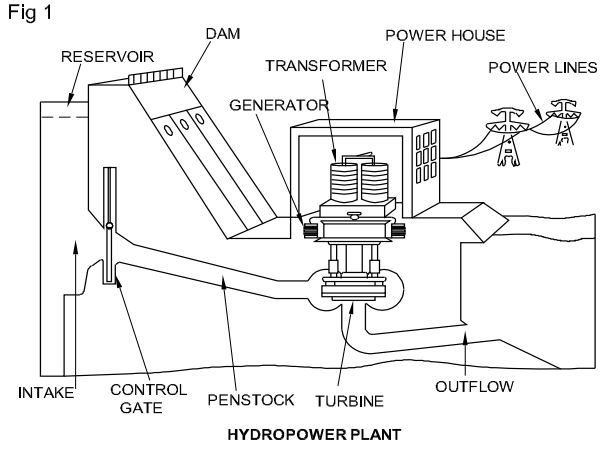
9 Note down the total installed capacity of the power station and maximum number of turbines working together at peak load hours.

10 Show your observation to your instructor.

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 _____

Fig 1



Visit to transmission/distribution substation

Objectives: At the end of this exercise you shall be able to
- **visit and trace the transmission and distribution line of substation**
- **identify the equipments in sequential stages of distribution substation**
- **prepare the layout and draw the single line diagram of the transmission and distribution substation**
- **visit and trace the transmission and distribution line of major substation.**

Requirements

Tools/Equipment /Material

• Drawing sheet	- 1 No.	• Eraser	- 1 No.
• Pencil (HB)	- 1 No.	• Scale-300mm	- 1 No.

PROCEDURE

The instructor may take the trainees to the nearest transmission /distribution main substation, and explain the name of the equipments, their specification and function also instruct the trainees to follow the safety regulation while visiting the substation.

1 Visit the transmission and distribution main substation.

2 Identify the sequential stages of transmission/ distribution substations.

3 Trace and identify the various equipments like transformers, feeders, circuit breakers, Isolator, CT & PT etc, from the generator to the consumer points in sequence of transmission and distribution substation.

4 Note down the earthing system. The major substation provided with system earthing. Note the different values of earth resistance displayed in the earth pit. Note down which equipment/installation requires the least earth resistance value and irregular value. Identify the hollow conductors used for connection between feeders.

5 Note down their details in Table 1 (Name, Specification and functions)

6 Refer the figures 1&2 showing transmission and distribution substations.

Table 1

Sl.No	Name of the equipments	Specification	Function
1			
2			
3			
4			
5			
6			
7			
8			

7 Locate the places of equipments and draw the single line diagram of transmission and distribution substation, which you have visited.

It may be like the diagrams (Fig 1&2) given for your guidance. Refer related theory of this exercise also.

8 Get it checked with your instructor.

Fig 1

TRANSMISSION SUBSTATION

Fig 2

DISTRIBUTION SUBSTATION

Draw actual circuit diagram of substation visited and indicate various components

Objectives: At the end of this exercise you shall be able to
- **visit of substation and note down the various components**
- **draw the actual circuit diagram of substation with components.**

Requirements

Materials

• Drawing sheet	- 1 No.	• Eraser	- 1 No.
• Pencil HB	- 1 No.	• Scale -300mm	- 1 No.

PROCEDURE

1 Visit the substation which is nearer to your institute with your instructor and note the various components installed as below.
- Incoming protection devices and their installations.
- Transformer specification - voltage rating capacity cooling method, earthing, HT and LT terminal connections.
- Installation of CTs and PTs and their connections.
- Installation of over voltage, under voltage, over current, earth fault relays and their protections - earthing - etc.
- Position of isolators, earth switches, feeders cable terminations and lights arrestors etc.
- Number of earth pits and their resistance values- periodical maintenance and testing procedure.
- The load distribution method adopted in substation to customers.
- Methods followed in substation to meet maximum demand and monitoring.
- Substation maintenance chart and methods to carryout maintenance without effecting power shut down totally.
- Any other points noticed or learned in the substation.

2 Draw the circuit diagram of substation, which actually you visited and draw the layout diagram of substation with various components and draw layout in your notebook.

3 Get it checked with your instructor.

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Prepare layout plan and identify different elements of solar power system

Objectives : At the end of this exercise you shall be able to
- **visit and interpret the details of solar power plant**
- **trace and identify the components used in solar plant and write their functions**
- **prepare and draw the schematic diagram of solar power plant.**

Requirements

Materials

- Drawing sheet - 1 No.
- Pencil HB - 1 No.
- Eraser - 1 No.
- Scale -300mm - 1 No.

PROCEDURE

Instructor may take the trainees to the nearest solar power plant to visit the various stages of power station and explain the function of each stage.

Before entering the power station the instructor should explain to the trainees all the safety regulations pertaining to the power plant.

1 Visit the solar plant and note the details of the plant.
   i Capacity of the plant _____ KW / MW
   ii Output voltage _____KV
   iii Permitted Maximum Load Circuit _____Amp.
2 Trace and locate the components used in that solar plant.
3 Note down their functions as in Table 1

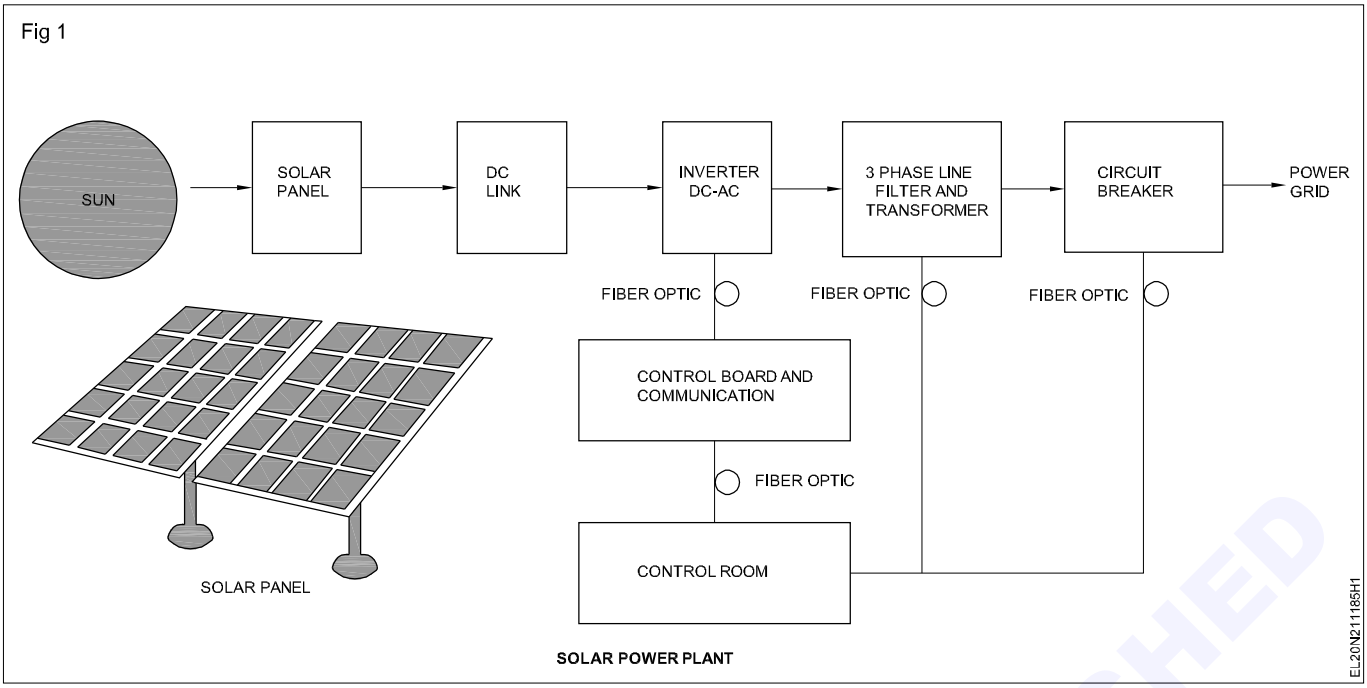
Table 1

Sl.No.	Name of the components	Functions/ specifications
1	Total solar panel area	
2	Method of mounting panels	
3	Controller circuits	
4	Battery system installed	
5	DC/AC Inverter Capacity & Voltage ratings	
6	Distribution panel to grid connections	

4 Note down the daily average power output of the plant for distribution.
5 Note specification of solar panels - make, voltage ratings etc.
6 Note tracking systems method provided for maximum output.
7 Note protection of cells from natural calamities.
8 Note installed cells whether in ground level or elevated.
9 Draw the schematic diagram of solar power plant as per the guidance. (Fig 1)
10 Write down important elements required for solar power station in your notebook.
11 Get your work checked by instructor.

Fig 1 is the model schematic diagram of solar power plant given for the general guidance of trainees. The trainees have to prepare and draw the schematic diagram of the solar power plant they visited.

Fig 1



SOLAR POWER PLANT

Prepare layout plan and identify different elements of wind power system

Objectives : At the end of this exercise you shall be able to
- **visit and identify the various components used in wind power generation plant**
- **prepare and draw the schematic diagram of wind power plant.**

Requirements

Materials

• Drawing sheet	- 1 No.	• Eraser	- 1 No.
• Pencil HB	- 1 No.	• Scale - 300 mm	- 1 No.

PROCEDURE

Instructor may take the trainees to the nearest wind power plant to visit the various stages of power station and explain the function of each stage.

Before entering the power station the instructor should explain to the trainees all the safety regulations pertaining to the power plant.

1 Visit the wind mill power plant, and note the details of the plant.
   i Capacity of the plant _____ KW / MW
   ii Output voltage _____KV
   iii Maximum load Current_____ Amp.

2 Trace and identify the equipments/parts used in this wind mill power plant.

3 Write the names of the equipments and their functions in Table 1.

Table 1

Sl.No.	Name of the equipments/parts	Specification Functions
1	No. of wind blades	_____
2	Gear box	_____
3	Generator	_____
4	Exciter	_____
5	Turbine controller	_____
6	Rectifier Unit (RU)	_____
7	Line Converter Unit (LCU)	_____
8	High voltage transformer	_____
9	Internal Supply Unit (ISU)	_____
10	Chopper	_____
11	Wind turbine	_____
12	Grid	_____

4 Note down the daily average power output of the plant.

5 Note down the minimum rpm of turbine to maintain the rated voltage.

6 Note down the chopper/circuit characteristics and its importance in turbine controller.

7 Note down the protection provided from natural calamities.

8 Prepare and draw the schematic diagram of wind power station in your diary and get checked by the instructor.

Fig 1 is the model schematic diagram of wind power station given for the general guidance of trainees. The trainees have to prepare and draw the schematic diagram of the plant they visited.

Fig 1

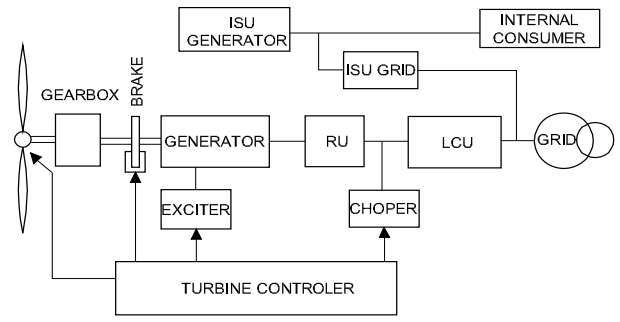
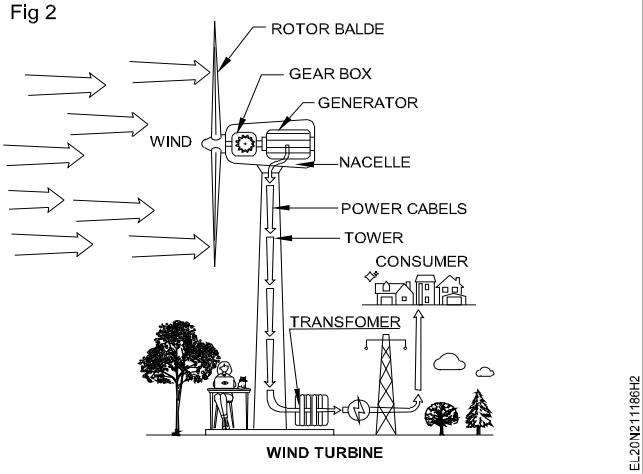


Fig 2



Assemble and connect solar panel for illumination

Objectives: At the end of this exercise you shall be able to
- **calculate the total no. of cells required to make series parallel combination for one panel**
- **fix the 4 Nos of LED lamp 12V/3W at required position in the lamp**
- **Wire the circuit from panel to light in the lab**
- **fix the panel board with control and protection devices to illuminate the lab**
- **assemble and install solar panel at mid clamp and roof top.**

Requirements

Tools/Equipments

- Trainees kit - 1 No.
- Multimeter - 1 No.
- Power drilling/hammering machine with suitable drill bits - 1 Set.
- Solar panel - 1 No.

Material

- Solar cells 0.45 V/57mt. 125mW/cm^2 - 540 cells
- Connecting wires 1 sq.mm PVC cable - as reqd.
- Gang box with one switch (F/type one way) 250V/5A - 4 Nos.
- Panel frame suitable to fix the wired solar cells - 4 Nos.
- LED lamp with shad and reflector 12V/3W - 4 Nos.
- Fixing screws, wiring accessories - as reqd.
- Base pipe - as reqd.
- Contact pipe - as reqd.
- Supporting pipe - as reqd.
- Rail splice - as reqd.
- Rail - as reqd.
- Rail contract AC - as reqd.
- End clamp - as reqd.
- Mid clamp - as reqd.
- M8x25mm screws - as reqd.
- Bolt and nuts - as reqd.

PROCEDURE

TASK 1 : **Calculate the number of cells required to illuminate one panel**

(Assume the lamp voltage is 12V and power 3W)

1 Determine the number of solar cells in series group.

No. of cells in series group = $\frac{\text{Total required voltage}}{\text{Volt/ cell}}$

$1\ \text{cell} = 0.45\ \text{V}$ and 57mA

= 27 cells.

27 x 0.45 = 12.15V considering line losses voltage of 0.15 V taken as extra (0.15V taken for line lines)

No. of series group required for the correct of 250mA

$= \frac{\text{Current required for one lamp}}{\text{Current in one series group}}$

(LED lamp requires 250 mA) = $\frac{250\text{mA}}{57\text{mA}}$

= 4.38 = 5 groups

Considering the line losses few cells one connector for extra current.

— — — — — — — —

TASK 2 : **Assemble of solar panel and its installation**

1 Collect solar cells and make the series connection. (27 cells in series) on the panel board.

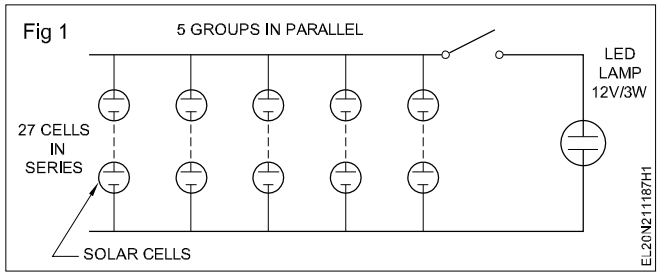
2 Prepare five numbers of series connection and wire them for parallel as shown in Fig 1.

3 Make four similar solar panels in total.

4 Locate the suitable places and fix it on root top where sunlights are falling directly.

Locate the places of fixing panels should not be under shadows of trees and buildings etc.

Fig 1



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TASK 3 : **Fix lamps and gang box**

1 Locate the lamp position and switch position as short as possible from solar panel for all the four panels.

2 Wire the panel to gang box and the lamp neatly.

Wiring can be done in PVC conduit or PVC casing and capping to give aesthetic look

3 Fix the lamp assembly and complete the wiring with switch control.

4 Test the wiring for any short (or) open circuit fault.

5 Connect the wire to the panel terminals and measure the voltage at lamp terminal.

6 Connect the lamp and operate the switch for illumination.

7 Report to your instructor for his approval.

— — — — — — — —

TASK 4 : **Assemble and install solar panel at mid clamp roof top**

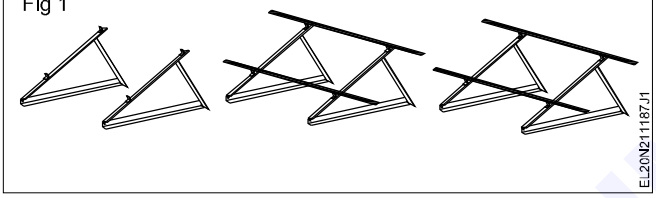
1 Check that sure the direction of installation of the solar panels receives more sun rays to mount the solar panel.

2 Collect contract pipe with M8 x 25 contact base pipe.

3 Fix the contact support pipe and contact pipe with M8 x 25 screw.

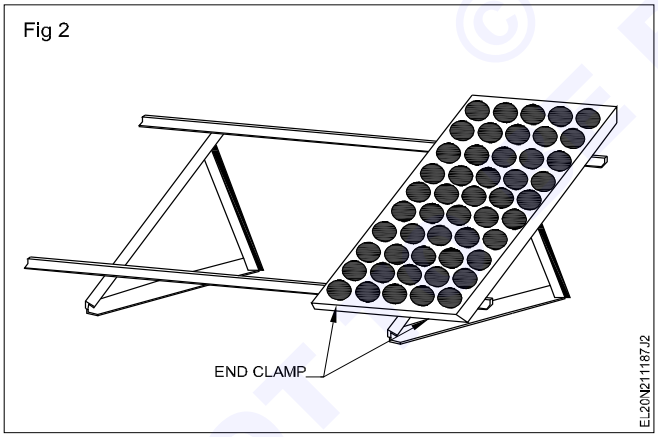
4 Take 2 fixed tile rack and position them with rail as in Fig 1.

Fig 1



5 Put one panel on the rack, use 2 end clamps to hold and fix it (Fig 2). (Attention end of rail distance must <25mm to 30mm).

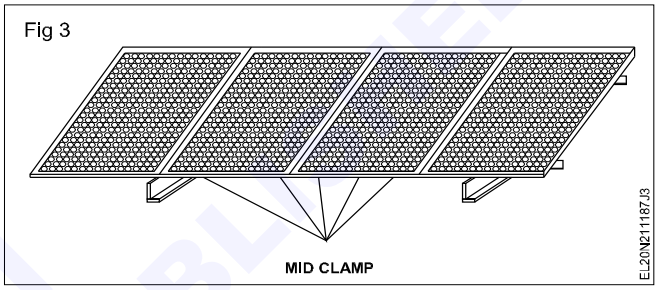
Fig 2



6 Install the modules an mid clamp and end clamp.

7 Install panel by fixing mid clamp between panels. (Fig 3)

Fig 3

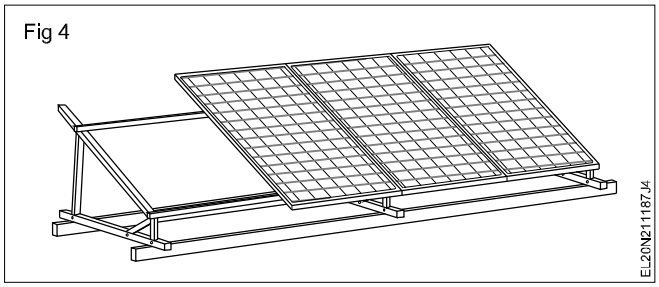


8 Select the best/perfect angle for solar panels with the help of manual to produce the maximum power.

9 Drill the hole on the roof with the help of drilling machine.

10 Fix the frame with the help of screws and place the panel on frame. (Fig 4)

Fig 4



11 Get the work checked by the instructor.

— — — — — — — —

Practice installation of insulators used in HT/LT lines for a given voltage range

Objectives: At the end of this exercise you shall be able to
- **identify the type of HT/LT line insulators**
- **install the shackle type insulator on HT over head line**
- **install the pin type insulator on LT over head line.**

Requirements

Tools/Instruments

- Insulated combination plier 200 mm - 1 No.
- DE spanner set 6mm to 25 mm - 1 Set.
- Adjustable spanner 6mm to 25 mm - 1 Set.
- Safety belt - 1 No.
- Wooden or nylon mallet 1/2 kg - 1 No.
- Ladder 6m long
- Jute rope of 25 mm dia and 15 m length - 1 No.
- Wire stretcher 25 mm - 1 No.
- Megger 500 V - 1 No.

Materials

- Shackle insulator, porcelain 1kV - 4 Nos.
- Pin insulator, porcelain 1kV - 2 Nos.
- Suspension insulator - 1 No.
- Strain insulator - 1 No.
- Ring insulator - 1 No.
- Stay/egg insulator - 1 No.
- 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**

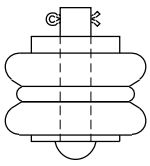
1 Identify the LT and HT type line insulators from Figures 1 to 6.

Fig 1

PIN INSULATOR

EL20N212188H1

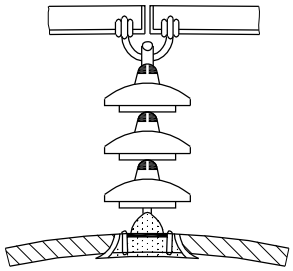
Fig 2



SHACKLE INSULATOR

EL20N212188H2

Fig 3



EL20N212188H3

2 Write their names with voltage range and purpose in Table 1.

3 Get it checked with your instructor.

Fig 4

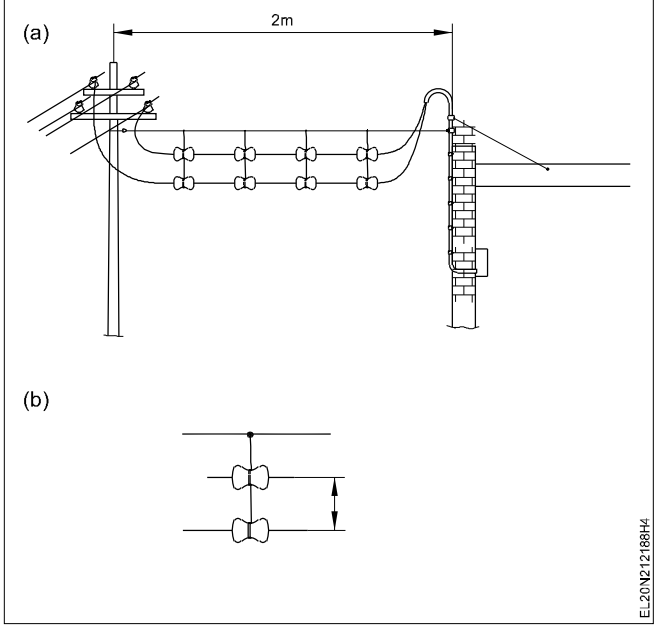


Fig 5

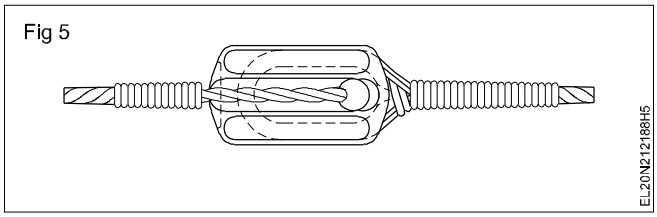


Fig 6

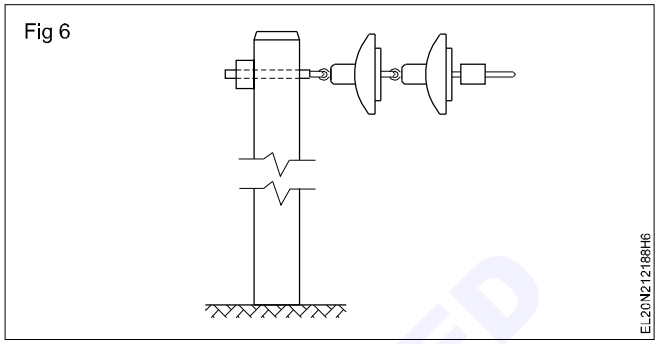


Table 1

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**

Take 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.

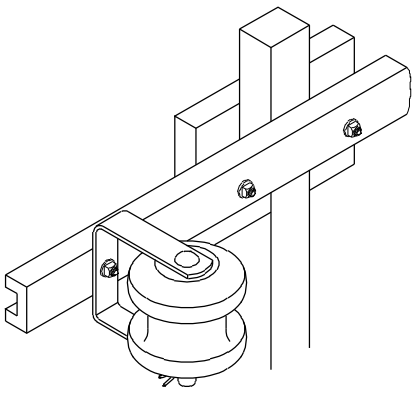
5 Ask the helper to hold the ladder, climb up the ladder with the guide rope and spanner set.

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)

Fig 1



SHAKLE INSULATOR MOUNTED IN A "C" CLAMP

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.

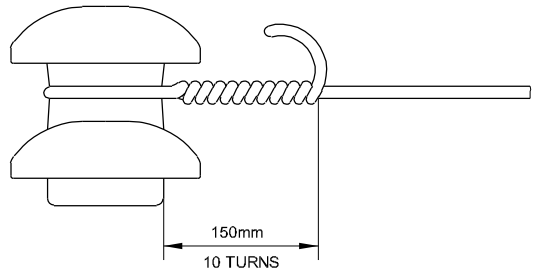
9 Ask the helper to properly tie the O.H. conductor to the rope and lift the conductor to the cross- arm position.

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)

Fig 2



BINDING OF A SHACKLE INSULATOR

11 Bind the shackle insulators with the one fixed at the last cross - arm.

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.

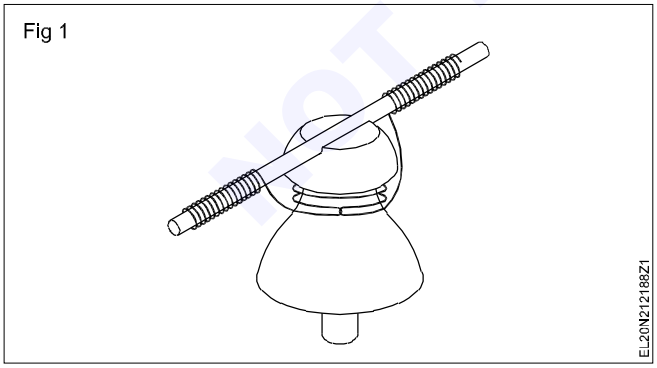
4 Bind the pin insulators as per procedure.

The binding wire must be of the same metal as the line wire.

Binding should be mechanically strong.

5 Bind the free ends of the binding conductor over the line conductor tightly in the opposite direction.(Fig 1)

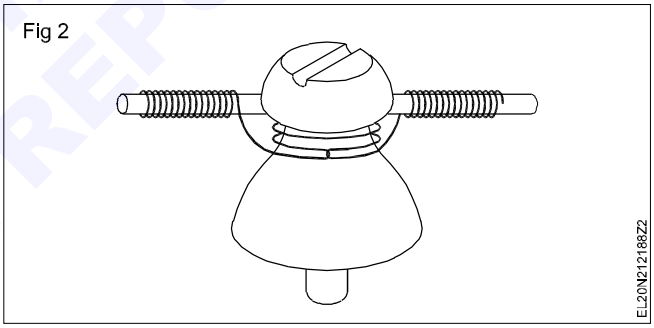
Fig 1



Binding should be tight without any gap.

Alternatively the conductor can be placed in the side groove for binding the conductor with the pin insulator as in Fig 2.

Fig 2



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. Enter in Table 1.

Table 1

Test results

Sl.No.	Measurement between	Insulation value
1	Insulation resistance between conductors	Megohm
2	Insulation resistance between first conductor and earth	Megohm
3	Insulation resistance between second conductor and earth	Megohm

The distribution lines shall be charged only when the megger test is satisfactory. It must be a minimum of 1MΩ and above for medium voltage lines.

10 Climb on the first pole and tie the jumpers for extending connections to the existing supply line to the new erected line. Carry out the same procedure for other conductor also.

Verify before touching any overhead line whether the line is dead and all the safety measures are followed.

— — — — — — — —

Draw single line diagram of transmission and distribution system

Objectives: At the end of this exercise you shall be able to
- **visit and trace the transmission and distribution system**
- **identify the equipments in sequential stages of transmission and distribution system**
- **prepare the layout and draw the single line diagram of the transmission and distribution system.**

Requirements

Tools/Equipment /Material

• Drawing sheet	- 1 No.	• Eraser	- 1 No.
• Pencil (HB)	- 1 No.	• Scale-300mm	- 1 No.

PROCEDURE

The instructor may take the trainees to the nearest transmission and distribution line system and explain the name of the equipment, their specification and function also instruct the trainees to follow the safety regulation while visiting the substation.

1 Visit the transmission and distribution line system and power plant.

2 Identify the sequential stages of transmission and distribution line system.

3 Trace and identify the various equipments like transformers, feeders, circuit breakers, Isolator, CT and PT etc, from the generation to the consumer points in sequence of transmission and distribution system.

4 Note down the earthing system. Note the different values of earth resistance displayed in the earth pit. Note down which equipment and installation requires the least earth resistance value and irregular value. Identify the hollow conductors used for connection between feeders.

5 Note down their details in Table 1 (Name, Specification and functions) for transmission system and for distribution system.

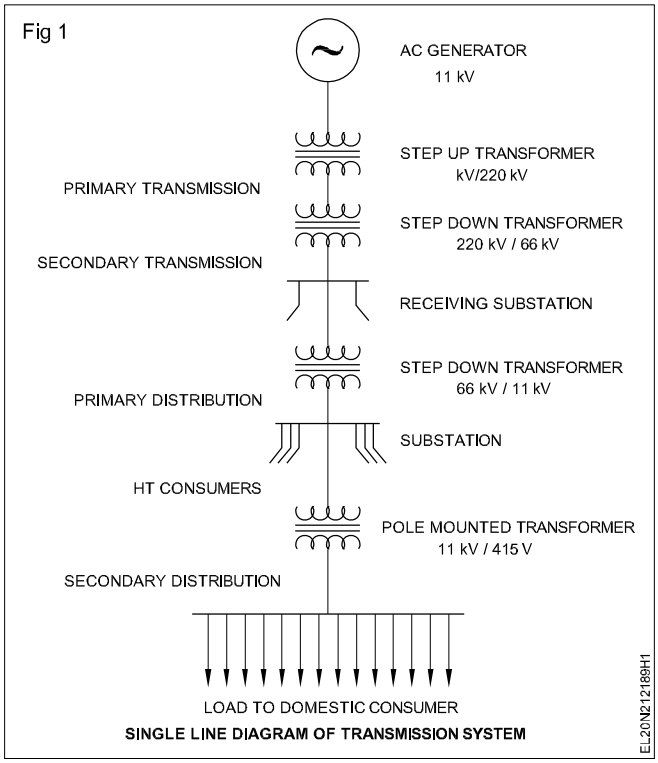
6 Locate the places of equipments and draw the single line diagram of transmission and distribution system. Which you have visited.

Table 1

Transmission system

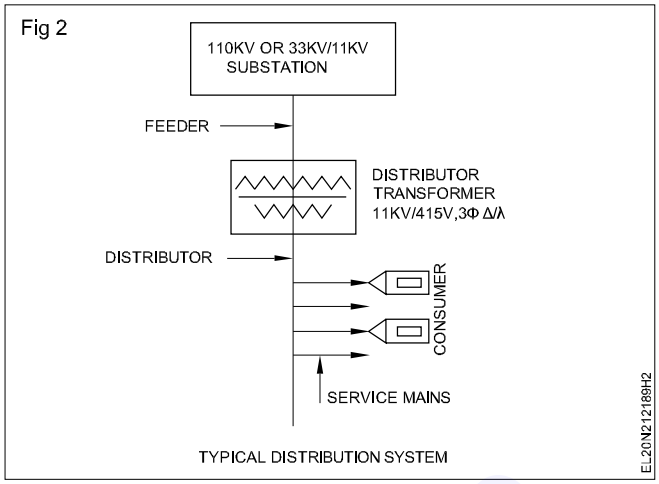
Sl.No	Name of the equipment	Specification	Function
1			
2			
3			
4			
5			
6			
7			
8			

Fig 1



SINGLE LINE DIAGRAM OF TRANSMISSION SYSTEM

Fig 2



TYPICAL DISTRIBUTION SYSTEM

Measure current carrying capacity of conductor for given power supply

Objectives: At the end of this exercise you shall be able to
- **identify and select 3 different conductors i.e. copper, aluminium and alloy**
- **connect the circuit and measure the breaking current of the conductor.**

Requirements

Tools/Instruments/Equipment

- Trainees tool kit - 1 No.
- Ammeter M.C. 0-10A - 1 No.
- Voltmeter M.C. 0-15V - 1 No.
- Rheostat 270Ω 2A - 1 No.
- Lead acid battery 12V 60AH - 1 No.

Material

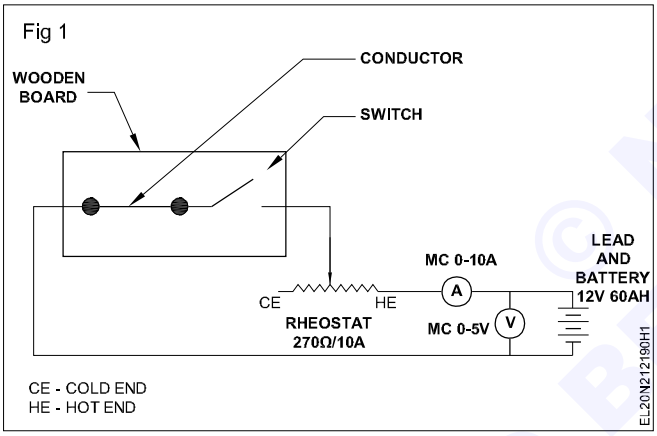
- Wooden board with switch 16A 250V - 1 No.
- 32 SWG copper conductor, aluminium conductor and alloy conductor - 10 cm
- Connecting wires 2.5 sq.mm copper - as reqd.

PROCEDURE

1 Select 32 SWG copper conductor, aluminium conductor and alloy conductor of 10 cm length each.

2 Connect it on the test board. (Fig 1)

Fig 1



3 Connect rheostat, ammeter voltmeter and battery. (Fig 1)

4 Keep rheostat at cold end (maximum resistance position) and switch 'ON' and note the ammeter and voltmeter readings and enter in the Table 1.

5 Move the rheostat at middle position and note down the ammeter and voltmeter readings and enter in Table 1.

At this stage the conductor may get heated up (or) it will show the system of heating.

6 Adjust further more the rheostat position to hot end (reduce the resistance) slowly keeping a watch on conductor it may brake now.

7 Observe if the conductor is not broken and increase further position of rheostat towards hot end till the conductor breaks and note down the corresponding meter readings in Table 1.

8 Note down this is the maximum current carry capacity of the conductor.

If the conductor is not broken, reduce the thickness of conductor (or) change the battery.

9 Connect the aluminium and alloy conductor separately and repeat the steps to find the maximum current capacity of the 2 to 9 conductors.

10 Tabulate all the readings and show to your instructor.

11 a Maximum current capacity of copper conductor is _____ Amp

b Maximum current capacity of aluminium conductor is _____ Amp

c Maximum current capacity of alloy conductor is _____ Amp

Table 1

Sl.No.	Rheostat Position			Conductor	Voltage	Current	Remarks
	Cold end	Mid end	Hot end				
1		X	X	Copper			
2	X		X				
3	X	X					
4		X	X	Aluminium			
5	X		X				
6	X	X					
7		X	X	Alloy			
8	X		X				
9	X	X					

'X' denotes the inactive positions of the rheostat and blank space denotes active positions in the above Table 1.

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Fasten, jumper in pin, shackle and suspension type insulators

Objectives: At the end of this exercise you shall be able to
- **select the pin type, shackle type and suspension type insulators**
- **fasten jumper in cross-arm of pole with pin insulator**
- **fasten the jumper in shackle type insulator**
- **fasten the jumper in suspension type insulator.**

Requirements

Tools/Equipment /Material

- Insulated combination plier 200mm - 1 No.
- DE spanner set 6 to 25mm - 1 Set
- Adjustable spanner 25mm - 1 No.
- Wooden or nylon mallet 1/2kg - 1 No.
- Ladder 6m long - 1 No.
- Wire stripper 150mm - 1 No.

Material

- Suspension type insulator - 2 Nos.
- Shackle type insulator - 2 Nos.
- Pin type insulator - 2 Nos.
- Flat aluminium tape - as reqd.
- Binding wire 14 SWG aluminium - 5m
- ACSR conductor - as reqd.
- Safety belt - 1 No.
- Clamp - as reqd.
- Nut and bolt - as reqd.

PROCEDURE

TASK 1 : **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.

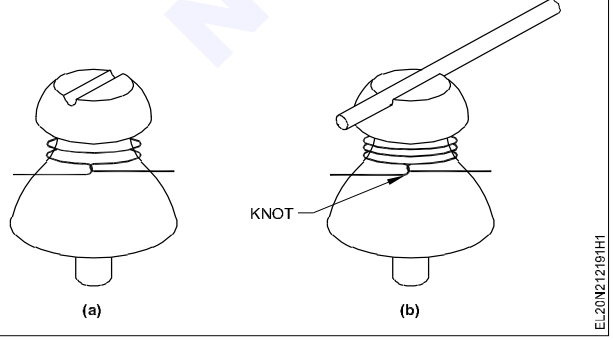
3 Tape the neck of the pin insulator with flat aluminium tape.

4 Lift the Aluminium Contactor 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.

Fig 1

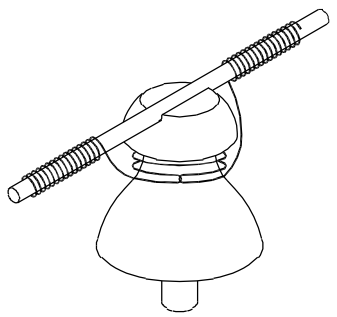


7 Make a knot of the binding wire with the free ends tightly. (Fig 1b)

Binding should have mechanical strength.

8 Bind the free ends of the binding conductor over the line conductor tightly in the opposite direction. (Fig 2)

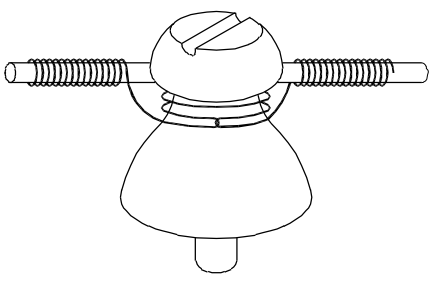
Fig 2



Binding should be tighten without any gap.

Where deviation or bend comes the ACSR conductor bind on the neck of the pin insulator. (Fig 3)

Fig 3



9 Complete the binding by giving about 15 turns on both sides.

10 Cut the extra binding wire and round off the raised ends.

— — — — — — — —

TASK 2 : **Fasten jumper in shackle 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.

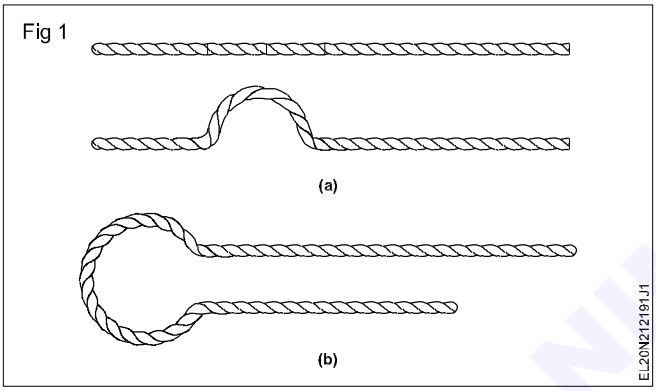
2 Fix the shackle insulator to the cross-arm with 'C' clamp.

3 Tape the ACSR conductor with flat aluminium tape where it touches the insulator.

4 Ask the helper to properly tie the O.H. conductor to the rope and lift the conductor to the cross-arm position.

While tying the conductor to the rope the helper should leave atleast 1 metre length of conductor free at the end for binding.

Fig 1

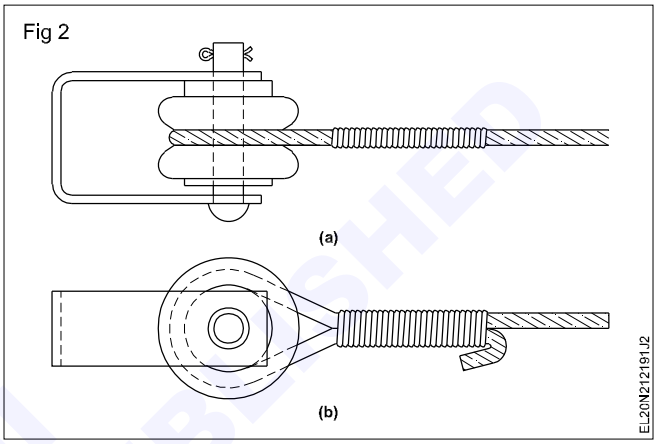


5 Insert the conductor around the groove of the insulator leaving half metre at the end. (Fig 1a & 1b)

6 Bind the ACSR conductor with 14 SWG aluminium binding wire tightly (Fig 2a) about 100 to 150 mm approximately.

7 Bend the end of the ACSR conductor in Fig 2(b). and complete the binding work .

Fig 2



Ground clearance of overhead conductor should not be less than 4.572 M for low and medium voltage.

— — — — — — — —

TASK 3 : **Fasten Jumper in suspension type 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 suspension insulator to the cross-arm.

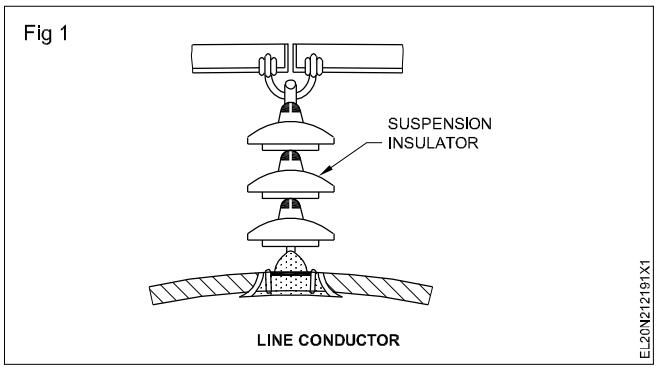
3 Ask the helper to properly lift the conductor to the cross-arm position.

4 Place the conductor in between two clamps.

5 Tight the bolt & nut of the clamp perfectly.

6 Bind the ACSR conductor with 14 SWG aluminium wire tightly Fig 1 in the suspension insulator.

Fig 1



7 Complete the work and report to your instructor.

— — — — — — — —

Erect an overhead service line pole for single phase 240V distribution system in open space

Objectives: At the end of this exercise you shall be able to
- **select the place to erect the pole**
- **select the type of pole to be erected**
- **fix the cross-arm on the pole**
- **dig the pit and erect the pole.**

Requirements

Tools/Instruments

- D.E. spanner set 6mm to 32mm - 1 Set.
- Combination pliers 200mm - 1 No.
- Heavy duty screwdriver 300mm - 1 No.
- Safety belt to work on pole - 1 No.
- Crowbar 2m long 40mm dia - 1 No.
- Spade - 1 No.
- Shovel - 1 No.
- Plumb bob with thread - 1 No.
- Cotton or jute rope 15m long - 1 No.
- Hammer ballpein 500g - 1 No.
- Safety belt - 1 No.
- Bamboo ladder - 1 No.
- Draw pulley - 1 No.
- Aligning rod - 1 No.
- Metal ram - 1 No.

Materials

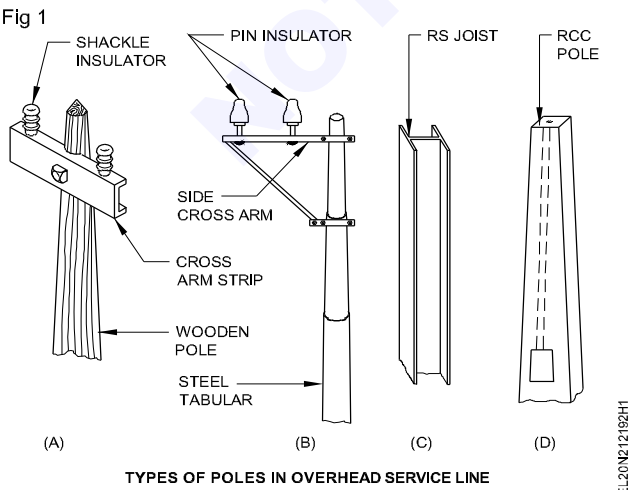
- Wooden/RCC/iron/tubular pole of 6m length - 1 No.
- M.S. angle iron cross-arm 50mm x 50mm x 6mm size suitable for 240V supply line - 1 No.
- 'C' clamp M.S. size as required with nuts, bolts and washers - 2 Sets.
- Country wood plank 2m long, 30cm width 5cm thick - 1 No.
- Cement, sand, blue metal chips etc as per the size of pit - as reqd.
- Stay insulator (egg insulator) - 2 Nos.
- Double screw stay tightener - 2 Nos.
- C.I. stay plate - 2 Nos.
- Stay rod - 2 Nos.
- H.D.G. steel wire (stay wire) 7/16 SWG - 16m
- 50 x 12mm size M.S. bolts and nuts with washers - 2 Nos.
- Base plate for pole - 1 No.
- Casuarina pole of suitable height - 4 Nos.
- Wooden box of suitable size having 2 side openings for concrete pedestal - 1 No.

PROCEDURE

1 Select the place for fixing the pole near the building based on the span.

2 Select the type of pole to be erected. (Fig 1)

Fig 1



TYPES OF POLES IN OVERHEAD SERVICE LINE

3 Dig a pit about 1/6th height of the pole having a diameter of minimum 3 times that of the dia of the pole bottom.

4 Prepare a mixture of concrete having a ratio 1:2:4 (one part cement, two part coarse sand and four part 2 cm blue metal chips) and pour the same in the bottom of the pit to a height of 15cms.

5 Ram the concrete and allow it to settle for a minimum period of 48 hours.

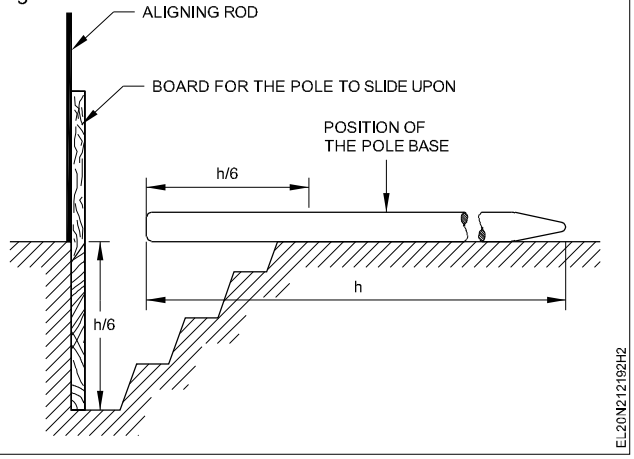
6 Keep the base plate for the pole at the bottom of the pit.

7 Fix a vertical straight pole on the plumb line in the pit. Refer (Fig 2)

8 Bring the pole and place it near the pit so that the bottom of the pole is at the edge of the pit.

9 Insert the wooden plank (board) vertically at one side of the pit facing opposite to the bottom portion of the pole.

Fig 2



10 Fix the cross arms at the top of the pole below 30 cm from the top, with the help of 'C' clamps rigidly.

11 Tie the two ropes just below the cross arms.

Ensure that the cross arm is in the required direction

12 Place the casuarina pole at a distance of 1/3 height of the top and also 1/3 height from the bottom of the pole.

13 Prepare concrete mixture in the ratio of 1:3:4 (cement, sand and 1 cm blue metal chips).

14 Lift the pole step by step with the help of a rope and casuarina pole (Fig 3) and place it on the pit exactly vertical.

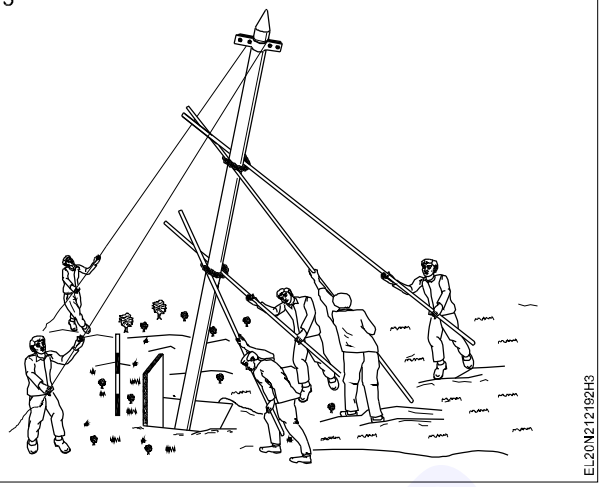
15 Check the vertical position with the help of an aligning a rod and plumb bob.

16 Pour the concrete mixture around the pole inside the pit and then place the wooden box around the pole.

17 Pour the concrete mixture in the box to a height of 0.5m above the ground level. Ram the mixture properly.

18 Cure the cement concrete for about 48 hours.

Fig 3



19 Remove the wooden box and plaster the cement concrete above the ground surface to have a smooth finish.

20 Fix the stay rod to the ground at a distance so as to get 45° to 60° between ground level and stay wire should be placed in the opposite direction to the line.

21 Cut the stay wire into 2 pieces of equal length.

22 Fix one end of each piece of the stay wire to the strain insulator (egg insulator).

23 Fix the other end of the second piece of stay wire to the stay. Tighten using a thimble.

24 Fix the stay and tighten to the stay.

Assuming the stay rod is fitted to the ground through a concrete structure which was sufficiently cured.

25 Tighten the stay tightener nut till there is no sag in the stay.

After drawing the overhead lines the stay should be tightened to compensate the tension of the overhead lines and to keep the pole in the vertical position.

— — — — — — — —

Practice on laying of domestic service line

Objectives: At the end of this exercise you shall be able to
- **locate the nearest pole, specify and estimate the quantity of materials required**
- **prepare the GI pipe, bend in the form of a goose neck and install it in position**
- **prepare the support GI wire with (ring insulator as) separators and service cable**
- **draw the service cable and connect it to the energy meter**
- **connect the service cable to the overhead lines through an aerial fuse**
- **earth the service cable support wire at both ends.**

Requirements

Tools/Instruments

- Electrician tool kit - 1 No.
- Pipe jumper 25 mm dia. 40 cm length - 1 No.
- Pipe wrench 50 mm - 1 No.
- Megger 500V - 1 No.
- Rawl plug tool No.10 with bit - 1 No.
- Hacksaw adjustable with blade 300 mm - 1 No.
- Safety belt - 1 No.
- Bamboo ladder 6 m. height - 1 No.
- GI die set with stock 15 to 40 mm - 1 set

Materials

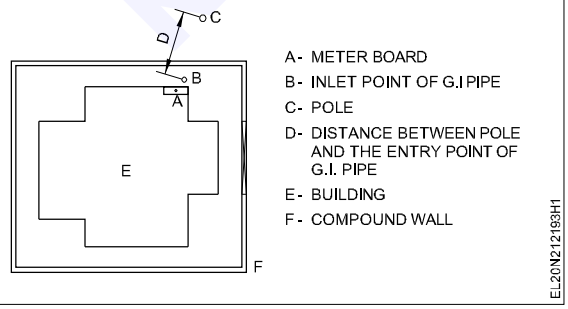
- Earth clips 40 mm - 6 Nos.
- Twin core service cable weather-proof or PVC sheathed insulated cable 2.5 sqmm., 250V grade - 20 m
- GI wire 10 SWG - 30 m
- GI wire 12 SWG and 22 SWG - 15m each
- GI wire 7/3.15 mm size - 5 m
- Porcelain ring insulator - 70 Nos.
- GI pipe 40 mm - 3 m.
- GI bends 40 mm - 1 No.
- MS clamps 40 mm, 3mm thick - 4 Nos.
- Wood screws 40 mm No.8 - 8 Nos.
- Silver paint 200 ml. - 1 No.
- Stay insulator - 2 Nos.
- Bombay nails - 8 Nos.
- Cable glands (heads) - as reqd.
- Bricks - as reqd.
- Sand - as reqd.
- Cable compound - as reqd.
- Solder - as reqd.
- Clamps for fixing cable - as reqd.

PROCEDURE

Drawing a service line is the work of the staff of the electricity board. Some of the trainees may get employment in state electricity board. When working on a service line it is utmost necessary to make a shut down before connecting the service cable to the service line.

1 Locate the nearest electrical pole and measure the distance from the pole to the building to which the service line is to be drawn (Fig 1).

Fig 1



Care should be taken to see that the service cable does not cross the adjacent building area. In some cases an intermediate pipe structure may be needed to avoid crossing.

2 Identify whether the supply required for the house is single or 3-phase.

3 Locate the position of the meter board and determine the height of GI pipe to be fixed for service connection. Refer to Fig 2, record the findings in the Table 1.

Preferably the entry height of the service cable of the GI Pipe should be at the height of the pole. If this is not possible due to the lower height of the house, arrange to fix the GI pipe at a maximum possible height.

4 Determine the length required for the goose neck bend and the thickness of the wall. Refer to Fig 2 and enter these particular in Table 1.

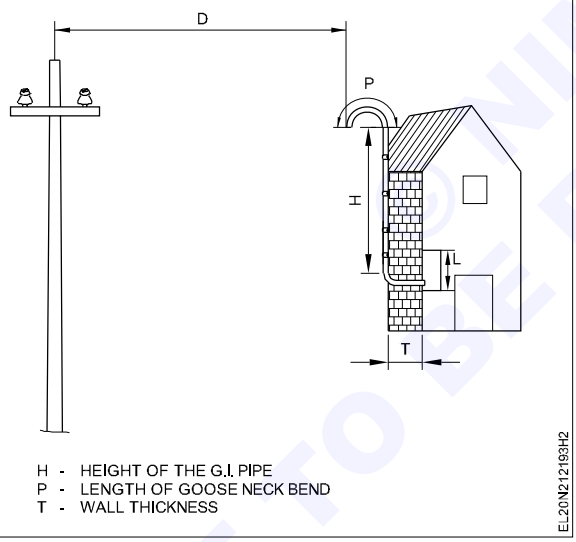
Normally a goose neck bend should have a diameter 12 times the diameter of the pipe. Say for a 25mm pipe the goose neck diameter will be 25x12=300 mm.

Table 1

Service connection measurements in metres for the supply of single/three phase

Distance between the pole and the entry point of the GI pipe D	Height of the GI pipe neck H	Length of the goose bend P	Wall thickness in mm T	Height of the meter board L	Total length
					Length of the GI pipe H+P+T - (Length of bend)metres. **Length of the GI wire as service line support wire.** D+P+3 metres. **Length of service cable** Single phase = [(D+H+P+T+L) 2] + 10% 3-phase = [(D+H+P+T+L) 4] + 10%

Fig 2



5 Determine the length of the cable required from the inside wall to the meter terminals and enter the recorded measurements in Table 1. Calculate the required length of service cable and GI pipe from the above particulars and enter the values in Table 1.

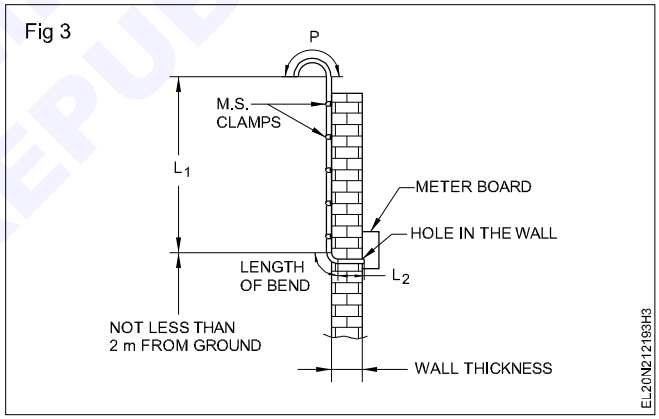
6 Mark and cut two pieces of GI pipe of length L_1 and L_2. Refer to Fig 3.

7 Thread the GI pipe of length L_1 and L_2 at one end.

8 Bend one end of the longer GI pipe L_1 to form the goose neck having a diameter equal to 12 times of the pipe diameter.

9 Make a hole in the wall with a pipe jumper such that the pipe when fitted is nearer to the energy meter terminals.

Fig 3



The hole should not be less than two metres from the ground.

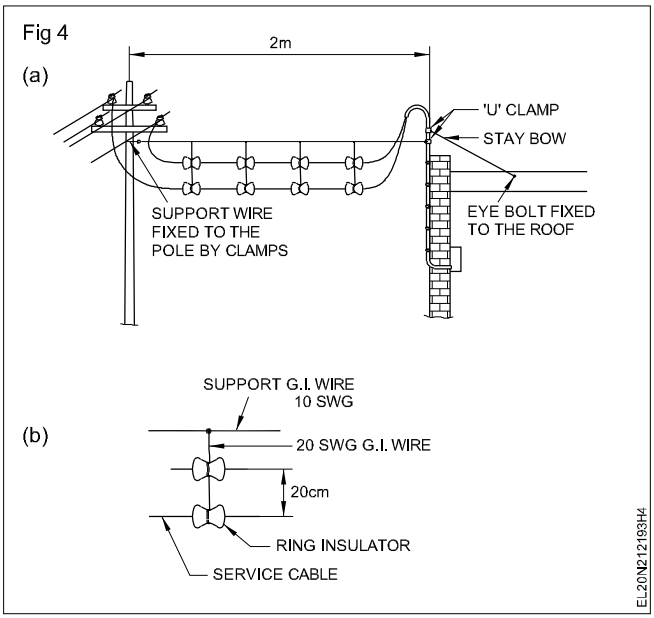
10 Fix the GI bend to the GI pipe. (Fig 3)

11 Pass the fish wire (GI wire of 20 SWG) through the assembled pipe.

12 Fix the GI pipe vertically to the wall using MS clamps. (Fig 3)

Use minimum one stay bow to the GI pipe in case the GI pipe has to be erected above the wall. Refer to (Fig 4a) and fix the other end of the stay bow to the eye bolt fixed to the roof.

13 Bind two numbers of the small ring insulators (separators) in the case of single phase supply, in one set by means of suitable GI wire of 20 SWG. (Fig 4b)



Keep 20 cm gap between the ring insulators for 250 volt and 30cm for 440 volt.

14 Bind such sets at a uniform distance to a main support G.I. wire of 10 SWG.

15 Pass the service wire (cable) through the ring insulators leaving sufficient length of wire for connection at both ends.

Mark the cables as phase and neutral at both ends.

16 Fix one end of the support GI wire to the vertical pipe, below the goose neck using 'U' clamps. (Fig 4a)

The 'U' clamp fixture should be sufficiently strong to withstand pull exerted by the weight of the service line and wind force.

17 Fix the other end of the support GI wire to the pole. (Fig 4a)

Use a ladder and wear a safety belt. Before climbing up the pole permission should be obtained from the electricity board and a shut down taken for safety.

18 Draw the service cables through the GI pipe by fish wire providing bushes at both ends of the pipe.

19 Connect the service lines to the energy meter and then to the cut outs.

20 Connect an earth continuity conductor (GI 12 SWG) between the 'U' clamp of the GI pipe and to the consumer main board earth terminal.

21 Provide earth clamps on the GI pipe for earthing.

22 Connect the phase cable of the service cable to the phase wire of the distribution line through a joint or by a connector.

In some electricity boards aerial fuses are introduced between the distribution line and the service cable. Follow the procedure as per the local regulation.

23 Connect the neutral cable of the service cable to the neutral wire of the distribution line through a joint or by a connector.

Service lines should be inspected by competent authority (EB) and the aerial fuse will be provided by them only.

24 Inspect the service line connections and then energise the line.

Install bus-bar and bus coupler on LT line

Objectives: At the end of this exercise you shall be able to
- **determine the location for installing bus bar and select the bus bar with bus coupler**
- **mount and fix the bus bar**
- **insert the plug -in-boxes in the bus bar system and also bus coupler**
- **test for earth continuity of bus bar and for insulation resistance.**

Requirements

Tools/Instruments

- Electrician tool kit - 1 No.
- DE spanner set (6 mm to 25 mm) - 1 Set
- Crimping tool - 1 Set
- Ladder with adjustable height - 1 No.
- High stool - 1 No.
- Hand hacksaw frame 300 mm - 1 No.
- Megger 500V - 1 No.

Materials

- Busbar of available current rating and standard length / current rating - 2 Nos.
- Plug - in boxes 32A - 2 Nos.
- Busbar brackets, M.S flat, for suspending the bus bar or GI pipe for supports and all supporting accessories - as reqd.
- Nut and bolts size and quantity for busbar extension standard accessories - as reqd.
- Bus coupler - 1 No.

PROCEDURE

1 Trace the workshop layout and calculate the total electrical capacity of machines, main power supply entry point and determine the rating.

2 Determine the busbar layout and the required length of the busbar.

3 Determine from the site what type of support is required to lay the busbar.

4 Mount and fix the busbars to the supporting structure. (Fig 1 and Fig 2).

5 Insert the plug - in-boxes in to the plug -in-points. (Fig 1)

Fig 1

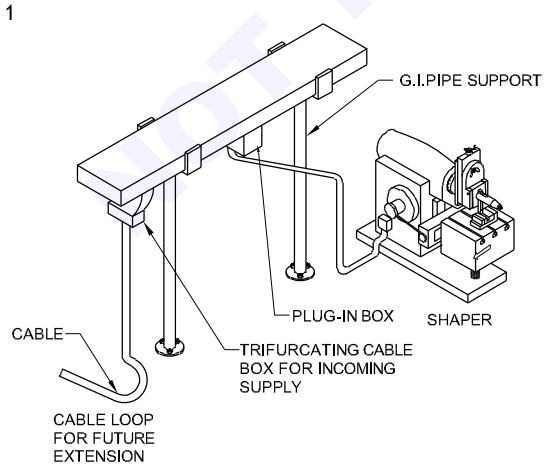
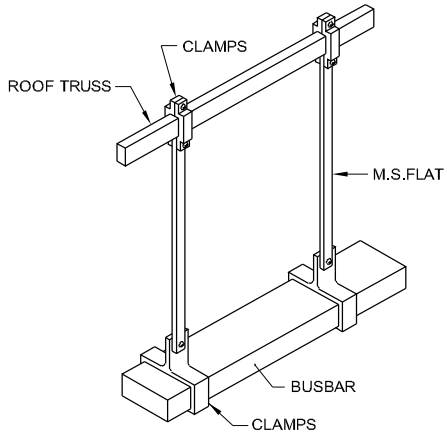
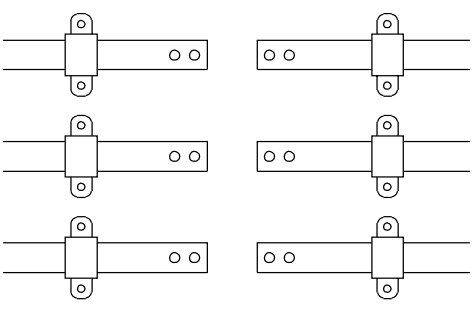


Fig 2



6 Couple the new busbar mechanically and electrically by using bus coupler, if another length is needed. (Fig 3)

Fig 3



If any over lapping ends of the busbar join by bolting together.

7 Secure busbar with screws locking plates.

A connector - assembly which is commercially available comprises of

- **rubber locating ring,**
- **busbar insulating tube**

If connector insulating tube in knocked out condition. While coupling, make sure that the connector - assembly is properly secured.

8 Terminate the plug in boxes to the loads through metal conduit runs and suitable cables.

9 Test the bus bar system for earth continuity.

10 Test the system for continuity and insulations.

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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 a electromagnetic relay**
- **identify the external parts of the single pole over current relay.**

Requirements

Tools/Equipment

- 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.

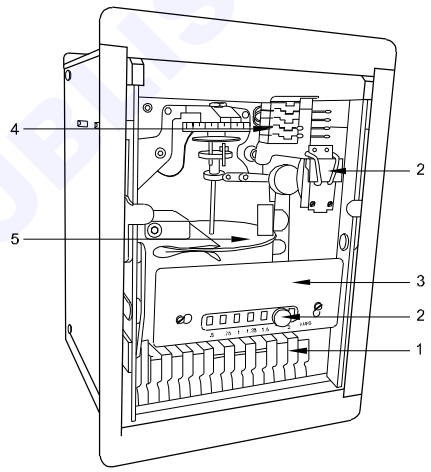
2 Note down the tap setting of current ranges at Table 2.

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.

Once the relay tripped the flag will indicate a red line once it is tripped needs manual resetting by operating the lever.

Fig 1



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		

TASK 2 : **Identify internal parts of a single pole over current relay**

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)

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.

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.

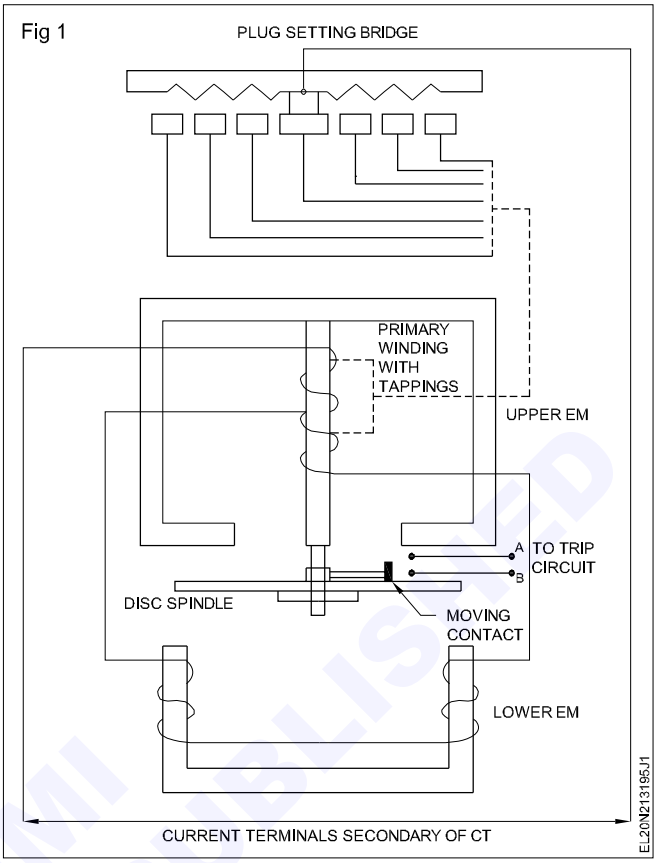
5 Locate the spiral spring mounted on the top of spindle to bring back the disc top its original position after tripping.

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.

Do not allow any dust or tiny particles enter inside. Dust will deposit in the pinion and effect the disc movement.

Fig 1



8 Close the front panel and show the findings to your instructor.

9 Note down the identified parts in Table 1.

10 Get it checked by your instructor.

Table 1

Sl.No.	Part No.	Name of the internal part	Function

— — — — — — — —

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

- Trainees tool kit - 1 No.
- Over current relay with manual (used in previous Ex.No.4.7.203) - 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.

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.

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

Note : 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.

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.

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 1.

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 1

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					

— — — — — — — —

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

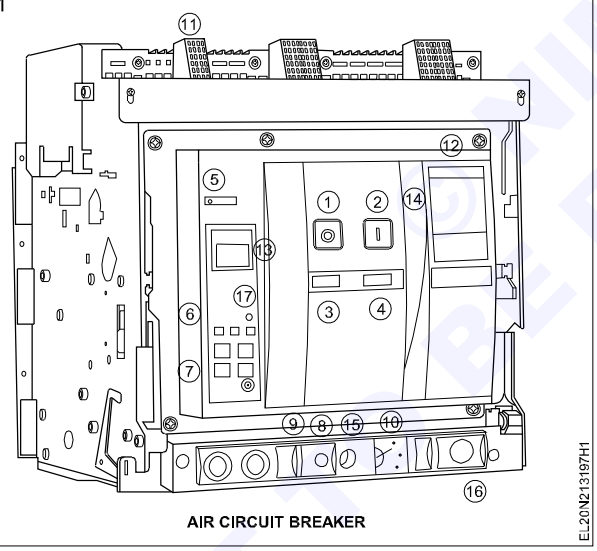
- Trainees tool kit - 1 No.
- Multimeter/ohm meter - 1 No.
- Air circuit breaker 3 phase 415V maximum capacity 400 KA with instruction manual - 1 No.

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)

Fig 1



AIR CIRCUIT BREAKER

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.

3 Write the corresponding label numbers against the corresponding external parts names only given in Table 1.

Table 1

Name of external parts

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.

Do not remove any permanent parts of the breaker.

2 Identify the main internal parts (Fig 1) fitted in the breaker and note down in Table 1.

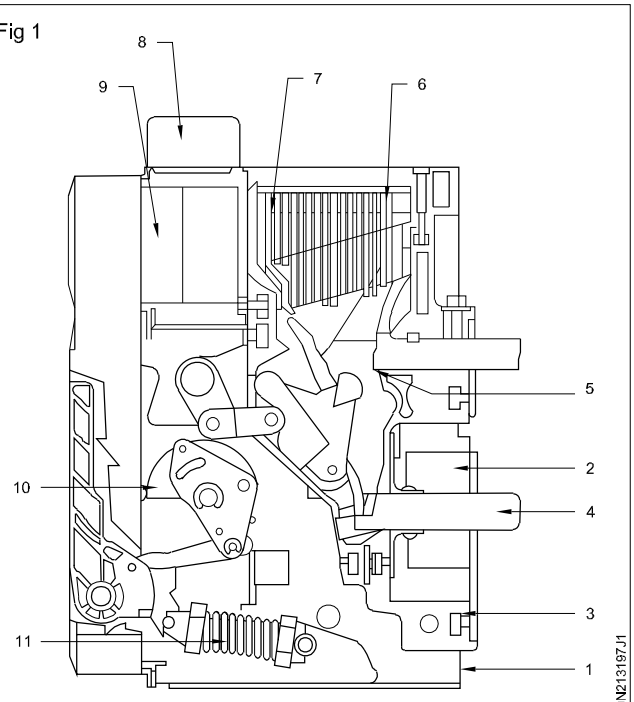
3 Locate the fixed main contact and movable main contacts.

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.

Fig 1



INTERNAL PARTS OF THE AIR CIRCUIT BREAKER

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 1

Name of internal parts

Sl. No	Parts no	Name of the part	Function
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			

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

- 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

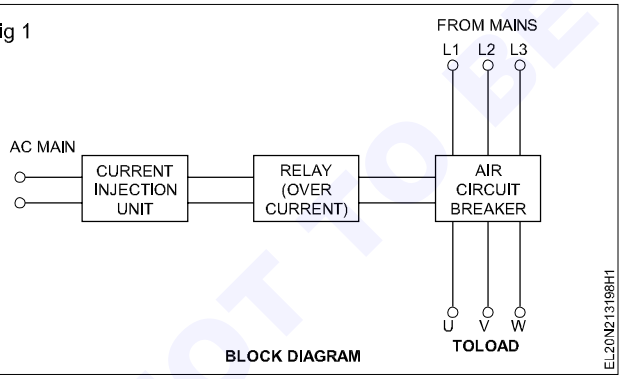
TASK 1: **Tripping of circuit breaker for definite time with set fault current**

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)

Fig 1



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.

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.

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.

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 1.

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 1.

8 Try to some higher value of fault current and repeat the step 5 to 7. Record the values in Table 1.

Table 1

Extreme inverse charts

Sl. No	Tap setting current	TMS value	Time	Multiplier	Total fault	Actual tripping	Error in %
1							
2							
3							
4							

— — — — — — — —

Practice on repair and maintenance of circuit breaker

Objectives: At the end of this exercise you shall be able to
- **follow the shut down 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/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.

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.

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, pitting 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 draw 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 (Table 1)

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.

If necessary correct them by mounting bolts.

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.

Fig 1

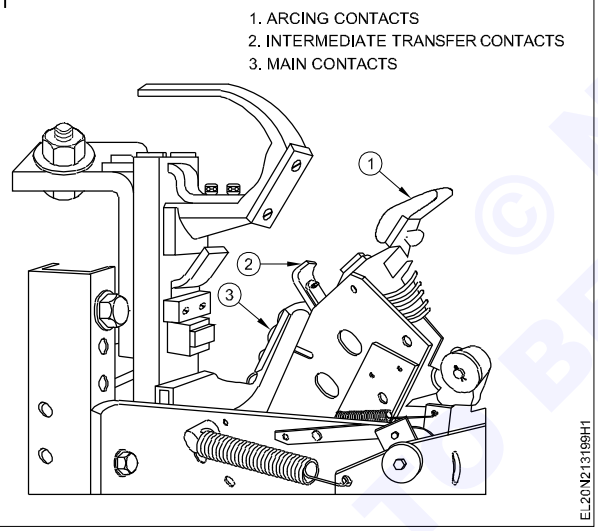
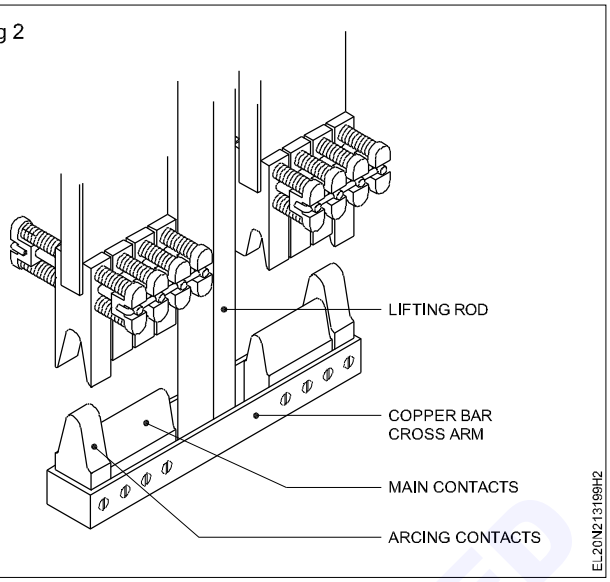


Fig 2



If pitting are heavy, use a flat file to remove the pitting. If the surface area is reduced more than ten percent due to pitting 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.

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.

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.

If the releases are found to be under friction clean the relevant part thoroughly.

Table 1

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							

Demonstrate different charger specifications

Objective: At the end of this exercise you shall be able to
- **explain differnt charger specification electric vehicle.**

Requirements

Materials

• A4 Sheet	- 1 No.	• Eraser	- 1 No.
• Pencil	- 1 No.	• Different chargers	- as reqd.

PROCEDURE

1 Table below showcases the mapping of different charger specification in India.

S.No.	Charging Station	Voltage (V)	Power (kW)	Type of Vehicle	Type of compatible charger
1	Level 1 (AC)	240	<=3.5 kW	4w ,3w,2w	Type 1, Bharat AC-001
2	Level 1 (DC)	>=48	<=15 kW	4w,3w,2w	Bharat DC-001
3	Level 2 (AC)	380-400	<=22 kW	4w,3w,2w	Type 1, Type 2, GB/T , Bharat AC-001
4	Level 3 (AC)	200-1000	22 to 4.3 kW	4w	Type 2
5	Level 3 (DC)	200-1000	Up to 400 kW	4w	Type 2, CHAdeMO, CCS1,CCS2

The Ministry of power has issued the revised consolidated guidelines and standards for charging infrastructure for E-Vehicle on 14th January 2022. The objective is to enable a faster adoption of E-vehicle in India by ensuring safe, reliable accessable and affordable E-vehicle charging infrastructure and eco-system.

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Perform installation of EV charging station for public place

Objective: At the end of this exercise you shall be able to
- **explain installation of EV charging station for public places.**

Requirements

Tools/Instruments

- Electrician tool kit - 1 No.
- EV charging station unit for public - 1 No.

Materials

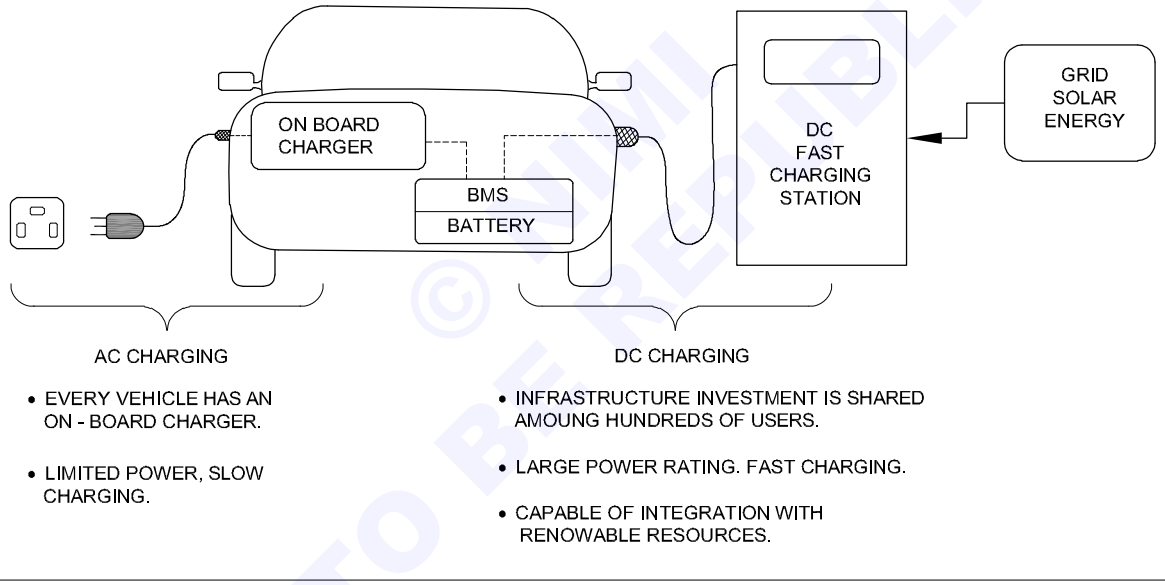
- Insulation tester - 1 No.
- Charging probes - as reqd.
- 6 square mm PVC copper insulated cable - as reqd.

PROCEDURE

1 Instructor may take the trainees to a nearest EV charging station.

2 Before entering EV charging station the trainer may explain all components of EV station. (Fig 1)

Fig 1



3 Components of EV station,

a Three pin plug socket

b On board charger

c Battery Management System (BMS)

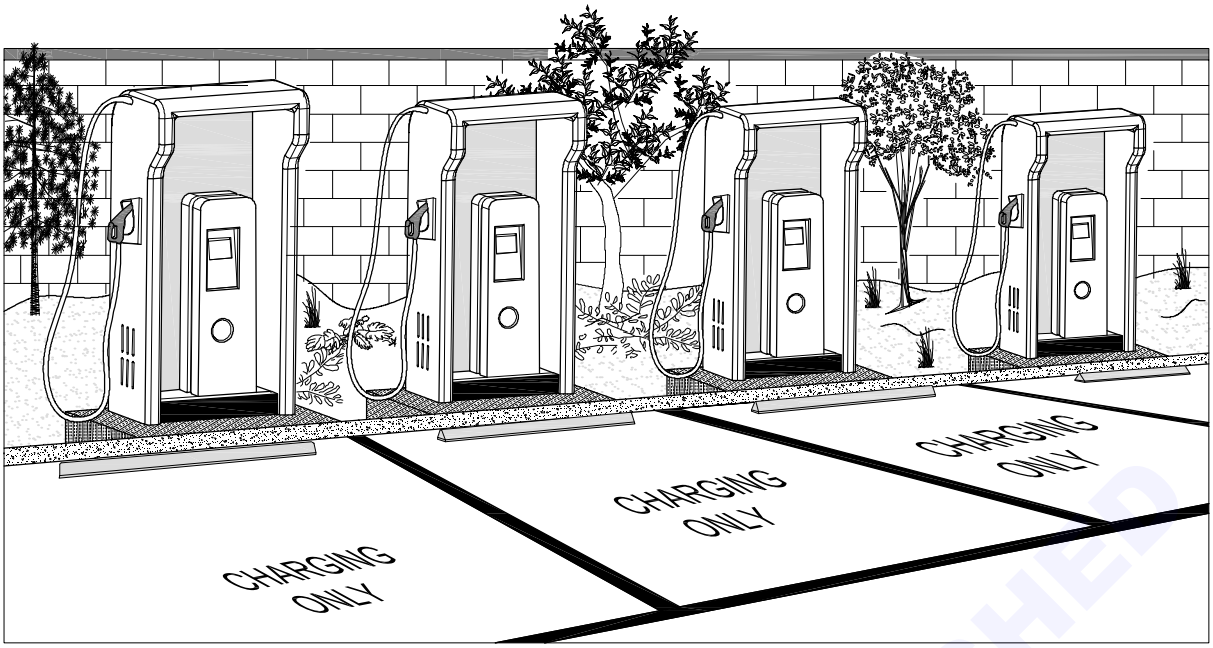
d DC fast charging station

4 Trace the various components of EV charging station by is specification.

5 Note down he block diagram of EV charging unit.

6 Get approvel rom he component authority then connect any E-vehicle (2-Wheeler or 4-Wheeler) to the charging unit and note down the voltage and current readings. (Fig 2)

Fig 2



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Perform installation of home EV charging stations

Objectives: At the end of this exercise you shall be able to
- **explain installation o home EV charging station.**

Requirements

Tools/Instruments

• Electrician tool kit	- 1 No.
• EV charging unit for home	- 1 No.
• Multimeter	- 1 No.

Materials

• Insulation tester	- 1 No.
• Charging probes	- as reqd.
• 4 square mm copper insulation cable	- as reqd.

PROCEDURE

1 Collect EV charging unit from the store.

2 Identify the suitable space for EV charging unit.

3 Fix charging unit on the wall.

4 Select suitable PVC cable (4 mm^2).

5 Connect 230V supply to he EV charging unit.

6 Before giving supply to the charging unit measure supply voltage using multimeter.

7 Connect EV charging unit to the four wheeler as shown in Fig 1.

8 Get approval from your instructor.

9 Avoid loose connections.

10 Show the control panel working to your instructor and get it approved.

Note: Remove the wiring as you did in the Ex.No.2.8.167(i) and preserve the remaining devices fitted for the next exercise 2.8.167(iv)

Fig 1

Project work

Objectives: The Trainees/Participants shall be able to
- **select a project work of their choice**
- **prepare the list of materials required and collect them**
- **list out the tools required**
- **prepare a brief note on the project**
- **complete the project and submit the project report with all the details.**

Note: Instructor has to explain in detail regarding the project works to be carried out in the section. The trainees may be divided in groups according to the strength available in section and give all details how to prepare and finish the work with complete workmanship and accuracy.

- Step to start and follow the project work
- Motivate the group by emphasising the technical work involved and its future influences.
- Divide the work equally and make sure in yoke participating with full interest.
- Start the project work, test it stage by stage and complete it.
- Test the completed project job for its functionality and its utility.
- Prepare a project report containing its technical parameters, specification, material requirement and its cost, operational procedure, maintenance, utility and marketing etc.
- Indicate the scope of future expansion, easy conversion to other project for advanced version in the report.
- Get it checked with your instructor.

The project should be completed with all operational with instructions necessary procedure.

Safety devices are to be placed according to the project and its functions.

Maintenance and repair instructions should be indicated clearly.

Note: Instructor has to evaluate the project work with all records and reports. Marks to be awarded for the project working, accuracy, workmanship, safety features and its work performance related to the viva questions.

Project works

1 Battery charger/Emergency light

2 Control of motor pump with tank level

3 DC voltage converter using SCRs

4 Logic control circuits using relays

5 Alarm/indicator circuits using sensors

Note :

1 Some of the sample project works (indicative only) are given against each semester.

2 Instructor may design their own project and also inputs from local industry may be taken for designing such new project.

3 The project should proudly cover maximum skills in the particular trade and must involve some problem solving skill. Emphasis should be on Teamwork: Knowing the power of synergy/collaboration, work to be assigned in a group (Group of at least 4 trainees). The group should demonstrate Planning, Execution, Contribution and Application of Learning. They need to submit Project report.

4 If the instructor feels that for execution of specific project more time is required than he may plan accordingly to produce components /sub-assemblies in appropriate time i.e., may be in the previous semester or during execution of normal trade practical.