WIREMAN

3rd Semester

TRADE PRACTICAL

SECTOR: Power Generation Transmission,Distribution, Wiring & Electrical Equipment

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 Generation, Transmission, Distribution, Wiring and Electrical Equipments**

Duration : **2 - Years (4 Semesters)**

Trade : **Wireman - 3rd Semester - Trade Practical**

First Edition : August 2015, Copies : 1000

Rs. 165/-

Published by:

NATIONAL INSTRUCTIONAL MEDIA INSTITUTE
P. B. No.3142, CTI Campus, Guindy Industrial Estate,
Guindy, Chennai - 600 032.
Phone: 044 - 2250 0248, 2250 0657
Fax : 91 - 44 - 2250 0791
email : nimichennai@vsnl.net, nimi_bsnl@dataone.in
Website: www.nimi.gov.in

FOREWORD

The National Instructional Media Institute (NIMI), Chennai, an autonomous body under the Directorate General of Training (DGT), Ministry of Skill Development & Entrepreneurship has been developing, producing and disseminating Instructional Media Packages (IMPs) for various trades under the Craftsman Training Scheme, Apprenticeship Training Scheme, Center of Excellence (CoE) Scheme and Modular Employable skills (MES) under Skill Development Initiative (SDI) Scheme. These IMPs are extensively used in the Government and Private Industrial Training Institutes and other Vocational Training Institutes to impart both Theory and Practical training and develop work- skills for the trainees and trainers.

Providing the current industry relevant skill training to students requires regularly updated syllabus and trainers who are trained in the latest syllabus. Mentor Councils were constituted in January 2014 to revamp courses to be run in 25 sectors. The Mentor Councils have representatives from thought leaders among various stakeholders viz. one of the top ten industries in the sector, innovative entrepreneur who have proved to be game-changers, academic/ professional institutions, champion ITIs for each of the sectors and experts in delivering education and training through modern methods like through use of IT, distance education etc..

11 sectors were identified as priority sectors and internal core groups were created to tap the expertise of officers in the various institutions of Directorate General of Training (DGT). A review of curriculum, admission criteria, course duration etc. was done and a revised curriculum was recommended.

The Institute has now come up with instructional material to suit the revised curriculum under Semester pattern for **Wireman Trade Theory 3rd Semester in Power Generation, Transmission, Distribution, Wiring and Electrical Equipments Sector** to enhance employability of ITI trainees across the country and also to meet the industry requirement.

I have no doubt that the trainers and trainees of ITIs, other vocational training institutes and industries will derive maximum benefits from this book and that NIMI's effort will go a long way in improving the quality of vocational training in the country by publishing the instructional materials for various courses and also assist in enhancing the employment opportunities of the trainees and other beneficiaries.

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

RAJESH AGRAWAL, I.A.S.,
Directorate General of Training/Joint Secretary,
Ministry of Skill Development & Entrepreneurship,
Government of India.

New Delhi - 110 001

PREFACE

This National Instructional Media Institute (NIMI) an autonomous body under the Directorate General of Training (DGT), Ministry of Skill Development & Entrepreneurship, Government of India was set up at Chennai in 1986 with technical assistance from the Govt. of the Federal Republic of Germany. The prime objective of this institute is to develop and disseminate uniform instructional materials for various trades as per the prescribed syllabi under the Craftsmen and Apprenticeship Training Schemes approved by NCVT.

The instructional materials are developed and produced in the form of Instructional Media Packages (IMPs). An IMP consists of Trade Practical book,Related Trade Theory book, Test and Assignment book, Workshop calculation & Science,Engineering Drawing, Instructor guide, Wall Charts and Transparencies.

Hon'ble **Prime Minister** of India during his speech on 15th August 2014 mentioned about developing **Skill India** and made the following announcement

"Skilling is building a better India. If we have to move India toward development then Skill Development should be our mission."

Providing the current industry relevant skill training to students requires regularly updated syllabus and trainers who are trained in the latest syllabus. Mentor Councils were constituted in January 2014 to revamp courses to be run in 25 sectors. The ultimate approach of NIMI is to prepare the validated IMPs based on the exercises to be done during the course of study. As the skill development is progressive the theoretical content on a particular topic is limited to the requirement in every stage. Hence, the reader will find a topic spread over a number of units. The test and assignment will enable the instructor to give assignments and evaluate the performance of a trainee. If a trainee possesses the same it helps the trainee to do assignment on his own and also to evaluate himself. The wall charts (NIMI Wall Chart are displayed in Premier Institutes like IIT-Madras etc.) and transparencies are unique, as they not only help the instructor to effectively present a topic but also helps the trainees to grasp the technical topic quickly. The instructor guide enables the instructor to plan his schedule of instruction, plan the raw material requirement ,

To fulfill the Prime Minister Vision of making **Digital India** NIMI has also taken the steps to diversify the Instructional Material in the form of **E- Book (Digitalized Content - www.nimilearningonline.in), E-Learning and Videos** for the IMP's developed. Thus the availability of a complete Instructional Media Package in an institute helps the trainer and management to impart an effective training. Hence, it is strongly recommended that the Training Institutes/Establishments should provide at least **one IMP** per unit. This will be small, one time investment but the benefits will be long lasting along with strengthening library facilities.

The **Wireman 3rd Semester - Trade Practical** under **Power Generation Transmission Distribution Wiring and Electrical Equipments Sector** is one of the book developed by the core group members of the Mentor Councils (MCs). This 3rd Semester book includes **Module 1 - Electronic Devices, Module 2 - Domestic Appliances, Module 3 - DC Machines** and **Module 4 - AC Machines**.

The **Wireman 3rd Semester - Trade Practical** is the outcome of the collective efforts of Team India Members of Mentor Council which includes academic/professional institutions (IITs etc.), experts from relevant industries, field institutes of DGT, champion ITIs for each of the sectors, and also Media Development Committee (MDC) members and staff of NIMI.

NIMI wishes that the above material will fulfil to satisfy the long needs of the Trainees and Instructor and helps the trainees for their employability in vocational training for all Engineering and Non-Engineering disciplines.

NIMI would like to take this opportunity to convey sincere thanks to all the Mentor Council Core Group members and Media Development Committee (MDC) members.

A. MAHENDIRAN
Director, NIMI.

Chennai - 600 032

ACKNOWLEDGEMENT

National Instructional Media Institute (NIMI) sincerely acknowledge with thanks for the co-operation and contribution extended by the following Media Developers and their sponsoring organisation to bring out this IMP **(Trade Practical)** for the trade of **Wireman - 3rd Semester** under the **Power Generation, Transmission, Distrubution, Wiring and Electrical Equipment** Sector for Craftsman Training Scheme. This Book is prepared as per Revised Syllabus.

MEDIA DEVELOPMENT COMMITTEE MEMBERS

Dr. S. P. Gupta	-	Deputy Director, Professor, Department of Electrical Engineering. IIT, Roorkee. Chairman, Mentor council.
Shri. M. Shajahan	-	Joint Director of Training, DGT, New Delhi. Mentor, Mentor council.
Shri. S. Mathivanan	-	Joint Director of Training, ATI, Chennai. Team Leader, Mentor council.
Shri. Amrit Pal Singh	-	Deputy Director of Training, DGE&T, New Delhi. Member, Mentor council.
Shri. B. Ravi	-	Deputy Director of Training, CTI, Chennai. Member, Mentor council.
Shri. C. C. Jose	-	Training Officer, ATI, Chennai. Member, Mentor council
Shri. M. Asokan	-	Training Officer, CTI, Chennai. Member, Mentor council
Shri. T. Muthu	-	Retd. Principal, MDC Member, NIMI, Chennai
Shri. N. Mahadevan	-	Retd. Training Officer, MDC Member, NIMI, Chennai
Shri. T. Mohanraj	-	Training Officer, NIMI, Chennai - 32 Co-ordinator, NIMI, Chennai

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

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

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

INTRODUCTION

This manual of trade practical is intended to be used in the workshop. It consists of a series of practical exercises to be completed by the trainees during the **Third semester** course of the ***Wireman*** trade, supplemented and supported by instructions/information to assist the trainees in performing the exercise. These exercises are designed to ensure that all the skills in the prescribed syllabus are covered including the allied trade skills. The syllabus for the **3rd Semseter** Power Sector is divided into **four modules**. The distribution of time for the various modules are given below.

Module 1 - Electronic Devices		11 Exercises	050 Hrs.
Module 2 - Domestic Appliances		12 Exercises	050 Hrs.
Module 3 - DC Machines		16 Exercises	175 Hrs.
Module 4 - AC Machines		25 Exercises	250 Hrs.
	Total	64 Exercises	525 Hrs.

A careful study of the syllabus and the content matter in the modules reveal that these modules are interlinked with each other. Further to this, the number of workstations available in the electrical section are limited by the machinery and equipment. Because of these constraints, it is necessary to interpolate exercises in various modules to form a proper teaching and learning sequence. The sequence of instruction suggested for various modules is given in schedule of instruction which is incorporated in the Instructor's Guide. There are 25 practical hours in a week of 5 working days and thus, 100 hours of practical in a month.

Contents of Trade Practical

The procedure for carrying out exercises during the **3rd semester** and the specific objectives to be achieved at the end of each exercise is arranged in the sequence indicated below.

Objectives

The skill objectives to be achieved at the end of each exercise are listed in the beginning of each exercise.

Requirements

The tools/instruments, equipments/machines and materials required to perform the exercise is given in the first page of each exercise.

Exercise drawing and Procedure

The skill training in the shop floor is planned through a series of practical exercises/experiments to support the theory information so as to make the trainees to achieve practical skills in the **wireman** trade with the relevant cognitive skills. A minimum number of projects have been included to make the training more effective and at the same time to improve the attitude of group work among the trainees. Pictorial, schematic, wiring and circuit diagrams have been included in the exercises wherever necessary to assist the trainees to broaden their views. The symbols used in the diagrams are in accordance with the Bureau of Indian Standards specifications.

More number of illustrations are available to make this manual, to the extent possible, less language oriented.

The procedure to be followed for completing the exercises are also given. To enhance the interaction between the trainee and instructor as well as between trainees various forms of intermediate test questions are included in the exercises wherever required.

Skill Information

Only the skill areas which are repetitive in nature are given as separate skill information sheets. On the other hand the skills which are to be developed in specific areas are included in the exercise itself. Titles of skill information sheets are given in italics in the content, with the page numbers indicated against each.

This manual on trade practical forms a part of the Written Instructional Material (WIM). WIM also includes manuals on trade theory and assignment/test. The answers to the assignment/test are to be written on the response sheets only.

CONTENTS

Determine the V/I characteristics of semiconductor diode

Objectives: At the end of this exercise you shall be able to
- **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 characteristic of the diode and determine the minority carrier current.**

Requirements

Tools and Instruments

- Multimeter 20kΩ/V or preferably Electronic Multimeter - 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 A - 1 No.

Equipment/Machines

- DC regulated power supply (RPS) 0-30V, 1A -1 No.

Materials

- Semiconductor diode IN 4001 or IN 4007 - 1 No.
- SPT switch 6A 240 V - 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.
- Lamp 6 V, 500 mA - 1 No.

PROCEDURE

TASK 1 **: Identify the terminal leads of a given diode**

1 Set the multimeter in ohms range (Ω x 1). Check the zero-setting of multimeter, if necessary correct it. Mark the polarity of the multimeter. If the polarity is not known, connect its leads to a M.C. voltmeter (0-3V), to find out the polarity of multimeter output voltage.

2 Observe the deflection of the voltmeter, if it indicates the voltage, mark the terminal of the multimeter corresponding to the voltmeter polarity.

3 If the voltmeter kicks back then mark the terminal of the multimeter opposite to voltmeter polarity.

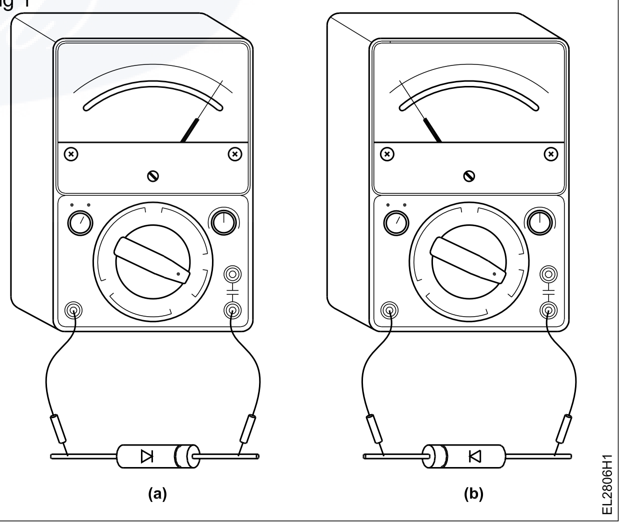
In digital multimeter the marked polarity and polarity of output voltage are the same

4 Connect the +ve marked terminal of 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**. As shown in Fig 1a.

b) If the meter does not deflect as in Fig 1b then the lead of the diode connected to +ve marked terminal of the multimeter is the cathode and the other is anode.

Fig 1



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.

— — — — — — — —

TASK 2 : **Determine the forward V/I characteristic of the diode**

1 Draw the circuit for the said task and get approved by your instructor.

2 Collect the components/instruments and check their condition. Record the specification of diode.

3 Construct the circuit in the bread board as per your circuit (or as per Fig 2).

4 Set initially RPS = 0 and switch ON the power supply.

5 Close the switch S and increase the RPS voltage in steps of 0.1 V as per the Table.1

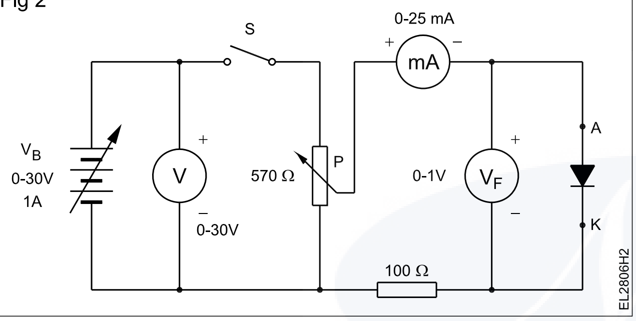
TABLE 1

V_S Volt	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	2.0
V_F Volt												
I_F mA	0											

6 Record the corresponding values of current (I_F) and voltage (V_F) in the Table.1.

While increasing the forward voltage (V_F) the forward current (I_F) of the diode should not exceed the rated forward current of diode.

Fig 2



7 Observe the value of voltage across the diode at which the current starts increasing.

8 Switch off the supply

9 Plot the graph with V_F on X axis and I_F on Y- axis.

10 Determine the forward resistance.

$$R_F = \frac{V_F}{I_F} \; ohms$$

11 From the graph determine the knee point voltage (Barrier potential) at which large quantity of current starts flowing. Enter the value below.

(Barrier potential) Knee point voltage __ volts.

If the knee point voltage is around 0.3 V or 0.7V the diode is germanium or silicon respectively.

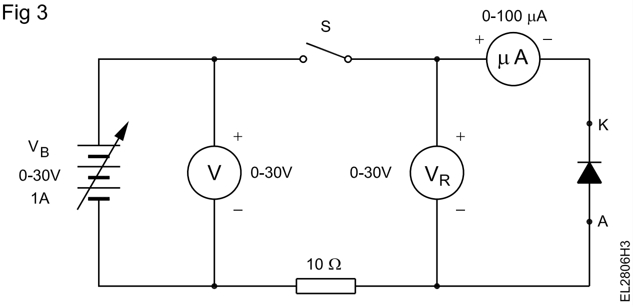
_ _ _ _ _ _ _ _

TASK 3 **: Determine the reverse V/I characteristic of a diode.**

1 Draw the circuit for the said task and get approved by your instructor.

2 Construct the circuit in a bread board as per the circuit (Fig 3). (Reverse the Diode terminals with respect to previous task)

Fig 3



3 Switch on the power supply and close the switch S.

4 Gradually increase the RPS voltage and note down the corresponding current (I_R) and voltage (V_R) in Table 2.

If the reverse voltage becomes equal to the PIV of the diode then the diode starts conducting. If the reverse voltage becomes more than the PIV, the diode will get damaged.

5 Switch off the power supply.

6 Plot the graph on the same graph sheet (Task 2) with V_R on x-axis and I_R on Y-axis.

7 From the graph determine the minority carrier current.

8 Repeat the experiment for different types of diodes.

TABLE 2

V_S Volts	0	5	10	15	20	30
V_R Volts						
I_R in Micro camps						

Identify and test the given zener diode

Objectives: At the end of this exercise you shall be able to
- **identify the polarity of a zener diode by visual inspection and test it for its condition**
- **select a proper zener diode as per circuit diagram**
- **connect the zener diode as per circuit diagram**
- **determine the forward and reverse bias characteristic of the zener diode and draw the graph**
- **determine the zener breakdown voltage from the graph.**

Requirements

Tools and Instruments

- Voltmeter MC 0-1 V - 1 No.
- Voltmeter MC 0-30V - 1 No.
- Ammeter MC 0-100 mA - 1 No.
- Multimeter - 1 No.

Equipment/Machines

- Regulated power supply (input 240 V AC, output 0-30 DC, 1 amp) - 1 No.

Materials

- Zener diode 10 volts 1W - 1 No.
- Zener diode (Assorted) - 5 Nos.
- Resistor 3k, 1W, - 1 No.
- Resin core solder - as reqd.
- Hook-up wire, single strand - as reqd.
- Resistor 5 ohm 5W - 1 No.
- P.C. board, general purpose - 1 No.
- Diode data manual - 1 No.
- 6 V, 500 mA Lamp - 1 No.

PROCEDURE

TASK 1:- **Determine the polarity of Zener diode and check its condition**

1 Take one of the given zener diodes. Record the component code number in Table 1.

2 Check and record the terminals of the zener in a similar way as you test a rectifier diode.

If you still don't know the terminals (+ve or -ve) of multimeter, check it using a voltmeter and make a mark on your meter.

3 From the polarity marking on the body of the zener and from the test carried out at step 2, identify and mark the cathode terminal of the zener.

4 Refer diode data manual and record the specifications of the zener diode under test in Table 1.

5 Repeat steps 1 to 4 for atleast five different types of zener diodes in the given lot.

6 Get your work checked by your instructor.

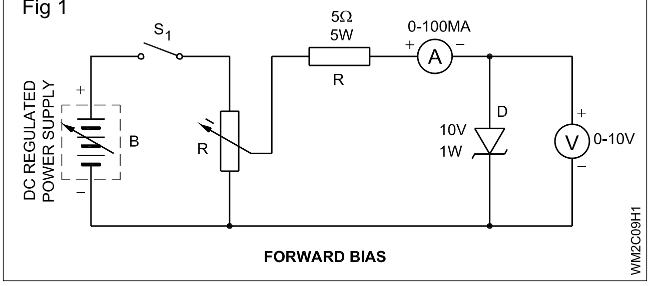
TABLE 1

Sl. No.	Zener code number	Condition of the Zener	Specification					
			Nominal zener voltage V_z	% toler-ance	Max power P_{max}	Zener current	Zener resistance	Type of package
1								
2								
3								
4								
5								

TASK 2:- **Determine the forward characteristic of zener diode**

1 Draw the circuit for the said task and get approved by your instructor.

Fig 1



FORWARD BIAS

2 Collect the instrument and components and check their condition.

3 Connect the circuit as per the diagram for forward bias (Fig 1) on a lug board.

4 Connect the DC regulators power supply to supply mains and switch ON by keeping it in 0V.

5 Increase the RPS voltage gradually from 0.1 V to 1 in steps of 0.1 V.

Care should be taken such that the zener curren (I_z) should be more than the forward current.

6 Record the readings of voltmeter and ammeter for every step in the Table 2.

7 Switch off the DC power supply.

TABLE 2

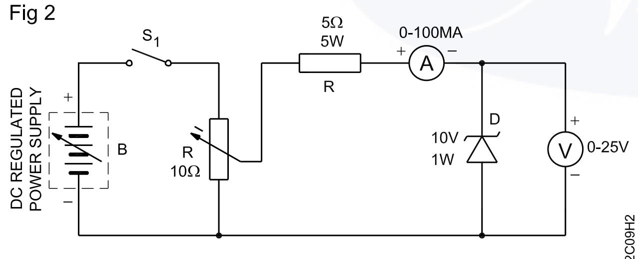
Output Voltage of RPS (Vs)	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1
Voltage Across Zener (V)											
Current I (mA)											

— — — — — — — —

TASK 3:- **Reverse characteristics**

1 Design and draw the circuit for the said task and get approved by your instructor.

Fig 2



REVERSE BIAS

2 Connect the circuit for reverse bias (Fig 2).

3 Switch on the DC power supply.

4 Increase voltage from 1V in steps of 1 volt until the full current of the zener is reached. Record the ammeter reading in Table 3.

$$\text{Max. zener current} = \frac{\text{Wattage of zener diode}}{\text{Voltage of zener diode}}$$

5 Draw the curves between the voltage and current in the graph for forward and reverse-bias as shown in Fig 3.

6 Mark the reverse breakdown voltage (Zener voltage) on the reverse characteristic curve.

The reverse break down voltage is ________

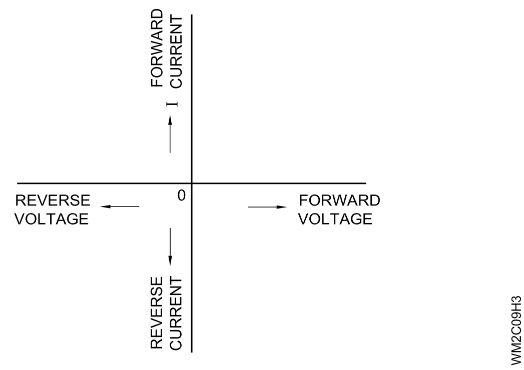
$$R_z = \frac{V}{I}\Omega$$

7 Calculate the zener resistance for each value of current.

TABLE 3

Vs (Volt)	$V_{(Volt)}$	$I_{(mA)}$	$R_{z(OHMS)}$
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

Fig 3



Construct and test a zener regulated power supply

Objectives: At the end of this exercise you shall be able to
- **check the condition of the zener using an ohmmeter**
- **identify the terminals of zener diodes**
- **calculate the value of a series resistor to be used with a zener for a given load condition**
- **wire and test the zener regulator power supply.**

Requirements

Tools/Equipments/Instruments

- Trainees tool kit - 1 No.
- Regulator Power supply, 0-30V,1A - 1 No.
- DC milliammeter,0 - 50mA - 1 No.
- DC Voltmeter 0 - 30 V - 2 No.

Materials/Components

- 12V, 400mw, Zener diode, - 1 No.
- 1Z12 or equivalent
- Resistor 1/2W, 100Ω - 1 No.
- Resisted, 2.2K, 1K, 470Ω, - 1 each.
- Patch cords - as reqd.
- Wire sleeve, yellow - 10 Cms.

NOTE: The value of zener diode and the resistor will have to be calculated before collecting them by the trianee for Task 1.

PROCEDURE

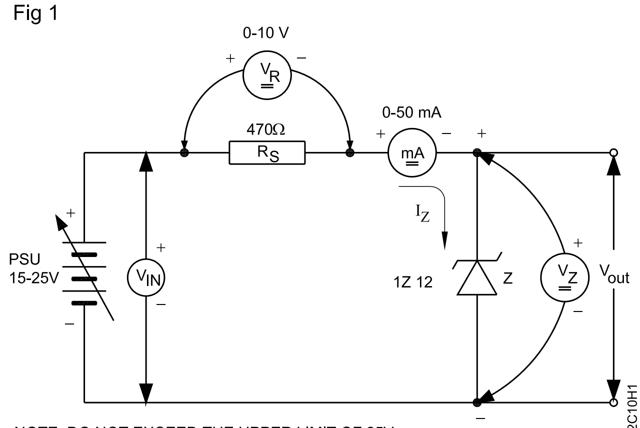
TASK 1:- **Construct a zener regulated power supply**

1 Draw the circuit for the said task and get approved by your instructor. The required output specification of the zener regulator are given below.
   – Regulated output voltage : 12V DC ±0.5V
   – Load current : Depends on zener current

2 Check the condition of the components used in the circuit.

3 Connect the series resistor, load resistance and zener diode to the power supply wired on the tag board as per diagram (Fig 1).

Fig 1



NOTE: DO NOT EXCEED THE UPPER LIMIT OF 25V

4 Increase the input voltage gradually from 5 to 25 V in steps of 5V.

5 Record the output voltage and current and record it in table 1.

The current should not be more than the zener current (I_Z)

6 Repeat steps by replacing the value of load resistance and check the output voltage.

Use a suitable value and wattage rheostat to load the output of power supply to 100mA.

TABLE 1

Vin (volts)	5	10	15	20	25
Vz (volts)					
Current (mA)					

Identify and check transistors

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.**

Requirements

Tools/Equipments/Instruments

- Trainees kit - 1 No.
- International Transistors Data Book - 1 No.
- Ohmmeter 0-200Ω or Multimeter - 1 No.
- Voltmeter MC 0 - 15V - 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: **Identifying transistor type and leads, referring to data manual**

1 Take any one transistor from the given assorted lot, enter its label number and transistor type in Table 1.

2 Refer to transistor data manual, find and record the following details of the transistor in Table 1

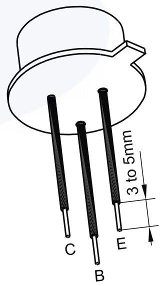
– Whether silicon or germanium
– Whether NPN or PNP
– Type of packaging or case outline (Example: TO5, TO7 etc.)

3 From the type of package recorded, refer to the transistor data manual and draw the pin diagram indicting base, emitter and collector for the transistor in Table 1.

4 Put sleeves as shown in 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

Fig 1



In some 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 : **Identify whether the given transistor is a PNP or NPN.**

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.

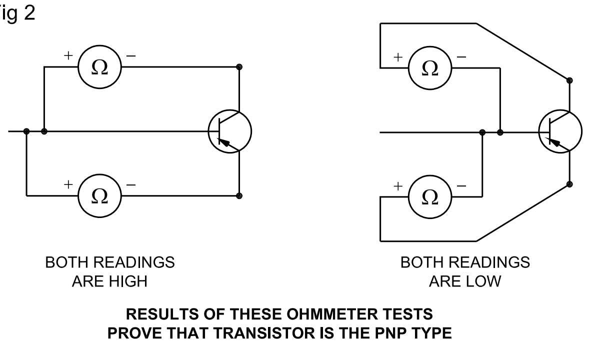
1 Ascertain the +ve and -ve polarity of the ohmmeter leads by voltmeter test

Ohmmeters in very low or very high ohms range can produce excessive current/voltage and may damage low power transistors while testing.

2 Read the resistance value of PN junctions of transistor as shown in Fig 2 and Fig 3 and record it in table 1.

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 2 and 3.

Fig 2



3 From the Recorded value, identify it is ____ transistor.

4 Repeat the steps for atleast 5 transistors of different types and recorded it in table 1.

Fig 3

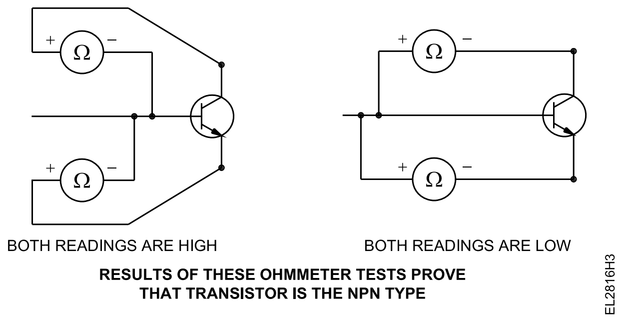


TABLE 1

Sl. No.	Lable No.	Transistor type No.	Semi-Conductor/ Type	Type of package	Pin Diagram	Junction resistance in one direction			Junction resistance Reverse direction			Turn on Yes/No	Remarks
						BE	BC	CE	BE	BC	CE		

— — — — — — — —

TASK 3 : **Testing transistor for its condition**

1 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 4a and 4b.

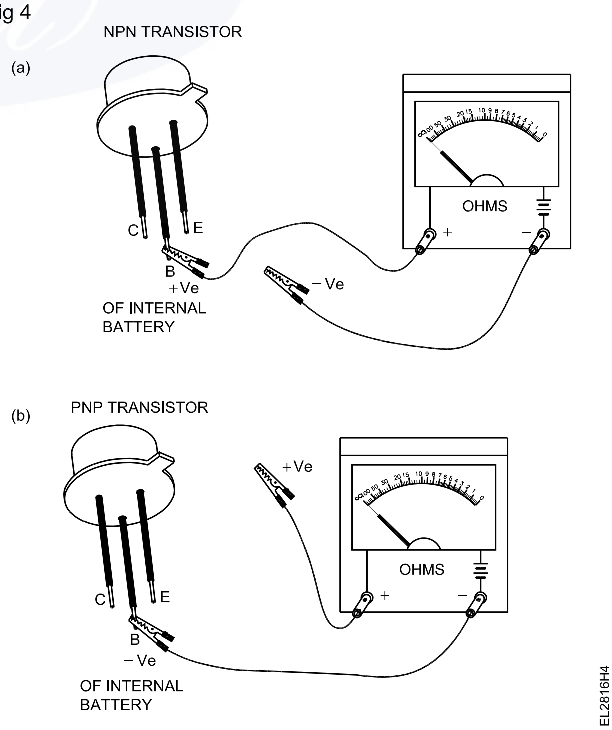
2 Clip the other meter prod to the emitter. Check if the base-emitter junction diode of transistor shows low resistance (few tens of ohms) or very high resistance (few tens of kiloohms). Record your observation in Table 1.

3 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.

4 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.

Fig 4



5 Repeat steps 2,3,4, and 5 and check the condition of the base-collector junction diode of the transistor.

6 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.

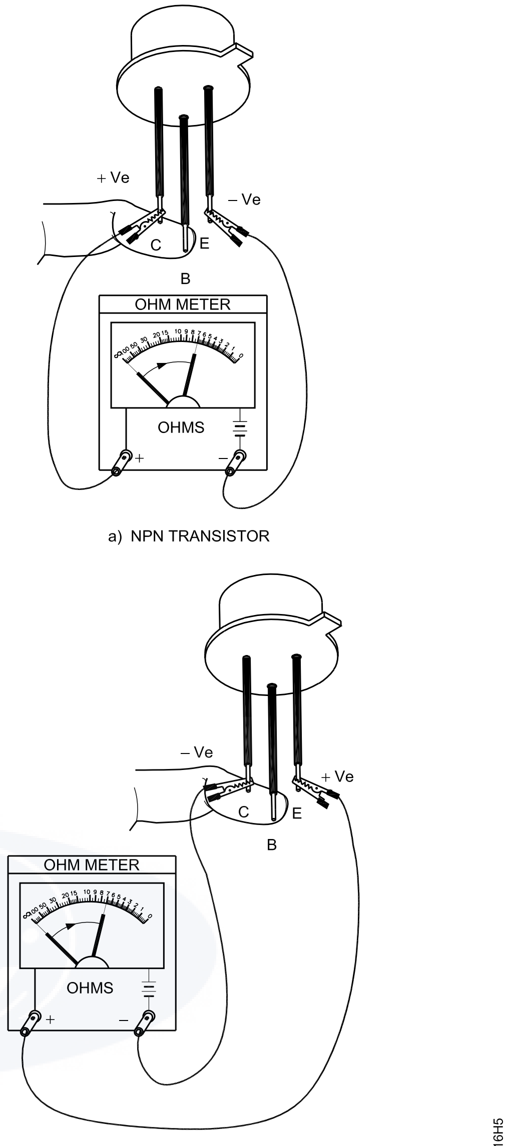
7 Clip the meter across the emitter-collector with correct polarity as shown in Fig 5a. Touch the base-collector with moist finger as shown in Fig 5b and check if the resistance shown by the meter decreases indicating that the transistor is turning ON. Record your observation as YES or NO in Table 1.

8 From the observations recorded at steps 5,6 and 7, give your conclusion on the overall condition of the transistor under test. Refer Table 2.

9 Repeat steps 1 to 8 for atleast five more transistors of different types.

10 Get your work checked by your instructor.

Fig 5



b) PNP TRANSISTOR

TABLE 2

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)

— — — — — — — —

Determine the input/output characteristics of a transistor

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

- **identify the specification of the given transistor from the data book**
- **form the transistor circuit as per the given circuit diagram**
- **plot the characteristics (input & output) of the given transistor in CE mode**
- **determine the input resistance, and beta (from the graph).**

Requirements

Tools and Instruments

- Voltmeter MC 0-15 V - 1 No.
- Voltmeter MC 0-5 V - 1 No.
- Ammeter MC 0-50 μA - 1 No.
- Ammeter MC 0-100 μA (multimeter) - 1 No.

Equipments/Machines

- DC regulated power supply (0-30V),1A- 1 No.

Materials

- Transistor BC 140 - 1 No.
- * Rheostat 1 K ohm - 1 No.
- * Rheostat 3 K ohm - 1 No.
- * 1.5 - volt dry cells - 2 Nos.
- * Connecting leads- - as reqd.
- * Tag board general purpose - one

PROCEDURE

TASK 1 **: Input characteristics (V_{BE} – I_B characteristics)**

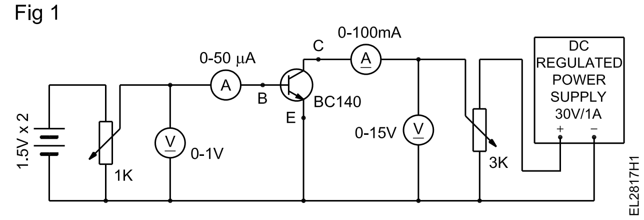
1 Refer to the data book and write the following specifications.

Transistor type No	....
NPN/PNP	....
$VCEO_{(Max)}$	..............volt
$VBEO_{(Max)}$	..............volt
$I_{c(Max)}$	..............mA
I_B (Max)	..............mA
Beta (hFE)	....
P_{TOT}	.............mw

2 Test the transistor for its condition

3 Set up the experimental circuit as shown in Fig 1.

Fig 1

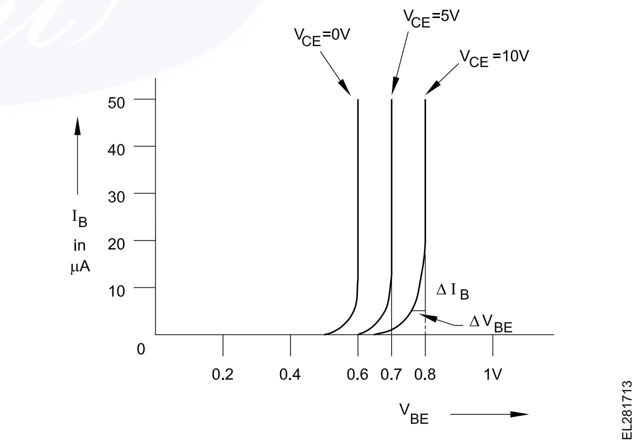


4 Adjust and set V_{CE} to zero volt. Change the V_{BE} from 0 volt to 0.9 volt, as shown in Table 1 and record I_B.

5 Adjust and set V_{CE} to 5 volt and change the V_{BE} from 0 volt to 0.9 volt as shown in Table 1 and record I_B.

6 Repeat the above step for other V_{CE} settings and record I_B in Table 1.

Fig 2



7 Switch OFF the power to the circuit. Plot graph for given graph I_B vs V_{BE} from the readings of Table 1.

8 The typical input characteristics is shown in Fig 2

9 Compute the Beta, $\beta = \frac{I_c}{I_B}$ V_{CE} is constant

10 Compute the value of input resistance (r_i) applying the formula $r_i = \frac{V_{BE}}{I_B}\ \Omega$

TABLE 1

V_{CE} = 0V		V_{CE} = 5V		V_{CE} = 10V	
V_{BE} in volt	I_B in mA	V_{BE} in volt	I_B in mA	V_{BE} in volt	I_B in mA
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9					

— — — — — — — —

TASK 2: **Output characteristics (V_{CE} – I_C characteristics)**

1 With the same experimental circuit.

Set V_{CE} and V_{BE} at '0' volt

Connect the meters in proper polarities as indicated in the circuit.

2 Adjust and set I_B to 10 mA. Vary V_{CE} from 2V to 10 in steps of 2V and record the Ic in Table. 2

3 Repeat the above step for other values of I_B as in Table 2.

4 Switch off the power to the circuit plot graph in the graph sheet for I_C - V_{CE} from the readings of Table 2. The O/P characteristics will be as shown in Fig 3.

5 Write the conclusion

Fig 3

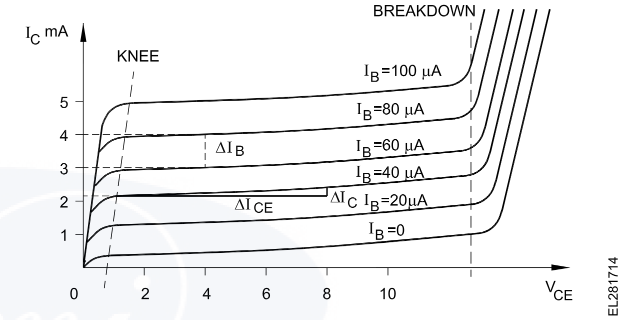


TABLE 2

I_B = 5 mA		I_B = 10 mA		I_B = 15 mA	
V_{CE} in volt	I_C in mA	V_{CE} in volt	I_C in mA	V_{CE} in volt	I_C in mA
2 4 6 8 10					

— — — — — — — —

Construct a voltage regulator

Objectives: At the end of this exercise you shall be able to
- **construct a given simple series regulator circuit**
- **construct and test a +12 Volts regulator using IC 7812 three pin regulator**
- **measure the output voltage and current**
- **measure the ripple at input and output of the regulator and find ripple factor RR.**

Requirements

Tools/Equipments/Instruments

- Trainees tool kit - 1 No.
- Unregulated DC power supply,18V DC - 1 No.
- CRO, 20 MHz - 1 No

Materials/Components

- Three pin voltage regulator - 1 No.
- Tag board - 1 No.
- Transistor SL100 or equivalent - 1 No.
- Zener diode, 12V, 1/4W - 1 No.
- Resistors, carbon, 1/4W
  180 Ω - 1 No.
  1K Ω - 1 No.
  220 Ω - 1 No.
  330 Ω, 820 Ω - 1 No.
- Capacitor, 10µF, 25 V, 220 nf, disc - 1 No.
- LED, Red colour - 1 No.
- Hook up wires (Red and Black) each - 1 Metre.
- µA 7812 or equivalent - 1 No.
- Heat sink for 7812 - 1 No.
- 10µF, 25 V, electrolytic capacitor - 1 No.
- Resin core solder -20 cms.

PROCEDURE

TASK 1: **Construct and test the given simple series regulator circuit**

1 Refer data book and record the required details of the given transistor in Table 1.

2 Test to confirm the condition of the given components.

3 Solder the components on the given Tag board as per the schematic diagram and layout shown in Fig 1 and 2 respectively. Get the wired circuit checked by your instructor.

4 Connect an unregulated dc voltage of 17V to the input terminals (2 & 3) of the wired series regulator board.

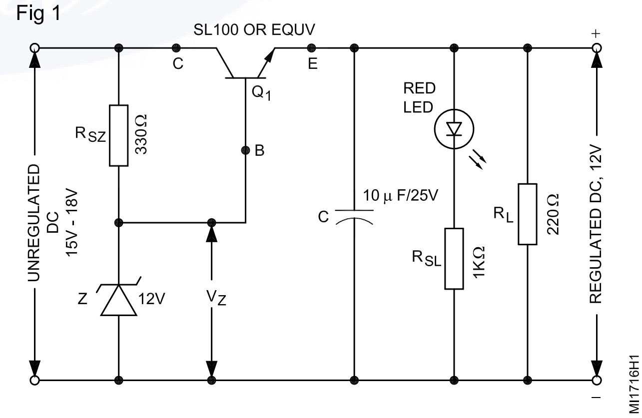
> **The required unregulated DC of 17 V can be obtained from the bridge rectifier with filter capacitor wired on PCB-1**

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.

Fig 1



8 Measure and record the following voltage levels.

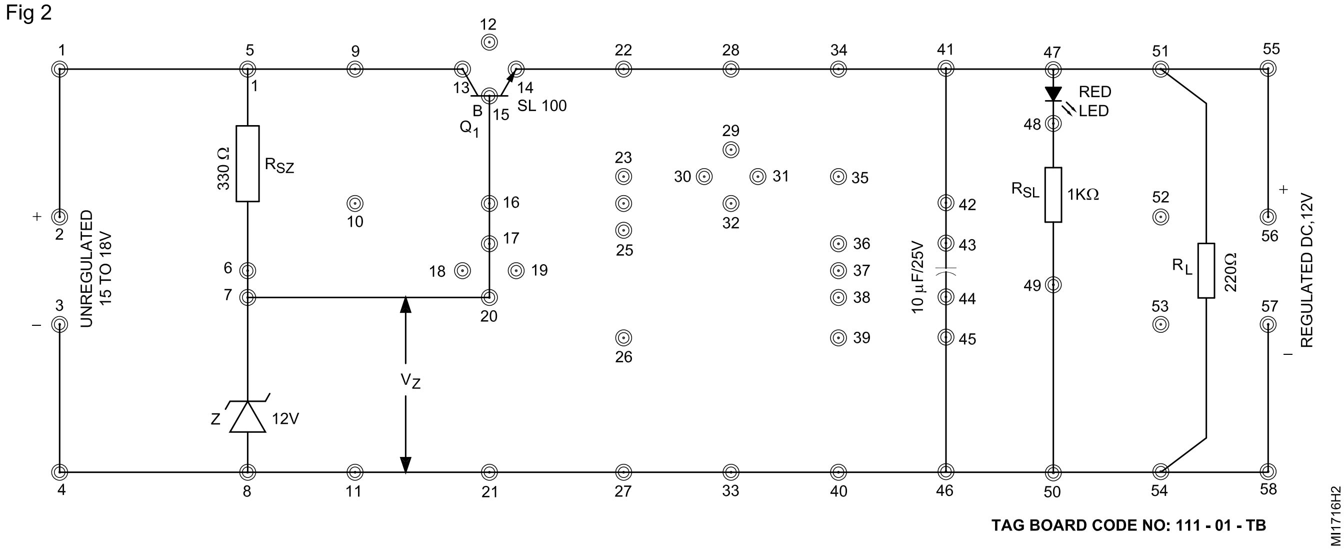
a) Voltage across zener, V_Z

b) V_{CE} of the transistor Q_1

c) V_{BE} of the transistor Q_1.

9 Using a CRO, measure and record the peak - peak ripple voltage at the input and output of the regulator.

Fig 2



10 Switch off mains supply. Replace the 220Ω load resistor R_L by a 180Ω resistor.

With R_L = 180Ω, the load current will increase from the earlier 55mA to 66mA. This results in a total load of 10.3mA through LED, plus, 66mA through R_L (10.3mA + 66mA = 76.3mA). By doing this, you are still in safe loading the regulator because the regulator was designed for a load of >100mA.

Do not use R_L of value lower than 180Ω, this will load the regulator beyond its designed load current which will damage the pass transistor.

11 With increased load current, repeat steps 7, 8 and 9.

12 Get the work checked by your instructor.

Table 1:

Specification of the transistor used

Pin layout	V_{CE} Max	I_C Max	Max. device dissipation	b_{dc}	Application

— — — — — — — —

Construct and test power supply using voltage regulator IC

Objective: At the end of this exercise you shall be able to
- **construct and test a +12 volts regulator using a 7812 three-pin regulator.**

Requirements

Tools/Equipments/Instruments

- Trainees tool kit - 1 No.
- Rheostat 100Ω, 1.5 A - 1 No.
- DC ammeter, 0-1A - 1 No.

Materials/Components

Component list for Tag board power supply
- Tag board Code No.111-05-TB - 1 No.
- Three-pin voltage regulator μA7812 or equivalent - 1 No.
- Heat sink for 7812 - 1 No.
- Capacitor 270 μf, disc - 1 No.
- Red LED - 1 No.
- Resistor 820Ω, 1/4 W and 1KΩ, 1/4W -1 each.
- Hook up wires (red and black colour) - 1 Mtr.
- Resin cored solder -10 cms
- Wire sleeve (R,Y,G) each - 2 cm

PROCEDURE

TASK 1: **To construct and test a +12 V fixed voltage regulator**

1 From the type code marked on the given 3 pin regulator IC, identify and record the IC's specifications.

2 Identify the terminals of 7812 and put sleeves to the terminals using colour coding scheme given below;

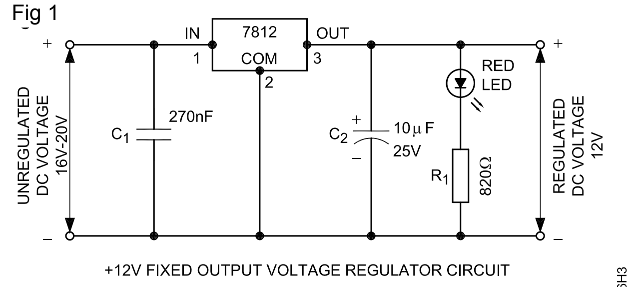
Input - Yellow/Orange sleeve.
Common - Green/Black sleeve.
Output - Red sleeve.

3 Get the work done in steps 1 and 2 checked by your instructor.

4 Fix the aluminium heat sink for 7812 on the tag board.

5 Construct the voltage regulator circuit referring to the schematic and layout diagram shown in Fig 1 & Fig 2.

Fig 1

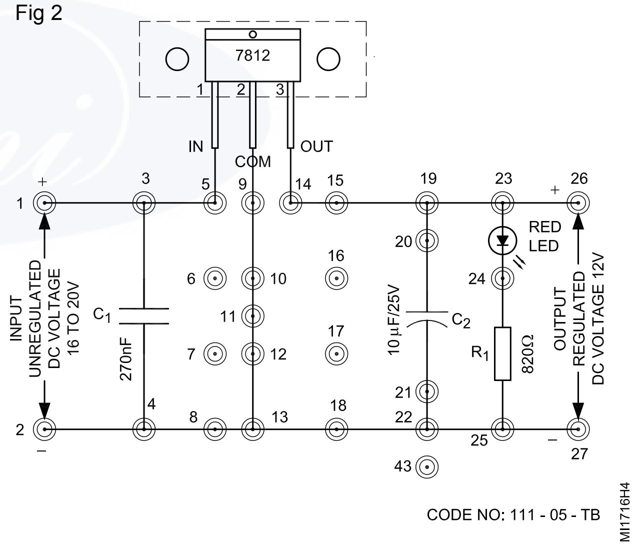


+12V FIXED OUTPUT VOLTAGE REGULATOR CIRCUIT
SPEC: OUTPUT DC:12V, RATED MAX LOAD 800mA

6 Get the neatness and correctness of your wiring checked by your instructor.

7 Apply 16 to 20 volts unregulated dc voltage to the input of the wired 12V regulator. Record the unregulated input voltage and no-load output voltage of the regulator.

Fig 2



The unregulated DC voltage to the regulator should not be more than 24 volts; otherwise the IC may get damaged.

8 Using loading rheostat, load the regulator in steps of 200 mA upto 800mA and at each step measure and record,

– Regulated dc output voltage

Loading is limited to 80% of its rated maximum of 1A. This is because the heat sink used with 7812 may not be very effective in taking away the heat.

10 Get the work checked by your instructor.

Troubleshooting in power supply

Objectives: At the end of this exercise you shall be able to
- **carry out step-by-step troubleshooting in a power supply having bridge rectifier and capacitor filter**
- **carry out a short cut method of troubleshooting the power supply through problem tree and service flow diagram.**

Requirements

Tools/Equipments/Instruments
- Trainees tool kit - 1 No.

Materials/Components
- Bridge rectifier with filter capacitor wired on tag board - 1 No.
- Spare components - as reqd.

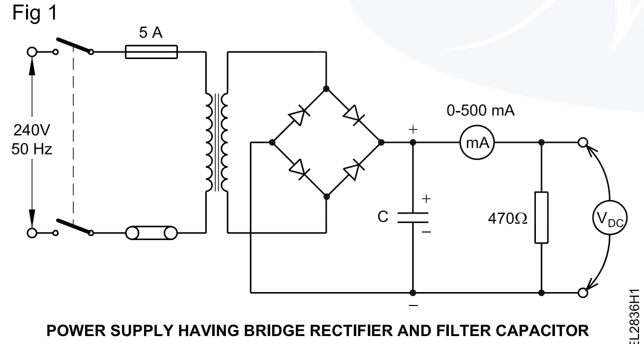
PROCEDURE

Hints to Instructor:
For TASK 1, create more than one fault in the bridge rectifier with filter capacitor wired on tag board. For Task 2 create another set of faults in the power supply for the trainees to identify and service the fault.

TASK 1: **Troubleshoot defects in bridge rectifier power supply following step-by-step method**

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.

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.

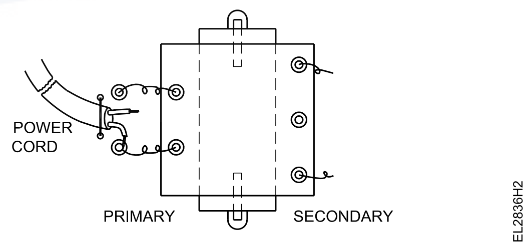
Correct the polarities found defective and record the defect observed and polarity corrected in Table 1.

3 Open one of the wire ends of the power cord connected to the power supply as shown in Fig 2.

This will disconnect the transformer primary from the power cord.

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.

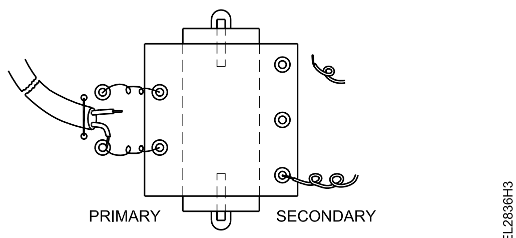
Fig 2



5 Check the continuity of transformer primary winding. If found open, record defect.

6 Remove the wires soldered at the secondary winding terminals of the transformer as shown in Fig 3. Check the continuity of the secondary windings. Record your observation.

Fig 3



7 Open one lead of each diode as shown in Fig 4. Check the condition of the diodes. Record your observation in Table 1.

Fig 4

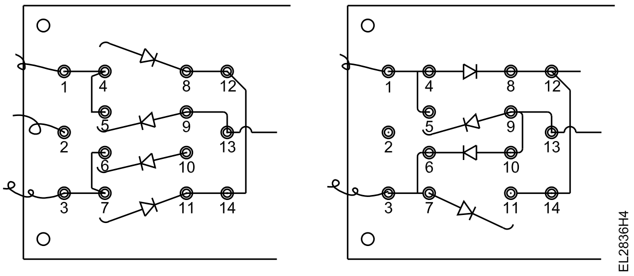


TABLE 1

Sl. No.	Name of the defective component	Nature of defect observed	Specification of the component to be replaced	Equivalents, if any, for the components to be replaced	Specification of the component replaced
Sample	**Solderpoint**	**Drysolder**	**.......**	**.......**	**Resoldered**

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 the 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 said 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 your 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 2 of record sheet.

Refer the problem tree corresponding to the SFD for finding the possible causes of the defects.

Whenever any component is found defective, record its type, cause of defect and other details in the Table 2.

Whenever any component is replaced, record the specification of the replaced component in Table 2.

Once serviced as per SFD is complete, record the final condition of the power supply in Table 2.

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 : ________________

TABLE 2

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 to be replaced	Specification of the component replaced

Identify, test SCRs and construct SCR as a switch

Objectives : At the end of this exercise you shall be able to
- **identify the specifications of SCR referring to data book**
- **identify the anode, cathode, gate pins of the given SCR**
- **conduct quic-test to find the condition of the given SCR**
- **construct a SCR as a ON/OFF switch.**

Requirements

Tools/Equipments/Instruments

- Trainees tool kit - 1 No.
- International SCR data book - 1 No.
- Regulaed power supply DC 12V/100mA - 1 No.
- Multimeter - 1 No.

Materials/Components

- Assorted type of SCRs - 20 Nos.
- Sleeve wires Red, Blue, Yellow, Black - 10 cms each.
- Tag board GPCB - 1 No.
- Solder, flux - as reqd.
- Connecting wires - as reqd.
- Patch cords fitted with crocodile clips - 3 Nos.
- SCR test Tag board - 1 No.
- SCRs, TY 6004, 2N 4444, 2N 4442 - 1 each
- Resistors, carbon film 1/4w
  - 330 ohms - 1 Nos.
  - 330 ohms - 1 Nos.
- Potentiometer, disc type 1/2w
  - 4.7K - 1 No.
  - 10K - 1 No.
- Micro switch - 2 Nos.
- Red LED - 1 No.
- Capacitor (DC) 1000mF/25V - 1 No.
- Resistors, carbon film
  - 56K (1/2W) - 1 No.
  - 56Ω (1W) - 1 No.
  - 56Ω (1/4W) - 1 No.
  - 1KΩ (1/4W) - 1 No.
- Bulb (12V, 0.1A) - 1 No.

PROCEDURE

TASK 1: **Identify SCR type and leads referring to data manual**

1 Pick any one SCR from the assorted lot. Enter the picked SCR label number and its Code number (printed on the SCR) in Table 1.

2 Draw a pencil sketch of the SCR pin diagram. Identify the Anode, Cathode and Gate pins of each SCR referring to the data manual.

3 Put sleeves of suitable length to the identified pins of the SCR using the colour scheme given below:

Gate Pin : BLUE sleeve
Anode : RED sleeve
Cathode : YELLOW sleeve

In some power SCRs, the metal case itself will act as anode. In such a case mark 'A' on the case using a pencil or put a RED colour dot using colour marker pen.

4 Get the work checked by your instructor.

5 Repeat steps 1 to 3 for atleast five different types of SCRs from the assorted lot.

— — — — — — — —

TASK 2: **Quick test SCRs using an ohmmeter**

1 Pick anyone SCR used in Task 1 whose terminals are identified.

2 Identify and mark the internal battery polarity at the terminals of the ohmmeter/multimeter (in ohms range) to be used for Quick-testing SCRs. Select Rx100 range.

3 Test each of the picked SCR following the table below and record the measured resistances in table 1.

– Between Anode - Cathode
  Irrespective of polarity
– Between Gate - Cathode
  (i) Forward biased
  (ii) Reverse biased
– Between Gate - Anode
  Irrespective of polarity

4 From the recorded readings, record your conclusion about the working condition of the SCRs.

5 For each of the picked SCR carryout the following steps to check the gating effect of SCRs and record the results in Table 2.

- Set multimeter to low resistance range
- Connect positive lead of multimeter to the anode and the negative lead to the cathode. Measure and record resistance.
- Short anode and gate of SCR using a piece of wire. Measure and record resistance between Anode and Cathode.
- Disconnect the shorted anode-gate, measure and record resistance between Anode and Cathode.

6 From the recorded readings in step 5 and from the knowledge acquired about working of SCR in lesson conclude the condition (GOOD/ OPEN/ SHORTED) of the SCR under test.

7 Repeat steps1, 3 to 6 for atleast two more SCRs.

8 Get the work checked by your instructor.

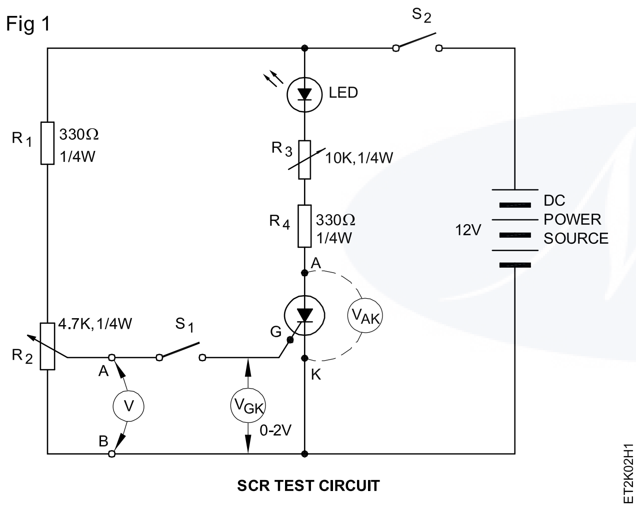
— — — — — — — —

TASK 3: **Testing SCRs function as a ON/OFF switch**

1 Collect the compents as per Fig 1 and check their condition

2 Construct the SCR test circuit as shown in Fig 1 on the tag board. Keep switches S_1 and S_2 open before connecting dc supply. Get the wired circuit checked by your instructor.

Fig 1



SCR TEST CIRCUIT

2 With switches S_1 and S_2 open, set DC power supply to 12V.

3 Set POT R_3 to zero Ohms. Set POT R_2 such that voltage across points A&B is zero volts.

> **This ensures that when S_1 is closed, initially the gate voltage is zero and hence the SCR does not get fired.**

4 With S_1 and S_2 open, record the status of LED in Table 1.

5 With S_1 open, close switch S_2. Record the status of LED, and the voltage across the SCR (V_{AK}) in Table 3.

> **In this condition, there is supply across the SCR but there is no triggering voltage/current to the SCR gate. In this condition if the SCR is good, it behaves as a open switch and hence V_{AK} will be equal to 12 volts.**

6 With S_2 closed, close switch S_1. Record the status of LED.

> **In this condition, there is supply across the SCR and the gate-trigger voltage/current is zero.**

7 Measuring the voltage V_{GK}, slowly raise the gate voltage by adjusting the POT R_2 until LED just lights-ON. Record value of V_{GK} in Table 3 of under the column V_{GK} and the status of LED.

> **V_{GT} is the minimum value of gate voltage(V_{GK}) required to turn-on the SCR.**
>
> **If the LED is ON, it indicates that the SCR is conducting acting as a closed switch.**
>
> **If the LED is not turning ON by adjusting R_2, consult your instructor.**

8 With the SCR conducting(LED on), measure and record the voltage across the SCR (V_{AK}).

> **In this condition, if the SCR is good, then the SCR behaves as a closed switch and hence the voltage across the SCR will be very low.**

9 Open switch S_1 and record the values of V_{GK},V_{AK} and the status of the LED.

> **If the SCR is good, then, value of V_{AK} will remain to be very low and LED keeps glowing indicating that gate voltage is no more required to keep the SCR in ON state.**

10 Open switch S_2 momentarily and close it. Record values of V_{GK},V_{AK} and the status of the LED.

> **If the SCR is good then the SCR gets turned off by breaking the load current**

11 Switch off 12 volts dc supply to the circuit. From the observations made in the experiment conducted.

12 Get your work checked by your instructor.

1 Table 1

Label No.	SCR type number	Measured resistance between						Conclusion
		A & K		G & K		G & A		
		Forward	Reverse	Forward	Reverse	Forward	Reverse	

2 Table 2

Label No.	Resistance between			Conclusion
	A & K before shorting anode with gate	A & K after shorting anode with gate	A & K after removing short between anode and cathode	

3 Table 3

S_1 on/off	S_2 on/off	S_3 on/off	Lamp on/off	SCR on/off	Remarks

(Trainee) (Instructor)

Construct and test a UJT relaxation oscillator

Objectives: At the end of this exercise you shall be able to
- **Identify the terminals and specification of a UJT**
- **test the given UJT**
- **construct and test relaxation oscillator using UJT**
- **measure time period and frequency.**

Requirements

Tools/Equipments/Instruments

• Trainee tool kit	- 1 No.
• Dual channel oscilloscope 15 MHz	- 1 No.
• Power supply unit 0-30V 2A variable	- 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	- 1 No.
• Potentiometer 1/2 w, 470 KΩ		- 1 No.
• Capacitor 0.02 μf, 25V		- 1 No.
• Hookup wires		- as reqd.
• Resin core solder		- as reqd.

PROCEDURE

TASK 1: **Find specifications of UJT, identify and sleeve leads**

1 Refer UJT data manual to find and record the specification of the given UJTs in Table 1.

2 Identify and put sleeves to its leads following the colour sequence given below; From the package type of the given UJTs, referring to the data manual.

Base 1 - blue

Base 2 - black

Emitter - red

3 Get your work checked by the instructor.

— — — — — — — —

TASK 2: **Test a UJT using Ohmmeter**

1 Identify and mark the internal battery polarity at the terminals of the ohmmeter/multimeter used for testing the UJT. Set the meter range to R x 100 or R x 1000 ohms.

Very low ohms range can produce excessive current through the UJT and damage it.

2 Test and record the resistance across the UJT terminals (forward bias/reverse bias) using the ohmmeter, for the given UJT.

3 Assess and record the condition of the UJT, from the recorded observations.

4 Repeat steps 2 and 3 for other given UJTs.

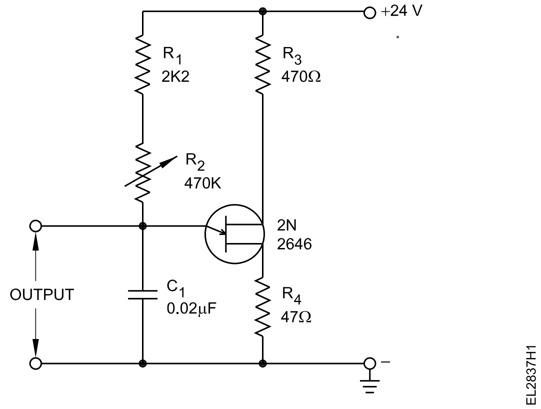
5 Get your work checked by your instructor.

— — — — — — — —

TASK 3: **Construct and test a UJT relaxation oscillator**

1 Assemble the relaxation oscillator on the general purpose PCB, Referring to the circuit diagram shown in Fig 1.

Fig 1



2 Get the wired oscillator checked by your instructor.

3 Energise the circuit with the stipulated DC supply.

4 Using CRO, observe the wave forms 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 formulas given below. With the potentiometer kept at minimum, middle and maximum 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

TABLE 1

Sl. No.	Waveform at the output terminals	Amplitude	time period (t)	Frequency
POT at one extreme end				
DOT at middle position				
POT at other extreme end				

Construct and test an electronic timer using UJT and SCR

Objectives: At the end of this exercise you shall be able to
- **build a timer**
- **test the circuit.**

Requirements

Tools/Equipments/Instruments

- Trainees tool kit - 1 No.
- Soldering Iron 35 W - 1 No.

Materials/Components

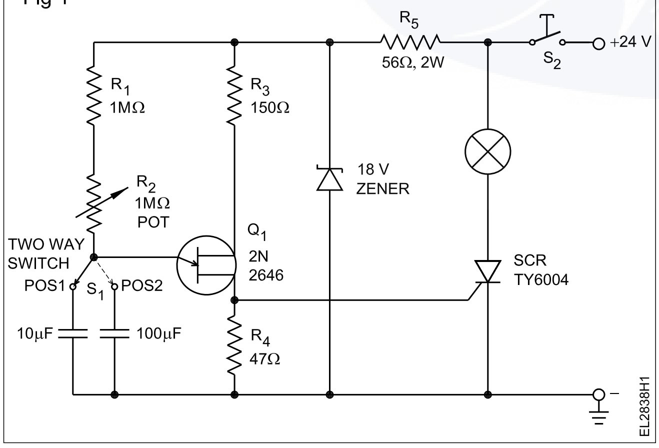
- Relaxation oscillator wired on PCB (Use the end product of Ex. 3.1.10) - 1 No.
- SCR C106 or equivalent - 1 No.
- Diode IN4007 - 1 No.
- Zener 18V - 1/2 watt - 1 No.
- Wire wound resistor 56Ω - 2w - 1 No.
- Carbon resistor, 1 MΩ - 1/2 W - 1 No.
- Lamp 24V/0.3A screw type with holder - 1 No.
- Wires - as reqd.
- Push button switch - 1 No.
- Solder and soldering paste - as reqd.
- Stop watch - 1 No.
- POT 1MΩ - 1 No.
- SPT, Two way toggle switch - 1 No.

PROCEDURE

1 Test for satisfactory working of the tested board of relaxation oscillator of Exercise 3.1.10.

Replace the components R_1, R_2, C_1 as per the circuit diagram (Fig 1) and check their condition.

Fig 1



3 Solder additional components on the wired relaxation oscillator board to make a timer Refer circuit at Fig 1.

3 Get your wired circuit checked by the instructor.

4 Keep the switch S_1 in position 1. (POS1)

5 Keep R_2 in minimum position.

6 Energise the circuit with the rated voltage.

7 Record the time taken by the circuit (time delay) to switch on the lamp from the time the circuit is energised using stop watch in Table 1.

8 Turn the potentiometer R_2 to minimum, middle and maximum position and repeat steps 5 & 6 for each position and enter the result in Table 1.

9 Change the position of Switch S_1 to position 2.

10 Repeat steps 5 to 8. Enter the results in Table 1.

11 Write the conclusion by

a) When the SCR is turned on the lamp will ________.

b) To turn the SCR 'on' the UJT has to produce a pulse at the __________ of the SCR.

c) The UJT can produce a pulse wave form depend ing on the time required to change the ________.

d) The changing time of capacitor is more when the POT resistor value is ________.

e) The charging time of capacitor is more when the value of resistors R_1 and R_2 are fixed but the value of ________ is more.

TABLE 1

Position of potentiometer	Delay time in sec. for positions 1 with 10 µF capacitor	Delay time in sec. for position 2 with 100 µF capacitor
One extreme end		
Another extreme end		
Approximate middle position		

Test and commission the given domestic appliance

Objectives : At the end of this exercise you shall be able to
- **read and interpret data of the given domestic appliances like heater, iron, kettle, hot plate, toaster etc.**
- **test the power cord for continuity with a test lamp/ohmmeter**
- **measure the insulation resistance between the terminals and the body of the appliance**
- **select the fuse size according to the load of the circuit**
- **carry out commissioning test for the given domestic appliances**
- **connect the domestic appliance.**

Requirements

Tools/Instruments

- Trainees tool kit - 1 No.
- Test lamps 240 V, 100 W - 5 Nos.
- Multi-range ohmmeter - 1 No.
- Megger 500 V - 1 No.

Equipment/Machines

- Heater 2000 W, 240 V - 1 No.
- Iron 750 W, 240 V - 1 No.
- Kettle 1000 W, 240 V - 1 No.
- Hotplate 1500 W, 240 V - 1 No.
- Toaster 600 W 240 V - 1 No.

Materials

- Fuse wires 5, 10, 15 A - as reqd.

PROCEDURE

1 Read the name-plate details of the appliance. Fill up the data in Table 1.

2 Calculate the current if not indicated in the name-plate. Determine the fuse size and replace the fuse in the circuit.

TABLE 1

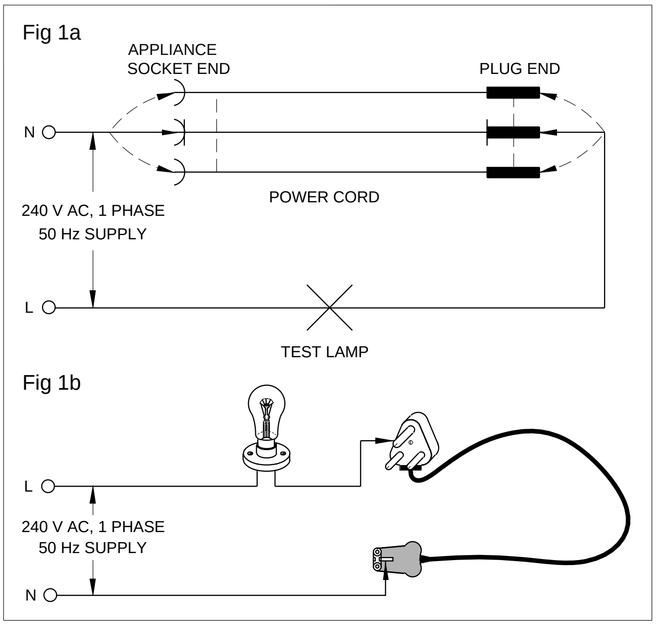
Name-plate

Name of appliance	
Make	
Supply voltage	
Phase	
Amps	
Hertz	
Watts	
Special mark	
Serial No	

3 Read and observe the procedure of installation recommended by the manufacturer. However, follow the steps 4 to 14 even though the manufacturer's instructions may not include such steps.

4 Remove/detach the power cord from the appliance if detachable.

5 Test the continuity of the phase, neutral and earth conductor of the cord by touching the plug pin and corresponding socket pins at the other end with leads of a series test lamp. (Figs 1a & b)



6 Test for the continuity of the conductors in the cord using an ohmmeter if electric supply or test lamp is not available. (Figs 2a and b)

7 If there is no continuity between the power cord plug pin and the power cord socket, rectify or replace the power cord.

Fig 2a

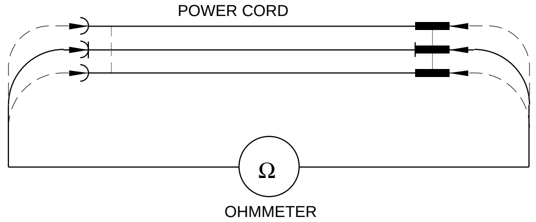
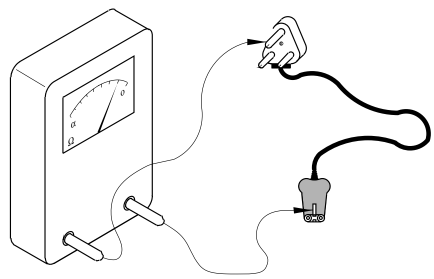


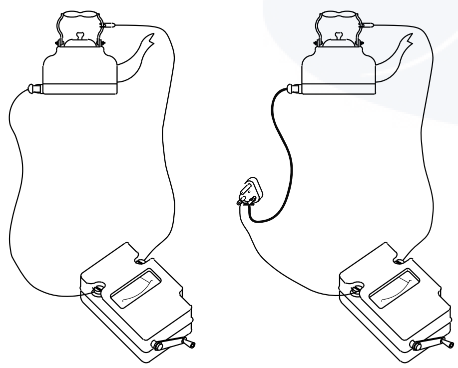
Fig 2b



8 If possible detach the power cord and measure the insulation resistance between the body of the appliance and the appliance terminals L & N as shown in Fig 3a.

9 Attach the power cord and measure the insulation resistance between the body of the appliance and the power cord plug pins. (Fig 3b).

Fig 3



10 Record the values in Table 2.

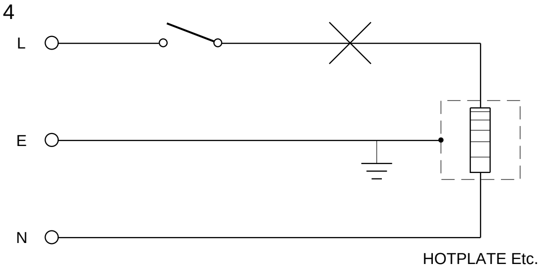
TABLE 2

Description	Value
Appliance only	
Line and body	
Neutral and body	
Power cord attached to the appliance	
Neutral pin and body	
Line pin and body	

If the insulation resistance value is less than one megohm, the appliance is not safe to use. Do not test the appliance with the supply. Report to your instructor about the low insulation resistance.

11 If the insulation resistance value is 1 megohm or more, connect the appliance with a lamp of suitable wattage in series and switch on the supply. (Fig 4)

Fig 4



12 Observe the glow condition of the lamp.

- If the glow is dim remove the lamp in series with the appliance; go to step 15.
- If the glow of the lamp is normal go to step No.13.

In case the appliance is a hotplate, before touching the hotplate, check for any electrical leakage with a line tester. A glow indicates there is shock hazard. Do not attempt to touch the open heater coils of the heater (stove).

13 Observe the heating of the appliance after a couple of minutes kept on with the lamp in series.

14 Repeat the test with a higher wattage lamp in series, if the lamp glow is normal.

A normal glow of lamp (of suitable wattage) when connected in series with the appliance is an indication of possible partial or full short in the element.

15 Connect the appliance directly to the supply for a few minutes and ascertain the hot condition in a suitable way.

Insulate your hand with a layer of cloth, and touch. If unable to decide, touch by bare hand for a short while to sense the raise in temperature or hotness.

16 Repeat the steps 1 to 15 for the following appliances.

- Water heater/geyser (for testing the water heater with supply it should be filled with water)
- Electric iron
- Kettle (For testing the kettle with supply it should be filled with water.)
- Toaster
- Heater (stove)

Test and replace the heating element in a kettle (sauce pan type)

Objectives: At the end of this exercise you shall be able to
- **test the power cord for continuity**
- **test the kettle element and identify the defect**
- **dismantle the kettle**
- **replace the old element with a new one**
- **assemble the kettle and test for its working**
- **measure the insulation resistance between the terminals and the body of the kettle.**

Requirements

Tools/Instruments

- Trainees tool kit - 1 No.
- Megger 500 V - 1 No.
- D.E. spanner set metric 6mm - 22mm - 1 Set.

Equipment/Machines

- Kettle (sauce pan type 500 W 240 V - 1 No.

Materials

- Element for kettle 500 W 230 V/240 V - 1 No.
- Asbestos sheet and fibre washers - as reqd.
- Test lamp 240 V, 60 W - 1 No.

PROCEDURE

TASK 1: **Replace heating element in a kettle**.

1 Record the name-plate details of the appliance.

NAME-PLATE DETAILS	
Name of appliance	
make	
supply voltage	
phase	
Amp	
Watts	
Sl. No.	

2 Disconnect the power cord and check the power cord for continuity of the cable, tightness of the terminal connection and insulation resistance between the line, neutral and earth terminals.

3 If found defective, either repair or replace the power cord.

4 Without opening the kettle, at the appliance socket, check the continuity of the kettle heating element either by using a test lamp or a Megger.

If there is no continuity, the element is assumed to be open and it has to be replaced. Go to step 6.

5 Check the insulation resistance between the appliance socket terminals and the body of the kettle.

If the insulation resistance is less than one megohm, the kettle element needs to be replaced.

6 Read the assembly diagram in the instruction book of the kettle and dismantle the parts in the sequence recommended by the manufacturer.

7 In the absence of the manufacturer's recommended sequence diagram of the assembly, the following parts may be removed observing the correct procedure. (Fig 1)

- Bottom cover
- Pressure plate
- Sole-plate with asbestos insulation
- Element

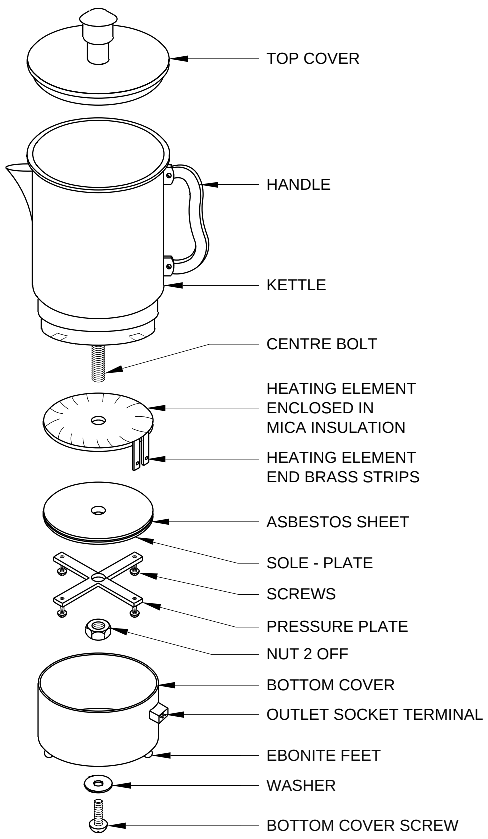
8 Obtain a suitable element of the right shape, wattage and voltage and necessary mica and asbestos sheets of the same type and quality.

9 Check the element for its continuity.

10 Replace the new element in position.

11 Assemble the parts in proper order and connect the appliance.

Fig 1



DISMANTLED VIEW OF A KETTLE

Take care to fit the asbestos sheet and the sole plate at the sole plate housing in the correct order.

12 Measure the insulation resistance between the body of the appliance and its terminals before and after connecting the power cord.

Switch 'ON' the kettle only after filling water in it.

13 Test the appliance with the supply for its working.

— — — — — — — —

Prepare, replace and test the heating element in a heater

Objectives : At the end of this exercise you shall be able to
- **prepare a heating element for the heater to the given specification**
- **replace the old element with the new one**
- **test the line cord for continuity**
- **measure the insulation resistance between the terminals and the body of the appliance**
- **connect the domestic appliance to the supply and test it.**

Requirements

Tools/Instruments

- Mallet 75 mm - 1 No.
- Drilling machine with 1.5 mm twist drill bit - 1 No.
- Wheatstone bridge - 1 No.
- Test lamp 60 W 240 V - 1 No.
- Megger 500 V - 1 No.

Equipment/Machines

- Open type of heater or stove without element suitable for 240 V, 1000 W capacity - 1 No.

Materials

- Nichrome wire 22 SWG, 15 m, 20 m - 1 No.
- Ceramic beads No.10 - 2 doz.
- GI Wire 8 SWG 80 cm - 1 No.
- U-nail clamp 14 SWG 3 cm, 2 mm dia. - 2 Nos.
- Brass machine screws with washers and double nuts - as reqd.

PROCEDURE

TASK 1: **Prepare a heating element for 1000 W, 240 V Heater from Nichrome wire.**

1 Calculate the resistance value of the element for a 1000 W 240 V heater using the formula

$$R = \frac{V^2}{W} = \text{..............................}ohms.$$

2 Measure the resistance of 1 metre of 22 SWG Nichrome wire using the Wheatstone bridge.

Resistance/metre ....ohms.

3 Calculate the length of Nichrome wire required for 1000 W, 240 V heater element

$$\text{Length(L)} = \frac{\text{Total resistance value of the heater element}}{\text{Resistance / metre}} \text{ metres}$$

$$L = \frac{\text{ohms}}{\text{ohm/metre}} \text{ metres}$$

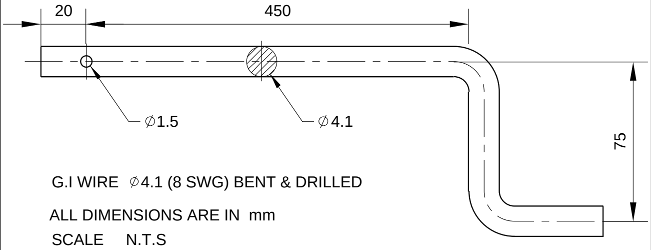
4 Measure and cut the required length (calculated length plus 250 mm allowance for handling during preparation) of Nichrome wire of 22 SWG from available stock.

5 Take 80 cm 8 SWG G I rod, straighten it and bend it at one end as shown in Fig 1.

The size of the rod depends on the groove size in the Porcelain/china clay base

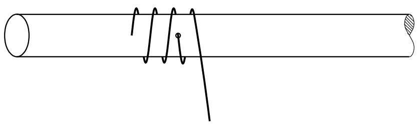
6 Punch and drill 1.5 mm hole in the G I rod about 2 cm from one end as shown in Fig 1.

Fig 1



7 Insert one end of the Nichrome wire in the hole and make a twist around the G I rod as shown in Fig 2.

Fig 2

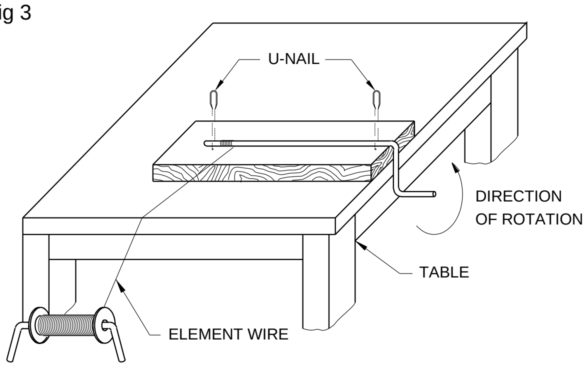


8 Fix the G I rod on a wooden plank with the help of two U-nail clamps as shown in Fig 3.

9 Keep the wooden plank over the table and prepare the closely wound nichrome wire by rotating the G I rod as shown in Fig 3.

10 Remove the U-nail clamps and take out the rod and then remove the Nichrome coil.

Fig 3

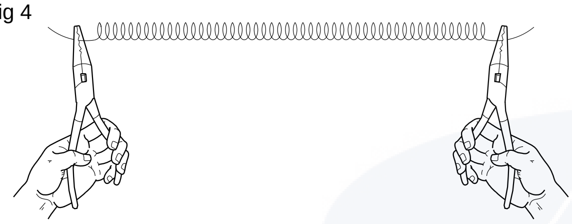


— — — — — — — —

TASK 2:- **Mount the prepared heating element on the porcelain base.**

1 Stretch the coil to the length of the groove in the porcelain base as shown in Fig 4.

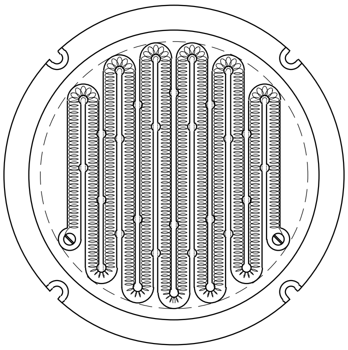
Fig 4



An unevenly stretched element will sag and produce hot spots and the element will fail easily.

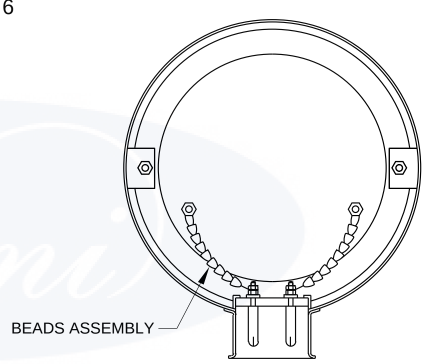
2 Place the element in the groove of the porcelain base and terminate in the screw terminals with suitable washers as shown in Fig 5.

Fig 5



3 Fix the porcelain base on the mounting and connect the element to the socket as shown in Fig 6.

Fig 6



Either use thick copper bare wire or two to three strands of Nichrome wire as lead wire.

Insulate the base connecting leads using porcelain beads as shown in Fig 7.

Fig 7

CROSS–SECTION OF THE BEADS

4 Measure the insulation resistance between the body and the terminals before and after connecting the power cord.

5 Test the heater with supply for its working.

— — — — — — — —

Replace and test the heating element in a non-automatic electric iron

Objectives : At the end of this exercise you shall be able to
- **check visually and test the iron for its condition**
- **identify and locate the faults in an electric iron**
- **dismantle an electric iron**
- **repair a faulty part or replace with a new one**
- **assemble and test the electric iron for its working.**

Requirements

Tools/Instruments

- Trainees tool kit - 1 No.
- Megger 500 V - 1 No.
- D.E Spanner 6 mm to 22 mm - 1 Set.

Equipment/Machines

- Electric irons - (of different makes) - 3 Nos.

Materials

- 3-core domestic flexible cord 23/0.2 mm of 660 V grade - 3 metre.
- Nichrome heating elements for electric iron (one for each make of iron) - 3 Nos.
- Fibre glass sleeves 4 mm - 0.2 metre.
- Asbestos sheet suitable for the selected makes - 3 Nos.
- Porcelain beads -10 grams.
- Test lamp 100 W 240 V - 1 No.

PROCEDURE

1 Record the name-plate details of the given iron.

Name Plate Details	
Name of appliance	
make	
supply voltage	
phase	
Amp	
Watts	

2 Check the electric iron and the power cord visually, identify the faults and enter the particulars in Table 1.

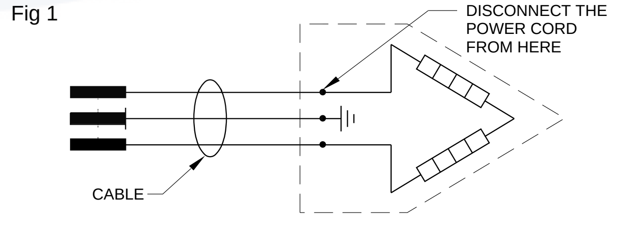
TABLE 1

Sl. No.	Types of test	Test results	
		Before dismantling	After dismantling
1	Visual test		
2	With power cord a) Continuity test b) Insulation test		
3	Without power cord a) Continuity test b) Insulation test		
4	Power cord only a) Continuity test b) Insulation test		

3 Test the electric iron and the power cord with a Megger for continuity and insulation, and record the findings in Table 1.

4 Disconnect the power cord from the iron. (Fig 1)

Fig 1



ELECTRIC IRON WITH CONNECTED POWER CORD

5 Carry out the test as prescribed in Sl.Nos.3 and 4 of Table 1 and enter the results.

6 Ascertain the area of problems other than the burnt out heating element and rectify the faults. Write down the faults and the repairs carried out in the space given below.

____

____

____

____

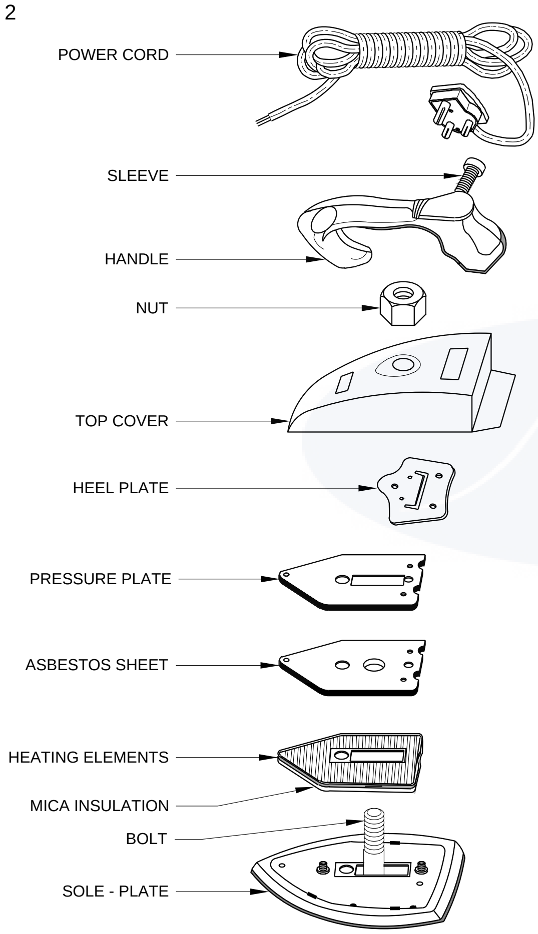
7 Read the assembly diagram of the iron. Dismantle the parts. Follow the sequence recommended by the manufacturer.

8 In the absence of the manufacturer's recommended sequence or diagram of the assembly (Fig 2) follow the sequence given below to remove the following parts

Order of the sequence to remove the parts

- Terminal connections
- Top cover
- Securing nuts for pressure plate
- Pressure plate
- Asbestos sheet
- Heating element
- Heel plate
- Sole-plate

Fig 2



EXPLODED VIEW OF AN ELECTRIC IRON

9 Remove the asbestos particles from the pressure plate and clean the pressure plate.

It is recommended to remove the asbestos and replace with a suitable new one.

10 Obtain a suitable heating element after checking its shape, wattage and voltage.

11 Check the new element for its continuity using an ohmmeter/ test lamp.

12 Replace with new element. Assemble the iron, including connection of the element.

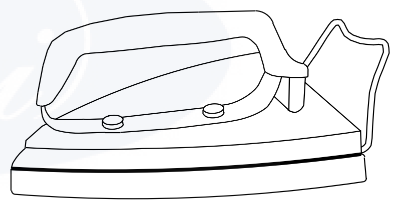
Ensure that the extension from the element is insulated (with porcelain beads or sleeves of mica or asbestos) properly.

13 Measure the continuity, insulation resistance of the electric iron between the body and the terminals before and after connecting the cord by a Megger and enter the results in Table 1.

14 Test the electric iron with supply for its working.

To achieve better skill the trainees are advised to attend to repairs of three or more different makes of irons.

Fig 3



Repair and test a defective automatic electric iron

Objectives : At the end of this exercise you shall be able to
- **check visually and test the given automatic iron for its condition**
- **identify and locate the faults in an automatic iron**
- **dismantle and repair, replace the defective parts**
- **reassemble and test it for its working.**

Requirements

Tools/Instruments

• Multimeter	- 1 No.
• Test lamp 240V, 100 W	- 1 No.
• Spanner set 6 to 22 mm	- 1 set.
• Megger 500 V	- 1 No.
• Wireman's tool kit	- 1 set.

Equipment/Machines

• 750 W, 240 V Automatic iron	- 1 No.

Materials

• 750 W, 240 V heating element	- 1 No.
• Thermostat control device	- 1 No.
• Insulating materials such as asbestos and mica sheets suitable for that iron	- as reqd.
• Fibre glass sleeves 4 mm	- 0.2 metres.
• Porcelain beads	- 10 grams.

PROCEDURE

1 Record the name-plate details of the given automatic electric iron in the space given below.

NAME-PLATE DETAILS	
Name of appliance	
make	
supply voltage	
phase	
Amp	
Watts	

2 Check the automatic electric iron and the power cord visually, identify the faults and enter the particulars in Table 1.

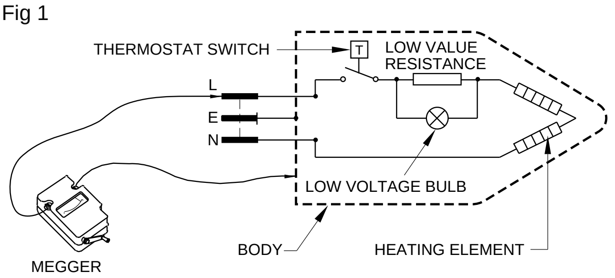
TABLE 1

Sl. No.	Types of test	Test results	
		Before dismantling	After dismantling
1	Visual test		
2	With power cord a) Continuity test b) Insulation test		
3	Without power cord a) Continuity test b) Insulation test		
4	Power cord only a) Continuity test b) Insulation test		

Always disconnect the iron from supply while testing with an insulation tester/Megger. Keep the iron on an asbestos pad to avoid heat damage and scratches to the sole plate.

3 Test the automatic iron and the power cord with a Megger, for continuity and insulation and record your findings in Table 1. (Fig 1)

Fig 1



MEASUREMENT OF INSULATION RESISTANCE BETWEEN THE BODY AND THE TERMINALS

4 Disconnect the power cord from the iron.

5 Carry out the tests indicated in Sl.Nos.3 and 4 of Table 1 and enter the results.

6 Ascertain the area of problems. Repair or replace the power cord, if necessary. Write down the type of fault and the repair carried out in the space given below.

____

____

7 Rectify the faults as indicated below.

A In the case of earth fault

i Disconnect the iron from the supply, dismantle it. Visually inspect and test with a multimeter/Megger for any contact of live wire with the body.

- Insulation failure
- Broken parts
- Damaged thermostat
- due to broken mica/porcelain insulation.

ii Rectify the fault by either repairing or replacing the defective parts.

B In case of open in element circuit

i Remove the cover to check the thermostat, indicator bulb circuit and element.

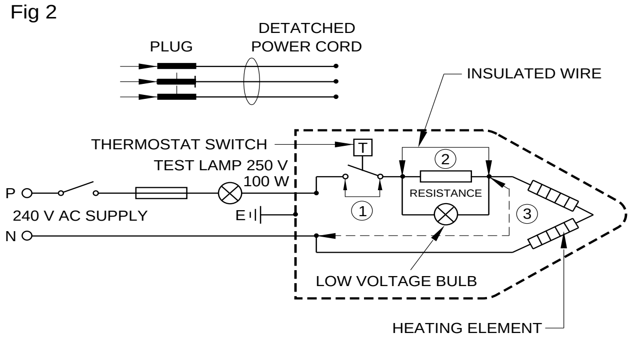
ii Connect the test lamp in series to the element circuit and short the contacts of the thermostat indicated by 1 in Fig 2. If the test lamp glows the thermostat is defective. Check the thermostat as directed in step C. If the test lamp is not glowing the defect may be either in the indicator lamp circuit or in the heating element.

iii Touch the terminals of the indicating bulb by a piece of insulating wire shown by 2 in Fig 2. If the test lamp glows the trouble is in this section.

iv Check whether the bulb is fused or the low resistance is open. (Normally a few turns of resistance wire is used as resistance.) A visual inspection will reveal the problem.

v Short the terminals of the element shown by 3 in Fig 2. If the test lamp glows the element is open. Replace the element.

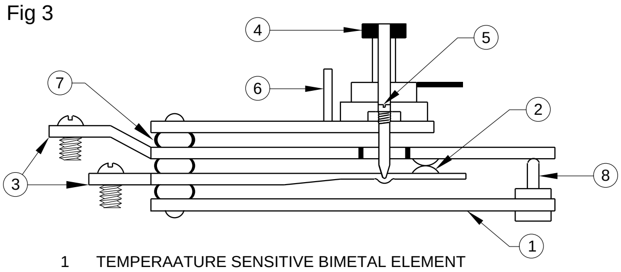
Fig 2



C Failure of temperature setting controller

i Check the adjusting knob for proper fixing and actuation of shaft. Refer to Fig 3, No.4.

Fig 3



1 TEMPERAATURE SENSITIVE BIMETAL ELEMENT
2 SILVER CONTACTS
3 SCREW TERMINALS
4 TEPERATURE SETTING CONTROL KNOB
5 TEMPERATURE CALIBRATION ADJUSTMENT SHAFT
6 TEMPERATURE CONTROL KNOB STOP
7 MICA INSULATION
8 INSULATED BLOCK

ii Inspect the contacts of the thermostat for their effective contact pressure.

iii Clean the pitted or burnt out contacts if reusable, or replace it.

iv Check for the actuating mechanism. (Heat the thermostat by a candle.)

v Turn the knob to the extreme position to check the opening of the contact (OFF) and closing of the contact points. (Rayon position)

Except for pitted contacts, loose fittings of the screws, no mechanical adjustments need to be done on the thermostat which was not dismantled by any unauthorised person. Once it was found that somebody adjusted the mechanical set up, realignment of the contact leaves may be required.

vi If the thermostat is beyond repair, replace it with the spare in good working condition.

8 After replacing/repairing the defective parts, assemble the iron.

9 Conduct the continuity and insulation test as given in Table 1 and enter the results.

10 If the continuity is OK and the insulation resistance value is higher than one megohm, connect the iron to the mains and check for its working condition.

11 Check the presence of leakage voltage existing between the body and the earth of the supply with a neon tester or voltmeter. If the neon tester glows, reinvestigate the fault and rectify it.

The neon tester should not glow or no voltage should exist between the body and the earth. Glowing of the neon tester or voltage reading indicates the iron is not safe to use.

Repair and rectify faults in room heaters

Objectives : At the end of this exercise you shall be able to
- **read and interpret the name-plate details of the room heater**
- **test the main cord for continuity and insulation**
- **measure the insulation resistance between the terminals and the body of the appliance**
- **dismantle the room heater**
- **trace and identify or locate faults**
- **replace faulty parts with good ones**
- **assemble the room heater and test for its working.**

Requirements

Tools/Instruments

- Trainees tool kit - 1 No.
- Test lamp 100 W, 240 V - 1 No.
- D.E.Spanners 6 to 22 mm - 1 Set.

Equipment/Machines

- Megger 500 V - 1 No.
- Multimeter - 1 No.
- Room heaters of different types - 1 No. each.

Materials

- Heating elements (bowl type) 1000 W, 240 V - 1 No.
- Heating elements (rod type) 1000 W, 240V - 1 No.
- 3-core domestic flexible cable 23/0.2 mm of 660 V grade - 2 m
- 3-pin plug top 6 A 240 V 3 Nos.
- Iron connector 16 A 240 V - 3 Nos.
- Fibre glass sleeve 4 mm - 0.5 m.
- GI sheet tray in available size and shape - 1 No.

PROCEDURE

TASK 1: **Service the bowl/rod type room heaters.** (Figs 1 and 2)

1 Record the name-plate details in the space given below.

Name Plate Details	
Name of appliance	
make	
supply voltage	
phase	
Amp	
Watts	

2 Visually inspect the power cord, plug, the terminal connections of the heater element, and enter your findings in Table 1.

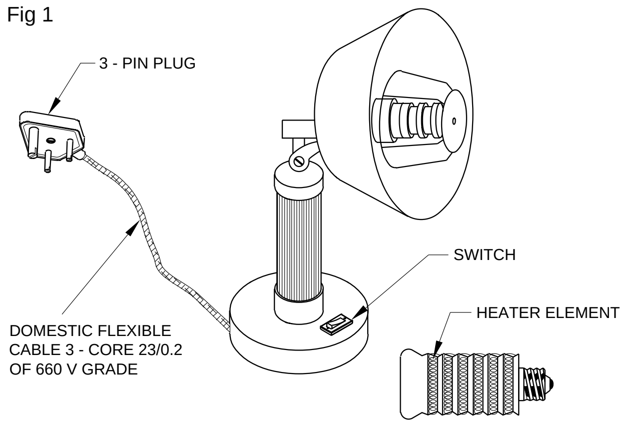
TABLE 1

Sl. No.	Area of inspection & defect	Remedial measure

3 Check the continuity and insulation resistance as given in Table 2 and enter the results.

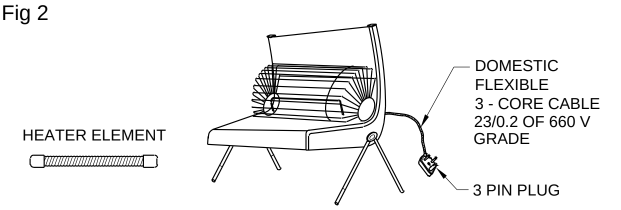
4 If any of the above is found defective, enter the defect in Table 1, repair or replace the parts.

Fig 1



BOWL TYPE HEATER

Fig 2



ROD TYPE HEATER

TABLE 2

Sl No.	Area tested	Results	
		Before dismantling	After dismantling
1	Heater with power cord a) Continuity test b) Insulation test		
2	Power cord only a) Continuity test b) Insulation test		
3	Heater only a) Continuity test b) Insulation test		

5 After ascertaining the defective area/part, if necessary, dismantle the bowl type heater.

Take care not to damage the bowl reflector or the porcelain parts of the heater.

6 Repair/replace the defective parts. If the reflector is dull even after cleaning, it should be plated, buffed and polished.

7 Assemble the heater.

8 During the process of assembly, test the heater in the descending order given in Table 2 and enter the results.

9 If the test results are found to be OK, connect the heater to the supply and test.

Insulation resistance value should not be less than one megohm.

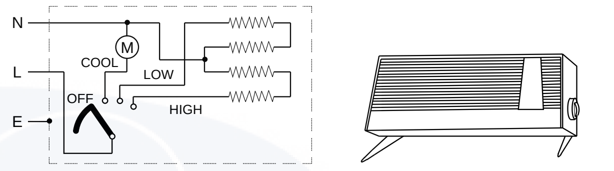
— — — — — — — —

TASK 2 : **Service air circulation type room heater.** (Fig 3)

1 Record the name-plate details in the space given below.

NAME-PLATE DETAILS	
Name of appliance	
make	
supply voltage	
phase	
Amp	
Watts	

Fig 3



SCHEMATIC DIAGRAM HOT AIR CIRCULATOR

Keep the dismantled parts in a tray.

2 Visually inspect the power cord, plug, terminal connections, fan motor, switch and the heater element and enter your findings in Table 3.

3 Check the continuity and insulation resistance as given in Table 4 and enter the results.

TABLE 3

Sl. No.	Area of inspection and defect	Remedial steps

4 If any part of the heater is found defective by visual inspection, enter the particulars in Table 3, and repair or replace them.

5 If the continuity and insulation resistance tests reveal any part as defective go to step 6.

6 Trace the connections of the heater and draw the schematic diagram in a separate paper. Refer to Fig 3.

7 After ascertaining the defective area/part, if necessary, dismantle the air circulation type heater.

TABLE 4

Sl No.	Area tested	Results	
		Before dismantling	After dismantling
1	Heater with power cord a) Continuity test b) Insulation test		
2	Power cord only a) Continuity test b) Insulation test		
3	Heater only a) Continuity test b) Insulation test		
4	Fan motor only a) Continuity test b) Insulation test		

8 Repair/replace the defective parts like motor, heater element, damaged power cord etc. If the reflector is dull even after cleaning, get it chrome-plated, buffed and polished.

9 Assemble the heater.

10 During the process of assembly, test the heater in the descending order given in Table 4 and enter the results.

11 If the test results are found OK, connect the heater to the supply.

— — — — — — — —

Service and repair an automatic toaster

Objectives : At the end of this exercise you shall be able to
- **read and interpret the name-plate data of a toaster**
- **test the line cord for continuity**
- **measure the insulation resistance between the terminals and the body of the appliance**
- **dismantle a toaster**
- **trace and identify or locate faults**
- **replace faulty parts with good ones/rectify them**
- **assemble the toaster and test for its working.**

Requirements

Tools/Instruments

- Screwdriver 150mm - 1 set of 4 Nos.
- D.E. Spanner - (6 to 22 mm) - 1 set.
- Test lamp 60 W 240 V - 1 No.

Equipment/Machines

- Megger 500 V - 1 No.
- Automatic toaster with pop-up mechanism and colour control - 1 No.

Materials

- Spares for the available automatic toaster - as reqd.
- 3-core flexible cable 23/0.2 mm - 2 m.
- Bread slices - as reqd.
- Service manual, if available - 1 No.
- Cleaning brush 0.5 cm dia. - 1 No.
- Cotton cloth 0.5 metre square - 1 No.
- Petrol and light spindle oil - as reqd.

PROCEDURE

1 Record the name-plate details of the toaster in Table 1.

2 Enter the details of the complaint from the customer in Table 1.

3 Switch off the power supply and remove the plug.

4 Open the crump tray and clean it with a cloth.

TABLE 1

Name of the customer ______________ Address ______________

Name of the appliance ______________ Serial No ______________

Wattage ______________ Current ______________ Voltage ______________

Supply ______________ Make ______________

Date of servicing	Consumer's complaint	Defects noticed	Details of repair and replacement

5 Use the cleaning brush to clean the bread crumps sticking to the heating elements.

Bread crumps will be sticking to the heater element surface. Use minimum force to dislodge the crumps. Rough handling of the brush will damage the element.

6 Open the inspection cover to get access to the electrical terminal connection, colour control timer, pop-up mechanism of the toaster. (Fig 1)

7 Conduct visual examination of

– power cord

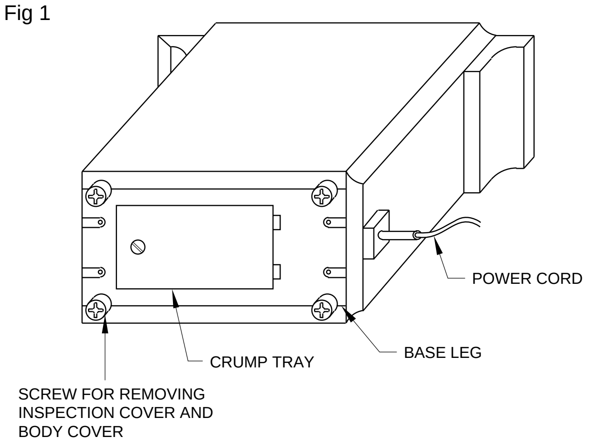


Fig 1

- – plug pin termination
- – termination at appliance.

8 Check for proper tightness and good electrical contact at the terminals. Replace the plug pin if found pitted. Enter the details in Table 1.

9 Mark and open the power cord cable end termination at the toaster end and conduct continuity test on the power cord and enter the results in Table 2.

10 Reconnect the power cord terminals as per markings. Refer to Fig 2 and measure the insulation resistance between the power plug terminals and the body of the toaster. Record the results in Table 2.

Minimum acceptable value of the insulation resistance is one megohm.

11 Investigate, repair and rectify the faults if the insulation value is less than one megohm.

12 Keeping the inspection cover open, re-plug the toaster's power cord plug to the supply.

13 Set the colour control to the desired range and push down the bread carriage to 'ON' position.

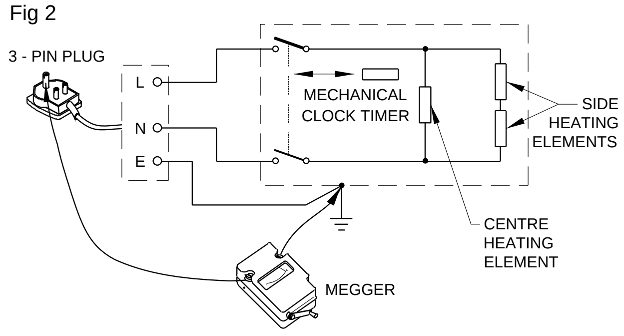


Fig 2

14 Observe whether the heating process is cut off by actuation of the clock mechanism thermostat (time depends on the setting of the colour control) and also observe whether the pop-up mechanism is working.

15 Switch off the supply and disconnect the power cord from the plug.

16 If the toaster pop-up mechanism is not working, investigate the operation of the colour control timer and the levers involved in releasing the pop-up mechanism.

17 Rectify the fault if repairable or replace the defective part.

For replacing the part, spares should be obtained from reputed manufacturers only. If the colour control setting, when set gives out too much blackening or too less blackening of the bread slice it would be practicable to advise the user to readjust the setting by the colour control knob rather than repairing or replacing the part.

18 Refit the inspection cover.

19 Toast the bread slices and check for the proper functioning of the unit.

TABLE 2

Test results

Sl. No.	Description of test	Measured value	Condition
1	Continuity test		
	a) Red coloured cable		OK / NOT OK
	b) Blue coloured cable		OK / NOT OK
	c) Black coloured cable (Between plug pins and toaster terminals)		OK / NOT OK
2	Insulation test		
	a) When the pop-up mechanism is in popped up position - between terminals and body.		OK / NOT OK
	b) When the pop-up mechanism is in downward position - between terminals and body.		OK / NOT OK (Strike off what is not applicable)

Repairing a toaster

1 Listen to the customer and note the complaints.

2 Inspect visually the power cord and every part of the toaster and note down the defects in the maintenance cord.

3 Proceed as stated below for the specific nature of fault \ complaint.

Nature of repairs

1 Toaster will not heat

Check for the undermentioned causes in the given sequence a) no power b) defective heater element c) defective clock timer of the pop-up mechanism.

> **While repairing the toaster, do not adjust the alignment screws or try to bend or straighten the levers unless you are sure of what you are doing.**

a **No power**

Check the fuse of the circuit and replace the fuse, if found blown.

Check the availability of power at the socket outlet using a test lamp.

Check the power cord for its condition, perfect continuity and no short between individual cables. Replace the cord, if necessary.

b **Defective heater element**

Check the element for its continuity between the heater elements and insulation value and between the terminal and the body. Replace the defective heating element with an identical good one. Switch on the supply and observe for its proper working.

c **Defective clock timer or pop-up mechanism**

Check whether the clock mechanism is free from dirt, dust, grime etc. Clean the parts with petrol. A light spindle oil could be used to lubricate the gears; check whether the controlling pins are intact. If found defective beyond repair, replace it.

Check the movement of the carriage and the locking strip. The pop-up mechanism should be free to move up or down. The locking strip could be moved to the left side against the holding spring. Check the spring tension. If necessary replace it.

2 Toaster burns the bread slice or does not brown it sufficiently.

Check for the undermentioned causes.

a) Defective timer assembly.
b) Sticky carriage.

Check the time for heating up, cooling down and total time. Check the timer assembly. If found dirty, clean it or replace it.

3 One side is untoasted.

Check for a defective heating element in the untoasted side and replace with a good identical one.

4 Carriage will not stay down.

a See to it that the arm on the latch keeper is held down in place by the latch release assembly or locking strip. Check the movement of all the parts. They should be free with no stickiness from foreign materials (dirt, grease and grime), burrs or bends. Clean and lubricate with light edible oil (coconut oil).

> **Some latches use a small coil spring that may break, fall out of the toaster and be lost. Unless you know that the spring was supposed to have been there, you may be at a loss to find out why the catch is not working properly.**

b Check the various latch assembles and carriage for free and proper action. Clean and lubricate.

c Check the action of the dashpot or flywheel assembly for proper push-up.

d Check the return carriage-elevator spring and make sure that it is not broken, jammed, distorted or disconnected. Replace, if it is broken or has no tension.

5 Carriage rises too slowly.

Check for bent, binding, fouled or corroded front and rear slide rods and carriage assemblies. Clean and lubricate the rods, or straighten if necessary.

6 Toaster is noisy or throws the toast out.

The dashpot is inoperative. Replace the plunger and/ or dashpot. If a flywheel assembly is used, check it for looseness. Also check the return spring for excessive tension, adjust the tension on the lift spring.

7 Toast burns.

a Check the main switch.

b Check for the toaster internal switch contacts for binding or welding.

c Check the timing calibration to be sure that it is properly set. If not, adjust or replace.

8 Toast is too light or too dark.

a Check for a defective timer assembly or thermostat.

b With some toaster models, if the toast is too light at all settings of the selector control, the slide control may be in the PASTRIES position. Move it to the TOAST position and check again.

Make necessary entries in Table 2 after reconditioning the toaster with proper explanation of the defect, and replacement details.

Service and repair a hair dryer

Objectives : At the end of this exercise you shall be able to
- **read the instruction manual and draft the procedure for dismantling a hair dryer**
- **inspect visually the hair dryer, identify the fault and rectify it**
- **connect the hair dryer to the supply and ascertain the defects**
- **test the hair dryer for continuity and insulation resistance**
- **dismantle and check the parts**
- **replace the defective parts**
- **repair the given hair dryer**
- **assemble and test the hair dryer.**

Requirements

Tools/Instruments

- Trainees tool kit - 1 No.
- Test lamp 60 W 240 V - 1 No.
- Watchmaker's spanner set - 1 No.
- Megger 500 Volt - 1 No.

Equipment/Machines

- Hair dryer, portable type 230/250 V with temperature control - 1 No.
- Soldering iron 65 watts, 240 V - 1 No.

Materials

- Hair dryer heating element suitable for the available hair dryer - 1 No.
- Thermostat for hair dryer - 1 No.
- 3-core flexible cord (23/0.2) with 3-pin plug 240 V 6 A - 1 No.
- Hair brush for cleaning - 1 No.
- CTC cleaning liquid - 500 ml.
- Cotton cloth - 30 cm sq.
- Suitable grease - 10 grams.
- Soldering lead, 40: 60 and soldering flux - as reqd.
- Service manual (if available) - 1 No.

PROCEDURE

TASK 1: **Servicing of a hair dryer**

1 Record the name-plate details of the hair dryer in Table 1.

TABLE 1

Name of appliance	
Sl.No	
Capacity of motor:watts	
Heater:watts	
Phase	
Type	
R.P.M.	
Volt	
Current	
Hz	

2 Conduct visual inspection of the

– main cord insulation

– plug pin terminals for tightness and good electrical contact.

3 Set right the defects, if any is noticed. Enter the details in Table 2.

TABLE 2
Visual inspection report

Sl. No.	Area of inspection	Remedial measure

4 Connect the hair dryer to the supply, and by observing the performance of the hair dryer, fill in Table 3.

5 Disconnect the hair dryer from the supply. Read the manufacturer's instructions and illustration, and draft the sequence for disassembling.

TABLE 3

Tick mark the condition

1 Running	Yes / No Slow
2 Noise	Normal / Excessive
3 Heating	Yes / No
4 Heating control	Functions. / Does not function.
5 Air delivery	Normal / No air / Below normal
6 Appliance heating	Normal / Very hot / Warms up
7 Sparking at brush position	No / Yes / Some

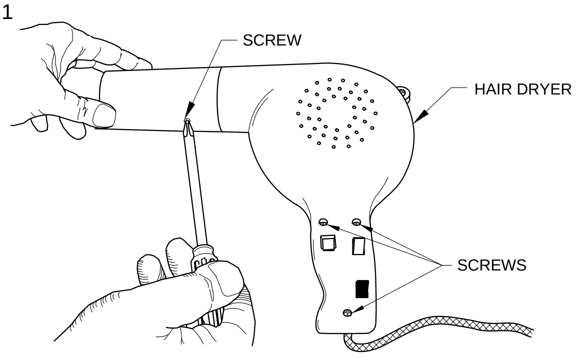
6 Check the continuity and insulation resistance as given in Table 4 and enter the results.

TABLE 4

Sl. No.	Types of Test Area	Before dismantling	After dismantling
1	Hair dryer with power cord. Switch in 'ON' position. a) Continuity test b) Insulation test		
2	Power cord only a) Continuity test b) Insulation test		
3	Hair dryer only a) Continuity test b) Insulation test		

7 After ascertaining the defective area/part dismantle the hair dryer by removing the heating element cover as shown in Fig 1, by unscrewing the screws from the ring bracket.

Fig 1

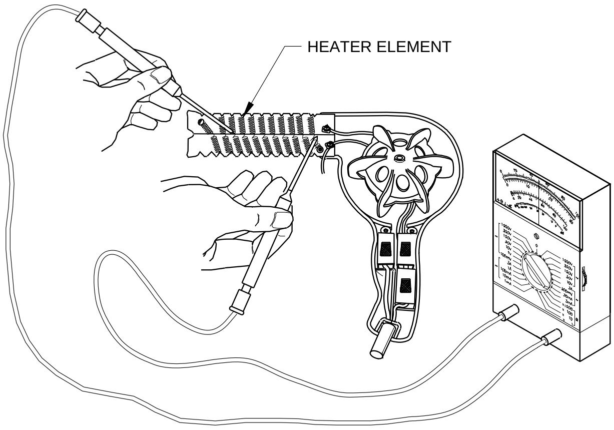


8 Clean the heater element, thermostat and internal parts.

9 Test the elements for continuity by a multimeter as shown in Fig 2. If the heater element is found defective, replace it.

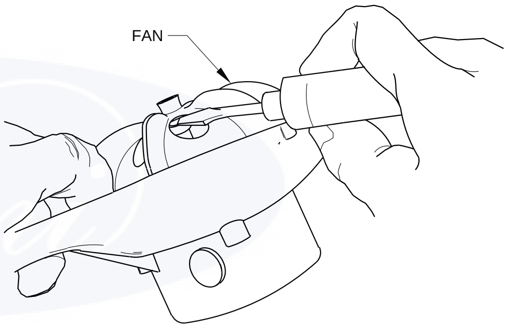
10 Test the soundness of the thermostat for its continuity across its terminals. If the thermostat is found defective, replace it.

Fig 2



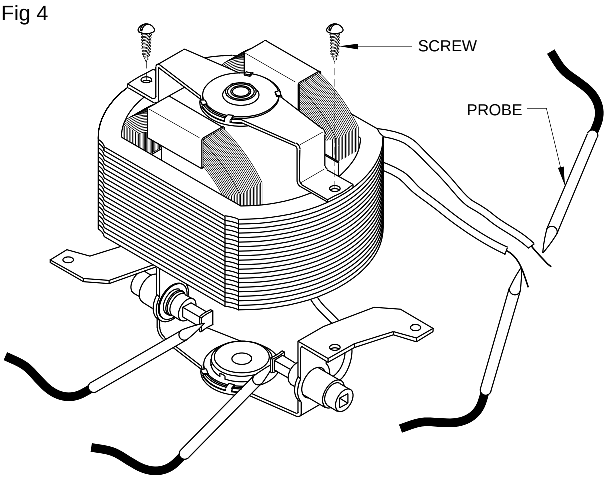
11 Remove the fan of the motor by using a screwdriver. (Fig 3)

Fig 3



12 Remove the two screws from the motor bracket and lift the motor out and test the motor field winding for continuity. (Fig 4) If the winding is found defective, rewind it.

Fig 4



13 Remove the two screws from the inlet side of the motor and lift the armature. Wipe and clean with a dry cloth. If the armature is found defective in a universal motor, replace it with one having the same specifications.

The bearing is lubricant-impregnated and requires no oil.

14 Clean the dust, and remove the hair from the bearing if any.

15 In the case of universal motors, check the brush tension and the length of brush. If necessary replace the brushes with same grade and size.

16 Reassemble the hair dryer.

17 Test the continuity and insulation resistance in the reverse order as given in Table 4 and enter the results.

18 If the continuity is OK and the insulation resistance is more than 1 megohm, connect the hair dryer to the supply and test its performance.

— — — — — — — —

TASK 2: **Repairing a hair dryer**

Listen to the customer's complaints. Visually inspect the hair drier and enter the details in Table 5. Complaints may be any one or several of the following.

1 **Dryer gives NO HEAT at any position and motor does not operate.**

a Check for blown fuse.

b Check the incoming voltage (low).

c Check the power cord and all the wiring connections for continuity.

d Check the switch for proper operations.

e Check for loose connections.

f Check the temperature control or thermostat for an open circuit; if faulty, replace it.

2 Dryer operates intermittently.

a Check the power supply socket for loose connection and rectify the defect.

b Check the power cord for damage or loose connection and rectify the defect.

c Clean the switch by spraying a switch cleaning solvent into the switch and recheck the switch. If it does not work properly, replace it.

d Check for loose connection. If you find any, fasten it.

e Check the fuse between the heater and temperature control or thermostat. If faulty, replace it.

3 Dryer gives no heat at any position, but motor runs.

a Check the heater element terminals for proper connections. (Fig 2)

b Check the heater contacts of the thermostat for contamination.

c Check the fuse link and heater element for continuity.

The thermostat must be closed before a continuity check can be made.

4 Motor does not run but the heater operates.

a See that the leads and connections to the motor are in order.

b Check the switch and terminals.

c Check the motor field for continuity. (Fig 4)

d Check the bearing and fan for smooth rotation and clean the dust and hair if any is sticking in the bearing.

e Check for striking impeller.

f Check the thermostat for proper cut off; also check the thermostat for temperature control and continuity.

5 Appliance is noisy.

a Check the tightness or ply of the motor mounting.

b Check whether the impeller or fan blade is secured on the shaft.

c Check for a warped fan blade.

d Check for proper bearing operation.

Be sure that the motor bearing is free and that the fan (or impeller) is not striking or rubbing the housing.

e Check the motor alignment.

f Ensure that all the spring washers and nuts are restored in their proper position so as to get the original alignment.

g Check for blockage in the air vent.

h Check for loose objects in the blower compartments.

i Check whether the noise is due to heavy sparking at the brush position. Check the spring tension of the brushes and also check the commutator and brush size.

TABLE 5

Hair dryer : maintenance card

Name of the customer ______________________ Address ______________________

Make ____ ____ ____ ______________________ Serial No ______________________

Wattage ______________________ Voltage ______________________

Date of servicing	Consumer's complaint	Defects noticed	Details of repair and replacement

— — — — — — — —

Service and repair a food mixer

Objectives : At the end of this exercise you shall be able to
- **read and interpret the data of the given food mixer**
- **identify the area of problem in the food mixer by visual inspection and tests**
- **dismantle the food mixer**
- **trace, identify and locate fault in the food mixer**
- **replace faulty parts with good ones**
- **clean and lubricate the bearings**
- **assemble the food mixer and test for its working.**

Requirements

Tools/Instruments

- Screwdriver set - 1 set.
- Test lamp 240 V, 100 W - 1 No.
- D.E. spanner set of six 6 mm to 22 mm - 1 set.
- Plastic spanner for opening jar screw - 1 No.
- Box spanner set of 6 mm to 22 mm - 1 set.
- Multimeter - 1 No.
- Megger 500 V - 1 No.
- Screwdriver 4 mm blade dia. - 1 No.

Equipment/Machines

- Food mixer 240 V 50 Hz. 400 watts - 1 No.

Materials

- Grease/lubricating oil - as reqd.
- Kerosene - as reqd.
- Cleaning brush - 1 No.
- Sandpaper smooth - as reqd.

PROCEDURE

TASK 1: **Servicing of a mixer**

1 Note down the name-plate details in the maintenance card. (Table 1)

2 Enter the details of the complaint from the customer in the maintenance card.

3 Switch on the mixer and check for its functioning.

4 Isolate the mixer from the supply.

5 Open the bottom cover and conduct visual inspection for:

– damages in the supply cord and loose terminal connections

– good condition of switches

– proper mounting of the motor.

TABLE 1

Maintenance Card

Name of the customer ________________ Address ________________

Make ________________ Serial No ________________

Wattage ________________ Voltage ________________

Date of servicing	Consumer's complaint	Defects noticed	Details of repair and replacement

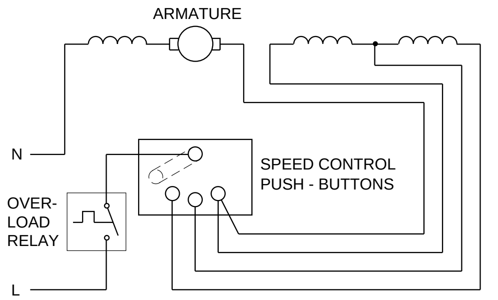
Check whether the nylon/rubber coupling of the jar and motor are properly seated, if not replace.

Sometimes the retaining spring and washer might have got spoiled and need to be replaced.

Enter the details in the maintenace card (Table 1).

6 Conduct an insulation test of the motor and record in the maintenance card (Table 2). The schematic diagram of a mixer circuit is given in Fig 1.

Fig 1



SCHEMATIC DIAGRAM OF A TYPICAL PORTABLE 3 - SPEED FOOD MIXER

The insulation resistance value should not be less than one megohm.

7 Improve the insulation value by heating or varnishing, if the insulation value is less than one megohm and enter the test results in the maintenance card. (Table 2)

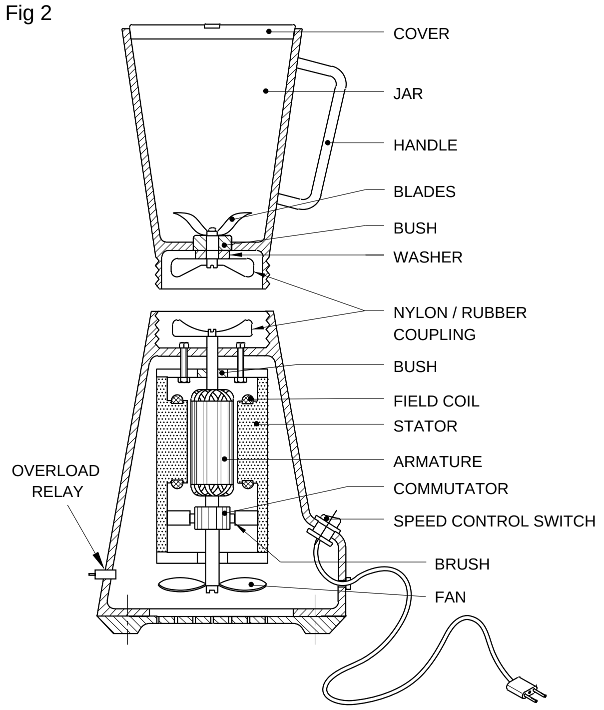
8 If the motor is opened for varnishing, clean thoroughly the stator and armature and bush bearings. (Fig 2)

9 Conduct the insulation test after varnishing and enter the results in the maintenance card (Table 2).

Remember that the nut on the blade and the centre shaft holding nut are to be loosened by clockwise movement and tightened by anti-clockwise movement in most of the mixers.

10 Lubricate the bearing as recommended by the manufacturer before assembly.

Fig 2



PARTS OF A FOOD MIXER

Most of the bearings need no lubrication. If required, a drop of light oil like 3-in-1 oil could be used.

11 Clean the commutator surface. A black carbon deposit could be removed by CTC. Seat the bushes properly over the commutator. Check for adequate length of brushes to exert spring pressure.

If the brush length is shorter by 1/3 of its original length it is better to replace with the new brushes of the same grade and size. The new brush has to be bedded to the commutator properly.

12 Assemble the motor and tighten the terminal screws.

13 Assemble the blade with the jar and nylon coupling at the bottom.

14 Connect the motor to the supply and start the mixer.

15 Observe the working of the mixer for smooth running.

TABLE 2

Date of servicing	Insulation resistance before varnishing/heating		Insulation resistance after varnishing/heating		Details for repair and replacement
	Between terminal and body	Between Armature and field	Between terminal and body	Between Armature and field	

TASK 2: **Repairing of mixer**

1 Listen to the complaints of the customer/user and enter in the maintenance card (Table 1).

Common complaints are listed in the troubleshooting chart along with reasons for the possible cause and the corrective action to be taken.

2 Inspect visually the following parts for trouble.

- Power cord and plug
- Terminal connections at the switch (back cover to be opened)
- Couplings
- Freeness of the shaft
- Burnt smell or discolouring of windings

3 Conduct the continuity and insulation tests and enter the values in Table 2. Ascertain the area of problem by analysing the customer's complaint, visual inspection and test results. (Refer to the maintenance card.)

4 Troubleshoot the mixer following the hints given in the troubleshooting chart.

TROUBLESHOOTING CHART

Problem	Possible cause	Corrective action
Mixer does not run.	a) Overload trip might have tripped.	a) Reset the overload relay and advice the customer not to overload the mixer in future.
	b) No power at the outlet.	b) If the mixer is running in your shop but not running at the customer's house ask the customer to get the socket repaired.
	c) Defective power cord or plug.	c) Test, repair or replace the power cord/plug.
	d) Locked shaft.	d) Unplug the supply and try to rotate the shaft by hand. Clean the bearings; lubricate the bearings as advised by the manufacturer. If the shaft is still tight, replace it with suitable bearings. The shaft might have got bent.
		e) Replace the shaft or armature assembly.
	e) Worn out brushes.	f) Replace the brushes and loose springs
	f) Open circuited.	g) Check the field and armature windings. If found defective get it rewound.
Blows fuse when switched on.	a) Shorted power cord.	a) Replace the cord.
	b) Locked shaft.	b) As in 'd' above.
	c) Defective armature or field coils.	c) Test the windings for short. If short is found, rewind.
	d) Poor insulation resistance.	d) Check, test and repair.
	e) Low capacity fuse.	e) Check the capacity of the fuse against the mixer rating.
Erratic operation and speed.	a) Defective cord	a) Check the cord for intermittent break. Repair or replace.
	b) Loose connection at socket or plug or at switch terminals.	b) Check and tighten the connections.
	c) Poor spring tension or worn out brushes.	c) Check, repair or replace.
	d) Defective switch.	d) Replace the switch.

Problem	Possible cause	Corrective action
Slow speed with weak power.	a) Wrong materials or too much quantity loaded for mixing. b) Jammed rotor. c) Tight blade assembly. d) Worn out brushes or loose spring. e) Bent shaft. f) Partially shorted or grounded winding or poor insulation resistance.	a) Verify from the customer about the load and advise accordingly. b) Rotate by hand. If found tight, clean the bearing and lubricate it. If it is found still tight, change the bearings or check for bent shaft. c) Check the spring, washer and assembly. Repair or replace. d) Check, repair or replace. e) Check, repair or replace. f) Check, test and repair/rewind
Mixer runs but becomes hot.	a) Overloading of mixer. b) Time rating of mixer is exceeded. c) Bent shaft and rotor is rubbing the stator. d) Improper coupling. e) Shorted winding.	a) Bring down the load in the mixer or advise the customer to go for a higher capacity mixer. b) Check the duration of the mixer is switched on by the customer and compare with the mixer rating. Advise accordingly. c) Check, repair or replace. d) Check, repair or replace. e) Check, test and rewind.
Mixer is noisy.	a) Dry bearing. b) Loose mounting screws. c) Rotor rubbing against stator. d) Bent fan blades. e) Broken or missing gasket.	a) Check and lubricate. b) Check and tighten the loose screws. c) Check the alignment and shaft for bending. Repair or replace the shaft. d) Check and straighten the blades. If not possible replace the fan blades. e) Replace.
Motor runs on one speed only.	a) Check the speed selector switch connections and function of switch. b) Partially burnt out field winding.	a) Repair or replace the switch. b) Test with multimeter. Repair or rewind.
Bad sparking at motor brushes.	a) Struck or worn out or loose brushes. b) Pittings or uneven commutator surface.	a) Check, reshape the brushes, replace the springs or reposition the brushes for proper tension. b) Use sandpaper or turn the commutator on a lathe.

Problem	Possible cause	Corrective action
Mixer produces shock.	a) Water leaking and coming in contact with live terminals. (Double insulated mixers with plastic body and two pin plug. No earth connection).	a) Check the drain hole in the coupler head assembly for blockage. Check the jar examine for leakage due to loose shaft or worn out bearing, ebonite washer breakage. Repair or replace.
	b) Vent hole in the mixer body clogged.	b) Clean the vent hole.
	c) Damaged power cord.	c) Check and replace.
	d) Absence of earth connection.	d) Check the earth connection in the mixer motor, power cord and at socket. Repair and redo the earth connection.
	e) Live parts coming in contact with metal body.	e) Check, repair, if the live parts are in contact with metal body recheck with a Megger.
Smoke coming from coupling.	a) Improper seating between coupling.	a) Check whether male and female parts of the coupling are properly seated. If not check the assembly. Include additional washers in the detachable blade assembly to make proper seating between couplings.
	b) Worn out coupling.	b) Check and change the coupling.
	c) Misaligned coupling.	c) Check the motor assembly and align.

5 After assembling the mixer conduct the continuity and insulation test. Enter the values in the maintenance cards given earlier.

6 After satisfactory values of the test are obtained, connect the mixer to the supply, and test run.

Service/repair and install a ceiling fan

Objectives : At the end of this exercise you shall be able to
- **service/repair a fan**
- **dismantle a ceiling fan**
- **trace and identify the faults in a ceiling fan**
- **replace faulty parts with good ones/rectified ones**
- **clean and lubricate the bearings**
- **test the motor winding for continuity**
- **check the speed regulator**
- **assemble the ceiling fan and test for its working**
- **install a ceiling fan and the regulator.**

Requirements

Tools/Instruments

- D E spanner set (6 mm to 22 mm) - 1 Set.
- Screwdriver 100 mm, 150 mm(each) - 1 No.
- Heavy duty screwdriver (300 mm x 8 mm) - 1 No.
- Megger 500 V - 1 No.
- Tachometer - 1 No.
- Soldering iron 35 W 240 V 50 Hz. - 1 No.
- Multimeter - 1 No.

Equipment/Machines

- Different makes of ceiling fans - 3 Nos.

Materials

- Twin-twisted PVC insulated cable. 23/0.2 of 660 V grade - as reqd.
- Grease for bearing - as reqd.
- Insulation tape P V C - as reqd.
- Test lamp 240 V 40 W - 1 No.
- Cleaning brush 1 inch - 1 No.
- Resin-cored soldering lead 60/40 - 10 gms.
- Soldering flux - as reqd.
- Kerosene oil - 1/2 litre.
- Petrol - 100 ml.
- Cotton cloth (cleaning) -0.5 sq.m.

PROCEDURE

TASK 1: **Servicing**

1 Enter the name-plate details in the maintenance card 1.

2 Enter the complaints from the customer in the maintenance card 1.

3 Visually inspect the fan, regulator and switch; enter the defects if any in the maintenance card 1.

4 Switch 'ON' the fan and check for its smooth functioning at different settings of the regulator. If the fan is not having any major defects proceed as given below.

5 Isolate the fan circuit from supply by:

– switching 'off the mains and removing the fuse units.

6 Conduct visual inspection:

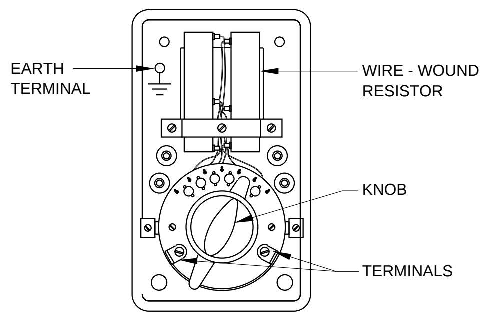
– for good condition of switch

– for proper mounting of regulator and firm fitting of knob.

7 Open the switch cover. Remove any external deposits, using a hair brush.

8 Check for firmness of termination, open the regulator, clean inside with a brush. Check, adjust and clean the contacts. Tighten the terminal. (Fig 1) Enter your observations in the maintenance card 1.

Fig 1



INSIDE VIEW OF A REGULATOR

Maintenance card 1

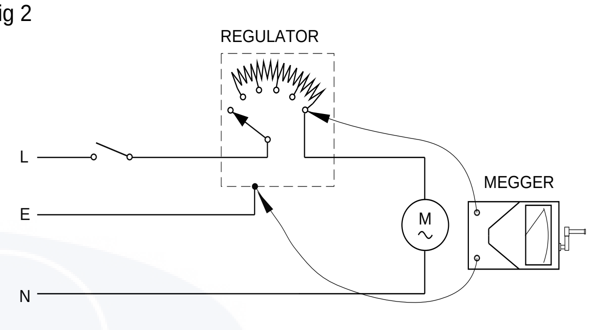
Name of the customer ________	Address ________		
Name of the appliance ________	Serial No ________		
Wattage ________	Current ________	Voltage ________	
Supply ________	Make ________	Sweep ________	

Date of servicing	Consumer's complaint	Defects noticed	Details of repair and replacement

9 Check the continuity of the winding. After the above test results are all right, go for insulation test.

10 Measure the insulation resistance between the outgoing terminal of the regulator fan motor and earth. (Fig 2) Record its value in the maintenance card 2.

Fig 2



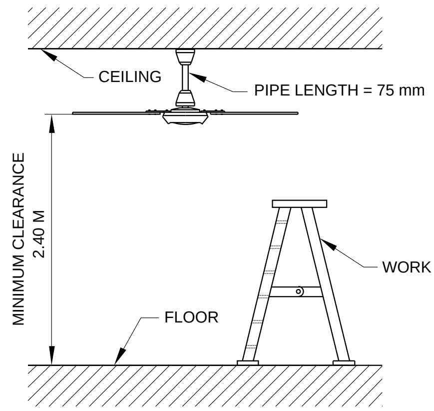
INSULATION RESISTANCE TEST

Maintenance card 2

Date of servicing	Insulation resistance before servicing/repairing between terminal and body	Insulation resistance after servicing/repairing between terminal and body	Details of repair and replacement
	a) Regulator		
	b) Fan		

11 Make arrangements to reach the ceiling fan through stable means of elevation. (Ladder, work horse, table etc.) Safety of the worker is of utmost importance while climbing over a ladder. (Fig 3)

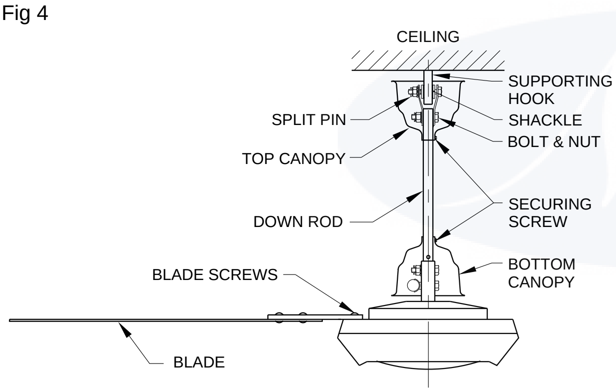
Fig 3



12 Remove the fan blades in succession and refit the screws and spring washers, in the body of the fan itself so that you may have easy access to them when refitting the blades.

13 Slide the top and bottom canopy for inspection and cleaning. (Fig 4)

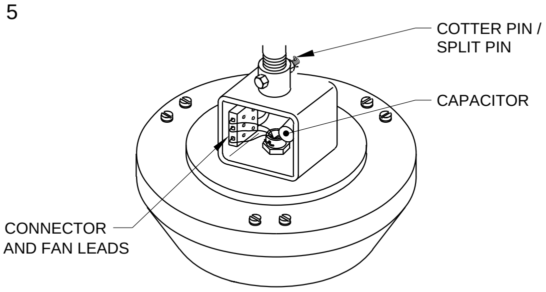
Fig 4



14 Inspect the supporting hook grommet, shackle, split pin etc.

15 Inspect the bolt, nut, split pin, check-nut, connections to the capacitor, fan leads, and connector. (Fig 5) Clean the external dust and dirt with a brush.

Fig 5



16 Clean the fan body, first with dry cloth and then with wet cloth.

17 On inspection after sliding the canopy, if any trace of moisture or water is found, bring the fan down with the rod for testing its insulation resistance.

In the case of moisture/water in the fan, it would have been indicated by less than one megohm resistance during the insulation test done as per Step 10.

18 Dry the fan body by using a 500 W bulb or in an oven.

Insulation resistance value should not be less than one megohm after drying.

19 Clean the blades thoroughly and mount them back. Apply a trace of grease/oil on the screws at the time of fixing the blades.

20 After assembling check again the fan circuit for continuity and insulation resistance to make sure the winding is all right. Enter the values of the insulation resistance in the maintenance card. (Page 2).

21 Test the fan for its smooth functioning, after resuming supply to the fan circuit.

22 Check the direction of rotation. It should be anticlockwise when viewed from bottom. If the direction of rotation is wrong, either change the running or auxiliary winding ends.

When the fan is found to be wobbling or making noise while running, it needs a thorough check up and overhauling.

23 Note the particulars stated in Table 1 and record your observations.

TABLE 1

Sl. No.	Types of test	Condition	
		Normal	**Abnormal**
1	Speed		
2	Noise		
3	Heat (after 10 min. run)		
4	Wobbling		
5	Function of regulator in all positions		

— — — — — — — —

TASK 2 : **Repairing**

Listen to the user's complaints. Complaint may be:

- fan is not running
- fan is noisy
- fan wobbles excessively
- motor runs hot.

Enter the details on the maintenance card 1.

Fan is not running.

1 There may be no incoming supply to the fan; check the concerned branch circuit fuse and ensure the availability of supply in the fan circuit.

2 Check for the supply in the outgoing lead from the regulator to the fan. If any fault is observed in the switch or regulator, or in the cables, rectify it.

3 Ensure free rotation of the fan by rotating manually.

> **Tight movement of the fan or noise during running may be due to worn out bearings. Replace the bearings.**

4 Check the supply at ceiling rose and at the fan terminals.

5 Give temporary connection for further testing, if there is no supply at the ceiling rose.

6 Even after step 5, if the fan is not running, switching off the supply, check the capacitor for loose connection.

> **Remove and test the capacitor for short or open. A leaky capacitor cannot be tested easily without connecting in the circuit. If found defective, replace the capacitor with an identical good capacitor.**

7 Switch ON the supply. If the fan is not running, may be it is due to a defect in the winding.

8 Again test the winding for continuity and insulation resistance. (Minimum 1 megohm)

9 If the results are not all right, lower the fan and send it for repair to the workshop.

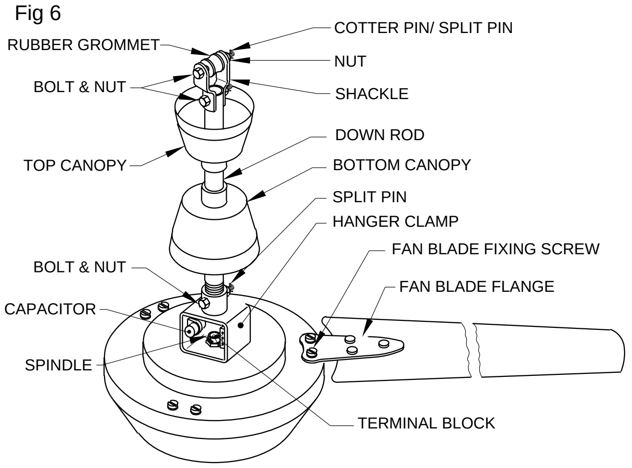
Fan is noisy.

1 Collect the history and nature of the noise in the fan from the user. Enter the details in the maintenance card 1.

2 Run the fan and observe the noise.

3 Identify the noise- whether the noise is due to one or a combination of the following reasons and rectify the fault. (The parts of a fan are shown in Fig 6.)

Fig 6



PARTS OF A CEILING FAN

- Slack canopy - touching the rotating body.
- Worn out grommet/partly out of the shackle.
- Loose element of the blade.
- Loose or missing screws.
- Slack capacitor housing.
- Broken or worn out split pin at the top or bottom.
- Lack of lubrication, or dirt in bearing.
- Worn out bearing/bush.
- Blade distortion/ breakage.
- Misalignment of blades.

> **Use kerosene first and then petrol to clean the bearing.**

Fan wobbles excessively.

1 Check and ensure that the screws which attach the fan blade flanges to the motor hub are tight.

2 Check and ensure that the fan blade flanges seat firmly and uniformly on the surface to the motor hub. If flanges are seated incorrectly loosen the flange screws and retighten.

3 Tighten the bolt and nut in the shackle and hanger clamp. Check also the grommet for damage. Replace the grommet, if necessary.

4 Interchange the adjacent (side by side) blade pair. If fan blades are out of balance. Interchanging the blades can redistribute the weight and result in smoother operation.

Motor runs hot.

1 Check for partial short circuit in winding. If defective, send it for rewinding.

2 Check for tight bearing, clean and grease it. If it is found defective, replace it with a good bearing.

3 A shorted capacitor also heats up the fan. Check and replace the capacitor.

TASK 3: **Installation of fan**

1 Select the down rod length such that the blades remain 2.4 metres above the floor and the clearance between the ceiling and the plane of the blades of the fan is not less than 300 mm.

Do not mix the blades of one set with another set as these blades are matched as a set by the manufacturer.

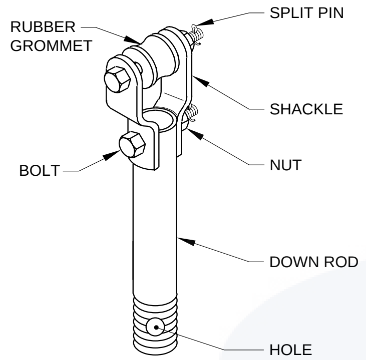
2 Insert the connection wires and then slip in canopies back to back through the down rod. (Fig 6)

3 Insert the down rod on the spindle and tighten with the bolt and nut separately packed with the hanger clamp. Provide a split pin and split to secure the bolt.

4 Remove the bolt and nut from the shackle assembly.

5 Insert the down rod top end in the shackle assembly and tighten with bolt and nut. (Fig 7)

Fig 7



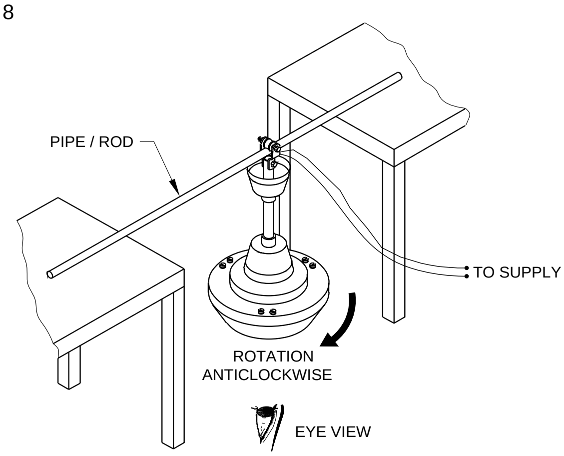
Providing split pin, cotter pin at both ends of down rod in fan is a must to prevent falling of the fan by slackening of bolt nut while running.

6 Connect the wires to the terminal block (as per the instructions of the manufacturer).

7 Check the bolt, nut and the rubber grommet, split pin in the shackle assembly.

8 Suspend the fan (without blades) by a pipe or rod inserted through the shackle and hanger clip as shown in Fig 8.

Fig 8



9 Connect it to the rated supply for a short while and observe for smooth running in the proper direction. (Anticlockwise direction looking from the ground)

10 Mount the fan in the ceiling hook/supporting hook. Ensure the split pin is inserted in the bolt and bent or the lock-nut is fitted.

11 Connect the wires to the ceiling rose. Slacken, slide and fix both the canopies to cover the top hook and spindle terminals block and capacitor.

Ensure that the canopies are fitted with just sufficient spacing.

12 Fix the blade with the screws already provided on the body.

— — — — — — — —

TASK 4 **:- Installation of fan regulator**

1 Read the manufacturer's instructions and diagram of the regulator connection and follow the instructions. (Fig 9)

Installation of a fan regulator of a particular type

2 Loosen the screw (1) inside the knob with the help of a small screwdriver.

3 Lift the knob (2) by a screwdriver.

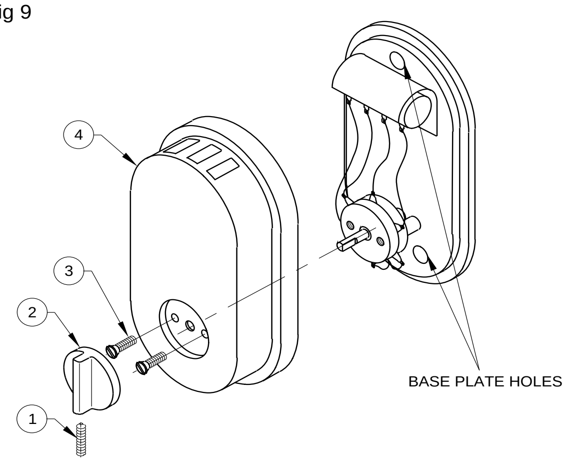
4 Remove top cover (4) by unscrewing the two screws (3) under the knob. (Fig 9)

5 Take out the wires through the base plate and make series electrical connections at the switch.

6 Fix the base plate to the wooden switch base at a proper position with the help of wood screws through the base plate holes.

7 Fix the top cover by two screws and insert the knob.

Fig 9



FAN REGULATOR

8 Tighten the knob by a grub screw (1).

9 Effect supply and test the fan for its working at all positions of the regulator.

— — — — — — — —

Service and repair a table fan

Objectives: At the end of this exercise you shall be able to
- **test the given table fan for its working**
- **dismantle the table fan**
- **trace and identify or locate faults in the table fan**
- **replace faulty parts with good ones**
- **test the capacitors**
- **clean and lubricate the bearings**
- **check the oscillation mechanism**
- **check the speed regulator**
- **reassemble the table fan and test for its working.**

Requirements

Tools/Instruments

- D.E. spanner set 6 - 22 mm - 1 Set.
- Cutting pliers 150 mm - 1 No.
- Screwdriver 150 mm - 1 No.
- Soldering iron 65W 230V - 1 No.

Equipment/Machines

- Table fans -3 Nos.
  (one each of three different sizes)

Materials

- Connecting cables - as reqd.
- Grease - as reqd.
- Three-in-one oil / SAE 30 - as reqd.
- Solder resin - cored - as reqd.
- Insulation tape - as reqd.
- SAE - 30 Oil - as reqd.

PROCEDURE

TASK 1: **Servicing of a table fan**

1 Record the available name-plate details of the table fan in Table 1.

TABLE 1

Name-plate details			
Manufacturer`s name			
Type		Sweep	
Voltage		Watts	
Current		P.F.	
Serial No.			

2 Switch `ON' the fan and check for its function, at different settings of the speed regulator and oscillation mechanism. Observe and record the condition.

Disconnect the fan from supply.

3 Conduct visual inspection on the
- main cord insulation
- plug pin termination for tightness and good electrical contact.

Set right the defects, if any is noticed.

Remove the front gaurd and blade assembly and clean them. (Fig 1)

4 Place the fan in a lying position on a pad or cloth.

Take care that the guard is not damaged.

5 Open the bottom cover and clean the dust and dirt with a brush.

6 Disconnect the main cord.

7 Conduct the insulation test on the main cord and record the values in Table 2. Replace it if the valve of insulation resistance is less than 1 megohm.

8 Measure the insulation resistance of the fan windings and record in Table 2. Send the fan for reconditioning if the value is less than 1 megohm.

9 Clean the regulator contacts. Reconnect the main cord. (Fig 1) Refix the borrom cover and keep the fan in normal position.

10 Remove the oscillating gear assembly. Clean and lubricate with fresh grease.

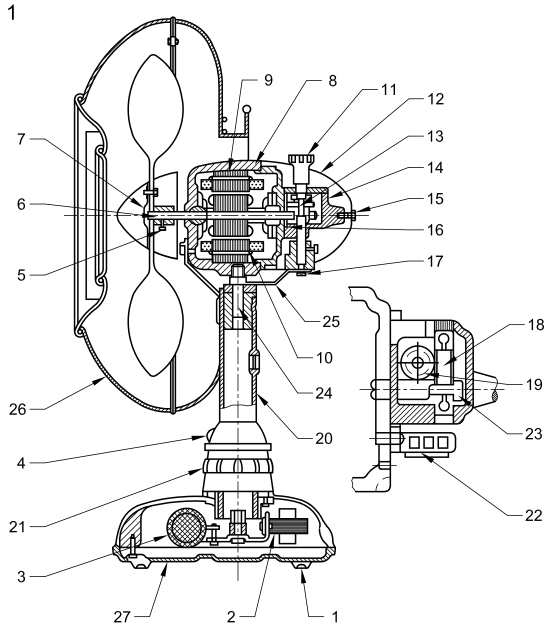
11 Lubricate the bush bearings with SAE 30 oil. (Fig 1) Fix the oscillation gear box in position.

12 Refix the blade and guard assembly. Switch `ON' the fan for its working.

TABLE 2

Testing area	Insulation resistance	Value in Meg ohms
Cord	Between conductors	
	Phase & Neutral	
	Phase & Earth	
	Neutral & Earth	
For winding	Running winding and body	
	Starting winding and body	
	Between starting and running winding	

Fig 1



1. RUBBER FEET
2. CHOKE LAMINATION
3. CAPACITOR
4. INDICATOR POINT
5. BLADE BUSH FIX, SCREW
6. SPINDLE
7. BLADE CARRIER BUSH
8. FRONT COVER
9. STATOR
10. ROTOR
11. KNOB
12. FALSE COVER
13. VERTICAL SPINDLE
14. GEARBOX
15. FALSE COVER FIX, SCREW
16. BUSH BEARING
17. LINK FIX, SCREW
18. WORM
19. VERTICAL GEAR
20. STAND
21. SWITCH
22. TERMINAL BLOCK
23. HORIZONTAL GEAR
24. PIVOT PIN
25. CRANK LEVER
26. WIRE GUARD
27. BOTTOM COVER

_ _ _ _ _ _ _ _

TASK 2: **Repairing of a table fan**

Listen to the user's complaints.

The complaints may be any one or a combination of the following.

A Fan is not running.

B Noisy.

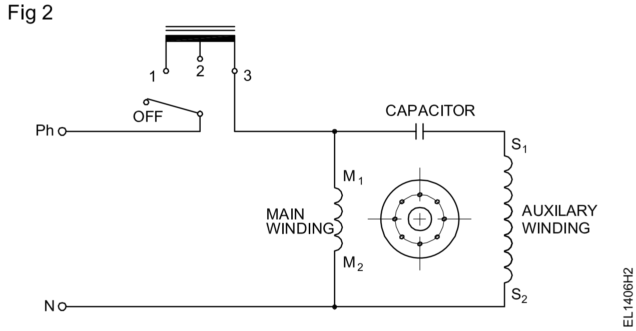
C Not oscillating.

D Fan produces humming noise.

E Bearings of the oscillating mechanism rattle.

F Oscillating mechanism is noisy.

Fig 2



A Fan is not running.

1 Check the socket outlet for the availability of supply.

2 Remove the bottom inspection cover.

3 Check the continuity of the power cord.

4 Check the regulator switch assembly. (Fig 2) Rectify if any fault is observed.

5 Ensure free rotation of the fan with your hand. Find the cause and rectify if it is too tight (bearing assembly, foreign body, etc.)

6 Check the capacitor. Replace, if defective. Rectify loose connections if any.

Check the winding for continuity and insulation. Send it for rewinding, if necessary.

B Fan is noisy.

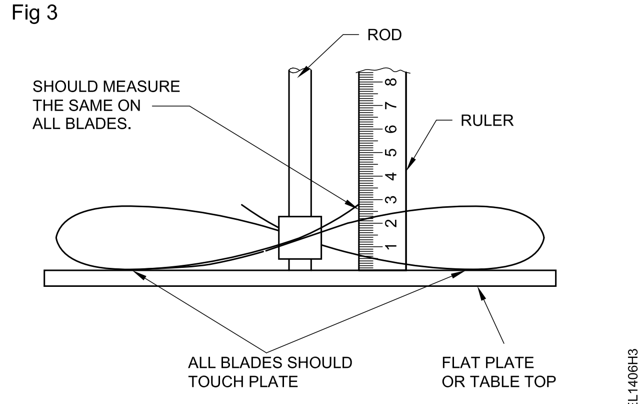
1 Collect the history and nature of the noise of the fan from the user.

2 Run the fan and observe the noise.

3 Identify the noise and find out if the noise is due to one or a combination of the following.

- Loose element of the blade.
- Loose or missing screws.
- Lack of lubrication or dirt in bearing.
- Worn out bush.
- Blade distortion/breakage. (Fig 3)
- Alignment of blades.
- Loosely fitted gaurds.

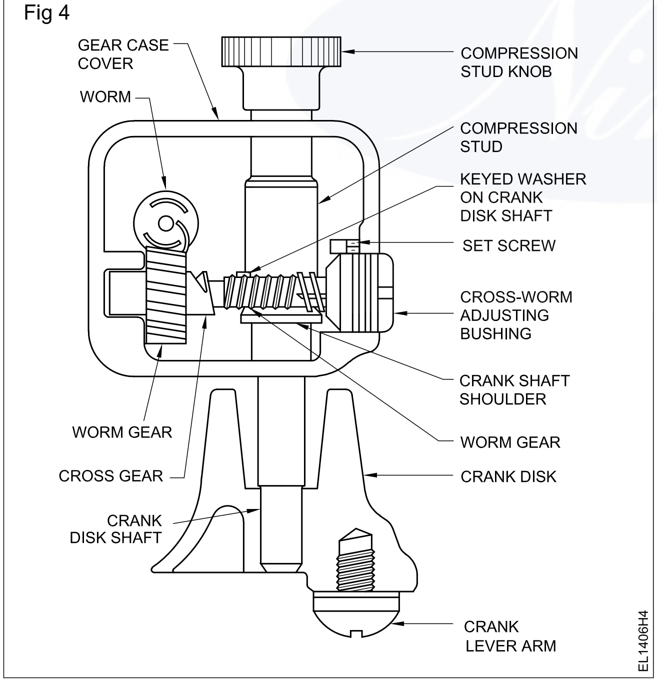
Fig 3



C Fan not oscillating.

1 Check the compression stud, worm gear and pinion. (Fig 4)

Fig 4



2 Check the gear for broken teeth.

3 Check for a bent rotor shaft.

4 Check the gear pin for proper setting. If it is loose, either knurl the end slightly and press it into place or replace the complete gear assembly.

D Fan produces humming noise.

1 Check the air gap for unevenness. If it is incorrect, check for correct fitting of the end-shields as per the markings.

2 Check armature for a bent shaft.

3 Check for worn out or loose bearing fit. If bearings are defective, replace them. When replacing, clean the gear case of all old grease. The bearing swivel studs washers and rotor shaft should be lubricated with a light film of SAE-30 motor oil.

E Bearings of the oscillating mechanism rattle.

1 Check for worn out bearings, particularly at the fan blade side.

2 Check the rotor for excessive wear.

3 Check for proper grease. Clean out the gear case and replace with the grease recommended in the service manual.

F Oscillating mechanism is noisy

Excessive end play between the compression stud and the cover may be the cause of this noise. To prevent excessive end play, use spacers between the compression stud and worm gear.

Before returning a fan to a customer, check the fan's operation against the manufacturer's specifications for current or power rating. The power consumption should not exceed the name-plate rating by more than 10% at any speed.

A test for the power consumption of a fan should always be made in a draught free room.

Wire up in PVC conduit a circuit for a calling bell and a buzzer

Objectives: At the end of this exercise you shall be able to
- **identify the position of straight wiring runs and accessories according to the layout**
- **mark the vertical and horizontal lines on the I.P.C. (installation practice cubicle) according to layout within an accuracy of 3mm**
- **mark the position of wiring accessories within an accuracy of 3mm**
- **cut non-metallic conduit pipes**
- **fix accessories to the pipes according to the pipe size by the tight grip method**
- **fix a conduit with necessary clamps and spacers on surface installation in accordance with B.I.S. recommendations**
- **draw wires in non-metallic conduit pipes**
- **prepare wooden blocks to terminate conduits and fix accessories**
- **check the continuity of cable, and test the circuit.**

Requirements

Tools/Instruments

- Combination pliers 200 mm - 1 No.
- Screwdriver 200 mm with 5mm blade - 1 No.
- Connector screwdriver 100 mm (with thin blade) - 1 No.
- Screwdriver 150 mm with 3mm blade - 1 No.
- Tenon-saw 300 mm - 1 No.
- Hacksaw frame 300mm with blade (24 T.P.I.) - 1 No.
- Plumb bob with thread - 1 No.
- Ball pein Hammer 250 grams - 1 No.
- Firmer chisel 25 mm - 1 No.
- Firmer chisel 12 mm - 1 No.
- Poker 150 mm - 1 No.
- Hand drilling machine with 4 mm bit - 1 No.
- Drill bit 6 mm - 1 No.
- Two feet four-fold wood rule - 1 No.
- Side cutter 150 mm - 1 No.
- Electrician's knife - 1 No.
- Half round rasp file 150 mm - 1 No.

Materials

- Bell-push (surface mounting) switch 6A 250V - 2 Nos.
- Electric bell 250V AC 50 Hz - 1 No.
- Buzzer 250V AC 50 Hz - 1 No.
- P.V.C. conduit pipe 20 mm 1.5mm thick - 3 m
- P.V.C. cable, aluminium of 1.5 mm^2 - 7 m
- Saddle, 20 mm. - 12 Nos.
- T.W. box 100x100x50 mm - 4 Nos.
- P.V.C. junction box 20mm 4 - way - 1 No.
- P.V.C. junction box 20mm 3 - way - 1 No.
- Wood screws 20 mm No.5 - 38 Nos.
- Wood screws 25 mm No.6 - 8 Nos.
- Terminal plate 16 Amps 3 - way - 1 No.

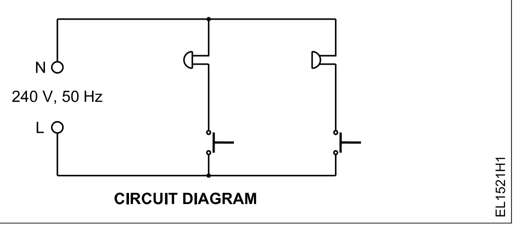
PROCEDURE

TASK 1: **Forming bell and buzzer circuit.**

1 Collect the calling bell, buzzer and two numbers of push-button switches.

2 Form the circuit according to Fig 1 either on the workbench or using a trainer board.

Fig 1



CIRCUIT DIAGRAM

3 Get it checked by the instructor.

If it is incorrect, make necessary changes.

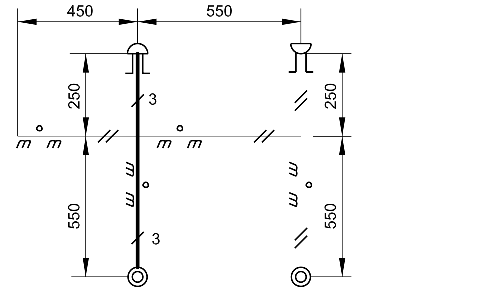
4 After getting the approval of the instructor, connect the main supply and test the circuit.

— — — — — — — —

TASK 2 : **Plan the wiring**

1 Draw your own wiring diagram and installation plan as per the task and compare them with Figs 3 and 4 respectively.

Fig 2



2 Determine the number of wires in each run according to the layout diagram (Fig 2) and wiring diagram (Fig 3) and size of the P V C pipes in each run according to the number of wires.

3 Indicate the size, specification and quantity of P V C pipes, P V C conduit accessories and T.W. boxes in the installation plan (Fig 4) and compare it with the given list.

Fig 3

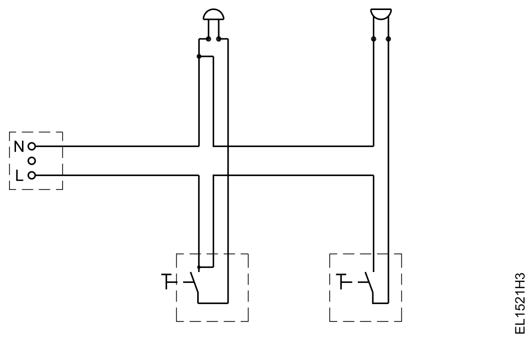
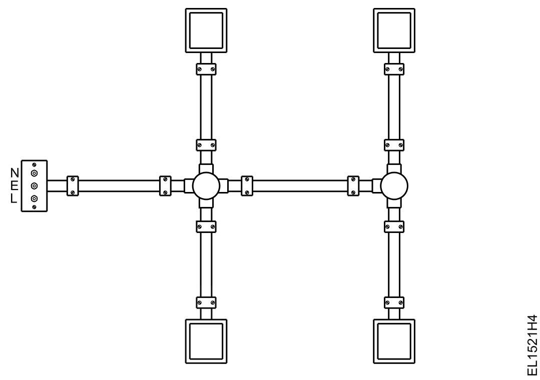


Fig 4



TASK 3: **Execute the wiring.**

1 Mark the layout on I.P.C. as per the layout.

2 Cut the P V C pipe as per the layout.

3 Fix the saddles as per the layout and installation plan.

For this work fix the saddle at a distance of 75 mm from the centre of the block and conduit accessories.Follow the code of practice while fixing the saddle.Fix only one side of the saddle initially. The other side is to be fixed while laying the conduit.

4 Fix the conduits and accessories on the I.P.C. with the help of the saddles as per the plan.

Conduit accessories should be fitted according to the conduit pipes. While doing the PVC conduit wiring commercially, the PVC adhesive should be used in the conduit and accessory joints.

5 Cut the cables according to the route and bunch them.

Leave an excess length of 200 to 300 mm in each cable for termination.

6 Insert the required cables in the appropriate pipes and accessories, as per layout and push the wires to the other end of the pipes.

7 Take the T.W. boxes. Place them at the conduit ends and mark the external diameter of the conduit pipe on the surface of the T.W. boxes.

8 Drill a number of holes inside this conduit marking, and remove the portion from the T.W. boxes by chiselling it out.

9 Use a half round, wood rasp file and file the edges to make a round hole. Check the fitting of the conduit pipe in the hole at intervals till a correct fitting is made.

10 Remove the top cover of the T.W. boxes and position the accessories on the top cover as per the layout.

11 Mark and drill through holes and pilot holes on the top cover of the T.W. board for cable entry, and accessory fixing respectively.

12 Fix the T.W. base boxes with wood screws on the I.P.C.

13 Prepare the end-termination of the cables as per the wiring diagram. Insert them through the cable-entry holes of the top cover of T.W. boxes.

14 Fix the top cover on the base boxes.

15 Terminate the cables in the accessories and fix them.

16 Fix the accessories on the top cover of the T.W. boxes.

17 Test the circuit after getting the approval of the instructor.

Identify the terminals, test for continuity&insulation resistance of a DC machine

Objectives : At the end of this exercise you shall be able to
- **enter the name-plate details of the given DC machine and interpret the details**
- **determine the pairs of the terminals of the windings of the DC machine by the test lamp method**
- **test and identify the field and armature terminals of the DC machine by the test lamp method.**
- **test a DC machine for continuity with a Megger**
- **test a DC machine for insulation between windings with a Megger**
- **test a DC machine for insulation between windings and body with a Megger.**

Requirements

Tools/Instruments

- Combination pliers 200 mm - 1 No.
- Screwdriver 150 mm - 1 No.
- DE spanner set 6 mm to 19 mm. - 1 set of six.
- Megger 500v - 1 No.

Equipment/Machines

- DC compound machine 250 V or 440 V, 3 kW rating - 1 No.

Materials

- PVC Insulated copper cable 3/0.91 of 660 V grade - 5 m.
- Kit-kat fuse unit 240 V, 16 A - 1 set.
- Pendent lamp-holder 240 V, 6 A - 1 No.
- SPT switch 240 V, 6 A - 1 No.
- BC lamp 100 W, 240 V - 1 No.
- Crocodile clips 16A - 2 Nos.

PROCEDURE

TASK 1: **Locate the terminals of a DC compound machine.**

1 Check the main switch of the DC machine is switched "Off" and fuse ---- is removed.

2 Enter the name-plate details of the given DC compound machine in Table 1 and interpret the details.

3 Remove the terminal box cover and sketch the layout of the terminals in the space given in Fig 1a.

TABLE 1

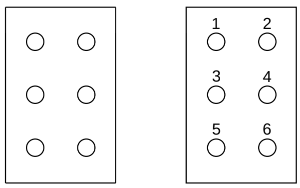
NAME-PLATE DETAILS

Manufacturer, Trade mark ....
Type, Model or List number ....
Type of current ....
Function ....Generator/Motor ....
Fabrication or serial number ....
Type of connection.........Sep/Shunt/Series/Compound
Rated voltage ....volts. Rated current .... amps
Rated power ....kw. Rated speed ....rpm
Rated Exc. voltage ....volts. Rated Exc. current ..amps
Rating class .... Direction of rotation ....
Insulation class .... Protection class ....

Do not spoil the screw heads or the nuts while removing the terminal cover, and store them in a proper place.

4 If there is no marking on the terminals, give your own marking as shown in Fig 1b.

Fig 1



(a) (b)

TERMINAL BOX

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

1 Prepare a test lamp for 240 V 25 W.

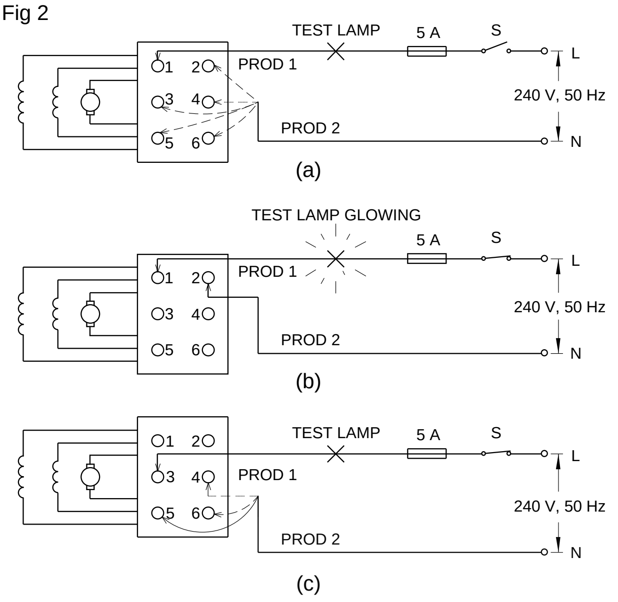
2 Identify one of the cables as the phase cable and connect it to the test lamp through the switch and fuse.

3 Connect the test Prod 1 to terminal 1, hold the insulated portion of Prod 2, and switch 'ON' the supply. Touch the Prod 2 to the rest of the terminals one by one as shown in Fig 2a.

Care should be taken to avoid any part of your body coming in contact with the bare portion of the prods as 240 V AC voltage is dangerous and cause shock hazards.

Keep the switch in the 'off' position when the test lamp is not in use.

Fig 2



IDENTIFYING TERMINALS OF A DC MACHINE

4 Observe the condition of the lamp. If the lamp lights as shown in Fig 2b while touching any one of the other terminals, then the terminals connected to Prod 1 and Prod 2 form a pair of the same circuit. Record the observations in Table 2.

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

The test lamp glows bright in both armature and series field pairs of terminals as the respective inductive resistances are of low value, whereas in shunt field circuit the light may glow dim or may give some sparks only when the prods are touched in the pair terminals due to high inductive resistance of the shunt field.

6 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 glows dim or the prod contact point gives spark as shown in Fig 3a forms the shunt field terminals.

7 Mark them in Fig 1b as E_1 & E_2 and record the same in Table 2.

You might have observed in this experiment, at the two sets or pairs of terminals the lamp lighted rather brightly. They may belong to either the armature or series fields. To distinquish the pairs of armature terminals out of the two pairs follow the steps given in Task 3.

TABLE 2

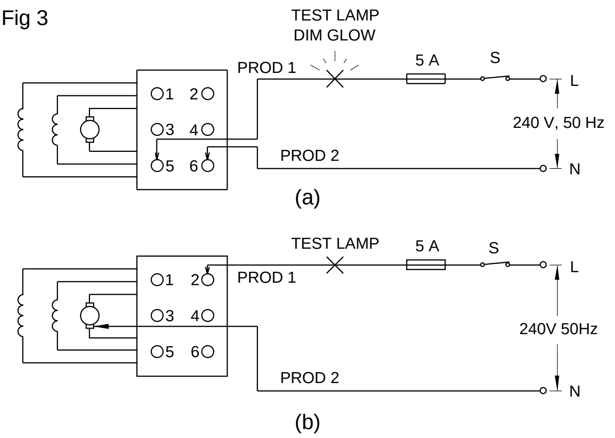
Sl.No.	Pairs of terminals	Condition of lamps	Identification
1	1 to 2		
2	1 to 3		
3	1 to 4		
4	1 to 5		
5	1 to 6		
6	3 to 4		
7	3 to 5		
8	3 to 6		
9	5 to 6		
10	BRUSH to — 2		
11	BRUSH to — 4		
12	BRUSH to — 6		

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

1 Connect Prod 1 to any one of the identified low resistive (where lamp was glowing bright) pairs as shown in Fig 3b.

2 Touch Prod 2 to any one of the brushes as shown in Fig 3a (lamp glows dim) high resistance then it is shunt field.

Fig 3



IDENTIFYING THE TERMINALS OF A DC MACHINE

Take care that the Prods do not touch with the body/frame of the machine or any other metal part except the brush.

3 If the test lamp burns, then that pair belongs to the armature terminals. Mark the terminals as A_1 and A_2 in Fig 1b and also enter in Table 2. If the test lamp does not glow try the other pairs.

4 The remaining two terminals will be of series field terminals. Mark them as D_1 and D_2 in Fig 1b **and also enter in Table 2.**

CONCLUSION

Armature terminals are..... and .... (mark them as A_1 & A_2.)

Shunt field terminals are.... and ....(mark them as E_1 & E_2.)

Series field terminals are .... and ....(mark them as D_1 & D_2.)

5 Show the result to your instructor.

— — — — — — — —

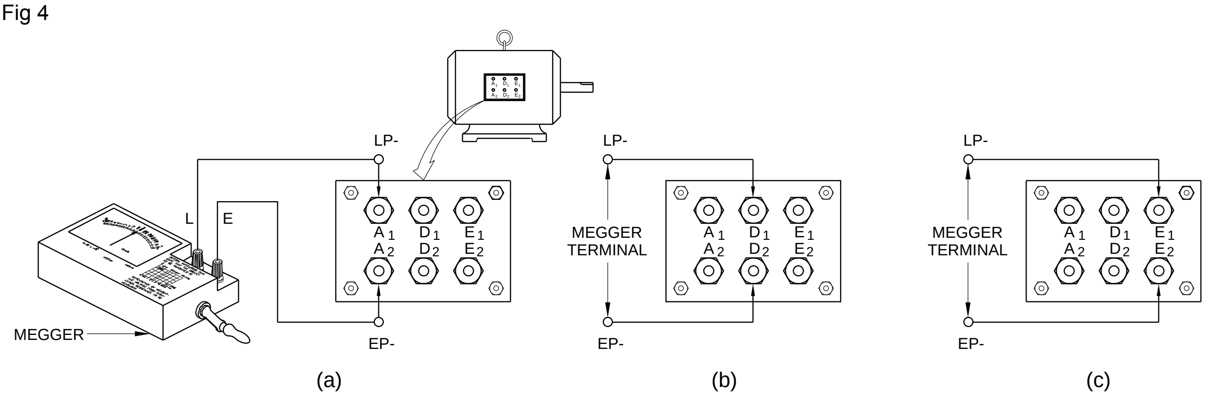
TASK 4: **Test a DC machine for its continuity**

1 Identify the pairs of the terminals from the marking.

2 Test the continuity of the armature terminals A_1 and A_2 using a Megger as shown in Fig 4a and repeat the same procedure across the field terminals D_1 and D_2 (Fig 4b) and shunt field terminals E_1 and E_2. (Fig 4c)

If continuity between the terminals of the same winding is not found, inform the instructor immediately. You can proceed to the insulation test, only when continuity exists between terminals of the same winding. However, sometimes the continuity test will not reveal internal short circuits. The best method is to measure the resistance of the winding and compare it with the previous reading to check the correctness.

Fig 4



CONTINUITY TEST ON DC MACHINE

— — — — — — — —

TASK 5: **Test a DC machine for insulation between windings.**

1 Fill up the columns 1 to 4 in Table 3.

2 Connect the Megger terminals between the armature and shunt field terminals as shown in Fig 5a.

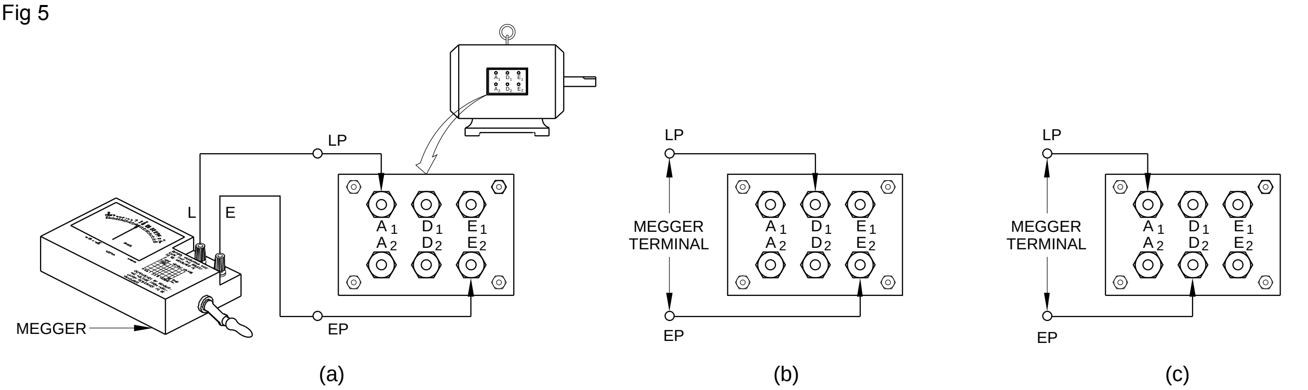
3 Rotate the Megger at its rated speed, and note down the reading in Table 3.

4 Repeat step 3 for testing the insulation between the shunt field and the series field as shown in Fig 5b, and then between the armature and the series field. (Fig 5c)

5 Enter the readings in Table 3.

The measured value should not be less than 1 megohm.

Fig 5



INSULATION TEST ON DC MACHINE

TABLE 3

Insulation resistance test between windings of a DC machine

Date	Time	Weather condition	Duty cycle of the machine	Test between terminals	Insulation resistance in megohms	Remarks
				Armature and shunt field		
				Shunt and series field		
				Series field and armature		

— — — — — — — —

TASK 6 : **Test a DC machine for insulation between armature/ field windings and body.**

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

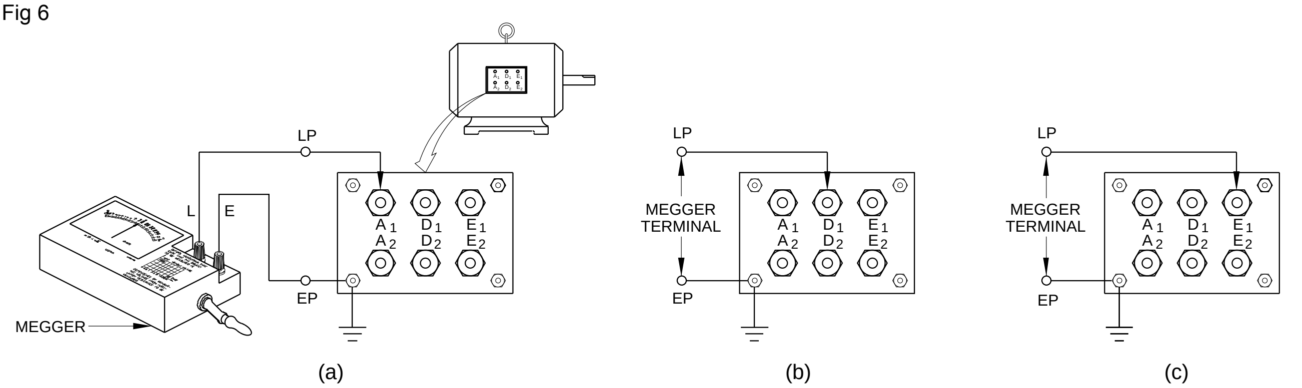
2 Connect the Megger between armature and the body as shown in Fig 6a and note down the readings in Table 4. Repeat the process and take the readings as shown in Figs 6b and 6c.

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

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

3 Show the results to your instructor and get it approved.

Fig 6



INSULATION TEST ON DC MACHINE

TABLE 4

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

Date	Time	Weather condition	Duty cycle of the machine	Test between terminals	Insulation resistance in megohms	Remarks
				Armature and body Series field and body Shunt field and body		

— — — — — — — —

Measure armature and field resistance of a DC shunt machine

Objectives : At the end of this exercise you shall be able to
- **test and identify the terminals of a DC machine by the test lamp method**
- **measure armature resistance by the Voltage drop method (Task 1)**
- **measure and verify armature resistance by the ohmmeter method (Task 2).**
- **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.**

Requirements

Tools/Instruments

- Screwdriver 150 mm - 1 No.
- Combination pliers 200 mm - 1 No.
- DE Spanners, set 6 mm to 19 mm - 1 set
- M.C. Voltmeter range 0 -15V - 1 No.
- MC Ammeter 0 to 5 A - 1 No.
- Shunt type Ohmmeter 0 to 50 ohms - 1 No.

Equipment/Machines

- DC shunt/compound machine 250 V of any rating - 1 No.
- Battery 6 V 60 AH - 1 No.
- Test lamp 240V 100 W - 1 No.
- Rheostat 50 ohms 4.1 amperes - 1 No.

Materials

- PVC insulated copper cable 1.5 sq mm 660 V grade - 5 m.
- Crocodile clips 16 A - 2 pairs.

PROCEDURE

1 Check the main switch of the DC shunt machine is switched 'OFF' and fuse carriers are removed.

2 Note down the name-plate details of the given DC machine in your practical notebook.

3 Remove the terminal cover.

Do not spoil the screw heads.
Use proper tools.
Store the screws carefully.

4 Check whether the brushes are in correct position in the holders and are touching the commutator.

5 Find out the armature terminals and shunt terminals by using the test lamp.

— — — — — — — —

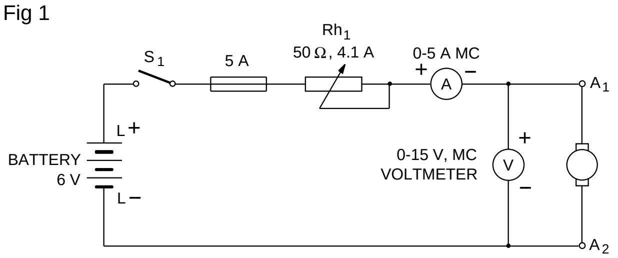
TASK 1: **Measure armature resistance using a voltmeter and an ammeter.**

1 Draw the circuit for the said task and get it approved by your instructor.

2 Collect the instruments and components and check their condition.

3 Connect the armature terminals to the ammeter, voltmeter, fuses, rheostat (Rh_1) and the battery as per the circuit (Fig 1) and get approval from your instructor.

Fig 1



MEASUREMENT OF ARMATURE RESISTANCE

4 Keep the rheostat (R_{h1}) 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 steady position by hand to avoid erroneous reading.

5 Adjust the reading of the ammeter to 0.5 amperes by adjusting Rheostat (Rh_1).

Move the armature to different positions and and see that the reading remains constant. If the readings are different, inform to your instructor.

6 Read and record the voltmeter and the ammeter readings in the Table 2.

7 Repeat steps 3 and 4 for 1, 1.5, 2 and 2.5 amperes. The current should be less than full load armature current.

8 Switch ‘OFF’ the circuit.

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

10 After the approval from the instructor, disconnect the circuit.

TABLE 2

Sl. No.	Volts	Amps.	R_a = V/I Armature resistance	Average Value
1		0.5		
2		1.0		
3		1.5		
4		2.0		
5		2.5		

— — — — — — — —

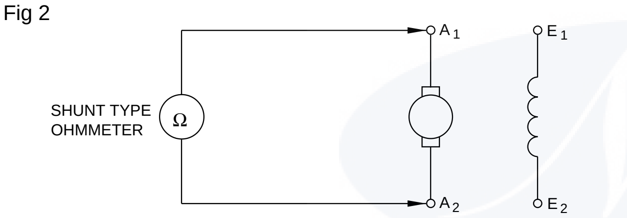
TASK 2:- **Measure the armature resistance by using an ohmmeter.**

1 Adjust the ‘Zero’ setting of the ohm-meter.

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

2 Connect the ohmmeter across armature terminals as shown in Fig 2 and measure the resistance.

Fig 2



MEASUREMENT OF ARMATURE RESISTANCE

Move the armature to different positions by hand and see that the reading remains constant. If the readings are different inform to your instructor.

3 Note down the ohmmeter readings and record it below.

Armature resistance value is _____ ohms.

— — — — — — — —

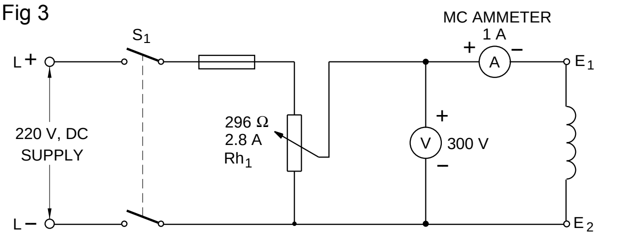
TASK 3: **Measure shunt field resistance by the voltmeter and the ammeter method.**

1 Draw the circuit for the said task and get it approved by your instructor.

2 Collect the instruments and components and check their condition and get it approved by your instructor.

3 Connect the circuit as per your diagram (Fig 3) and get the approval of the instructor.

Fig 3



MEASUREMENT OF THE SHUNT FIELD RESISTANCE

4 Switch ‘on’ the circuit and adjust the rheostat to get 100 mA.

5 Read and record the voltmeter and the ammeter readings in Table 3.

TABLE 3

Sl. No.	Volts	Amps.	R_{sh} = V/I Field resistance	Average Value
1		0.1		
2		0.2		
3		0.3		
4		0.4		
5		0.5		

6 Repeat steps 2 and 3 for 200, 300, 400 and 500 mA .

7 Switch off the circuit and complete the tabular columns.

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

9 After his approval disconnect the circuit.

— — — — — — — —

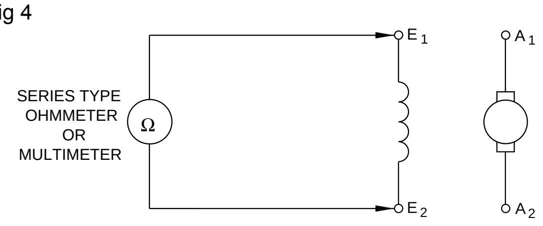
TASK 4: **Measure shunt field resistance by the ohmmeter.**

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

> **A series type ohmmeter is used to measure high value resistances.**

2 Connect the meter leads to the shunt field terminals of the machine as shown in Fig 4.

Fig 4



MEASUREMENT OF SHUNT FIELD RESISTANCE

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 as well as 3 and 4. If there is any difference write the reasons for the same in the space given below.

CONCLUSION

____

____

____

____

— — — — — — — —

Build up voltage in a separately excited DC generator (No-load characteristics curve)

Objectives : At the end of this exercise you shall be able to
- **measure the speed of the DC generator with a tachometer**
- **connect and adjust the field regulator to produce the required output voltage of a separately excited DC generator**
- **determine the relation between field current and induced emf in a separately excited DC generator when the speed is constant.**

Requirements

Tools/Instruments

- Trainees tool kit - 1 No.
- Round nose pliers 200 mm - 1 No.
- DE spanners 6 to 19 mm - 1 set
- MC voltmeter (0 - 300 V) - 1 No.
- MC ammeter (0 - 1 A) - 1 No.
- Tachometer 300 - 3000 rpm - 1 No.

Equipment/Machines

- Rheostat 296 ohms, 2.8 A - 1 No.
- DPIC switch with fuse 240 V, 16 A - 1 No.
- DC shunt generator 250 V 3/5 kW (To be used as separately excited) - 1 No.
- Prime mover coupled to the DC shunt machine with complete equipment to control the speed - 1 No.

Materials

- 3/22 PVC Insulated copper cable 660 V grade - 10 metres.
- Insulation tape - 0.20 metre.
- Fuse wire 1 amp - 0.2 metre.

PROCEDURE

1 Read, interpret and record the name-plate details of the given DC generator and enter in your practical note book.

2 Draw the circuit diagram for the said task and get it approved by your instructor.

3 Collect the cable, fuse wire, rheostat and meters according to the circuit diagram (Fig 1).

4 Connect the voltmeter, ammeter and rheostat with the generator as per the circuit diagram.

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

6 Keep the field circuit switch of the generator open.

7 Start the prime mover and measure the speed by a tachometer.

8 Adjust the speed of the generator to the rated value by adjusting the speed regulator of the prime mover.

9 Measure the voltage across the armature of the generator and enter this value in Table 1.

> **The measured voltage will be very low. Sometimes we may have to use a low range M.C. voltmeter. Consult your instructor, if necessary.**
>
> **This voltage is due to the residual magnetism as the field current is zero.**

TABLE 1

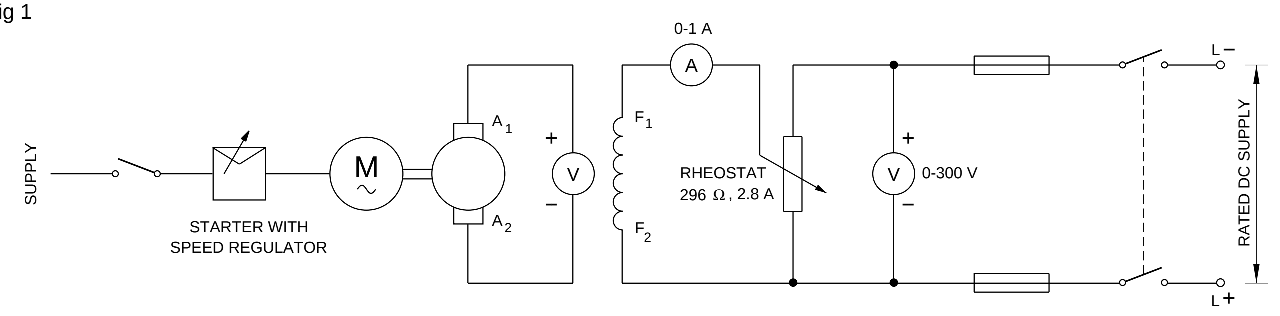
Sl. No.	Field current in Amps	Induced voltage in volts	Speed (held constant at rated value

10 Adjust the rheostat to minimum output position and switch'ON' the DC supply to the field of the generator. Adjust the rheostat to get 0.1 ampere in the field circuit.

11 Read the field current and the corresponding generated voltage, enter the values in Table 1.

12 Gradually increase the field current in steps of 0.1 ampere by slowly moving the movable arm of the rheostat towards the maximum position and note down the corresponding value of the induced voltage and field current and enter the values in Table 1.

Fig 1



SEPARATELY EXCITED DC GENERATOR

The varying of the rheostat value should be done positively and slowly in forward direction.

Any reverse movement should be avoided. The current should not exceed the rated field current.

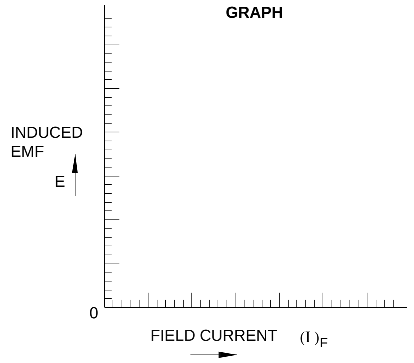
13 Increase the field current to such a value that the value of the induced emf reaches just above the rated value.

Check the speed of the generator at intervals. If necessary adjust it to the rated speed.

14 Draw a graph showing the induced voltage as a function of field current keeping the field current on X-axis and induced voltage on Y-axis. (Fig 2)

15 Write your conclusion why there is an initial value of voltage even when there is no field current and why the final value of the induced voltage remains almost constant even at the increased field current.

Fig 2



CONCLUSION

____

____

____

____

— — — — — — — —

Build up voltage in a DC shunt generator (No load characteristic curve)

Objectives : At the end of this exercise you shall be able to
- **measure the existence of residual voltage and create residual magnetism, if necessary**
- **measure the speed of the 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.**

Requirements

Tools/Instruments

- Combination pliers 200 mm - 1 No.
- Ammeter MC 0-1 A - 1 No.
- Screwdriver 150 mm - 1 No.
- Voltmeter MC 0-300 V - 1 No.
- Stop watch - 1 No.
- Revolution counter 4 digits - 1 No.

Equipment/Machines

- DC shunt generator 2 to 4 kW 250 V - 1 No.
- Rheostat 296 ohms 2.8 A - 1 No.
- Knife switch SPST 16 A - 1 No.

Materials

- PVC insulated cable 2.5 sq.mm 660 V grade - 5 m.

PROCEDURE

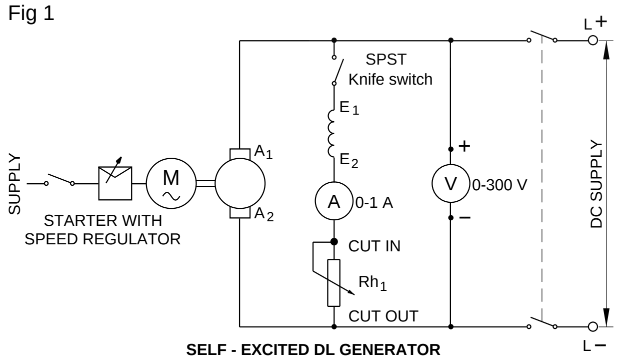
1 Read and interpret the name-plate details of the given DC shunt generator and record them in your practical note book.

2 Identify the terminals of the given DC shunt generator.

3 Draw the circuit diagram for the said task and get it approved by your instructor.

4 Collect the instruments and rheostat etc., and check their condition.

Fig 1



SELF - EXCITED DL GENERATOR

5 Connect the circuit with the machine as per the diagram (Fig 1 .

6 Keep the field SPST switch open and the field rheostat in cut 'in' position. Get the approval of the Instructor.

7 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 prime mover.

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

The number of revolutions made by the machine in a minute gives the rpm.

9 Adjust the prime mover speed in such a way that the generator runs at its rated speed.

Keep the speed constant through out the experiment.

10 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 battery for a short time as explained under flashing of field in the Related Theory.

11 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.

12 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 2.

TABLE 1

Sl. No.	Field current in amps	Induced voltage in volts	Speed held at constant rated value

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

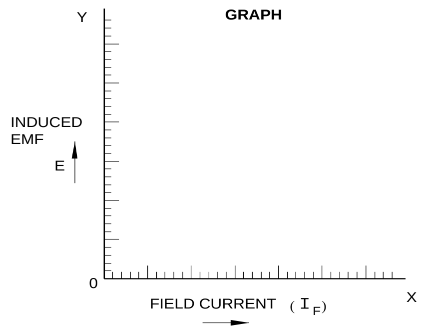
13 Switch 'OFF' the DC generator after reducing the field current to OA switch off and the prime mover.

14 Draw a graph keeping the induced voltage in the 'Y' axis and the field current in the X - axis as shown in Fig 2.

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

13 Show your readings and the graph to your instructor and get his approval.

Fig 2



MAGNETISATION CHARACTERISTIC OF A DC GENERATOR

— — — — — — — —

Plot the load characteristic curve of a DC shunt generator

Objectives : At the end of this exercise you shall be able to
- **connect the DC shunt generator and build up the voltage**
- **load the DC shunt generator**
- **determine the performance characteristic of the DC shunt generator at different loads**
- **plot the external characteristic curve.**

Requirements

Tools/Instruments

- Trainees tool kit - 1 No.
- Shunt type ohmmeter (0 - 50 Ohms) - 1 No.
- DC ammeter 0-15 amps - 1 No.
- DC ammeter 0-1 amp - 1 No.
- DC voltmeter 0-300 V - 1 No.

Equipment/Machines

- Rheostat 296 ohms 2.8 A or field regulator - 1 No.
- DPST knife switch 16 A - 1 No.
- Lamp load 240 V 3 kW - 1 No. (if a lamp load is not available, you can use a water load as shown in Fig 1.)
- DC Shunt generator 250 V, 2 to 4 kW - 1 No.

Materials

- PVC insulated cable 2.5 sq mm 660 V grade - 6 m.
- Fuse wire 15 amps - 0.2 m.
- PVC insulated flexible cable 14/0.2 of 660 V grade - 2 m.

PROCEDURE

1 Read and interpret the name-plate details of a DC shunt generator and record them in your practical note book.

2 Identify the terminals of the DC shunt generator.

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

4 Select appropriate cables, switch, rheostat, load and meters, according to the capacity of the given DC shunt generator and draw the circuit diagram for the said task and get it approved by your instructor.

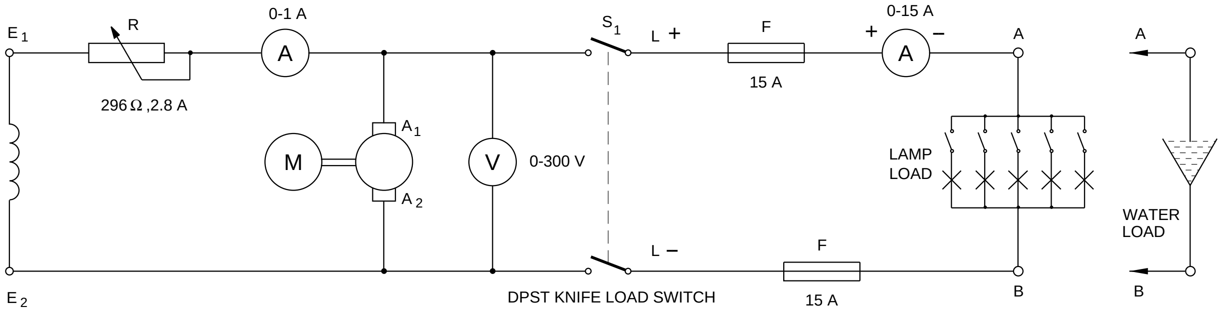
5 Collect the instruments, rheostat and lamp load etc., and check their condition.

6 Connect the meters, rheostat and lamp load with the terminals of the DC shunt generator as per the diagram (Fig 1).

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

Alternatively a water load could be used as the load.

Fig 1



LOADING OF DC SHUNT GENERATOR

8 Keep the field regulator resistance in 'cut-in' position.

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

9 Start the prime mover and bring it to the rated speed of the generator after getting approval from your instructor.

10 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.

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

12 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.

13 Increase the load current up to 125% of its rated value in 5 or 6 equal steps of load current.

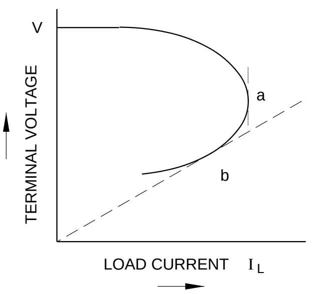
14 Note down the corresponding terminal voltage and field current for each step of load current in Table 1.

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

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

17 Draw the graph of external characteristic of the DC shunt generator by keeping the terminal voltage in the Y-axis and load current in the X-axis. Refer to Fig 2.

Fig 2



LOAD CHARACTERISTIC CURVE OF DC SHUNT GENERATOR

18 Show it to your instructor and get his approval.

19 Disconnect the circuit.

TABLE 1

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

— — — — — — — —

Plot the load characteristic curve of a DC compound generator - Cumulative & 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 performance characteristic of the DC compound generator (cumulative and differential).**

Requirements

Tools/Instruments

- Trainees tool kit - 1 No.
- Voltmeter MC 0-300 V - 1 No.
- Ammeter DC 0-15 A - 1 No.
- Rheostat 296 Ω, 2.8 A - 1 No.
- Fuse unit 15 amps - 2 Nos.

Equipment/Machines

- DC compound generator 220 V 3 KW - 1 No.
- Lamp load/resistance load/water load of capacity 240 V 3 kW - 1 No.

Materials

- PVC insulated copper cable 4 sq mm of 660 V grade - 5 m
- DPST knife switch 16 amps/250V - 1 No.

PROCEDURE

TASK 1:- **Load performance of a DC long shunt compound generator (a) cumulative (b) differential**

1 Read and interpret the name-plate details of the given DC compound generator and record it in your practical note book.

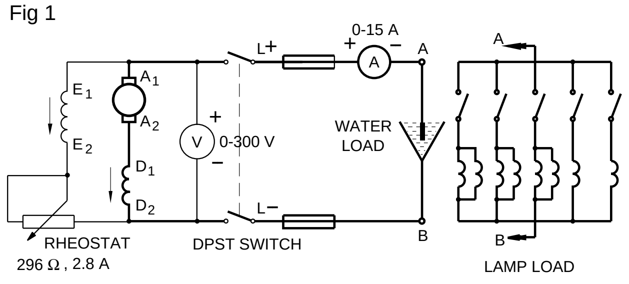
2 Draw the circuit diagram for the said task and get it approved by your instructor.

3 Collect the meters, rheostat and cables etc., and check their condition.

4 Identify the terminals of the DC compound generator either from the marking or by testing.

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

Fig 1



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

Whether the compound generator is connected for cumulatively compound or differentially compound could be determined only after loading.

6 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.

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

8 Now switch 'ON' the load.

9 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.

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

TABLE 2

Long shunt compound generator

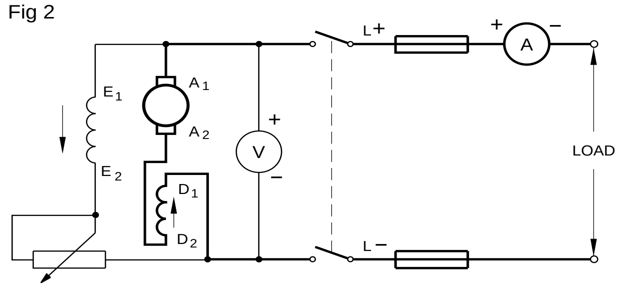
I Exercise			II Exercise		
Sl. No.	Load Current	Terminal voltage	Sl. No.	Load Current	Terminal Voltage
Type of connection			Type of connection		

Check whether the terminal voltage falls or raises with the increased load. If the terminal voltage falls heavily, the internal connection is for a differentially compounded generator. If it raises or falls slowly it is for a cumulatively compounded generator. Sometimes the terminal voltage will remain constant from no load to full load. This type of generator is called a level compounded generator and it comes under the category of the cumulatively compounded generator. To change the generator from one type to the other, the series field terminals have to be interchanged. Fig 2 shows the connection diagram of the compound machine after interchanging the series field terminals.

11 Reduce load to zero ad open the load switch and stop the prime mover.

12 Interchange the connections of the series field (or as shown in Fig 2).

Fig 2



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

13 Repeat the working steps 6 to 10 and draw the external characteristic curve for this second set of readings in the same graph sheet.

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

— — — — — — — —

TASK 2 :- **Performance of DC short shunt compound generator a) Cumulative b) Differential.**

1 Draw the circuit diagram for the said task and get it approved by your instructor.

2 Repeat the working steps 4 to 14 of task 1 for short shunt cumulative and differential compound generators and enter the values in Table 2.

TABLE 2

Short shunt compound generator

I Exercise			II Exercise		
Sl. No.	**Load Current**	**Terminal voltage**	**Sl. No.**	**Load Current**	**Terminal voltage**
Type of connection			Type of connection		

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

4 Write your conclusion regarding the following in the space provided at the bottom.

a Differentially long shunt compounded generator

b Cumulatively long shunt compounded generator

c Differentially short shunt compounded generator

d Cumulatively short shunt compounded generator

CONCLUSION

____

____

____

____

— — — — — — — —

Maintain, service & troubleshoot the D.C. motor starters (2 point, 3 point & 4 point)

Objectives: At the end of this exercise you shall be able to
- **identify the parts of the D.C. motor starters**
- **trace and draw the schematic diagram of the starters**
- **check and clean the contact studs**
- **measure the resistance of the no volt coil and the starter resistance**
- **set the over load relay.**

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

- 2 point starter 3 HP 220 V DC - 1 No.
- 3 point starter 3 HP 220 V DC - 1 No.
- 4 point starter 3 HP 220 V DC - 1 No.
- DC motor 220 V 3HP 10 A - 1 No.
- DC series motor 220 V 3HP 10A - 1 No.

Materials

- DPST main switch 240 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 - 500 ml.

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 ________	2 point 3 point / 4 point
Amps ____________	Volts ____________
Make ____________	Serial No.__________

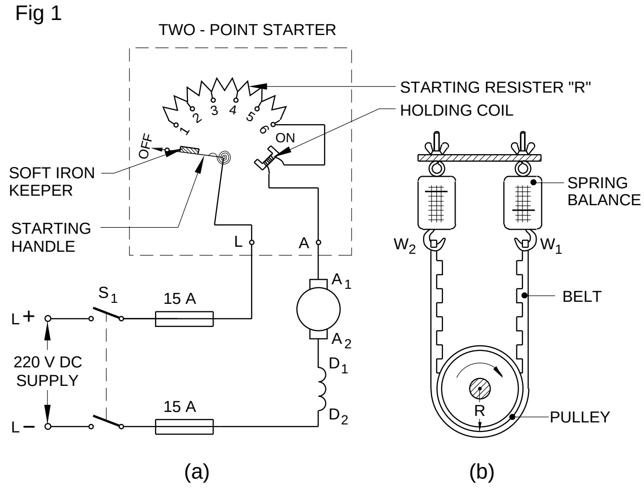
2 Identify the different parts of the starter and draw the starter diagram and label the parts in your record.

3 Trace the internal connections of the starter and draw the schematic diagrams. Fig 1, 2 & 3 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.

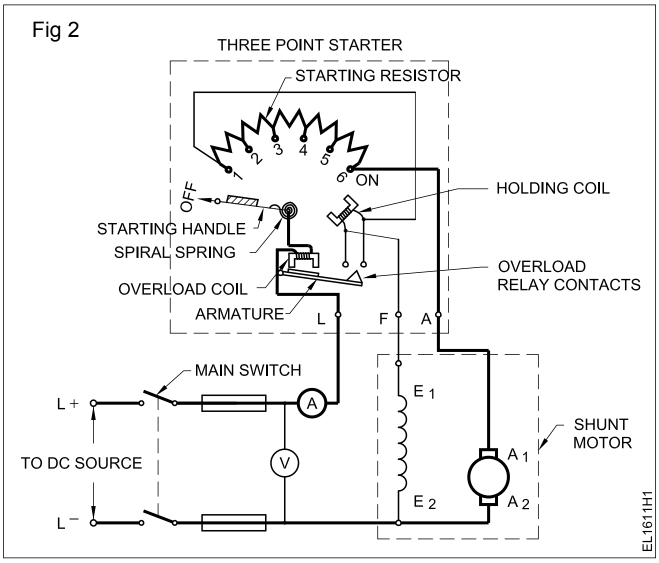
Fig 1



STARTING A DC SERIES MOTOR

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.



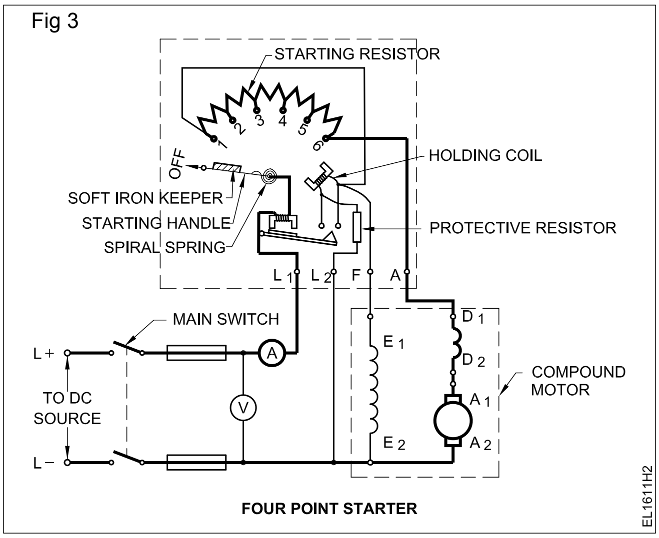


Chart - 1
General Maintenance Procedure for DC Starters

Trouble area	Cause	Remedy
1 Check the stationary and movable contact studs for burns and pittings.	a) Loosely fitted studs/Face plate b) over load c) Insufficient pressure on contact studs due to loosely fitted handle. d) Improper operation.	a) Tighten the nuts in the rear of the contact studs /Face plate b) Reduce the load. c) Add a washer or two over the handle and tighten the handle studs 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 b) Shorted resistance due to: i) excessive vibration of the panel ii) loose mounting of the resistance	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. 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		
		Date of installation	Condition	Date	Condition	Remarks
1	Colour of the no volt coil (visual inspection)		Yellow			
2	Resistance value of the no volt coil		2500 ohms			
3	Insulation resistance between the no volt coil and the core		5.5 Megohms			
4	Protective resistance of the 4 point starter		1000 ohms			
5	Resistance value of the starting resistance		10 ohms			

8 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.

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

10 Connect the DC motor with the starter.

11 Make necessary loading arrangement for the DC motor.

12 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.

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

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 Tight 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. 4 Mechanical obstructions	1 Fix the core firmly 2 Replace the magnetic assembly. 3 Clean with suitable solvent. 4 Check up and rectify

Trouble	Cause	Remedy
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 Check up obstructions & rectify. 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.

Connect, start, run and reverse a DC shunt motor

Objectives: At the end of this exercise you shall be able to
- **connect the 3-point starter to the 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.**

Requirements

Tools/Instruments

- Trainees tool kit - 1 No.
- DE spanner set 6 mm - 19 mm - 1 set
- Megger 500 V - 1 No.
- Shunt type ohmmeter 0-2 K or multimeter - 1 No.

Equipment/Machines

- DC shunt Motor 220 V 3 HP - 1 No.
- ICDP switch 240 V 16 A - 1 No.
- 3-point starter suitable for 220 V 3HP DC shunt motor - 1 No.

Materials

- PVC insulated stranded copper cable 2.5 sq.mm 660 V grade - 6 m.
- Fuse wire 10 amperes - 0.2 m.

PROCEDURE

1 Confirm the main switch of the given DC shunt motor is switched “OFF” and fuse carriers are removed.

2 Read and interpret the name-plate details of the given DC shunt motor and record it in your practical note book

3 Identify the terminals of the DC shunt motor from the markings.

4 Test the DC shunt motor for continuity, insulation and earth.

There should be continuity between the armature terminals A_1 and A_2 and also between the shunt field terminals E_1 and E_2. The insulation resistance between the armature and shunt field windings and between the windings and the frame should not be less than one megohm.

— — — — — — — —

TASK 1: **Connect start and run a DC shunt motor**

1 Draw the circuit diagram for the said task and get it approved by your instructor.

2 Collect the ICDP switch, 3 point starter and cables and check their conditions.

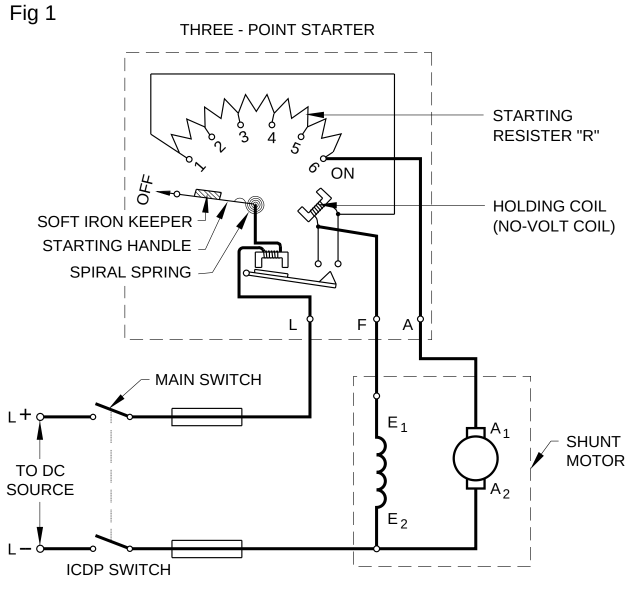
3 Connect the DC shunt motor as per the diagram (Fig1).

4 Check the supply voltage and confirm with the data given in the name - plate.

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

6 Switch ‘ON’ the ICDP switch and gradually move the starter handle from “OFF” to on position. Leave the starter handle in ‘ON’ position.

Fig 1



DC SHUNT MOTOR CONNECTED TO 3-POINT STARTER

7 Observe the direction of rotation from non-driving end side and enter it in Table 1.

8 Stop the motor by switching ‘OFF’ the ICDP switch; wait until the shaft comes to a stand still position.

9 Remove the fuse carriers From ICDP switch.

TABLE 1

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

— — — — — — — —

TASK 2:- **Change the direction of rotation**

METHOD 1 :By changing the armature terminals

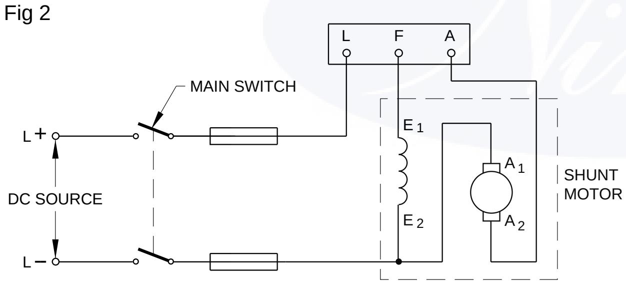
1 Draw the circuit diagram for the said method and get it approved by your instructor.

2 Connect the DC shunt motor as per diagram (Fig 2).

3 Replace the fuse carriers.

4 Repeat the working steps 6 to 9 of Task 1.

Fig 2



METHOD 2 : By changing the shunt field terminals

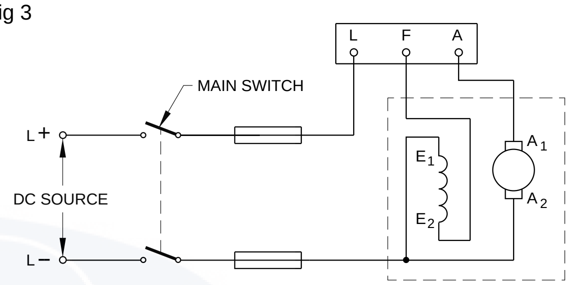
1 Draw the circuit diagram for the said method and get it approved by your instructor.

2 Connect the DC shunt motor as per diagram (Fig 3).

3 Replace the fuse carriers.

4 Repeat the working steps 6 to 9 of Task 1.

Fig 3



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

CONCLUSION

a Necessity of starter ______________________

____

____

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

____

____

____

— — — — — — — —

Connect, start, run and reverse a DC series motor

Objectives : At the end of this exercise you shall be able to
- **read and interpret the name-plate details of a DC machine**
- **test and identify the terminals of the DC series motor**
- **connect the 2-point starter and start the motor**
- **measure the speed of the machine by a tachometer**
- **reverse the direction of rotation of the DC series motor**
  - **– by changing the armature terminals**
  - **– by changing the field terminals.**

Requirements

Tools/Instruments

- Trainees tool kit - 1 No.
- Megger 500 V - 1 No.
- DE Spanner set 6 mm to 19 mm - 1 No.
- Tachometer 0 to 10,000 r.p.m. - 1 No.

Equipment Machines

- DC series motor 220 V 3 HP - 1 No.
- 2 point starter for 220 V 3 HP DC series motor - 1 No.
- Loading arrangement or complete brake test arrangement - 1 set.

Materials

- 2.5 sq mm PVC copper multi-strand cable 660 V grade - 6 m.
- Fuse wire 16 amps - As reqd.
- 240 V 16 A ICDP switch - 1 No.

PROCEDURE

1 Switch off the mains and remove the fuse carriers from the ICDP, of the given DC series motor.

1 Read and interpret the name-plate details of the DC series motor and enter them in your practical note book.

3 Identify the terminals of the DC series motor.

4 Measure the insulation resistance: between: (a) the windings and (b) the windings and the body.

Insulation value should not be less than 1 megohm.

— — — — — — — —

TASK 1:- **Connect, start and run the DC series motor.**

1 Fix and set up a suitable brake load for the series motor.

2 Draw the circuit diagram for the said task and get it approved by your instructor.

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

3 Collect proper rating of the ICDP switch, cables, fuse wire and 2-point starter according to the circuit diagram and check their condition.

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

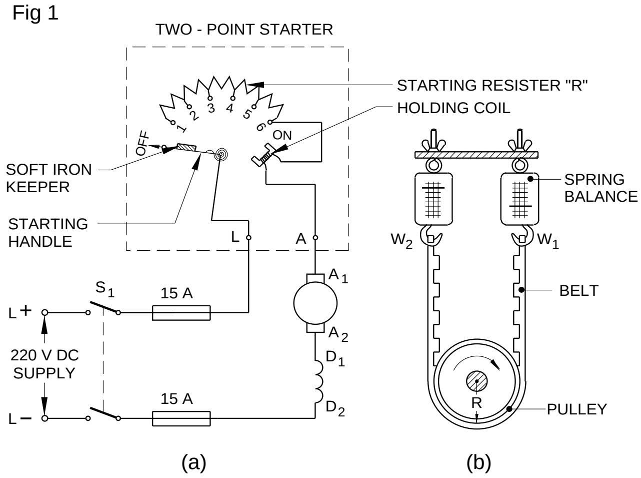
4 Connect the motor as per circuit diagram (Fig 1) and get it approved by the instructor.

Check whether the belt is in position for loading the pulley and keep it in slight load position.

5 Switch ‘ON’ the ICDP after inserting the fuse carriers and move the 2-point starter gradually in clockwise direction till the ‘ON’ position is reached. Leave handle in “ON” position and observe the direction of rotation.

6 Record the direction of rotation from non driving end side in Table 1.

Fig 1



STARTING A DC SERIES MOTOR

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

8 Stop the motor by switching off the ICDP and wait till the starter handle comes to 'OFF' position. Remove the fuse.

> **If the 2-point starter provided to you is without a 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.**

TABLE 1

Sl. No.	Figure	Direction of rotation	Speed in rpm.
1	Fig 1		
2	Fig 2		
3	Fig 3		
4	Fig 4		

— — — — — — — —

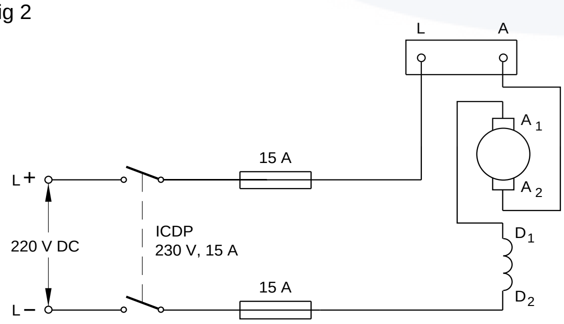
TASK 2:- **Reverse the direction of rotation.**

METHOD 1 : By changing the armature terminals

1 Draw the circuit diagram for the said method and get approved by your instructor.

2 Connect the motor as per diagram (Fig 2) and check the loading arrangement for correctness. Repeat the steps 5 to 8 of Task 1.

Fig 2



REVERSING THE DIRECTION OF ROTATION OF A DC SERIES MOTOR BY CHANGING ARMATURE CONNECTION

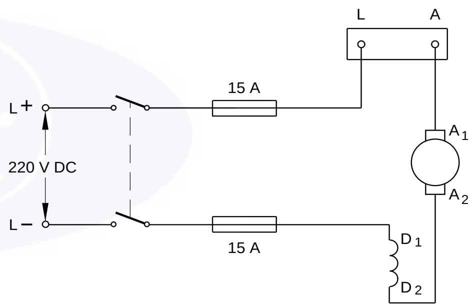
METHOD 2 : Reverse the direction of rotation by changing the field terminals.

1 Draw the circuit diagram for the said method and get approved by your instructor.

2 Connect the motor as per diagram (Fig 3) and check the loading arrangement for its correctness. Repeat the steps 5 to 8 of Task 1.

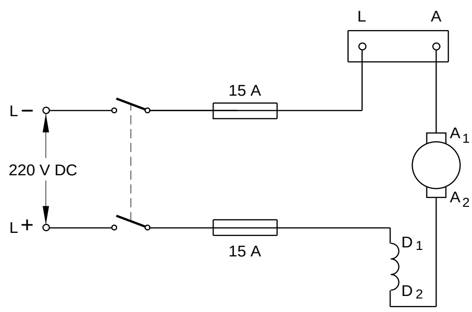
3 Effect of changing the supply terminals on the direction of rotation could be checked by connecting the DC series motor as shown in Fig 4. Check the loading arrangements for correctness. Repeat the steps 5 to 8 of Task 1.

Fig 3



REVERSING THE DIRECTION OF ROTATION OF THE DC SERIES MOTOR BY CHANGING FIELD CONNECTION

Fig 4



NO EFFECT ON THE DIRECTION OF ROTATION OF THE DC SERIES MOTOR BY CHANGING THE SUPPLY TERMINALS

4 Compare the connections of Fig 3 and Fig 4. Check the direction of rotation in both the cases.

5 Write the conclusion based on this experiments in the space given below.

CONCLUSION

____

____

____

Connect, start, run and reverse a DC compound motor

Objectives : At the end of this exercise you shall be able to
- **identify the terminals of the DC compound motor**
- **identify the parts of a 4-point starter**
- **connect, start and run the DC compound motor through 4-point starter (long shunt)**
- **reverse the direction of rotation of the DC compound motor**
  - by changing the armature connections
  - by changing the shunt field and series field connections
- **measure the speed of the motor by using a revolution counter and a stopwatch.**

Requirements

Tools/Instruments

- Trainees tool kit - 1 No.
- DE spanner set 6 mm to 19 mm - 1 set
- Megger 500 V - 1 No.
- Test lamp with 240 V 25 watts lamp - 1 No.
- Shunt ohmmeter or multimeter - 1 No.
- Revolution counter cyclometer 4 digits - 1 No.
- Stopwatch 30 minutes - 1 No.

Equipment/Machines

- Motor compound DC 220 volts 2 to 3 H.P. - 1 No.
- ICDP switch 240 volts 16 amperes - 1 No.
- 4-point starter 220 V 16 A - 1 No.

Materials

- PVC insulated stranded copper cable 2.5 sq mm. 660 V grade - 6 metres.

PROCEDURE

TASK 1: **Connect, start and run a DC compound motor (long shunt) through a 4-point starter.**

1 Switch off the main switch and remove fuse carrier of the given DC compound motor.

2 Read and interpret the name-plate details of the given DC compound motor and enter in your practical note book.

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

4 Design and draw the circuit diagram for the said task and get it approved by your instructor.

5 Collect the switch, starter and cables according to the diagram and check their condition.

The ratings of the switch, starter cables etc given in this sheet are for a DC compound motor of 220 V 3 HP rating.

6 Open the 4-point starter, trace the connection, sketch the internal parts and draw the diagram. Measure the value of the starting series resistor, protective resistor, no-volt coil and enter the values in Table 1.

7 Give the connections as per diagram (Fig 1) and get it approved by your instructor.

8 Switch ON the ICDP after inserting the fuses and move the starter handle gradually until the 'ON' position is reached and leave the handle in "ON" position.

TABLE 1

Sl. No.	Value of the series resistor of the starter (in ohms)	Value of the protective resistor (in kilo-ohms)	Value of the no-volt coil resistance (in ohms)

9 Observe the direction of rotation of the motor. The direction of rotation of the motor is _______.

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

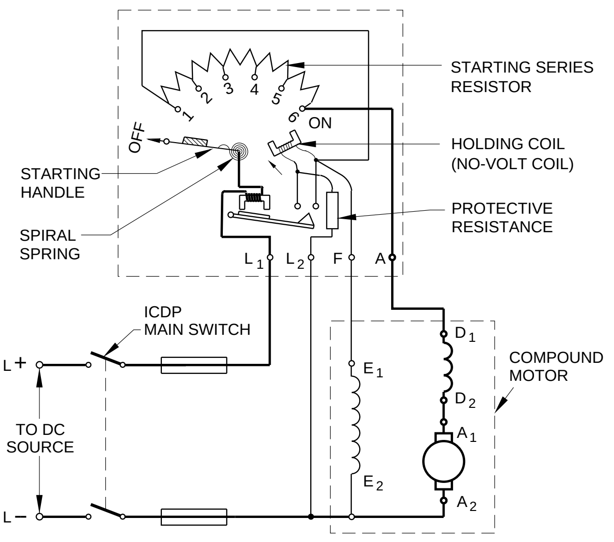
11 Take the stopwatch and set its reading to zero.

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 and stopped at the same time.

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

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

Fig 1



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

14 Press the start button of the revolution counter and the stopwatch simultaneously.

15 Just when the stopwatch reads one minute, press the 'off' button of the stopwatch and the revolution counter simultaneously and read the revolution per minute.

The observed speed of the motor in revolution per minute is ______________.

If you are not able to stop the stopwatch exactly in one minute's time, find out the rpm. through calculation by applying the following formulae.

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

$$= \frac{\text{Number of revolution in the counter (N)}}{\text{Stopwatch time in 'X' minutes}}$$

16 Stop the motor by switching off the ICDP switch and wait till the shaft comes to rest. Remove the fuses.

— — — — — — — —

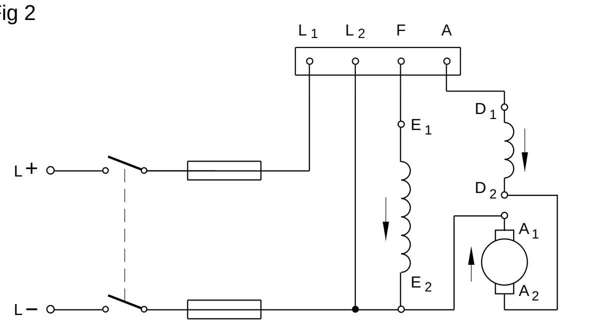
TASK 2: **Reverse the direction of DC compound motor (Long shunt).**

METHOD 1 : By changing armature connections.

1 Draw the circuit diagram for the said method and get it approved by instructor.

2 Connect the circuit as per diagram (Fig 2) and get it approved by your instructor.

Fig 2



3 Switch 'ON' the ICDP after inserting the fuses and start the motor by the starter; observe the direction of rotation from Non-Driving End (NDE) side.

The direction of rotation of the motor is __________.

3 Stop the motor by switching off the IC.DP switch; wait until the motor stops completely and remove the fuses.

METHOD 2 : By changing the shunt field and series field terminals.

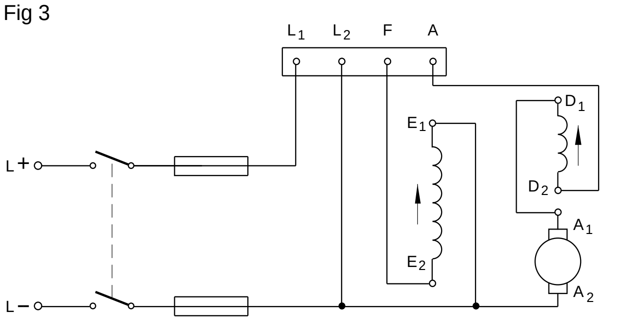
In this case the series field terminals also need to be changed along with shunt field to retain the earlier characteristics of the compound motor.

1 Draw the circuit diagram for the said method and get it approved by instructor.

2 Connect the circuit as per diagram (Fig 3) and get it approved by your instructor.

3 Switch ON the ICDP after inserting the fuses and start the motor by the starter and observe the direction of rotation. The direction of rotation of the motor is _______________.

Fig 3



4 Switch off the supply and remove the fuses. Write your observation regarding the method of changing the direction of rotation of the DC compound motor.

5 Show your observation to your instructor.

6 Disconnect the connections and keep the tools, equipments and materials in their places.

— — — — — — — —

Conduct performance test on a DC shunt motor

Objectives : At the end of this exercise you shall be able to
- **connect the 4-point starter and start the DC shunt motor**
- **measure the speed of the machine**
- **load the DC shunt motor**
- **draw the characteristic curves for**
  - **speed versus load**
  - **torque versus load**
  - **speed versus torque**
- **determine the efficiency of the DC shunt motor at different loads.**

Requirements

Tools/Instruments

- Trainees tool kit - 1 No.
- Megger 500 V - 1 No.
- Test lamp - 1 No.
- Multimeter/ohmmeter 0 to 2 k ohms - 1 No.
- DE spanner set 6 mm to 19 mm - 1 set.
- Tachometer 300 to 3000 rpm. - 1 No.

Equipment/Machines

- DC shunt motor 220 V 2/3 HP - 1 No.
- 240 V 16 A ICDP switch - 1 No.
- 220 V 4-point starter for DC motor 3 HP - 1 No.
- Rheostat 100 ohms 2 amps - 1 No.
- 0 - 10 A DC ammeter - 1 No.
- 0 - 300 V MC voltmeter - 1 No.
- Brake test arrangement with two spring balances of 25 and 50 kg rating - 1 set.

Materials

- PVC insulated multi-strand copper cable 2.5 sq mm 660 V rating - 6 m.
- Fuse wire 16 amps - as reqd.

PROCEDURE

TASK: **Determine the relation between load curent, speed and torque**

1 Switch 'OFF' the mains and remove the fuses of the given DC shunt motor.

2 Read and interpret the name-plate details and enter in your practical note book.

3 Determine the terminals of the DC shunt motor.

4 Test the shunt motor for continuity, short circuit and insulation resistance between

a the windings

b the windings and the earth.

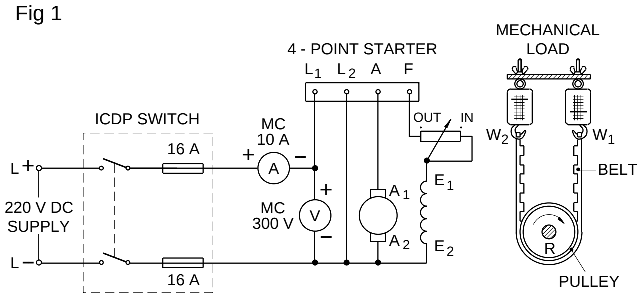
5 Draw the circuit diagram for the said task and get it approved by your instructor.

6 Collect the ICDP switch, cables, fuse wire and 4-point starter according to the diagram and check their condition.

> **Rating given for the switch, fuse, cable and 4-point starter in this exercise is for 220 V 3 HP motor only.**

7 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 at zero value and get approval from the instructor.

Fig 1



PERFORMANCE TEST ON THE DC SHUNT MOTOR

8 Switch 'ON' the ICDP after inserting the fuses and move the 4-point starter handle, gradually up to the 'ON' position and kept it in "ON" position.

9 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 1.

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

11 For each step, measure the speed, read the meters, spring balances and record them in Table 2. Load the motor up to its full load value.

12 Gradually reduce the load and switch OFF the motor, ICDP and remove the fuses.

13 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 metres.

where

W_1 - is the reading of the tight side spring balance and

W_2 - is the reading of the slack side spring balance in kilograms.

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

15 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.

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

Use different colours for each curve.

17 Write the conclusion highlighting the relation between

– speed and load

– torque and load

– torque and speed.

____

____

____

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

Output = $\frac{2\pi NT}{60}$ Newton metres/sec. or watts

where 'N' is the speed in r.p.m.

'T' is the torque in Newton metres

(To convert the torque in kg metre to Newton metre multiply kg m x 9.81)

Input = VI watts

where V is the applied voltage, I is the line current.

Hence efficiency (%) = $\frac{\text{Output}}{\text{Input}} \times 100$ %

$= \frac{2\pi NT \times 100}{60 \times VI}$ %

TABLE 1

Sl. No.	Applied voltage (volts)	Line current (amps)	Input = VI watts	Spring balance		Radius of pulley (metre)	'T' Torque in (Kilogram metre)	'T' Torque in (N.m) Nm = 9.81 x kg m	'N' Speed in rpm	OP = $\frac{2\pi NT}{60}$ Nm/sec or watts	Efficiency (%) $\frac{\text{Output}}{\text{Input}} \times 100$
				W_1	W_2						

Conduct performance test on a DC series motor

Objectives : At the end of this exercise you shall be able to
- **measure the series field resistance**
- **connect the two-point starter and start the motor**
- **measure the speed of the machine**
- **vary the load of the DC series motor**
- **determine the performance characteristic of the DC series motor and draw the following curves**
  - **- speed versus load**
  - **- torque versus load**
  - **- speed versus torque.**

Requirements

Tools/Instruments

- Trainees tool kit - 1 No.
- D E spanner set 6 mm to 19 mm - 1 set.
- 500 V Megger - 1 No.
- Test lamp 240 V, 100 W - 1 No.
- Multimeter/ohmmeter 0 to 2 kilo-ohms - 1 No.
- M C ammeter 0-16 A - 1 No.
- M C voltmeter 0-300 V - 1 No.
- Tachometer 300 - 10000 rpm. - 1 No.

Equipment/Machines

- DC series motor 220 V 2 to 3 HP - 1 No.
- ICDP switch 240 V 16 A - 1 No.
- 2-point starter for the given DC series motor - 1 No.
- Dial type spring balance 25 kg capacity - 2 Nos.
- Prony brake system complete - 1 set.

Materials

- 2.5 sq.mm PVC multi-strand copper cable 660 V grade - 6 m
- Fuse wire 15 amps - as reqd.

PROCEDURE

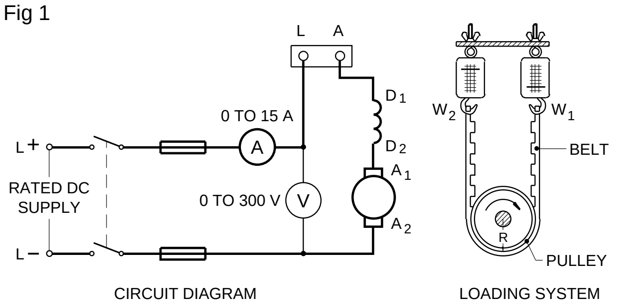
1 Switch off the main switch and remove the fuses of the given DC series motor.

2 Note down the name-plate details in your practical note book.

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

4 Draw the circuit diagram for teh said task and get it approved by your instructor (Fig 1).

Fig 1



DC SERIES MOTOR

5 Collect the equipments, apparatus and cables and check their condition.

> **The DC series motor should not be started or made to run without load. Make sure that the motor is loaded atleast with a slight load.**

6 Connect the circuit as per the diagram or as per Fig 1 and get it approved by your instructor.

7 Insert the fuses and switch on the ICDP switch.

8 Start the DC series motor by gradually moving the starter handle to 'ON' position and keep it 'ON' position.

9 Observe the speed, load current and input voltage. Adjust the load current to 1/4th of the full load value by adjusting the load.

10 Measure the speed, load current voltage and spring balance reading, and record them in Table 1.

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

12 Tabulate all the readings in the tabular column provided in Table 1.

13 After taking all the readings, stop the motor by switching off the ICDP and remove fuses.

Do not remove the mechanical load before switching off.

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

Radius of the pulley ..... metres.

15 Draw the following characteristic curves.

a) Speed versus load

b) Torque versus load

c) Speed versus torque

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

CONCLUSION

____

____

____

TABLE 2

Sl. No.	Applied voltage (volts)	Line current (amps)	Input = VI watts	Spring balance		Radius of pulley (metre)	'T' Torque in (Kilogram metre)	'T' Torque in (N.m) Nm = 9.81 x kg m	'N' Speed in rpm	O/P = $\frac{2\pi NT}{60}$ Nm/sec or watt	Efficiency (%) $\frac{Output}{Input} \times 100$
				W_1	W_2						

Conduct performance test of a DC compound motor

Objectives : At the end of this exercise you shall be able to
- **test and identify the terminals of the DC compound motor**
- **connect the 4-point starter with the DC compound motor and start the motor**
- **load the DC compound motor**
- **determine the performance characteristic of a DC compound motor at different loads**
- **draw the characteristic curves for**
  - **– speed versus load**
  - **– torque versus load**
  - **- speed versus torque**
  - **– load versus efficiency.**

Requirements

Tools/Instruments

- Trainees tool kit - 1 No.
- DE spanner set 6 mm to 19 mm - 1 set.
- Test lamp 240 V, 100 W - 1 No.
- Tachometer - 1 No.
- Megger (0-500 V) - 1 No.
- Multimeter/ohmmeter 0 to 2 k ohms - 1 No.
- MC voltmeter 0 - 300 volts - 1 No.
- DC Ammeter 0 to 10 A - 1 No.

Equipment/Machines

- 220 V 3 HP DC compound motor with prony brake loading arrangement - 1 No.
- ICDP switch 240 V 16 A - 1 No.
- 4-point starter 250 V suitable for DC 3 HP compound motor - 1 No.
- SPST knife switch 240 V 16 A - 1 No.
- Rheostat 220 ohms 3.7 amps - 1 No.

Materials

- 2.5 sq mm PVC insulated multi-strand copper cable - 6 m.
- Fuse wire 6A, 10 A - as reqd.

PROCEDURE

TASK 1: **Identify the terminals and test the condition of the DC compound motor.**

1 Switch off the main switch and remove the fuses of the given DC compound motor.

2 Read and interpret the name-plate details and enter in your practical note.

3 Identify the terminals of the DC compound motor.

4 Test the DC compound motor for continuity, insulation and ground faults, and make sure the machine is in good condition.

The rating of the switch, fuse cable and 4-point starter should be changed according to the rating of the given DC compound motor.

— — — — — — — —

TASK 2: **Connect the machine as long shunt cumulative compound motor and test it for its performance.**

1 Draw the circuit diagram for the said task and get it approved by your instructor.

2 Collect cables, ICDP switch and loading arrangement according to the diagram and check their condition.

3 Connect the machine as long shunt (cumulative) compound motor with the switches, fuses, meters and starter as per diagram (Fig 1) and get it approved by the instructor.

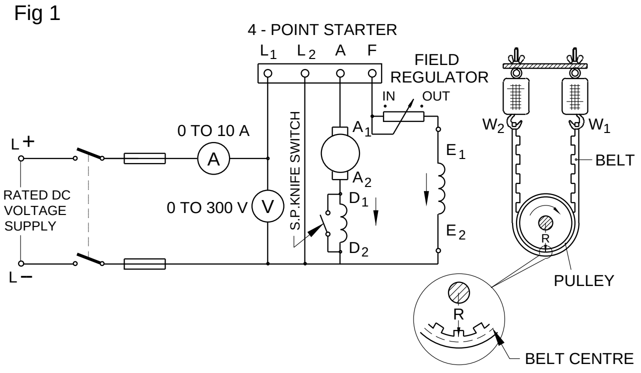
4 Arrange the prony brake for loading the motor.

5 Keep the series field shorted by the SPST knife switch.

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

6 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.

Fig 1



DC COMPOUND MOTOR (LONG SHUNT CUMULATIVE)

7 Open the series field shorting switch.

8 Measure the speed and adjust the speed to the rated value and note down the readings in Table 1.

9 Increase the load step by step up to the full load.

When applying the load the speed may increase if it is differential mode. Then stop the motor and interchange the connections of the series field for cumulative.

10 For each step of increasing the load, measure the speed, read the meters and spring balances and record them in Table 1.

11 Gradually reduce the load, switch off the motor.

12 Measure the pulley radius for calculating the torque.

Radius of pulley = ... metre.

The torque = (W_1 – W_2) in kgs x Radius in meters. T = kg metre. where W_1 is the tight side spring balance reading and W_2 is the slack side spring balance reading in kgs.

13 Calculate the torque in Newton–metre = kg. metre x 9.81

14 Calculate the input = V x I in watts.

15 Calculate the output

$= \frac{(2\pi NT)}{60}$ Newton metres/sec. or watts.

16 Calculate the percentage efficiency = (OP x 100)/IP.

17 Enter the values of the efficiency for various load currents in Table 1.

18 Draw the speed-load characteristic curve keeping the load current in the X-axis and speed in the Y-axis.

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

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

21 Write your conclusion highlighting the relation between
speed vs load
torque vs load
speed vs torque.

CONCLUSION

____

____

____

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

TABLE 2

Sl. No.	Applied voltage (volts)	Line current (amps)	Input = VI watts	Spring balance W_1 W_2	Radius of pulley (metre)	'T' Torque in (Kilogram metre)	'T' Torque in (N.m) Nm = 9.81 x kg m	'N' Speed in rpm	O/P = $\frac{2\pi NT}{60}$ Nm/sec or watt	Efficiency (%)

— — — — — — — —

TASK 3:- **Connect the machine as a long shunt differential pound motor and test it for its performance.**

Tasks 3 and 5 to be carried out by the trainees under the direct supervision of the instructor.

1 Complete the circuit given in Fig 2 for long shunt differential compound motor keeping in view the note under step 9 of Task 2 and get the approval of your instructor.

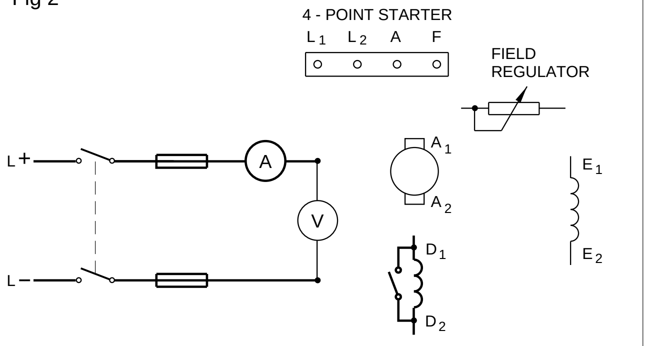
2 Connect the machine as a long shunt differential compound motor with the switches, meters and starter as per the approved diagram shown in Fig 2.

3 Repeat the steps 3 to 10 of Task 2 but enter the readings in Table 2.

If the connections are correct, the speed may increase at the increased load.

4 Repeat the steps 11 to 19 of Task 2 and write the conclusions.

Fig 2



DC LONG SHUNT DIFFERENTIAL COMPOUND MOTOR

CONCLUSION

TABLE 2

Sl. No.	Applied voltage (volts)	Line current (amps)	Spring balance W_1 W_2	Radius of pulley (metre)	'T' Torque in (Kilogram metre)	'T' Torque in (N.m) Nm = 9.81 x kg m	'N' Speed in rpm	O/P = Nm/sec or watt	Efficiency (%)

— — — — — — — —

Control the speed of a DC shunt motor by armature resistance control & field control method

Objectives : At the end of this exercise you shall be able to
- **connect, start and run the the DC shunt motor**
- **measure the speed of the DC motor**
- **vary the speed of the DC shunt motor with the help of armature circuit resistance, and find the relationship between armature voltage and speed.**
- **connect the DC shunt motor through a 4-point starter and a shunt field regulator**
- **vary the speed of the DC motor with the help of the shunt field control regulator and find the relationship between the field current and speed.**

Requirements

Tools/Instruments

- Trainees tool kit - 1 No.
- Tachometer 150 to 3000 rpm. - 1 No.
- Megger 500 V - 1 No.
- Test lamp 240V, 10W - 1 No.
- Rheostat 50 ohms 4.1 amps - 1 No.
- Voltmeter MC 0 to 300 V - 1 No.
- Ammeter MC 0 to 15 A - 1 No.

Equipment/Machines

- DC shunt motor 220 V 3 HP - 1 No.
- ICDP switch 240 16 A - 1 No.
- Rheostat 250 Ohms, 3.7 A - 1 No.
- 4 point starter 15 A, 250 V - 1 No.

Materials

- PVC insulated stranded copper cable 2.5 sq.mm 660 V grade - 10 mts
- Fuse wire 15 amps - as reqd.

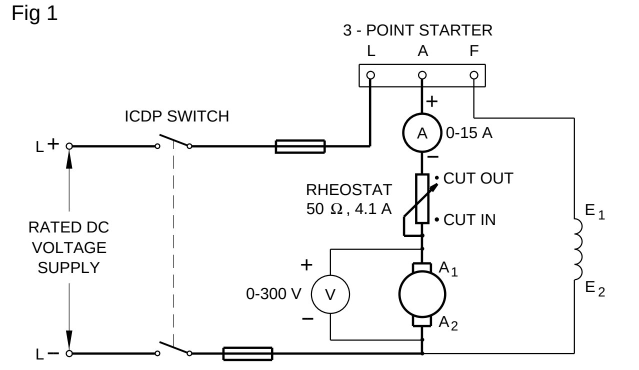
PROCEDURE

TASK 1: **Armature control method of DC shunt motor**

1 Draw the circuit diagram for the said task and get it approved by your instructor.

2 Collect a 3-point starter, rheostat, ammeter and voltmeter according to the diagram and check their condition.

Fig 1



SPEED CONTROL OF THE DC SHUNT MOTOR BY ARMATURE CONTROL METHOD

3 Make the connections as per the circuit diagram (Fig 1) and get approval from your instructor.

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

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

6 Measure the speed, armature current, voltage across the armature and enter them in Table 1.

TABLE 1

Sl. No.	Armature current (I_a)	Voltage across armature	Speed (rpm)	Remarks

7 Gradually increase the armature circuit resistance in steps. Measure and record the speed and corresponding armature current and voltage across the armature in Table 1.

8 Switch 'OFF' the supply to the motor and remove the fuses.

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

10 Write your observation highlighting the relationship between voltage across the armature and speed.

NOTE

(Back emf) E_b = Applied voltage – Total armature circuit voltage drop

$$= E - I_a R_T \text{ (where } R_T = R_a + R_{ar})$$

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

E_b = Applied voltage - [Internal armature resistance drop ($I_a R_a$) + External armature rheostat drop ($I_a R_{ar}$)]

Assuming the internal armature resistance drop is negligible we can see that

Voltage across the armature = Back emf E_b.

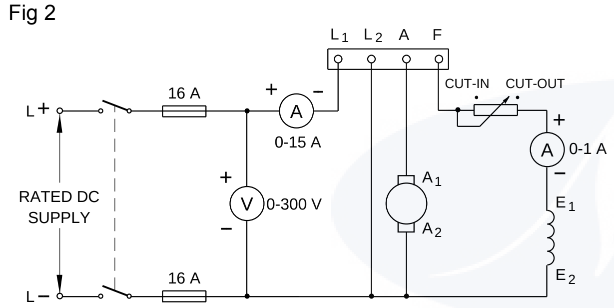
— — — — — — — —

TASK 2: **Field Control method of DC shunt motor**

1 Draw the circuit diagram for the said task and get it approved by your instructor.

2 Make the connections as per the circuit diagram (or as shown in Fig 2) and get it approved from the instructor.

Fig 2



SPEED CONTROL OF THE DC SHUNT MOTOR BY FIELD CONTROL METHOD

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

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

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

5 Measure the speed, field current, voltage, and enter them in Table 2.

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

7 Measure the speed, feild current, voltage and enter them in Table 2

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

TABLE 2

Sl. No.	Voltage	Line current	Field current	Speed

Calculate the 130% speed value from the name-plate details. Do not exceed the speed more than 130% of the rated value.

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

10 Switch 'OFF' the supply of the motor and remove the fuses.

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

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

OBSERVATION

____

____

____

— — — — — — — —

Overhaul a DC machine

Objectives: At the end of this exercise you shall be able to
- **conduct visual inspection of the electrical machine**
- **measure the resistance of windings and test the machine for insulation**
- **dismantle the DC motor**
- **remove, inspect and install the bearings**
- **clean the parts**
- **test the armature and inspect the commutator**
- **reassemble the DC machine**
- **adjust the brush tension and bedding of the brushes and correct the rocker arm position**
- **check the performance of the machine at no-load and load.**

Requirements

Tools/Instruments

• Trainees tool kit	- 1 No.
• Pulley puller 6" (150mm)	- 1 No.
• Center punch 100 mm length	- 1 No.
• Spanner set 6 mm to 19 mm	- 1 set.
• Tray 300 x 300 mm	- 1 No.
• Mid-head screwdriver 50mm	- 1 No.
• Megger 500 volts	- 1 No.
• Blowlamp 1/2 pint	- 1 No.
• External growler	- 1 No.
• 'Man-on-line' board	- 1 No.
• Multimeter/ohmmeter	- 1 No.

Equipment/Machines

- DC machine 2 to 3 HP 250 or 220 V.

Materials

• Kerosene	- 1 litre.
• Cotton cloth	- 1/4 sq. m.
• Carbon tetrachloride	- 500 ml.
• Round brush for cleaning,12mm	- 1 No.
• Petrol	- 200 ml.
• Sandpaper No.1	- 1 sheet.
• Hacksaw blade 300 mm	- 3 Nos.
• Sandpaper 'oo' smooth	- 1 sheet.
• Mobile oil SAE 40	- 1/2 litre.
• Cotton waste	-100 gms.
• Grease or equivalent	- 100 gms.
• Hardwood 3 sq.cm 20 cm long	- 2 pieces.

PROCEDURE

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

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

3 Check the maintenance card, if available, to locate the area of defect in the machine.

4 Remove the foundation bolts of the machine, shift the machine to the workbench and note the name-plate details in your practical note book.

If the motor is heavy keep it on the concrete floor. Keep the workbench/concrete floor clean and free from dirt and dust.

5 Conduct visual inspection of the machine and record the deflects, if any, in Table 1.

TABLE 1

Visual inspection report

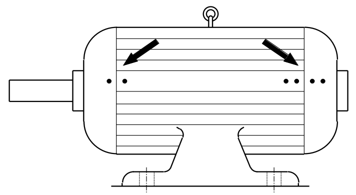
6 Measure the resistance and insulation value of the winding and armature and record in Table 2.

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

Do not use water.

8 Make punch marks on both the end covers and yoke in dot marks to help in aligning the end covers while reassembling.(Fig 1)

Fig 1



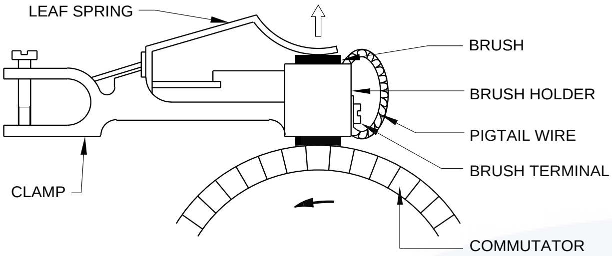
IDENTIFICATION PUNCH MARKS

9 Mark the rocker arm position with respect to the end covers.

10 Remove the brushes from the brush holder by taking the following steps.

- i Unscrew the brush terminal.
- ii Lift the leaf spring.
- iii Remove the brush from the brush holder. (Refer to Fig 2).

Fig 2

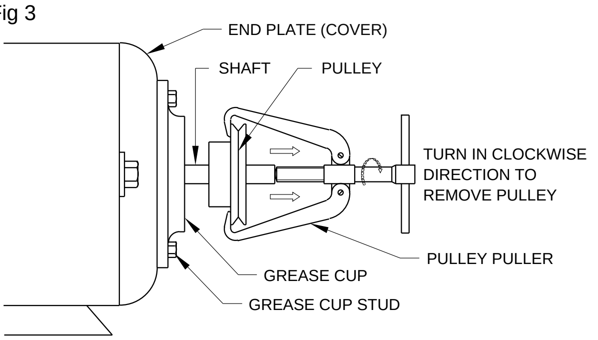


BRUSH HOLDER MECHANISM

11 If the pulley is found fitted in the shaft, remove it with a pulley puller as shown in Fig 3.

12 Remove the grease cup stud and open the grease cup. Refer to Fig 3.

Fig 3



REMOVAL OF THE PULLEY

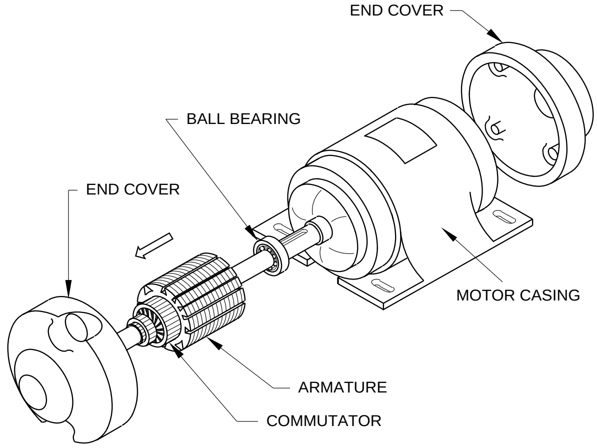
The screws, studs, bolts and nuts removed from the machine must be immersed in kerosene to remove the rust and dirt.

13 Loosen the studs in both the end covers and then remove the end covers on the shaft side using hardwood.

Slowly open one end of the end cover 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.

14 Remove the armature from the body of the machine as shown in Fig 4.

Fig 4

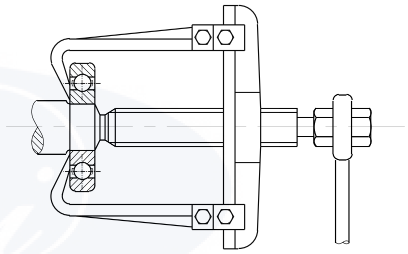


REMOVAL OF THE ARMATURE

15 Check the bearings for wear and tear, breakage or stall.

16 Remove the bearing using a bearing puller as shown in Fig 5.

Fig 5



REMOVAL OF THE BEARING

17 Clean the bearings in kerosene oil and then blow air to remove the dust, if any, and check the condition of the bearings.

Replace the bearings, if found defective.

18 Grease the bearing and cover it with plastic paper and store it.

New bearings need no cleaning. Do not remove the new bearing from package until it is needed. Before opening the new bearing keep the work-bench clean and tidy. For fixing the bearing in the shaft follow the guidelines given in Fig 6.

19 Clean the yoke and armature with a brush and an air blower. Clean the seating portion of end cover and yoke with sand paper.

20 Test the armature with a growler for any short or open.

21 Test the field winding for resistance value continuity and insulation resistance and record it in Table 2 (in the appropriate column).

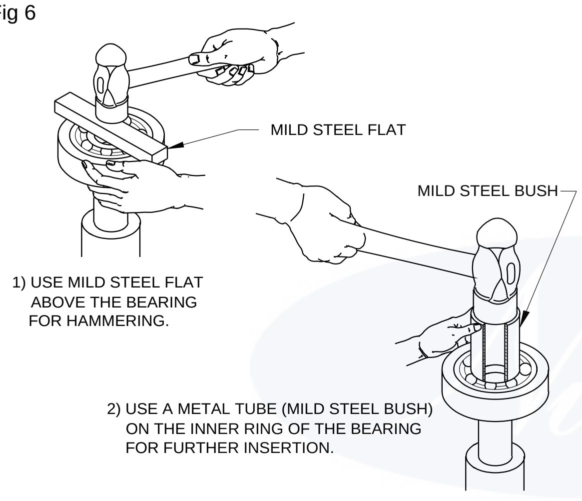
If the insulation is found weak, dislodge the field coils from the poles, re-insulate with leatheroid paper and apply varnish.

TABLE 2

Test report

Sl. No.	Between terminals	Before over hauling	During overhauling	After overhauling
	Insulation Resistance			
1	Armature and shunt field			
2	Shunt and series field			
3	Series field and armature			
4	Shunt winding to body			
5	Series winding to body			
6	Armature winding to body			
	Resistance Value			
7	Armature			
8	Series field			
9	Shunt field			

Fig 6



GUIDELINES FOR FIXING THE BEARING ON THE SHAFT

22 Reassemble the yoke, armature and end covers.

23 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 and at the same time feeling the shaft for free rotation.

24 Insert the brush in the holder, adjust the brush tension and bed the brushes by using a silicon abrasive paper above the brush commutator as shown in Fig 7.

25 Position the rocker arm in the end cover as per the original marking.

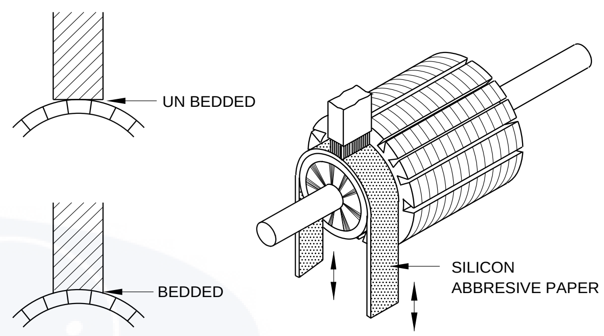
26 Test the winding and armature for resistance value continuity and insulation resistance, and record in Table 2 .

27 Connect the voltmeter, ammeter and the motor to the rated supply voltage and measure the no-load current, terminal voltage and rpm.

No-load current ________
Terminal voltage ________
rpm ____________________

28 Re-install the motor in the foundation and tighten the foundation bolts.

Fig 7



METHOD OF BEDDING THE BUSHES

29 Test it with the rated load and record the readings.
Full load current _____ V ____
rpm. _____________.

30 Observe whether the motor is operating smoothly without any vibration. A check list for mechanical functions is given in Table 3. Fill up all the possible columns after checking the operation of the motor.

TABLE 3

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

Maintain, service and troubleshoot the DC machine

Objectives : At the end of this exercise you shall be able to
- **interpret the name-plate details of the DC machine and record them**
- **visually inspect the DC machine and pre-test it to locate the fault, if any**
- **dismantle the DC machine and overhaul it**
- **maintain and service the parts of the DC machine**
- **reassemble and test the DC machine**
- **troubleshoot the DC machine**

Requirements

Tools/Instruments

• Trainees tool kit	- 1 No.
• Multimeter	- 1 No.
• Ammeter MC 0-500 mA	- 1 No.
• Ammeter DC 0-15 A	- 1 No.
• Voltmeter DC 0 - 300 V	- 1 No.
• Electric portable blower 240 V, 50 Hz	- 1 No.
• Growler - external with ammeter	- 1 No.
• Bearing puller	- 1 No.
• D.E. spanner set 2 mm to 20 mm	- 1 set
• File, flat bastard 250 mm	-1 No.
• File, flat smooth 250 mm	- 1 No.
• Megger 500 V	- 1 No.

Equipment/Machines

• DC machine 220 V, 3 HP	- 1 No.
• Arbor press	- 1 No.

Materials

• PVC insulated copper wire 2.5 sq mm, 660 V grade	- 10 mts.
• Cleaning brush 3 cm dia	- 1 No.
• Carbon tetrachloride (CTC)	- 50 ml.
• Grease type according to the machine	- as reqd.
• Kerosene oil	- 1 litre.
• Lubrication oil of required type	- as reqd.
• Cotton cloth	- as reqd.
• Sandpaper zero grade	- as reqd.
• Insulation tape steel grip 20 mm	- 0.2 mts.
• Fuse wire	- as reqd.

PROCEDURE

TASK 1: **Ascertain the condition of the DC compound motor.**

1 Confirm that the ain switch of the given compound motor is switched off and fuses are removed.

2 Interpret the name-plate details of the given DC machine and record in your practical note book.

3 Visually inspect the machine and enter your finding in Table 1.

4 Conduct the continuity test, resistance measurement and insulation test and enter the result in Table 2.

4 Obtain the above test values at the time of installation from the section in-charge and enter the values in Table 3.

A careful study of the test results and the result values, compared between the earlier and present conditions, clearly indicates how the machine behaves. Discuss the results with co-trainees and with the instructor.

5 Dismantle the DC machine.

6 Clean each part with the help of a brush and a blower.

TABLE 1

Visual inspection

Sl.No.	Description	Noticed as/at (strike out items not applicable)
1	Rotation of the shaft	Free / Slightly tight /Not rotating
2	Symptom of burn	Armature / Field / Commutator / Brush / Terminal block / No place
3	Burning smell	Armature / Field / Commutator / Brush / Terminal block / No place
4	Damaged parts	
5	Loose connection	

TABLE 2

Test results

Sl. No.	Description of the test	Test result at the time of instalation	Test result before servicing	Test result after servicing
1	Continuity between			
i	series field terminals	....	....	....
ii	shunt field terminals	....	....	....
iii	armature terminals.	....	....	....
2	Resistance value between			
i	series field terminals	....	....	....
ii	shunt field terminals	....	....	....
iii	armature terminals.	....	....	....
3	Insulation resistance value between			
i	series field and the frame	....	....	....
ii	shunt field and the frame	....	....	....
iii	armature and the frame	....	....	....
iv	series field and shunt field	....	....	....
v	series field and armature	....	....	....
vi	shunt field and armature.	....	....	....

— — — — — — — —

TASK 2: **Maintain and service the parts of the DC motor as stated below.**

If the field coil is found to be defective follow the procedural steps given below.

1 Measure the resistance of each field coil as shown in Fig 1 and compare with the value given by the manufacturer. If it is low or high, replace the coil with a similar coil of the correct value.

2 Measure the insulation resistance between the field terminals and the frame with a Megger as shown in Fig 2. If it shows low value disconnect the series connection of the field coils and check each field coil for insulation resistance. Replace the coil which has low insulation resistance (less than 1 megohm)with a new coil. Enter the defect and action taken to rectify the defect in Table 3 in the appropriate place.

In case the armature is found to be defective follow the procedural steps given below.

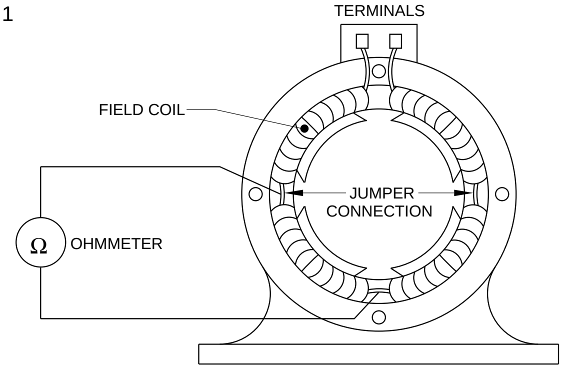
3 Test the armature for short or open circuits by connecting the ohmmeter test leads to two adjacent commutator bars, as shown in Fig 3.

4 Set a reading as near mid-scale as possible as shown in Fig 3.

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

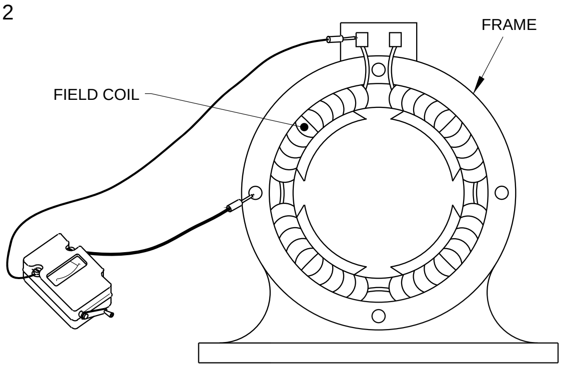
6 Record the defect and action taken in table 3.

Fig 1



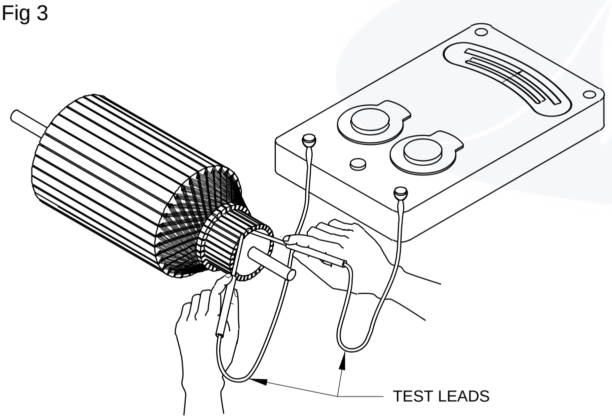
MEASUREMENT OF RESISTANCE IN FIELD COIL

Fig 2



INSULATION RESISTANCE MEASUREMENT BETWEEN TERMINAL AND FRAME

Fig 3



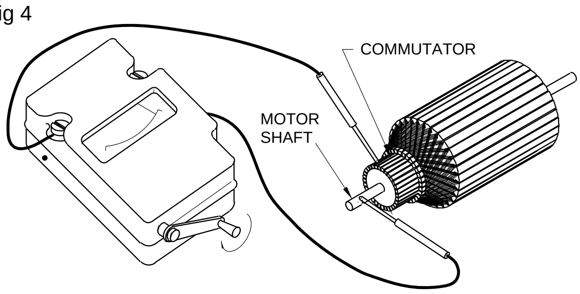
ARMATURE RESISTANCE TEST

6 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 as shown in Fig 4. Record the defect and the action taken to rectify the defect in Table 3 in the appropriate place.

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

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

Fig 4

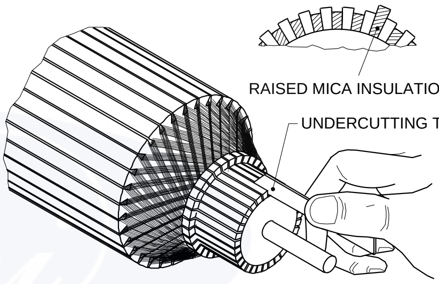


In case a single open or short or ground coil is detected in the above tests, the coil could be replaced with a similar coil. On the other hand if a number of coils are found to be defective, the armature needs to be rewound.

In case the commutator and brushes are found to be defective follow the procedure given below.

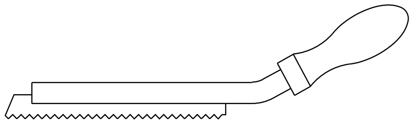
7 Check the commutator for raised mica insulation. If found, undercut the mica by using an undercutting tool. (Fig 5)

Fig 5



A tool made from a piece of hacksaw blade with the sides of the tooth ground down parallel to the thickness of the mica and held in a suitable holder as shown in Fig 6 could be used for undercutting the mica.

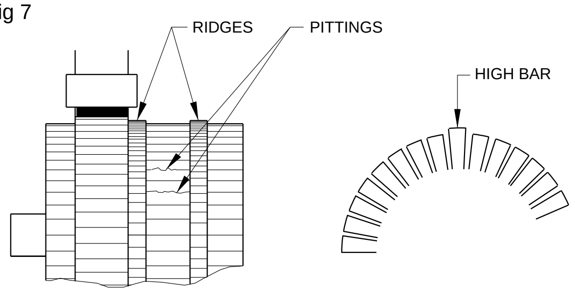
Fig 6



UNDERCUTTING TOOL

8 Check the commutator for pittings, ridges and high bars. (Fig 7). If any is found, they could be removed by skimming the commutator (turning in a lathe).

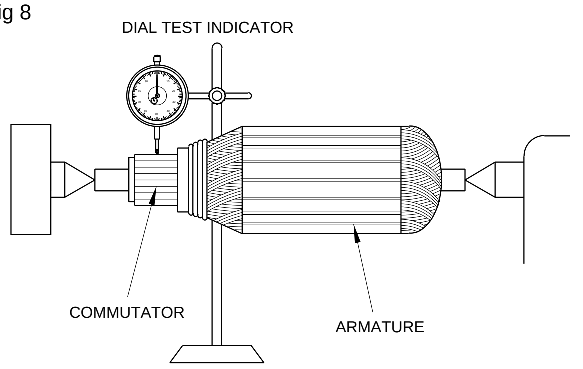
Fig 7



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

9 Before skimming (turning) check with a dial test indicator that the shaft centre is the true commutator centre as shown in Fig 8.

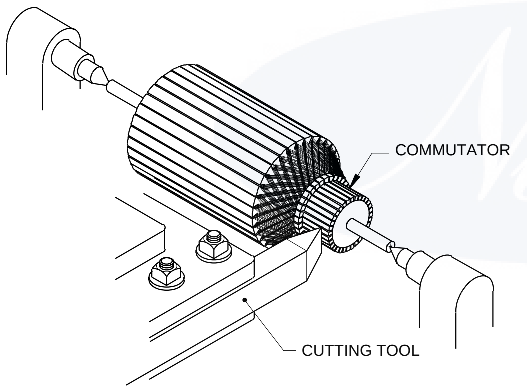
Fig 8



CHECKING OF COMMUTTATOR CENTER BY USING DIAL TEST INDICATOR

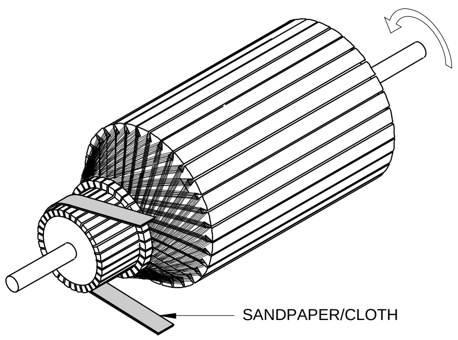
10 Get the help of a good turner to turn the armature in a lathe. Use a driving dog to turn the shaft and remove minimum copper from the surface of the commutator till the pitting, ridges and high bars are rectified. (Fig 9).

Fig 9



11 Use the sandpaper/sand- cloth to give a fine finish to the commutator surface by rotating the armature. (Fig 10) Enter the defect and the action taken to rectify the defect in Table 3 in the appropriate place.

Fig 10



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

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

12 Check the commutator connections in the raisers. If necessary, re-solder the suspected soldering spots.

13 Clean away the dust, dirt and carbon deposits from the brush holder and assembly using carbon tetrachloride. (CTC)

14 Check the length of the brushes.

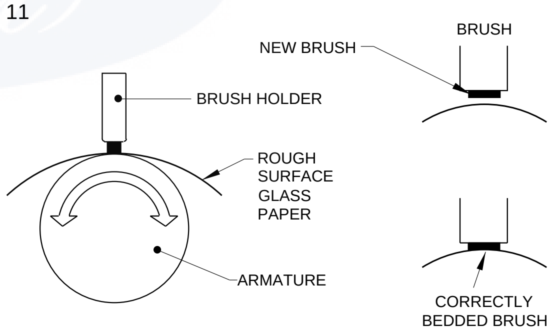
If the length of the brush is reduced to 1/3rd of the original length, the brush should be replaced.

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.

15 Check the new brush whether it slides freely in the holder without undue side play. If necessary file with a smooth file, keeping the brush sides parallel.

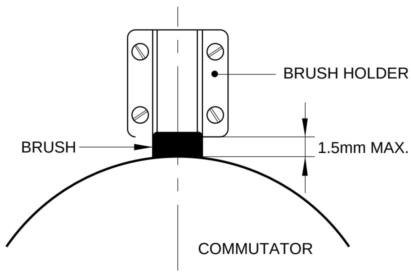
16 Insert the new brush and shape the end over the curve of the commutator, using glass- paper wrapped around the commutator and apply light pressure in the brush. (Fig 11)

Fig 11



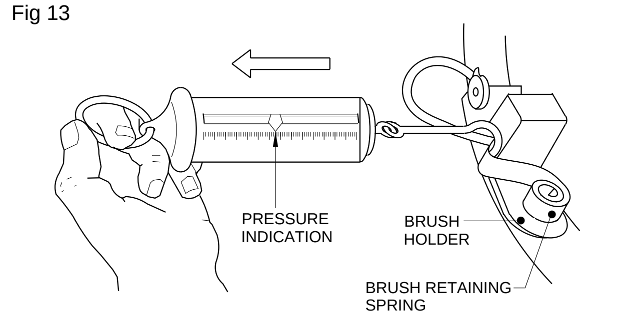
17 While assembling the brush in the brush holder check that the brush holder is not more than 1.5 mm (1/16 in.) away from the commutator surface. If necessary adjust, keeping it square to the commutator. (Fig 12)

Fig 12



18 Check the spring tension. If it is adjustable, set it to the minimum pressure that will prevent sparking or follow the instructions given by the manufacturer. (Fig 13)

Fig 13



19 Check the bearing for ply, wearing out and damage.

20 If found OK, clean the bearing using kerosene oil and then with lubrication oil.

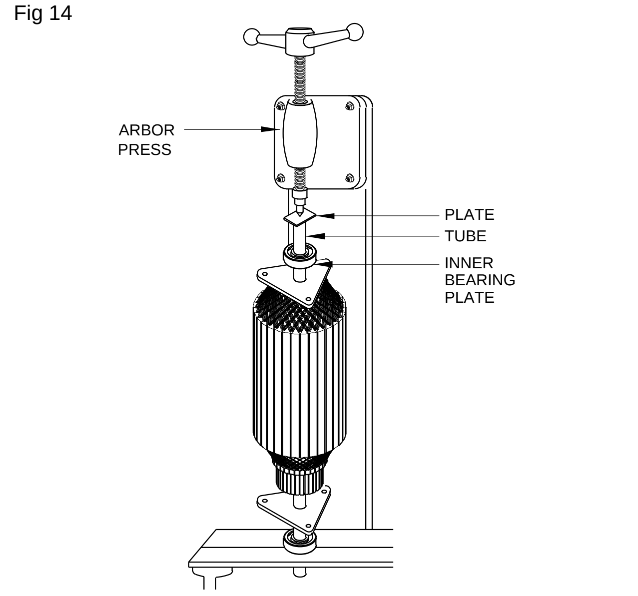
21 Pack the recess with a grease recommended by the manufacturer up to 80% of the space.

22 If the bearing is found defective, remove the defective one with the help of a bearing puller.

23 Replace it with a new bearing having the same specification.

24 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 14).

Fig 14



25 Assemble the DC motor and check if condition.

TABLE 4

Fault and rectification record

Sl.No.	Area of defect	Action taken for rectification
1	Fault in field coil	a Individual coil resistance measurement is the same as the other/not the same. b Individual coil insulation resistance is the same as the other/not the same.
2	Fault in the armature	a Shorted coil b Open coil c Grounded coil
3	Fault in the commutator	a Raised mica b Pittings in commutator surface c Burn at commutator segments d Ridges on commutator e High bars on commutator f Defective solder on raisers g Short between segments
4	Defect in brush	a Worn out b Loose fitting c Bad bedding d Defective spring tension
5	Defect in bearing	a Worn out b Damaged c Dry

— — — — — — — —

Connect the balanced and unbalanced loads in 3-phase star and delta system and measure the power of 3-phase loads

Objectives: At the end of this exercise you shall be able to
- **identify and connect the terminals of a single-phase wattmeter**
- **connect single wattmeter in star, balance the load and measure the power**
- **connect two wattmeters in the circuit as per the given diagram**
- **connect two wattmeters in unbalanced, star-connected load and measure the power**
- **identify and connect 3-phase wattmeter and measure the power in star.**
- **connect the balanced resistive load in delta and measure the phase and line voltage and current.**

Requirements

Tools/Instruments

- Single-phase wattmeter 250V/5A - 1 No.
- Wattmeter 500V/5A - 2 Nos.
- PF meter, single phase 250V,5A - 1 No.
- Voltmeter 0-500 V M.I. - 1 No.
- Ammeter 0-5A M.I. - 1 No.
- ICTP Switch (16 A 500 V) - 1 No.

Equipment/Machines

- 3-phase, 415V AC induction motor 3 HP coupled with DC generator - 1 No.

Materials

- 200W, 240V lamps - 3 Nos.
- 100W, 240V lamps - 3 Nos.
- Capacitor 400V AC 4 MFD - 2 Nos.
- Connecting leads - as reqd.
- Pendent-holders 6A 240V - 6 Nos.

PROCEDURE

TASK 1: **Connect balanced load in star and measure the power with one single element wattmeter.**

1 Connect the circuit as per the given circuit diagram. (Fig 1)

> **Connect proper voltage and current ranges of wattmeters suitable to the given load.**

2 Switch `ON' the 3-phase supply and read the wattmeter and record the wattmeter readings in Table 1.

3 Measure the power in the other two phases by connecting the wattmeter in turn and record.

4 Total the readings of the wattmeters and check its confirmity with the calculated total power.

5 Repeat steps 1 to 4 for different load conditions.

Fig 1

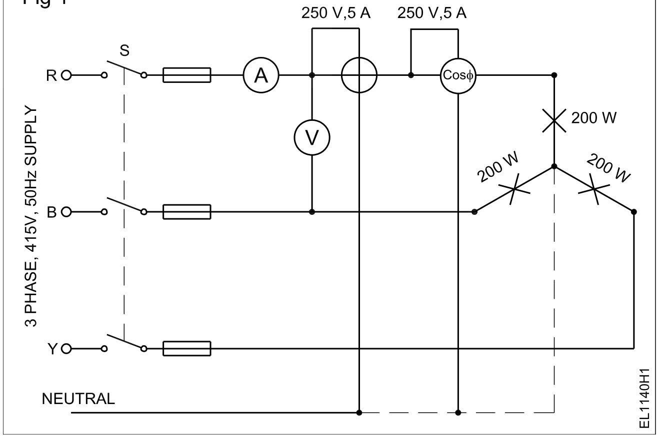


TABLE 1

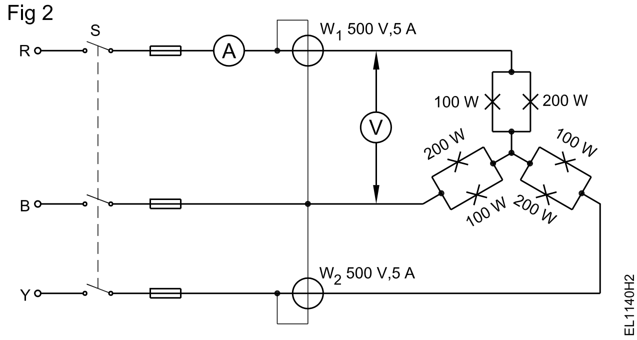
Type of Load	Wattmeter connected in the line						Calculated Total power	Total power = Total of three wattmeter readings
	W_R	W_Y	W_B	E_L	I_L	P_F	$W=\sqrt{3}\,E_L I_L \cos\theta$	$W_R + W_Y + W_B = W$
1								
2								
3								
4								

TASK 2:- **Power measurement by two-wattmeter method in 3-phase load**

1 Connect the circuit as per the given circuit diagram. (Fig 2)

> **Connect proper ranges of meters suitable for the given load.**

Fig 2



2 Switch on the 3-phase supply and observe for the proper deflection of wattmeters. If both wattmeters deflect properly, go to step 4, otherwise continue from step 3.

3 Switch off the supply, if any one wattmeter deflects in the reverse direction. Change the connection of the current coil of the reverse deflected wattmeter. Go to step 5.

4 Read the wattmeters W_1 & W_2 and record in Table 2. Add the readings W_1 and W_2 and record the total power; go to step 6.

5 Switch on the supply and read the wattmeters W_1 & W_2. Record the values in the table. Record the readings of the wattmeter with the changed current coil as negative quantity.

6 Measure the 3-phase power for different load conditions specified below:

R = 400 W bulb

Y = 400 W bulb parallel 4 MFD capacitor

B = 200 W bulb

> **The instructor should personally connect 3ϕ motor for proper running.**

7 Calculate the PF in all the above cases and enter them in Table 2

TABLE 2

Type of load	W_1	W_2	Total ($W_1 + W_2$)	Calculate PF (Cosθ) $\tan\theta = \frac{3\sqrt{W_1 - W_2}}{W_1 + W_2}$ Determine Cosθ

— — — — — — — —

TASK 2: **Connect the balanced resistive load in delta and measure the phase and line voltage and current**

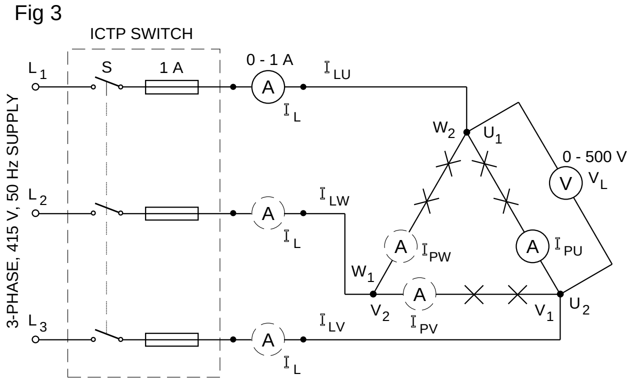
1 Form the circuit as per the circuit shown in Fig 3.

2 Switch ON the 3-phase supply. Measure the line voltages by connecting the voltmeter leads between two of the terminals U_1V_1, V_1W_1, W_1U_1.

3 Measure the phase voltage by placing the voltmeter leads across the lamps i.e. U_1U_2 or V_1V_2 or W_1W_2.

4 Record the line voltages and phase voltages measured under the appropriate column in Table 3.

Fig 3



5 Measure the line and phase currents and enter the readings in Table 3.

An ammeter connected between the supply and load indicate line current. An ammeter connected in series with single load (two lamps in series) will indicate phase current.

6 Repeat the above steps for different lamp loads.

Connect 2 equal wattage lamps of 240V in series across 415V supply.

7 Find the ratio between line and phase value of voltages. i.e.

$$\frac{V_{U1V1}}{V_{U1U2}} =$$

$$\frac{V_{V1W2}}{V_{V1V2}} =$$

$$\frac{V_{W1U2}}{V_{W1W2}} =$$

8 Verify the ratio between the line current and phase current taking into consideration 200 watts load. i.e.

$$\frac{I_{LU}}{I_{PU}} = \frac{I_{LV}}{I_{PV}} = \frac{I_{LW}}{I_{PW}} = \_\_\_\_\_\_$$

RESULT

In Delta:

Line current = ______________ X phase current.

Line voltage and phase voltage are __________

TABLE 3

S. No.	Load in Watts per phase	Line Voltage			Phase Voltage			Line Current			Phase Current		
		V_{U1V1}	V_{V1W1}	V_{W1U1}	V_{U1U2}	V_{V1V2}	V_{W1W2}	I_{LU}	I_{LV}	I_{LW}	I_{PU}	I_{PV}	I_{PW}
1	40 W												
2	100 W												
3	200 W												

— — — — — — — —

Identify the terminals and measure the insulation resistance and earth effectiveness of a 3-phase induction motor

Objectives : At the end of this exercise you shall be able to
- **read and interpret the name-plate details of an AC 3-phase induction motor**
- **test and identify the terminals of the 3-phase induction motor by 1) the two lamp method 2) the voltmeter method 3) the single lamp method.**
- **perform the insulation resistance test between the phase windings**
- **perform the insulation resistance test between the winding and the body**
- **test the effectiveness of earth connection.**

Requirements

Tools/Instruments

- Trainees tool kit - 1 No.
- D.E. spanner 6 mm to 19 mm - 1 set
- Megger 500 V - 1 No.
- Ohmmeter - low range 0-10 ohms - 1 No.
- Earth tester with spikes and connecting leads - 1 set
- Voltmeter MC 0-10 V - 1 No.
- Ammeter 0-20 A MC - 1 No.
- Calibrated rheostat 0-1 ohms 10 amps - 1 No.
- Battery 6 V,60 AH - 1 No.
- MI voltmeter 300 V - 1 No.
- MI voltmeter 500 V - 1 No.

Equipment/Machines

- AC 3-phase, 415 V squirrel cage induction motor - as available.

Materials

- Connecting cables 70/0.2 of 660 V grade and length 40 m - 1 No.
- Connecting cables 70/0.2 of 660 V grade and length 10m - 1 No.
- Testing prods - 1 pair.
- Test lamp 240 V, 60 W - 1 No.
- Pendent lamp-holder 240 V 6 A -2 Nos.

PROCEDURE

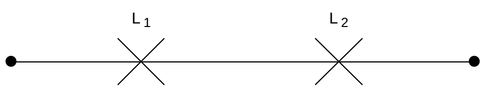
TASK 1: **Identifying the terminals of 3 phase induction motor**

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 of 240 V, 60 W or 100 watts each. (Fig 1)

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

Fig 1



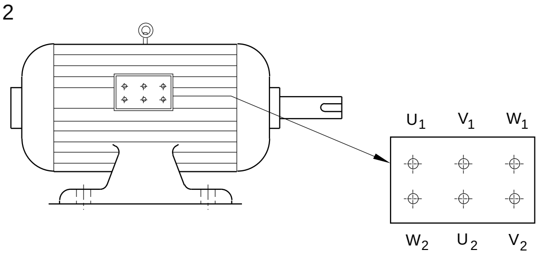
L_1, L_2 SHOULD BE EQUAL IN WATTAGE & VOLTAGE

3 After finding 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 and V for ‘V’ coil and W and W for ‘W’ coil.

Assuming the terminal marked as U_1 by you is the beginning of coil ‘U’ proceed as below.

Fig 2



AC 3-PHASE SQUIRREL CAGE MOTOR

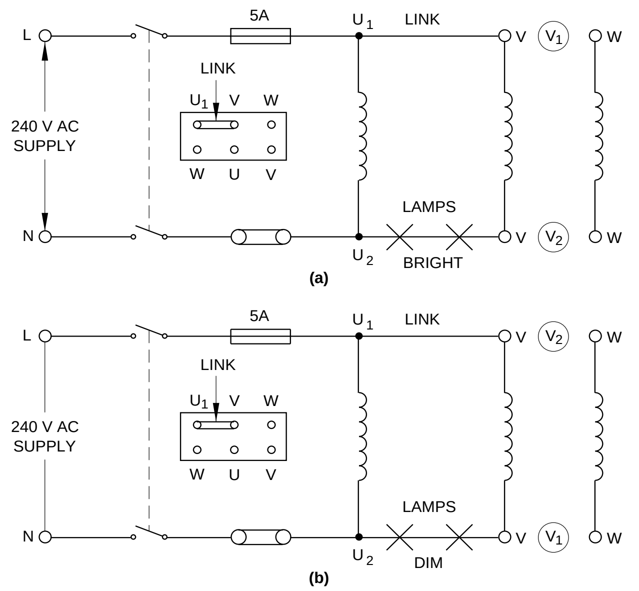
5 Connect the terminals U_1 V and then connect the lamps to the winding ends U_2 and V as shown in Fig 3a and give 240 V AC voltage across U_1 and U_2.

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

7 If the lamps burn dim as shown in Fig 3b then the linked ends are dissimilar ends. For example the connected ends are U_1V_2.

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

Fig 3



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

When the current flows through the coils, they produces 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 brightly. In the case of dissimilar connections the voltage at lamp terminals will be low and the lamps will give dim light.

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

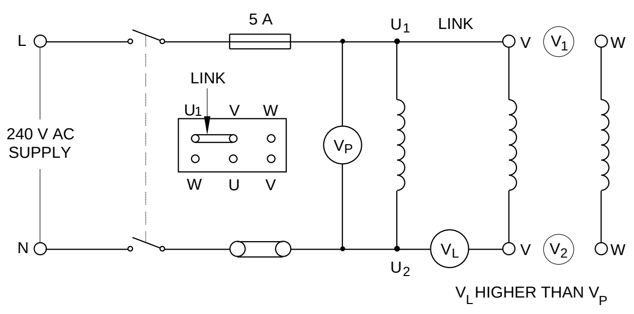
METHOD 2: **Identifying the terminals of 3-phase induction motor with the help of a voltmeter**

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 500 V 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.

3 On switching 'on' the supply if the voltmeter V_L reads more than V_P then the linked terminals are similar as shown in Fig 4 (i.e. U_1V_1).

Fig 4



IDENTIFYING THE TERMINALS OF A 3-PHASE INDUCTION MOTOR

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

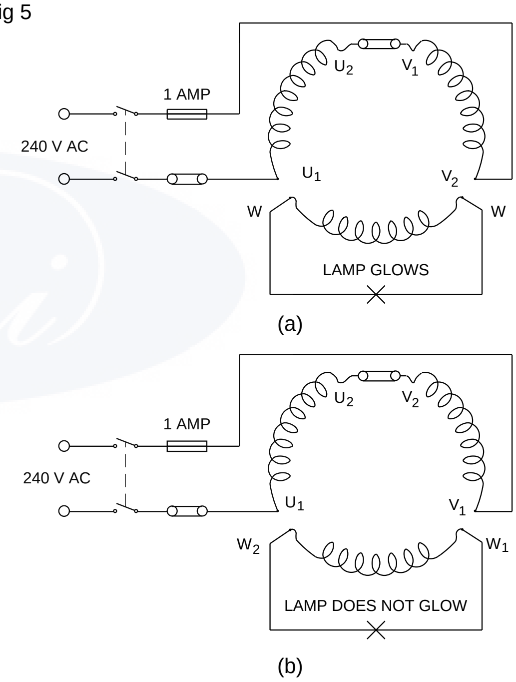
5 Test in the same way the remaining terminals of the coil 'W' and mark them as W_1 and W_2.

Normally small capacity, 3-phase induction motor terminals are arranged in the terminal box as shown in Fig 2 to facilitate either star or delta connection to be made in the terminal box itself by links and to be started by a DOL starter. Compare your terminal markings with the terminal marking given in the terminal plate. Discuss with your instructor for further clarification, if there is any difference.

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

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

Fig 5



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

3 If the lamp does not glow, the linked terminals are similar (i.e. U_2V_2). Then 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 lamp does not glow.

— — — — — — — —

TASK 2: **Measure the insulation resistance value between the windings.**

1 Note the name-plate details and enter them in your practical note book in a format as given in Table 1.

TABLE 1

NAME-PLATE DETAILS

Make ....
Type, Model ....
Serial Number ....Rating.......................
Function ....Alternator/Motor ....
Types of connection ... .HP/kW/kVA...........
Rated voltage ....volts. Rated current ...... amps
speed ....rpm Frequency..................Hz
Power Factor ....Excitation/Rotor voltage..........
Insulation class .... Protection class ....

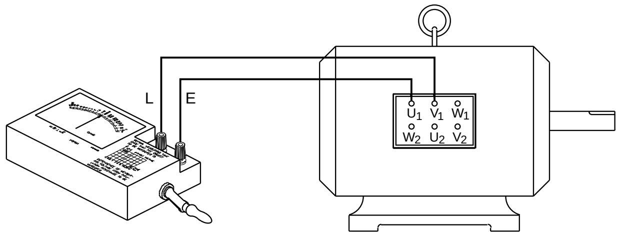
Before starting the Megger test, see that the supply is off, fuse-carriers are removed and the motor is disconnected from the starter.

2 Identify the terminals of the given AC induction motor from the markings.

As a precautionary measure, remove all the links in the terminal plate and check the continuity of each winding. The end terminals of the same winding should have continuity.

3 Connect the test leads of the Megger as shown in Fig 6 to the terminals U_1 and V_1.

Fig 6



4 Rotate the Megger at its rated speed and note down the readings in Table 2.

5 Repeat the steps 3 and 4 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.

The measured insulation value should not be less than 1 megohm or the value given in the Related Theory information whichever is lower.

TABLE 2

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_2 and frame		
5	V_2 and frame		
6	W_2 and frame		

— — — — — — — —

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 as shown in Fig 7.

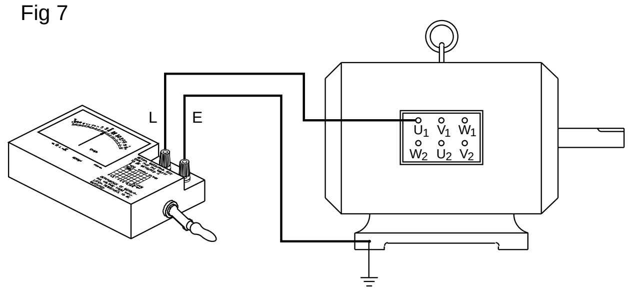
The Megger connection to the frame should be done at the earthing stud of the frame. Before connecting remove the paint, dust, dirt and grit thoroughly at the earthing stud.

2 Rotate the Megger at its rated speed and note down the readings in Table 2.

3 Repeat the steps 1 and 2 for the other two windings.(V_1 and W_1)

4 Compare the measured value with the standard value.

Fig 7



— — — — — — — —

TASK 4: **Check the effectiveness of earth connection**

In addition to the above tests the wireman should ensure the effectiveness of earth connection under following conditions.

CONDITION 1

Check and ensure that the Earth Continuity Conductor (ECC) connected to the main earth electrode is in perfect continuity, having a resistance not more than 1 ohm.

CONDITION 2

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

1 Check the continuity of the ECC and assume its resistance as one ohm, if it is found OK and enter the value in Table 3.

2 Measure the earth electrode resistance and enter the value in Table 3.

3 Write the conclusion in the remark column indicating whether the fuse will blow in case of earth fault in the above circuit or suggest methods to be adopted to have effective earth connection in the above case in the space given below.

CONCLUSION

____

____

____

Write below your suggestion to have effective earth connection to isolate the circuit under earth fault by fuse or circuit breaker.

____

____

TABLE 3

Sl. No.	**Resistance of ECC.**	**Resistance of earth electrode R_{EE}**	**Total earth resistance $R_E = R_{ECC}+R_{EE}$**	**Voltage between phase and earth E_P**	**Earth fault current** $IF = \frac{E_P}{R_E}$	**Fuse rating of the motor circuits**	**Remarks**

— — — — — — — —

Identify the elements of a motor control and check their operation

Objectives : At the end of this exercise you shall be able to
- **identify the parts of a contactor like no-volt coil, main and auxiliary contacts, overload relay and 'ON' 'OFF' push-button stations, their operation and connection**
- **test and ascertain the minimum operating voltage of the no-volt coil**
- **test and ascertain the setting of overload relay**
- **set the overload relay according to the motor rating**
- **connect an AC squirrel cage induction motor through contactor, overload relay and 'ON' and 'OFF' push-button stations**
- **start and stop the motor with the use of push-button stations.**

Requirements

Tools/Instruments

- Trainees tool kit - 1 No.
- Electrical drilling machine 6 mm capacity with 2,3 and 4 mm drill bits. - 1 No.
- Multimeter - 1 No.
- Ammeter MI 0 - 10 A - 3 Nos.
- Voltmeter MI 0 - 500 V - 1 No.
- Ammeter MI 0 - 500 mA - 1 No.
- Stopwatch - 1 No.

Equipment/Machines

- 3-phase squirrel cage induction motor 3 HP 415 V,50 Hz - 1 No.
- Dimmerstat/auto-transformer/Variac 240 V/0-270 V 5 A - 1 No.
- 3-phase lamp load 415 V, 5 kW - 1 No.

Materials

- PVC insulated cable 2.5 sq.mm. 660 V grade - 10 mts.
- Magnetic contactor 3-phase 20 A, 240 V - 1 No.
- Thermal overload relay 3 to 6 amps range - 1 No.
- 'ON' and 'OFF' push-button station having one normally closed and one normally open contact in each set - 1 No.
- Test lamp with BC bulb 40 W, 240 V - 2 Nos.
- ICTP switch 16 A, 415 V - 1 No.
- ICDP switch 16 A, 240 V - 2 Nos.
- Laminated boards of size 200 mm (L) x 150 mm (B) x 3 mm (T) - 3 Nos.
- Machine screws 2 BA 25 mm long with two washers and nuts - 10 Nos.

PROCEDURE

TASK 1: **Collect the equipment and record the name-plate details.**

1 Note down the name-plate details of the given AC 3-phase squirrel cage induction motor in your practical note book.

2 Collect the contactor unit, start/stop push-button units, thermal overload relay with laminated boards, necessary fixing screws, ICTP switch and suitable connecting cables in knocked out condition.

3 Note down the specification of the contactor and overload relay in Table 1 and 2 respectively.

TABLE 1

Contactor

TABLE 2

Overload relay

TASK 2: **Identify the parts of a contactor and investigate their operation.**

1 Inspect visually the given contactor.

2 Identify the mounting holes for fixing screws.

3 Dismantle the contactor carefully.

4 Identify the parts like protective housing, contact supports, main and auxiliary contacts, no-volt coil, armature, yoke, springs etc.

5 After a careful study, draw the schematic diagram for the given contactor in Table 3 in the space provided (4th column) just below the reference sample schematic diagram.

> **The schematic diagram given in Table 3 is for a particular contactor. The contactor given to you may have different identification marks. If so, draw a new schematic diagram in the space given below the sample diagram.**

6 Identify the incoming and outgoing terminals of the power circuit. Note down the same in Table 3, second column and fifth column for continuity check.

> **If there is a difference in the identification marks incorporate the new numbers/marks in the 5th column 'continuity between terminals' in the 'dash' line after striking off the numbers i.e. 1& 2, 3 & 4 etc.**

7 Assemble the contactor and check the operation of the moving magnetic core and the moving contacts by using pressure by hand.

8 Trace and check the terminal connections to the fixed contacts.

9 Check the continuity between the incoming and outgoing terminals when the contactor is open and when closed manually, and write the condition in the 6th column of Table 3.

10 Next identify the no-volt coil and its connecting terminal markings . Enter the details in the 2nd column of Table 3.

11 Measure the resistance of the no-volt coil by a multimeter and write in Column 6 of Table 3.

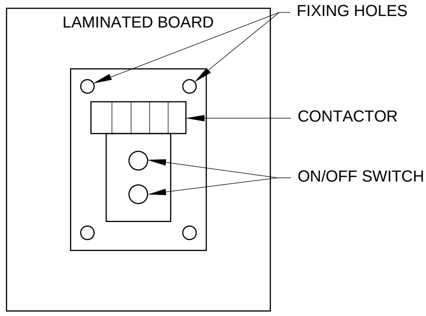
12 To determine the minimum voltage required for the operation of the no-volt coil, first, position the contactor on the laminated board and mark the fixing holes. (Fig 1)

13 Drill holes in the marked places with the help of an electric drilling machine.

14 Fix the contactor on the laminated board with the help of machine screws.

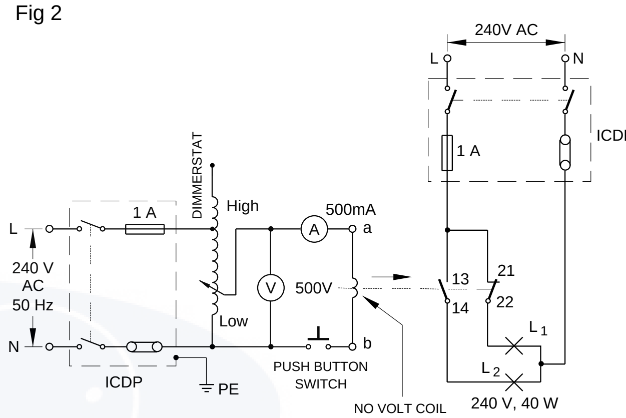
15 Fix the laminated board with the contactor in vertical position on a wooden board or workbench.

Fig 1



16 Connect the no-volt coil circuit through an ammeter push-button 'ON' switch and a dimmerstat/auto-transformer as shown in Fig 2.

Fig 2



17 Connect a voltmeter as shown in the no-volt coil circuit.

18 Connect the two lamps L_1 and L_2 with the auxiliary terminals 21, 22, 13 and 14 as shown in Fig 2 and energise it.

> **If the markings are different in the available contactor, check and connect equivalent markings.**

19 Keep the knob of the auto-transformer (Dimmerstat/ variac) in the low position such that the output is approximately zero.

20 Switch on the supply and slowly increase the voltage to 100 V by turning the auto-transformer knob.

> **Now the no-volt coil is connected across 100 V AC, though the operating voltage written on the no-volt coil is 240 V or any other rating given in your starter no-volt coil. In this condition if the contactor does not operate then the indication is lamp L_1 will be on and lamp L_2 will be off.**

21 Push the 'ON' button. See whether the no-volt coil holds the movable contacts down.

> **If the magnetic coil holds (operates) this will be indicated by L_1 'off' and L_2 'on'.**

22 Write your observation in Table 4.

23 If the magnetic contact does not hold, increase the applied voltage in steps of 25 V up to the rated voltage of the no-volt coil and observe the operation by pushing the 'ON' button at every step. Write your observation in Table 5.

Do not increase the voltage beyond 110% of the rating of the no-volt coil. For a 415 V no-volt coil, while doing this task, suitably increase the applied voltage till it reaches 110% rating.

24 Write your conclusion.

a The noted rating of the no-volt coil is ______ volts.

b The no-volt coil does not operate below _________volts.

c What will happen if the no-volt coil is operated at a higher voltage rating?

____

____

____

____

TABLE 3

Sl. No.	Device	Symbol	Schematic diagram	Continuity between terminals	Write whether open or close
1	Contactor Identification mark Incoming terminals ___________ ___________ Outgoing terminals ___________ ___________		Sample for reference	Under normal condition 1 & 2...... _________ 3 & 4...... _________ 5 & 6...... _________ 21 & 22.... ________ 13 & 14.... ________ Under manually closed condition 1 & 2...... _________ 3 & 4...... _________ 5 & 6...... _________ 21 & 22.... ________ 13 & 14.... ________	
2	No-volt coil Terminals of no-volt coil ___________ ___________ ___________			a & b Resistance value _________ohms Voltage rating __________ volts.	

TABLE 4

Sl.No.	Applied voltage across the no-volt coil (Voltage rating of the coil=240V)	Condition:Write about the holding of no-volt mechanism	Remarks:Write about observed noise.
1	100 V		
2	125 V		
3	150 V		
4	175 V		
5	200 V		
6	225 V		
7	250 - keep this voltage for a short duration only if the coil is rated for 240 V.		

— — — — — — — —

TASK 3: **Identify the parts of the overload relay and investigate their operation.**

1 Identify the parts of the overload relay like incoming and outgoing terminals, bimetallic strips, series heating elements, mechanical levers, overload setting arrangement and resets, if any.

2 Draw a free hand sketch to illustrate the mechanism in a separate sheet of paper and get the approval of your instructor.

3 Observe the following and note it down in Table 5.

 a Range of current setting.

 b Identification of relay contact terminals.

 c Their continuity.

4 If the schematic given in Table 6 does not tally with the given relay, draw the schematic diagram for the given relay in the space below the given sample schematic.

> **If there is a difference in identification of the terminals incorporate this in the 5th column of Table 6 after striking the printed numbers.**

5 To determine the setting of overload relay, draw the circuit as shown in Fig 3, incorporating the necessary changes in marking according to the given OL relays.

6 Show the connections to your instructor and get his approval.

7 Position the overload relay on the given laminated board and mark the fixing holes. (Fig 1)

8 Drill holes in the marked places in the laminated board.

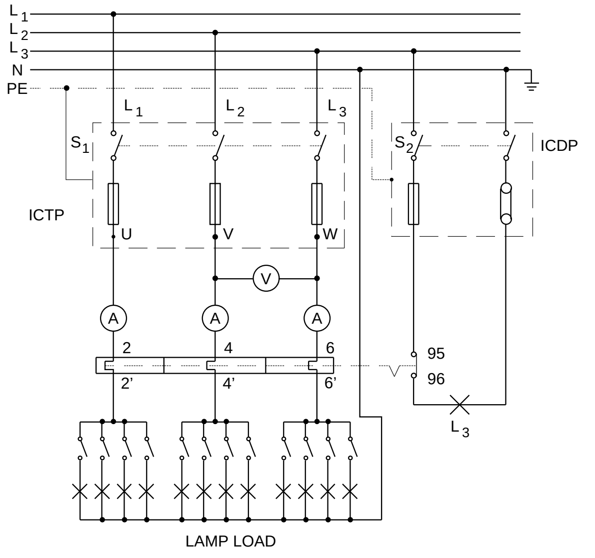
9 Fix the overload relay on the laminated board with the help of machine screws.

10 Fix the laminated board with the overload relay in vertical position on the wooden board of the work bench.

11 Connect the circuit as shown in Fig 3. Switch OFF all the sub-circuit switches in the lamp load.

12 Set the OL relay to 3 amps.

Fig 3



13 Switch 'ON' the ICTP switch 'S_1' for the main supply.

14 Switch 'ON' the lamp circuit such that all the three phases are loaded equally to 3 amps. Then switch off the main supply through switch S_1.

> **Wait for some time, say 5 minutes, for the relay to cool off.**

15 Switch on the mains to the relay circuit through switch S_1 as well as switch S_2, and at the same time start the stop- watch.

16 The lamp L_3 will lit,indicating the contact 95 and 96 is in closed position.

17 Wait for 5 minutes and observe whether the relay operates and switch off the lamp L_3. When the relay operates, stop the watch and note the timing in Table 7.

18 Switch off the main switch S_1 and wait for 5 minutes for cooling the overload relay.

TABLE 5

Sl. No.	Device	Symbol	Schematic diagram	Continuity between terminals	Write whether open or closed
1	Thermal overload relay			2 and 2' 4 and 4' 6 and 6'	
2	Range of current setting			95 and 96 98 and 95	
3	Relay contact terminals				
4	Condition				

TABLE 6

Sl No.	Relay setting	Load in amps.	Operating time	Remarks
	3			
	4			
	5			
	6			

19 If it does not operate, increase the load current to 4 amps. Observe for 5 minutes. Note down the operating time in Table 6.

20 Switch 'OFF' the mains and allow 5 minutes for the relay to cool down.

21 Increase the load current to 6 amps, observe the operation and record it.

22 Adjust the OL relay for 4 amps.

23 Repeat the procedure given in steps 13 to 21 with the set load currents for 4, and then to 5 & 6 amps at various load current and note down the observation in Table 6.

24 Write your observation regarding the relation between the overload relay setting, load current and the time of operation.

____

____

____

____

— — — — — — — —

TASK 4: **Identify the parts of the push-buttons and investigate their operation.**

1 Identify the colour of the push-button and its purpose.Write your observation in Table 7.

2 Identify the terminals and their connection when the button is pressed or released. Enter the details in Table 7.

TABLE 7

Sl. No.	Device	Symbol & schematic diagram	Condition; continuity between terminals	Write whether close or open
1	'ON'push button-colour		Under normal condition 1 and 2...... ________ 3 and 4...... ________ When switch is pushed. 1 and 2...... ________ 3 and 4...... ________ Write whether the push-button holds or gets released when the finger pressure is released	____________ ____________ ____________ ____________ ____________ ____________ ____________ ____________
2	'OFF' push button-colour		Under normal condition. 1 and 2...... ________ 3 and 4...... ________ When switch is pushed. 1 and 2...... ________ 3 and 4...... ________ Write whether the push-button holds or gets released when the finger pressure is released.	____________ ____________ ____________ ____________ ____________ ____________

— — — — — — — —

TASK 5: **Draw the schematic diagram. Full circuit diagram of a contactor relay and push-button station with motor. Start and stop the motor.**

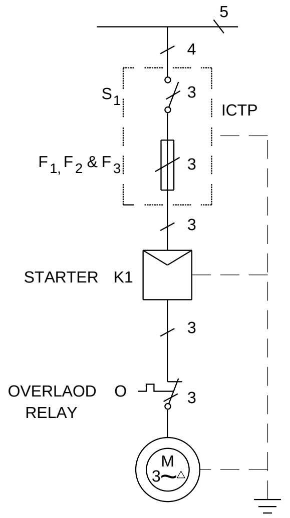
1 Draw and complete the circuit given in the schematic diagram (Fig 7) with the help of the layout diagram 4, power circuit diagram (Fig 5) and control circuit diagram (Fig 6).

2 Show the connection to your instructor diagram and get it approved.

At this stage verify the letters/alphabets given in the available contactor, overload relay with those of the approved diagram. If any variation is found incorporate the same in the approved diagram.

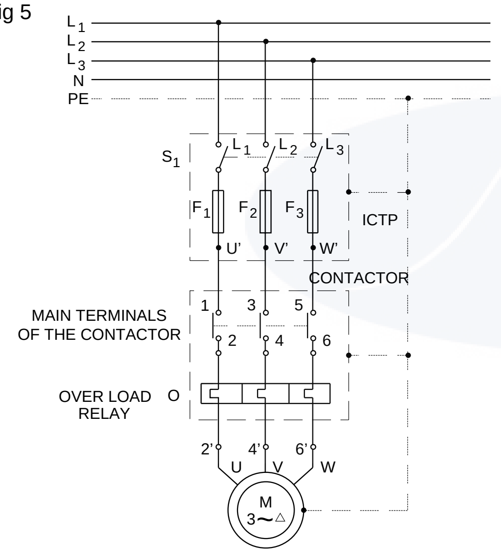
Ensure that the motor is double earthed, continuity of earth continuity conductor is good and the earth electrode resistance is within the stipulated safe value.

Fig 4



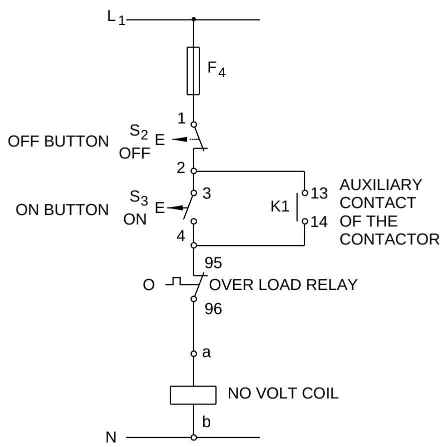
LAYOUT DIAGRAM OF THE CONTACTOR CONNECTION TO THE MOTOR

Fig 5



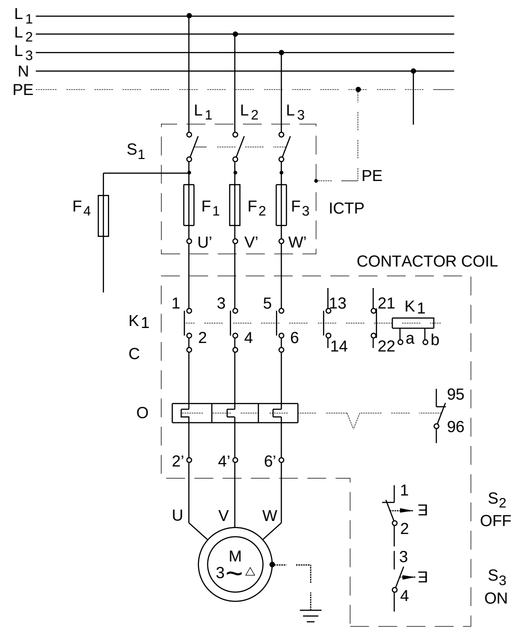
POWER CIRCUIT DIAGRAM OF CONNECTION OF CONTACTOR TO THE 3PHASE INDUCTION MOTOR

Fig 6



CONTROL CIRCUIT OF THE CONTACTOR

Fig 7



COMPLETE CIRCUIT DIAGRAM OF THE CONTACTOR AND THE 3PHASE SQUIRREL CAGE INDUCTION MOTOR

3 Fix the laminated boards vertically so that the position of the contactor and overload relay corresponds to their respective working positions.

Cable termination should be tight. Check whether the no-volt coil moves freely in the slot. If the contactor is of the PVC moulded type and not fitted in a metal enclosure, earthing is not necessary. But earth the ICTP.

4 Connect the power circuit by connecting the contactor output terminals 2' 4' and 6' to the motor terminals UVW and the contactor input terminals 1, 3 & 5 to the mains L_1, L_2 & L_3 terminals through a ICTP switch as shown in the approved diagram in step 2 of Task 5.

5 Connect the control circuit by connecting the no-volt coil and overload relay circuit starting from fuse F_4 and ending with the neutral as shown in the approved diagram.

Assumption - The no-volt coil is for 240 V AC and has to be connected between one phase and the neutral. If the no-volt coil voltage rating is for 415 V it has to be connected between two phases.

6 Set the overload relay according to the motor rating.

7 Provide correct capacity back up fuse as per the motor rating in the ICTP switch and get your connections approved by the instructor.

8 Switch 'ON' the main supply and the ICTP switch. Start the motor by pushing the 'ON' button, observe the direction of rotation and record it in the presence of your instructor. The direction of rotation is ________.

9 Stop the motor by pushing the OFF button. Switch OFF the ICTP. Remove the fuses and disconnect all the connecting cables.

Assemble a DOL starter, connect and operate a 3-phase induction motor

Objectives : At the end of this exercise you shall be able to
- **identify and collect the parts of the DOL starter**
- **assemble the DOL starter when contactor, overload relay, push-button stations and single strand cables are given in a semi-knocked out condition**
- **connect and harness the hook-up cable for control circuit**
- **mount the DOL starter, the main ICTP switch and connect the 3-phase induction motor**
- **earth the motor, the starter and the switch**
- **set the overload relay**
- **replace correct capacity back up fuses**
- **start and stop the 3-phase induction motor through DOL starter**
- **measure the starting and the running currents of the 3-phase squirrel cage motor**
- **measure the actual speed of the 3-phase squirrel cage motor to determine the synchronous speed, slip and percentage slip.**

Requirements

Tools/Instruments

- Trainees tool kit - 1 No.
- Ammeter MI 0-20 amps - 1 No.
- Voltmeter MI 500 V - 1 No.
- Plumb bob with thread - 1 No.
- Spirit level - 1 No.
- Tachometer 0-3000 rpm - 1 No.

Equipment/Machines

- 3-phase squirrel cage motor 3 HP 415 V, 50 Hz - 1 No.
- DOL starter 4 - 6 amps 415 V with overload relay, no-volt coil & push-button station - 1 No.
  (The Instructor is requested to dismantle the contactor, overload relay and the internal connecting hookup cables before giving to the trainees.)
- ICTP switch 16 A 415 V - 1 No.

Materials

- PVC insulated single strand copper cable 16 SWG - 0.5 m.
- PVC insulated single strand copper cable 18 SWG - 0.5 m.
- Machine screws 2 BA 30 mm long with 2 washers and one nut - 4 Nos.
- Connecting cable for motor -as reqd.

PROCEDURE

1 Note down the name-plate details of the given AC 3-phase squirrel cage induction motor in your practical note book.

2 Collect the contactor unit, overload relay unit, start/stop push-button unit, necessary fixing screws,hook-up cables, ICTP switch and DOL starter base and cover.

3 Prepare the list of items you have received from your instructor in Table 1.

4 Record the name-plate details of the contactor and overload relay in Tables 2 and 3 respectively.

5 Investigate and check the contactor input and output terminals, auxiliary and main terminals, movable and fixed contacts, no-volt coil, overload relay, their rating number of NC and no contacts.

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

7 Identify the mounting screw holes in the contactor, overload relay and the corresponding holes in the starter base box.

TABLE 1

List of items

Sl.No.	List of Items
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	
11	
12	
13	
14	
15	

TABLE 2

Contactor

TABLE 3

Overload relay

8 Draw the complete circuit diagram for the given DOL starter with overload relay, no-volt coil, 'ON' and 'OFF' push-buttons.

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

i Fig 1 base and cover of a DOL starter.

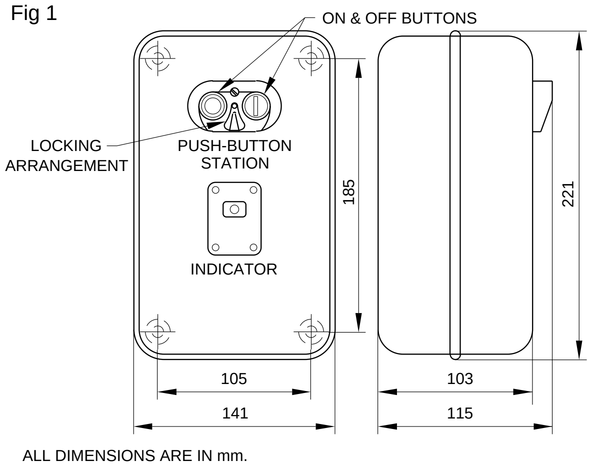
ii Fig 2 push-buttons only.

iii Fig 3 overload relay package with push-button strips in the foreground which will get actuated when the push-buttons are pressed.

iv Fig 4 contactor with no- volt coil.

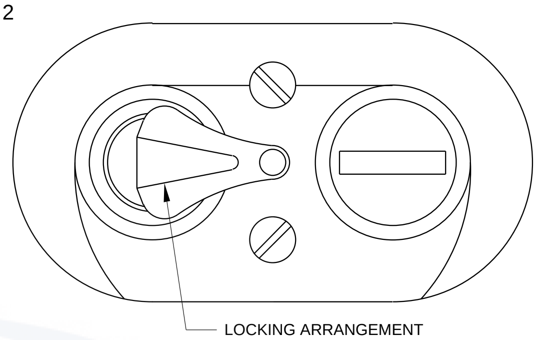
9 Get the diagram approved by the instructor.

Fig 1



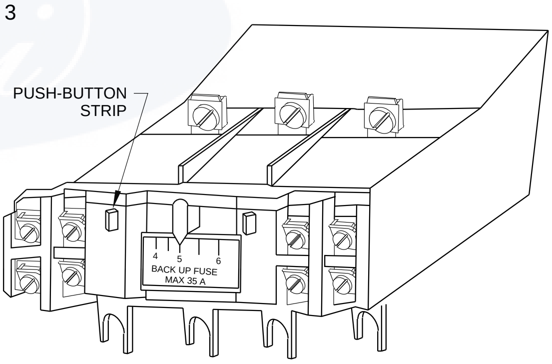
DIMENSIONS OF BASE AND COVER OF DOL STARTER

Fig 2



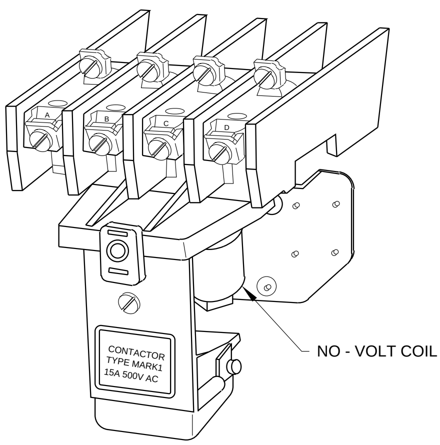
PUSH-BUTTON STATION

Fig 3



OVERLOAD RELAY

Fig 4



CONTACTOR

10 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 the OL relay.

11 Identify the place of connection of the hook-up cables with the help of the approved diagram. Measure and cut the hook-up cables leaving allowance for harnessing.

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

13 Harness the hookup cables such that the cables do not interfere with any moving mechanism of the starter.

14 Check once again the complete connection of the DOL starter internal wiring.

15 Get the wiring approved by the instructor.

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

17 Mount the starter vertically on the wall/frame.

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

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

18 Connect the main supply to the starter incoming terminals through the ICTP switch. (Fig 5)

A complete diagram showing the internal diagram of the starter of a particular make along with ICTP and motor is given for your guidance. You can replace the internal diagram of the given starter in place of the starter diagram shown in Fig 5.

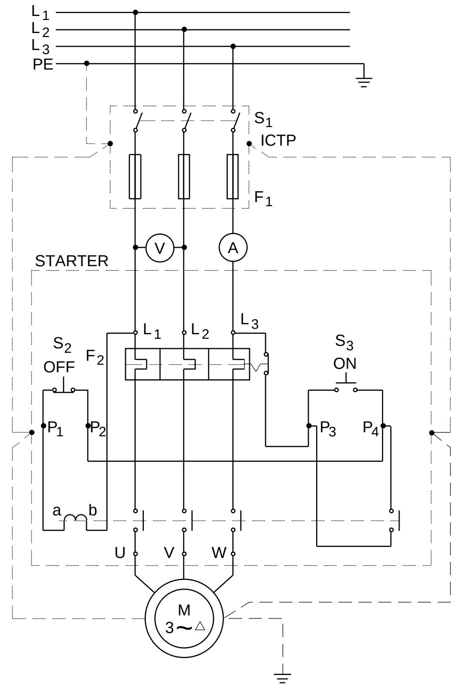
19 Connect the starter outgoing terminals to the 3-phase squirrel cage induction motor along with ammeter and voltmeter as shown in Fig 5.

Before connecting the 3-phase squirrel cage motor, test it for continuity and insulation as you have done in Exercise 3.4.04.

20 Connect the protective earth continuity conductors (two separate PE connections) to the motor and starter case, ICTP switch, and securely connect the PE continuity conductors to the main earth. (Fig 5)

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

Fig 5



CIRCUIT DIAGRAM OF DOL STARTER WITH PROTECTIVE DEVICE

22 Provide the back-up fuse as recommended by the manufacturer of the starter considering the horse-power rating of the motor.

For your guidance the back up fuse rating for the specified horse power/kw rating is given in the Related Theory exercise.

Preferably check for the back up fuse rating in the pamphlet supplied along with your starter.

23 Get the main connections, earth connections, overload setting and the back-up fuse rating approved by your instructor.

24 Switch on the ICTP.

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

26 Read the ammeter for the starting current at the time of starting and enter the value in Table 4.

27 Read the voltmeter and ammeter values while the motor is running normally and enter the values in Table 4.

28 Measure the actual speed of the rotor with the help of a tachometer and record it in Table 5.

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

30 Switch OFF the mains, remove fuses and disconnect the connections.

31 Show the readings to your instructor and get his approval.

TABLE 4

Sl.No.	No-load condition		Line voltage	Remarks
	Starting current in amps.	Running current in amps.		

TABLE 5

Sl.No.	Syn.speed	Actual speed at no-load	Fractional slip at no-load	% slip at no-load

Connect & control a 3-phase squirrel cage induction motor with inch and remote control

Objectives : At the end of this exercise you shall be able to
- **connect a basic contactor with an inch control station for controlling 3-phase squirrel cage induction motor**
- **connect a basic contactor with remote control start, stop and inch control stations for controlling 3-phase squirrel cage induction motor**
- **connect the power circuit of a 3-phase squirrel cage induction motor**
- **operate the 3-phase squirrel cage induction motor through inch and remote control.**

Requirements

Tools/Instruments
- Trainees tool kit - 1 No.
- Wire stripper 150 mm - 1 No.

Equipment/Machines
- 3-phase squirrel cage induction motor 415 V, 5 HP - 1 No.
- DOL starter 415 V, 6 - 10 A with four N/O contacts - 1 No.
- Start & stop push-button station with one normally open and one normally closed contacts respectively - 2 Nos.
- Inch push-button with one normally open and one normally closed contacts - 2 Nos.

Materials
- 2.5 sq. mm. PVC multi-strand aluminium cable 660 V grade - 10 mts.
- PVC insulated single strand 18 SWG copper hook up cable 660V grade - 1 mts.
- PVC insulated multi-strand copper cable 21/.02 of 660 V grade - 2 mts.

PROCEDURE

Normally only one inch control will be provided in a machine like a lathe to check the trueness of the job. However, big lathes may have more than one inch control along with remote 'on' and 'off' push-button stations. This exercise incorporates both single and double inch stations.

TASK 1: **To connect inch push-button with DOL starter**

1 Enter the name-plate details of the AC 3-phase squirrel cage induction motor in your practical note book.

2 Collect the DOL starter, two numbers inch push-buttons and one push-button station with 'ON' and 'OFF' push-buttons.

3 Enter the name-plate details of the DOL starter in Table 1.

4 Investigate the DOL starter and draw the diagram of the DOL starter circuit in a separate sheet of paper.

5 Investigate the internal connections of the given 'ON' and 'OFF' push-buttons and also inch push-buttons and draw the schematic diagram in Table 2.

6 Compare the diagram drawn by you in Steps 4 and 5 with the diagram of the DOL starter given in Fig 1 and the connection with inch push-button given in Fig 2 and study the circuit function.

7 Modify and draw the circuit diagram of the DOL starter (drawn in step 4) incorporating the inch control on a separate paper.

TABLE 2

DOL starter

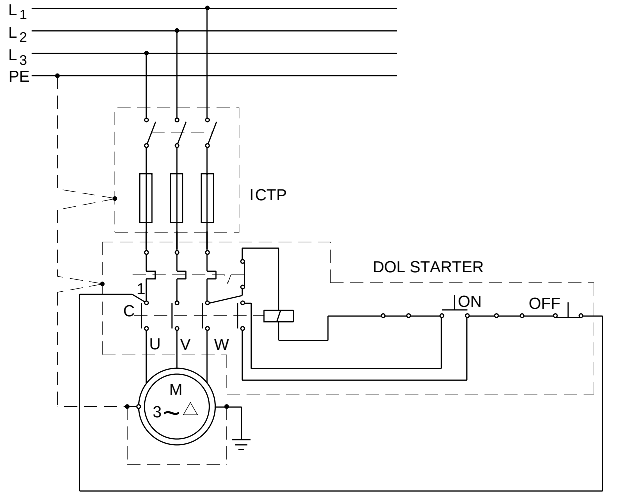
TABLE 3

Sl.No.	Accessory	Schematic diagram
1	'ON' push-button	
2	'OFF' push-button	
3	Inch push-button	

8 Draw the ICTP switch and motor connections to the circuit diagram drawn in step 7 and get the approval of your instructor.

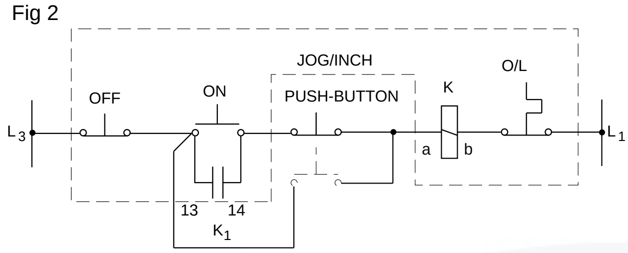
If necessary, mount the inch push-button stations on laminated boards.

Fig 1



CIRCUIT DIAGRAM

Fig 2



JOG / INCH CONTROL CIRCUIT DIAGRAM

9 Make the necessary modification and connect the DOL starter with the inch push-button as per the approved diagram.

10 Connect also the ICTP switch, DOL starter and the 3-phase squirrel cage motor as per the approved diagram.

11 Connect the PE conductor to the ICTP switch, DOL starter, inch push-button station and the motor and get the approval of your instructor.

12 Provide the rated back-up fuses in the ICTP switch.

13 Switch 'ON' the ICTP.

14 Switch 'ON' the motor by pushing the 'ON' push-button switch of the DOL starter.

15 Switch 'OFF' the motor by pushing the 'OFF' push-button switch of the DOL starter.

16 Push the inch button momentarily and watch the rotation.

17 Switch 'ON' the motor with the start-button, wait for some time and then press the inch control button continuously.

18 Observe the function of the motor. Release the inch control button.

19 Write the conclusion.

CONCLUSION

a When the inch push-button is pressed and released how does the motor runs?

____

____

____

b When the inch push-button is pressed continuously how does the motor runs?

____

____

____

— — — — — — — —

TASK 2: **To connect dual inch push-button stations and one remote control push-button station**

Control circuit diagram given in Fig 3 incorporates two inch push-button stations and two 'on' and 'off' control stations for your guidance.

1 Draw the circuit diagram of the DOL starter with the two inch push-button stations and remote control 'ON' OFF stations as per the accessories supplied to you.

2 Compare the control diagram drawn by you for the given specific accessories with the schematic shown in Fig 3.

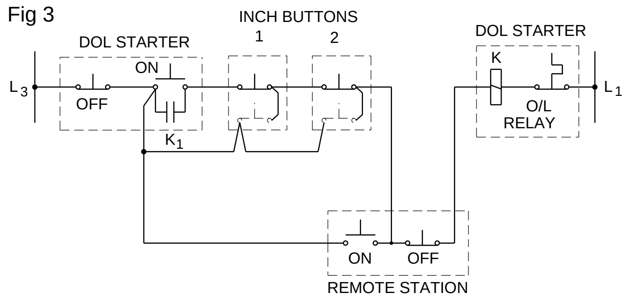
3 Draw the complete circuit diagram of DOL starter, remote control stations, ICTP and motor.

4 Show the completed circuit diagrams to your instructor and get his approval.

5 Wire up the DOL with starter inch push-button stations and 'ON' and 'OFF' push-button stations, ICTP and motor as per approved diagram (step 4 of Task 2).

6 Connect the PE conductor to the ICTP switch, motor starter inch and remote push-button stations.

Fig 3



CONTROL CIRCUIT DIAGRAM WITH DUAL INCH & REMOTE PUSH-BUTTONS

7 Show the connections to your instructor and get his approval.

8 Provide the rated back up fuses and switch 'ON' the ICTP.

9 Operate the inch push-buttons and the 'ON' OFF push-buttons and observe the operation of the motor in the presence of your instructor.

10 Switch 'OFF' the ICTP and remove the fuses and disconnect the connections.

— — — — — — — —

Connect, start, run & reverse a 3-phase squirrel cage induction motor through manual reversing switch

Objectives : At the end of this exercise you shall be able to
- **connect the manual forward and reverse switch along with the 3-phase squirrel cage induction motor and DOL starter**
- **run and reverse the direction of rotation of the 3-phase squirrel cage induction motor through the manual reversing switch.**

Requirements

Tools/Instruments

- Trainees tool kit - 1 No.
- DE spanner set 6 mm to 19 mm - 1 set.
- Multimeter - 1 No.
- Manual type forward and reverse switch three-pole three positions, 16 amps 415V. - 1 No.
- DOL starter 6/10 amps 3-phase 415 V - 1 No.
- ICTP switch 16 amps 415 V - 1 No.

Equipment/Machines

- 3-phase 415 V, 5 HP squirrel cage induction motor - 1 No.

Materials

- 2.5 sq.mm PVC multi-strand aluminium cable 660 V - 15 m.

PROCEDURE

1 Read and interpret the name-plate details of the 3-phase squirrel cage motor and enter in your practical note book.

2 Ascertain the terminals of the squirrel cage induction motor.

3 Select a suitable size ICTP, DOL starter, rotor type forward and reverse switch, cables and fuse etc. according to the available 3-phase squirrel cage induction motor.

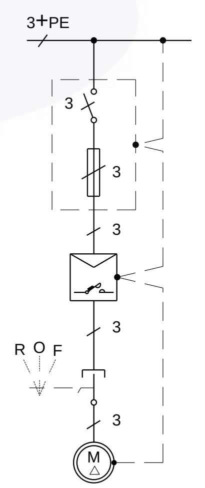
Inclusion of DOL starter is to facilitate safety. In certain industrial connections the D.O.L. starter is not used. Motor is left with fuse protection only.

4 Trace out the connection of the given DOL starter and forwarding/reversing switch with the help of a multimeter and draw the diagrams.

5 Show the traced connections and get the approval of the instructor.

6 Draw the complete connections diagram showing ICTP, DOL starter, forward and reversing switch connections to the motor.

Fig 1

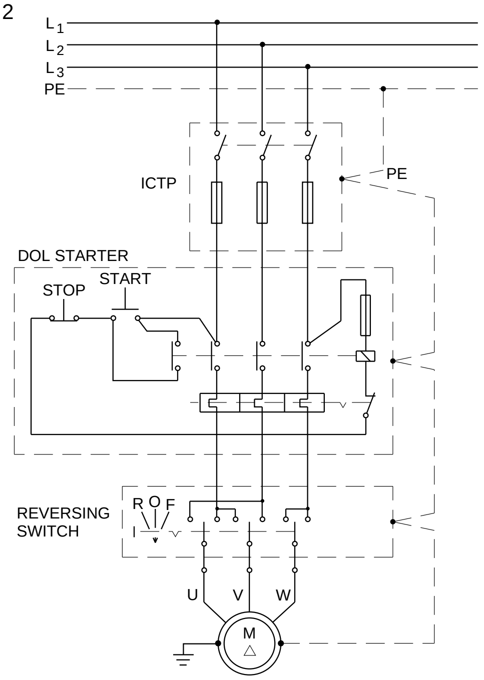


LAYOUT DIAGRAM FOR FORWARD/REVERSE SWITCH CONNECTION TO A MOTOR

The layout diagram Fig 1, the schematic diagram given in Fig 2 and the wiring diagram in Fig 3 are for your guidance. Make necessary changes in your diagram to suit the requirement of the given DOL starter and forward/ reversing switch.

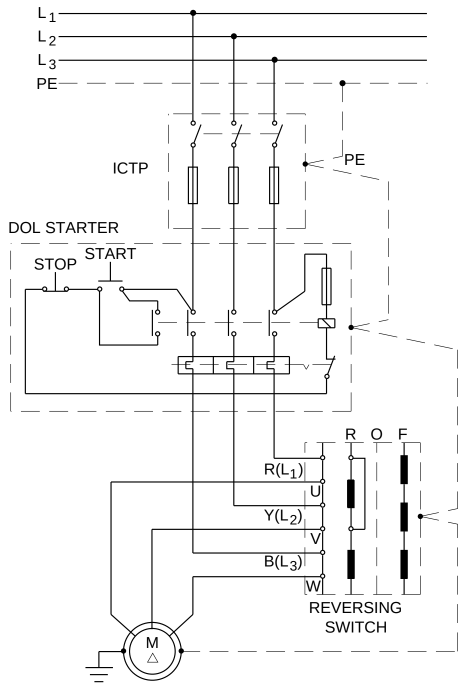
7 Keep the forward reversing switch in the OFF position.

Fig 2



COMPLETE SCHEMATIC DIAGRAM

Fig 3



COMPLETE SCHEMATIC DIAGRAM

8 Show the connections to the instructor and get his permission to switch 'ON'.

9 Switch 'ON' the ICTP and switch 'ON' the DOL starter by pushing the 'ON' button.

10 Move the forward reversing switch handle to forward position and watch the direction of rotation of the motor. The DOR of the motor is _______________.

11 Bring the reversing switch to 'OFF' position and wait until the motor comes to rest.

When reversing a motor we should allow it to come to the standstill position before attempting to operate in the opposite direction to avoid strain to the motor.

12 Move the reversing switch to the reverse position for changing the direction of rotation and note the direction. Now the DOR of the motor is__________.

13 Stop the motor, switch off the mains, remove the fuse carriers and disconnect the supply leads, main switch, starter and forward and reversing switch.

— — — — — — — — — —

Connect, start, run & reverse 3-phase squirrel cage induction motor by manual star-delta starter

Objectives : At the end of this exercise you shall be able to
- **identify the parts of a manual star-delta starter and trace the connections**
- **draw the star/delta formation of the motor winding through the starter handle operation**
- **provide proper back up fuse in the main switch of the 3-phase squirrel cage motor according to the motor rating**
- **connect the manual star-delta starter with the 3-phase squirrel cage induction motor**
- **adjust the overload relay according to the motor current rating**
- **start the 3-phase squirrel cage induction motor through the manual star-delta starter**
- **stop the 3-phase squirrel cage induction motor through the manual star-delta starter**
- **reverse the direction of rotation of the squirrel cage induction motor.**

Requirements

Tools/Instruments

- Trainees tool kit - 1 No.
- Side cutter 150 mm - 1 No.
- Wire stripper 150 mm - 1 No.
- MI ammeter 10 amps - 1 No.
- MI voltmeter 0-500 V - 1 No.

Equipment/Machines

- 3-phase squirrel cage induction motor 415 V, 5 HP - 1 No.
- Manual star-delta starter 6/10 A, 415 V with overload relay and no-volt coil - 1 No.

Materials

- PVC insulated stranded aluminium cable 660 V grade - 2.5 sqmm -25 m.
- Fuse wire 10 amps - as reqd.
- Black insulation tape - as reqd.

PROCEDURE

1 Read and interpret the name-plate details of the given 3-phase squirrel cage induction motor and starter, and enter in Table 1.

TABLE 1

Starter: Name-plate details

Make ....
Type, Model ....
Serial Number ....Rating.......................
Function ....Alternator/Motor ....
Types of connection ... .HP/kW/kVA...........
Rated voltage ....volts. Rated current ...... amps
Speed ....rpm Frequency...................Hz
Power Factor ....Excitation/Rotor voltage..........
Insulation class .... Protection class ....

2 Switch 'off' the mains, remove the fuse carriers and keep them in safe custody.

3 Remove the terminal cover of the motor and front cover of the starter.

To connect a star-delta starter, the squirrel cage induction motor must have six terminals which are normally marked as U_1, V_1, W_1 & U_2, V_2, W_2.

4 Identify the parts of the given star-delta starter, trace the connections and study its operation. Draw the traced out circuit and get it approved by the instructor.

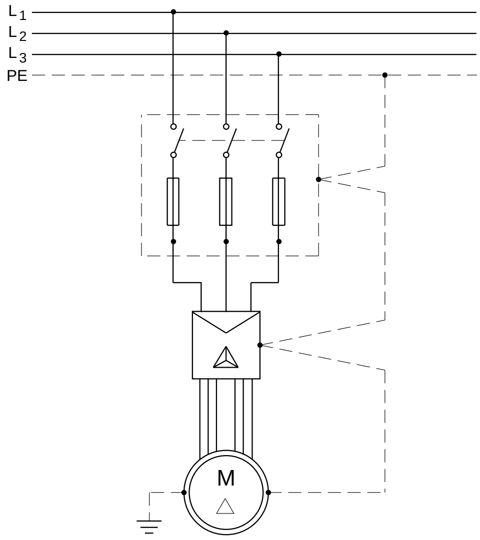
Layout diagram in Fig 1, schematic diagram of a star-delta starter in Fig 2 and a practical circuit in Figs 3 are given for your guidance.

5 Draw the complete connection diagram incorporating the ICTP switch, the given star-delta starter and motor and get it approved by your instructor.

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

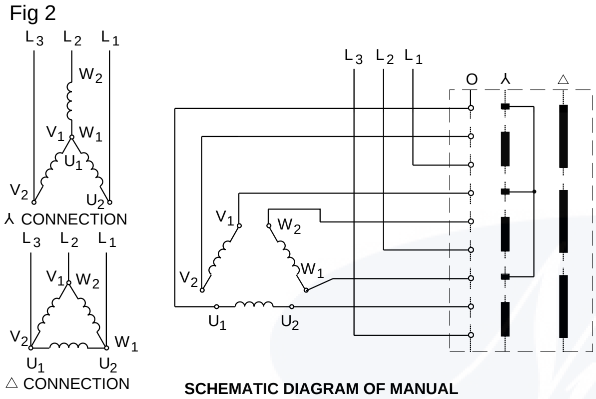
7 Connect three cables from supply line L_1, L_2 & L_3 to the main switch as shown in Fig 3.

Fig 1



LAYOUT DIAGRAM OF STAR - DELTA STARTER CONNECTED TO THE MOTOR

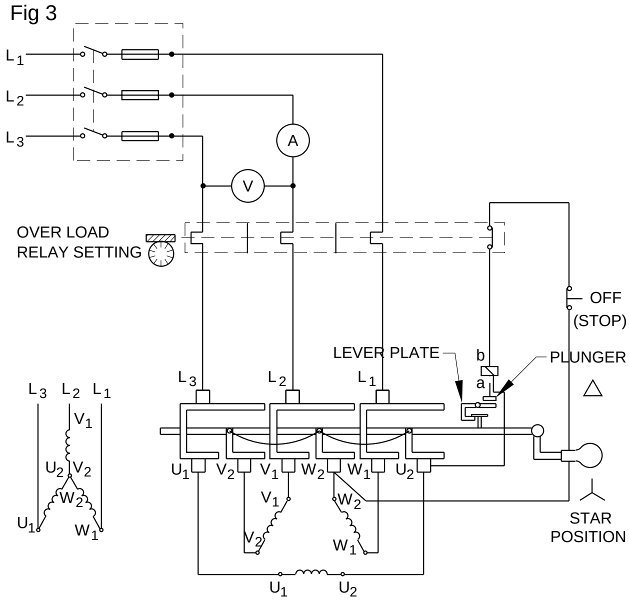
Fig 2



SCHEMATIC DIAGRAM OF MANUAL STAR-DELTA STARTER CONNECTIONS

8 Insert the ammeter in series with one of the line cables from the main switch and a voltmeter across two line cables as shown in Fig 3.

Fig 3



STAR - DELTA SWITCH IN STAR POSITION

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

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

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

Assumption - The starter and main switch are fixed on Installation Practice Cubicle's vertical surface and the motor is mounted on a rigid frame.

12 Check the connection for correctness and tightness. Get it approved by the instructor.

13 Switch 'on' the main, observe the voltmeter reading and move the handle to star position positively. Just at the same time observe the starting current and enter in Table 2.

14 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 delta position positively.

15 Note down the direction of rotation and enter it in Table 3.

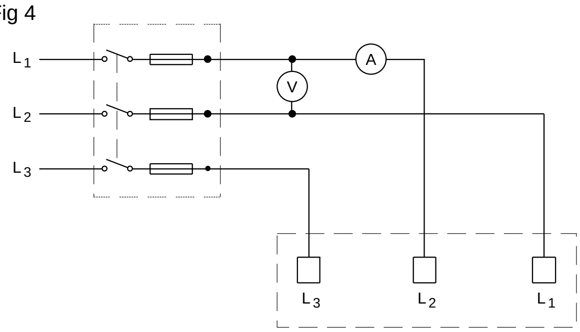
16 Note down the current taken by the motor in the running condition and enter the value of current in Table 2.

17 Then stop the motor by pushing the stop-button of the starter.

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

19 Interchange the two line cables L_1 and L_2 to terminals L_2 and L_1 respectively as shown in Fig 4.

Fig 4



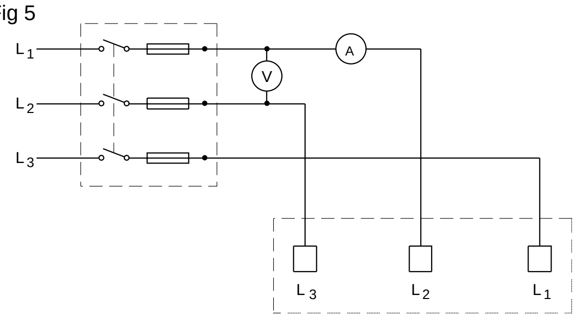
20 Insert the fuse carriers in the main switch.

21 Repeat steps No.13 to 16 and record the information in Table 2 and Table 3.

22 Stop the motor, switch off the supply and remove the fuse, then interchange the line cables L_2 and L_3 respectively as shown in Fig 5.

23 Insert the fuse carriers in the main switch.

Fig 5



24 Repeat steps No.13 to 16 and record the information in Tables 3 and 4.

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

____

____

____

____

____

26 Switch ‘off’ the mains, remove the fuse-carriers and remove all connections.

TABLE 2

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

TABLE 3

Sl.No.	Description	Direction of rotation
1	1st start connection	
	L_1 to L_1	
	L_2 to L_2	
	L_3 to L_3	
	2nd start connection	
2	L_1 to L_2	
	L_2 to L_1	
	L_3 to L_3	
3	3rd start connection	
	L_1 to L_2	
	L_2 to L_3	
	L_3 to L_1	

— — — — — — — —

Connect a 3ϕ Induction motor in star & delta and determine the relation between line and phase values and measure the power in star & delta

Objectives: At the end of this exercise you shall be able to
- **connect the balanced motor load in star**
- **connect the voltmeters and measure phase and line voltages in star connection**
- **connect the ammeters and measure the line and phase currents in star connection**
- **connect the balanced motor load in delta**
- **connect the voltmeters and measure phase and line voltages in delta connection**
- **connect the ammeters and measure phase and line currents in delta connection**
- **measure the power in both star and delta modes.**

Requirements

Tools/Instruments
- Ammeter 0-25A MI - 6 Nos.
- Voltmeter 0-500 V MI - 6 Nos.
- ICTP switch - 32 A 500 V - 1 No.
- LPF watt meter 500V/10A - 2Nos.

Equipment/Machine
- 3 phase squirrel cage Im 415 V, 51 + P
- Manual star - delta starter 6/10A
  415 V with OL velay & no volt coil

Materials
- PVC insulated stranded aluminium cable 660 V grade, 255 ml - 25
- Fuse wire - 10 amp - as reqd.

PROCEDURE

1 Note the name plate details and enter them in your practical note book in a format given in table 1.

TABLE 1
Starter: Name-plate details

Make ....
Type, Model ....
Serial Number ....Rating.....................
Function ....Alternator/Motor ....
Types of connection ... .HP/kW/kVA.........
Rated voltage ....volts. Rated current ..... amps
Speed ....rpm Frequency..................Hz
Power Factor ....Excitation/Rotor voltage........
Insulation class .... Protection class ....

2 Connect the circuit as per the diagram shown in Fig 1.

3 Replace the fuse wire in ICTP to 10 A capacity.

4 Switch 'ON' the 3-phase supply.

5 Put the handle of the starter in 'START' position, V_{L1}, V_{L2} and V_{L3} and measure the line voltage and enter in Table No 1.

6 Measure the phase voltages(V_P) - V_{P1} V_{P2} and V_{P3} by placing the voltmeter leads between one line and star point N and enter the readings in Table 1.

7 Measure the line current (I_L) - I_{L1}, I_{L2}, I_{L3}, and phase current (I_P) - I_{P1}, I_{P2}, I_{P3} and enter the reading in Table 1.

8 Measure the power W_1 and W_2 and enter in Table 1.

As the load is equal in all the phases, the line and phase currents will be same in all the phases.

9 Calculate the ratio between the line voltage (V_L) and phase voltage (V_P).

$$\frac{V_{L1}}{V_{P1}} =$$

$$\frac{V_{L2}}{V_{P2}} =$$

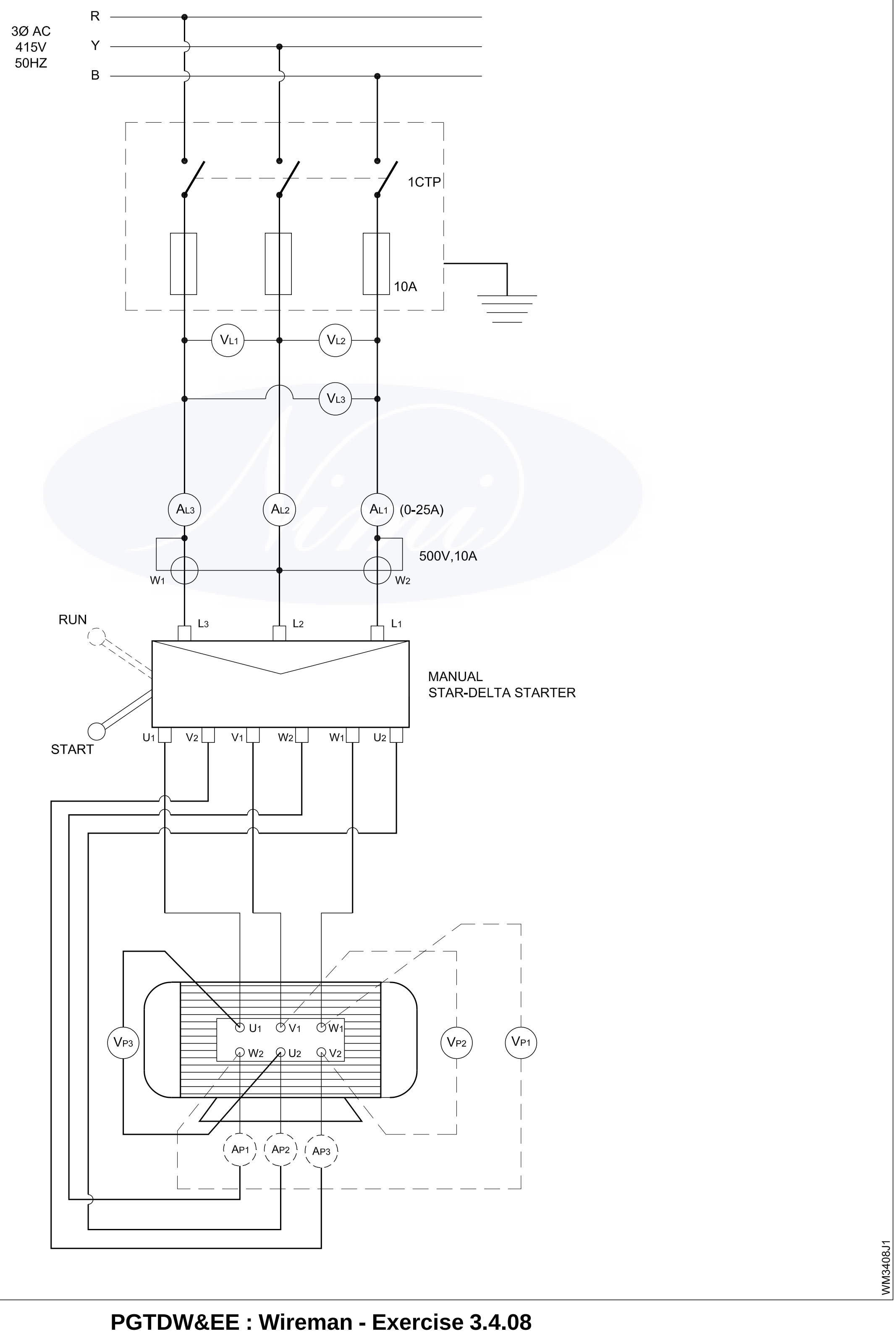
$$\frac{V_{L3}}{V_{P3}} =$$

TABLE 1

Star connected load

Sl. No.	Load in watts per phase	Line voltage V_{L1} V_{L2} V_{L3}	Phase voltage V_{P1} V_{P2} V_{P3}	Line current I_{L1} I_{L2} I_{L3}	Phase current I_{P1} I_{P2} I_{P3}	Power W_1+W_2
1	40 W					
2	100 W					
3	200 W					

Fig 1



10 Verify the ratio between line current (I_L)and phase current (I_P).

$$\frac{I_{L1}}{I_{P1}} = \frac{I_{L2}}{I_{P2}} = \frac{I_{L3}}{I_{P3}}$$

RESULT

In star : Line current and phase current are _________

Line voltage = _________ X phase voltage.

11 Put the handle of star-delta starter in "RUN" position

12 Measure the line and phase voltage V_{L1}, V_{L2} and V_{L3}, V_{P1}, V_{P2} and V_{P3} and enter in Table 2.

13 Measure the line current I_{L1}, I_{L2}, I_{L3}, and phase current I_{P1}, I_{P2} & I_{P3} and enter in Table 2.

14 Measure the power W_1 and W_2 and enter in table 2.

An ammeter connected between supply and load indicates line current and an ammeter connected in series to the winding indicates phase current.

15 Calculate the ratio between line current (I_L) and phase current (I_P).

$$\frac{I_{L1}}{I_{P1}} =$$

$$\frac{I_{L2}}{I_{P2}} =$$

$$\frac{I_{L3}}{I_{P3}} =$$

16 Verify the ratio between line voltage (V_L) and phase voltage (V_P).

$$\frac{V_{L1}}{V_{P1}} = \frac{V_{L2}}{V_{P2}} = \frac{V_{L3}}{V_{P3}}$$

RESULT

1 Line voltage and Line current are_________

2 Line current = _________ X phase current.

TABLE 2

Delta connected load

Sl. No.	**Load in watts per phase**	**Line voltage**			**Phase voltage**			**Line current**			**Phase current**			**Power**
		V_{L1}	V_{L2}	V_{L3}	V_{P1}	V_{P2}	V_{P3}	I_{L1}	I_{L2}	I_{L3}	I_{P1}	I_{P2}	I_{P3}	W_1+W_2
1	40 W													
2	100 W													
3	200 W													

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

Objectives: At the end of this exercise you shall be able to
- **read and trace the internal circuit diagram of the semi-automatic star-delta starter**
- **identify the major parts of the semi-automatic star-delta starter**
- **connect the squirrel cage induction motors to the semi-automatic star-delta starter**
- **set the overload relay**
- **make internal connections between the contactors as per diagram for the semi-automatic star-delta starter.**

Requirements

Tools and Instruments

- Screwdriver set - 1 Set.
- D.E. Spanner set - 1 No.
- Multimeter - 1 No.

Equipment/Machines

- 3-phase squirrel cage induction motor - 5 HP/3 HP 415V 50Hz - 1 No.

Materials

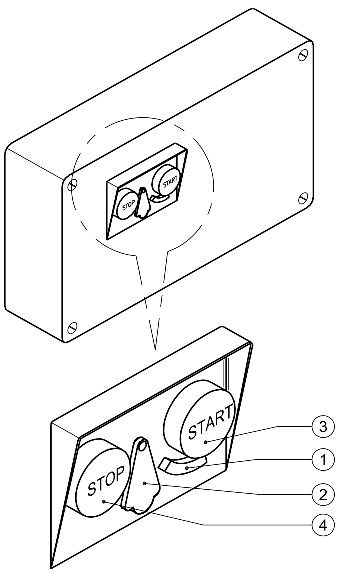
- Contactors without enclosure Rating 415V 10A, with AC coil, contact arrangement - 3 main + 2 NO + 2 NCAux. - 3 Nos.
- Thermal overload relay contactor mounting range 4 - 6.5A - 1 No.
- Stop-start push buttons - 1 No.
- Connecting leads - as reqd.
- I C T P switch 16A 415V - 1 No.

PROCEDURE

1 Collect the various components of a semi-automatic star-delta starter from the instructor (i.e Contactors, overload relay, start-stop-push-button etc.)

2 Name the external parts indicated by numbers as shown in Fig 1

Fig 1

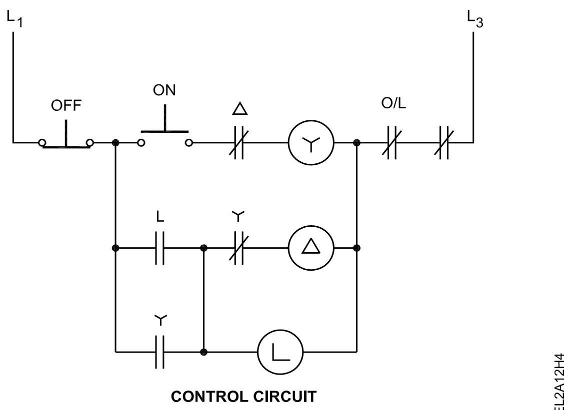


1 ....
2 ....
3 ....
4 ....

3 Draw and complete the connections in Fig 2 for the power circuit only confirming to Fig 5 (i.e connection between supply, contactors, overload relay and motor terminals).

4 Read the control circuit diagram. Fig 4 and draw the connections of the control circuit of the contactors diagram (Fig 3) for semi-automatic star-delta operation.

Fig 4



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

6 Mount the contactors, overload relay etc. on a plain vertical board.

7 Name the contactors (i.e) main, star and delta.

8 Wireup the control circuit.

Fig 2

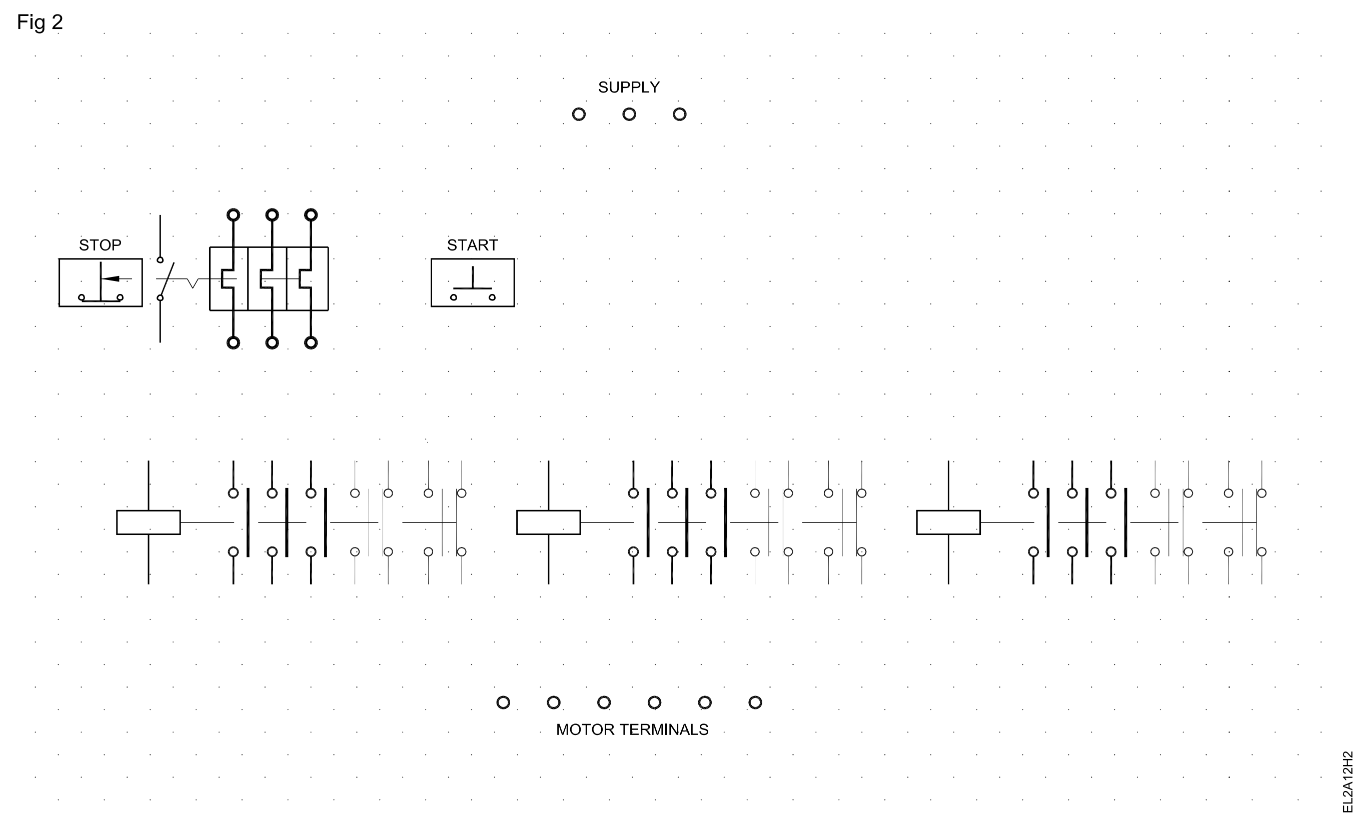
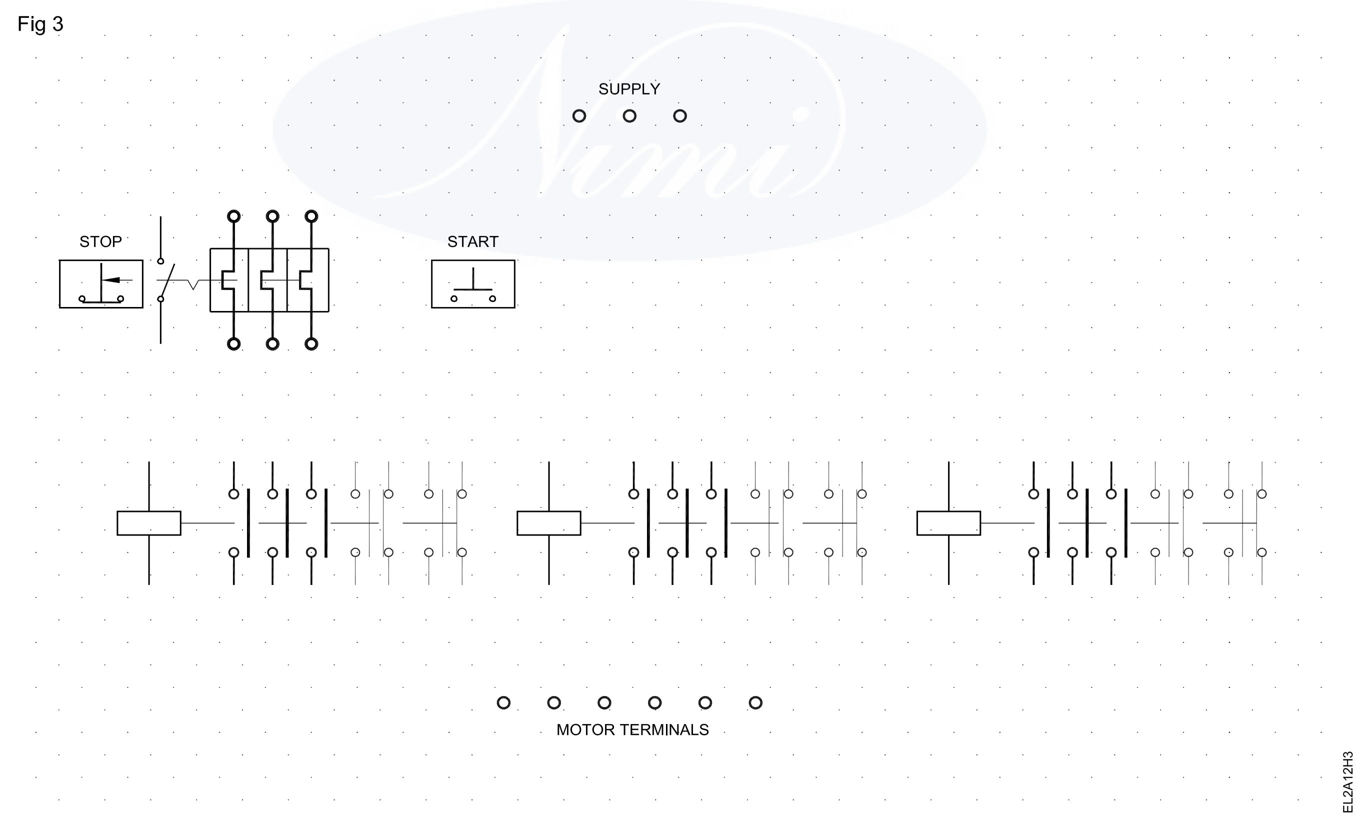


Fig 3



Use single strand conductors for control circuit connections. Make proper terminations.

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

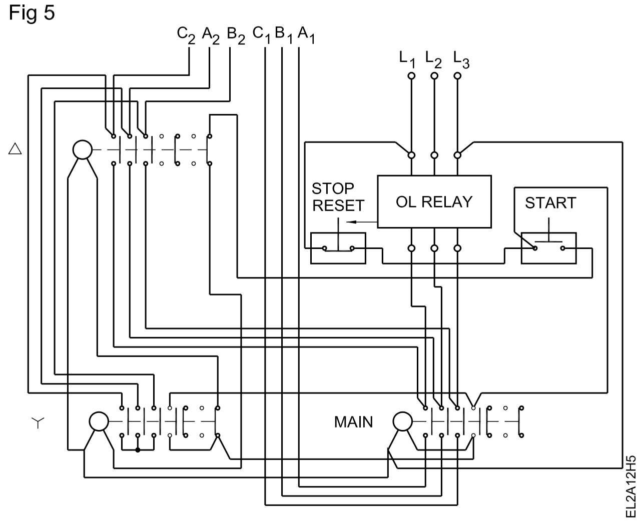
10 Call the instructor and get his approval to make the power circuit connections of the semi-automatic star-delta starter.

11 Wireup the power circuit for the semi-automatic star-delta starter according to the circuit diagram Fig 5.

12 Check the suitability of the starter for the given motor.

13 Switch on the ICTP. Press the star-button of the starter. Observe the starting.

Fig 5



Check the fuse rating in ICTP is suitable for the motor. Check the supply in all the phases.

14 When the motor reaches approximately 70% of the normal speed, release the start-button and observe the close and open condition of the contactors.

15 Press the start-button again and ensure there is no effect on the motor running.

16 Actuate the overload relay manually, and check its functioning.

17 Then press the start-button to restart the motor. Record your observation.

The motor..............(fails to start/starts)

18 Record your findings for the motor not starting when the start-button is pressed immediately after overload relay tripping.

— — — — — — — — — —

Make internal connections of automatic star-delta starter and test it

Objectives: At the end of this exercise you shall be able to
- **identify the major parts of an automatic star-delta starter**
- **read the circuit diagram provided with the automatic star-delta starter (control and power circuit)**
- **make internal connections of an automatic star-delta starter between contactors, timer and start/stop push-buttons and overload relay**
- **connect the squirrel cage induction motor to an automatic star-delta starter**
- **check for the functioning of the starter no-volt release**
- **set the timer unit with appropriate timing.**

Requirements

Tools and Instruments

- Screwdriver set - 1 Set.
- Spanner set - 1 No.
- Voltmeter MI 250/500V - 1 No.
- Multimeter (VOM) - 1 No.

Equipment/Machines

- 3-phase 415V, squirrel cage induction motor, with 6 terminals brought out at the terminal box 3 HP/5 HP - 1 No.
- Automatic star-delta starter suitable for the above motor - 1 No.

Materials

- ICTP switch 16 amp 500V - 1 No.
- Test lamp/testing board - 1 No.
- Connecting cables - as reqd.
- TW Board 300x450mm - 1 No.
- Contactor with three 10A main contacts and two 2A auxiliary changeover contacts of 1 No. and 1 NC & 415V no-volt coil - 3 Nos.
- Timer unit 5s - 30s 415V operation - 1 No.
- Overload relay 3-phase 16A, 415V - 1 No.
- Start/stop push-buttons - one each

PROCEDURE

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.

1 ....

2 ....

3 ....

4 ....

5 ....

Fig 1

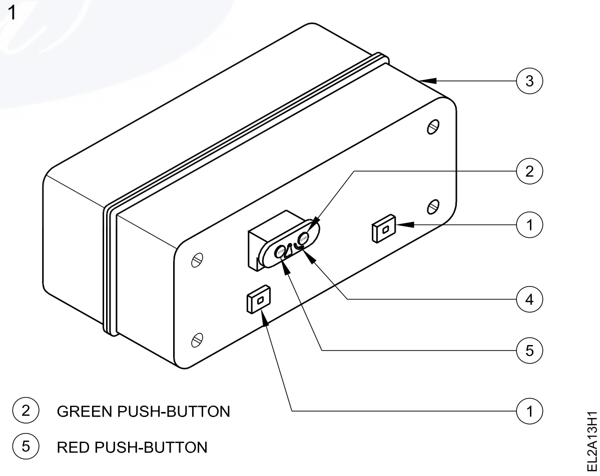
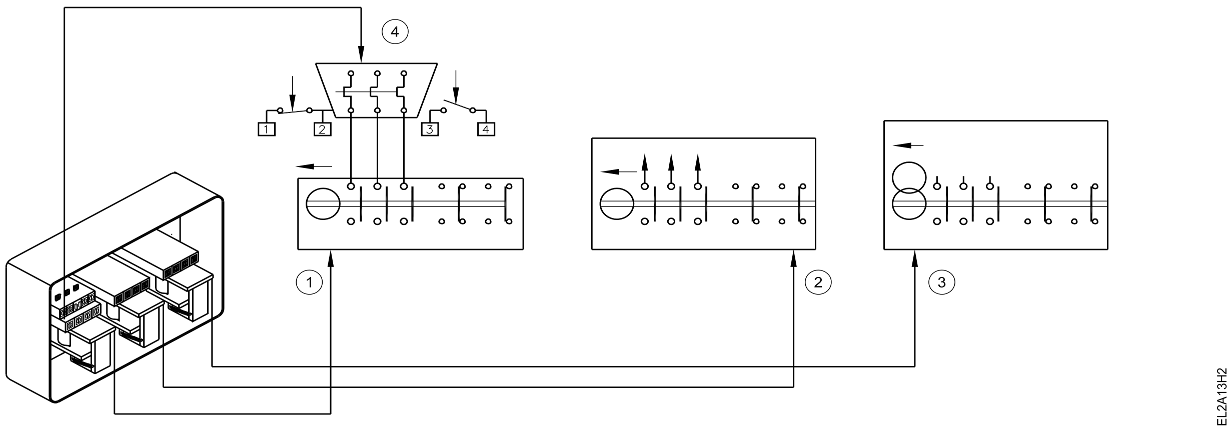


Fig 2



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

1 ....

2 ....

3 ....

4 ....

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

5 Draw and complete the connections in Fig 4 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 provided (Fig 5) 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 Wireup 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.

Fig 3

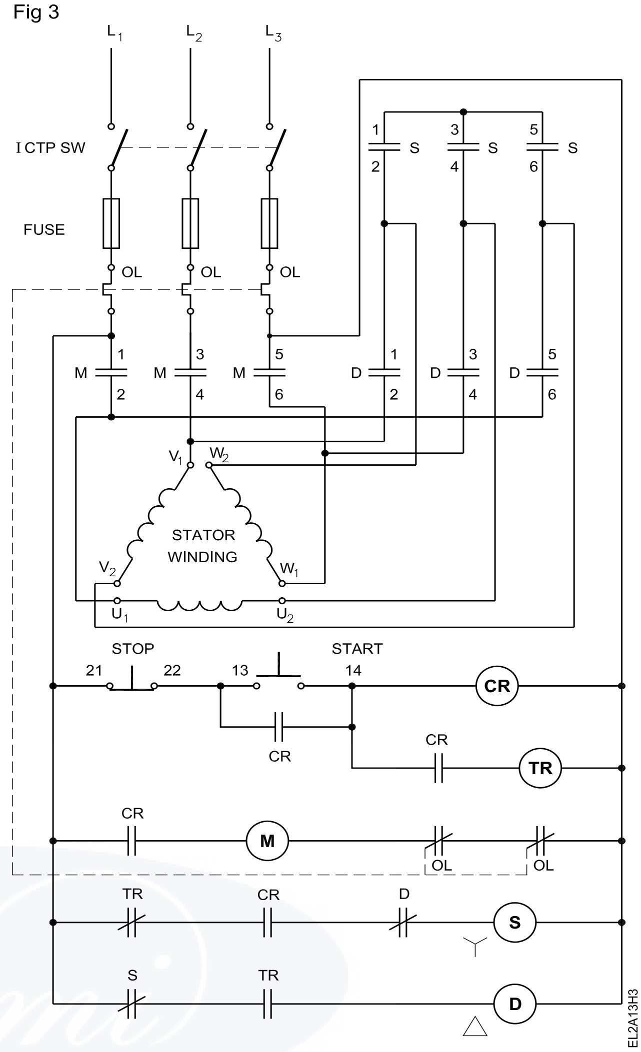


Fig 4

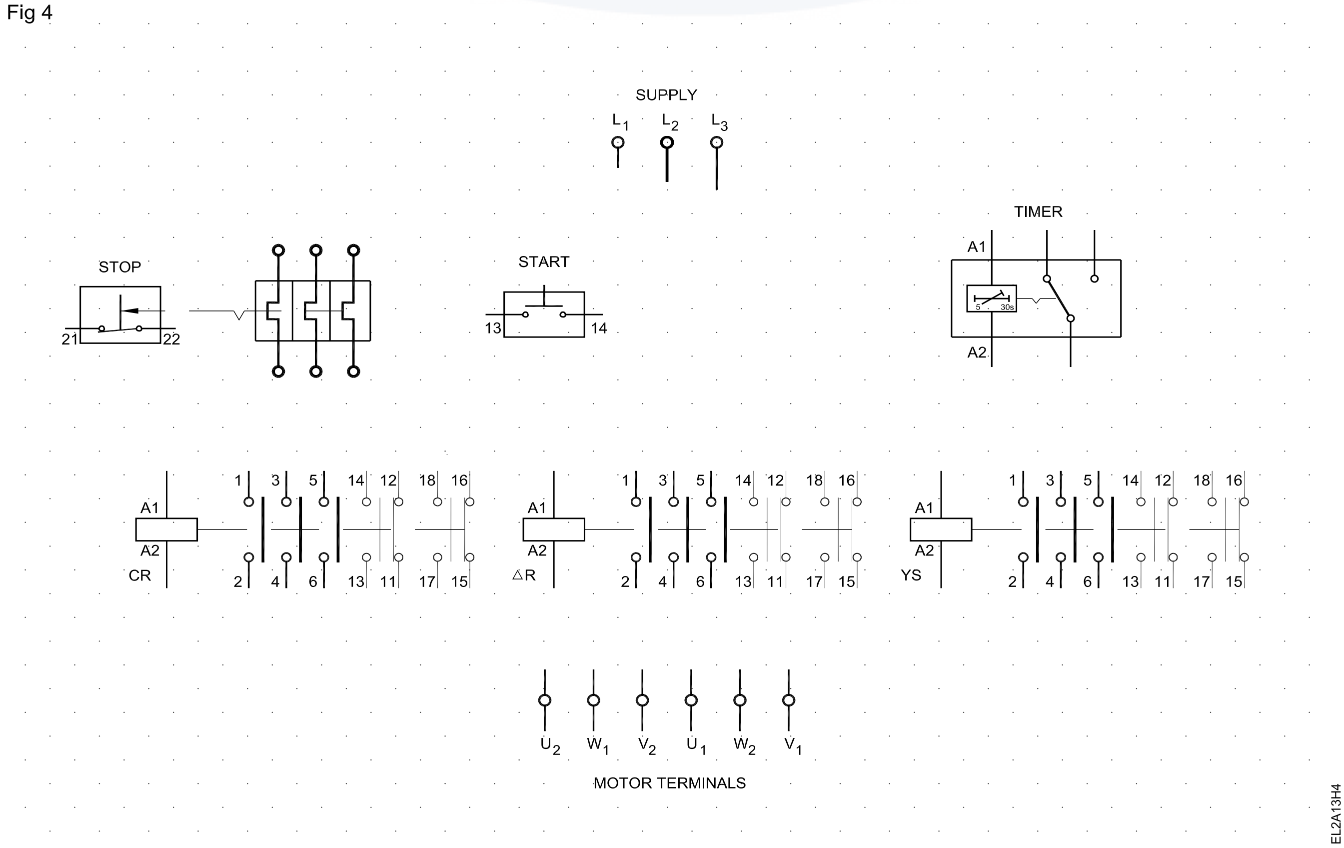
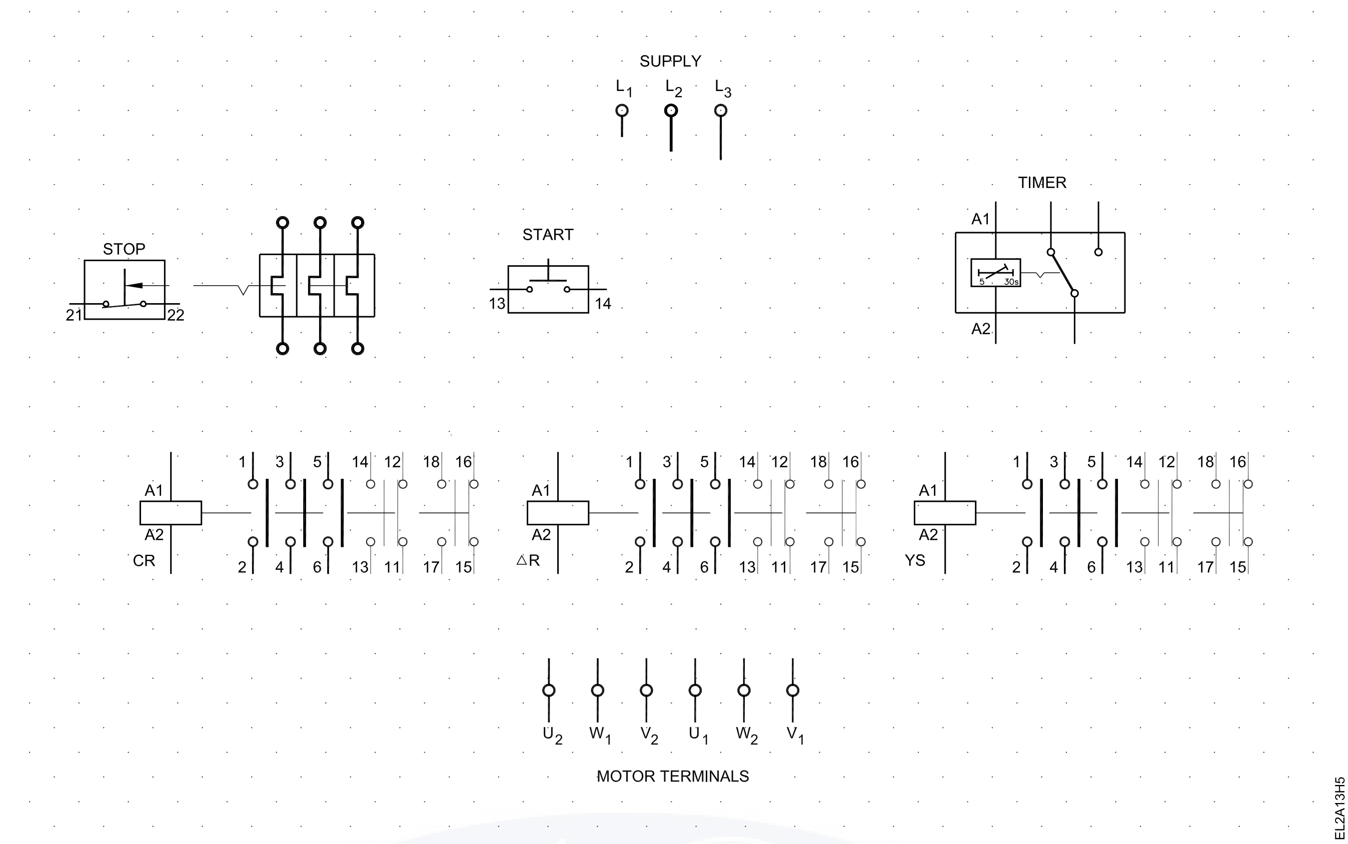


Fig 5



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.

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

c) at 70% of normal speed

If it is above 70% of normal speed reduce the time setting.

If it is below 70% of normal speed increase the time setting.

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, run & reverse the direction of rotation of a 3-phase slip ring induction motor through rotor resistance starter

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 terminals of the 3-phase slip ring induction motor**
- **identify the parts of the 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 currents and speed**
- **reverse the direction of rotation.**

Requirements

Tools/Instruments

- Trainees tool kit - 1 No.
- Voltmeter MI (0 to 500 V) - 1 No.
- Tachometer 0 to 3000 rpm - 1 No.
- Ammeter MI (0 to 20 A) - 1 No.
- Megger 500 V - 1 No.

Equipment/Machines

- AC 3-phase slip ring induction motor 415 V 5 HP - 1 No.
- Rotor resistance starter complete set suitable for 5 HP 415 V 3-phase slip ring induction motor - 1 No.

Materials

- PVC insulated, stranded aluminium cable 2.5 sq. mm. 660 V grade - 15 m.
- PVC insulated, flexible cable 14/0.2 mm 660 V grade - 2 m.
- Insulation tape -as reqd
- GI wire 8 SWG - 10 m.

PROCEDURE

TASK 1: **Connect the slip ring motor.**

1 Record the name-plate details of the given motor and the starter and enter them in Table 1.

TABLE 1

Name-plate details of the rotor resistance starter

Make	
Type, Model	
Serial Number	Rating.....................
Function	Alternator/Motor ....
Types of connection	HP/kW/kVA.........
Rated voltage ....volts.	Rated current ..... amps
Speed ....rpm	Frequency..................Hz
Power Factor	Excitation/Rotor voltage........
Insulation class	Protection class ....

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

> **Slip ring terminals can be identified by checking the continuity from terminals to 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.

> **Fig 1 gives the generalised circuit diagram of a rotor resistance starter. Compare it with the traced out diagram. This is for your guidance only. There may be variations in the practical circuit.**

4 Select the ICTP switch, cables and fuse wire according to the rating of the motor.

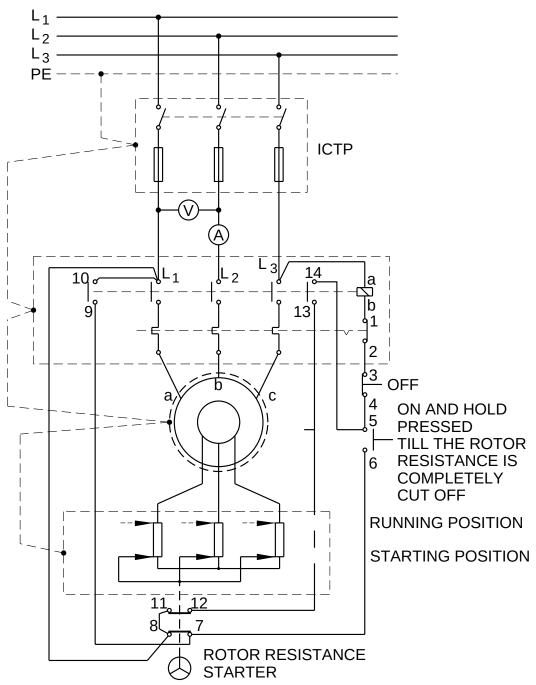
5 Draw the circuit diagram connecting the ICTP, starter, rotor resistance and the motor and get it approved by the Instructor.

6 Connect double earth independently for the main switch, starter and the motor. (Use GI wire No.8 SWG as earth wire.)

7 Connect the motor, starter, main switch, meters as per the approved diagram and get it checked by the instructor.

8 Check the supply and provide proper rating fuses in the main switch according to the motor rating.

Fig 1



CIRCUIT DIAGRAM OF THE ROTOR RESISTANCE STARTER WITH ICTP SWITCH & MOTOR

To start and run the motor

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

'Cut in' position of rotor resistance in general is indicated in the starter as 'starting position' or 'off position'.

10 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.

11 Note down the reading of the voltmeter, ammeter at the time of just starting and normal running positions. Record it in Table 3.

12 Release the pressure from the start push-button.

13 Note down the direction of rotation. The direction of rotation is ___________.

14 Measure the speed and enter in Table 2.

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

16 Try to start the motor when the rotor resistance handle is in running position. Referring to Fig 1, the motor starts only when the rotor resistance handle is in the starting position. The motor will not start in any intermediate position or in the running position.

Investigate the following:

i Whether the motor could be started when rotor resistance handle is at running position.

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

iii Whether the motor could be started when the rotor resistance handle is at the starting position.

Write your conclusion.

____

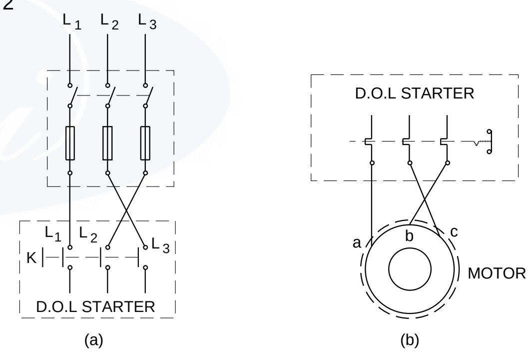
____

____

17 Switch OFF the ICTP and make sure the supply is disconnected and the fuses removed and kept in safe custody.

18 Interchange any two of the line wires either in the starter terminal as shown in Fig 2a or in the motor terminals as shown in Fig 2b.

Fig 2



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

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

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

TABLE 2

Sl.No.	Line voltage in volts	Starting current in amps	Running current in amps	Speed in rpm.

Connect, start & run 3 phase squirrel cage induction motor through an auto-transformer starter

Objectives: At the end of this exercise you shall be able to
- **connect a 3-phase induction motor with an auto-transformer starter**
- **start and run a 3-phase squirrel cage induction motor by auto transformer starter**
- **change the direction of rotation of the motor.**

Requirements

Tools/Instruments

- Trainees tool kit - 1 No.
- Multimeter - 1 No.
- Insulation tester, 500 V - 1 No.

Equipments/Machines

- Auto-transformer starter 3-phase 440V with fixed tapping - 1 No.
- Three-phase squirrel cage induction motor 415V, AC, 3KW/5HP - 1 No.

Materials

- Contactors 415V AC with 240V operating coil voltage
  16A - 3 power circuit contacts - 4 Nos.
  2A - 4 auxiliary change over contacts - 4 Nos.
- Delay timer relay, 240V AC, operating coil with 1 or 2 normally open contacts - 3 Nos.
- Connecting cable copper 1.5sq.mm for control circuit - 10m
- Power cable single strand 2.5sq.mm copper - as reqd.

PROCEDURE

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

2 Check the earthing connection for its effectiveness.

3 Trace the diagrams Fig 1 and Fig 2. What are the indications of the following symbols in the diagram?

Fig 2

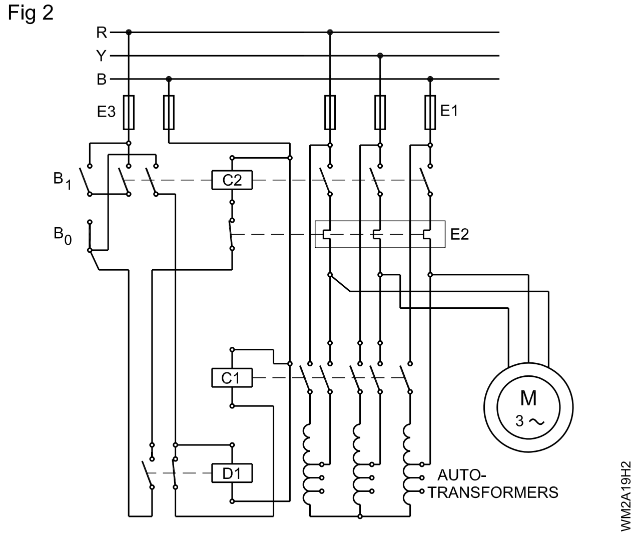
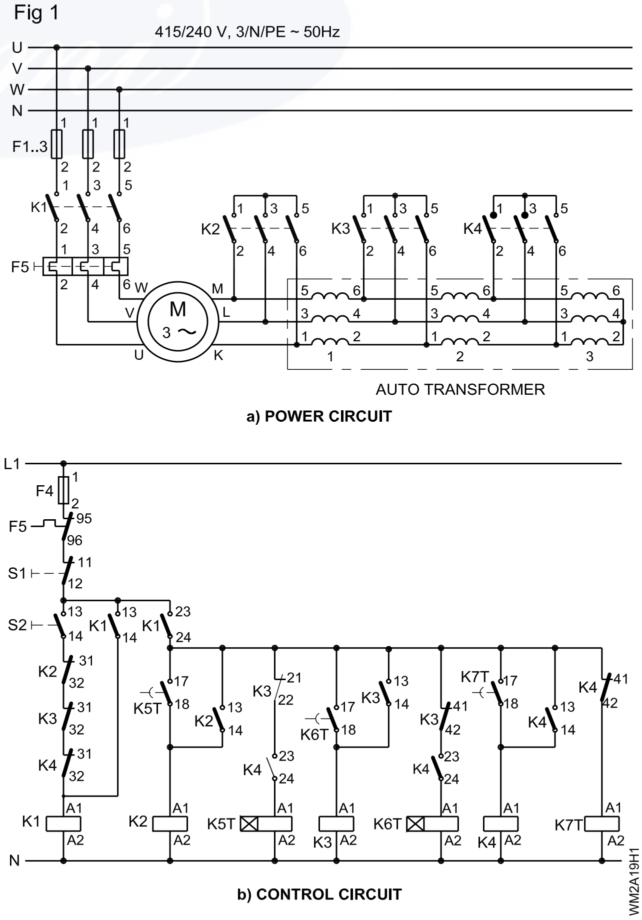


Fig 1



a) POWER CIRCUIT

b) CONTROL CIRCUIT

4 Draw the power lines connecting the contactors, auto-transformer and motor for sequential operation in Fig 3.

5 Mark the different terminals of contators corresponding to the actual panel provided as shown in Fig 4.

6 Draw the control circuit connections including timer and overload trip for sequential operation in Fig 3.

Get the circuit checked by the instructor before proceeding.

7 Make connections as per diagram.

8 Switch on S_1. 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 4

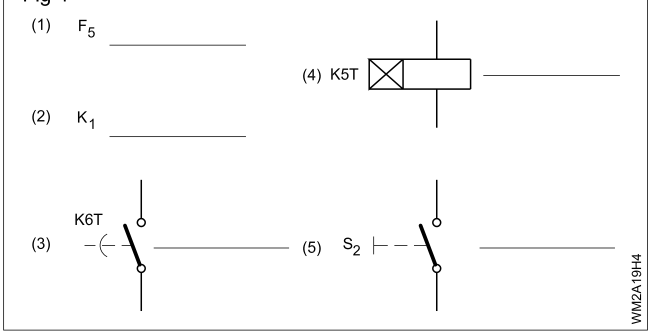
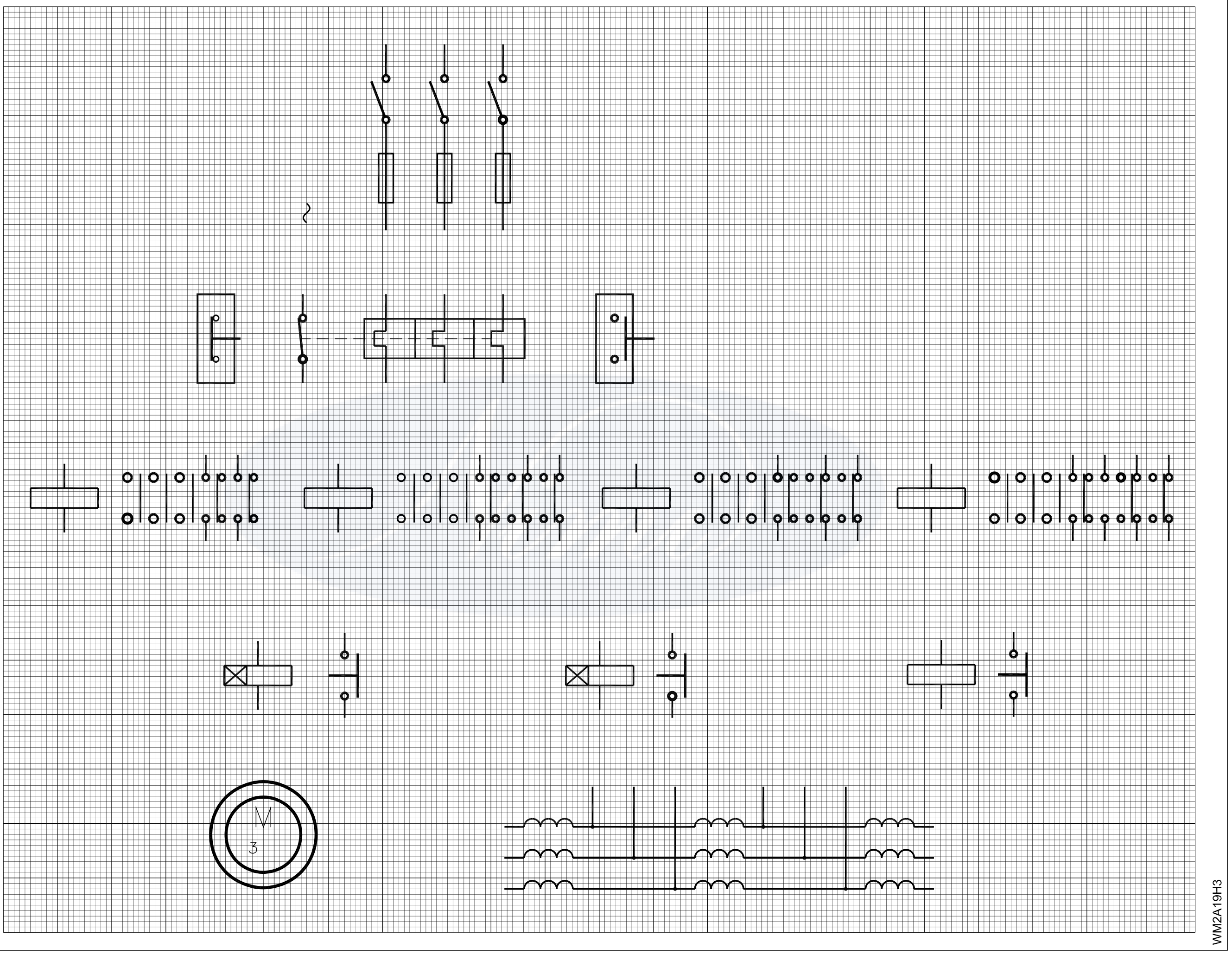


Fig 3



Connect a single phasing preventer to run a 3-phase induction motor and test for its operation

Objectives: At the end of this exercise you shall be able to
- **refer to the manufacturer's data of the single phasing preventer**
- **trace the connection diagram**
- **draw the wiring connection**
- **test the operation of the single phasing preventer for its function**
- **check for visual faults**
- **identify the stage of fault with the help of meters**
- **identify the faulty components and replace them.**

Requirements

Tools/Instruments
- Cutting plier 200mm - 1 No.
- Screwdriver 150mm - 1 No.
- Connector screw driver 100mm - 1 No.
- Voltmeter M.I. 0-500V - 1 No.
- Multimeter - 1 No.
- Test lamp 100W 240V - 1 No.

Equipments/ Machines
- Three-phase induction motor 3.6 kW, 415V - 1 No.
- Starter 3-phase, DOL type - 1 No.
- Single phasing preventor (voltage sensing) - 1 No.
- Single phasing preventor (current sensing suitable for the above motor) - 1 No.

Materials
- PVC insulated aluminium cable 2.5 sq.mm. 650V grade - as reqd.
- Rheostat 8A/50 ohms - 1 No.

PROCEDURE

TASK 1: **Connect and test a Single Phasing Preventer (S.P.P.) voltage sensing type/current sensing type.**

1 Refer to the manufacturer's data and record the details in Table 1.

TABLE 1

i	Manufacturer/Make ....
ii	Type ....
iii	Supply voltage .... Phase .... Hz ....
iv	Serial No ....
v	Connection ...... Voltage sensing/Current sensing

2 Draw the wiring diagram as given by the manufacturer.

3 Fig 1 shows the wiring diagram for the current sensing type single phasing preventer and Fig 2 shows the wiring diagram for voltage sensing type single phasing preventer. The figures are given for your reference.

Fig 1

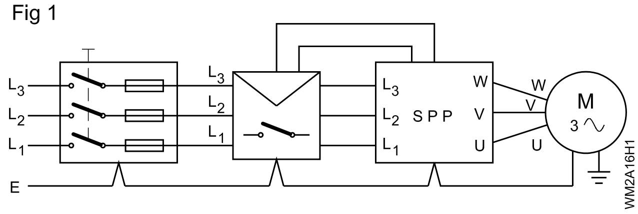
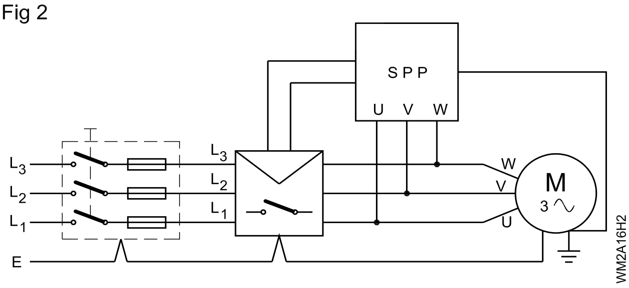


Fig 2



4 Trace the control circuit of the starter which is connected to the relay contact of the single phasing preventer and draw in the circuit. The control circuit diagram in Fig 3 is given for your reference. Compare the traced circuit with the manufacturer's diagram.

5 Connect the single phasing preventer as per the manufacturer's leaflet/diagram.

6 Provide proper earth connections to the motor, starter and single phasing preventer.

7 Show the connection to your instructor and get his approval.

8 Switch on the power supply and operate the 'ON' button of the starter and observe the working of the motor as well as the indication on the single phasing preventer if any.

Most of the single phasing preventers will operate only one particular order of phase sequence of the supply system. If the phase sequence is not correct, the phase failure relay will not energise even under normal operating conditions.

If the phase failure relay does not energise under normal operating condition, interchange any two of the incoming supply leads to the single phasing preventer to correct the phase sequence.

RESULT

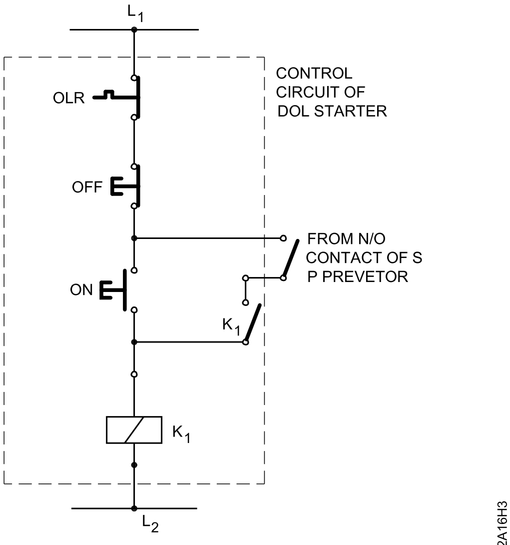
Strike off the sentence which is not applicable.

Motor starts and works normally / starts but does not hold on / does not start at all.

Indicating lamp of single phasing preventer is off / on indicates fault / OK.

9 Verify the proper working of the single phasing preventer by simulating a single phase condition either by removing a fuse in one of the line or by disconnecting one wire connected to the single phasing preventer.

Fig 3



CONNECTION OF SINGLE PHASING PREVENTOR WITH DOL STARTER

RESULT

By simulating the single phasing condition the starter trips / does not trip.

— — — — — — — — — —

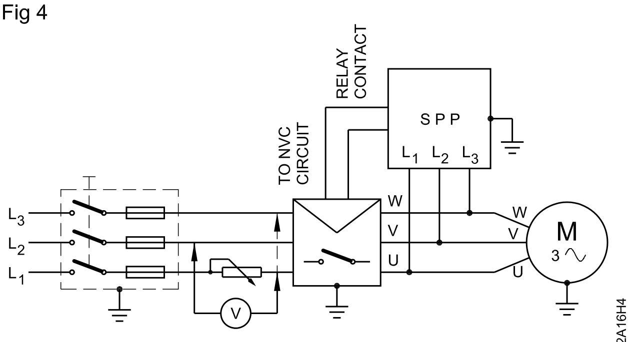
TASK 2: **To test the Single Phasing Preventer (S.P.P.) for its operation if the three phase supply is unbalanced**

Assumption: The single phasing preventer is provided with an accessible preset adjustment for operation. No adjustment is possible if the single phasing preventer is permanently adjusted and epoxy sealed.

1 Open the cover of the single phase preventer and identify the potentiometer for unbalanced settings by referring to the manufacturer's leaflet/ instruction on the cover.

2 Connect the single phasing preventer in proper phase sequence with a suitable rheostat in one line as shown in Fig 4 or 5 depending upon type of single phasing preventor.

Fig 4



CONNECTION OF VOLTAGE OPERATED SPP

3 Keep the rheostat in the cut out position and switch on the power supply, motor starter and ascertain the motor single phasing preventer and the starter functions normally.

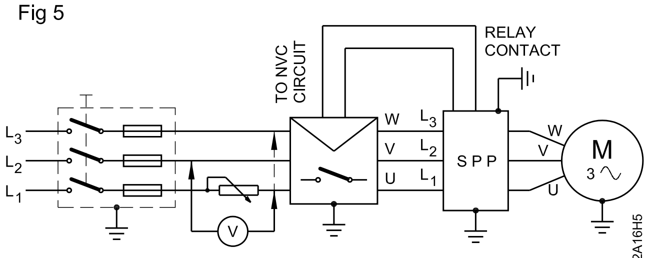
4 Measure the line voltages across each line and record the same.

i Voltage between L1 and L2 ....

ii Voltage between L2 and L3 ....

iii Voltage between L3 and L1 ....

Fig 5



CONNECTION OF CURRENT OPERATED SPP

5 Simulate an unbalanced condition by varying the rheostat gradually until the single phasing preventer trips.

The single phasing preventer requires above 5 to 10 seconds for tripping after the unbalanced condition is established.

6 Measure the line voltages across each line in unbalanced condition at which the single phase preventer trips and record the same.

i Voltage between L1 and L2 ....
ii Voltage between L2 and L3 ....
iii Voltage between L3 and L1 ....

Normally a single phasing preventer trips at about 5 to 10% variation in unbalanced line voltages.

7 If a single phasing preventer has to be adjusted for some other unbalanced voltage, operate the preset adjustment.

Frequent adjustment of preset resistor may cause loose connection of the preset and result in erratic function of the single phasing preventer.

— — — — — — — —

TASK 3: **Troubleshooting of single phasing preventer**

Assumption: The instructor will provide a defective single phase preventer or create simple fault for troubleshooting.

1 Collect the name-plate details of the given single phasing preventer and enter the same in Table 2.

TABLE 2

Mechanical / Current sensing / Voltage sensing

Make .... Type .... Sl.No ....

No. of phase .... Voltage .... Frequency ......

KW ....

2 Trace the connection details and investigate the functional features of the single phasing preventer.

3 Inspect the single phasing preventer for visual defects like charred terminals / deformation of leads / decolouration due to excess heating, insulation burn out, smell etc.

Visual observation

Single phasing preventer OK/ Not OK.

4 Measure the continuity where ever possible like transformer, relay contacts etc.

RESULT

Continuity OK / Not OK

5 Measure the insulation resistance between the terminals and ground connection.

RESULT

Insulation resistance OK / Not OK

6 After the inspection and initial test results are OK, connect the single phasing preventer in the circuit and test for normal working.

RESULT

Single phasing preventor OK /Not OK.

7 If the single phasing preventer is not working. Check for phase sequence.

RESULT

Phase sequence OK / not OK

8 If the single phasing preventer is not working with proper phase sequence measure the terminal voltages both at input and output where ever possible.

RESULT

Voltages balanced / unbalanced / Not OK.

9 If the voltages are not OK trace and rectify. If the voltages are unbalanced adjust the preset check the function.

10 If the voltages are OK, trace and check the control circuit.

11 When the control circuit is OK, test the starter connected with the single phasing preventer.

RESULT

Starter control circuit is OK/Not OK

12 Write your conclusion about the defects and rectification carried out in the S.P.P. circuitry.

— — — — — — — —

Measure the slip of 3-phase squirrel cage induction motor by tachometer for different output. Draw slip/load characteristic of the motor

Objectives: At the end of this exercise you shall be able to
- **select suitable instruments from the name-plate details of the motor**
- **measure the speed of the induction motor using a direct reading tachometer**
- **load the induction motor mechanically**
- **determine the slip from the actual speed**
- **calculate the output of the induction motor**
- **draw the graph of slip/load characteristics.**

Requirements

Tools and Instruments

- Tachometer - multi-range 300, 1000, 3000, 10000 rpm - 1 No.
- Ammeter MI, 0 - 10A - 1 No.
- Voltmeter MI, 0 - 500V - 1 No.
- Wattmeter 500V 10A - 2 Nos.

Equipment/Machines

- 3-phase squirrel induction motor 3 HP 415V 50 HZ - 1 No.
- Brake loading system - 1 No.
- DOL starter 10A 3 phase - 1 No.

Materials

- Graph sheet - 1 No.
- ICTP switch 16A, 415V - 1 No.
- Connecting cables - as reqd.

PROCEDURE

1 Record the name-plate details of the motor in Table 1.

2 Make the connections as per diagram. (Fig 1)

3 Check the supply for the rated value.

4 Measure the radius of the brake drum (R_P) and thickness of belt (R_t) and record in Table 2.

5 Switch 'ON' S.

6 Start the motor on no load.

Fig 1

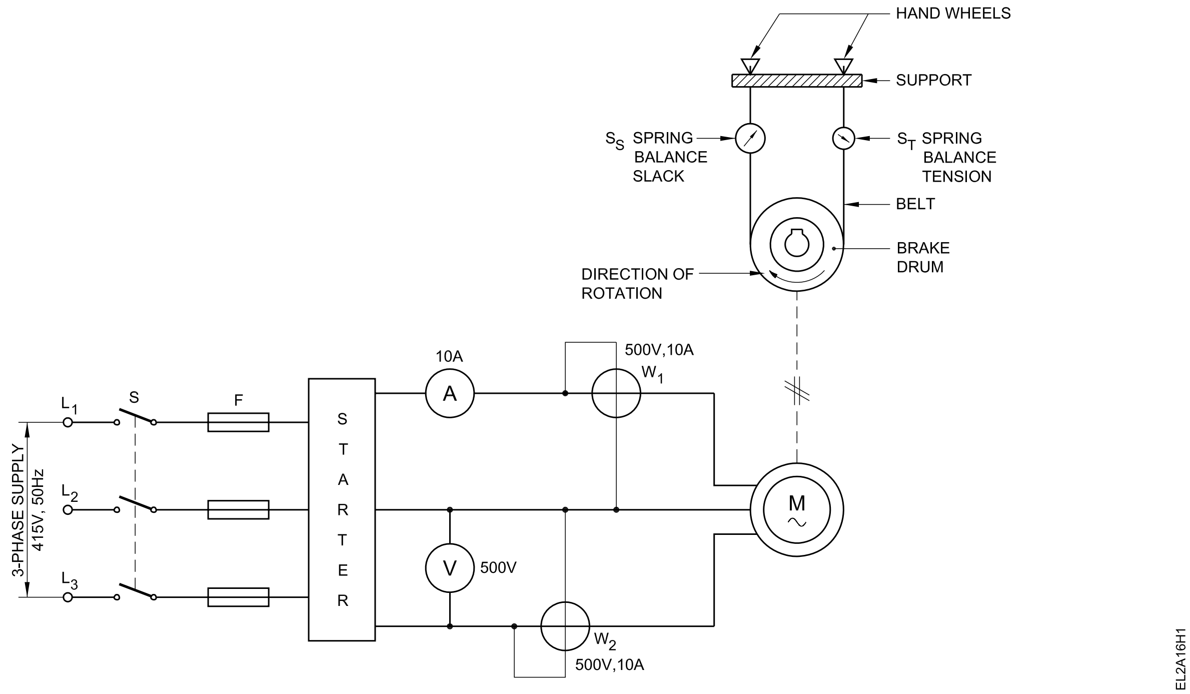


TABLE 1

Name-plate details

Manufacturing Co.	____________	Machining type	____________
Serial No.	____________	Connection	____________
Voltage	____________	Phase ________	Frequency ________
Current	____________	Output	____________ kW/HP
Power factor	____________	Speed	____________

TABLE 2

Sl. No.	$R = R_p + R_t$ (W1 + W2)	Speed	Slip	S_T spring balance tension	S_s spring balance slack	$S_T - S_S$
1						
2						
3						
4						

TABLE 3

$(W_1 + W_2)$	$T = R(S_T - S_S)$	BHP = $2\pi NT/4500$
1		
2		
3		
4		

7 Measure the speed by a tachometer and apply the formula to calculate the slip at no-load and record in Table 2.

$$\text{slip} = \frac{\text{syn speed } (N_S) - \text{act. speed } (N)}{\text{syn. speed } (N_S)}$$

$$\text{i.e} \quad s = \frac{N_s - N}{N_s}$$

8 Load the motor with brake to about 25%, 50%, 75% & 100% of full load and record the readings of $W_1 + W_2$ in Table 3.

The sum of the readings W_1 & W_2 of wattmeters will provide guidance to determine the load condition.

9 Measure at every load the spring balance readings, and the speed, and record in Table 2.

10 Calculate the BHP applying the formula for each load condition.

BHP = $2\pi NT/4500$

where $T = R\ (S_T - S_S)$ kgm

R = Radius of pulley + thickness of belt in metre

N = speed in rpm

11 Draw the graph of the slip/load characteristics.

Conclusion:

The slip ____________ with the increase in load (output) on a squirrel cage induction motor.

Why does the speed decrease? Give your response ________________________________

____

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

- Voltmeter MC 0-30V - 1 No.
- Ammeter MC 0-2.5A - 1 No.
- Ammeter MI, 0 - 2A - 1 No.
- Ammeter MI, 0 - 10A - 1 No.
- Wattmeter 500V, 1A/2.5A low power factor - 2 Nos.
- Wattmeter 125/250V, 10/5A multirange - 2 Nos.
- Voltmeter MI 0 - 500V - 1 No.
- * Voltmeter MI, 0-75, 150, 300V multirange - 1 No.

Equipment/Machines

- 3-phase squirrel cage induction motor 415V, AC, 50Hz, 3 HP - 1 No.
- DOL starter 415V, AC, 50Hz, 3 HP - 1 No.
- 3-phase auto-transformer Y input 415V, output 0-500V 3 KVA - 1 No.
- Lock bar/locking arrangement - 1 No.
- DC power supply 0.30 VDC - 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 in Table 2.

2 Collect the instruments to connect the circuit as shown in Fig 1.

3 Make the connections as per circuit diagram shown in Fig 1.

4 Check the supply for the rated value and switch 'ON' the ICTP. (S_1) (If the value is not correct adjust by auto transform)

5 Start the motor without any load.

6 Read and record the wattmeter, ammeter and voltmeter readings in Table 1.

TABLE 1

Input voltage	Power input $W_o = (W_1 + W_2)$	No-load current I_o

7 Switch 'OFF' the supply and disconnect all connections of the meters, and the motor.

8 Check the connections of the 3-phase supply leads to the motor terminals. If six terminals are available identify each phase winding.

Fig 1

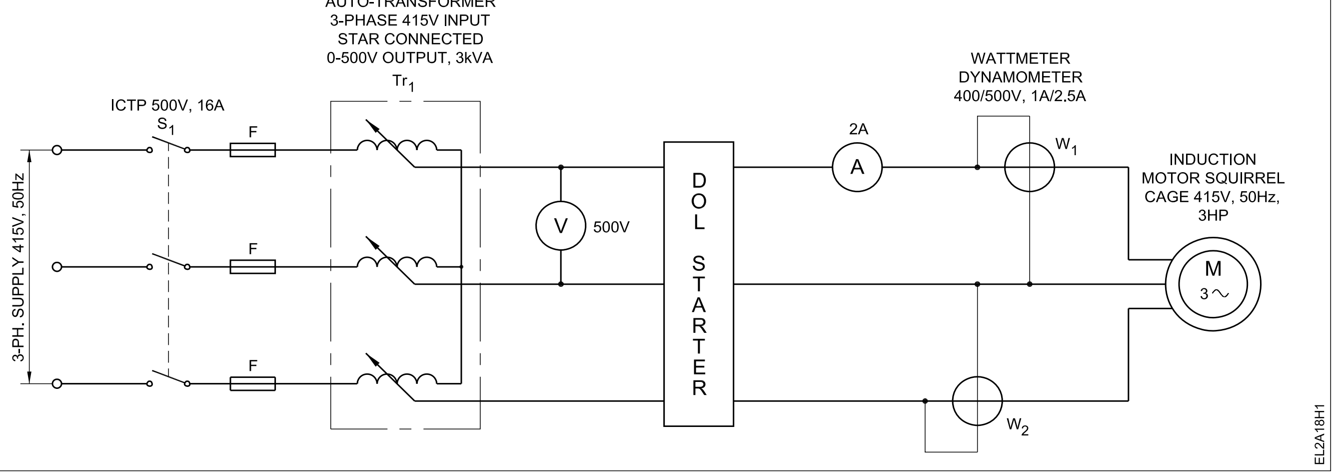


TABLE 2

Manufacturer's Name	: ____________		
Voltage	: ____________	Phase	: ____________
Current	: ____________	Speed	: ____________
Power factor	: ____________	kW/HP	: ____________
Connection	: ____________	Rating	: ____________
Starting current	: ____________		

9 Measure the resistance of the stator using DC low voltage supply, ammeter and voltmeter. Record the reading in Table 3.

TABLE 3

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

$R = R_P \parallel 2R_P$ (R_P is parallel with $2R_P$)

i.e $\frac{1}{R} = \frac{1}{2R_P} + \frac{1}{R_P}$

$Rp = \frac{3}{2}R$

CALCULATIONS

The no-load input (W_0):

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 = $W_o - (I_{oph})^2R \times 3$.

— — — — — — — —

TASK 2: **Blocked rotor test**

1 Collect the instruments to connect the circuit as per diagram, Fig 2.

2 Make the connections as per circuit diagram, Fig 2.

Keep the auto-transformer at zero output voltage position.

3 Switch on ICTP 'S_1'.

4 By holding motor shaft firly 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 4.

Fig 2

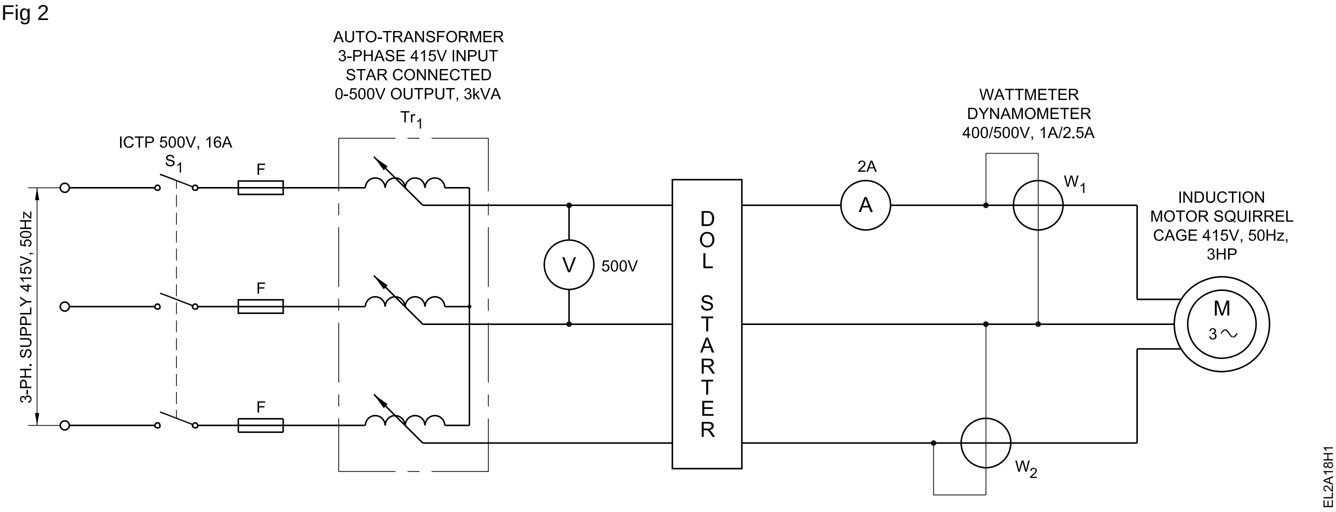


TABLE 4

Input voltage V	Power input W	Blocked current I

Calculation

Wattmeter reading = full load I^2R loss.

$= 3\ I_P^2 R_e$

where R_e = Resistance of stator winding per phase

I^2 R at No load $= = 3\ I_o^2 R_o$

Magnetic losses = No load input – copper loss.

Total loss = full load I^2R loss + Magnetic loss

= Block rotor wattmeter reading + Magnetic losses

Efficiency $= \dfrac{\text{Output}}{\text{Input}}$

Determine the efficiency of the motor at full load.

Constant losses

= Copper loss at full load $= 3\ I_P^2 R_e$ watts

where R_e – equivalent resistance/phase

I_P – full load current/phase

Copper loss at full load = _________ watts.

Input

= √3 V I Cosθ = ___________ watt.

Total losses = constant losses + copper loss

Therefore, efficiency = ____________

6 Find the efficiency when the input current is 0.7 full load and p.f is 0.8.

CONCLUSION

____

____

____

____

____

Test & identify the terminals of a three-phase alternator and measure insulation resistance

Objectives: At the end of this exercise you shall be able to
- **read and interpret the name plate details of the given alternator**
- **identify the terminals of alternator**
- **measure the insulation resistance values of windings.**

Requirements

Tools/Instruments
- Trainees tool kit - 1 No.
- Ohmmeter - 1 No.
- Megger 1000V - 1 No.

Equipments/ Machines
- 3-phase alternator 3.5KVA 415V, 50 Hz - 1 No.

PROCEDURE

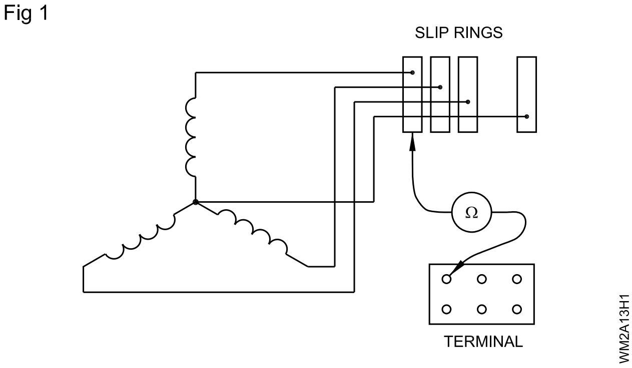
1 Open the inspection cover of the slip rings in the alternator count the number of slip rings.

For a 3-phase rotating armature type there will be four slip rings. For rotating field type there will be two slip rings.

Remove the terminal box cover in case of a rotating armature type alternator.

2 Conduct the continuity to identify the AC output terminals of the alternator by touching the slip rings and terminals with the leads of the ohmmeter, as shown in Figure 1.

Fig 1



3 Mark the terminals having continuity (zero ohms) between the slip rings and terminals as L_1, L_2, L_3 and N (star point) (for neutral terminal identification follow the step 8).

4 Conduct the continuity test for the remaining two terminals which are from the field winding. Measure the resistance of the field winding and note down the value.

Field winding resistance ....Ω

The field winding resistance depends upon the rating of the alternator.

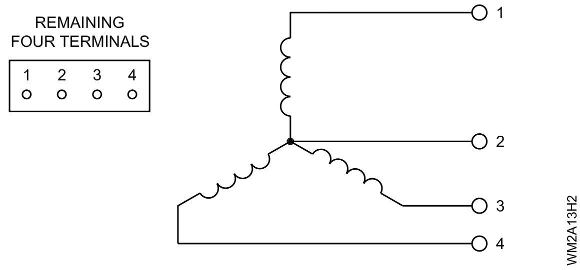
5 Mark these field terminals as F_1 and F_2.

In case of rotating field type alternator.

6 Conduct the continuity test between the slip-rings and terminals by using ohmmeter.

7 Mark those terminals showing continuity with slip rings as F_1 and F_2 which are the field windings.

Fig 2



To identify the neutral from the remaining four terminals.

8 Measure the resistance between pairs of terminals as shown in Figure 2 and Table 1.

TABLE 1

Pair of terminals	Resistance in Ohms
1 - 2	
1 - 3	
1 - 4	

Result

Compare the above measured values. Consider the low value. Say for example 1-2. Then terminal 2 is the neutral terminal. Mark it as N. Mark the other terminals as L_1, L_2, L_3.

Conduct the insulation resistance test between field winding and body also between L_1, L_2, L_3 and body. Record the values in the Table 2.

TABLE 2

Insulation resistance

Between	**In Mega ohms**
L1 & Body	
L2 & Body	
L3 & Body	
F1 & L1, or L2 or L3	
F1 & Body	

The above measured insulation resistance values should be greater than 1 mega ohm.

Name plate details

Read the name-plate details of the given alternator and record the same in Table 3.

TABLE 3

Manufacturer's Name	
Volts/phase V	Current ....A
No. of Phases.........	Frequency ....Hz
KVA	Power factor ....
R.P.M....................	Connection ....
SL.No....................	
Excitation	
Volts V	Type
Current ....A	

— — — — — — — —

Connect, start, run a three-phase alternator (MG Set) and build up the voltage

Objectives: At the end of this exercise you shall be able to
- **connect the alternator and run at its rated speed**
- **build up the voltage to its rated value.**

Requirements

Tools/Instruments

- Trainees tool kit -1 No.
- MC voltmeter (0-100V) -1 No.
- MC Ammeter (0-1A) -1 No.
- MI voltmeter (0-500V) -1 No.
- Frequency meter (45-55Hz)(415 V) -1 No.
- Tachometer, 0 - 3000 rpm -1 No.

Equipments/ Machines

- Alternator 3.5 KVA 3-phase 415V, 50Hz coupled with DC shunt motor 5HP with 3-point starter, suitable DC source - 1 No.

Materials

- Rheostat - 500 Ω, 1A - 2 Nos
- Connecting leads - as reqd.
- Knife switch DP - 250V, 15A - 2 Nos

PROCEDURE

1 Read the name plate details of the given alternator and record the same in Table 1.

TABLE 1

Manufacturer's Name	
Volts/phase V	Current .... A
No. of Phases..........	Frequency ....Hz
KVA	Power factor ....
R.P.M.....................	Connection ....
SL.No.....................	
Excitation	
Volts V	Type ....
Current ....A	

2 Make the connections as per circuit diagram shown in Fig 1.

3 Close the switch S1 and start the shunt motor keeping its field rheostat (R1) in cut out position.

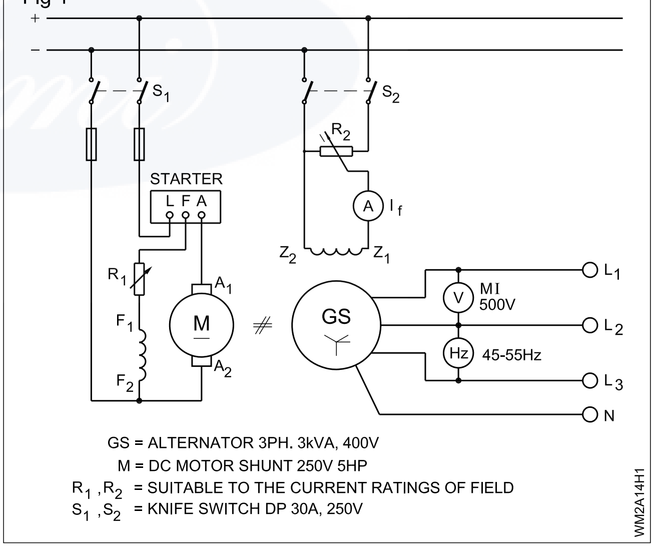
4 Adjust the speed of the shunt motor to the alternator's rated speed by operating the rheostat R1. Measure the speed using tachometer.

5 Observe the terminal voltage for zero excitation current and record in Table 2.

6 Close the switch S2 and adjust the excitation current from zero to rated value in 8 steps.

Excitation current should not be increased more than the desired value.

Fig 1



7 Observe and record the terminal voltage for each setting of excitation current in Table 2. Observe the frequency at the rated terminal voltage and verify the value with name plate detail.

8 Calculate the phase value of voltage

$V_{ph} = \frac{V_L}{\sqrt{3}}$ and complete the table.

TABLE 2

Sl. No.	Excitation current I_F Amps	Terminal Voltage V	Voltage per phase V
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
RATED SPEED		.... RPM	

A graph may be plotted with excitation current on X-axis and phase voltage on Y-axis using the above values. This curve shows the Open Circuit Characteristics (O.C.C.) of the alternator.

— — — — — — — — — —

Load the three-phase alternator and determine its voltage regulation at various types of load (UPF & LPF)

Objectives: At the end of this exercise you shall be able to
- **connect and run the alternator at its rated speed**
- **build up the voltage and frequency to its rated value**
- **load the alternator with resistive and inductive loads**
- **determine the voltage regulations at full load.**

Requirements

Tools/Instruments

- Trainees tool kit - 1 No.
- MC Ammeter (0-1A) - 1 No.
- MI Voltmeter (0-500V) - 1 No.
- MI Ammeter (0-10A) - 1 No.
- Frequency meter (45-55Hz) (415V) - 1 No.
- Power factor meter (2-element) - 1 No.
- Tachometer - 1 No.

Equipments/ Machines

- Alternator 3-phase 3.5 KVA 415V, 50Hz coupled with shunt motor 5 HP with starter - 1 No.
- Water rheostat /load - 3-phase -1 No.
- Induction motor - 3-phase 415V 5 HP with brake loading arrangements -1 No.

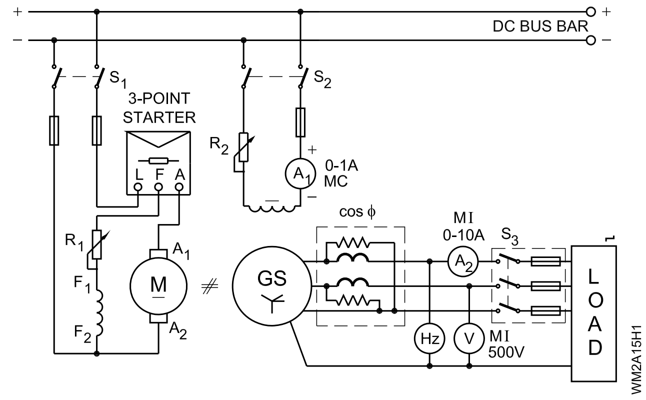
Materials

- Variable resistor 500Ω 1A -2 No.
- ICTP switch 500V, 32A -1 No.
- Knife switch 250V, 15A -2 Nos

PROCEDURE

1 Make the connections as per circuit diagram shown in Figure 1.

Fig 1



2 Keep the switches S_2 and S_3 open. Keep the rheostat R_2 in cut in position. (maximum resistance inserted in field circuit).

3 Close switch S_1 and start the DC shunt motor through the 3-point starter with R_1 in cutout position.

4 Adjust the speed of the motor by operating R_1, to the rated speed of the alternator. Measure the speed using tachometer.

5 Close S_2 and increase the excitation current and build up the voltage to the rated value as per name plate detail.

6 Close the switch S_3 and increase the load (water rheostat) gradually up to the rated full load current.

7 Measure and record the terminal voltage, power factor at full load current in Table 1.

8 Switch off S_3 and measure, record the terminal phase voltage at no- load.

9 Calculate the voltage regulation at full load unity PF by using the formula

$$\%\ \text{Voltage regulation} = \frac{V_{\text{No load}} - V_{\text{Full load}}}{V_{\text{Full load}}} \times 100$$

Inductive Load (Lagging PF)

10 Disconnect the water rheostat load and connect the 3-phase squirrel cage induction motor, with brake loading arrangements.

11 Keep the brake load minimum and close the switch S_3. Gradually increase the load on motor by operating the brake arrangement till the full load current is delivered by the alternator.

12 Measure and record the terminal voltage, power factor at full load current in Table 2.

13 Switch off S_3 and measure, record the terminal phase voltage at no-load.

14 Calculate the voltage regulation at full load lag PF by using the formula

$$\% \text{ Voltage regulation} = \frac{V_{\text{No load}} - V_{\text{Full load}}}{V_{\text{Full load}}} \times 100$$

TABLE 1

Resistive load (Unity Power Factor UPF)

Terminal (phase) voltage on full load	**Terminal voltage on No-load (phase)**	**Load current in A**	**Load power factor**

TABLE 2

Inductive load (Lagging Power Factor LPF)

Terminal (phase) voltage on full load	**Terminal voltage on No-load (phase)**	**Load current in A**	**Load power factor**

15 Enter the results in tabular column and compare them.

Type of load	**% Voltage regulation**
Resistive (UPF)	
Inductive (LPF)	

Connect the two 3 phase alternators in parallel by lamps and synchroscope method and test it

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**
- **synchronise the two 3 phase alternators by dark and bright lamp method**
- **synchronise the two 3 phase alternators by synchroscope method.**

Requirements

Tools/Instruments

- Trainees tool kit - 1 No.
- Voltmeter MI 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/415 V 50 Hz coupled with prime mover(/adjustable speed control) - 2 Nos.
- Rheostat 150 ohms/1A - 1 No.

Materials

- TPIC switch 16A, 415V - as reqd.
- ICDP / Knife switch 16A, 240V - 1 No.
- ICTP / Knife switches 16A, 415 V - 2 Nos.
- 100W/240 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
2. Note down the details of alternators in Table - 1

Table 1

Name-plate details

Manufacturer, Trade Mark............................	Rated frequency...
Type, model or list number...........................	Rated power.......................................kW/HP
Type of current...	Rating class...
Function..Alternator	Insulation class...
Fabrication or serial number.........................	Rated current...................................... amps
Type of connection......................................	Rated speed..r.p.m
Rated exc. current ....amps	Rated exc. Voltage.....................................V
Rated voltage... volts	Protection class..
Direction of rotation.......................................	

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 as in 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.**

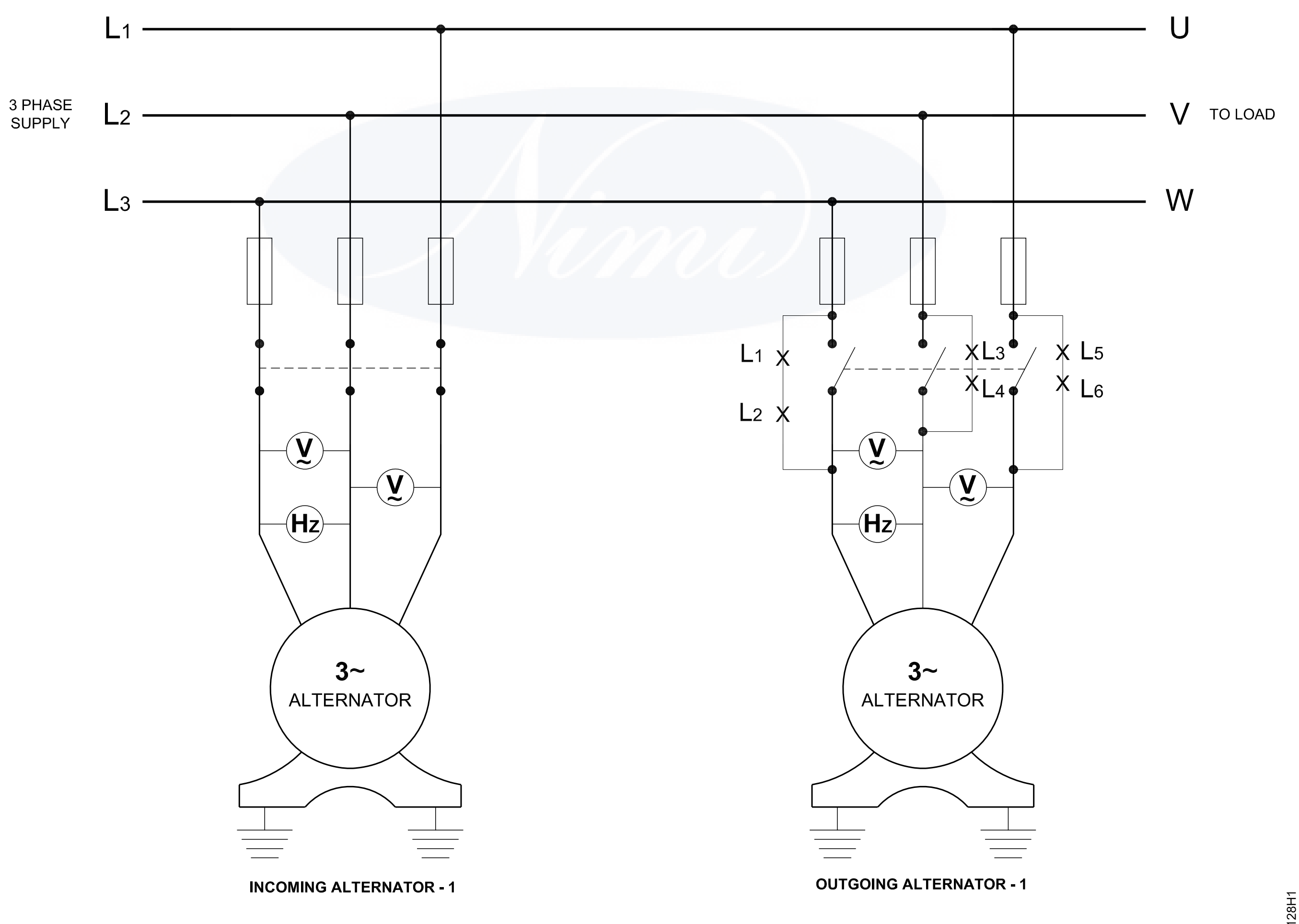
3 Keep the main switch of incoming alternator - 1 in closed position after ensuring the phase sequence are correct

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 their measure the frequency and note down the readings of voltmeter and frequency meters in Table - 2

Fig 1



PARALLEL OPERATION OF 3 PHASE ALTERNATOR BY DARK LAMP METHOD

Table - 2

S. No.	Voltage reading inVolt	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 - 3

Table - 3

S. No.	Voltage reading inVolt	Frequency in Hz
1	L1 - L2	L1 - L2
2	L2 - L3	L2 - L3
3	L3 - L1	L3 - L1

9 Look at 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 Look at 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 swich 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 - 4 & Table - 5

Table - 4

Alternator - 4

S. No.	Voltage reading inVolt	Frequency in Hz
1	L1 - L2	L1 - L2
2	L2 - L3	L2 - L3
3	L3 - L1	L3 - L1

Table - 5

Alternator - 5

S. No.	Voltage reading inVolt	Frequency in Hz
1	L1 - L2	L1 - L2
2	L2 - L3	L2 - L3
3	L3 - L1	L3 - L1

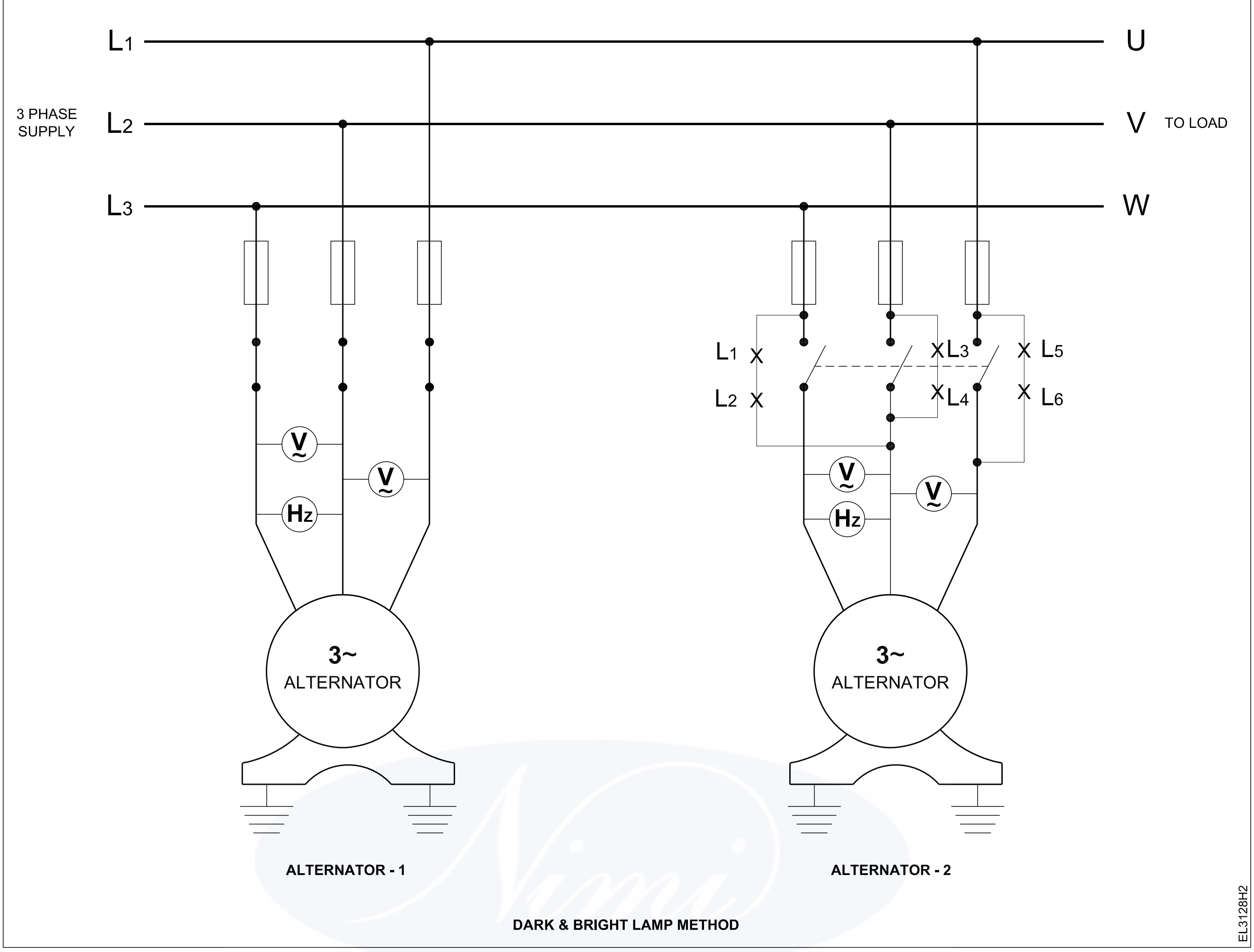
5 Look at the condition of the lamps

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 stand still lighting

10. If 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

Fig 2



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.

11. Close the main switch of alternator - 2 when the lamps are bright condition

Now the 2 alternators are synchronised (paralled) and ready for sharing the load

12. Switch 'ON' the common load for both alternators

13. Check the loads are shared equally by the two alternators

— — — — — — — —

TASK 4: **Connect two alternators in parallel by using synchroscope**

1 Collect the instruments as shown in Fig 3.

2 Connect the equipment and instruments as shown in Fig .

Keep `open' the bus-bar switch S_1 and synchronising switch S_2.

3 Start the incoming alternator with low excitation.

4 Close the bus-bar switch S_1.

One alternator is connected to the bus-bar that produces the rated V.

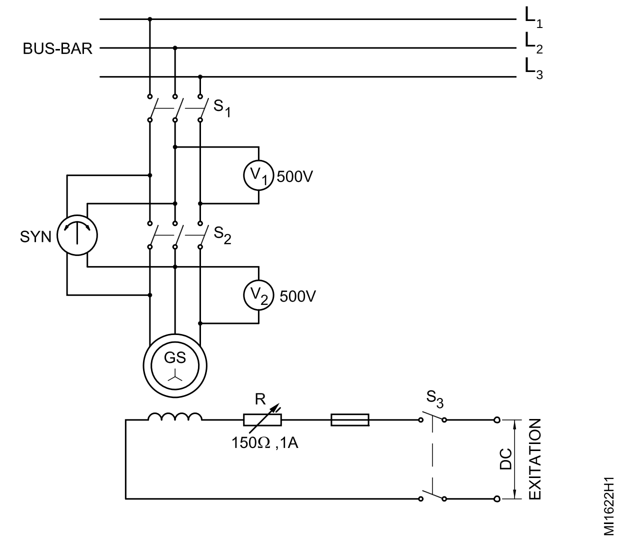
5 Observe the bus-bar voltage V_1 and incoming voltage V_2.

6 Adjust the excitation of the incoming alternator till $V_1 = V_2$. The voltage of incoming and exciting machine should be equal.

7 Observe 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.

Fig 3



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.

Overhauling of AC motors

Objectives: At the end of this exercise you shall be able to
- **test the motor for continuity and insulation**
- **run the motor and observe sound and mechanical vibrations**
- **mark the dismantling parts for proper re-assembling**
- **remove the brushes and set them for proper seating on commutator**
- **clean the motor and internal parts**
- **varnish the windings**
- **check the bearing and replace grease**
- **re-assemble the motor and test it for proper working.**

Requirements

Tools/Instruments

- Trainees tool kit - 1 No.
- Multimeter - 1 No.
- Megger 500V / 1000V - 1 No.

Equipments/ Machines

- Single-phase induction motor, capacitor start - 1 No.
- Single-phase series motor - 1 No.
- Single-phase universal/split-phase/ capacitor run motor - 1 No.

Materials

- Sheet metal tray for components - as reqd.
- Insulating varnish air drying-good quality - as reqd.
- White cloth - as reqd.
- Kerosene oil - as reqd.
- Thinner (good quality) - as reqd.
- Sleeves - as reqd.
- Hair brush for cleaning - 1 No.
- Paint brush 25mm bristle - 1 No.

PROCEDURE

TASK 1: **Dismantling AC motor**

1 Place the motor on a clean, level and solid surface, e.g. workbench, concrete floor.

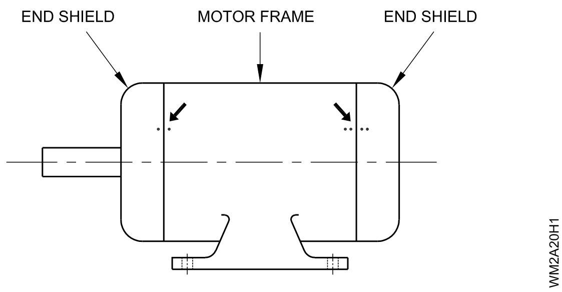
Do not open the motor on a dirty floor.

2 Clean the outside of motor to remove all dirt and dust with a dry rag, cloth or brush. Removing grease using some petrol or kerosene oil.

Do not use water.

3 Mark the exact position of both the END SHIELDS and the MOTOR FRAME with a sharp centre punch, scriber or a file. This will help maintain the true bearing alignment when reassembling. Observe the difference in marking at both end shields. (Fig 1)

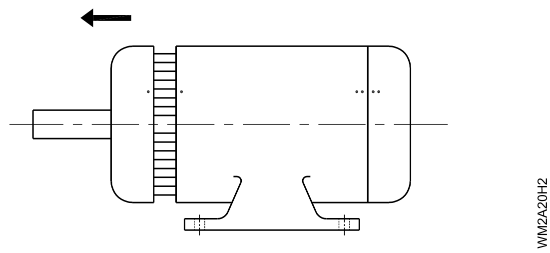
Fig 1



4 Take out the carbon brushes, if the motor has any, to avoid damages.

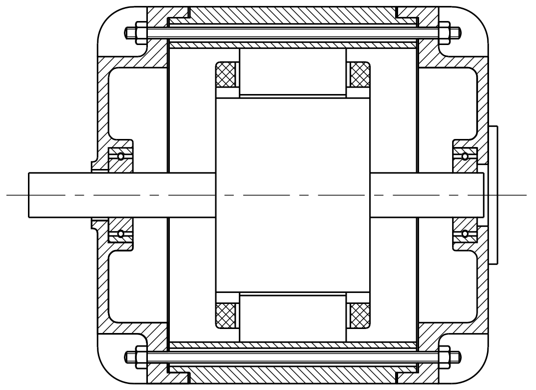
5 Open the nuts or screws using exact size spanners or correct size screwdriver. DO NOT USE PLIERS. If the screw and nuts are very tight, apply light hammer blows and soften with petrol or kerosene oil. (Fig 2)

Fig 2



Certain motors have through studs with nuts on either side to fix the end shields with the frame. After slackening the nut on one side it may tend to rotate freely. Arrest free rotation by holding the other nut with a spanner of proper size. (Fig 3)

Fig 3



6 Open END SHIELD on shaft extension side first. On the opposite side very often the motor lead wires are attached or the centrifugal switch is mounted.

Be careful - not to tear off the wires from the motor winding - not to damage the centrifugal switch.

7 Clean the inside of the motor carefully with compressed air, rags etc or a small (new) paint brush with some petrol or kerosene oil. Do not use too much cleaning fluid directly on the windings as it may damage the insulation.

8 Place all parts of the motor in a tray or box. Do not mix the parts from other motors or tools.

— — — — — — — —

TASK 2**: Overhauling of AC motor**

1 Read and follow the general procedure for overhauling of motors recommended by the manufacturer.

2 Follow the steps given as the general guide for overhauling of motors, as recommended by the Bureau of Indian Standards vide IS 900 - 1965.

a) Dismantle the motor without using excessive force and without hammer blows. If possible, do not open the cartridge bearing housings.

b) Clean every part free of dust, dirt, oil and grit using a blower, compressed air hose, bellows or brushes, and wash with petrol to which a few drops of oil can be added, if necessary. Complete removal of foreign matter is essential.

c) Check all parts for damage or wear, and repair or replace as necessary.

d) Measure the insulation resistance and dry out if necessary until correct value is obtained. Repair or replace any damaged windings.

e) Re-enamel or revarnish all windings and internal parts except the stator bore and rotor outer iron surface; dry thoroughly.

f) Re-assemble without using any excessive force.

Make sure that the machine leads are on the correct terminals and that everything is well tightened.

g) Check the insulation resistance again.

h) Check the air gaps.

i) Put back to work after making all checks and applying all rules as for initial starting.

3 Overhaul the given single-phase capacitor start motor.

Observe the functioning of the centrifugal switch.

Note the conditions of contacts. Repair or replace if necessary.

4 Overhaul the given single phase series motor.

Exercise care while the commutator is undercut.

5 Overhaul any other type of single phase induction motor.

— — — — — — — —

Connect & test the single phase motor starter for proper protection of the motor

Objectives: At the end of this exercise you shall be able to
- **identify and collect the parts of a D.O.L. starter**
- **assemble the D.O.L. starter when contactor overload relay, push-button stations and single-strand cables are given in semi-knocked out condition.**
- **connect and harness the hook-up cable for control circuit.**
- **mount the D.O.L. starter, the main ICDP switch and connect the single phase induction motor**
- **earth the motor, the starter and the switch**
- **set the overload relay**
- **replace correct capacity back-up fuses**
- **start and stop the single phase induction motor through D.O.L. starter**
- **measure the starting and the running currents of the single phase motor**
- **measure the actual speed of the single phase motor.**

Requirements

Tools/Instruments

- Combination plier 200mm - 1 No.
- Screwdriver 300mm with 4mm blade - 1 No.
- Connector screwdriver 100mm - 1 No.
- Side cutting plier 200mm - 1 No.
- Electrician's knife100 mm - 1 No.
- Ammeter MI 0-20 amps - 1 No.
- Voltmeter MI 0-300V - 1 No.
- Plumb bob with thread - 1 No.
- Spirit level - 1 No.
- Tachometer 0-3000 r.p.m. - 1 No.

Equipments/ Machines

- Single-phase induction motor, 1 HP 240V 50Hz capacitor start - 1 No.
- D.O.L. starter 10 amps 240V with overload relay, no-volt coil & push-button station -1 No.

(Instructor is requested to dismantle the contactor, overload relay and the internal connecting hook-up cables before giving the equipment to the trainees.)

Materials

- PVC insulated, single strand copper cable 16SWG -0.5m.
- PVC insulated, single strand copper cable 18SWG -0.5m.
- Machine screws 2 BA, 30mm long with 2 washers and one nut -4 Nos
- ICDP switch 16A 240V -1 No.

PROCEDURE

1 Note down the name-plate details of the given AC single phase induction motor in Table 1.

TABLE 1

Name-plate details

Manufacturer, Trade Mark	
Type, Model or list number	
Fabrication or serial number	
Rated voltage .... volts	Rated current .... amps
Rated power .... k.w.	Rated speed ....r.p.m.
Insulation class	

2 Collect the contactor unit, overload relay unit, start/stop push-button unit, the necessary fixing screws, hook-up cables, ICDP switch and D.O.L. starter base and cover.

3 List the items you received from your instructor in Table 2.

4 Record the name-plate details of the contactor and overload relay in Tables 3 and 4 respectively.

5 Investigate and check the contactor input and output terminals, auxiliary and main terminals, movable and fixed contacts, no-volt coil, overload relay, their rating, normally closed relay contacts and their operation.

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

7 Identify the mounting screw holes in the contactor overload relay and the corresponding holes in the starter base box.

8 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 the following diagrams are given for a starter of a particular make. (Fig 1, 2, 3 & 4)

Fig 1 Base and cover of D.O.L.starter.

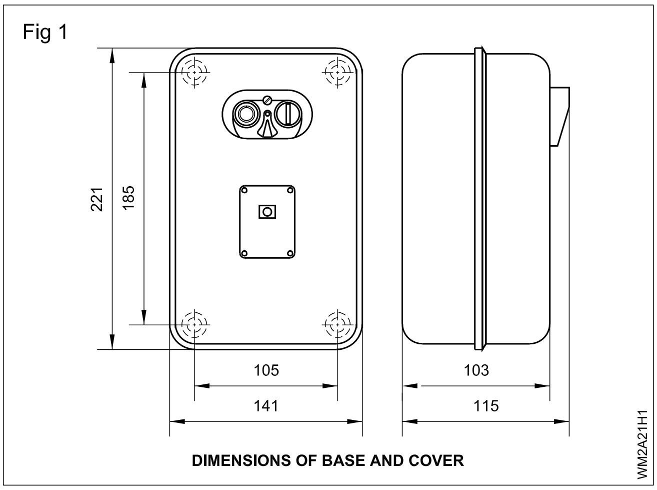


Fig 2 Push-buttons only.

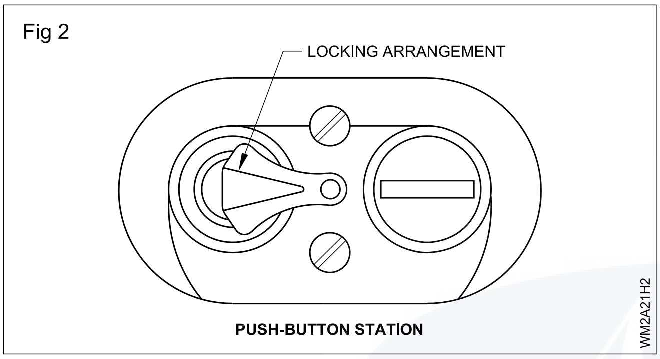


TABLE 2

List of items

1	______	9	______
2	______	10	______
3	______	11	______
4	______	12	______
5	______	13	______
6	______	14	______
7	______	15	______
8	______		

TABLE 3

Contactor

....

....

....

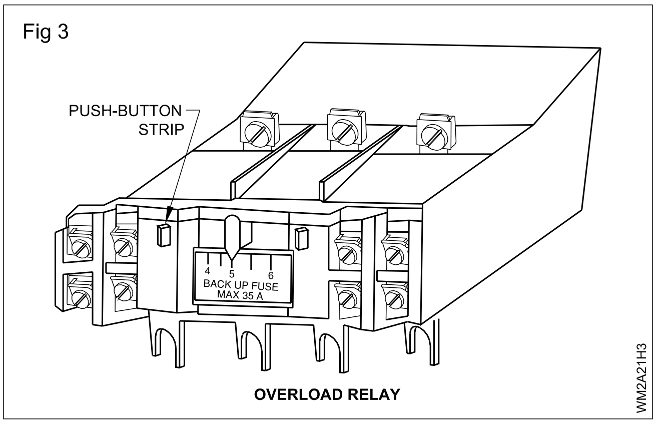


Fig 4 Contactor with no-volt coil.

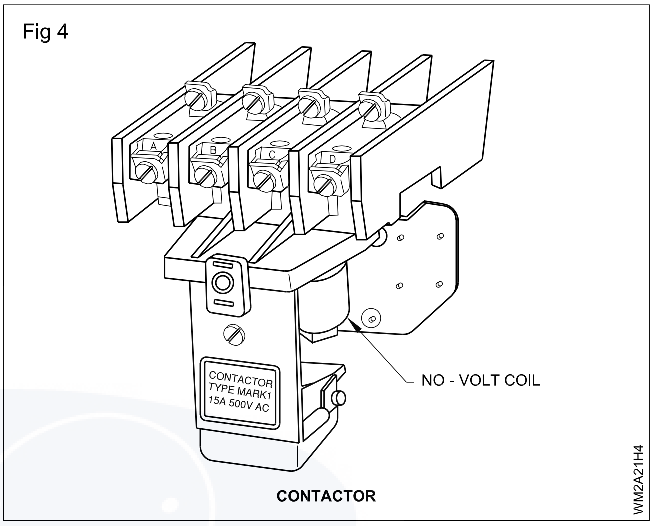


TABLE 4

Overload relay

....

....

....

9 Get the diagram approved by the instructor.

10 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.

11 Identify the place of connection of the hook-up cables with the help of the approved diagram. Measure and cut the hook-up cables leaving allowance for harnessing.

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

13 Harness the hook-up cables such that the cables do not interfere with any moving mechanism of the starter.

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

15 Get the wiring approved by your instructor.

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

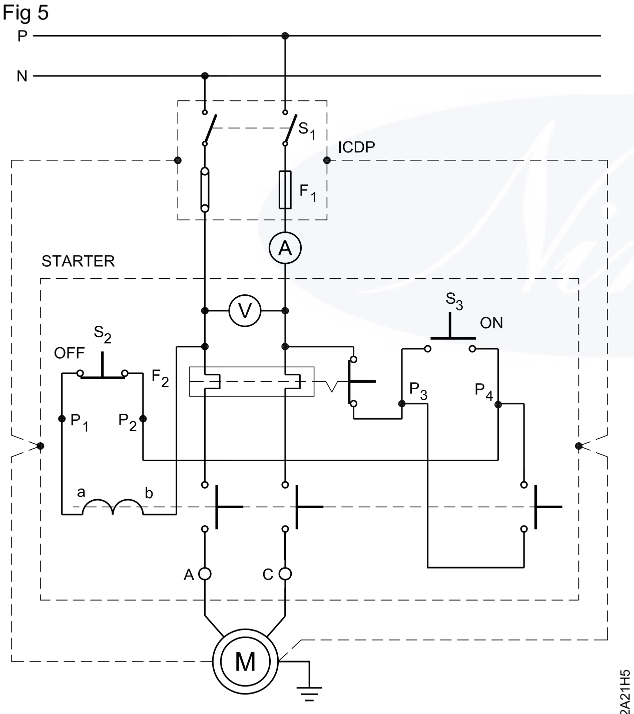
17 Mount the starter vertically on the wall/frame.

> **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.**

18 Connect the main supply to the starter incoming terminals through the ICDP Switch. (Fig 5)

> **A complete diagram showing the internal diagram of a starter of a particular make along with I.C.D.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



D.O.L STARTER FOR SINGLE PHASE MOTOR

19 Connect the starter outgoing terminals to the single phase induction motor along with the ammeter and voltmeter as shown in Fig 5.

> **Before connecting the single phase motor, test it for continuity installation.**

20 Connect the protective earthing continuity conductors (two separate P.E. connections) to the motor and starter case, ICDP switch and connect securely the PE continuity conductors to the main earth. (Fig 5)

21 Note the full load current of the motor and set the overload relay of the starter to that rating.

22 Provide a back-up fuse as recommended by the manufacturer of the starter considering the horse-power rating of the motor.

23 Get the main connections, earth connections, over-load setting and the back-up fuse rating approved by your instructor.

24 Switch on the ICDP.

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

26 Read the ammeter for the starting current at the time of starting and enter the value in Table 5.

27 Read the voltmeter and ammeter values when the motor shows normal running and enter the values in Table 5.

28 Measure the actual speed of the rotor with the help of a tachometer and record it in Table 6.

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

30 Switch OFF the mains, remove the fuses and disconnect the connections.

TABLE 5

Sl. No.	No load Condition		Speed
	Starting current	Running Current	

TABLE 6

Sl. No.	Rated speed of the motor	Actual speed of the motor

Connect, start, run & reverse the single phase capacitor type induction motor

Objectives: At the end of this exercise you shall be able to
- **read and interpret the name plate details of an AC single phase motors**
- **identify the pairs of terminals of the starting and running winding of a single phase motors**
- **connect, start, run and reverse the direction of rotation (D.O.R) of the motors.**

Requirements

Tools/Instruments

- Trainees tool kit - 1 No.
- Ohmmeter / multimeter - 1 No.
- Megger 500V - 1 No.

Equipments/ Machines

- Single-phase motor, Type capacitor start induction run 230V 50Hz 0.5HP - 1 No.
- AC Single-phase capacitor, start capacitor run motor 230V, 0.5HP, 50Hz - 1 No.
- Push button DOL starter for 0.5 HP motor -1 No.

Materials

- ICDP switch 240V 16A - 1 No.
- Forward & Reverse switch 240V 15 amps - 1 No.
- PVC insulated standed copper wire (3/20) 3/0.914 mm 660 V grade - 6 mtr
- Bare copper wire 14SWG - 4 mtr.

PROCEDURE

TASK 1 : **Running of single phase capacitor start induction run motor (CSIR)**

1 Record the name plate details of the given motor and enter in Table 1.

TABLE 1

Sl.No	Type ....
Volts	Amps ....
HP	k.W. ....
Rating	

2 Remove the terminal cover of the motor.

3 Identify the pairs of terminals of the windings by ohmmeter and measure the resistance of each windings and note the values in Table 2.

TABLE 2

1	Resistance of the winding ....Ohms...........
2	Resistance of the winding ....Ohms...........

Comparatively the winding which has high resistance is the starting winding and the other is running windings. However the manufacturer's instructions are authentic and if available should be followed.

4 Check the continuity of the centrifugal switch by using ohm meter.

Normally when the motor is not running the centrifugal switch will be in closed condition.

5 Measure the insulation resistance values between the starting, and running windings and body using megger.

6 Record the values in the table given below.

Insulation resistance

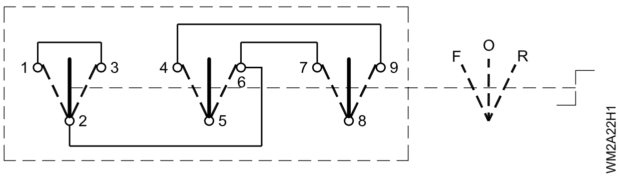
1	Between windings	.....MΩ
2	Between running winding and body	.....MΩ
3	Between starting winding and body	.....MΩ

The minimum permissible insulation resistance value should be more than one mega ohm.

7 Study the reversible switch (forward and reverse) for its contacts linking during forward and reverse positions and link them.

Normally the standard 3-phase forward and reverse switches are being used in single phase motor connections. Therefore the terminals are to be linked accordingly.

Fig 1



8 Connect the forward and reverse switch terminals by internal links as shown in the diagram. Fig 1.

9 Connect the motor with starter and reversible switch as per the circuit diagram in Fig 2.

10 Check and adjust the OLR for the name plate full load current of the motor.

11 Show the connections to your instructor and get his approval.

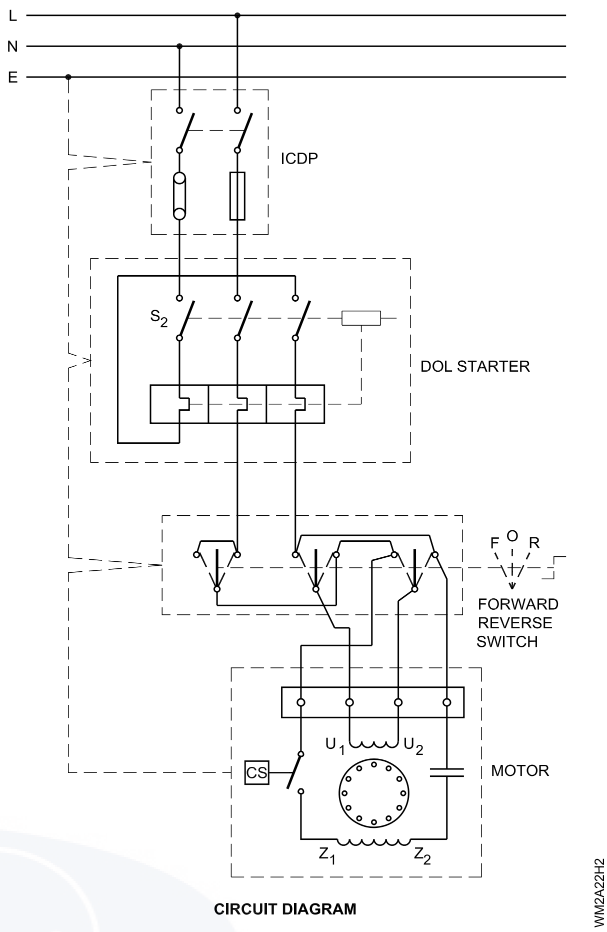
12 Switch on the supply and energise the motor and observe the D.O.R. of the motor.

13 Change the reversible switch handle to off position and allow the motor to come to rest.

14 Now change the reversible switch hand to the other direction and observe the D.O.R. of the motor.

D.O.R. of the single phase split phase motor having centrifugal switch can be reversed only when the motor covers to stand still.

Fig 2



— — — — — — — —

TASK 2 : **Running of single phase capacitor start capacitor run motor (CSCR)**

1 Read and record the name-plate details of the given single phase capacitor-start, capacitor-run motor in your practical note book in a format as given in Task 1.

2 If the motor is connected to the supply, switch off the ICDP, remove the fuse carriers and disconnect it from supply.

3 Open the terminal box and identify the terminal markings.

4 Using a Megger/insulation tester find out the continuity between the winding terminals.

5 Measure the resistance between the terminals of the same winding with the help of an ohmmeter and identify the starting and running windings. Enter the value of resistance in Table 3.

In a four-terminal machine, the pairs of terminals which give low resistance are running winding terminals. During ohmmeter testing, the pairs of terminals in which the meter pointer shows a short initially and gradually moves to resistance value is identified as starting/auxiliary winding terminals. The change in reading is due to the capacitors connected in starting winding. Normally the connection diagram is pasted inside the terminal box for reference.

6 Measure the insulation resistance between the starting and running windings and also between the winding and body with the help of the Megger and enter the values in Table 4.

7 Show the readings to your instructor and get his approval.

8 Select suitable size of switch, starter, cables and fuse etc. according to the motor rating.

9 Identify the starting and running windings, condensers and check their condition and data, enter them in Table 5. Also compare and analyse the data of the starting and running condensers.

10 Show the readings to your instructor and get his approval.

11 Check the condition of the centrifugal switch and assure it is working.

12 Connect the motor to rated AC supply through the switch and starter as per the circuit diagram. (Fig 3)

Give earth connection to the body of the motor, ICDP switch and DOL starter as a matter of safety.

TABLE 3

Sl.No.	Terminal pairs	Resistance	Remarks
1			Running/Starting
2			Running/Starting

TABLE 4

Sl.No.	Terminals	Insulation resistance	Remarks
1	Body to starting winding		Good/bad
2	Body to running winding		Good/bad
3	Between windings		Good/bad

13 Insert suitable size of fuse in the ICDP switch according to the rating of the motor.

14 Get the approval of your instructor for starting. Switch on the ICDP and start the motor by pressing the start button of the starter.

15 Observe the direction of rotation and record the DOR below. Direction of rotation is clockwise/anticlockwise.

To change the direction of rotation

16 Stop the motor, switch off the ICDP Remove the fuse and interchange the running winding terminals as shown in Fig 4.

17 Repeat the steps 14 and 15. The DOR is clockwise/anticlockwise.

Fig 3

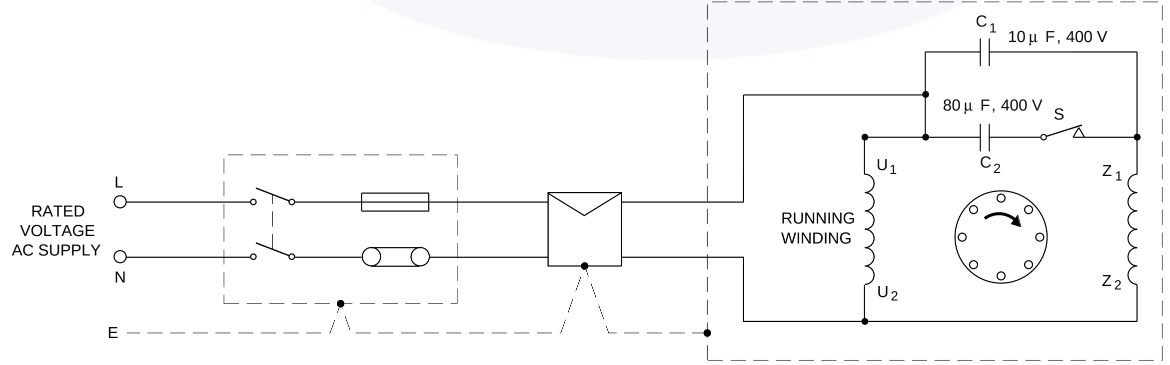


Fig 4

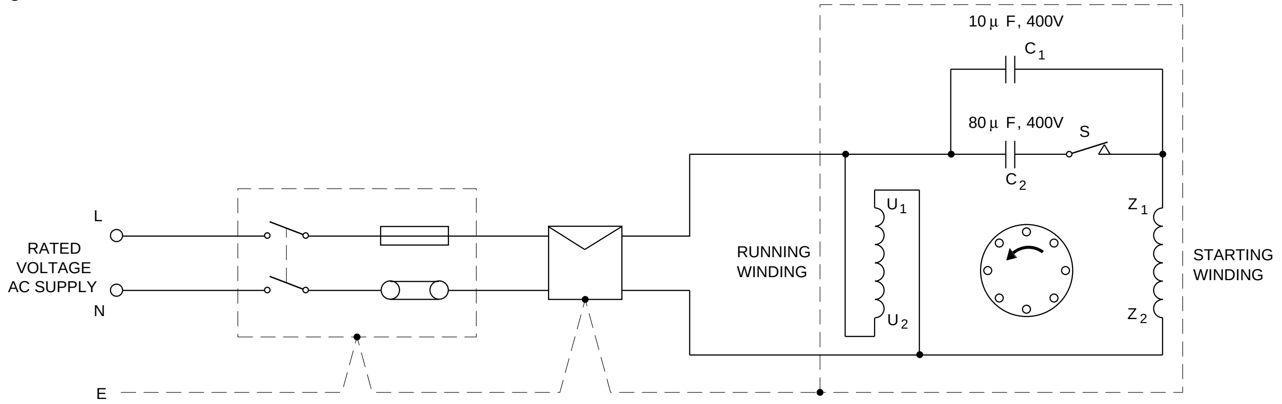


TABLE 5

Sl.No.	Component part	Type	Value in micro-farad	Voltage	Duty	Condition
1	Running condenser					
2	Starting condenser					

The direction of rotation could be changed either by changing the running winding terminal connections or by changing the starting winding terminal's connections whichever is easier. The schematic diagram shown in Fig 3 is for a four terminal machine. For a ten terminal machine only the terminals U_1 and U_2 could be changed easily.

18 Stop the motor, interchange the starting winding terminal connections as shown in Fig 5 keeping the running winding connection as in Fig 3 and repeat the steps No.14 and 15. The DOR is clockwise/anticlockwise.

19 Stop the motor, reconnect the starting and running winding as shown in Fig 3. Only interchange the supply terminal connections at the starter outgoing side as shown in Fig 6 and repeat the steps 14 and 15. The DOR is clockwise/anticlockwise. Note down the change of DOR with respect to Fig 3.

20 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 for his approval.

CONCLUSION

____

____

____

____

____

Fig 5

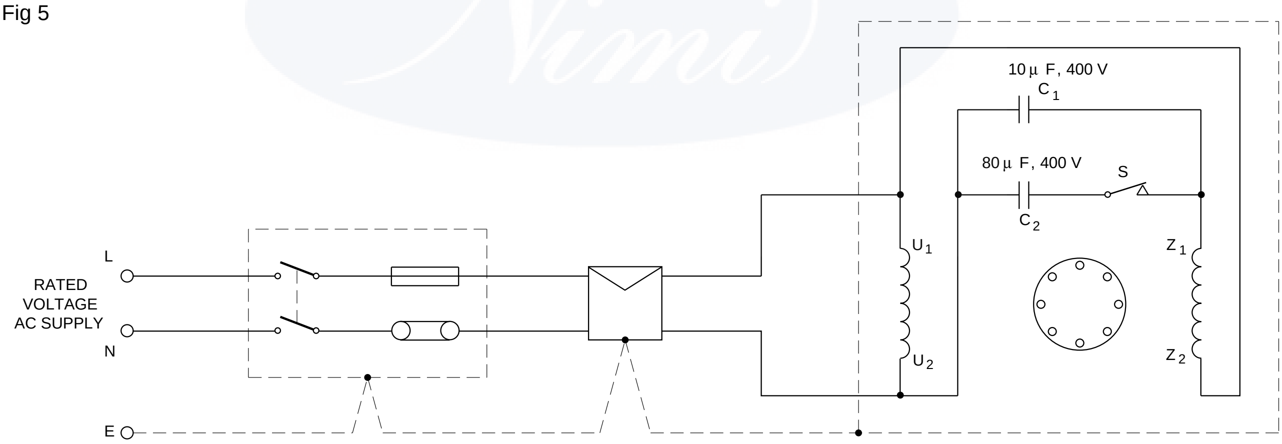
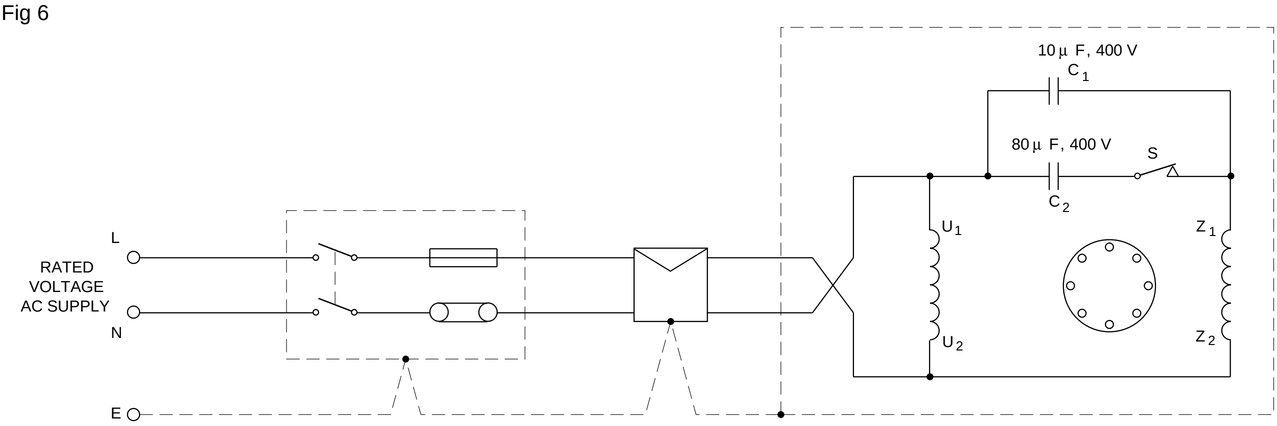


Fig 6



Connect, start, run & reverse the direction of rotation of a universal motor

Objectives : At the end of this exercise you shall be able to
- **read and interpret the name-plate details of a universal motor**
- **identify the parts of a universal motor**
- **connect a universal motor to the supply through a DOL starter and start the motor**
- **reverse the direction of rotation of a universal motor.**

Requirements

Tools/Instruments

- Trainees tool kit - 1 No.
- DE spanner set 6 mm to 19 mm - 1 No.
- Megger 500 V - 1 No.
- Test lamp, 240 V, 60W - 1 No.
- Tachometer 0 - 3000 rpm. - 1 No.

Equipment/Machines

- Universal motor 240 V, 50 Hz., 0.5 HP - 1 No.

Materials

- 2.5 sq.mm. multi-strand PVC copper cable - 10 mts.
- Bare copper wire 14 SWG - 5 mts.
- 250 V 16 A, ICDP switch - 1 No.
- DOL starter 240 V suitable for 0.5 HP. Single phase motor with 1 amp to 2.5 amps OLR - 1 No.

PROCEDURE

TASK 1: **Identify the parts and test the insulation of a universal motor.**

1 Read and interpret the name-plate details of the given universal motor and enter them in your practical note book.

TABLE 1

Sl.No	Type ....
Volts	Amps ....
HP	k.W. ....
Rating	

2 Switch off the mains and remove the fuse-carriers of the given universal motor circuit and disconnect the motor from supply.

3 Identify the terminals with the help of a test lamp.

Visually check and identify the parts to confirm whether the motor is of universal type. It should have an armature and field poles which are connected in series, and only two connecting terminals are brought out, as shown in Fig 1. If four terminals are brought out the field is to be connected in series with the armature. (Fig 2)

4 Measure the insulation resistance between the windings (if four terminals are provided), and between the windings and the body, and enter in Table 2.

Fig 1

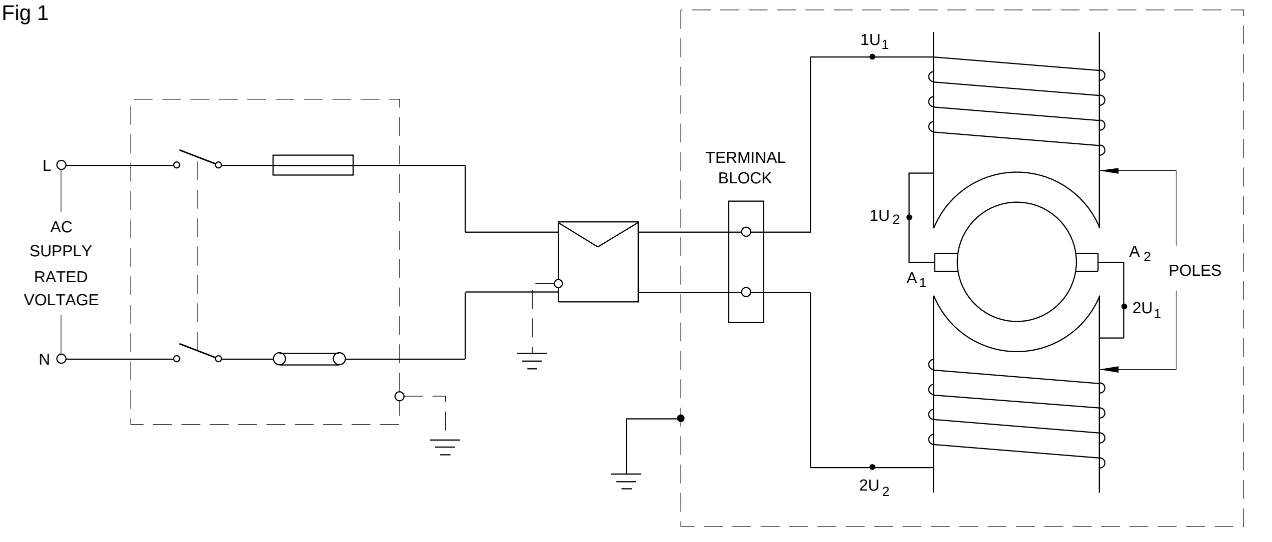
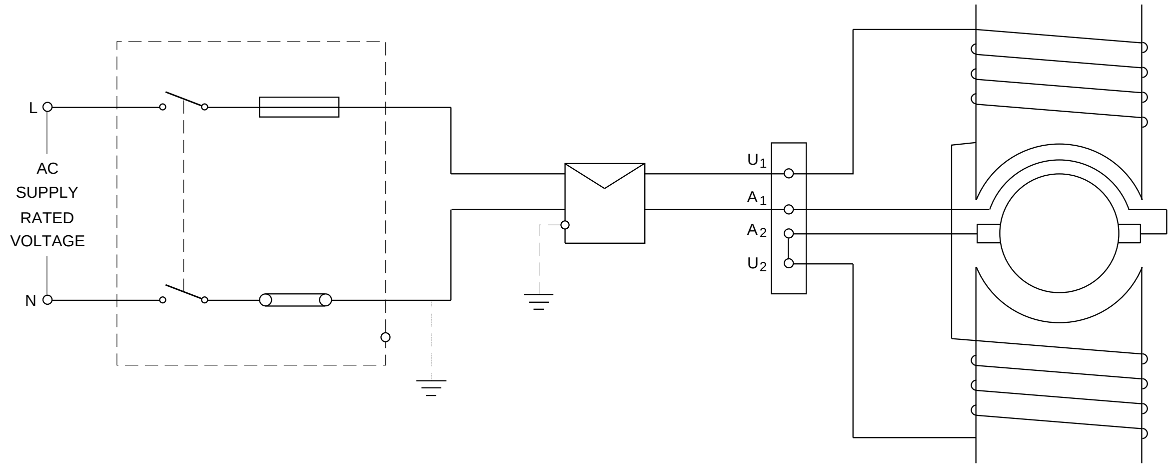


Fig 2



Insulation resistance should not be less than one megohm.

5 Check whether the universal motor is incorporated with compensating winding or interpoles or both.

6 The supplied universal motor is incorporated with a) compensating winding b) inter-pole.

TABLE 2

Insulation resistance between windings ....megohms.
Insulation resistance between winding and body .... megohms.

— — — — — — — —

TASK 2: **Connect, start and run a universal motor.**

1 Arrange and adjust a suitable load for the given universal motor.

A universal motor has a 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 a proper rating of ICDP 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 1 with proper frame earth connections.

Check for the correct load arrangement before starting the motor.

5 Switch on the ICDP and push the 'ON' button of the starter.

6 Observe the DOR and record it. The DOR is _______.

7 Measure the speed by a tachometer and record it. The speed is ________rpm.

The speed of a universal motor depends upon the load. While setting the range of the tachometer, first set at a higher range and then step down the range to a suitable measurable value.

8 Stop the motor by the stop-button of the starter. Switch off the ICDP and remove the fuse.

— — — — — — — —

TASK 3: **Change the direction of rotation.**

1 Generally the DOR of the universal motor is designed for one direction of rotation 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 the field or armature terminals. While changing the armature terminals of compensated universal motors, change the compensating winding terminals also with the approval of your instructor.

2 Discuss with your instructor the possibility of alternate connections to the ones shown in Fig 2.

3 Change either the field or armature terminals.

4 Follow the procedural steps 5 to 8 of Task 2 and record the direction of rotation and speed in the space given below.

The DOR is___________________.
The speed is ___________________.

— — — — — — — — —

Connect, start & run a shaded pole motor and repulsion motor

Objectives : At the end of this exercise you shall be able to
- **read and interpret the name-plate details of a shaded pole motor and repulsion motor**
- **identify the parts of the shaded pole motor and repulsion motor**
- **connect the shaded pole motor and repulsion motor to the supply through the DOL starter and start the motor**

Requirements

Tools/Instruments

- Trainees tool kit - 1 No.
- DE spanner set 5 mm to 20 mm - 1 No.
- Test lamp - 1 No.
- Megger 500 V - 1 No.
- Ohmmeter/Multimeter - 1 No.
- Tachometer 150 to 3000 rpm. - 1 No.

Equipment/Machines

- Shaded pole motor 1/8 HP, AC 240 V 50 Hz. - 1 No.
- Repulsion motor single phase 240, 50Hz - 1 No.

Materials

- 2.5 sq. mm. PVC copper multi-strand cable 660 V grade - 6 mts.
- Bare copper wire 14 SWG - 4 mts.
- ICDP switch 250 V, 16 A - 1 No.
- Manual DOL starter 2/4 amp, 240 V with overload relay - 1 No.
- SPDT switch 240 V 16 A - 1 No.

PROCEDURE

TASK 1: **Interpret the name plate details and identify the parts of the shaded pole motor.**

1 Read and interpret the name-plate details of the given shaded pole motor and enter them in your practical note book.

TABLE 1

Sl.No	Type ....
Volts	Amps ....
HP	k.W. ....
Rating	

2 Switch off the mains and remove the fuse carriers from the ICDP switch of the given shaded-pole motor.

3 Identify the parts and terminals of the shaded pole motor. Test the winding for continuity and insulation resistance value.

As it has the squirrel cage type rotor, only two terminals of the stator are brought out.

— — — — — — — —

TASK 2: **Connect, start and run the shaded pole motor**

1 Select and arrange proper rating of ICDP switch, cables, fuse wire and DOL starter according to the rating of the given shaded pole motor.

2 Connect the motor as per circuit diagram given in Fig 1.

3 Provide suitable earth connection to the ICDP switch, starter and motor.

4 Provide fuses of suitable rating according to the motor rating in the ICDP switch and also set the starter overload relay to the motor rating.

5 Switch on the ICDP and press the 'ON' button of the DOL starter.

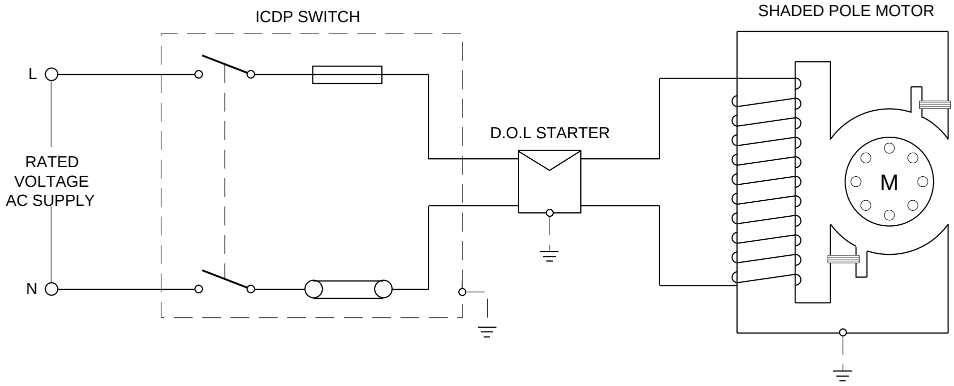
6 When the motor starts to run, observe the direction of rotation and record it in Table 2.

7 Measure the speed by a tachometer and record in Table 2.

TABLE 2

Sl. No.	DOR	Speed in rpm.	Position of SPDT Switch
TASK 2			
TASK 3			

Fig 1



SCHEMATIC DIAGRAM OF CONNECTION OF A SHADED POLE MOTOR

8 Stop the motor by pressing the stop-button of the starter and switch 'off' the ICDP and remove the fuse.

9 Wait until the motor comes to a standstill position.

— — — — — — — —

TASK 3: **Connect and start a repulsion motor**

1 Read and interpret the name-plate details of the given repulsion motor and enter the details in Table 3.

Visually check and ascertain that the given motor is a repulsion motor. It should have a wound rotor with commutator, short-circuited brushes and a rocker-arm with moving arrangement. Identify the type of the repulsion motor with the help of the information given.

TABLE 3

Customer.................	Date...............	Job No..............	Make...................
Frame No................	Model............	Type................	Hp.......................
Volts.......................	Amperes........	Phase.............	Cycles.................
Serial No.			
Suggestion/Complaint...........			Signature of the
....			section in-charge

2 Disconnect the repulsion motor from the supply, if it is connected.

3 Test the insulation value between the winding and frame, and note the value in Table 4.

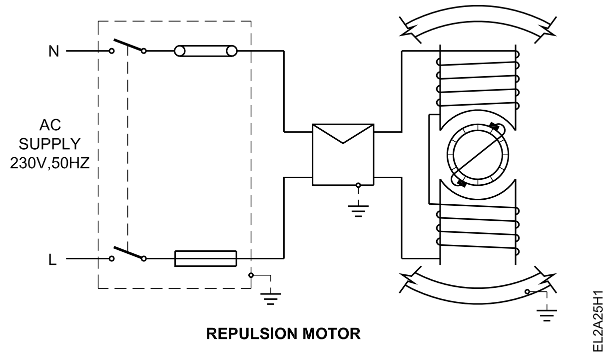
4 Show the readings to your instructor and get his approval.

5 Connect the circuit in accordance with the circuit diagram shown in Fig 2.

6 Before switching on, keep the brush-rocker handle away from the zero position neutral zone, depending upon the desired direction of rotation.

At the '0' position of the rocker-arm, the motor will not start though the windings are connected to the supply, resulting in heating up of the motor.

Fig 2



REPULSION MOTOR

7 Switch 'ON' the ICDP and press the 'ON' button of the starter to start the motor. Measure the speed, direction of rotation and enter in Table 5.

8 Slowly shift the rocker arm position away from the earlier position and note down the speed in each step and enter in Table 5.

Normally the rocker-arm position is indicated on a graduated scale.

9 Switch off the motor. Shift the brush-axis in the opposite direction to the earlier position.

10 Switch on start the motor, observe the direction of rotation and speed, then enter the values in Table 5.

11 Slowly shift the rocker-arm position away from the earlier position. Note down the speed at each step and enter in Table 5.

12 Switch off the supply and disconnect the motor and accessories. Draw your conclusion showing the relationship between brush position, speed and D.O.R.

CONCLUSION

____

____

____

____

____

TABLE 4

Sl.No.	Terminals	Insulation resistance	Remarks
1	Winding and body		
2	Brushes and winding		
3	Brushes and body		

TABLE 5

Sl. No.	Rocker-arm position	Speed	Direction of rotation

Fabricate, install and wire up a panel board for a motor generator set

Objectives: At the end of this exercise you shall be able to
- **read and record the name-plate details of the MG set**
- **draw the schematic connection diagram of the MG set panel**
- **prepare the list of accessories to be installed on the panel**
- **prepare the template for the accessories and determine the dimensions of the panel**
- **draw the layout of the panel**
- **fabricate the panel**
- **mount the panel on the wall**
- **fix the electrical accessories on the panel**
- **wire up the panel**
- **harness the cables**
- **install the conduit runs from the MG set to the panel and wire up**
- **earth the MG set panel and the conduit runs**
- **test the installation for continuity, insulation and earth continuity**
- **test the installation (with supply) by energising.**

Requirements

Tools/Instruments

- Trainees tool kit - 1 No.
- Hacksaw 300 mm - 1 No.
- Measuring steel tape 5 m - 1 No.
- Cold chisel 25 mm dia. 200 mm long - 1 No.
- Portable electric power drilling machine 12 mm capacity - 1 No.
- DE spanner set 8-22 mm - 1 set
- Adjustable spanner 300 mm - 1 No.
- Heavy duty metal shears 450 mm - 1 No.
- Tap M10 set of three - 1 No.
- HSS drill bit 6 mm to 12 mm - 1 set
- 250 g plumb bob with thread - 1 No.
- Spirit level 300 mm - 1 No.
- Masons trowel - 1 No.
- Mortar pan - 1 No.
- Try square 300 mm - 1 No.
- Bench vice 100 mm jaw - 1 No.
- GI bucket 10 litre - 1 No.
- Test lamp 60 W, 240V - 1 No.
- Spade - 1 No.
- Flat file 300 mm bastard - 1 No.
- Round file 300 mm bastard - 1 No.
- Megger 500 V - 1 No.
- Earth tester - 1 No.

Equipment/Machines

- Motor-generator set 220V, 3 kW 1450 rpm. coupled with A.C. induction motor 3.5 kW, 415V 50 Hz - 1 set
- Voltmeter MC 0-300 V - 1 No.
- Ammeter MC 0-20 amps - 1 No.
- Change over rotary switch 500V - 1 No.
- Field regulator toroidal type 250V, 2 amp 300 ohm - 1 No.
- Ammeter MC 0-2 amp - 1 No.
- Star Delta starter 500 Volt overload unit 6-10 amp - 1 No.
- Ammeter MI 0 to 15 amp - 1 No.
- Voltmeter MI 0 to 500 V - 1 No.

Materials

- MS angle iron 35mm x 35 mm x 6 mm - as reqd.
- MS bolts M10 x 12 mm - as reqd.
- MS sheet 1200 mm x 1000 mm x 1.5 mm sheet - 1
  or Hylam sheet 1200 mm x 1000 mm x 6 mm - 1 sheet
- Cement - 20 kg.
- Kit-kat fuse 240V, 6 amp - 3 Nos.
- ICTP switch 415V 32 amp - 1 No.
- ICDP 240V, 16 amp - 1 No.
- Bakelite, batten holder 6 amp 250V - 4 Nos.
- Kit-kat fuse 240V, 16 amp - 2 Nos.
- SPT switch 240V 6 amp - 4 Nos.
- Colour bulbs 250V, 15W red,yellow, blue,green - 1 each.
- PVC cable 7/0.914 grade 600 V - as reqd.
- PVC cable 3/0.914 grade 600 V - as reqd.
- PVC cable 1/1.12 250V grade - as reqd.
- Brass nut-bolts M3 x 50 mm for fixing accessories on panel (with double washers and double nut each) - 25 Nos.
- Banana socket and plugs 240V 16 amp capacity - 6 Nos.
- HDBC or G.I. wire 10 SWG for earth connection - 10 m
- Fuse wire 30 amps capacity - as reqd.
- Number/letter cable labels of assorted size - as reqd.
- Cable bands or PVC straps for cable - as reqd.
- Hacksaw blade 300 mm 18 TPI - 6 Nos.

PROCEDURE

This exercise has been introduced to expose the trainees to the fabrication, installation and wiring of a panel board for a MG set. The MG set chosen for this exercise has an AC motor coupled to a DC generator. According to the workshop requirement any possible combinations like DC motor coupled to an alternator etc. could be taken with necessary modification in the panel. The fabrication work for the panel board, MS frame can be done through the welding section under the supervision of the instructor.

TASK 1: **Preparation of layout for MG set panel board**

1 Interpret the name-plate details of the motor and generator set and record them in Tables 1 and 2.

2 Estimate the components required for the MG set panel board and accordingly draw the schematic diagram of connection of the MG set panel board with the required switches, indicators, regulators and instruments in your record.

3 Show the schematic diagram to your instructor for approval and denote the approved schematic diagram as Fig 'S'.(Schematic diagram Fig 1 is given below is for your guidance.

4 Collect the required accessories from the section stores as per the modified diagram and measure their approximate dimensions.

5 To prepare the template take a colour card board and cut out dimensions of the accessories to 1/5th scale to facilitate the determination of the exact position of the accessories, spacing of accessories and the actual size of the panel.

Only two dimensions are to be taken viz. length and width. thickness need not be considered at this stage. While taking the length and breadth include the projected handle etc. in the measurement. Figs 2a and 2b are given as examples.

TABLE 1

Name plate details of the motor

Make	**Frame No**	**Model**	
________	________	________	
Phase	**Kilowatt/H.P**	**r.p.m**	**PF**
________	________	________	________
Volts	**Amperes**	**Frequency**	
________	________	________	
Rating	**Connection**	**Insu. class**	
________	________	________	

Fig 2

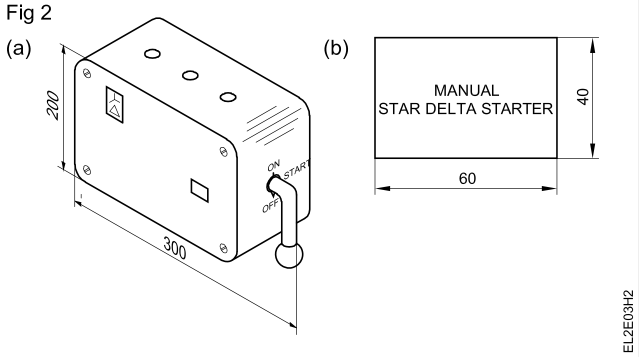


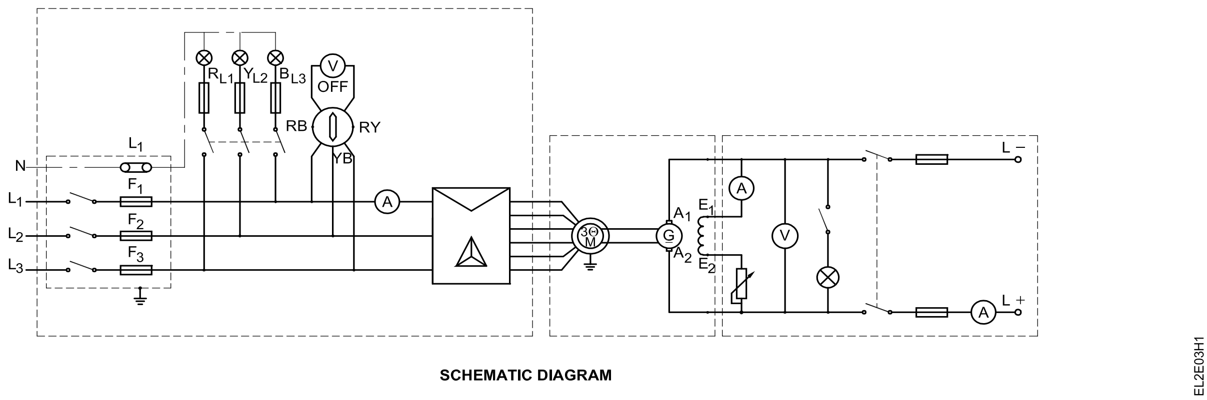
TABLE 2

Name-plate details of the generator

Manufacturer, trade mark	____________
Type, model or list number	____________
Type of current	____________
Function	____________
Generator/motor .	____________
Fabrication or serial number	____________
Type of connection	____________ sep/shunt/series/compound
Rated voltage	____________ volts
Rated current	____________ amps
Rated power	____________ K.W.
Rated speed	____________ r.p.m.
Rated exc. voltage	____________ V
Rated exc. current	____________ amps
Rating class	____________
Direction of rotation	____________
Insulation class	____________
Protection class	____________

For example the supplied star/delta starter has the following dimensions. ie. 300 mm x 200 mm. Draw the layout to 1/5th scale and make a cardboard template having the following size of 1/5 th scale. i.e. for star/ delta starter 60 mm x 40 mm.

Fig 1



SCHEMATIC DIAGRAM

6 Make the cardboard templates for all the accessories, and write the name of the accessories on each.

7 Place a A_3 size drawing paper on a drawing board.

8 Place the templates on the drawing paper in such a way as to suit the technical and aesthetic requirement.

9 Check with the schematic diagram (Fig 1) according to the choice taken in step 4 and see the placement satisfies the operational requirements. Determine at this stage the width and length of the panel board, keeping allowance in the sides for the angle iron supports.

The panel board will be supported by angle irons in the sides for small panels and may have one additional centre piece of angle iron for bigger panels. The size of the angle also depends upon the size of the panel. It is required to place the accessories within the free space available in the panel excluding breadth of angle irons. The templates could be fixed to the drawing paper with the help of drawing pins.

10 Show the drawing paper along with the templates to your instructor for approval. The layout diagram shown in Fig 3 is given to you for your guidance.

11 Measure the length and width of the panel board directly from the drawing and multiply the measurement by five times to get the actual measurement.

For example if Fig 4 shows the finalised and approved panel plan drawing with the following dimensions then the actual measurement would be

length 240 x 5 = 1200 mm

breadth 200 x 5 = 1000mm.

Fig 3

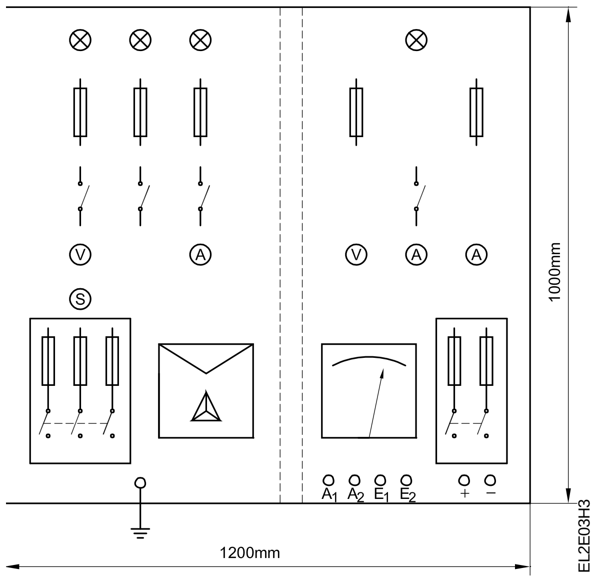
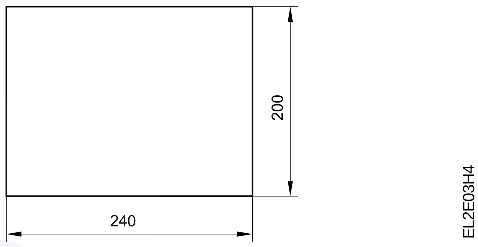
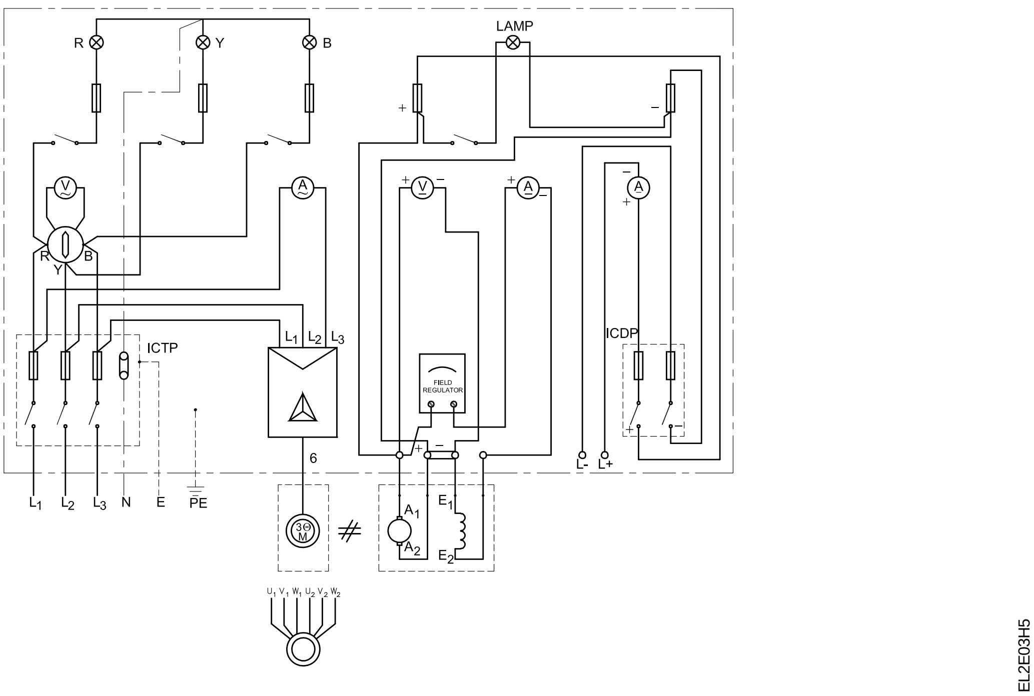


Fig 4



12 Describe the wiring diagram based on the schematic diagram Fig 'S' and the layout diagram Fig 'P', which are approved by the instructior in your record. Fig 5 is the wiring diagram based on the schematic diagram Fig 1 and the layout diagram Fig 3 and is given for your guidance.

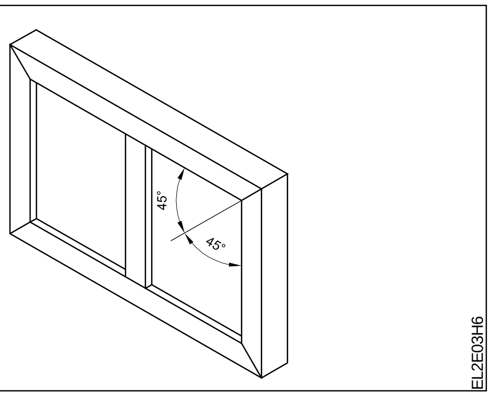
Fig 5



TASK 2: **Preparation of frame for MG set panel board**

1 Measure the angle iron and cut them in such a way that the corners are formed by 45^0 angle. Fig 6 is given for your guidance.

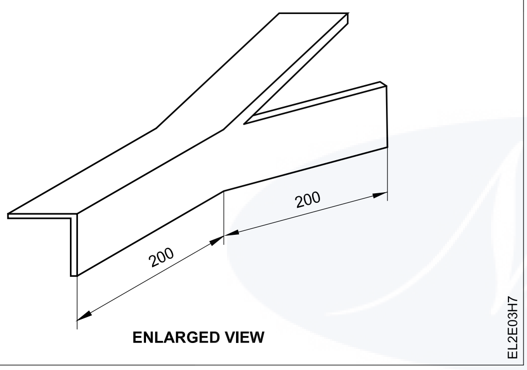
Fig 6



2 Measure the M.S. flat and cut it to size so that it just fits in between the angle irons to form the centre piece.

3 Cut pieces of angle irons for the wall support as shown in Fig 7.

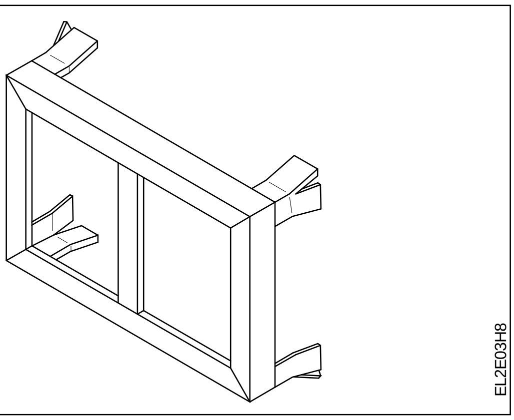
Fig 7



4 The end of each piece to be cut and split as shown in Fig 7.

5 Get all the pieces welded carefully to form the angle iron support panel frame as shown in Fig 8, from the welding section.

Fig 8

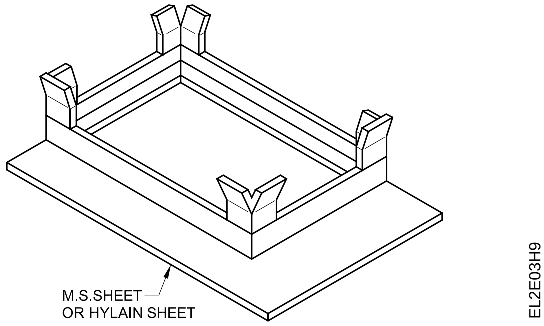


Welding heat may warp and distort the panel and this has to be corrected with the help of a vice and hammer.

6 Grind the welded ends to form a smooth surface.

7 Take a M.S. sheet of thickness of 1.5 mm and place the angle iron frame over the sheet as shown in Fig 9.

Fig 9



or Hylam sheet could be used. The procedure given below is say M.S. Sheet

8 Mark along the sides of the angle iron with a sharp scriber.

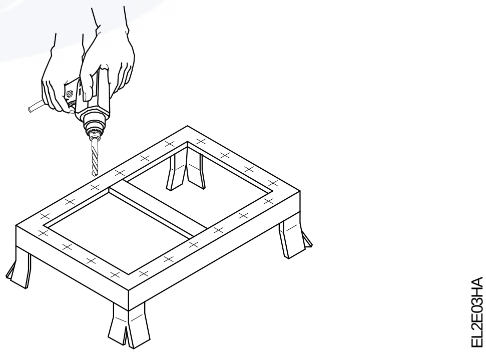
9 Use heavy shears to cut out the marked portions of the sheet.

You can also use a sharp cold chisel and hammer to cut out the portions.

10 Straighten the sheet, file the edges to remove burrs and chamfer the edges.

Check at intervals, whether the sheet just covers the angle iron frame without projections. Always place the sheet in the same position as it was measured. For this you may have to mark the sheet and angle iron correspondingly.

Fig 10



11 Mark by a centre punch and make holes in the angle iron as shown in Fig 10 with a drill bit of size 8.5 mm.

12 Make holes in the M.S. or Hylam sheet correspondingly with a drill bit of size 10 mm.

13 Make threads in all angle iron holes with taps to suit machine screws M10.

14 Check the fitting of the M.S. sheet on the angle iron using a few machine screws and then remove the sheet.

15 Mark on the wall the relative position of the angle iron legs.

16 Make holes in the wall to a depth sufficient enough to hold the panel with all its weight.

A minimum of 200 mm depth is required.

17 Prepare concrete mixture of 1:2:4 (one part cement, 2 parts of sharp small stones and 4 parts of clean sand).

18 Grout the angle iron legs to the wall maintaining horizontal and vertical positions.

19 Cure the grouting for atleast 36 hours by wetting the surface of grouting by pouring water at intervals.

The angle iron frame should maintain verticality and horizontality. Use a plumb bob while checking the vertical position of the frame and a spirit level for horizontal position.

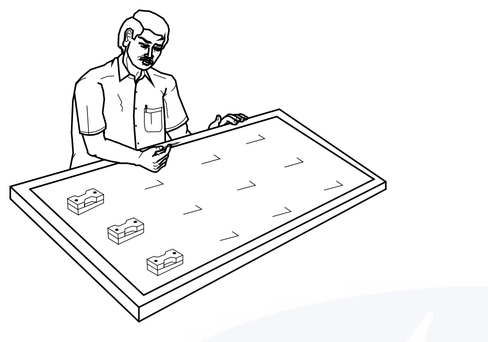
The angle iron frame needs to be supported by necessary structures to avoid displacement till the concrete is fully cured.

— — — — — — — —

TASK 3: **Mount and connect the accessories for MG set panel board**

1 Place the accessories on the M.S. or Hylam sheet at the appropriate positions as per approved lay out diagram and mark the fixing holes and cable holes. Refer Fig 11.

Fig 11



2 Drill holes accordingly with appropriate drill bits depending upon the size of fixing screws or bolts and cable size and number.

Fixing holes can be either straight holes in which a nut and bolt could be used or threaded holes where the fixing screws could be used to fit the accessories.

3 Fix the M.S. or hylam sheet on the angle iron frame and paint it in case of M.S. sheet with grey enamel paint. Wait till the paint becomes dry.

4 Mount the accessories on the M.S. sheet or Hylam sheets according to the layout.

5 Wire up the panel according to the schematic wiring diagram and label the cable ends with numbers or letter labels.

Use PVC bushes where cable ends are taken through MS sheet.

6 Harness the wires properly using cable holders, suitable rubber bushes etc as shown in Figs 12 and 13.

7 Run conduit wiring from the MG set to the panel as per layout diagram and wire the MG set and panel according to the connection diagram.

Fig 12

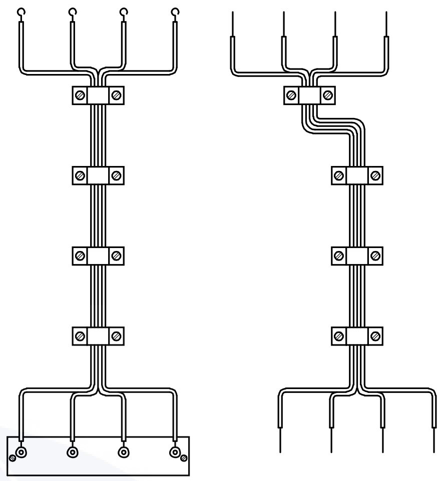
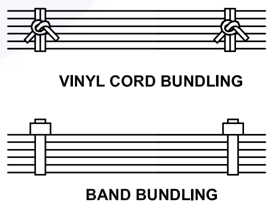
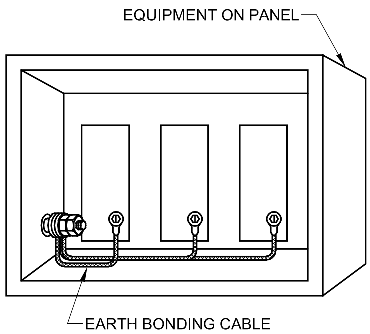


Fig 13



8 Earth the M.G. set, panel and all the accessories including metal conduit. Use bonding cable wherever necessary as shown in Fig 14.

Fig 14



— — — — — — — —

TASK 4: **Testing of M.G. set panel board**

1 Test the panel board installation for i) continuity ii) insulation and iii) earth continuity.

Result

a Continuity __________ OK/NOT OK

b Insulation resistance

(i) on AC side__________ Megohm

(ii) on DC side__________ Megohm

c Earth resistance __________ ohm

2 Adjust the overload setting of the star/delta starter and wire up fuses of correct capacity.

Result

a Overload adjustment__________ amp/percentage

b Fuse rating __________ amp.

3 Start and run the AC motor and adjust the generator voltage to the stipulated value.

4 Test the MG set on load.

Result

a Supply voltage __________ volt

b Line current __________ amp

c Speed __________ r.p.m.

d Generator voltage __________ volt

e Excitation current __________ mA/A

f Load current __________ amp

— — — — — — — —