ELECTRICIAN (POWER DISTRIBUTION)

NSQF LEVEL - 4

1st Year

TRADE PRACTICAL

SECTOR: POWER

(As per revised syllabus July 2022 - 1200 Hrs)

Directorate General of Training

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

NATIONAL INSTRUCTIONAL MEDIA INSTITUTE, CHENNAI

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

Sector : Power

Duration : 2 Years

Trades : Electrician (Power Distribution) - Trade Practical - 1st Year - NSQF Level - 4 (Revised 2022)

Developed & Published by

National Instructional Media Institute
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Guindy, Chennai - 600 032
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First Edition : December 2023 Copies : 500

Rs.415/-

FOREWORD

The Government of India has set an ambitious target of imparting skills to 30 crores people, one out of every four Indians, to help them secure jobs as part of the National Skills Development Policy. Industrial Training Institutes (ITIs) play a vital role in this process especially in terms of providing skilled manpower. Keeping this in mind, and for providing the current industry relevant skill training to Trainees, ITI syllabus has been recently updated with the help of Media Development Committee members of various stakeholders viz. Industries, Entrepreneurs, Academicians and representatives from ITIs.

The National Instructional Media Institute (NIMI), Chennai, has now come up with instructional material to suit the revised curriculum for **Electrician (Power Distribution) - Trade Practical - 1st Year - NSQF Level - 4 (Revised 2022) - in Power Sector** in **Annual Pattern.** The NSQF Level - 4 (Revised 2022) Trade Practical will help the trainees to get an international equivalency standard where their skill proficiency and competency will be duly recognized across the globe and this will also increase the scope of recognition of prior learning. NSQF Level - 4 (Revised 2022) trainees will also get the opportunities to promote life long learning and skill development. I have no doubt that with NSQF Level - 4 (Revised 2022) the trainers and trainees of ITIs, and all stakeholders will derive maximum benefits from these Instructional Media Packages IMPs and that NIMI's effort will go a long way in improving the quality of Vocational training in the country.

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

Jai Hind

Atul Kumar Tiwari, *I.A.S*
Secretary
Ministry of Skill Development & Entrepreneurship,
Government of India.

December 2023
New Delhi - 110 001

PREFACE

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

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

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

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

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

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

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

Chennai - 600 032 **EXECUTIVE DIRECTOR**

ACKNOWLEDGEMENT

National Instructional Media Institute (NIMI) sincerely acknowledges with thanks for the co-operation and contribution extended by the following Media Developers and their sponsoring organisation to bring out this IMP for the trade of **Electrician (Power Distribution) - 1st Year - Trade Practical - NSQF Level - 4 (Revised 2022)** under the **Power** Sector for ITIs.

MEDIA DEVELOPMENT COMMITTEE MEMBERS

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NIMI - COORDINATORS

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Shri. G. Michael Johny	_	Manager, NIMI, Chennai - 32.

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

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

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

INTRODUCTION

TRADE PRACTICAL

The trade practical manual is intented to be used in workshop . It consists of a series of practical exercises to be completed by the trainees during the 1^{nd} year course of the **Electrician (Power Distribution)** under **Power Sector.** Trade supplemented and supported by instructions/ informations to assist in performing the exercises. These exercises are designed to ensure that all the skills in compliance with NSQF Level - 4 (Revised 2022) syllabus are covered.

This manual is divided into Eleven modules. The Eleven modules are given as below

Module 1	-	**Safety Precautions**
Module 2	-	**Electrical Wire Joints & Solderings**
Module 3	-	**Measurements Using Instruments**
Module 4	-	**Electronics Circuits**
Module 5	-	**Cells and Batteries in Substation**
Module 6	-	**Wiring Installation and Testing**
Module 7	-	**Illumination**
Module 8	-	**AC Motor & Starters**
Module 9	-	**Alternator and Synchronous Motors**
Module 10	-	**Speed Control of AC Motors**
Module 11	-	**Inverter, Stabilizer, Battery Charger and UPS**

The skill training in the shop floor is planned through a series of practical exercises centred around some practical project. However, there are few instances where the individual exercise does not form a part of project.

While developing the practical manual a sincere effort was made to prepare each exercise which will be easy to understand and carry out even by below average trainee. However the development team accept that there is a scope for further improvement. NIMI, looks forward to the suggestions from the experienced training faculty for improving the manual.

TRADE THEORY

The manual of trade theory consists of theoretical information for the two years course of the **Electrician (Power Distribution)** Trade Theory NSQF Level - 4 (Revised 2022) under **Power Sector**. The contents are sequenced according to the practical exercise contained in NSQF Level - 4 (Revised 2022) syllabus on Trade Theory attempt has been made to relate the theoretical aspects with the skill covered in each exercise to the extent possible. This correlation is maintained to help the trainees to develop the perceptional capabilities for performing the skills.

The Trade theory has to be taught and learnt along with the corresponding exercise contained in the manual on trade practical. The indicating about the corresponding practical exercise are given in every sheet of this manual.

It will be preferable to teach/learn the trade theory connected to each exercise atleast one class before performing the related skills in the shop floor. The trade theory is to be treated as an integrated part of each exercise.

The material is not the purpose of self learning and should be considered as supplementary to class room instruction.

CONTENTS

LEARNING / ASSESSABLE OUTCOME

On completion of this book you shall be able to

S.No.	Learning Outcome	Ref. Ex.No.
1	Prepare profile with an appropriate accuracy as per drawing following safety precautions. (Mapped NOS: PSS/N2001)	1.1.01 - 1.1.19
2	Prepare electrical wire joints, carry out soldering and crimping. (Mapped NOS: PSS/N0108)	1.2.20 - 1.2.25
3	Verify basic characteristics of electrical and magnetic circuits and perform measurements using analog / digital instruments. (Mapped NOS: PSS/N1707)	1.3.26 - 1.3.57
4	Assemble simple electronic circuits and test for functioning. (Mapped NOS: PSS/N2504)	1.4.58 - 1.4.72
5	Carry out installation, testing and maintenance of batteries and battery room in distribution substation. (Mapped NOS: PSS/N2504)	1.5.73 - 1.5.85
6	Estimate, Assemble, install and test wiring system. (Mapped NOS: PSS/N1707)	1.6.86 - 1.6.97
7	Plan and install electrical illumination system and test. (Mapped NOS: PSS/N1707)	1.7.98 - 1.7.103
8	Plan, Execute commissioning, testing of AC motors& Starters and carry out their maintenance. (Mapped NOS: PSS/N1709)	1.8.104 - 1.8.116
9	Perform testing and carry out maintenance of Alternator and Synchronous motor. (Mapped NOS: PSS/N1711)	1.9.117 - 1.9.124
10	Perform speed control of AC motors by using solid state devices/ AC drives. (Mapped NOS: PSS/N1709)	1.10.125 - 1.10.127
11	Detect the faults and troubleshoot inverter, stabilizer, battery charger and UPS etc. (Mapped NOS: PSS/N6002)	1.11.128 - 1.11.132

SYLLABUS

1st Year **Duration: Two years**

Duration	Reference Learning Outcome	Professional Skill (Trade Practical) (With inidcative hour)	Professional Knowledge (Trade Theory)
Professional Skill 95 Hrs; Professional Knowledge 21 Hrs	Prepare profile with an appropriate accuracy as per drawing following safety precautions. **(Mapped NOS: PSS/ N2001)**	1 Visit various sections of the institutes and location of electrical installations. (05 hrs) 2 Identify safety symbols and hazards. (05 Hrs) 3 Preventive measures for electrical accidents and practice steps to be taken in such accidents. (05 hrs) 4 Practice safe methods of fire fighting in case of electrical fire. (05 hrs) 5 Use of fire extinguishers. (05 Hrs) 6 Practice elementary first aid. (05 hrs) 7 Rescue a person and practice artificial respiration. (05 Hrs) 8 Disposal procedure of waste materials. (05 Hrs) 9 Use of personal protective equipments. (05 hrs) 10 Practice on cleanliness and procedure to maintain it. (05 hrs)	Scope of the "Electrician – Power Distribution" Trade. Power sector scenario in India. Safety rules and safety signs. Introduction to Electricity Act2003, CERC, SERC. First aid safety practice. Hazard identification and prevention. Personal safety and factory safety. Response to emergencies e.g. power failure, system failure and fire etc. Types and working of fire extinguishers. Standard distance for safe working zone, clearance from live HV electrical system. (09 hrs.)
		11 Identify trade tools andmachineries. (10 Hrs) 12 Practice safe methods of lifting and handling of tools & equipment. (10 Hrs) 13 Select proper tools for operation and precautions in operation. (05 Hrs) 14 Care & maintenance of trade tools. (05 Hrs)	Concept of Standards and advantages of BIS/ISI. Trade tools specifications. Introduction to National Electrical Code-2011. Store keeping of equipments for Repair works. (05 hrs.)
		15 Workshop practice on filing and hacksawing. (15 Hrs)	Description of files, hammers, chisels, hacksaw frames, blades, their specification and grades. (07 hrs.)
Professional Skill 40 Hrs; Professional Knowledge 07Hrs	Prepare profile with an appropriate accuracy as per drawing following safety precautions. **(Mapped NOS: PSS/ N2001)**	16 Practice in marking and cutting of straight and curved pieces in metal sheets. (10 Hrs) 17 Workshop practice on drilling, chipping, internal and external threading of different sizes. (15Hrs) 18 Practice of making square and round holes, securing by screw and riveting. (06Hrs) 19. Prepare an open box from metal sheet. (09 Hrs)	Marking tools; Introduction to fitting tools, calipers, Dividers, Surface plates, Angle plates, Scribers, punches, surface gauges Types, Uses, Care and maintenance. Sheet metal tools: Description of marking & cutting tools. Types of rivets and riveted joints. Use of thread gauge. Care and maintenance of tools. (07 hrs.)

Duration	Reference Learning Outcome	Professional Skill (Trade Practical) (With inidcative hour)	Professional Knowledge (Trade Theory)
Professional Skill 56Hrs; Professional Knowledge 10Hrs	Prepare electrical wire joints, carry out soldering and crimping. **(Mapped NOS: PSS/ N0108)**	20 Prepare terminations of cable ends (02 hrs) 21 Practice on skinning, twisting and crimping. (10 Hrs) 22 Identify various types of cables and measure conductor size using SWG and micrometre. (8 Hrs) 23 Make simple twist, married, Tee and western union joints. (13 Hrs) 24 Make Britannia straight, Britannia Tee and rat tail joints. (13 Hrs) 25 Practice in Soldering of joints / lugs. (10 Hrs)	Fundamentals of electricity, definitions, units & effects of electric current. Conductors and insulators. Conducting materials and their comparison. Joints in electrical conductors, contact resistance measurement and required pressure. Techniques of soldering. Types of solders and flux. (10 hrs.)
Professional Skill 60Hrs; Professional Knowledge 10Hrs .	Verify basic characteristics of electrical and magnetic circuits and perform measurements using analog / digital instruments. **(Mapped NOS: PSS/ N1707)**	26 Practice on measurement of parameters in combinational electrical circuit by applying Ohm's Law for different resistor values and voltage sources. (04 Hrs) 27 Measure current and voltage in electrical circuits to verify Kirchhoff's Law (03 Hrs) 28 Verify laws of series and parallel circuits with voltage source in different combinations. (03 Hrs) 29 Measure voltage and current against individual resistance in electrical circuit (04 hrs) 30 Measure current & voltage and analyse the effects of shorts and opens in series and parallel circuits. (04 Hrs) 31 Measure resistance using voltage drop method. (04 Hrs) 32 Measure resistance using Wheatstone bridge. (03 Hrs) 33 Determine the change in resistance due to temperature. (03 Hrs) 34 Verify the characteristics of series parallel combination of resistors. (03 Hrs) 35 Determine the poles and plot the field of a magnet bar. (03 Hrs) 36 Wind a solenoid and determine the magnetic effect of electric current. (04 Hrs) 37 Measure induced emf due to change in magnetic field. (04hrs) 38 Determine direction of induced emf and current. 1(04hrs) 39 Practice on generation of mutually induced emf. (04 hrs)	Ohm's Law; Simple electrical circuits and problems. Kirchhoff's Laws and applications. Series and parallel circuits. Open and short circuits in series and parallel networks. Laws of Resistance and various types of resistors. Wheatstone bridge; principle and its applications. Effect of variation of temperature on resistance. Different methods of measuring the values of resistance. Series and parallel combinations of resistors. Magnetic terms, magnetic materials and properties of magnet. Principles and laws of electro magnetism. Self and mutually induced EMFs. **Electrostatics:** Capacitor Different types, functions, grouping and uses. Inductive and capacitive reactance, their effect on AC circuit and related vector concepts. Handling of charging and discharging of static capacitors and other static charged equipment. (10 hrs.)

Duration	Reference Learning Outcome	Professional Skill (Trade Practical) (With inidcative hour)	Professional Knowledge (Trade Theory)
		40 Measure the resistance, impedance and determine inductance of choke coils in different combinations. (04 Hrs) 41 Identify various types of capacitors, charging / discharging and testing. (03Hrs) 42 Group the given capacitors to get the required capacity and voltage rating. (03Hrs)	
Professional Skill 60Hrs; Professional Knowledge 10Hrs	Verify basic characteristics of electrical and magnetic circuits and perform measurements using analog / digital instruments. **(Mapped NOS: PSS/ N1707)**	43 Measure current, voltage and PF and determine the characteristics of RL, RC and RLC in AC series circuits. (08Hrs) 44 Measure the resonance frequency in AC series circuit and determine its effect on the circuit. (06hrs) 45 Measure current, voltage and PF and determine the characteristics of RL, RC and RLC in AC parallel circuits. (08Hrs) 46 Measure the resonance frequency in AC parallel circuit and determine its effects on the circuit. (06hrs) 47 Measure power, energy for lagging and leading power factors in single phase circuits and compare characteristic graphically. (08Hrs) 48 Measure Current, voltage, power, energy and power factor in three phase circuits. (06hrs) 49 Practice improvement of PF by use of capacitor in three phase circuit. (06Hrs) 50 Measure power factor in three phase circuit by using power factor meter and verify the same with voltmeter, ammeter and wattmeter readings. (10Hrs)	Comparison and Advantages of DC and AC systems. Related terms frequency, Instantaneous value, R.M.S. value Average value, Peak factor, form factor, power factor and Impedance etc. Sine wave, phase and phase difference. Active and Reactive power. Single Phase and three-phase system. Problems on A.C. circuits. Classification of electrical instruments and essential forces required in indicating instruments. PMMC and Moving iron instruments. Measurement of various electrical parameters using different analog and digital instruments. Measurement of energy in three phase circuit. (10 hrs.)
Professional Skill 60Hrs; Professional Knowledge 08Hrs	Verify basic characteristics of electrical and magnetic circuits and perform measurements using analog / digital instruments. **(Mapped NOS: PSS/ N1707)**	51 Ascertain use of neutral by identifying wires of a 3- phase 4 wire system and find the phase sequence using phase sequence meter. (08Hrs) 52 Determine effect of broken neutral wire in three phase four wire system. (06hrs) 53 Determine the relationship between Line and Phase values for star and delta connections. (08Hrs) 54 Measure the Power of three phase circuit for balanced and unbalanced loads. (08Hrs)	Advantages of AC poly-phase system. Concept of three-phase Star and Delta connection. Line and phase voltage, current and power in a 3 phase circuits with balanced and unbalanced load. Phase sequence meter. Basic concept of Digital MultiFunction Meter.

Duration	Reference Learning Outcome	Professional Skill (Trade Practical) (With inidcative hour)	Professional Knowledge (Trade Theory)
		55 Measure current and voltage of two phases in case of one phase is shortcircuited in three phase four wire system and compare with healthy system.(10 hrs) 56 Measure electrical parameters using tong tester in three phase circuits. (10 Hrs) 57 Measure various electrical parameters using digital multifunction meter.(10hrs)	Basic concept of Accuracy class of meters. Communication from MFM to SCADA system. Improvement of power factor using Capacitor Bank. (08 hrs.)
Professional Skill 50Hrs; Professional Knowledge 10Hrs	Assemble simple electronic circuits and test for functioning. **(Mapped NOS: PSS/ N2504)**	58 Determine the value of resistance by colour code and identify types. (06Hrs) 59 Test active and passive electronic components and its applications. (10Hrs) 60 Determine V-I characteristics of semiconductor diode. (06Hrs) 61 Construct half wave, full wave and bridge rectifiers using semiconductor diode. (14Hrs) 62 Check transistors for their functioning by identifying its type and terminals. (06Hrs) 63 Use transistor as an electronic switch and series voltage regulator. (08Hrs)	Resistors – colour code, types and characteristics. Active and passive components. Atomic structure and semiconductor theory. P-N junction, classification, specifications, biasing and characteristics of diodes. Rectifier circuit - half wave, full wave, bridge rectifiers and filters. Transistors; Principle of operation, types, characteristics various configuration and biasing of transistor. Application of transistor as a switch, voltage regulator and amplifier. (10 hrs.)
Professional Skill 50Hrs; Professional Knowledge 10Hrs	Assemble simple electronic circuits and test for functioning. **(Mapped NOS: PSS N2504)**	64 Operate and set the required frequency using function generator. (05Hrs) 65 Make a printed circuit board for power supply. (05Hrs) 66 Construct simple circuits containing UJT for triggering and FET as an amplifier. (05Hrs) 67 Troubleshoot defects in simple power supplies. (05Hrs) 68 Construct power control circuit by SCR, Diac, Triac and IGBT. (05Hrs) 69 Construct variable DC stabilized power supply using IC. (05Hrs) 70 Practice on various logics by use of logic gates and circuits. (06Hrs) 71 Generate and demonstrate wave shapes for voltage/ current of rectifier and single stage amplifier using CRO. (08Hrs) 72 Construct 1ϕ or 3ϕ bridge rectifier/ inverter/ logic gate, measure input and output voltage and analyze waveforms by using oscilloscope (06Hrs)	Basic concept of power electronics devices. IC voltage regulators Digital Electronics - Binary numbers, logic gates and combinational circuits. Functions & settings of oscilloscope and waveform analysis. Construction and working of SCR, DIAC, TRIAC and IGBT. Types and applications of various multivibrators. (10 hrs.)

Duration	Reference Learning Outcome	Professional Skill (Trade Practical) (With inidcative hour)	Professional Knowledge (Trade Theory)
Professional Skill 50Hrs; Professional Knowledge 10Hrs	Carry out installation, testing and maintenance of batteries and battery room in distribution substation. **(Mapped NOS: PSS/ N2504)**	73 Identify and use of various types of cells. (02Hrs) 74 Measure voltage of different cells and Batteries. (03Hrs) 75 Practice on grouping of cells for specified voltage and current under different conditions with due care. (02Hrs) 76 Measure specific gravity of electrolyte and determine correction factor. (03Hrs) 77 Identify various components of battery charger used in sub station. (02Hrs) 78 Perform proper setting of voltage according to mode of charging and practice on Battery charging. (03Hrs) 79 Perform setting and carry out Trickle charging of Battery. (05Hrs) 80 Practice charging and discharging of Ni-Cd battery. (05Hrs) 81 Charge batteries by using float and boost charger. (05Hrs) 82 Check DC leakage and practice for its protection. (05Hrs) 83 Carry out testing of batteries. (05Hrs) 84 Practice on routine, care/ maintenance of batteries. (05Hrs) 85 Determine the number of solar cells in series / parallel for given power requirement. (05Hrs)	Chemical effect of electric current and Laws of electrolysis. Explanation of Anodes and cathodes. Types of cells, advantages/ disadvantages and their applications. Lead acid cell; Principle of operation and components. Types of battery charging, Load test of Ni-Cd and Lead Acid batteries, Safety precautions, test equipment and maintenance. Grouping of cells for specified voltage and current. Alkaline batteries Types of Battery operation: - Floating operation - Change over operation Boost charging Two Battery two charger system End cell cutting. C5 and C10 charging methods Factors affecting Battery life: - Over charging - Under charging - Leakage Correction factor, Calculation of Battery capacity Inspection of Battery Principle and operation of solar cell. Awareness of maintenance free battery concept. Safety compliance of battery room. (10 hrs.)
Professional Skill 60Hrs; Professional Knowledge 12Hrs	Estimate, Assemble, install and test wiring system. **(Mapped NOS: PSS/ N1707)**	86 Identify various conduits and different electrical accessories. (03Hrs) 87 Practice cutting, threading of different sizes & laying Installations. (03Hrs) 88 Prepare test boards / extension boards and mount accessories like lamp holders, various switches, sockets, fuses, relays, MCB, RCCB, RCBO, MPCB, MCCB etc. (06Hrs) 89 Draw layouts and practice in PVC Casing-capping, Conduit wiring with minimum to a greater number of points of minimum 15 metres. length. (06Hrs)	I.E. rules on electrical wiring. Types of domestic and industrial wirings. Study of wiring accessories e.g. switches, fuses, relays, MCB, RCCB, RCBO, MCCB etc. MPCB and its accessories. Under voltage, over voltage, shunt modules. Grading of cables and current ratings. Principle of laying out of domestic wiring.

Duration	Reference Learning Outcome	Professional Skill (Trade Practical) (With inidcative hour)	Professional Knowledge (Trade Theory)
		90 Wire up PVC conduit wiring to control one lamp from two or three different places. (06 Hrs) 91 Wire up PVC conduit wiring and practice control of sockets and lamps in different combinations using switching concepts. (06Hrs) 92 Wire up the consumer's main board with ICDP switch MCB and distribution fuse box. (05Hrs) 93 Prepare and mount the energy meter board. (03Hrs) 94 Estimate the cost/bill of material for wiring of hostel/ residential building and workshop. (04Hrs) 95 Practice wiring of hostel and residential building as per IE rules. (06Hrs) 96 Practice wiring of institute and workshop as per IE rules. (06Hrs) 97 Practice testing / fault detection of domestic and industrial wiring installation and repair. (06Hrs)	Voltage drop concept. PVC conduit and Casingcapping wiring system. Different types of wiring - Power, control, Communication and entertainment wiring. Wiring circuits planning, permissible load in sub-circuit and main circuit. Estimation of load, cable size, bill of material and cost. Inspection and testing of wiring installations. Special wiring circuit e.g. godown, tunnel and workshop etc. (12 hrs.)
Professional Skill 40Hrs; Professional Knowledge 12Hrs	Plan and install electrical illumination system and test. **(Mapped NOS: PSS/ N1707)**	98 Group different wattage of lamps in series for specified voltage. (04 Hrs) 99 Practice installation of various lamps e.g. fluorescent tube, HP sodium vapour, metal halide etc. (14Hrs) 100 Prepare decorative lamp circuit. (05 Hrs) 101 Prepare decorative lamp circuit to produce rotating light effect/running light effect. (05 Hrs) 102 Install light fitting for show case lighting. (06Hrs) 103 Install light fittings with various types of LEDs and fixture. (06Hrs)	Laws of Illuminations. Types of illumination system. Illumination factors, intensity of light. Type of lamps, advantages/ disadvantages and their applications. Calculations of lumens and efficiency. Different types of LEDs and fixtures. Luminous efficiency of LED Various color temperatures – Cool Day light - 5700K/ 6500K, Warm white - 2700K/ 300K False Recess type / Surface type. (08 hrs.)
Professional Skill 90Hrs; Professional Knowledge 16 Hrs	Plan, Execute commissioning, testing of AC motors& Starters and carry out their maintenance. **(Mapped NOS: PSS/ N1709)**	104 Identify parts and terminals of three phase AC motors. (05 Hrs) 105 Practice reading of power and control schematic drawings of motors. (05 Hrs) 106 Connect, start and run three phase induction motors by using DOL, star-delta starters. (05 Hrs) 107 Connect, start, run and reverse the direction of rotation of slip-ring motor through rotor resistance starter. (08 Hrs)	Introduction of DC motors and their applications. Working principle of three phase induction motor. Squirrel Cage Induction motor, Slip-ring induction motor; construction, characteristics, Slip and Torque. Different types of starters for three phase induction motors, its necessity, basic contactor circuit, parts and their functions.

Duration	Reference Learning Outcome	Professional Skill (Trade Practical) (With inidcative hour)	Professional Knowledge (Trade Theory)
		108 Practice on connection and settings of Soft starters. (06 Hrs) 109 Determine the efficiency of three phase squirrel cage induction motor by no load test and blocked rotor test. (06 Hrs) 110 Test for continuity and insulation resistance of three phase induction motor. (06 Hrs) 111 Perform speed control of three phase induction motor by various methods like rheostatic control, autotransformer etc. (12 Hrs) 112 Identify parts and terminals of different types of singlephase AC motors. (05 Hrs) 113 Install, connect and determine performance of single-phase AC motors. (08Hrs) 114 Start, run and reverse the direction of rotation of single-phase AC motors. (08 Hrs) 115 Practice on speed control of single phase AC motors. (08 Hrs) 116 Practice repair and maintenance of AC motors. (08 Hrs)	Basic knowledge of soft starter Single phasing prevention. No load test and blocked rotor test of induction motor. Losses & efficiency. Various methods of speed control. Braking system of motor. Maintenance and repair. Working principle, different method of starting and running of various single-phase AC motors. Domestic and industrial applications of different AC motors. Characteristics, losses and efficiency. (16 hrs.)
Professional Skill 65Hrs; Prof essional Knowledge 15Hrs	Perform testing and carry out maintenance of Alternator and Synchronous motor. **(Mapped NOS: PSS/ N1711)**	117 Identify parts and terminals of alternator. (07 Hrs) 118 Test for continuity and insulation resistance of alternator. (08 Hrs) 119 Connect, start and run an alternator and build up the voltage. (08 Hrs) 120 Determine the load performance and voltage regulation of three phase alternator. (08 Hrs) 121 Parallel operation and synchronization of three phase alternators. (08 Hrs) 122 Identify parts and terminals of a synchronous motor. (06 Hrs) 123 Connect, start and plot Vcurves for synchronous motor under different excitation and load conditions. (10 Hrs) 124 Carry out maintenance of Alternator and synchronous motor. (10 Hrs)	Principle of alternator, e.m.f. equation, relation between poles, speed and frequency. Types and construction. Efficiency, characteristics, regulation, phase sequence and parallel operation. Effect of changing the field excitation and power factor correction. Working principle of synchronous motor. Effect of change of excitation and load. V and anti V curve. Power factor improvement. Rotary Converter, MG Set description and Maintenance. (15 hrs.)

Duration	Reference Learning Outcome	Professional Skill (Trade Practical) (With inidcative hour)	Professional Knowledge (Trade Theory)
Professional Skill 20Hrs; Professional Knowledge 05Hrs	Perform speed control of ACmotors by using solid state devices/ AC drives. **(Mapped NOS: PSS/ N1709)**	125 Enter motor data and perform auto tuning on thyristors/ AC drive. (06 Hrs) 126 Perform reversing the direction of rotation of AC motors by using thyristors / AC drive. (08 Hrs) 127 Perform connections and identify parameters of AC drives. (06 Hrs)	Working, parameters and applications of AC drive. Speed control of 3 phase induction motor by using VVVF/AC Drive. (05 hrs.)
Professional Skill 44Hrs; Professional Knowledge 08 Hrs	Detect the faults and troubleshoot inverter, stabilizer, battery charger and UPS etc. **(Mapped NOS: PSS/ N6002)**	128 Identify and assemble circuits of voltage stabilizer and UPS. (08 Hrs) 129 Assemble circuits of battery charger and inverter. (08 Hrs) 130 Test, analyze defects and repair voltage stabilizer, emergency light and UPS. (09 Hrs) 131 Maintain, service and troubleshoot battery charger and inverter. (09 Hrs) 132 Install an Inverter with battery and connect it in domestic wiring for operation. (09 Hrs)	Basic concept, block diagram and working of voltage stabilizer, battery charger, emergency light, inverter and UPS. Preventive and breakdown maintenance. (08 hrs.)

Visit various sections of the institutes and location of electrical installations

Objectives: At the end of this exercise you shall be able to
- **visit the various sections/trade in your ITI and draw the layout of your ITI**
- **record the telephone numbers of the ITI office, hospitals, police station and fire station**
- **draw the layout of your section**
- **identify the locations that have electrical installations.**

PROCEDURE

TASK 1: **Visit various sections of the ITI and draw the layout of your ITI**

Instructor will lead the new trainees to various sections of the ITI.

1 Visit the various sections in your ITI and identify the sections of the ITI. List the trades and record it in your note book.

2 Collect the information about the staff members in each trade.

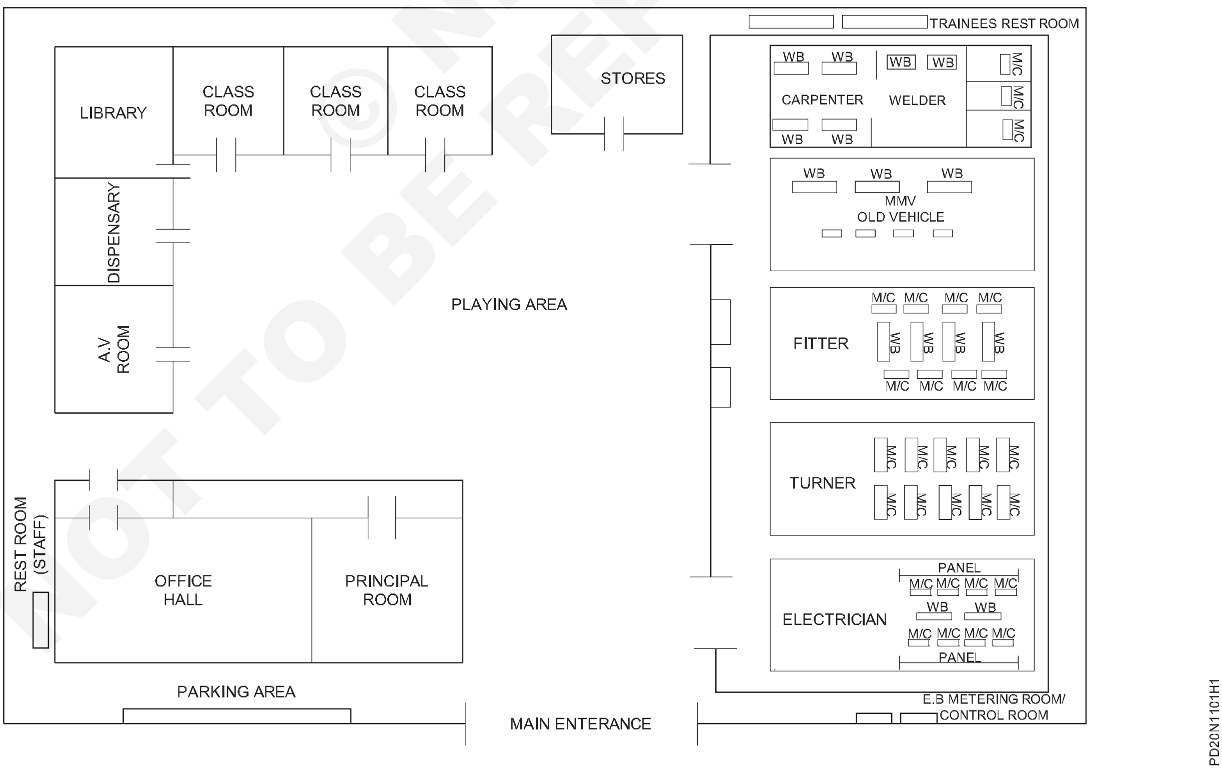
3 Identify the location of the ITI with details about the railway and bus stations in the locality and note down the list of bus route numbers which ply near the ITI.

4 Collect the telephone numbers of the ITI office, nearest hospitals, nearest police station and the nearest fire station and record.

5 Draw the layout of your ITI showing various trades.

Note: A Sample layout of the ITI (Fig 1) is given for your reference. Now draw the new layout of your ITI, with the trades/sections.

Fig 1



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TASK 2: **Draw the layout of your section in the ITI**

1 Draw the plan of your section to a suitable scale in a separate sheet of paper (A4 size).

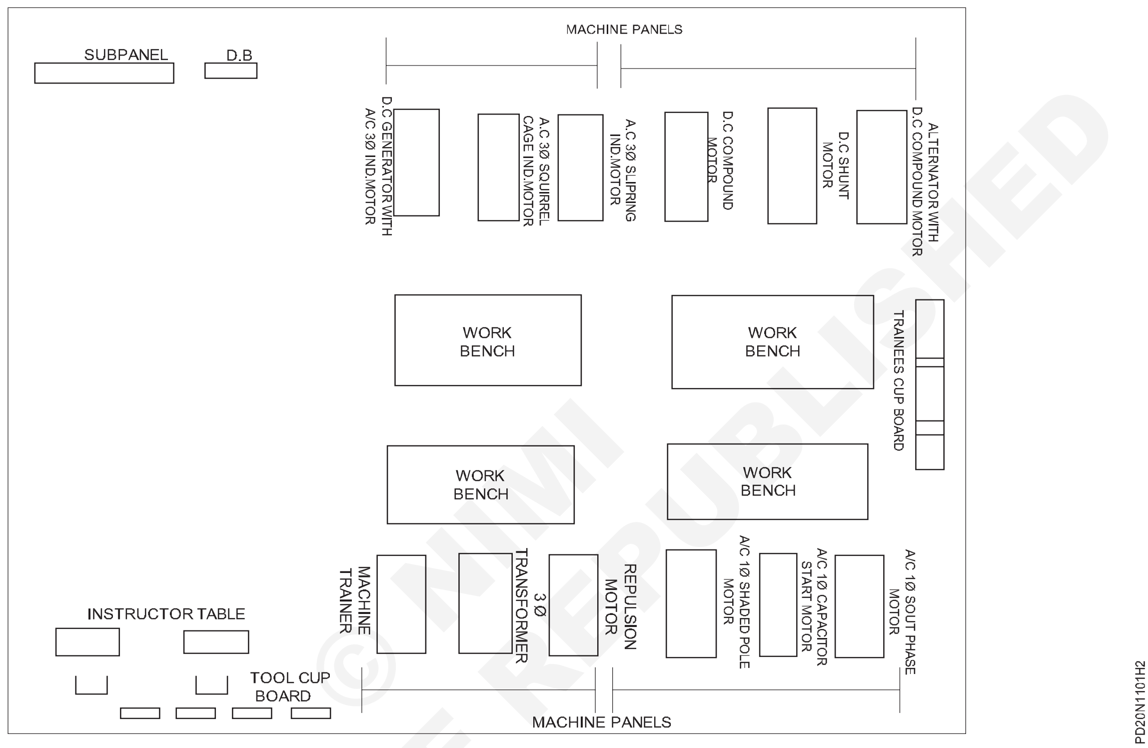
2 Take the length and the breadth measurements of machine foundations, work benches, panels, wiring cubicles, doors, windows, furniture, etc.

3 Draw the layout of the machines, work benches, panels and furniture.

The section plan should be in the same scale as in step 1 as per the actual placement of the machine foundations, panels, furniture, work benches etc.

Note : The sample layout of a typical electrician trade section is given for your reference (Fig 2). You have to draw your section's is layout using the sample as reference.

Fig 2



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TASK 3: **Identify the locations of electrical installations**

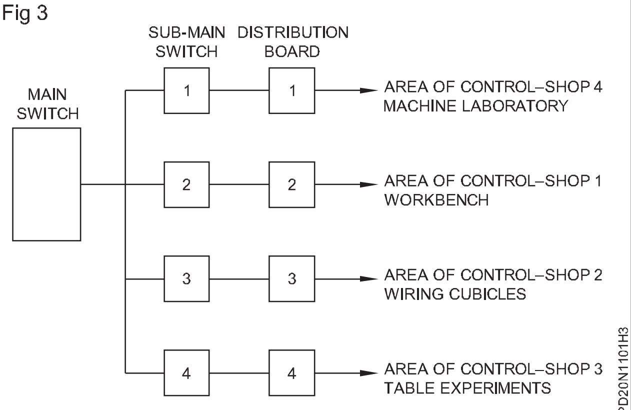
1 Identify the main switch and mark its position in the layout. (Fig 3)

2 Identify each of the sub-main switches, the area of control in the section and mark them on the layout.

3 Identify 3 or 4 spots in various locations of the electrician sections layout and identify the respective sub-main switches.

4 Practice switching 'off' the control switches, depending upon the area of control,imagining that victim are electrocuted in a specific location/spot.

Fig 3



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Identify safety symbols and hazards

Objectives: At the end of this exercise you shall be able to
- **identify the safety symbols from the chart and their basic categories**
- **write their meaning and description mentioning where they are used**
- **identify road safety signs in traffic signals from the chart**
- **read and interpret different types of occupational hazards from the chart.**

Requirements

Materials

- Basic safety signs chart - 1 No.
- Road safety signs and traffic signal chart - 1 No.
- Occupational hazards chart - 1 No.

PROCEDURE

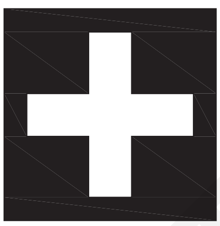
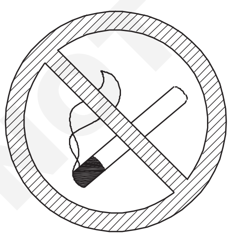
TASK 1: **Identify safety symbols and interpret what they mean with the help of their colour and shape**

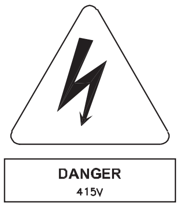
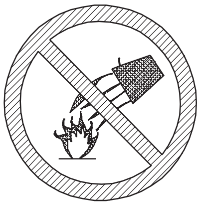
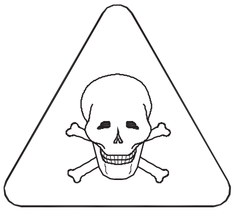
Instructor may provide charts with various safety signs for the road safety signs in traffic signals. Then, explain the categories meaning and colour. Ask the trainees to identify the signs and record it in Table 1.

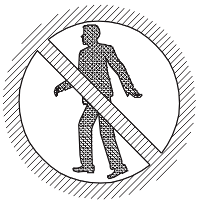
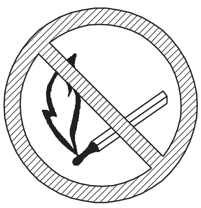
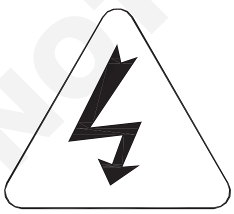
1 Identify the signs and their categories from the chart.

2 Write the name, categories, meaning and description of each sign and its place of use in Table 1.

Table 1

No.	Safety signs	Name of the sign and category	Place of use
1	 RED CROSS		
2	 No Smoking		
3	 Wear protective gloves		

No.	Safety signs	Name of the sign and category	Place of use
4			
5	 DO NOT EXTINUISH WITH WATER		
6	 DO NOT EXTINUISH WITH WATER		
7	 TOXIC HAZARD		
8	 WEAR EYE PROTECTION		

No.	Safety signs	Name of the sign and category	Place of use
9	 RISK OF FIRE		
10	 PEDESTRIANS PROHIBITED		
11	 WEAR HEARING PROTECTION		
12	 SMOKING AND NAKED FLAMES PROHIBITED		
13	 RISK OF ELECTRIC SHOCK		

TASK 2: **Identify the road safety signs and traffic signal signs**.

Instructor will explain all the road safety signs and traffic signal signs

1 Identify the sign and give details of its kind and meaning in Table 2.

2 Get it checked by the instructor

Fig 1

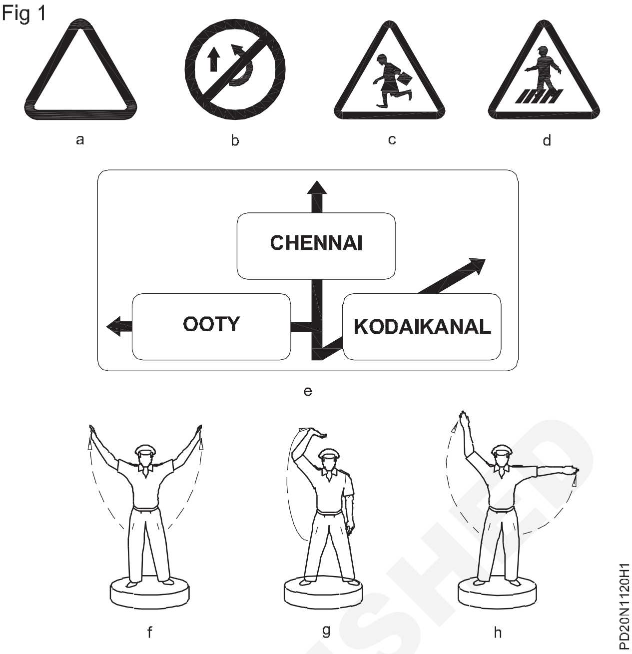


Table 2

Figure Number	Label	Kind of road sign	Name of the signal	Meaning of the sign
1	a			
2	b			
3	c			
4	d			
5	e			
6	f			
7	g			
8	h			

— — — — — —

TASK 3: **Read and interpret the different types of personal protective equipment (PPE) from the chart**

Instructor may brief the various types of occupational hazards and their causes.

1 Identify the occupational hazard matching it to the corresponding situation with the given potential in Table 3.

2 Complete the details and get it checked by your instructor.

Table 3

Sl.No.	Source or potential harm	Type of occupational hazard
1	Noise	
2	Explosive	
3	Virus	
4	Sickness	
5	Smoking	
6	Non-control device	
7	No earthing	
8	Poor housekeeping	

— — — — — — — —

Preventive measures for electrical accidents and practice steps to be taken in such accidents

Objectives: At the end of this exercise you shall be able to
- **practice and follow preventive safety rules to avoid electrical accidents**
- **rescue the electric shock victim.**

Requirements

Materials

- Heavy insulated screwdriver 200 mm - 1 No.
- Electrical safety chart (or) display - 1 No.
- Gloves - 1 No.
- Rubber mat - 1 No.
- Wooden stool - 1 No.
- Ladder - 1 No.
- Safety belt - 1 No.

PROCEDURE

TASK 1: **Practice and follow preventive safety rules to avoid electrical accidents**

1 Do not work on live circuits. If unavoidable use rubber gloves or rubber mats.

2 Do not touch bare conductors.

3 Stand on a wooden stool or an insulated ladder while repairing live electrical circuits/appliances or replacing fused bulbs.

4 Stand on rubber mats while working, operating switch panels, control gears, etc.

5 Always use safety belts while working on poles or high- rise points.

6 Use screwdrivers with wooden or PVC insulated handle when working on electrical circuits.

7 Replace (or) remove fuses only after switching off the circuit switches.

8 Open the main switch and make the circuit dead.

9 Do not stretch your hands towards any moving part of the rotating machine and around moving shafts.

10 Always use earth connection for all electrical appliances along with 3-pin sockets and plugs.

11 Do not connect earthing to the water supply electrical lines.

12 Do not use water on electrical equipment.

13 Discharge static voltage in HV lines/equipment and capacitors before working on them.

14 Keep the workshop floor clean and tools in good condition.

— — — — — —

TASK 2 : **Rescue the electric shock victim**

1 Proceed with treatment as early as possible without panic or becoming emotional.

2 Switch OFF the power or remove the plug or wrench the cable free.

3 Move the victim from contact with the live conductor by using dry non-conducting materials like wooden bars. (Fig 1 & 2)

> **Avoid direct contact with the victim. Wrap your hands with dry material if rubber gloves are not available. If you are uninsulated, do not touch the victim with your bare hands.**

Fig 1

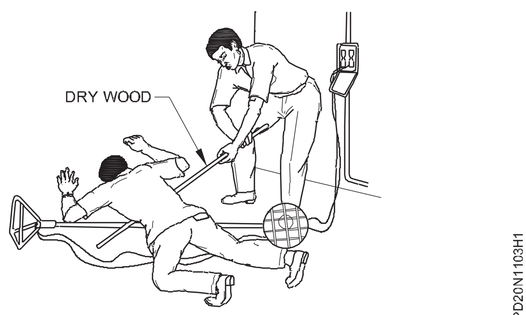
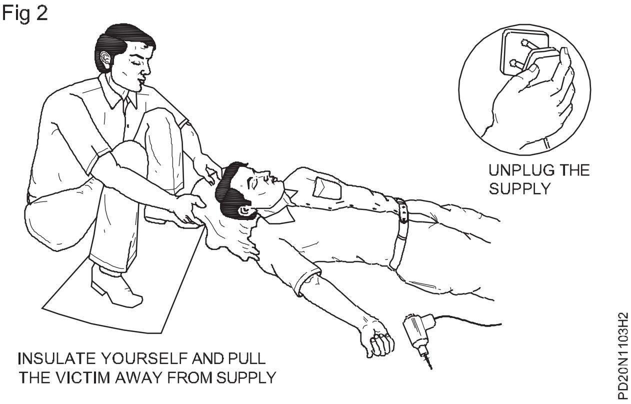


Fig 2



4 Keep the patient warm and at mental rest.

Ensure that there is good air circulation. Seek help to shift the patient to a safer place. If the victim is aloft, take steps to prevent him from falling.

5 Loosen the clothing near the neck, chest and waist and place the victim in a relaxed position, if the victim is unconscious.

6 Keep the victim warm and comfortable. (Fig 3)

Fig 3

7 Send someone to call the doctor, in case of electric burns.

If the victim has electrical burns due to shock, it may be very painful and is dangerous. If a large area of the body is burnt do not give treatment. Give first-aid as given in step 8

8 Cover the burnt area with pure running water.

9 Clean the burnt area using a clean cloth/cotton.

10 Send someone to call the doctor immediately.

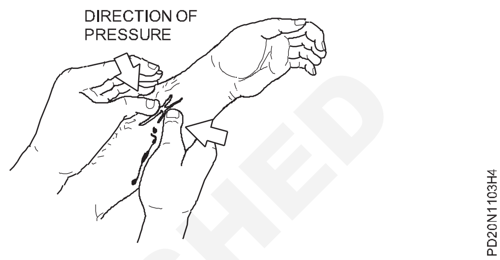
In case of severe bleeding

11 Lay the patient flat.

12 Raise the injured part above the body level. (If possible)

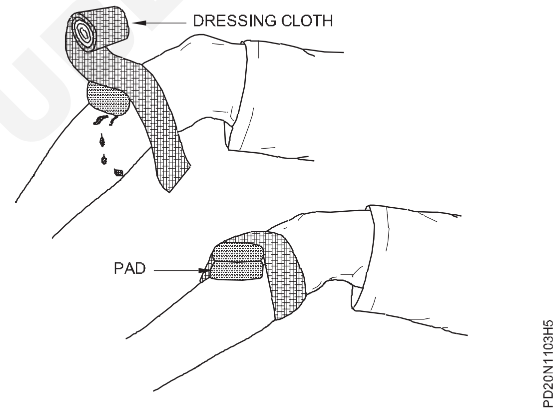
13 Apply pressure on the wound ,as long as necessary, to stop the bleeding. (Fig 4)

Fig 4



14 cover the injured area with a clean pad and bandage firmly, if it is a large wound. (Fig 5)

Fig 5



If bleeding is severe, use more than one dressing.

15 initiate right methods of artificial respiration, if the person is unconscious

— — — — — —

Practice safe methods of fire fighting in case of electrical fire

Objectives: At the end of this exercise you shall be able to
- **demonstrate the ability of fire-fighting during electrical fire**
- **as a member of the fire-fighting team**
- **as a leader of the group.**

Requirements

Equipment/Machines

- Fire extinguishers- CO_2 - 1 No.

PROCEDURE

General procedure to be adopted during electrical fire

1 Raise an alarm. Follow the methods given below to raise an alarm signals when the fire breakes out.

– Raise your voice and shout Fire! Fire! to draw attention.

– run towards fire alarm/bell to activate

– switch off the mains (if possible)

2 when you hear the alarm signal:

– stop working

– turn off all machinery and power

– switch off fans/air circulators/exhaust fans. (it's good to switch off the sub-main)

3 If you are not involved in the fire fighting:

– leave the place using the emergency exit.

– evacuate the premises

– assemble at a safe place along with others

– check, if anyone has called the fire services

– close the doors and windows, but do not lock or bolt

As a member of the fire-fighting team

4 If you are involved in fire fighting:

– take instructions to extinguish fire in an organised way.

If taking instructions:

– follow the instructions, and obey. Be safe and do not get trapped.

– do not use your own ideas.

As a leader of the group

If you are giving instructions:

– locate and use co_2 fire extinguisher

– seek for sufficient assistance and inform the fire brigade

– locate locally available suitable means to put out the fire

– judge the magnitude of the fire, Ensure that emergency exit paths are clear with no obstructions and then attempt to evacuate the place. (Remove explosive materials, substances that would easily catch fire.

– Put off the fire with assistance identifying people with assigned responsibility for each activity.

5 Report the measures taken to put out the fire, to the authorities concerned.

Detailed reports on the fire accidents, even if they are small accidents, shall help in identification of the causes of the fire. The identified causes shall help in taking preventive measures to avoid similar occurrences in the future

— — — — — —

Use of fire extinguishers

Objectives: At the end of this exercise you shall be able to
- **select fire extinguishers according to the type of the fire**
- **operate the fire extinguisher**
- **extinguish the fire.**

Requirements

Equipment/Machines

- Fire extinguishers-CO_2 - 1 No.
- Scissors 100 mm - 1 No.
- Cell phone - 1 No.

PROCEDURE

1 Alert people in the surrounding area by shouting when you see fire (Fig 1a & b).

2 Inform fire service or arrange to inform them immediately (Fig 1c).

3 Open the emergency exit and ask the people inside the area to go away (Fig 1d).

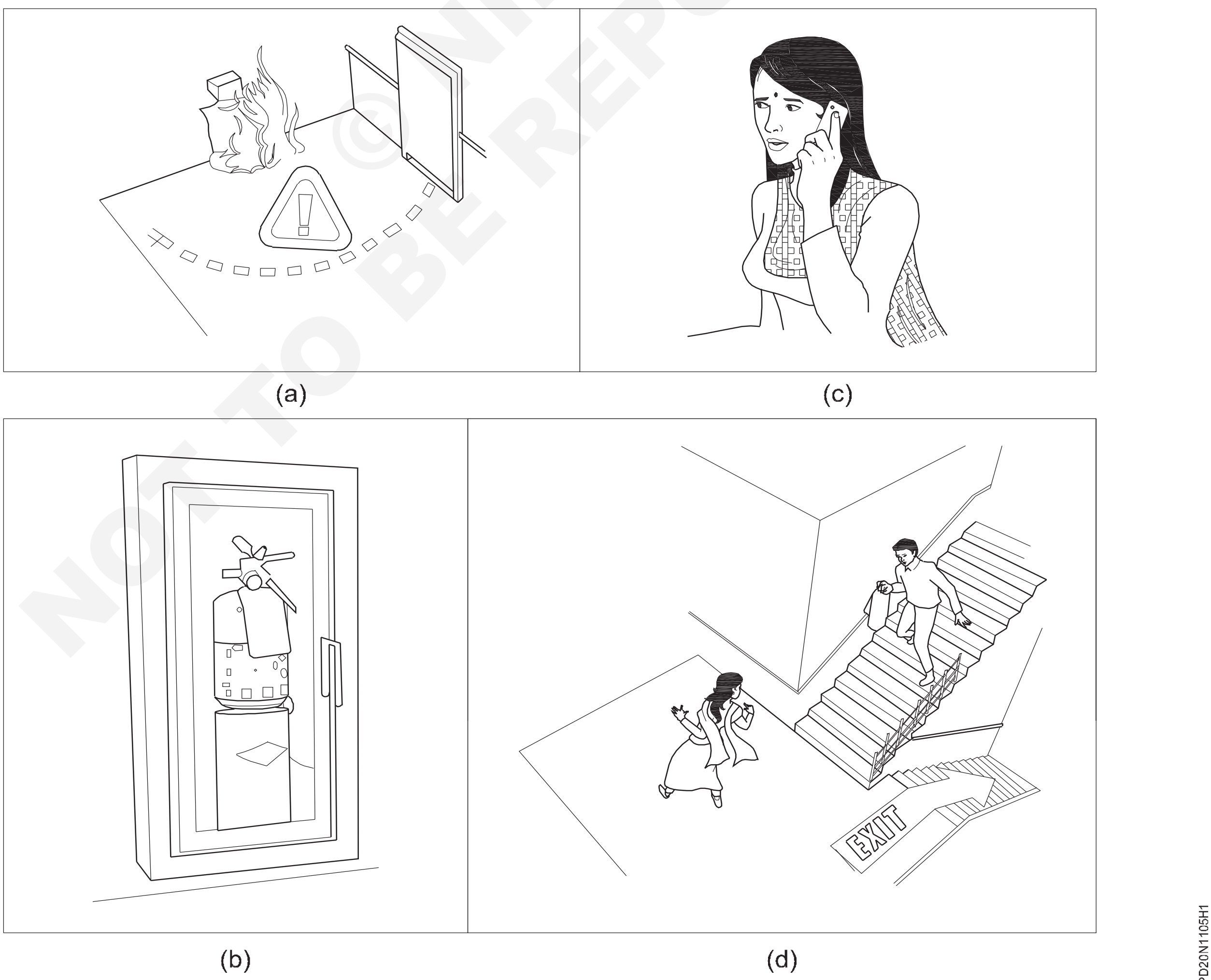
4 Switch "OFF" all electrical power supply.

Do not allow people to go near the fire.

5 Analyze to identify the type of fire. Refer Table1.

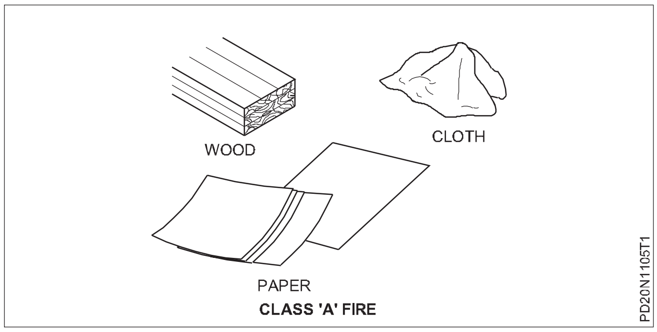
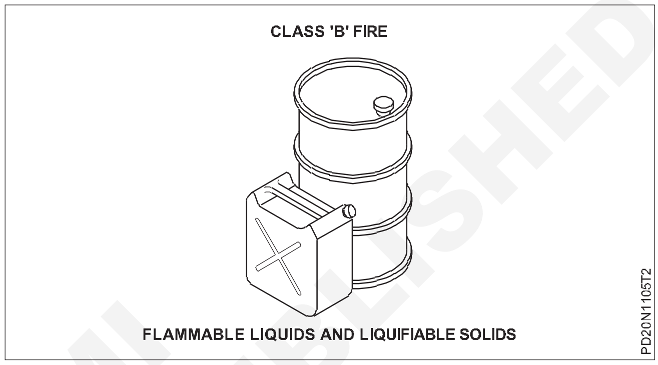
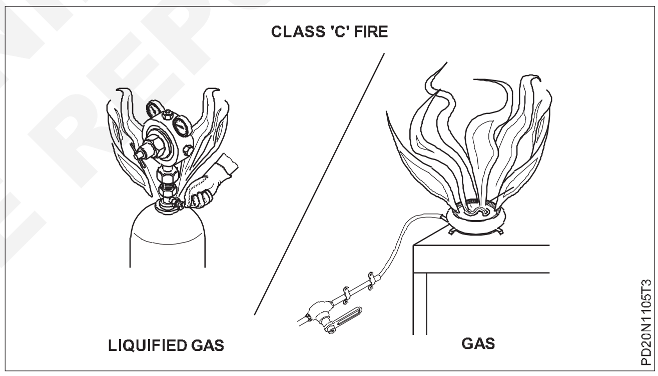
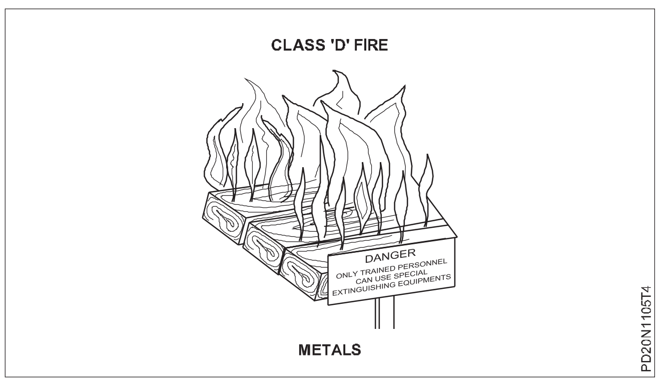
6 Assume that is it type D fire (Electrical fire).

Fig 1



(a) (c) (b) (d)

Table 1

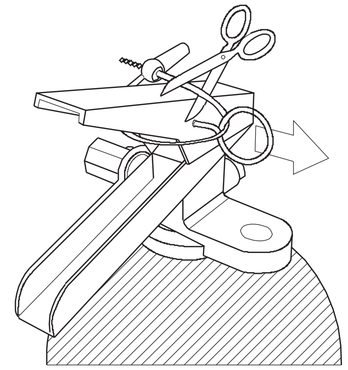
<table>
<tr><td>Class 'A': Wood, paper, cloth, solid material</td><td>
</td></tr>
<tr><td>Class 'B': Oil-based fire (grease, gasoline,oil) and liquefiable solids</td><td>
</td></tr>
<tr><td>Class 'C': Gas and liquefied gases</td><td>
</td></tr>
<tr><td>Class 'D': Metals and electrical equipment</td><td>
</td></tr>
</table>

6 Select CO_2 (carbon dioxide) fire extinguisher.

7 Locate and take the CO_2 fire extinguisher. Check for its expiry date.

8 Break the seal. (Fig 2)

Fig 2

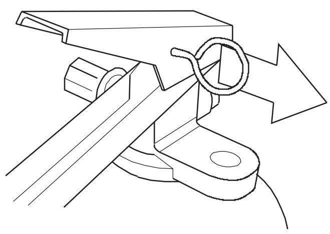


BREACKING OF SEAL

PD20N1105H2

9 Pull the safety pin from the handle. (Fig 3) (the Pin is located at the top of the fire extinguisher.) (Fig 3)

Fig 3



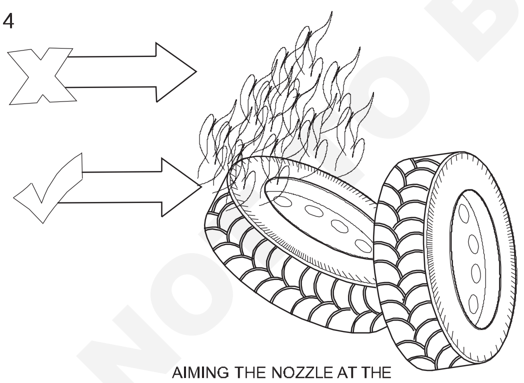
PULLING THE SAFETY PIN

PD20N1105H3

10 Aim the extinguisher nozzle or hose at the base of the fire. (This will remove the source of the fuel fire.) (Fig 4)

Keep your self low.

Fig 4



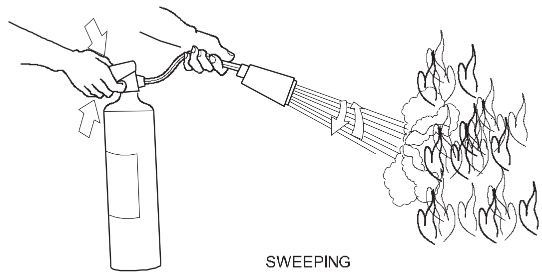
AIMING THE NOZZLE AT THE BASE OF THE FIRE

PD20N1105H4

11 Slowly squeeze the handle lever to discharge the agent. (Fig 4)

12 Sweep from side to side approximately 15 cm over the fuel fire until the fire is put off. (Fig 5)

Fig 5



SWEEPING

PD20N1105H5

Fire extinguishers are manufactured for use from a distance.

Caution

- While putting off fire, the fire may flare up.
- Do not panic so long as it is being put off promptly
- If the fire does not respond well even after you have used the fire extinguisher, move away from the fire point.
- Do not attempt to put out a fire when it emits toxic smoke. Leave it to the professionals.
- Remember that your life is more important than the property. So do not take risks.

In order to remember the simple operation of fire extinguisher, remember P.A.S.S.

This will help to use the fire extinguisher.

P for pull

A for aim

S for squeeze

S for sweep

— — — — — —

Practice elementary first aid

Objective: At the end of this exercise you shall be able to
- **prepare the victim for elementary first aid.**

Requirements	
Equipment/Materials	
• Number of Persons (Instructor can divide the trainees into suitable Number of groups.)	- 20 Nos.

PROCEDURE

Assumption: For easy manageability, Instructor may divide the trainees into groups and ask each group to perform one method of resuscitation.

TASK 1: **Prepare the victim before giving first-aid treatment**

1 Loosen the tight clothing as it may interfere with the victim's breathing. (Fig 1)

Fig 1

LOOSENING TIGHT CLOTHING

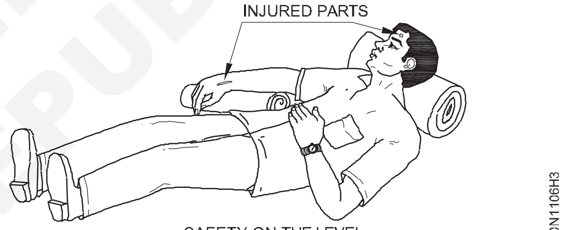
2 Remove any foreign material or false teeth from the victim's mouth and keep the victim's mouth open. (Fig 2)

Fig 2

KEEP THE MOUTH OPEN

3 Safely bring the victim to the level ground, taking the necessary safety measures. (Fig 3)

Fig 3



SAFETY ON THE LEVEL GROUND

Do not waste too much time in loosening the clothes or trying to open the tightly closed mouth.

4 Avoid violent operations to prevent injury of the victim's internal parts.

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TASK 2: **Prepare the victim for artificial respiration**

Observe the condition of electric shock victim.

If breathing has stopped, try to provide artificial respiration

1 Send word for professional assistance. (If no other person is available, you stay with the victim and help as best as you can.)

2 Look for visible injury in the body and decide on the suitable method of artificial respiration.

- In the case of injury/burns on the chest and/or belly follow the mouth to mouth method.
- In case the mouth is closed tightly, use Schafer's or Holgen–Nelson method.
- In the case of burn and injury in the back, follow Nelson's method.

3 Place the victim in the correct position before giving artificial respiration.

All actions should be taken immediately.

Delay by even a few seconds may be dangerous.

Take extreme care to prevent injury to the victim's internal organs.

4 Cover the victim with coat, sacks or improvise with your own method. Help to keep the victim's body warm.

5 Proceed to perform the suitable artificial respiration method.

— — — — — —

Rescue a person and practice artificial respiration

Objective: At the end of this exercise you shall be able to
- **rescue a victim from electric shock**
- **apply respiratory methods**
  - **Nelson's arm - Lift back method**
  - **Schafer's method**
  - **mouth to mouth method**
  - **mouth to nose method**
  - **revive breathing during cardiac arrest.**

Requirements

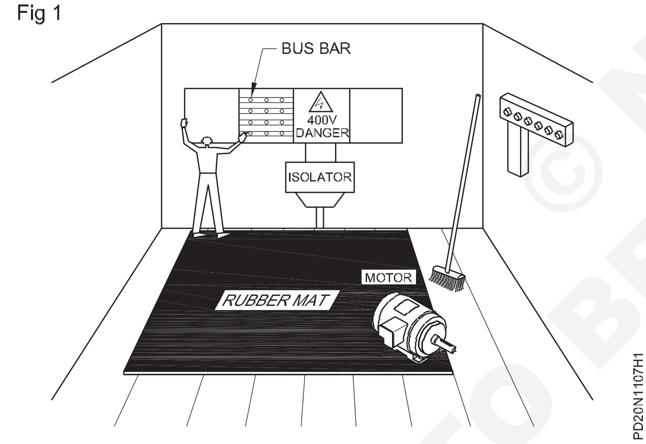
Equipment/Materials

- Control panel arrangement - 1 No.
- Motor - 1 No.
- Rubber mat - 1 No.
- Wooden stick - 1 No.
- 2 persons for demonstration purpose

PROCEDURE

TASK 1**: Rescue a person (mock victim) from live supply (simulated).**

Fig 1



1 Observe the person (mock victim) receiving an electric shock. Interpret the situation quickly.

2 Safely move the victim away from the `live` equipment by disconnecting the supply or using any insulating material. (Fig 1)

> **Do not run to switch off the supply that is far away.**
> **Do not touch the victim with bare hands until the circuit is made dead or the victim is moved away from the equipment.**
>
> **Push or pull the victim away from the point of contact of the live equipment, without causing serious injury to the victim.**

3 Physically move the victim to a nearby place.

4 Check for the victim's natural breathing and consciousness.

5 Take steps to revive breathing if the victim is unconscious and not breathing.

— — — — — —

TASK 2 : **Revive breathing in the victim by Nelson's arm-Lift back pressure method**

> **Nelson's arm-lift back pressure method must not be used when there are injuries to the chest and belly.**

1 Place the victim with his arms folded with the palms one over the other and the head resting facing the ground with his cheek over the palms.

2 Kneel on one or both knees near the victim's hand.

3 Place your hands on the victim's back beyond the line of the armpits, with your fingers spread outwards and downwards, thumbs just touching as in Fig 1.

4 Gently rock forward keeping your arms straight until they are nearly vertical, and steadily keep pressing the victim's back as shown in Fig 2 to force the air out of the victim's lungs.

Fig 1

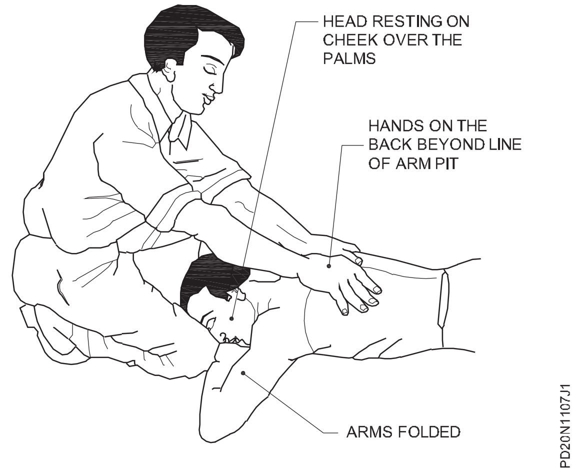


Fig 2

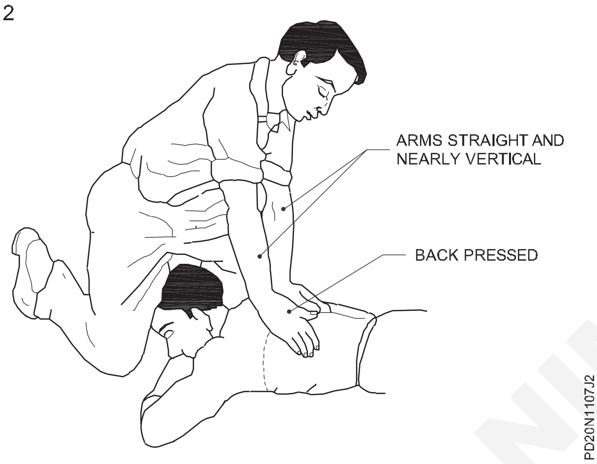


Fig 3

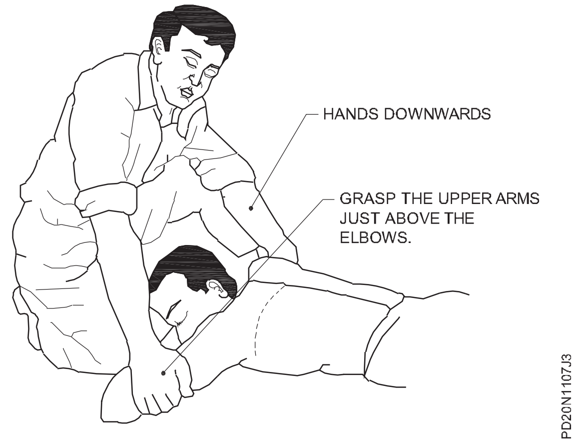
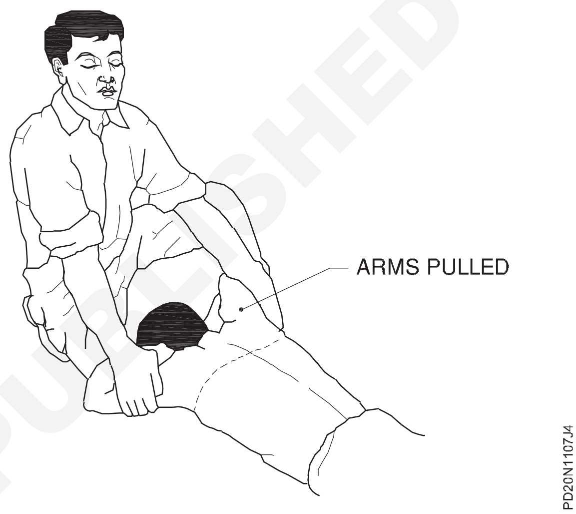


Fig 4



5 Synchronise the above movement of rocking back wards with your hands sliding downwards along the victim's arms, and grasp his upper arm just above the elbows as shown in Fig 3. Continue to rock backwards.

6 As you rock back, gently raise and pull the victim's arms towards you as shown in Fig 4 until you feel the tension in his shoulders. To complete the cycle, lower the victim's arms and move your hands up to the initial position.

7 Continue artificial respiration till the victim starts to breathe naturally. Please note, in some cases, it may take hours.

8 When the victim revives, keep the victim warm with a blanket, wrapped around him or with hot water bottles or warm bricks. Stimulate blood circulation towards the heart by stroking the insides of the arms and legs.

9 Keep him in the lying position and do not let him exert himself.

Do not give him any stimulant, until he is fully conscious.

— — — — — —

TASK 3 : **Revive breathing in the victim by Schafer's method**

Do not use this method when the victim has injuries on the chest and belly.

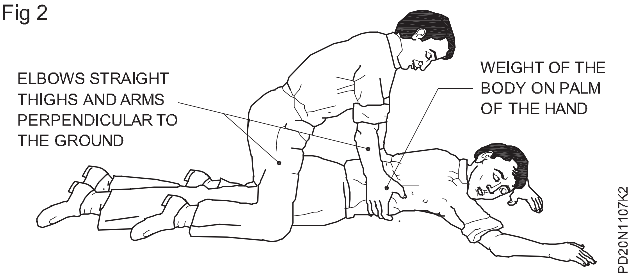
1 Lay the victim on his belly, one arm extended direct forward, the other arm bent at the elbow and with the face turned sideward and resting on the hand or forearm as shown in Fig 1.

2 Kneel when the victim is astride, so that his thighs are between your knees with your fingers and thumbs positioned as in Fig 1.

Fig 1

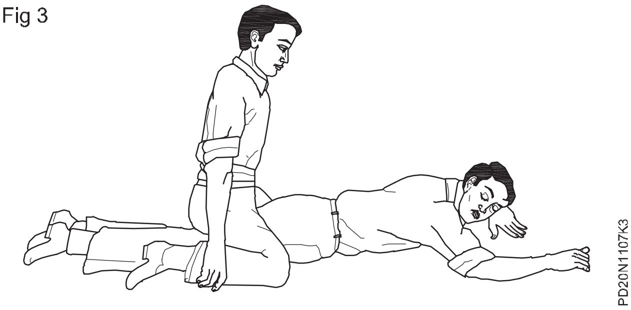
3 With the arms held straight, slowly swing forward so that the weight of your body is gradually brought to bear upon the lower ribs of the victim to force the air out of the victim's lungs as shown in Fig 2.

Fig 2



4 Now immediately swing backwards removing all the pressure from the victim's body as shown in Fig 3, to allow the lungs to fill with air.

Fig 3



5 After two seconds, swing again forward and repeat the cycle twelve to fifteen times per minute.

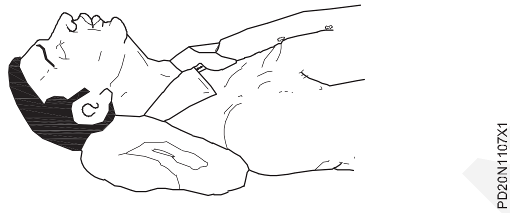
6 Continue it till the victim begins to breathe naturally.

— — — — — —

TASK 4: **Revive breathing in the victim by mouth-to-mouth method**

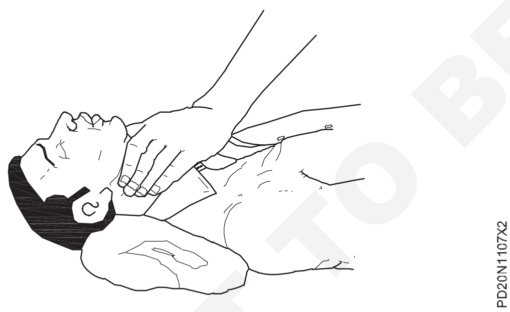
1 Lay the victim flat on his back and place a cloth roll under his shoulders to ensure that his head is thrown well back. (Fig 1)

Fig 1



2 Tilt the victim's head back so that the chin points straight upwards. (Fig 2)

Fig 2



3 Grasp the victim's jaw as shown in Fig 3, and raise it upwards until the lower teeth are higher than the upper teeth you may also place your fingers on both sides of the jaw near the victim's ear lobes and pull upward. Maintain this jaw position throughout the duration to revive respiration to prevent the tongue from blocking the air passage.

4 Take a deep breath and place your mouth over the victim's mouth as shown in Fig 4 making airtight contact. Pinch the victim's nose shut with the thumb and forefinger. If you dislike direct contact, place a porous cloth between your mouth and that of the victim's. For an infant, place your mouth over the infant's mouth and nose. (Fig 4)

Fig 3

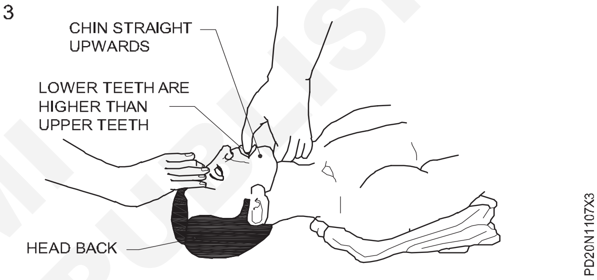
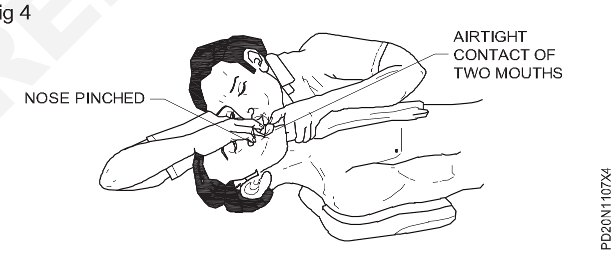


Fig 4



5 Blow into the victim's mouth (gently in the case of an infant) until his chest rises. Remove your mouth and release the hold on the nose, to let him exhale, turning your head to hear gushing the out of air. The first 8 to 10 breathing should be as rapid as the victim responds. Thereafter the rate should be slowed down to about 12 times per victim's minute (20 times for an infant).

If air cannot be blown in, check the position of the victim's head and jaw and recheck the mouth for obstructions. Then, try again more forcefully. If the chest still does not rise, turn the victim's face down and strike his back sharply to dislodge obstructions.

Sometimes air enters the victim's stomach as evidenced is the swelling of the stomach. Expel the air by gently pressing the stomach during the exhalation period.

— — — — — —

TASK 5: **Revive breathing in the victim by Mouth-to-Nose method**

Use this method when the victim's mouth will not open, or has a blockage you cannot clear.

1 With the fingers of one of your hand that keep the victim's lips firmly shut. Seal your lips around the victim's nostrils and breath the air into him. Check to see if the victim's chest is rising and falling. (Fig 1)

2 Repeat this exercise at the rate of 10-15 times per minute till the victim responds.

3 Continue this exercise till the arrival of the doctor.

Fig 1

— — — — — —

TASK 6 : **Revive breathing in a victim who is under cardiac arrest**

In cases where the heart has stopped beating, you must act immediately.

1 Check quickly whether the victim is under cardiac arrest.

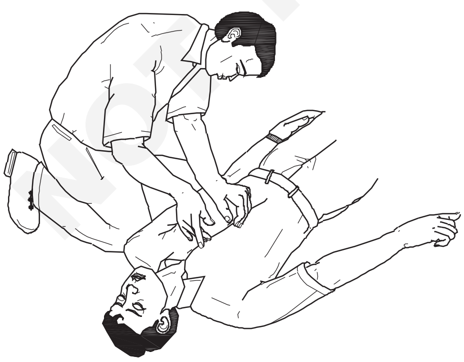
Cardiac arrest could be ascertained by the absence of the cardiac pulse in the neck (Fig 1), blue colour around lips and dilated pupil of the eyes.

Fig 1

2 Lay the victim on his back on a firm surface.

3 Kneel alongside facing the chest and locate the lower part of the breastbone. (Fig 2)

Fig 2

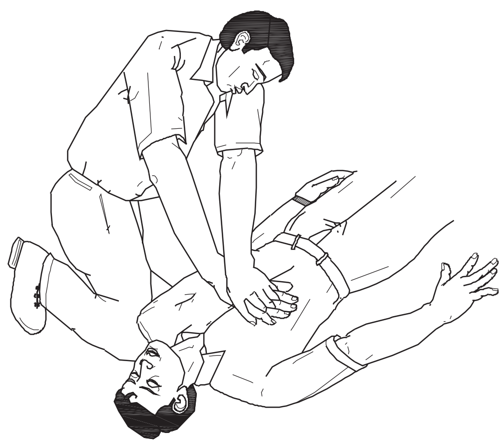


4 Place the palm of one of your hands on the centre of the lower part of the breastbone, keeping your fingers off the ribs. Cover the palm with your other hand and lock your fingers together as shown in Fig 3.

Fig 3

5 Keeping your arms straight, press sharply down on the lower part of the breastbone. Then release the pressure. (Fig 4)

Fig 4



6 Repeat step 5, fifteen times at the rate of at least one time per second.

7 Check the cardiac pulse (Fig 5).

8 Move back to the victim's mouth to give two breaths (mouth-to-mouth revival of breathing) (Fig 6).

9 Continue with another 15 compressions of the heart followed by two breaths of mouth-to-mouth revival of breathing. Check the pulse at frequent intervals.

Fig 5

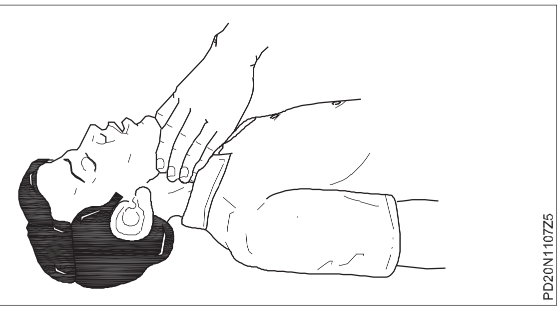
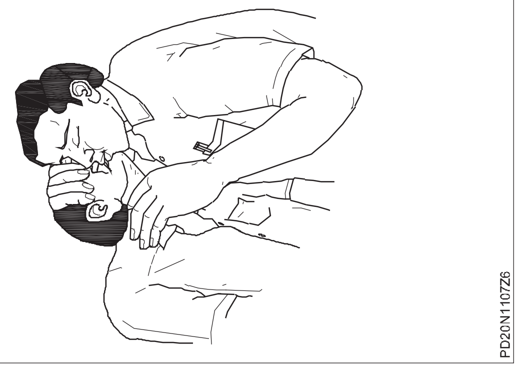


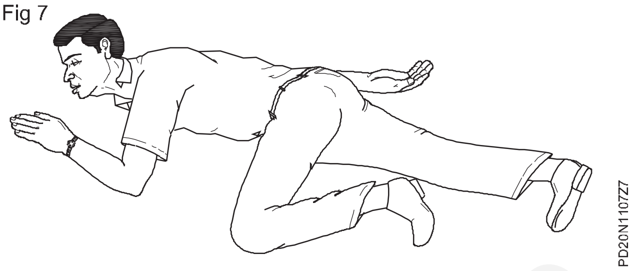
Fig 6



10 As soon as the heartbeat is revived, stop the compressions immediately. Continue mouth-to-mouth revival of breathing until natural breathing is fully restored.

11 Place the victim in the recovery position as shown in Fig 7. Keep him warm and quickly get medical help.

Fig 7



Other steps

1 Send for a doctor immediately.

2 Keep the victim warm with a blanket around him or wrapped up with hot water bottles or warm bricks. Stimulate blood circulation towards the heart by stroking the insides of the arms and legs.

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Disposal of procedure of waste materials

Objectives: At the end of this exercise you shall be able to
- **identify the different type of waste material**
- **segregate the waste materials in the respecive bins**
- **sort non-saleable and saleable materials separately and maintain record.**

Requirements

Materials

- Shovel - 1 No.
- Plastic/Metal bins - 4 Nos.
- Trolly with wheels - 3 Nos.
- Brush and gloves - 1 Pair

PROCEDURE

1 Collect all the waste materials in the workshop.

2 Identify and segregate them like cotton waste, metal chips, chemical waste and electrical waste (Fig 1) separately and label them.

3 Sort waste materials as saleable, non saleable, organic and inorganic materials.

4 Record the sorted waste material and fill Table-1.

Fig 1

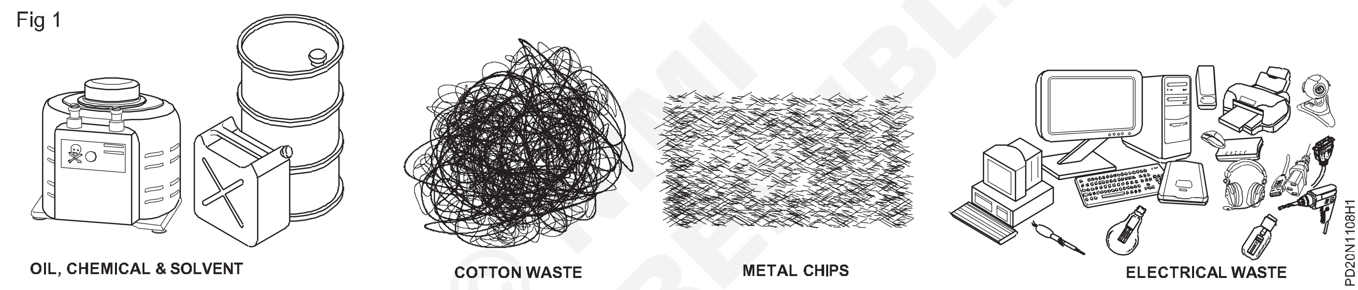


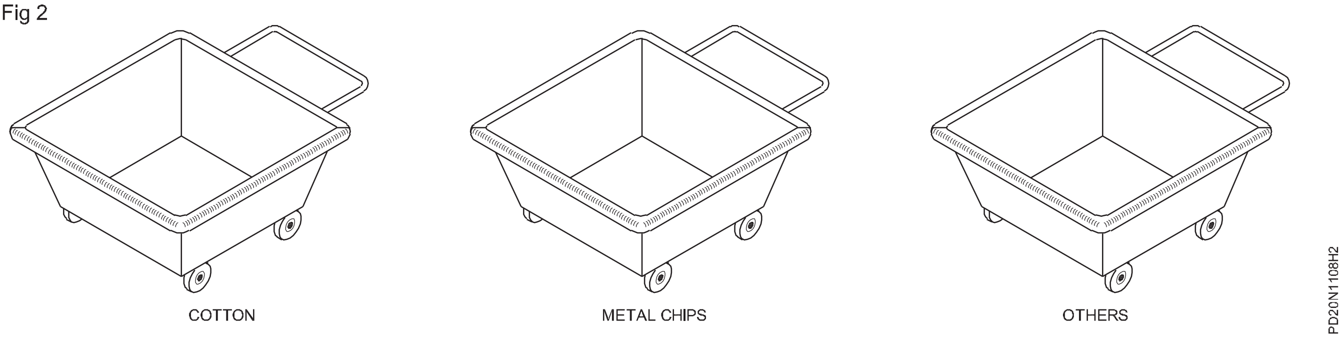
Table 1

Sl.No.	Name of the waste material	Quantity	Saleable or non Saleable
1			
2			
3			
4			
5			
6			

5 Arrange at least 3 trolleys with wheels for disposal. Stick label on each trolly as "Cotton Waste", "Metal Chips" and "others". (Fig 2)

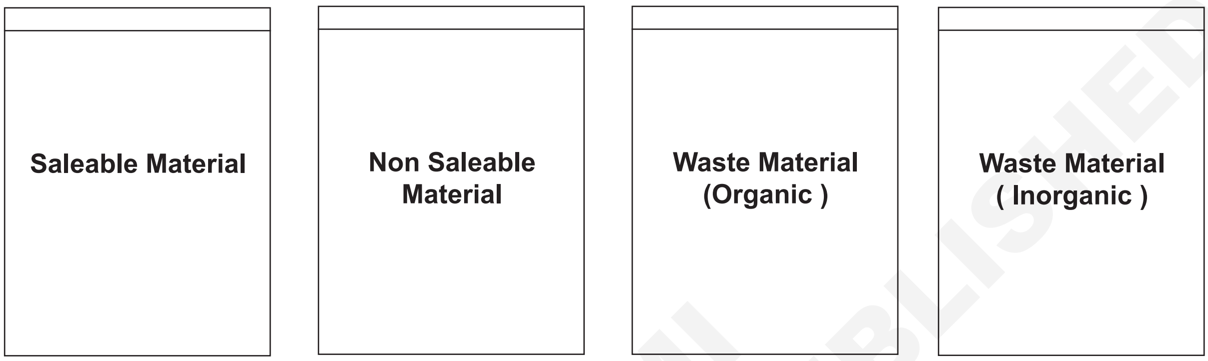
6 Put the cotton waste in the cotton trolly and similarly put the metal chips waste and others in the respective trolleys.

Fig 2



7 Keep 4 more bins to collect saleable scrap, non saleable scrap, organic waste and Inorganic waste and label them. (Fig 3)

Fig 3



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Skill Sequence

Separate the cotton waste and dispose it

Objective: This shall help you to
- **separate and dispose cotton waste.**

1 Collect the chips by hand shavel with the help of a brush.

2 Clean the floor if oil has been spilt.

Do not handle the chip with bare hand. Separate the chip according to the metal.

3 Separate the cotton waste and store it in the bin provided for the purpose.

4 Store the each category in the assigned bins.

Each bin has respective label.

5 Collect all the saleable material and non salable one seperately and put them in the respective bins.

6 Collect all the non-saleable materials like cotton waste, paper waste, wooden pieces, etc., and keep them in the respective bin as in Fig 3.

7 Check the non-saleable material (organic) and send it for disposal by burning after getting approval.

8 Check the saleable material and segregate like Aluminium, Copper, Iron, Screws, nuts and other items separately and send it to the stores for disposal by auction (or) as per recommended procedure.

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Use of personal protective equipment

Objectives: At the end of this exercise you shall be able to
- **read and interpret different types of Personal Protective Equipment (PPE) from the chart (or) real PPE**
- **identify and name the PPEs corresponding to the type of protection and write their uses.**

Requirements

Tools / Equipment

- Chart showing different types of PPEs - 1 No.
- Real PPEs(available in section) - as reqd.

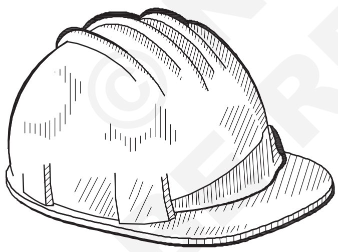
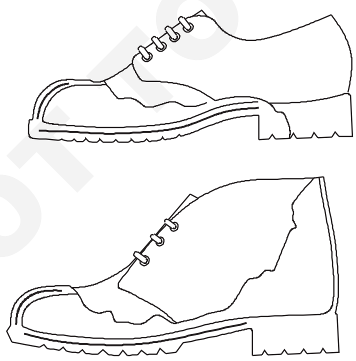
PROCEDURE

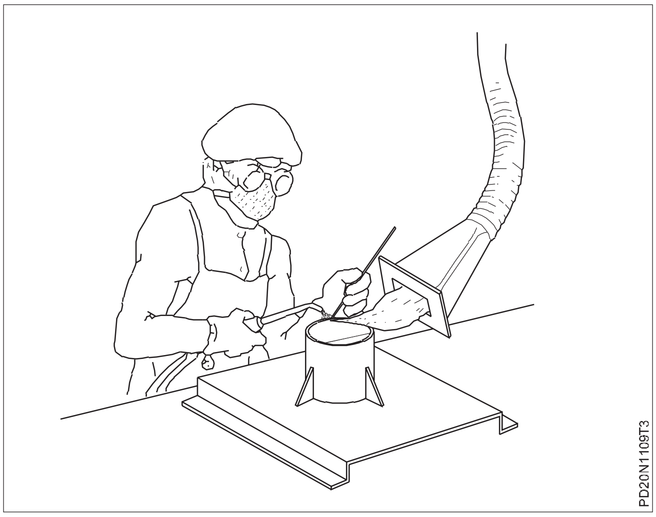
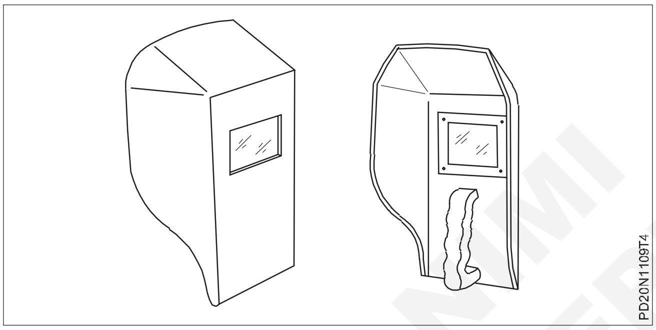
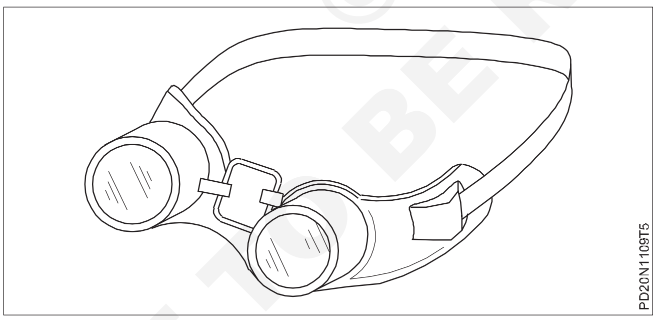
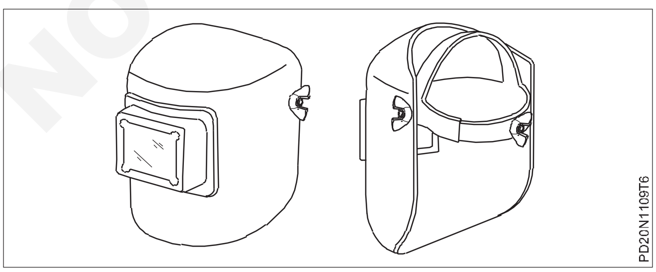
Instructor may arrange the available different types of PPEs in the table or provide the chart showing the PPEs. Instrcutor may also explain the types of PPEs and their uses, and the hazards for which each type is used.

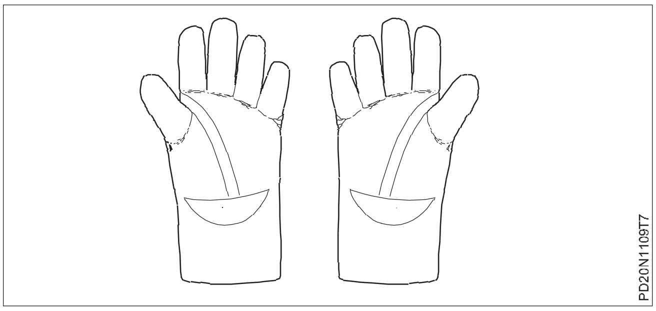
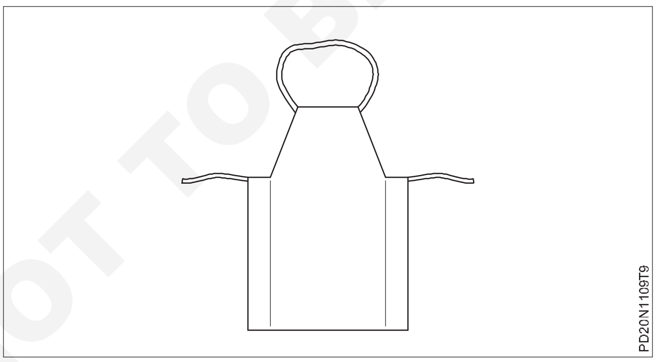
1 Identify the different types of PPEs and write their names with the help of the chart and write in Table 1.

2 Write the type of protection and uses in the space provided against each PPE in Table 1.

Table 1

Sl. No.	Sketches	Name of PPE	Type of protection	Uses
1				
2				

Sl. No.	Sketches	Name of PPE	Type of protection	Uses
3				
4				
5				
6				

Sl. No.	Sketches	Name of PPE	Type of protection	Uses
7				
8				
9				

3 Get it checked by your instructor.

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Practice on cleanliness and procedure to maintain it

Objectives: At the end of this exercise you shall be able to
- **identify the places/machinery/equipment that are to be cleaned**
- **collect the cleaning materials/devices required for cleaning**
- **clean the machines/equipment and devices installed in your section.**

Requirements

Tools / Equipment

- Portable vacuum cleaner/blower - 1 No.

Materials

- Emery sheet-'O' grade - 1 No.
- Dusting cloth - as reqd.
- Dust bin (labelled) - 3 Nos.

PROCEDURE

Switch OFF all the machinery and equipment before starting the cleaning process. Use a mask or cover the mouth and nose.

Instructor has to brief the Japanese 5S concept to the trainees before starting the work.

Sort
Set in order
Shine
Standardise
Sustain
} **5s - concept**

1 Identify the areas/equipment/machine that need to be cleaned.

2 Keep the movable items in one place and group them.

3 Clean the dust carefully, without damaging any part/ connection in the machine / equipment, using a cloth.

4 Use wet dusting cloth on areas that are wired.

5 Remove rust on parts of the equipment (or) devices using an emery sheet.

Do not remove lubricants in the machine while wiping/cleaning.

6 Use vacuum cleaners to suck dust from areas where a brush or cloth cannot help.

7 Collect the waste materials found in the lab and put it in the specified dustbin, as shown in Fig 1.

Dusting and cleaning can be arranged by dividing the trainees into groups under the supervision of the instructor.

8 Clean places where water or oil has been spilt on the floor

Note down abnormal things that you noticed while cleaning and report it to the instructor to take corrective action.

9 Put all the materials and equipment used for cleaning in their respective places.

10 Inspect and ensure that all machines are working after cleaning in the presence of the instructor.

11 Discuss abnormal things that you came across while cleaning with the instructor. Prepare a report if the instructor asks for it

Instructor may assign trainees the responsibilty of cleaning in batches. Disposal of waste may be organised as a routine actvity by coordinating with the stores.

Fig 1

Organic Waste	Inorganic Waste	Metals Scrap

— — — — — —

Identify trade tools and machineries

Objectives: At the end of this exercise you shall be able to
- **identify tools and draw their sketches**
- **identify the machineries in the lab and note down their names.**

Requirements

Tools/Instruments

- Combination plier (150 mm) - 1 No.
- Long round nose plier (200 mm) - 1 No.
- Screwdriver (150 mm) - 1 No.
- Firmer chisel (12 mm) - 1 No.
- Wood rasp file (250 mm) - 1 No.
- Flat file bastard (250 mm) - 1 No.
- Bradawl (6 mm x 150 mm) - 1 No.
- Gimlet (4 mm x 150 mm) - 1 No.
- Ratchet brace (6 mm) - 1 No.
- Rawl jumper holder with bit No. 8 - 1 No.
- Triangular file bastard (150 mm) - 1 No.
- Saw-tooth setter - 1 No.

Equipment/Machines

- Electric bench grinder - 1 No.

Materials

- Lubricating oil - 100 ml
- Cotton waste - as reqd.
- Cotton cloth - 0.50 m
- Grease - as reqd.
- Emery sheet - 1 sheet.

The instructor shall arrange for the necessary tool/equipment from other sections and also arrange for the required materials from scrap for practising the use of tools.

PROCEDURE

TASK 1 : **Identify tools with specification**

Assumption - A set of trainees tool kit and specified tools as given in this exercise are displayed on the workbench. Trainees are required to identify the tools from the specifications given and draw the sketch of the tools in the space allotted for the purpose.

1 Identify the tools from the specification given.

2 Draw a neat sketch against each item.

In case the specifications are different write the correct specification of the items given to you.

Table 1

Sl. No.	Name of tool with specification	Sketch of tools
i	Combination plier with pipe grip, side cutter and insulated handle - size 150 mm,	
ii	Long round nose pliers 200 mm,	
iii	Screwdriver 150 mm	
iv	Firmer chisel 12 mm	
v	Wood rasp file 250 mm	
vi	Flat file bastard 250 mm	
vii	Bradawl 6 mm x 150 mm square-pointed	
viii	Gimlet 4 mm x 150 mm	
ix	Ratchet brace 6 mm capacity	
x	Rawl jumper holder with bit No.8	
xi	Triangular file bastard 150 mm	

3 Get your sketches checked by your instructor.

— — — — — —

TASK 2: **Identify the machineries installed in the electrician section**

Instructor shall explain the names of the machineries installed in the electrician section and their locations. Then ask the trainees to write the name, and other details of each machine in the section.

1 Identify and locate the machines and their names in your section.

2 Read and recognise the name plate of each machine.

3 Write the name and other details of each machine against their names in Table 2.

Table 2

Sl. No.	Name of the machine	Name and other details
1	D.C. shunt generator	
2	Motor Generator set (A.C. motor with D.C generator)	
3	D.C. Compound generator	
4	D.C. Series motor	
5	D.C. Shunt motor	
6	D.C. Compound motor	
7	Motor generator set (D.C. motor with A.C generator)	
8	A.C.Squirrel cage induction motor	
9	A.C Slipping induction motor	
10	Universal motor	
11	Synchronous motor	
12	Diesel generator set	
13	Electrical machine trainer4	

Get it checked by your instructor.

— — — — — —

Practice safe methods of lifting and handling of tools and equipment

Objectives: At the end of this exercise you shall be able to
- **demonstrate how to lift and handle heavy equipment during working conditions while**
  - **lifting from floor**
  - **during lift**
  - **carrying**
  - **lowering to bench**
  - **lifting from bench**
  - **lowering to floor.**

Requirements

Tools and equipment

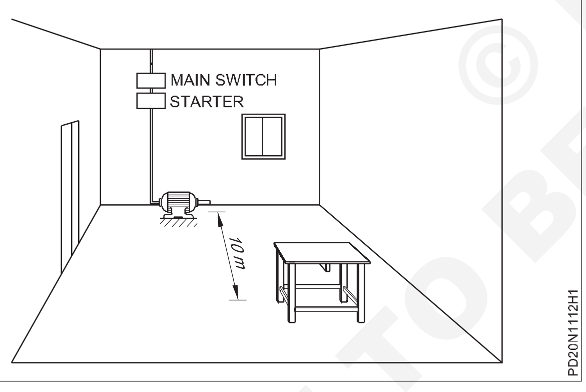
- Single phase one HP 240V/50Hz capacitor start induction motor - 1 No.
- D.E. Spanner set 5 mm to 20 mm - set of 8 - 1 No.
- Work bench or table - 1 No.

PROCEDURE

Instructor has to demonstrate, how to lift and handle heavy equipment and then ask the trainees to practice.

Assume one single phase motor has to be lifted and lowered to be placed on the floor. (Fig 1)

Fig 1



1 Switch OFF the motor and remove the fuse carriers.

Ensure that the equipment is disconnected from power supply and that the base plate nuts of the motor have been removed.

2 Ensure that you know the position where the equipment is to be placed.

3 Assess whether you need any assistance to carry the equipment.

4 Check for clear route to the location where the motor is to be placed. Remove obstacles, if any.

5 Position yourself close to the equipment to be lifted.

6 Lift the equipment from the floor using the correct posture.

7 Carry the equipment to the work bench safely, keeping the equipment close to your body.

8 place the equipment carefully on the bench, and adjust it to the correct position.

Assume that the overhauling work is over and the motor is to be placed in its orginal place.

9 Lift the equipment correctly with a firm grip.

10 Carry the equipment to its original place.

11 Safely lower the equipment with your feet apart, knees bent, back straight and arms close to your body.

12 Safely place the equipment on the floor.

If you feel the equipment is too heavy, take help from others.

— — — — — —

Select proper tools for operation and precautions in operation

Objectives : At the end of this exercise you shall be able to
- **select proper tools for specific uses**
- **follow care and maintenance and procedures with precaution for each tool.**

Requirements

Tools

- Combination plier - 150 mm - 1 No.
- Flat nose plier 150 mm - 1 No.
- Diagonal cutting plier 150 mm - 1 No.
- Round nose plier 150 mm - 1 No.
- Screw driver 150 mm - 1 No.
- Star-headed screw driver 100 mm - 1 No.
- Neon tester - 1 No.
- Electrician's knife 100 mm - 1 No.
- Try square 150 mm - 1 No.
- Firmer chisel 12 mm - 1 No.
- Tenon saw 300 mm - 1 No.
- Plumb bob - 1 No.
- Centre punch 50 mm - 1 No.
- Cold chisel - 1 No.
- Hacksaw frame with blade - 1 No.
- Portable electric drilling machine - 1 No.

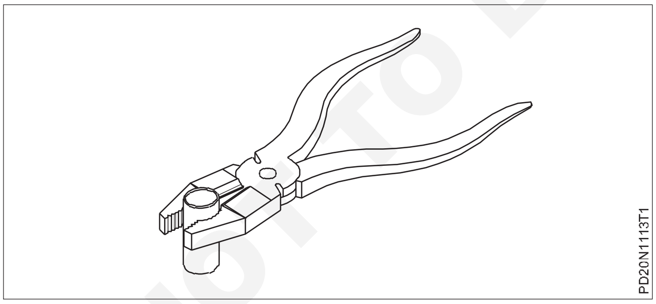
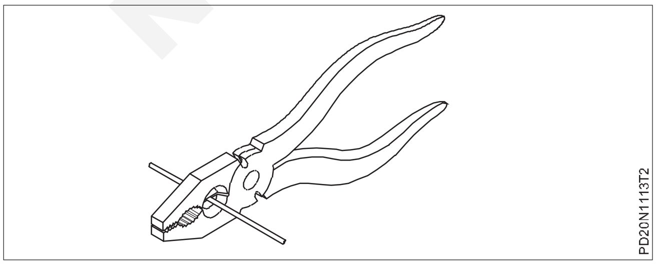
PROCEDURE

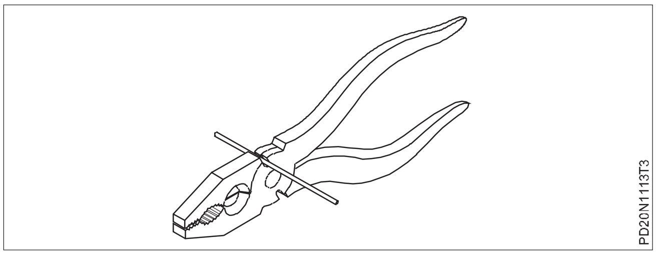
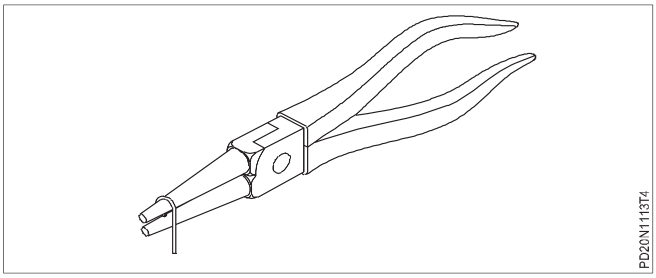
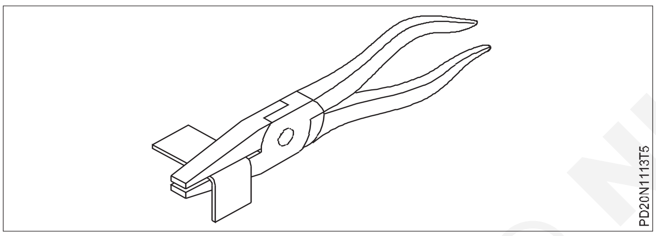
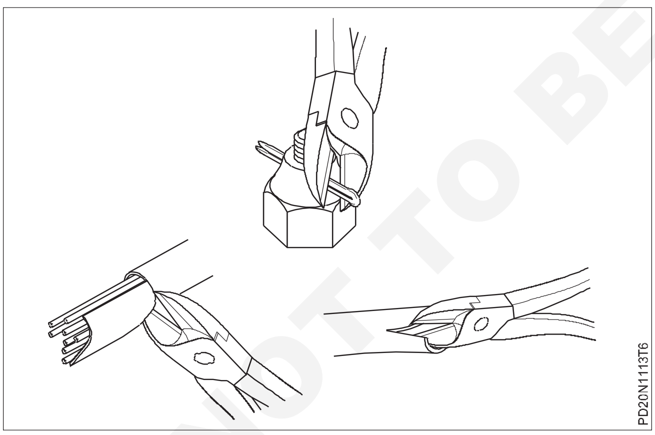
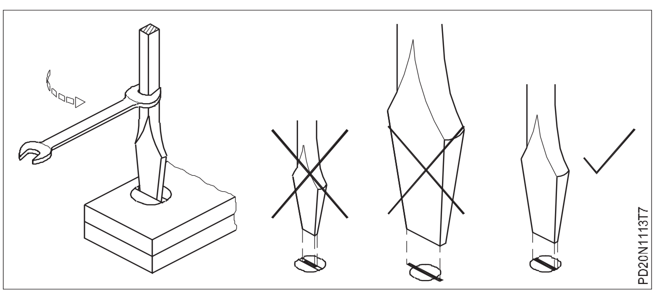
TASK 1: **Select the proper tools for specific uses**

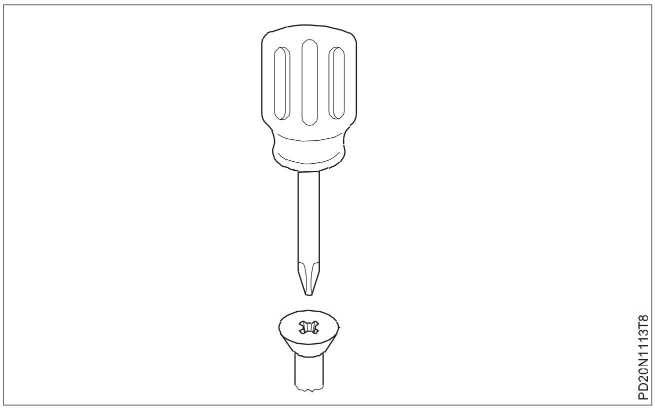
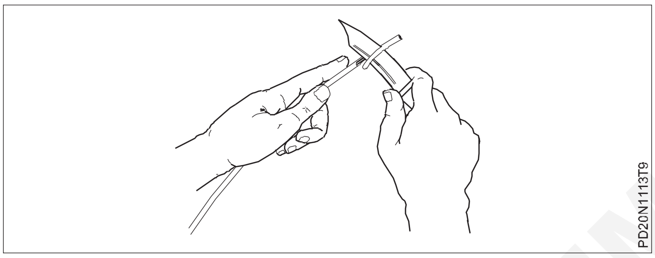
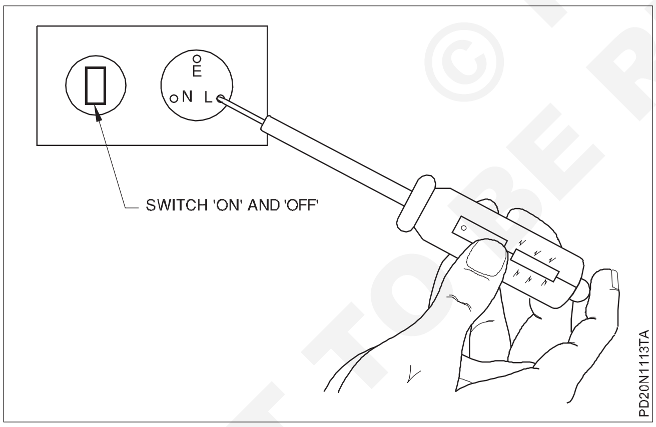
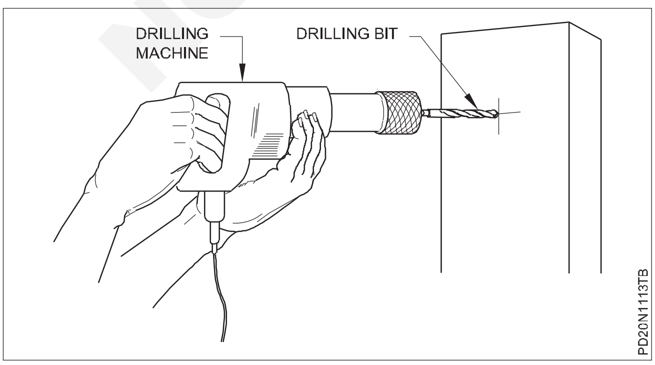
1 Identify proper tools for specific uses from Fig 1 to 16,

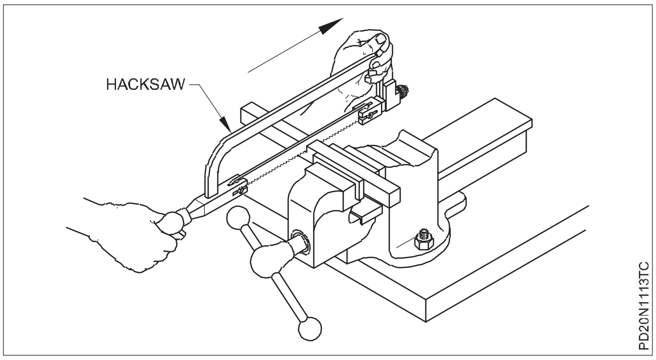
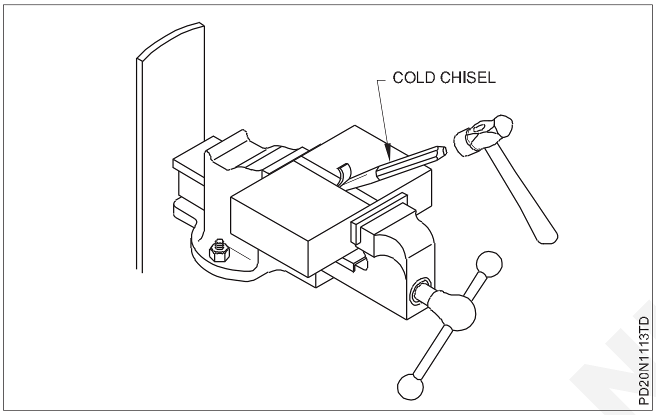
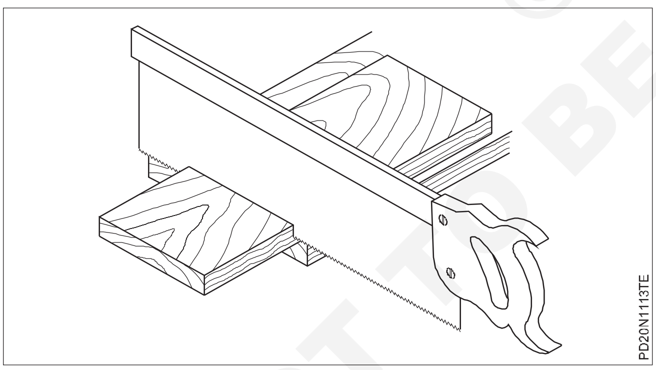
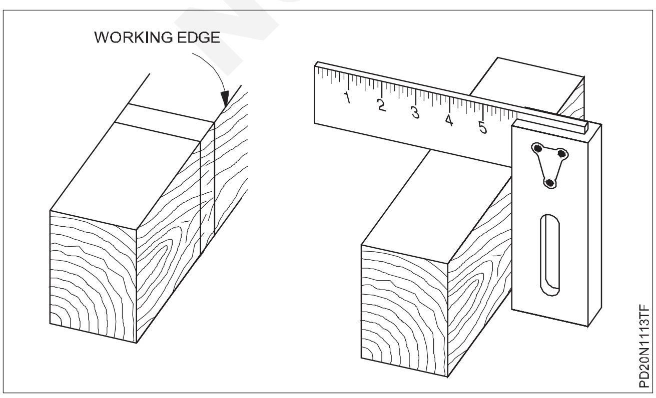
2 Write the uses of each selected tool and the precautions to be followed while handling in Table 1.

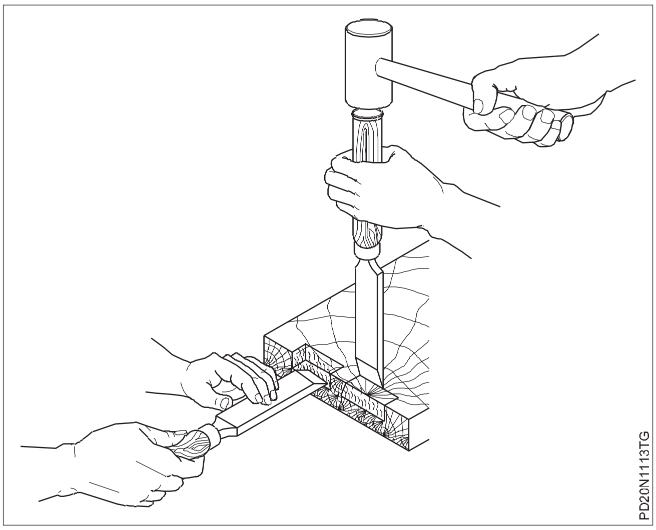
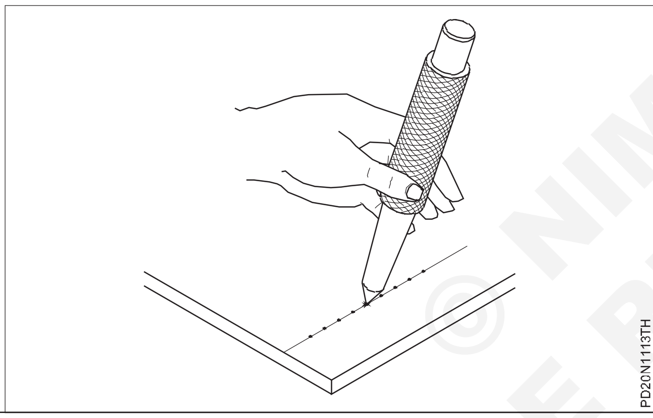
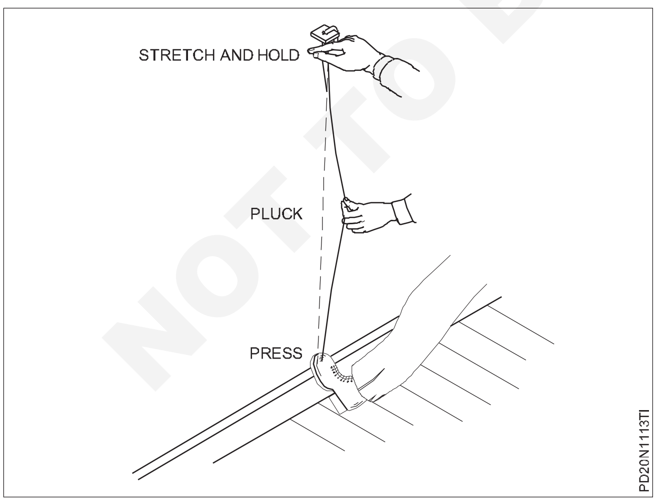
Table 1

Tool	Uses/Operation used for	Care, Maintenance and Precautions in operation
1 Combination pliers  		

Tool	Uses/Operation used for	Care, Maintenance and Precautions in operation
		
2 Pliers - round nose 		
3 Pliers - flat nose 		
4 Pliers - diagonal cutting 		
5 Screwdriver 		

Tool	Uses/Operation used for	Care, Maintenance and Precautions in operation
6 Screwdriver (Star) 		
7 Electrician's knife 		
8 Neon tester 		
9 Portable electric drilling machine 		

Tool	Uses/Operation used for	Care, Maintenance and Precautions in operation
10 Hacksaw 		
11 Cold chisel 		
12 Tenon saw 		
13 Try square 		

Tool	Uses/Operation used for	Care, Maintenance and Precautions in operation
14 Firmer chisel 		
15 Centre punch 		
16 Plumb bob 		

4 Get it checked by your instructor.

— — — — — —

Care and maintenance of trade tools

Objective : At the end of this exercise you shall be able to
- **perform care and maintenance of tools.**

Requirements

Tools/Instruments

- Combination plier (150 mm) - 1 Set.
- Long round nose plier (200 mm) - 1 No.
- Screwdriver (150 mm) - 1 No.
- Firmer chisel (12 mm) - 1 No.
- Wood rasp file (250 mm) - 1 No.
- Flat file bastard (250 mm) - 1 No.
- Bradawl (6mm x 150 mm) - 1 No.
- Gimlet (4 mm x 150 mm) - 1 No.
- Ratchet brace (6 mm) - 1 No.
- Rawl jumper holder with bit No. 8 - 1 No.
- Triangular file bastard (150mm) - 1 No.
- Saw tooth setter - 1 No.

Equipment/Machines

- Electric bench grinder - 1 No.

Materials

- Lubricating oil - 100 ml
- Cotton waste - as reqd.
- Cotton cloth - 0.50 m
- Grease - as reqd.
- Emery sheet '00' - 1 sheet.

PROCEDURE

TASK 1: **Perform care and maintenance of tools**

Prevent rust formation

1 Inspect all the tools. If the tools are rusted, use fine emery paper to remove the rust.

> **While removing rust keep your hands safe from sharp edges. Do not use emery paper on steel rule or tape.**

2 Apply a thin coat of oil over the surface of the rusted tool and clean with a cotton cloth.

> **A hammer should not have any trace of oil on its striking surface.**

3 Check and lubricate tools for easy movement of the jaws of the pliers, blades of knives, jaws of wrench, pincers, gears of the hand drilling machine.

4 Apply a drop of oil on the hinged/geared surface, if the movement is hard.

5 Activate the jaws and gears till the muck/grim in the surfaces are cleaned

6 Apply a drop of oil again and clean the tools with a cotton cloth.

Remove the mushroom

7 Check the cold chisel and the hammer's striking face for mushrooms. If you find mushrooms report to your instructor to enable him to remove the mushroom through grinding.

Reshaping the screwdriver tip

8 Check the tips of the flat tipped screwdrivers. If the tip is blunt or disfigured report to the instructor.

> **Observe how the screwdriver tip is ground to form a perfect cornered tip for effective use.**

Sharpen and set the saw-teeth

9 Check the teeth of the Tenon saw.

10 If the saw-teeth are blunt, report to your instructor.

> **Observe how the saw-teeth is filed to make the saw-teeth sharp.**

11 Check the saw-teeth setting.

> **The teeth of the Tenon saw should be set to be able to alternately remove dust while sawing.**

12 If the setting is not proper report to the instructor.

13 Check how the teeth are set by a saw-setter.

— — — — — —

Workshop practice on filing and hacksawing

Objectives: At the end of this exercise you shall be able to
- **file a surface flat and check it with straight edge and light gap**
- **file two adjacent sides to 90° and check it with Try square**
- **perform operations of marking a straight line**
- **file and finish surfaces to an accuracy of 0.5 mm.**

Requirements

Tools/Instruments

• File, flat bastard, double cut - 300 mm	- 1 No.
• File, flat second cut, double cut 300 mm	- 1 No.
• Try square - 150 mm	- 1 No.
• Jenny caliper - 150 mm	- 1 No.
• Ball peen hammer - 200 gm	- 1 No.
• Hacksaw frame (200 mm) with blade (24 TPI)	- 1 No.
• Mild steel square bar 25 x 25m x 50mm	- 1 No.

Equipment/Machines

• Bench vice - 50 mm Jaw size	- 1 No.

Materials

• ISA 5555 Thickness	- 8 mm
Length	-150 mm.

PROCEDURE

TASK 1: **Practice on filing**

1 Check the length and size of the given M.S.angle iron as per the sketch using a steel ruler.

2 Fix at right angle with one side (surface 'A') at least 15 mm above the jaws of the bench vice.

3 File the reference side (surface 'A' indicated in Fig 1) with the bastard file.

4 Test the flatness with the blade of the Try square.

> **Do not touch the surface of the job while filing.**
>
> **Use a vice clamp for protecting the finished surfaces.**

5 File the adjacent surface `B' with a bastard file.

6 Test the flatness and also check the right angle with the Try square.

7 File the side 'C' at right angle to surfaces 'A', 'B'.

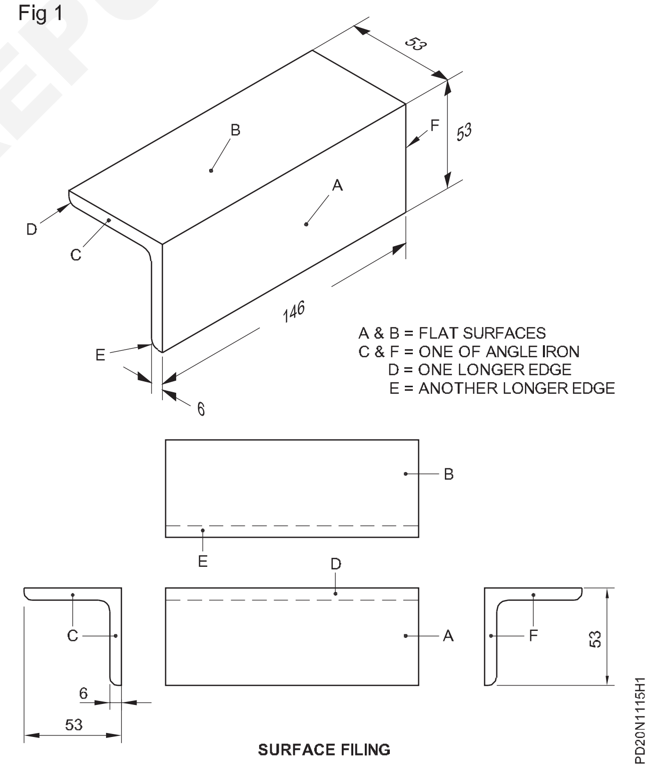
8 Evenly apply marking media (lump chalk) on the surfaces 'A' and 'B'.

9 Place surface 'B' on the levelling plate and scribe a line parallel to 'B' on surface A at a distance of 53 mm as shown in Fig 1. Similarly on surface 'A' mark a line parallel to 'B' at a distance of 53 mm.

10 Place surface 'C' on the levelling plate and scribe a line parallel to 'C' on surfaces 'A' & 'B' at a distance of 146 mm from surface 'C'.

11 Punch all the scribed lines.

Fig 1



12 File the sides 'D', 'E' and 'F' with a bastard file.

13 Finish the job with a second cut file. File within ± 0.5 mm and check the right angles with reference to surfaces 'A' and 'B'.

14 Deburr all sharp edges.

Do not overtighten the vice.

Do not allow any pining of the file handle. Use a file card for removing pining of the file.

— — — — — —

Skill sequence

Types of filing

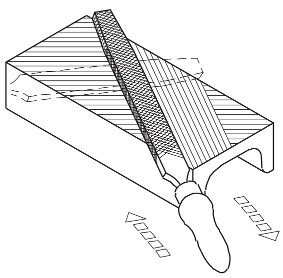
Objective: This shall help you to

- **file a flat surface.**

Filing method : The method of filing adopted depends on the type of surface profile to be filed, the type of surface texture required and the amount of materials to be removed.

Diagonal filing: This type of filing is done when heavy reduction of material is required. The strokes are at an angle of 45°. Because the stroke directions cross, the surface texture formed clearly indicates the high and low spots. Frequent checking of the level is not necessary, particularly, after one has developed a steady movement of the file. (Fig 1)

Fig 1

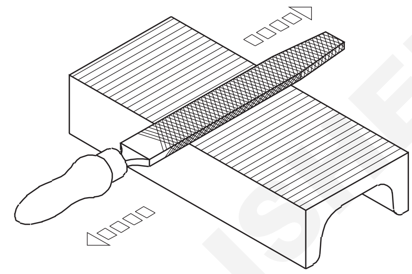


DIAGONAL FILING

PD20N1115J1

Transverse filing: In this method the file strokes are at right angles to the longer side of the work. This is commonly used to reduce material from the edges. Using this method, the size of the work piece is brought close to the finishing size, and then final finishing is done by longitudinal filing. (Fig 2)

Fig 2

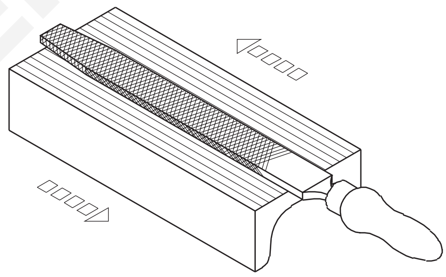


TRANSVERSE FILLING

PD20N1115J2

Longitudinal filing: The file is moved parallel to the longer side of the work. Usually all surfaces are smooth–finished by this method. The filed surface texture will show uniform and parallel lines. (Fig 3)

Fig 3



LONGITUDINAL FILING

PD20N1115J3

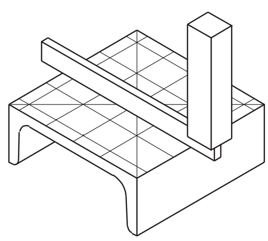
Checking flatness and squareness

Objectives: This shall help you to

- **check flatness**
- **check squareness.**

Checking flatness: During the initital stages of filing the evenness of the surface is visible to a reasonable degree of perfection from the surface texture of diagonal filing. To ensure perfection the surface should be checked with a straight edge. To do this, the blade of a Try square can serve as a straight edge. Flatness should be checked in all directions to cover the entries surface. (Fig 1)

Fig 1

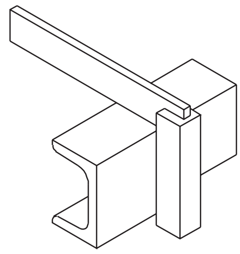


FLATNESS CHECKING

PD20N1115X1

Checking squareness: While checking for squareness, the larger finished surface serves as reference surface. Ensure that the references surface is perfectly finished before filing the other surfaces. (Fig 2)

Fig 2

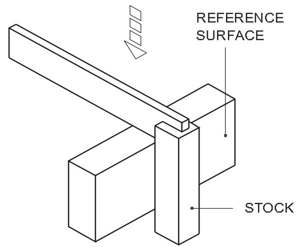


SQUARENESS CHECKING

PD20N1115X2

Burrs, if any, should be removed before checking with the Try square. While checking with the Try square, press the stock against the reference face and then slowly bring the blade down. (Fig 3)

Fig 3



CHECKING WITH TRYSQUARE

PD20N1115X3

Pressure is always applied to the stock against the reference surface.

Practice in hacksawing

Objectives: At the end of this exercise you shall be able to
- **file one face flat and check by straight edge and light gap**
- **file angle to 90° within Try square accuracy**
- **mark straight lines**
- **mark parallel lines using a surface gauge**
- **mark parallel lines using a Try square**
- **file and finish surfaces flat and parallel within ± 0.5mm**
- **file and finish radius**
- **saw M.S.flat along a straight line.**

Requirements

Tools/Instruments

- File, flat bastard, double cut 300 mm - 1 No.
- File, flat, second cut, double cut 300 mm - 1 No.
- Try square - engineer's rule 150 mm - 1 No.
- Jenny caliper 150 mm - 1 No.
- Engineer ball peen hammer 200 gm - 1 No.
- Centre punch 100 mm - 1 No.
- Dot punch - 1 No.
- Steel rule 300 mm - 1 No.
- Hacksaw blade 300 mm - 1 No.
- Surface gauge - 1 No.
- Radius gauge - 1 Set.
- File card - 1 No.
- Vice clamp - 1 pair.
- Divider - 1 No.
- Straight edge - 1 No.

Equipment/Machines

- Bench vice 50 mm jaw - 1 No.
- Surface plate - 1 No.
- Angle plate - 1 No.

Materials

- 60 ISF 8 (Length - 350 mm.) - 2 Nos.

PROCEDURE

1 Check the raw material size with the sketch using the steel ruler.

2 Securely fix the job in the bench vice.

3 File the reference face A (Fig 1) with a bastard file.

4 Check the flatness with the straight edge.

5 File adjacent edge or datum edge B (Fig 1) with a bastard file.

6 Check the right angle with a Try square.

7 File adjacent edge or datum edge C (Fig 1) with a bastard file.

8 Check the right angles to the datum edge B and reference surface A.

9 Evenly apply chalk on the surface A.

10 Place the job on the levelling plate and scribe the lines by the surface gauge, parallel to the datum edge B (size 58 mm) and on datum edge C (size 350 mm).

11 Scribe the saw, cut parallel lines a, b, c & d as per the sketch. (Fig 1)

12 Scribe two arcs of radius 10 mm with the divider at the datum edge C as in the Fig 1.

13 Punch all the scribed lines and also the arcs by a dot punch.

14 File the edges D and E with a file.

15 Check for the right angle between edges D and E and also with the surface A.

16 Check the finished piece for length 350 mm and breadth 58 mm with an outside caliper.

17 Saw the depth a, b, c, and finally saw part at 'd' in Fig 1.

18 File and finish the saw - Cut surface of part 1 for a length of 300 mm.

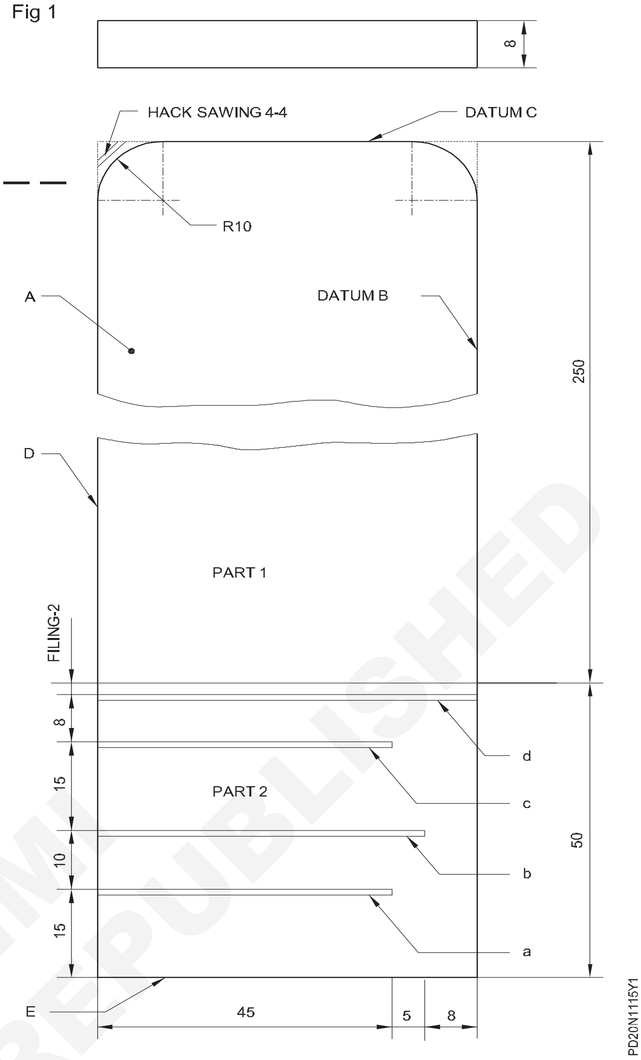
19 Saw the corners for removing the unwanted metal for filing the radius.

20 File and finish two corners by radius filing on part 1.

21 Check the radius with a radius gauge.

22 File and finish the job with a second cut file within a tolerance of ± 0.5 mm (use outside calipers for checking).

Fig 1



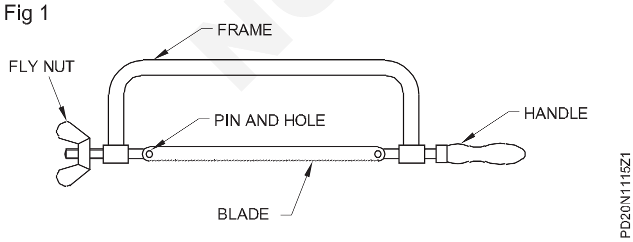
Fixing of hacksaw blade on the frame and sawing

Objectives: This shall help you to
- **fix the hacksaw blade on the frame**
- **practice sawing with dimensions.**

The teeth of the blade should point from the handle.

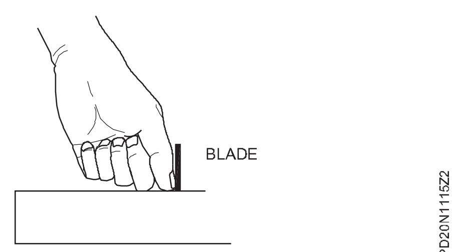
1 Fix the blade to the frame in good tension. (Fig 1)

Fig 1



2 Set your thumb nail vertically to the location of the cut, and this location should be at least 10 mm from the vice. (Fig 2)

Fig 2



3 Hold and press the hacksaw straight. (Fig 3)

Do not use force when pulling back. Occasionally apply cutting compound while cutting.

Use the full length of the hacksaw blade.

4 Make the last few cuts holding the piece to be cut in your left hand. (Fig 4)

Fig 3

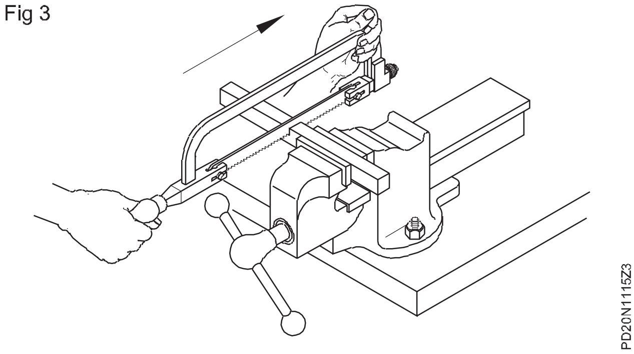
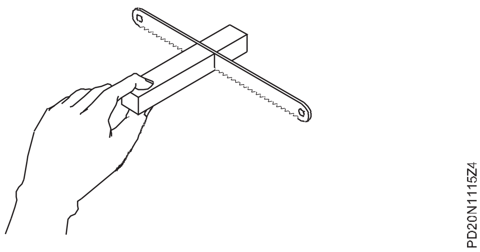
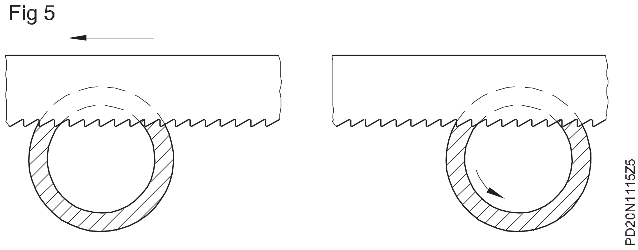


Fig 4



For this section use a fine grade blade. A minimum of two to three teeth should be in contact with the work. (Fig 5)

Fig 5



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Practice in Marking and Cutting of Straight and Curved Pieces in Metal Sheets

Objectives: At the end of this exercise you shall be able to
- **mark straight lines of given dimensions using steel rule and scriber**
- **shear MS sheet using straight snip**
- **mark curved lines of given dimensions using divider**
- **shear along curved lines using bent snip and cut 90° notch**
- **make holes using a punch.**

Requirements

Tools/Instruments

- Steel rule 300 mm - 1 No.
- Scriber 200 mm - 1 No.
- Straight snips 250 mm - 1 No.
- Bent snip 250 mm - 1 No.
- Divider 200 mm - 1 No.

Materials

- Sheet iron ISST 220 x 0.5 x 300.
- Sheet iron ISST 55 x 0.5 x 105 (for riveting Task - 4 same sheet can be used for Tasks 1 to 3)) - 2 Nos.

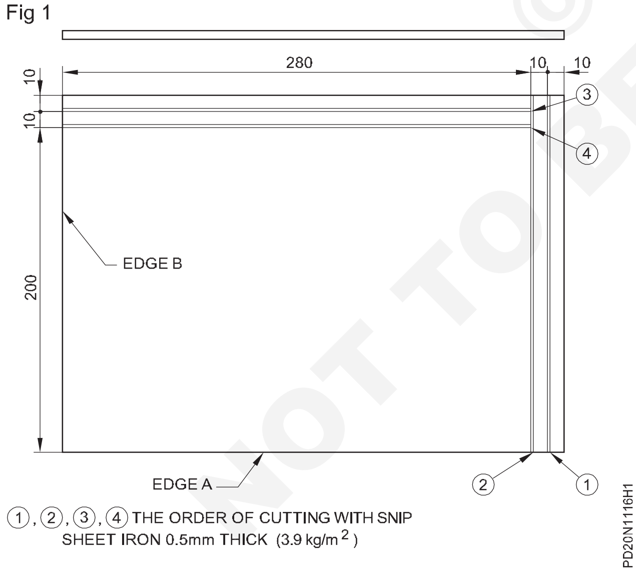
PROCEDURE

TASK 1: **Practice for marking in metal sheet**

1 Check the dimensions of the given raw material.

2 Take edges A and B as datum. Mark from edge B a measurement 'V', mark for cut No. 2. Make at least 3 such 'V' marks along cut No.2. (Fig 1)

Fig 1



3 Using a scale, draw a straight line with a scriber connecting all the 3 'V' marks made.

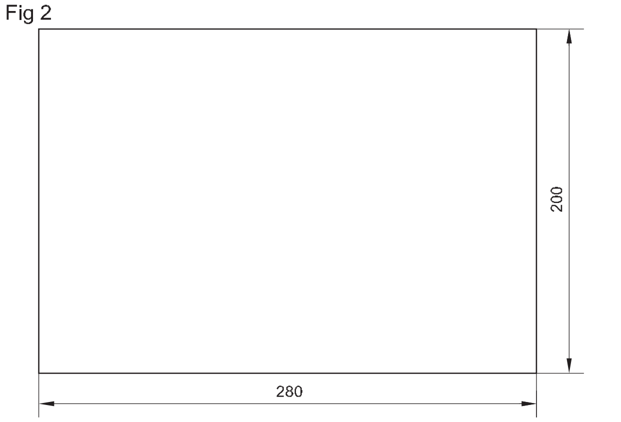
4 Draw a line parallel to the scribed line at a distance of 1 mm. (This line is drawn outside the measurement to guide the snip, while cutting sheet metal.)

5 Repeat steps 2 and 3 for marking to cut along line 1.

6 Keeping edge A as reference, mark straight lines for shearing along lines 3 and 4 respectively, repeating steps 2 and 3.

7 Shear along the marked guidelines for 1, 2, 3 and 4 in that sequence. The final piece is shown in Fig 2.

Fig 2



Skill sequence

Mark straight lines using steel rule and scribers

Objective: This shall help you to

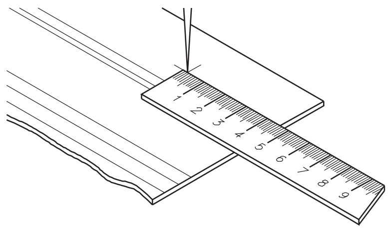
- **mark the given dimensions on the sheet metal using a scriber, steel rule, Try square and straight edge.**

Generally, marking media is not applied on sheet iron (metal) for marking lines. Instead, a scriber and steel rule are used.

A scriber is used to transfer measurement and to draw lines.

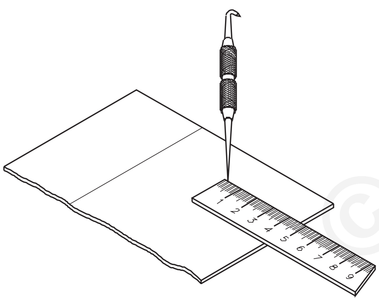
Place the steel rule on the sheet metal to transfer the dimension from the datum edge or line. (Fig 1)

Fig 1



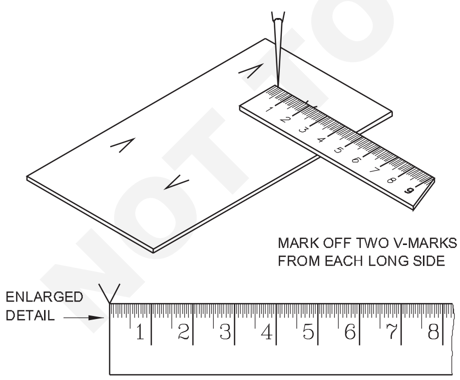
Scribe a V-mark for the required distance. (Fig 2)

Fig 2



Make at least two V-marks to draw a straight line parallel to the datum. (Fig 3)

Fig 3



Scribe a line through both points of the V-marks (Fig 4), using the straight edge and the scriber.

Draw the line exactly through the points of the V-marks. (Fig 5)

Fig 4

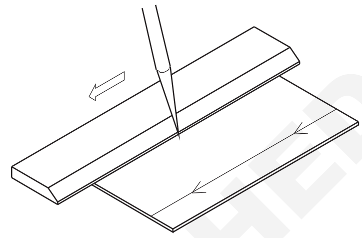
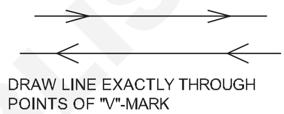


Fig 5



Lines that need not or must not be removed are scratched on the material with the sharp point of the scriber.

Hold the scriber in the correct angle to get into the corner when scribing along a straight edge. (Figs 6 & 7)

Fig 6

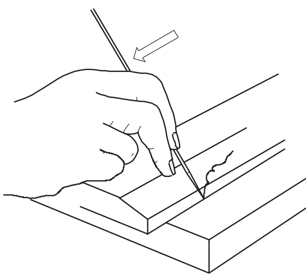
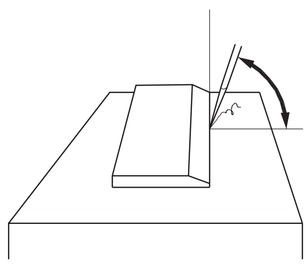


Fig 7

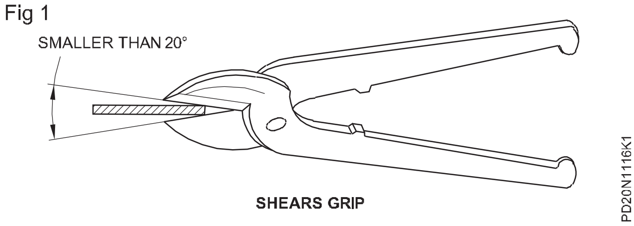


Cut sheet metal using straight snips

Objective: This shall help you to
- **cut thin sheet metals with the help of straight snips.**

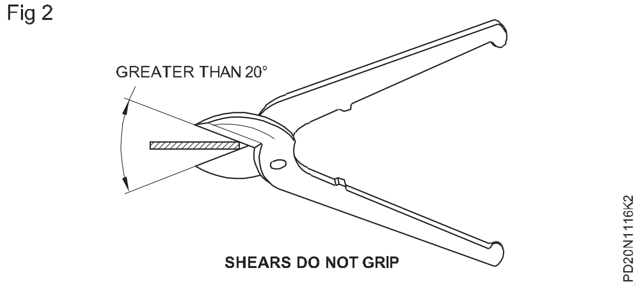
Hold the sheet in one hand, and with the other hand hold the snip handle at the end, and place the upper blade of the snip on the marked line with an initial angle measuring lesser than 20°. (Fig 1)

Fig 1



Open and grip the sheet by the blade. The opening angle of the blade should not be more than 20°. (Fig 2)

Fig 2

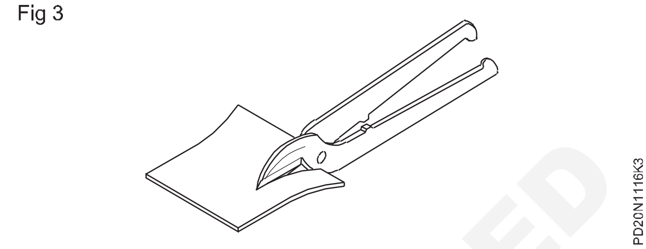


Keep the blade perpendicular to the surface of the sheet.

Hold the snips straight, up and down.

While holding the snips on the sheet, allow lesser width on your left side in every cutting, as shown in Fig 3.

Fig 3



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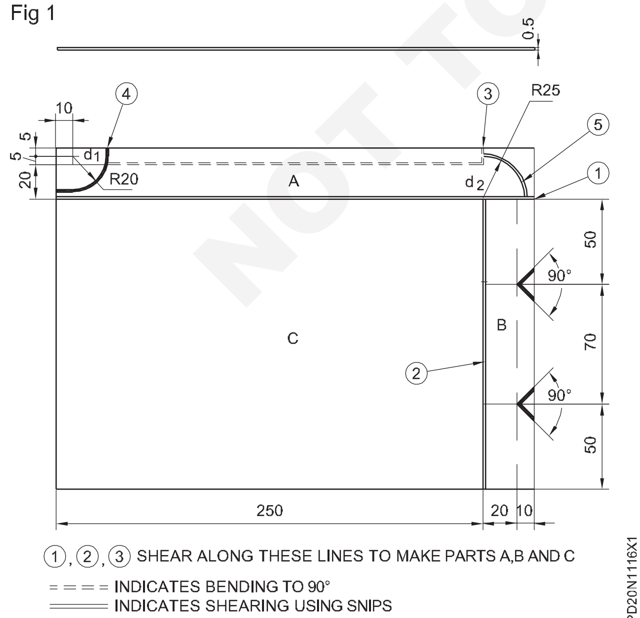
TASK 2: **Practice on cutting curved pieces in metal sheets**

1 Check the dimension of the given sheet iron.

2 Using the steel rule, mark the required dimension for straight lines as per the diagram. (Fig 1)

3 Locate centre d_1 for curve '4', as per the measurements in the drawing.

Fig 1



4 Make indent mark with prick punch (tip angle, 30°).

5 Transfer the radius measurement from steel rule to the divider.

6 With the point d_1 as centre, scribe the curve 4.

7 With the same centre and radius reduced by 1 mm, scribe the guide mark.

8 Repeat steps 3 to 7 for curve 5 with d_2 as centre.

9 Shear along line 1 using straight snips.

10 Shear along line 2 using straight snips.

11 Shear along line 3 in part A using straight snips.

12 Shear along curve 4 using bent snip.

13 Shear along curve 5 using bent snip.

14 Mark the bending to 90° line as per the drawing. (Fig 1) Hold the part A along the bending line measurement marked in the angle plate (fixed in bench vice).

15 Clamp the extending end of the angle plate with G clamp.

16 Hammer the projecting portions in stages (15°, 30°, 45°, 60° and 90°) with a soft mallet. (Fig 2)

17 Cut both the notches with the straight snip in part B. (Fig 3).

Fig 2

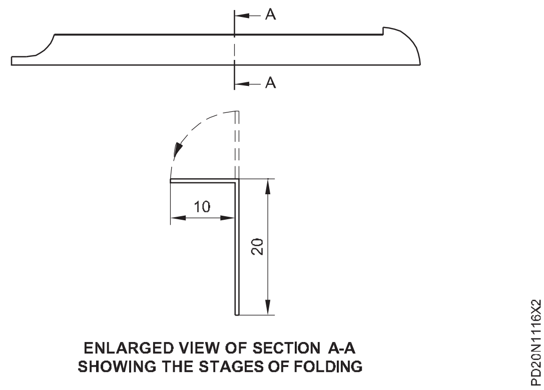
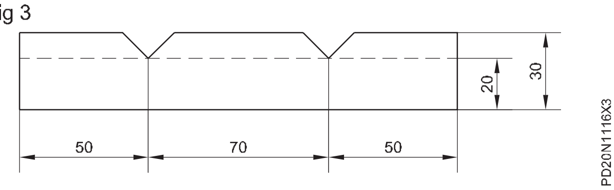


Fig 3



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Skill sequence

Marking curved lines using divider

Objective: This shall help you to
- **scribe curved lines using dividers.**

On the sheet, mark a centre line using the scriber and steel rule.

Hold the centre punch on the marked line. First keep the punch at an angle and then position it upright. Then hit on it with a hammer. (Fig 1)

Fig 1

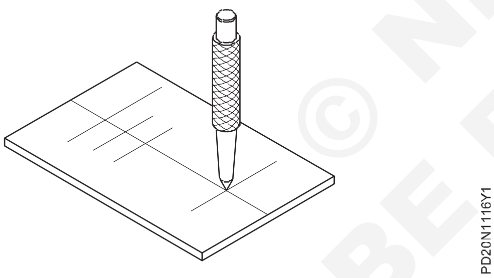
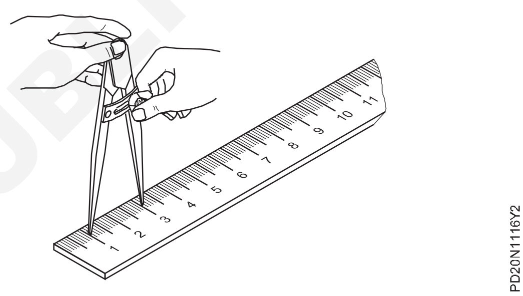


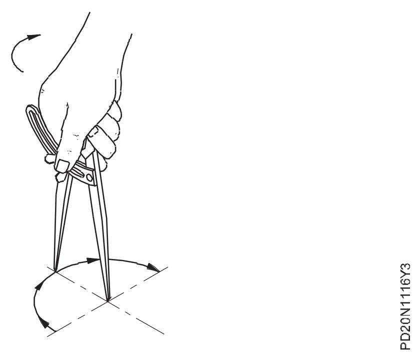
Fig 2



Set one point of the divider on the 1 cm mark of a rule, and adjust the second leg to the required radius. (Fig 2)

Place the divider on the sheet with the point of one leg on the centre punch mark. Hold the divider vertically. Swing the divider clockwise exerting a little pressure. Incline the divider in the direction of the line to be drawn to prevent slipping. (Fig 3)

Fig 3



Curve-cutting using bent snips

Objective: This shall help you to
- **shear internal and external curves in steel sheet using the bent snips.**

A bent snip can be used for cutting internal and external curves.

Bent snips are used for cutting holes. First, a rough cut is made. Then the hole is finished off. (Fig 1)

For circular cutting, rotate the sheet while making a continuous cut.

First, a rough cut can be made. (Fig 2) for trimming a cylinder, keep the lower blade outside the cut. (Fig 3)

Fig 1

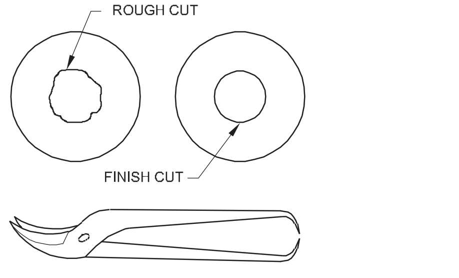


Fig 2

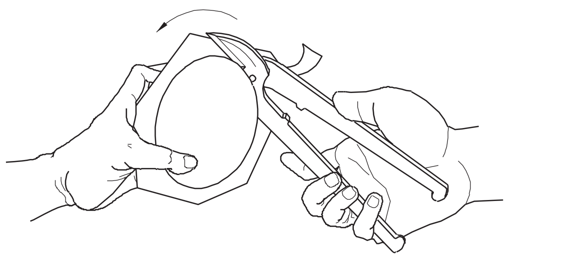
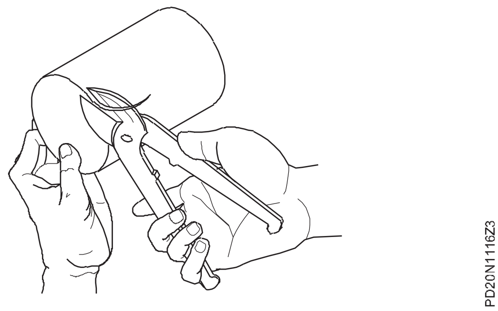


Fig 3



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Workshop practice on drilling, chipping, internal and external threading of different sizes

Objectives: At the end of this exercise you shall be able to
- **drill pilot holes matching the sizes of screws with a hand drill machine or an electric hand drilling machine**
- **drill holes of larger diameter after pilot drilling.**

Requirements

Tools/Instruments

- Steel rule 300 mm - 1 No.
- Try square 200 mm - 1 No.
- Marking gauge - 1 No.
- `G' Clamp No.6 - 1 No.
- Hand drill machine 6 mm - 1 No.
- Ratchet brace - 1 No.
- Bench vice 50 mm jaw - 1 No.

Equiment/Machines

- Portable electric hand drilling machine (6 mm) - 1 No.
- Pillar electric drill machine 12 mm capacity - 1 No.

Materials

- 58 ISP length 300 mm (Finished part of previous exercise)
- Drill bit S.S.6 mm - 1 No.
- Countersunk bit 6 to 10 mm - 1 No.
- Drill bit SS 3 mm - 1 No.

PROCEDURE

TASK 1: **Practice on drilling pilot holes using hand drilling machine**

1 Mark lines with a marking gauge, 15 mm from each end, according to the drawing for the central line of pilot holes. (Fig 1)

2 Mark hole centres as per the drawing with a steel rule and pencil from one edge on the central lines already drawn, on both the faces.

Mark hole locations within ± 0.5 mm accuracy.

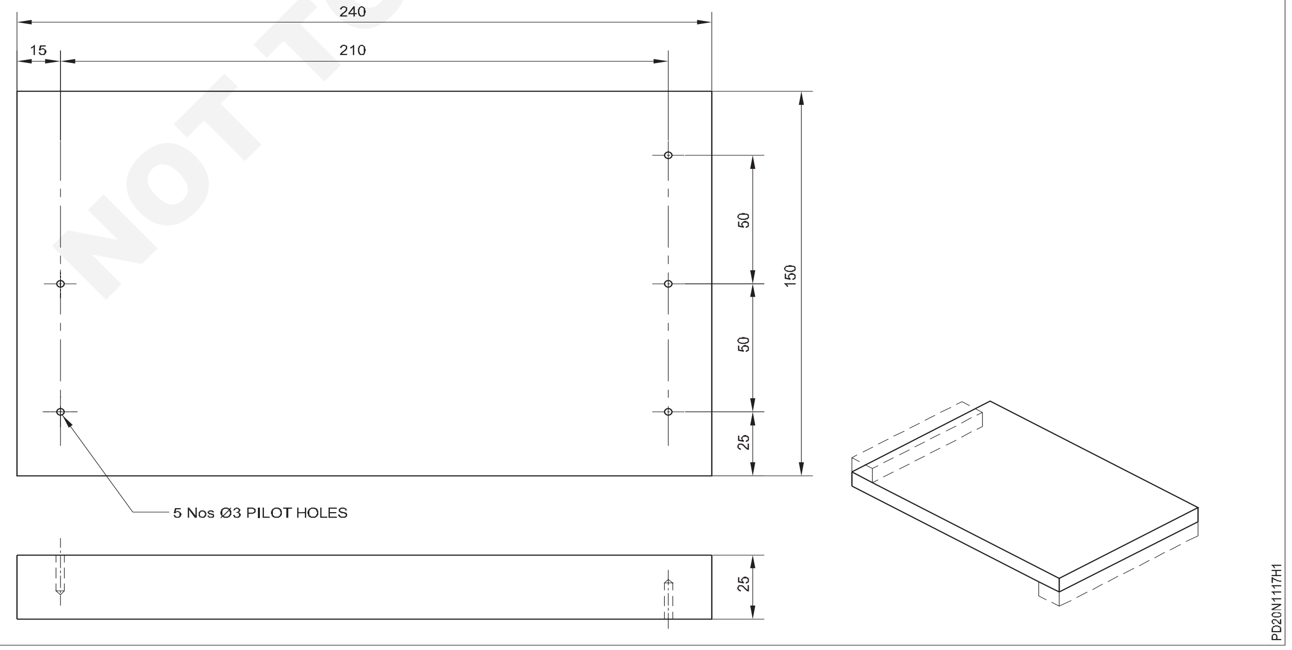
3 Punch the hole centres with the centre punch / sharpened nail.

4 Fix the job on the workbench with the bench vice `G' clamp.

5 Drill 3 mm diameter. pilot holes to a depth of 15 mm at the locations already marked by using hand drilling machine.

Do not drill holes deeper than specified.

Fig 1

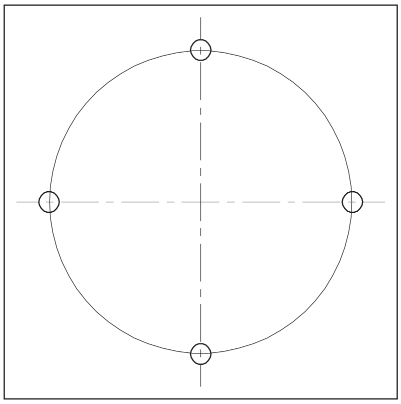


TASK 2: **Practice on drilling holes with larger diameter after pilot drilling**

1 Punch the centre of the hole to be drilled using a centre punch (90°).

2 Punch witness marks using a 60° prick punch on the periphery of the hole to be drilled. (Fig 2)

Fig 2

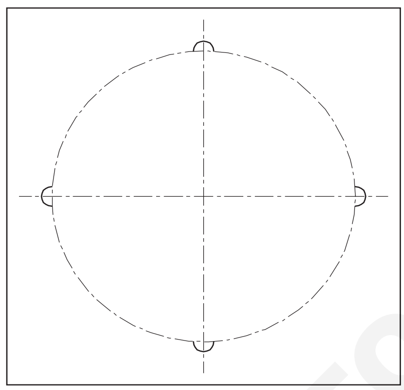


These witness marks guide to ensure that the hole drilled is exactly in its place.

If the drilled hole is perfectly located, half witness marks are visible at the circumference of the hole. (Fig 3)

3 Set the job securely in the machine vice on the parallels.

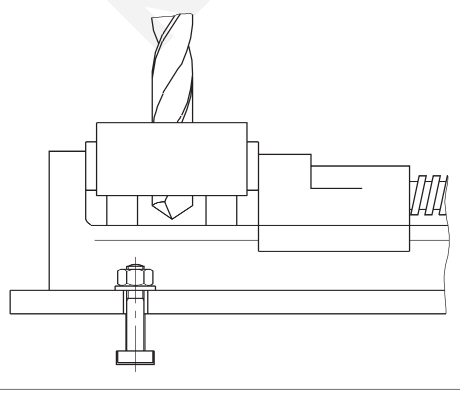
Fig 3



Make sure that the largest size drill to be used must clear the parallel during drilling. (Fig 4)

4 Fix the drill chuck into the spindle of the drilling machine after cleaning the mating parts.

Fig 4



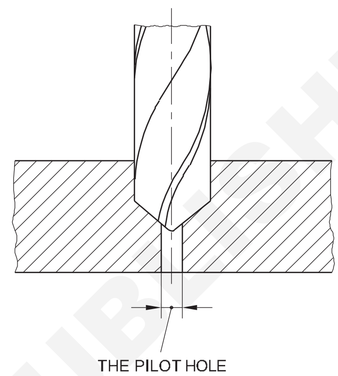
5 Select a smaller diameter drill as a pilot drill before using the required large size drill.

The diameter of the pilot drill/ hole should be at least equal to the web thickness of the large drill.

Since, the web of large diameter drills are thicker, the dead centres of those drills do not seat in the centre punch marks. This can result in the shifting of the hole location. Thick dead centres cannot easily penetrate into the material and will place severe strain on the drill.

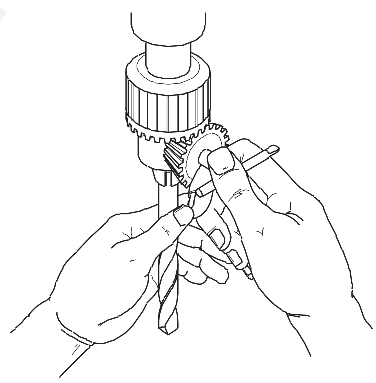
These problems can be overcome when we drill pilot holes initially. (Fig 5)

Fig 5



6 Securely fix the drill deep into the drill chuck. (Fig 6)

Fig 6



7 Determine the speed of the spindle (r.p.m.) from the recommended cutting speed and the diameter of the drill or use a table and get the r.p.m.

8 Open (or) remove the belt guard and change the belt to the pulley of the required cutting speed or to the nearest r.p.m. and replace the gaurd.

Do not change the belt when the spindle is rotating. (Fig 7)

9 Run the spindle and check that the drill is rotating and in the clockwise direction (from right to left).

10 Bring the drill point and centre punch mark in line by adjusting the vice. When the alignment is satisfactory, clamp the vice to the machine table. (Fig 8a & b).

Fig 7

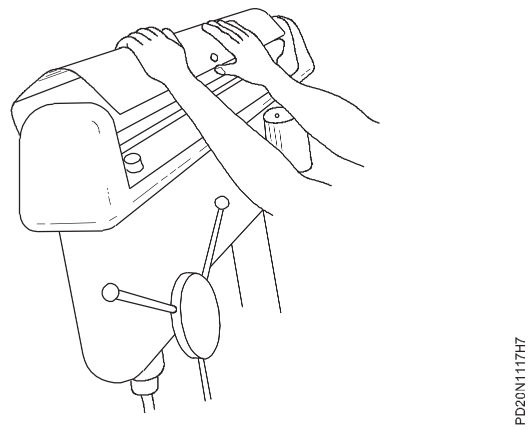
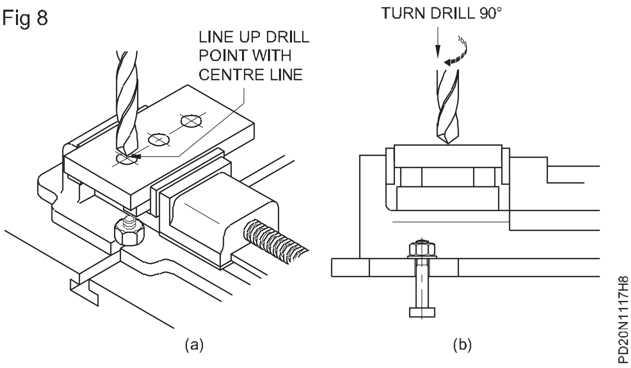


Fig 8



11 Recheck the alignment. Switch ON the machine and feed the drill gently on to the work. Recheck the starting of the drill.

12 Use a steady force and feed the drill gently into the job.

13 Provide continuous flow of cutting fluid to prevent overheating of the drill.

14 Gradually reduce the feed force as the drill reaches the bottom of the hole.

15 Withdraw the drill from the hole and switch OFF the machine.

16 Remove the pilot drill and the drill chuck from the machine. (Fig 6)

17 Fix a large diameter drill into the machine spindle directly.

18 Determine and reset the spindle speed (r.p.m.).

Note that the bigger the diameter of the drill is lesser than the r.p.m. and greater than the feed.

19 Drill to enlarge the hole with steady feed. Stop the machine, remove the job and clean the chips using a brush.

Skill sequence

Method of fixing drill bits in a drilling machine

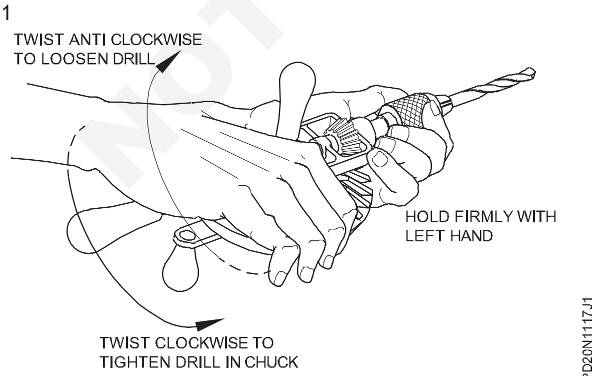
Objective: This shall help you to
- **fix a drill bit and check for eccentricity.**

A drill bit should be firmly fitted for in the drilling machine, so that straight and circular holes can be drilled. This prevents accidents too.

The drill bit must be centrally located and held firmly in the chuck of the drilling machine.

Fixing a drill bit in a hand drill machine: Hold the gear of the drilling machine with one hand. (Fig 1)

Fig 1



Unscrew, the sleeves of the chuck with the other hand to provide sufficient clearance for the drill shank in the jaws. (Fig 1)

Insert the drill shank into the chuck.

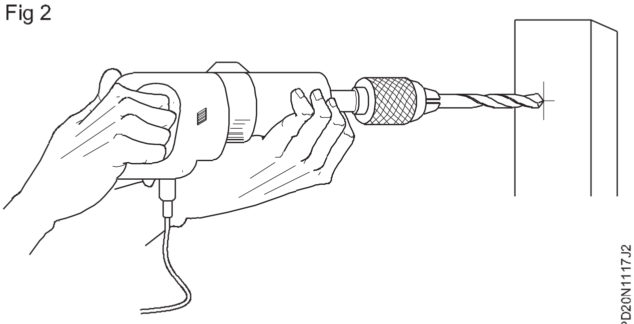
Keep the drill centrally seated, and tighten the chuck.

Twist the hand holding the gear to the right to further tighten the drill while firmly holding the chuck with the other hand. (Fig 1)

To remove the drill, slacken the jaws by twisting the hand in the opposite direction (from what was done for fixing).

Fixing a drill bit in an electric hand drill machine : The same procedure used for fixing a drill bit in a hand drill machine is followed except in the case of slackening and tightening the jaws of the chuck.(Fig 2)

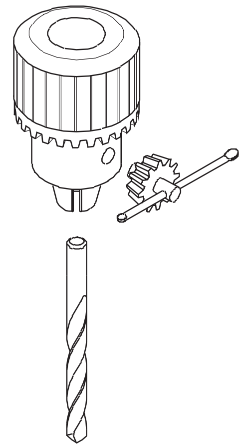
Fig 2



Slackening and tightening the jaws of the chuck is done using a special drill chuck key provided with the machine. (Fig 3)

> **When using a power drill, make sure that the material to be drilled is fixed firmly in a clamp/ vice.**
>
> **To prevent accidents never attempt to hold the work piece by hand.**

Fig 3



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Locating hole by drilling centre hole

Objective: This shall help you to
- **drill centre holes with a drilling machine.**

Drilling centre holes using combination drills is an accurate method of locating the position of the holes (i.e. within ± 0.25 mm). In drilling operations, this method will be helpful while drilling deeper holes, and holes in fairly accurate locations. For doing centre drilling, follow the steps given below.

1 Hold the combination centre drill in the drill chuck and check whether it runs true'. Adjust the spindle speed to suit the combination drill.

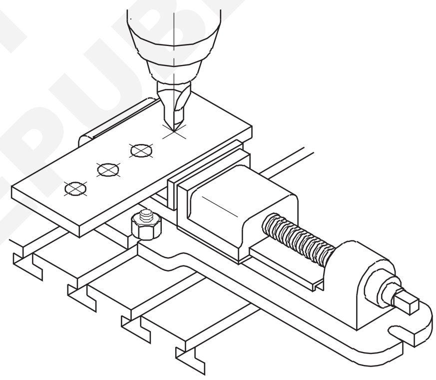
2 Adjust the job together with the vice and align it with the centre punch mark. (Fig 1)

3 Drill a centre hole up to a depth of 3/4th of the countersink. Do not apply undue pressure on the centre drill.

4 Apply sufficient quantity of cutting fluid.

5 Remove the centre drill, hold the twist drill of the required diameter. Check if it 'runs true'. Start drilling the through hole.

Fig 1



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Sharpening of drills

Objective: This shall help you to
- **sharpen drills on an off hand grinder.**

A drill will loose sharpness of its cutting edges due to continuous use. Improper use of drills will also spoil the cutting edges.

Spoiled or blunt cutting edges of the drills must be sharpened on a grinder.

Check the grinding wheel for loading, glazing, trueness and cracks. Call your instructor for advice. Dress and true the wheel if necessary.

Protect your eyes either with goggles or by lowering the eye protecting shield near the tool rest and adjust the tool rest at 2 mm closer to the wheel, if necessary.

Check if enough coolant is there in the container.

Switch the grinder on.

Hold the shank of the drill lightly in one hand between the thumb and the forefinger, and with the other hand hold the portion near the point. (Fig 1)

> **The hand near the point of the drill should be pivoted lightly on the tool rest at 'x' for easy manipulation. (Fig 2)**

Hold the drill level (Fig 2) and turn it to 59° to the face of the wheel and swing the drill slightly downward and towards the left. (Fig 3 & 4)

Rotate the drill to the right by turning it between the thumb and the forefinger. (Fig 4)

Fig 1

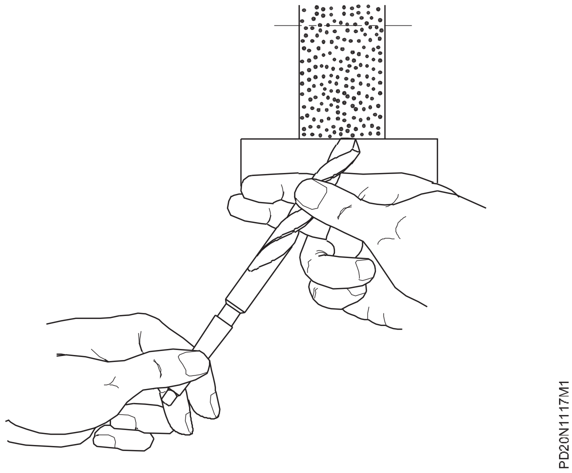


Fig 2

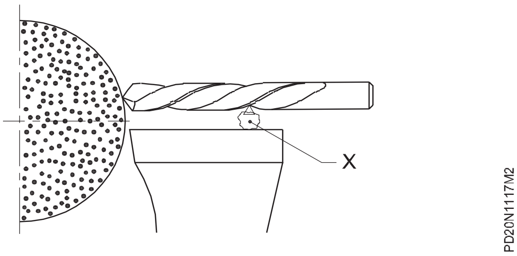


Fig 3

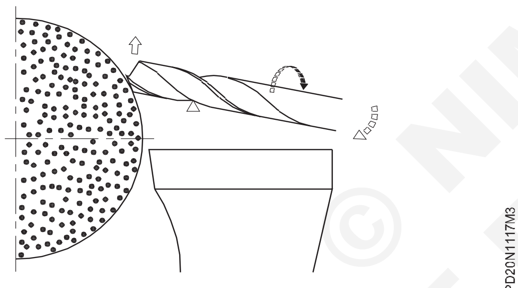
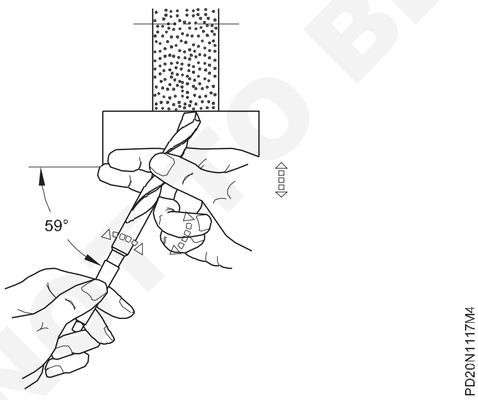


Fig 4



This turning movement is not necessary for drills of smaller diameters.

While swinging and turning the drill make sure you do not grind the other cutting edges.

All movements of the drill for angular turning, swinging and forward movements should be well coordinated. They should result in one smooth movement to produce a uniformly finished surface.

Repeat the process to re-sharpen the other cutting edges.

Check both the cutting edges with a drill angle gauge, for correctness of the lip angle and same in size of the lip lengths. (Figs 5 & 6)

Fig 5

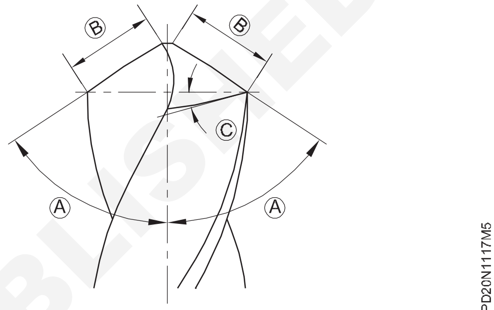
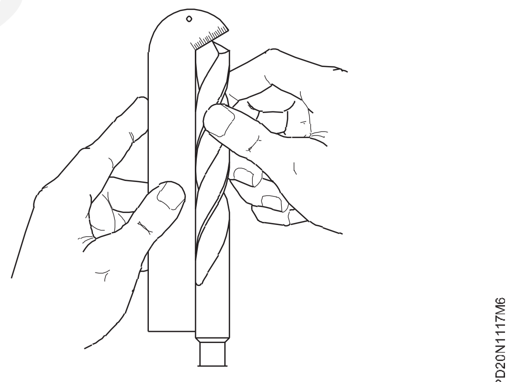


Fig 6



Check the lip clearance angle in Fig 5 visually. The angle should be between 8° to 12°.

Practice on chipping exercise has already been dealt in Ex. No. 1.2.17 as Sub Exercise 1.2.17- 1

Practice on making internal threading using hand taps

Objective: At the end of this exercise you shall be able to
- **form internal threads by hand tap and using wrench.**

Requirements

Tools/Instruments

- Surface gauge - 1 No.
- Hacksaw frame 250 to 300 mm - 1 No.
- Ball pane hammer 200 gm - 1 No.
- M10 tap and wrench - 1 Set
- Steel rule 300 mm. - 1 No.
- Twist drill 8.5 and 11.5 - 1 No each.

Equiments/Machines

- Bench vice (100 mm) - 1 No.
- Drilling machine pillar type - 1 No.
- Angle plate - 1 No.
- Surface plate - 1 No.
- Drilling accessories chuck sleeve and drill - as reqd.

Materials

- Hexagonal nut (available size) - 1 No.
- Square nut (available size) - 1 No.
- Lubricant oil - as reqd.

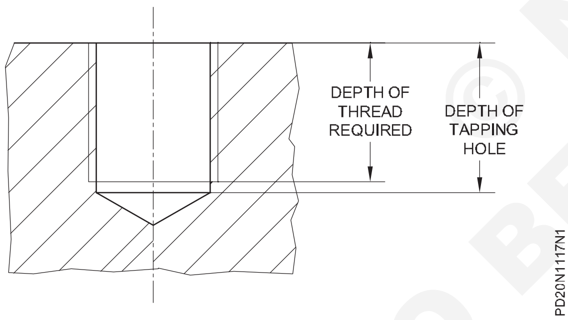
PROCEDURE

Drilling a hole

1 Determine drill size for tapping using the table for doing it.

2 Drill a blind hole using the depth stop arrangement. The depth of the tapping hole should be slightly more than the depth of the required thread. (Fig 1)

Fig 1



Procedure for threading

3 Remove metal chips, if any, from the blind hole by turning it upside down and slightly tapping it on the wooden surface.

> **Do not clear the chips by blowing as it can cause injury to your eyes.**

4 Screw a matching hexagonal nut on the first tap to act as the depth stop. (Fig 2)

5 Thread the blind hole until the nut touches the plate surface.

6 Remove the chips from the hole frequently, using a flattened and bent wire. (Fig 3)

Fig 2

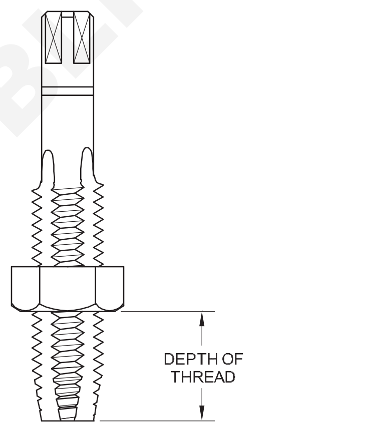
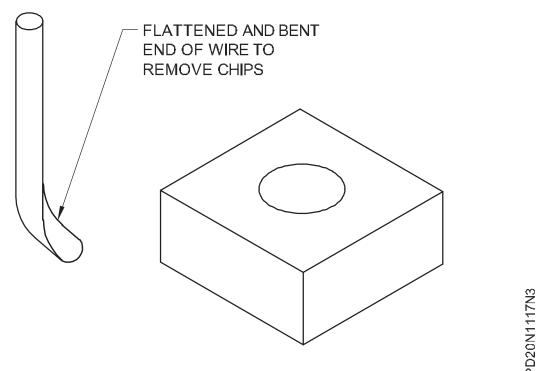


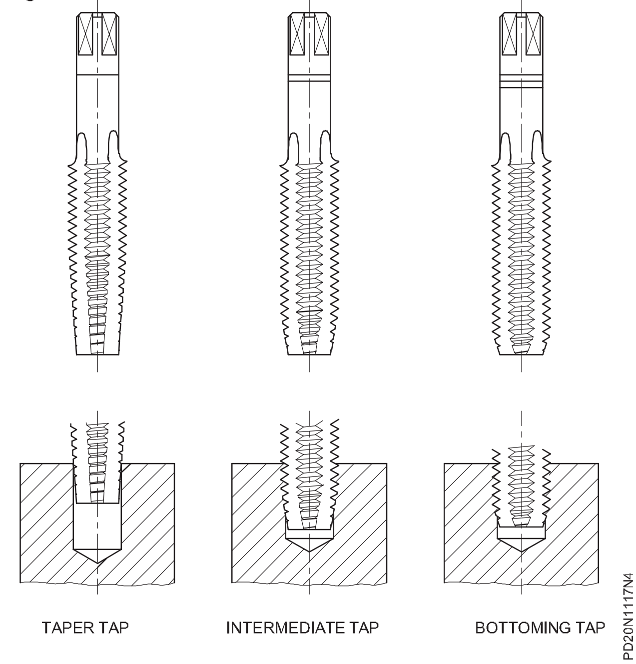
Fig 3



7 Finish tapping the hole with intermediate and bottoming tap (Fig 4). Set the nut to control the depth of the thread.

8 Repeat and practice steps 4 to 7 for forming internal thread on a square nut.

Fig 4



Skill sequence

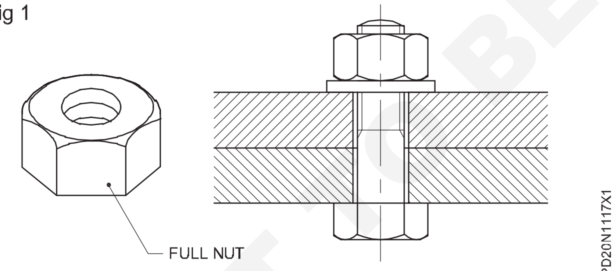
Hexagonal and square nut

Objective: This shall help you to
- **use of hexagonal and square nuts.**

Hexagonal nuts

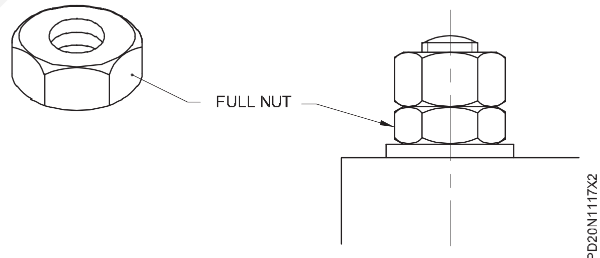
This is the most commonly used type of nut in structural and machine tool constructions. (Fig 1)

Fig 1



Hexagonal nuts are available in different thicknesses. Thin nuts are used as lock-nuts. (Fig 2)

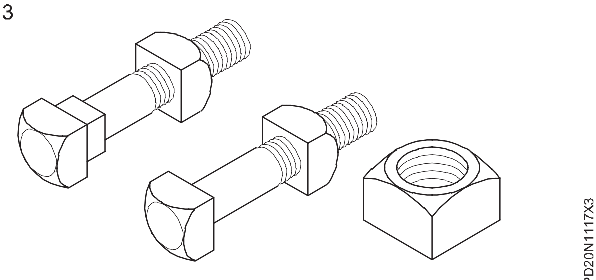
Fig 2



Square nut

Square bolts are provided with square nuts. In bolts for coaches, mostly, square nuts are used. (Fig 3)

Fig 3



Practice on making external threading by using stock & die set

Objectives: At the end of this exercise you shall be able to
- **measure and cut the conduit pipe according to the requirement**
- **prepare the conduit pipe ends for threading and fastening in a pipe vice**
- **cut the threads on heavy gauge metal conduit according to the requirement using a conduit die set**
- **mark the position of bending on conduit pipes.**

Requirements

Tools/Instruments

• Pipe vice 50 mm	- 1 No.
• Steel rule 600 mm	- 1 No.
• Hacksaw with a blade of 24 teeth per 25 mm (25 TPI)	- 1 No.
• Flat file bastard 200 mm	- 1 No.
• Half round file bastard 200 mm	- 1 No.
• Reamer 16 mm	- 1 No.
• Oil can 200 ml	- 1 No.
• Conduit stock and dies for 18 mm conduit	- 1 Set.
• Wire brush 50 mm	- 1 No.

Materials

• Conduit pipe 19 mm diameter 1 m long	- 1 No.
• Lubricant - coconut oil (for a batch of 16 trainees)	-100 grams
• Chalk piece	- 1 No.
• Cotton waste	- as reqd.

PROCEDURE

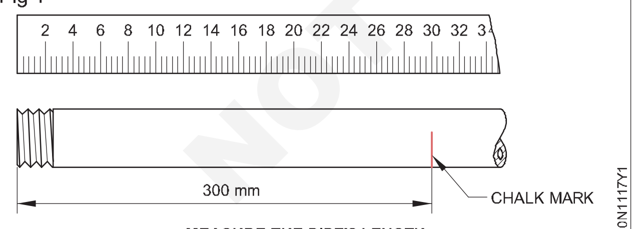
TASK 1: **Preparation of conduit pipe for cutting**

Assume that the job needs a 300 mm long conduit drop while a 3000 mm standard length pipe is only available. Normally both the ends of a standard length pipe will have threads. To make the required conduit drop, the available 3000 mm pipe is to be cut for a length of 300 mm and threaded again at the end where it is cut.

Cutting could be done either using pipe cutters or with hacksaws. Cutting with a hacksaw is popular, and the method is explained below.

1 Measure 300 mm from the threaded end of the pipe and mark it with chalk as shown in Fig 1.

Fig 1

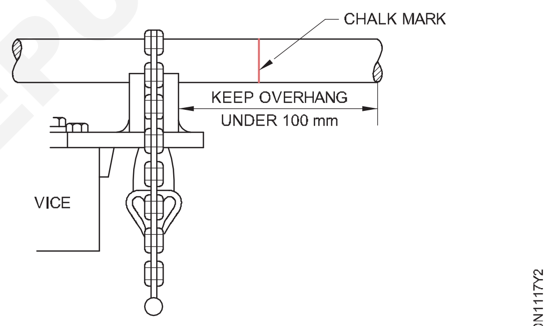


MEASURE THE PIPE'S LENGTH

2 Open the jaw of the vice and insert the pipe so that it is horizontal and parallel to the jaw serrations.

3 Keep the chalk mark of the pipe within 100 mm of the vice as shown in Fig 2.

Fig 2

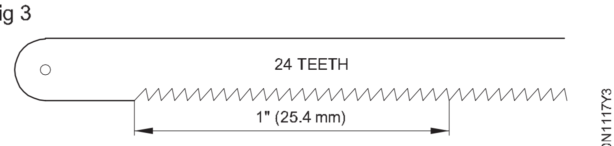


GRIP THE PIPE IN THE VICE FOR SAWING

4 Close and tighten the vice jaw.

5 Select a hacksaw with a blade having 24 teeth per 25 mm (25 TPI), as shown in Fig 3.

Fig 3

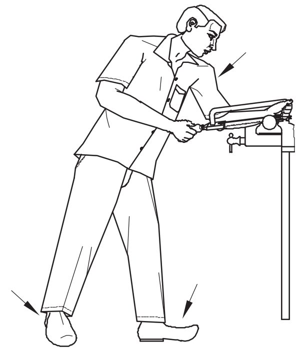


HACK SAW BLADE

Ensure that the hacksaw blade is firmly tightened in the frame and that the teeth point in the forward direction.

6 Take the hacksaw and position yourself, as shown in Fig 4, with your left shoulder pointing in the direction of the cut. Note the position of the feet, which allows for free and controlled movement of the body while cutting.

Fig 4

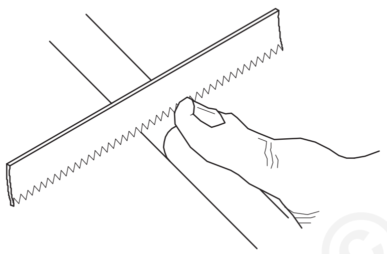


HACK SAWING - POSITION OF SAWING

7 Grip the hacksaw handle with the right hand and position the hacksaw blade on top of the cutting line.

8 Prepare to cut by guiding the blade with the thumb of your left hand exactly on the cutting line against the saw blade as shown in Fig 5.

Fig 5

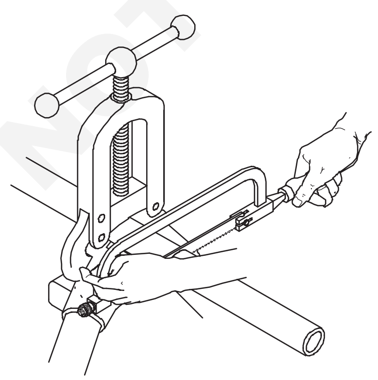


USE THUMB AS A GUIDE INITIALLY

9 When the initial cut has been made, move the left hand to the front end of the hacksaw frame and use both hands for the cutting operation as shown in Fig 6.

10 When sawing, use the full length of the blade, gradually increasing the pressure on the forward stroke, and releasing the pressure as the blade is drawn back. (Fig 6)

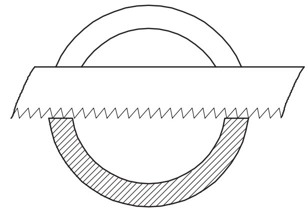
Fig 6



HOLDING SAW WHILE SAWING

11 Saw with steady, even strokes, keeping the blade upright and square to the cut as shown in Fig 7.

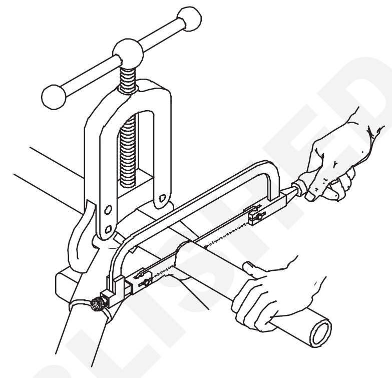
Fig 7



HOLD STRAIGHT

12 When getting near to the end of the cut, the conduit must be supported with your left hand as shown in Fig 8. Finish the cut.

Fig 8

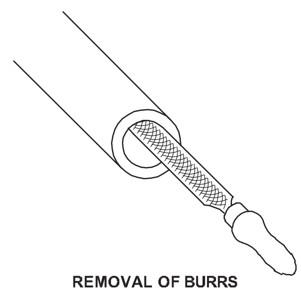


END OF SAWING

Support the free end of the conduit to prevent the blade of the hacksaw from being damaged.

13 Use a reamer or half round file to remove the inside burrs as shown in Fig 9.

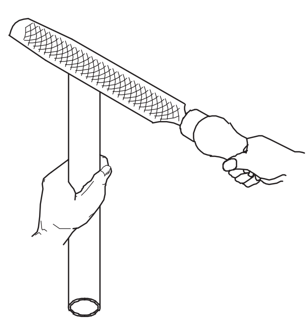
Fig 9



REMOVAL OF BURRS

14 Use the flat portion of the half round file to smoothen the sharp edges. (Fig 10)

Fig 10



REMOVAL OF SHARP EDGES

15 Clean the hacksaw and vice in the end and keep them in their respective places.

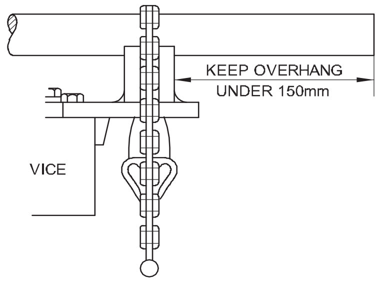
TASK 2: **Preparation of conduit pipe for threading.**

1 Open the jaw of the vice and insert the pipe so that it is horizontal and parallel to the jaw serrations.

2 Keep the end of the tube within 150 mm of the vice.

3 Close and tighten the vice as shown in Fig 1.

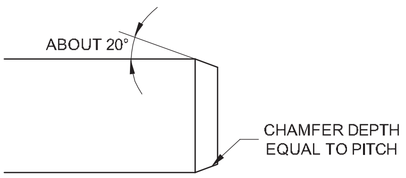
Fig 1



HOLD THE PIPE IN THE PIPE VICE FOR THREADING

4 File the end of the tube flat and chamfer the outer edge to an angle of about 20° as shown in Fig 2.

Fig 2



BEFORE THREADING, CHAMFER THE EDGE OF THE PIPE

Make the depth of the chamfer equal to the pitch of the thread (1.5 mm for conduit).

5 Choose the correct dies and stock suitable for the pipe to be threaded.

Assembly drawing for the quick cut stock and dies is given in Fig 3. The die size is engraved on the die itself. Check the size with that of the pipe. The handle of the stock is not shown in the picture for clarity.

6 Insert each half of the die in the cap(stock) with the chamfered threads positioned (leading faces) adjacent to the guide.

7 Screw the guide into position.

8 Adjust each adjusting screw equally to make the die halves centralized to the pipe axis.

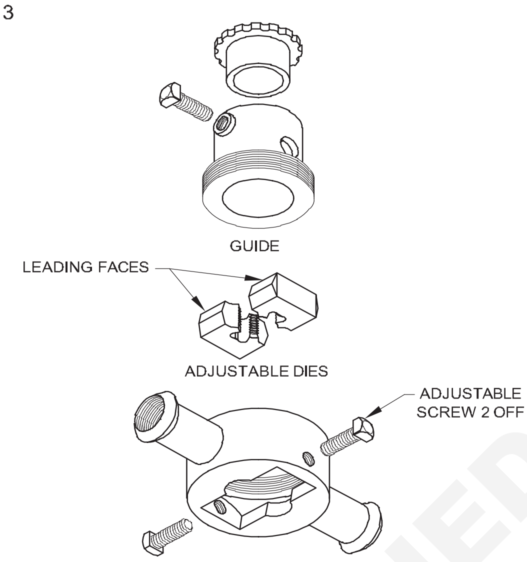
9 Slide the stock guide over the end of pipe, adjust the adjusting screws such that the dies grip the pipe evenly on both sides.

10 Apply pressure to the stock and keep the handles at right angles to the pipe as shown in Fig 4.

11 Rotate the handles clockwise in a plane at right angles to the pipe axis as shown in Fig 5.

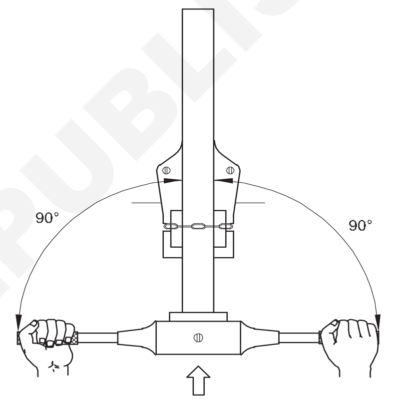
12 Apply the lubricant to the part to be threaded after the thread has been started.

Fig 3



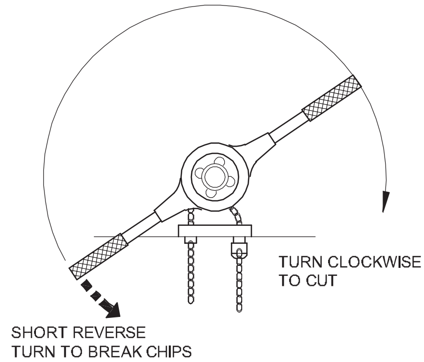
DIE SET (HANDLE NOT SHOWN)

Fig 4



MOUNTING THE DIE SET IN THE CONDUIT

Fig 5



THREADING PROCESS

The lubricant allows the die to cool the heat developed and thereby helps the edges to stay sharp producing a better thread finish.

13 Make one or two complete turns in the clockwise direction.

Check whether the stock is at right angle to the pipe axis.

Practice of Making Square and Round Holes, Securing by Screw and Riveting

Objectives: At the end of this exercise you shall be able to
- **make holes in the sheet metal using a punch**
- **joining sheet metal by using rivet set and snap.**

Requirements

Tools/Instruments

- Steel rule 300 mm - 1 No.
- Scriber 200 mm - 1 No.
- Straight snips 250 mm - 1 No.
- Bent snip 250 mm - 1 No.
- Divider 200 mm - 1 No.
- Hammer ball peen 200g - 1 No.
- Mallet (wood) - 1 No.
- Hatchet stake available size - 1 No.
- `G' clamp 250 mm - 1 No.
- Rivet set - 1 No.

Materials

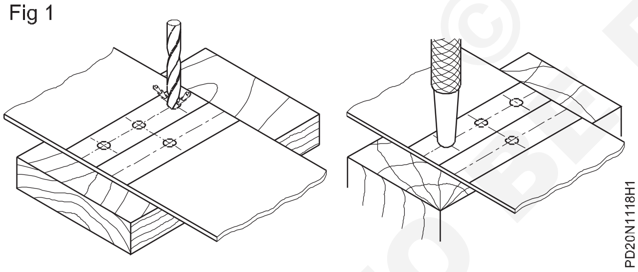
- Sheet iron ISST 220 x 0.5 x 300.
- Sheet iron ISST 55 x 0.5 x 105 (for riveting Task - 4 same sheet can be used for Tasks 1)) - 2 Nos.
- Trimmers rivets No. 14 - 10 Nos.

PROCEDURE

TASK 1: **Practice on making holes using a punch**

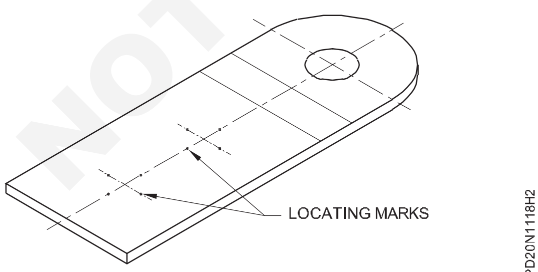
Holes in sheets are made either by drilling or by punching. (Fig 1)

Fig 1



1 Make location points with the help of a scriber and punch on the sheet. (Fig 2)

Fig 2

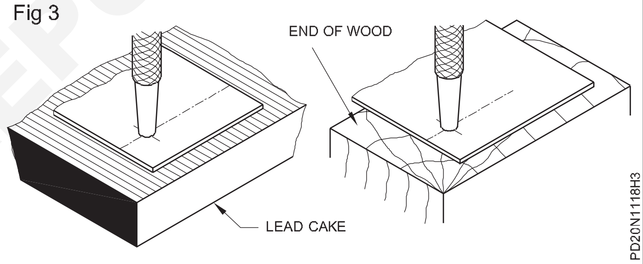


2 Use a lead slab as support. The end of a wooden block can also be used as a support. (Fig 3)

3 Make a hole on the sheet using centre punch Fig 3.

The sheet should be placed on the end of the wood. Otherwise, distortion may be caused as shown in Fig 4.

Fig 3



A hole can become smaller than the punch size when flattened. (Fig 5)

Keep the punch vertical. Ensure that the point of the punch coincides with the locating marks.

Fig 4

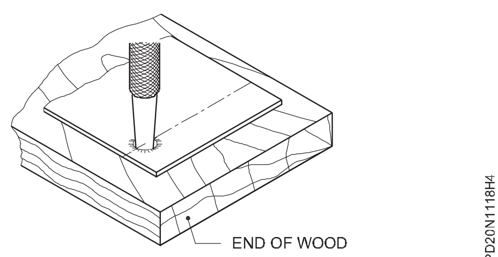
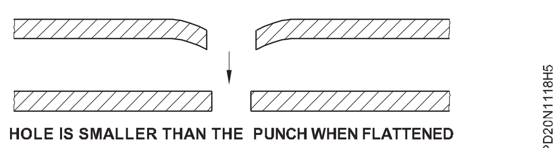


Fig 5

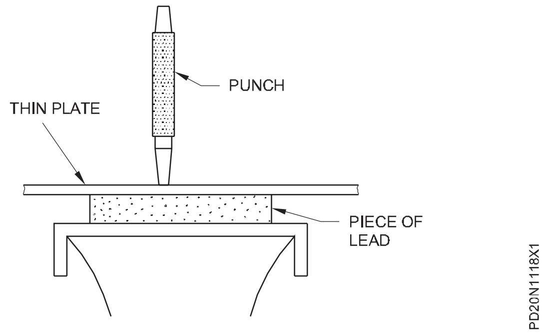


Joining sheet metal by using rivet set and snap

Objective: This shall help you to
- **rivet the thin plates with a rivet set.**

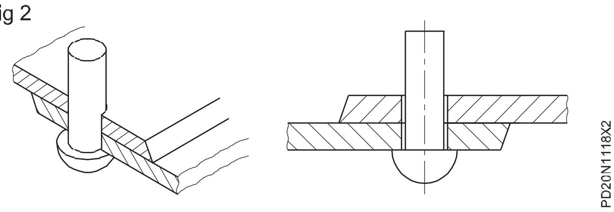
In thin plates the holes for rivets are punched as shown in Fig 1.

Fig 1



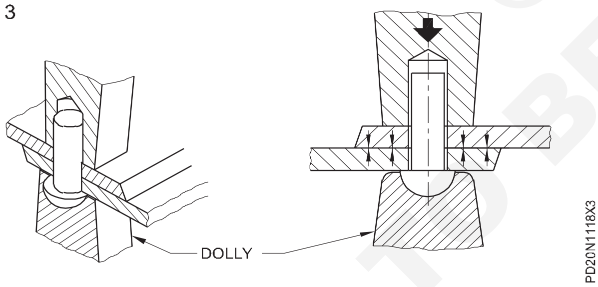
Pass the rivet through the punched hole in the sheet as shown in Fig 2.

Fig 2



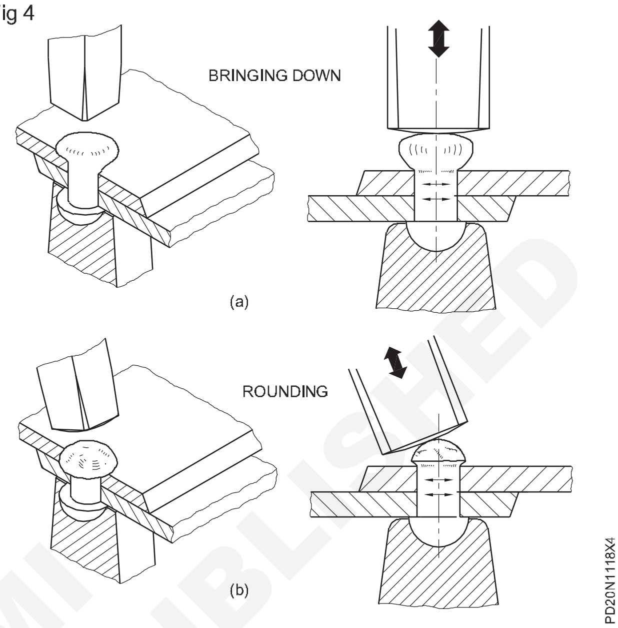
To firmly set the rivet in the sheet, use a rivet set. The rivet head is to be supported with a dolly. A dolly is used to prevent the rivet head from expanding when it is struck with the hammer. (Fig 3)

Fig 3



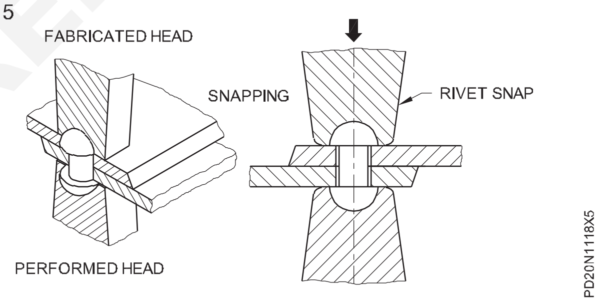
The shank is to be rounded by giving glancing blows with the hammer (as shown in Fig 4) for firming the head.

Fig 4



Finally, place the rivet snap on the rivet (as shown in Fig 5) and finish the work by giving a few blows with the hammer.

Fig 5



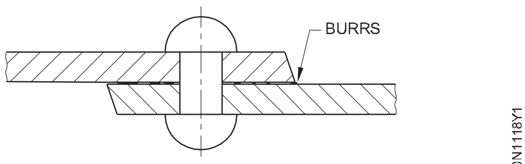
Faults in riveted joints

Objective: This shall help you to
- **identify the faults in riveted joints and the cause.**

The following faults may be noticed in riveted joints.

Burrs between workpieces as shown in Fig 1.

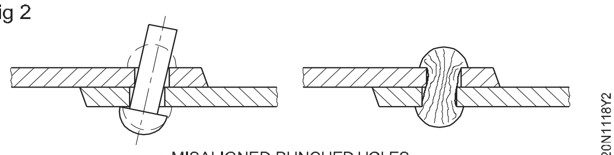
Fig 1



BURRS BETWEEN WORKPIECES

Incorrect alignment of punched holes in workpieces. (Fig 2)

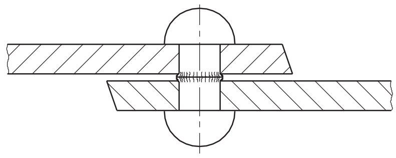
Fig 2



MISALIGNED PUNCHED HOLES

Incorrect setting of the rivet with the rivet set. (Fig 3)

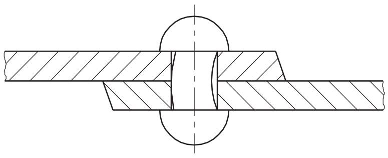
Fig 3



INCORRECT POSITION OF RIVET

Punched holes may be found to be too large. (Fig 4)

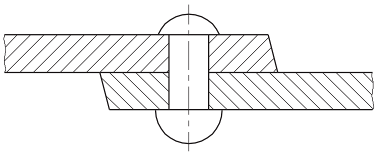
Fig 4



TOO LARGE PUNCHED HOLE

Rough rivet length may be found to be too short. (Fig 5)

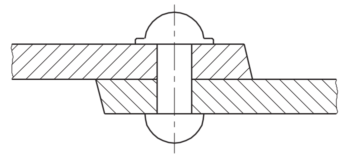
Fig 5



RIVET LENGTH TOO SHORT

Rough rivet length may be found to be too long. (Fig 6)

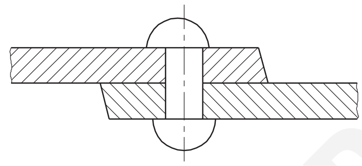
Fig 6



RIVET LENGTH TOO LONG

Closed head may be found to be displaced. (Fig 7)

Fig 7



DISPLACED HEADS

The rivet set and rivet snap must be free from burrs.

Removing rivets from metal sheet

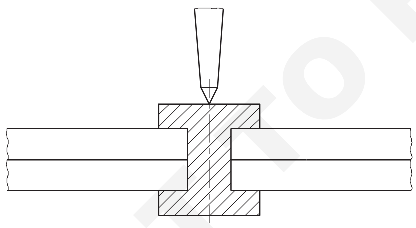
Objective: This shall help you to
- **remove the rivet from the metal sheet.**

The most satisfactory method of removing a rivet on light gauge sheet metal is by drilling.

Carry out the following steps:

1 Flatten and centre punch exactly at the centre of the formed head. (Fig 1)

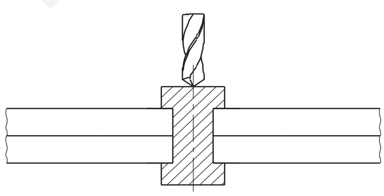
Fig 1



CENTER-PUNCH HEAD

2 Select a twist drill slightly smaller than the shank of the rivet. (Fig 2)

Fig 2

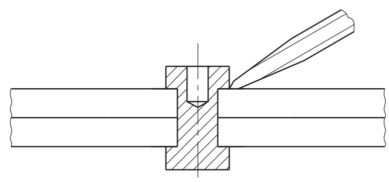


DRILL HEAD

3 Drill into the head of the rivet up to the surface of the metal. (Fig 3)

4 Remove the rivet head with a cold chisel. (Fig 3)

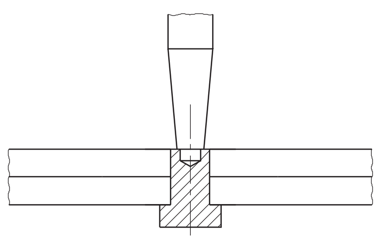
Fig 3



KNOCK HEAD OFF WITH CHISEL

5 Place the head of the rivet into a nut, a little larger than the head of the rivet with a solid punch slightly smaller than the size of the rivet shank. Punch the shank out of the head. (Fig 4)

Fig 4



DRIVE RIVET OUT WITH PUNCH

Another simple method of removing rivets is to cut off the formed head using a sharp cold chisel. The remaining portion of the rivet is removed by hammering, with a solid punch.

Precaution: The metal should not be distorted.

The rivet hole should not be enlarged.

Prepare an open box from metal sheet

Objectives: At the end of this exercise, you shall be able to
- **draw a development plan for a given open rectangular box in a single sheet**
- **drill hole of small diameter using hand drilling machine**
- **shear straight edge using straight snip**
- **make holes in sheet metal using cold punch**
- **make holes in sheet metal using hollow punch.**

Requirements

Tools/Instruments

- Steel rule 300 mm - 1 No.
- Scriber 200 mm - 1 No.
- Divider 150 mm - 1 No.
- Snips 250 mm - 1 No.
- Hammer 200 g - 1 No.
- Hatchet stake - as reqd.
- Mallet wood - 1 No.
- Hollow punches set 3 to 25 mm - 1 set.

Equipment/Machines

- Hand drilling machine - 6mm

Materials

- Sheet iron ISST (in mm) - 52 x 0.5 x 150

PROCEDURE

1 Check the dimension of the given sheet iron.

2 Mark all the dimensions as per drawing (Fig 1) for cutting, bending and punching holes.

3 Drill 2 mm diameter holes on all corners of box using hand drilling machine.

4 Shear over a length of 8.5 mm for bending indicated by No. 1 in Fig 1.

5 Bend all the four corners to 90°. Bending width of 8 mm is indicated by No. 2 in Fig 1.

6 Bend the sides B & D to 90° using suitable stack. (Fig 2)

> **Ensure the overlapping parts are well within the bending line of side A and side C.**

Fig 2

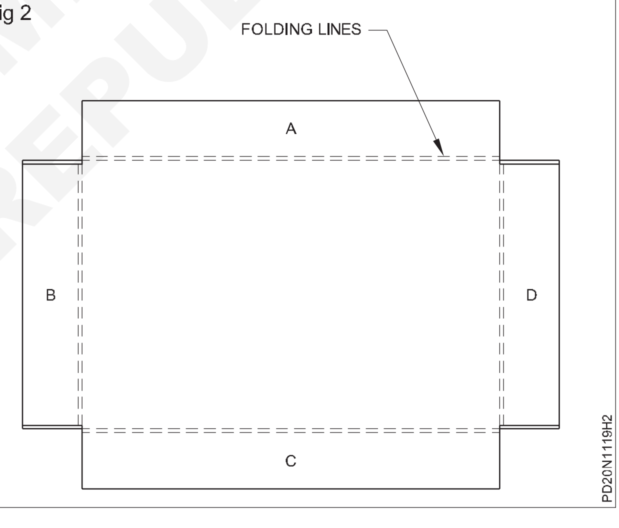
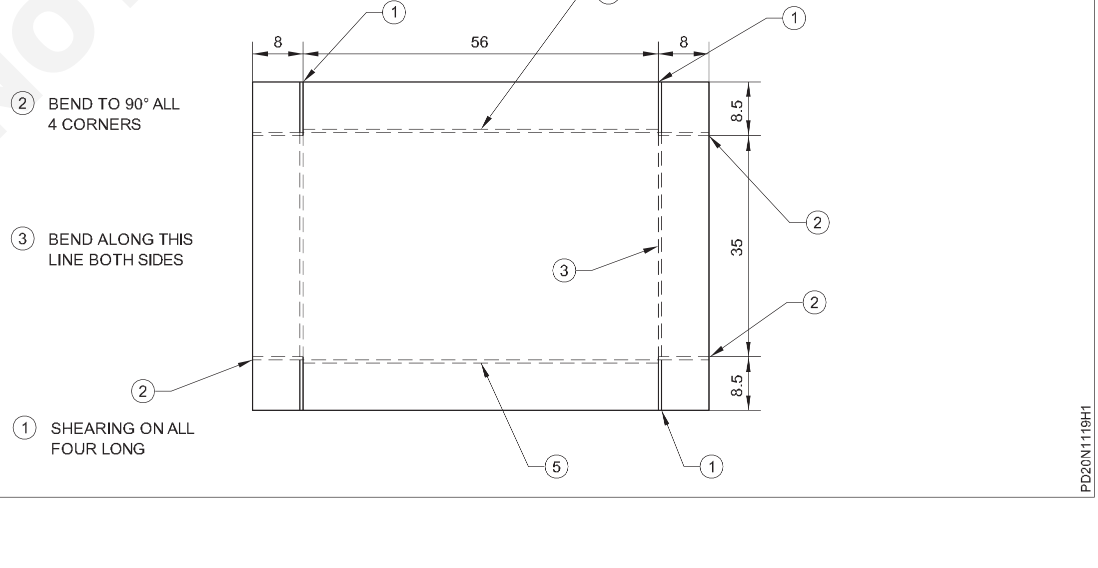


Fig 1



7 Bend the sides A and C to 90°. Use suitable stack. (Fig 3)

8 Repeat steps 1 to 8 and prepare another open box.

9 Mark the centre lines as per the dimensions given in (Fig 3), in one of the open end boxes.

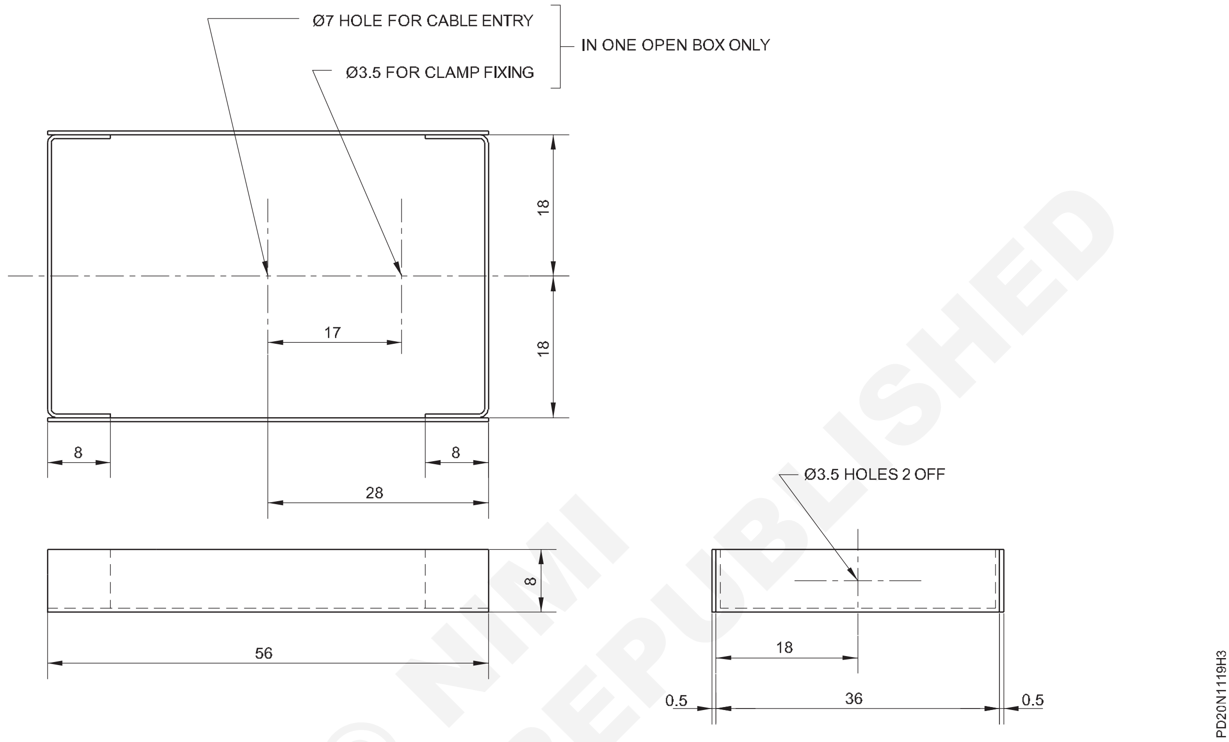
10 Make two marks on the holes of both the lines of at a distance equal to the radius to locate punches.

11 Place sheet at the end of wood or lead cake.

12 Punch holes with correct size punches after exactly locating their positions.

13 Flatten the surface by gently hammering with the soft mallet.

Fig 3



Skill Information

Laying out development pattern of rectangular open box directly on sheet metal

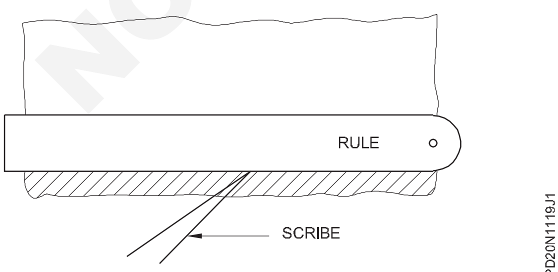
Objective: This shall help you to

- **draw a pattern for making a single open box.**

The steps to lay out the pattern remain the same.

Check the sheet metal on which your pattern will be made. Check the bottom edge of the sheet with a straight edge. (Fig 1)

Fig 1



Square up the left hand end of the sheet. (Fig 2) The ends of the sheet seldom remain a perfect square at the edges. (Fig 3) The usual method is to draw a line about 5 mm from the end using a square. (Fig 4)

Always make your layout in the lower, left hand corner of the sheet.

Measurements should be from the bottom and left hand square line.

Never try to cut your metal to the exact size. Measure from all the four edges to make the layout.

Fig 2

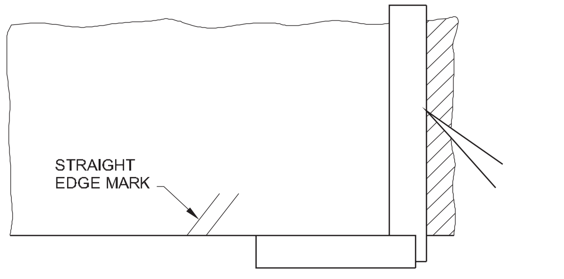


Fig 3

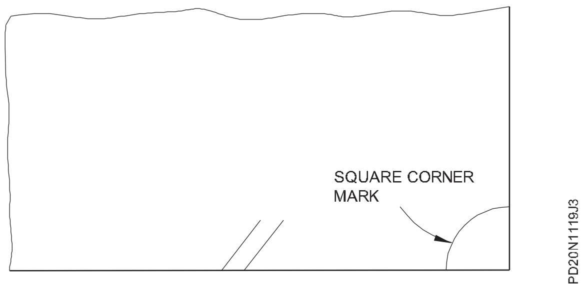
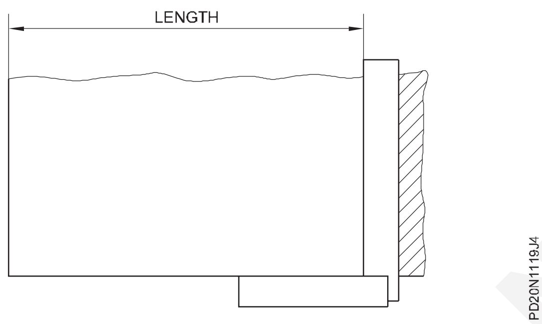


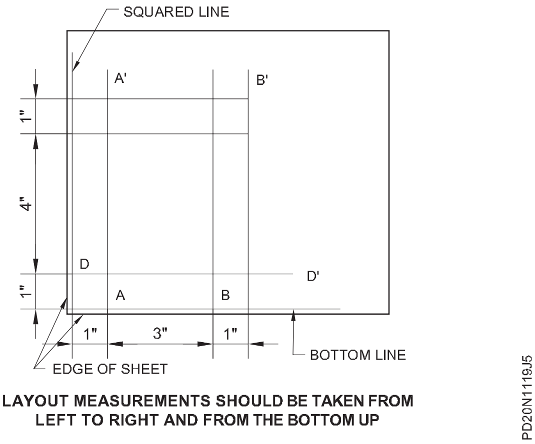
Fig 4



Make measurement at both ends of each line and draw a line through the two points.

Draw all the vertical and horizontal lines first. Then add lines for metres, notches, seams, edges and laps. (Fig 5)

Fig 5



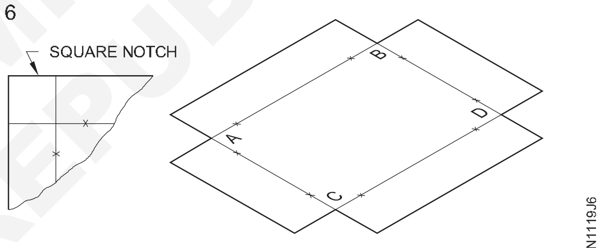
Prick mark all bend lines. Before to Top forming the pattern, prick mark all the bend lines about 5 mm from the end of the line.

Do not depend upon the corners of notches for bend locations.

Check the shape of the basic patterns.

When the layout is ready check the overall dimensions on each side of the pattern. (Fig 6)

Fig 6



NOTCHED PATTERN

— — — — — —

Prepare terminations of cable ends

Objectives: At the end of this exercise you shall be able to
- **prepare a loop termination**
- **prepare the cable end of fine multistranded wire**
- **identify the connecting parts of the socket of an appliance and connect it to cable with earth contact**
- **connect the appliance to the cable with earth contact**
- **identify the connecting parts of a 3-pole (plug) pin and connect the cable.**

Requirements

Tools/Instruments

- Steel rule 300 mm - 1 No.
- Electrician's knife 100 mm - 1 No.
- Wire stripper (manual) 150 mm - 1 No.
- Combination pliers 200 mm - 1 No.
- Screwdriver 100/150 mm x 4 mm - 1 No.
- Screwdriver 100 mm x 2 mm - 1 No.
- Long round nose pliers 150 mm - 1 No.
- Side cutting pliers 150 mm - 1 No.

Materials

- Pieces of 250 to 300 mm long aluminium and copper - as reqd.
- Single conductor cable 1.5 sq.mm - as reqd.
- Single conductor cable 2.5 sq. mm - as reqd.
- Bare copper wire No.10 SWG - small pieces 300 mm long or as available.
- Multistrand cable14/0.2 mm - small pieces 300 mm long or as available. - as reqd.
- Multistrand cable 23/0.2 mm - as reqd.
- Multistrand cable 48/0.2 mm - 2 Nos.
- Single pole plug (double banana plug) 4 mm screw type connection - 4 Nos.
- Crocodile clips insulated 2A and 6A, 250 V - 2 Nos.
- Test lamp with bulb 40 W, 240 V - 1 No.
- PVC cable 3-core copper 23/0.2 mm - 5 m
- Socket 2-pole with earthing contact 6A, 250 V grade - each of different rating and make - 4 pairs
- Plug 2-pole with earthing contact - 4 pairs
- Socket 2-pole with earthing contact 6A - 5 Nos.
- PVC Cable 3-core 48/0.2 mm - 3.5 m
- Plug 3-Pole 6A, 250 V different makes - 2 Nos.
- Plug 3-Pole 16 A, 250 V different makes - 2 Nos.
- Metal clad plug 2-pin with earth 20A - 2 Nos.

PROCEDURE

TASK 1: **Preparation of loop termination (Solid conductor) (Fig 1)**

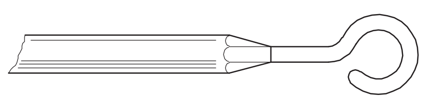
1 Collect a single conductor cable of 1.5 sq.mm (copper) about 250 to 300 mm long from scrap.

2 Mark on the insulation the length 'L' from the cable end. The length 'L' is five times the diameter of the terminal screw.

3 Loop in fine multistrand conductor. (Fig 2)

4 Make termination in screw on terminal. (Fig 3)

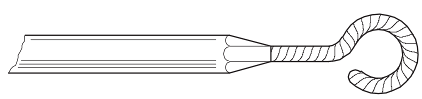
Fig 1



LOOP IN SOLID CONDUCTOR

PD20N1220H1

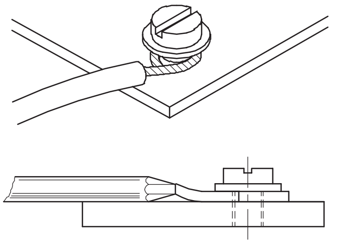
Fig 2



LOOP IN FINE MULTI-STRAND CONDUCTOR

PD20N1220H2

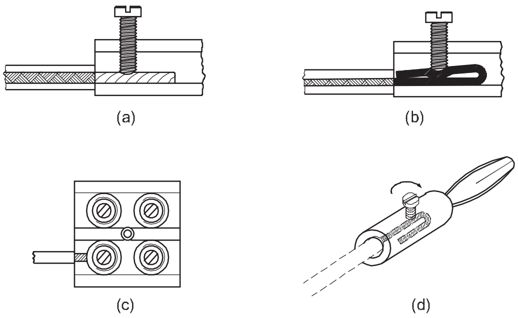
Fig 3



TERMINATION IN SCREW ON TERMINAL

5 Connect the terminated cable in different types of connectors. (Fig 4 a,b,c,d).

Fig 4



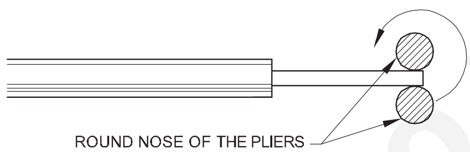
6 Skin the insulation over the length 'L'. (Fig 5)

Fig 5

MAKING A LOOP IN THE WIRE

7 Grip the bare conductor with the round nose pliers as shown in Fig 6.

Fig 6

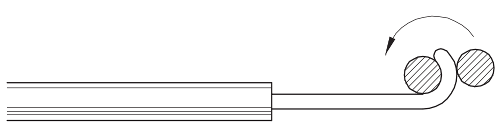


MAKING A LOOP IN THE WIRE

The diameter of the jaw at the gripping point of the round nose pliers is little more than the terminal screw diameter.

8 Turn the firmly gripped nose pliers to form the required loop. (Fig 7)

Fig 7



MAKING A LOOP IN THE WIRE

9 Finally set the loops with the nose pliers as shown in Fig 8.

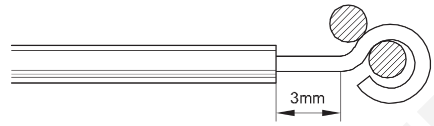
The hook (loop) should go at least about three quarters of the way around the screw.

Check the inner diameter of the loop with the terminal screw.

Never make the hook long as the conductor may overlap.

Keep the length of the exposed conductor to the minimum, not more than 3 mm, to prevent accidental contact with other wires. (Fig 8)

Fig 8



MAKING A LOOP IN THE WIRE

10 Repeat the task for 2.5 sq.mm copper single conductor cable.

11 Repeat the task for aluminium cable single conductor of 1.5 sq. mm and 2.5 sq. mm.

12 Repeat the task for bare copper wire of 10 SWG and other available sizes.

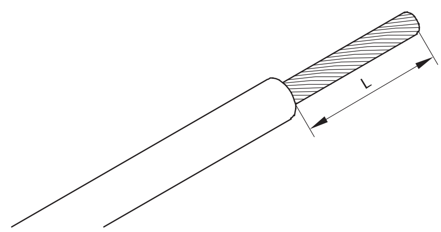
Preparing a fine multistrand cable end for termination to screw-on terminal of terminal blocks

13 Collect a piece of fine multistrand flexible copper cable, of size 14/0.2 mm.

14 Mark the length 'L' from the end of cable. Length 'L' is equal to five times the diameter of the terminal screw.

15 Remove the insulation to the length 'L' (Fig 9) using a pair of wire stripping pliers.

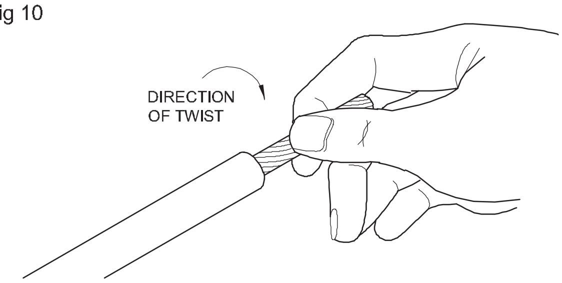
Fig 9



MULTI STRAND CABLE

16 Retwist the bared strands in the same direction with your fingers. (Fig 10) Note, that the strands are twisted in the wire in a certain direction.

Fig 10



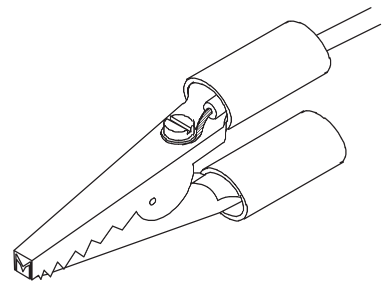
TWISTING THE MULTI-STRAND CABLE CORE

17 Repeat the steps No.4 to No.6 stated for solid conductor to finalise the termination.

18 Repeat the task with other sizes of cables.

19 Repeat the task for terminating flexible cable end on crocodile clips. (Fig 11)

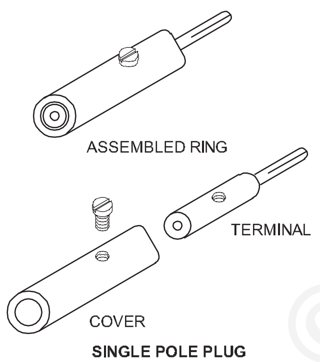
Fig 11



Prepare termination in a fine multistrand cable for single pole plug.

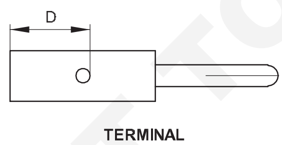
20 Open the given single pole plug. (Fig 12)

Fig 12



21 Measure with a steel rule the distance 'D' between the outer edge of the terminal screw hole and the edge of the terminal. (Fig 13)

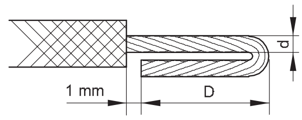
Fig 13



22 Remove insulation to the length equal to (2D + 1) mm.

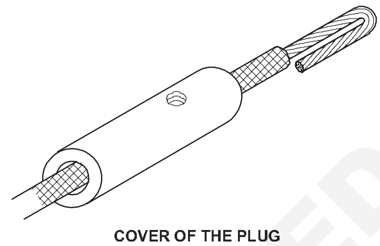
23 Bend a loop at the end of the wire to the required dimensions, with your fingers. (Fig 14)

Fig 14



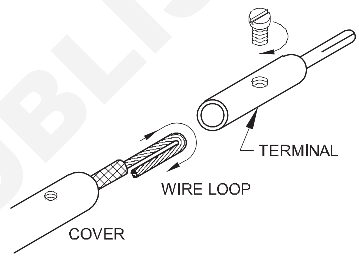
24 Push the wire through the cover of the plug. (Fig 15)

Fig 15



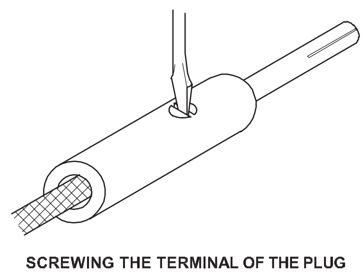
25 Insert the loop into the terminal (single pole plug). (Fig 16)

Fig 16



26 Assemble the plug by pushing its cover over the terminal and by inserting and tightening the terminal screw with a screwdriver. (Fig 17)

Fig 17



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Practice on skinning, twisting and crimping

Objectives: At the end of this exercise you shall be able to
- **skin the cable insulation using the electrician's knife**
- **skin the cable insulation using manual stripper**
- **skin the cable insulation using auto-stripper**
- **practice on making a straight twist joint**
- **prepare termination of cable lugs using crimping tool.**

Requirements

Tools/Instruments

- Electrician tool kit - 1 No.
- Electrician's knife 100 mm blade - 1 No.
- Wire stripper, manual 200 mm - 1 No.
- Wire stripper auto–eject 150 mm - 1 No.
- Combination pliers 150 or 200 mm - 1 No.
- Steel rule 300 mm - 1 No.
- Diagonal cutter or side cutting pliers 150 mm - 1 No.

Materials

Aluminium cables of the following sizes:
- PVC single strand cable 1/1.4, 1.5 sq. mm - 3 m
- PVC single strand aluminium cable 1/1.8, 2.5sq. mm - 3 m

Flexible cables with copper conductor of size:
- PVC cable 14/0.2 mm - 3 m
- PVC cable 23/0.2 mm - 3 m
- PVC cable 48/0.2 mm - 3 m
- PVC cable 80/0.2 mm - 3 m
- PVC cable 128/0.2 mm - 3 m
- PVC cable,PVC sheathed cable – assorted small pieces - as reqd.

PROCEDURE

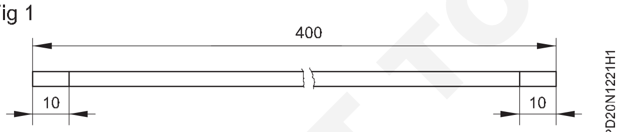
TASK 1 **: Skinning cable insulation using the electrician's knife**

1 Mark the length of the 1.5 sq. mm cable at 400 mm from its end.

2 Cut the cable using combination pliers on the mark.

3 Mark the length of insulation to be skinned from either end. (Fig 1)

Fig 1



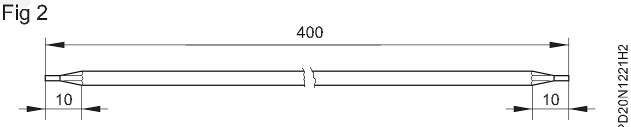
4 Check the sharpness of the knife blade and re-sharpen, if necessary.

> **Use an oilstone to sharpen the knife's blade.**
>
> **Visible thickness at the cutting edge of the knife blade indicates a blunt edge. In the case of a sharp edge, the thickness or end will not be visible.**

5 Remove the insulation of the cable for about 10 mm at the ends using a knife. (Fig 2) Keep the knife blade at an angle less than 20° to the cable.

6 Check for nicking over the conductor. Also check if the cable is not shaved.

Fig 2



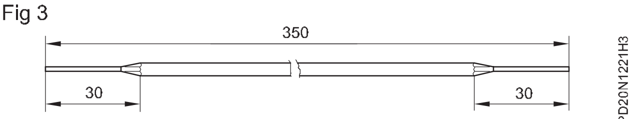
7 Clean the surface of the bare conductor and show it to the instructor.

8 Cut the cable at 12 mm from either end using a combination plier.

9 Repeat steps No.5 to No.8, until the cable is of 350 mm length

10 Mark the insulation that is to be removed as in Fig 3 and repeat steps 5 and 6.

Fig 3



11 Repeat the skinning of cable insulation of 2.5 sq. mm, 14/0.2 mm, 23/0.2 mm, 48/0.2 mm, 80/0.2 mm and 128/0.2 mm flexible cables.

> **The length of the cable after skinning both the ends shall be suitable for termination using crimping and screw.**

12 The length of the finished skinned cable should be 300, 500, 600, 800, 1000 mm.

These cable pieces are to be used for later exercises.

In the case of flexible stranded cables to ensure that the strands are not cut is essential.

— — — — — —

TASK 2**: Skinning cable insulation using a manual stripper**

1 Mark the length of the cable to be trimmed off.

2 Trim the cable at the mark using a combination plier diagonal cutter.

3 Straighten the ends where the insulation is to be skinned.

4 Mark the point where the insulation is to be skinned.

5 Adjust the jaws of the manual stripper and set them to suit the cable conductor.

6 Set the jaws at the mark, press the handle of the stripper and turn to cut the insulation.

Do not nick the conductor. For better practice try on a small waste piece.

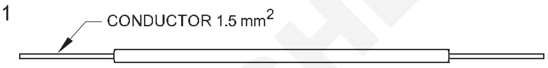
7 Pull the stripper to remove the insulation.

Partially cut insulation can be removed only with more force. Excessive force, indicates improper cutting of insulation.

8 Repeat the skinning of insulation for 10 mm to develop skill in the use of the wire stripper.

9 Remove insulation to the required extent at the ends as per Fig 1.

Fig 1



10 Be careful with flexible cables to ensure that you do not nick even a single strand.

— — — — — —

TASK 3 **: Skinning cable insulations using auto-stripper**

1 Mark the length of the insulation to be removed from the ends.

2 Straighten the cable ends.

3 Select a proper set of stripper.

4 Locate the jaws of the stripper exactly on the mark.

5 Press the stripper.

Further pressing may damage the insulation from the cable end, that is also to be removed.

6 Check that the cable conductor is not nicked.

7 Repeat steps No 1 to 7 for different sizes of cables.

— — — — — —

Skill sequence

Hand tools for skinning - knife

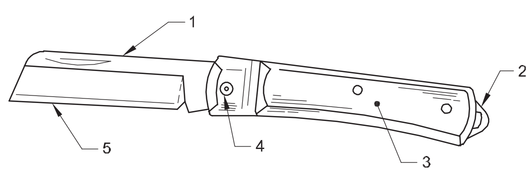
Objectives: This shall help you to
- **identify the parts of the knife used for skinning**
- **perform care and maintenance in using the knife.**

The most frequently used tool for skinning is the knife

A knife may have a single or double blade. A single blade knife is the most commonly used one. (Fig 1)

- back of the blade
- hanger
- haft
- hinge pin
- blade

Fig 1

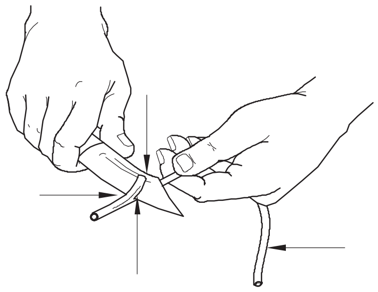


Be careful while using the knife.

Always cut keeping the object to be cut away from your body.

Slice the insulation at an angle of approximately 15° to avoid cutting into the conductor. (Fig 2)

Fig 2



> **Knives should not be used to remove insulation on very fine single or stranded conductors.**
>
> **Knives should not be used to cut conductors.**

Hand tools for skinning - manual wire stripper

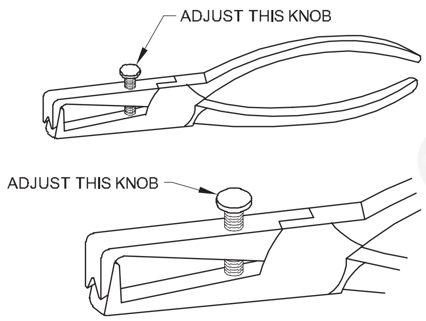
Objectives: This shall help you to
- **identify the parts of the manual wire stripper**
- **perform care and maintenance of manual wire stripper.**

Hand operated wire stripping tools can be used to remove P.V.C. or rubber insulation from a single core cable without damaging the conductor. They are of two types manual and auto-eject.

Manual wire stripper: The jaws have V shaped notches to cut the insulation.

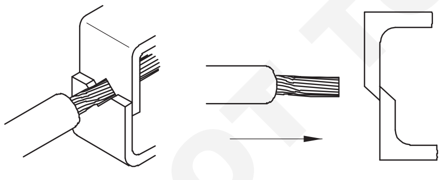
The adjuster screw allows to cut a wide range of wire diameters. (Figs 1 and 2).

Fig 1



MANUAL STRIPPER

Fig 2

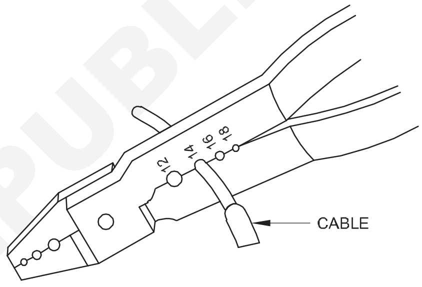


MANUAL STRIPPER

Often one cutter becomes sharper than the other, and cuts more than halfway through the wires, damaging the conductors. In such an event, the blunt cutter should be sharpened.

Fig 3 shows manual wire stripper.

Fig 3



MANUAL WIRE STRIPPER

This tool has a series of sharp openings in its scissor blade to allow stripping of wire in gauge of different sizes or diameters. The gauge size of the wire must match with the opening in the wire stripper to prevent cutting into the wire and weakening it.

> **Precautions:**
>
> - **When using this tool, make sure that it is correctly adjusted before trying to strip the insulation from the cable so that it does not damage the conductor.**
> - **Do not use this tool to cut metallic conductors.**

Hand tools for skinning - auto-eject stripper

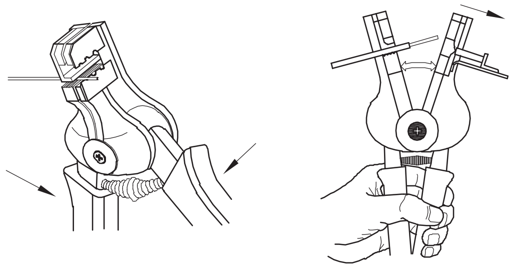
Objectives: This shall help you to
- **identify an auto-eject stripper**
- **take care while using an auto-eject stripper.**

Auto-eject strippers are used to cut the insulation from electrical wire without damaging the wire strands. They remove the insulation automatically. (Fig 1)

This stripper has two sets of jaws: one set grips the insulation while the other set has cutting edges.

When the handles are apart, both sets of jaws are open. (Fig 2)

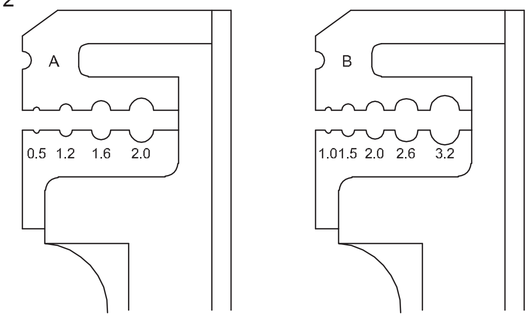
Fig 1



AUTO - STRIPPER

PD20N1221U1

Fig 2



JAWS OF AN AUTO STRIPPER

PD20N1221U2

This stripper operates automatically when the correct position on the blade matching the diameter of conductor in mm is selected, and the handles are compressed together.

In an auto-eject stripper, we can select different blade sizes to match different sizes of conductors.

Precautions: While using this stripper the cable insulation should be put in the proper slot to avoid damage to the conductor.

Skinning - Using a knife

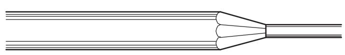
Objective: This shall help you to

- **strip the wire insulation with the electrician's knife.**

Material: PVC insulated the wire 2.5 sq. mm - 1 metre.

Tools: Electrician's knife (100 mm) - 1 No.

Fig 1



PENCIL CUT

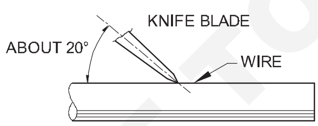
PD20N1221V1

Pencil cut using a knife (Fig 1)

1 Set the knife to the wire

- Hold the section to be stripped on the ball of your index finger.
- Hold the knife at about 20 degrees angle. (Fig 2)

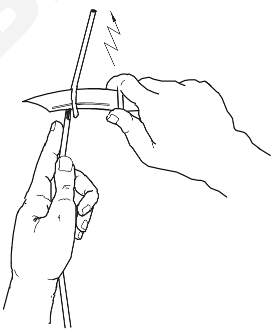
Fig 2



PD20N1221V2

2 Cut the insulation. (Fig 3)

Fig 3



PD20N1221V3

- Move the knife forward as you saw it back and forth.

Be sure not to damage the core.

- Move your index finger along the direction of cutting.

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Sub Exercise (S.Ex.) 1.2.21 - 1

Prepare termination of cable lugs by using crimping tool

Objectives: At the end of this exercise you shall be able to
- **skin the cable end**
- **select the pressure terminal (compression connector) that suits the size of the wire and that of the terminal**
- **select the pressure pliers that match the size of the pressure terminal**
- **use the crimping tool to crimp the lugs at the cable end.**
- **use an eyelet crimping plier for eyelet termination.**

Requirements

Tools/ Instruments

• Pressure pliers 200 mm	- 1 No.
• Electrician's knife 100 mm	- 1 No.
• Wire stripper (manual) 200 mm	- 1 No.
• Combination pliers 200 mm	- 1 No.
• Crimping pliers 150/200 mm	- 1 No.
• Wire stripper auto-eject 200 mm	- 1 No.
• Steel rule 300 mm	- 1 No.
• Side cutting pliers 150 mm	- 1 No.
• Eyelet closing pliers 200 mm with eyelets having inner diameter of 3,4,5,6,7 mm.	- 1 No.

Materials

• Crimping eyelet, eye hole dia. 6 mm	- 12 Nos.
• Crimping ferrule 4 mm,10 mm long	- 6 Nos.
• Crimping spade lug 6A	- 6 Nos.
• Crimping spade lug 10A	- 6 Nos.
• Crimping spade lug 16A	- 2 Nos.
• Conducting paste	- 1 tube

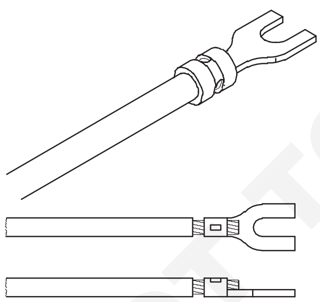
PROCEDURE

TASK 1: **Crimping of lug connector**

1 Collect the cable (fine multistrand copper conductor).

2 Collect the spade connector suitable for the wire thickness and terminal size of 6 mm diameter (Fig 1, 2 & 3).

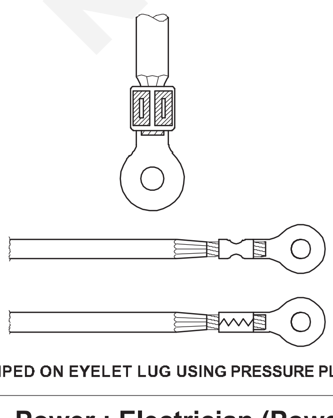
Fig 1



CRIMPED ON SPADE CONNECTOR

PD20N1221X1

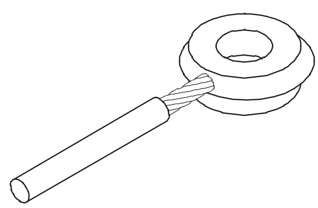
Fig 2



CRIMPED ON EYELET LUG USING PRESSURE PLIERS

PD20N1221X2

Fig 3

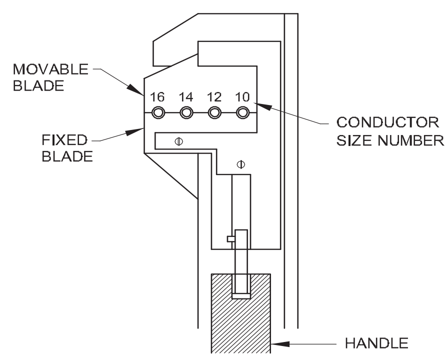


CRIMPED ON CLOSED LUG CONNECTOR

PD20N1221X3

3 Select the wire stripper blade size to match the wires thickness (auto-eject) or adjust the jaws of the stripper. (Fig 4)

Fig 4



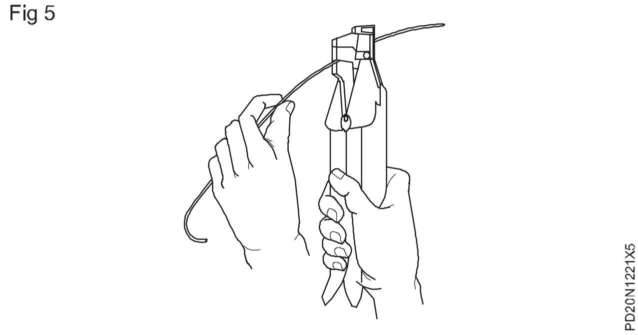
AUTO - WIRE STRIPPER

PD20N1221X4

4 Strip a length of insulation that suits the terminal size (spade connector) (Fig 5)

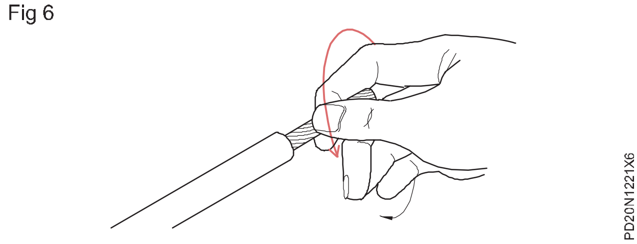
Be sure not to cut or damage the wire core.

Fig 5



5 Twist the strands of the wire lightly in the direction of strands. (Fig 6)

Fig 6

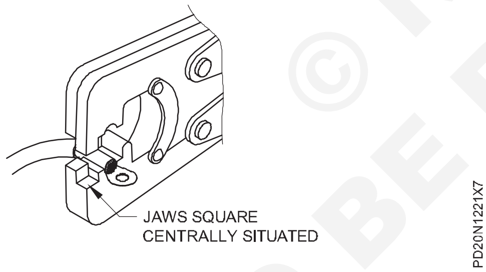


6 Select the crimping pliers that matches the terminal size.

7 Clamp the spade connector with the crimping pliers with the matching position of jaws.

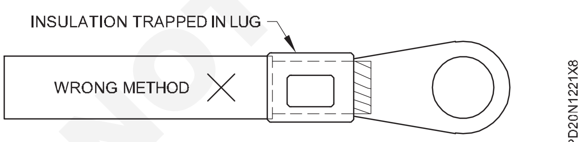
8 Insert the wire far enough in the compression connector. (Fig 7)

Fig 7



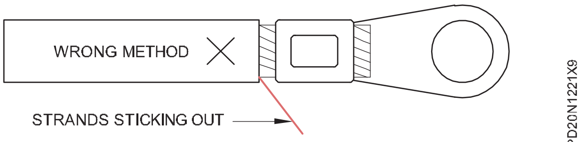
Do not clamp the insulation in the terminal. (Fig 8)

Fig 8



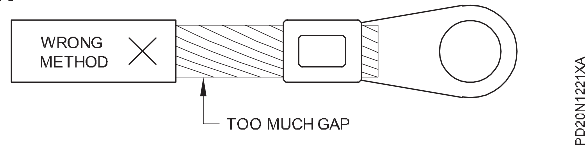
Strands must not stick out of the connector. (Fig 9)

Fig 9



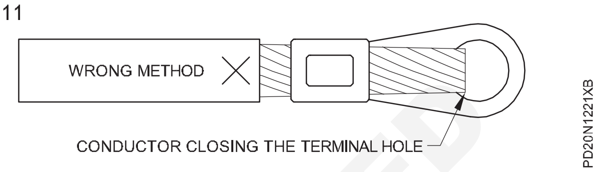
Do not strip too much insulation. (Fig 10)

Fig 10



Adjust the length of the wire so that it does not interfere with the terminal hole. (Fig 11)

Fig 11

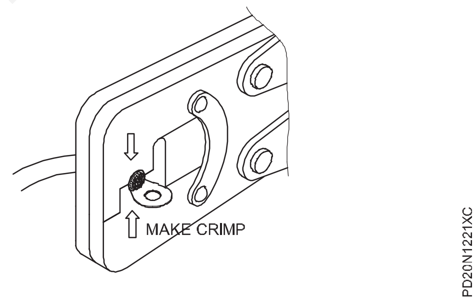


9 Apply light pressure to create a light impression on the compression connector.

10 Check whether the press is located in the middle of the band of compression connector and, if necessary, make final adjustment.

11 Apply sufficient pressure in the handle to press the compression connector fully, as shown in Fig 12.

Fig 12



12 Check whether the prepared compression/crimping joint is firm by pulling the cable and compression connector.

13 Repeat the crimping of compression in the connectors of various sizes of copper and aluminium conductors of different lengths.

Trim the appropriate length of the skinned cable ends to suit the compression connectors.

The types of compression connectors to be fixed at the cable ends will be as prescribed by your instructor. Fig 2 shows the eyelet lug compression connected/crimped on to the flexible cable.

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TASK 2**: Crimping an eyelet**

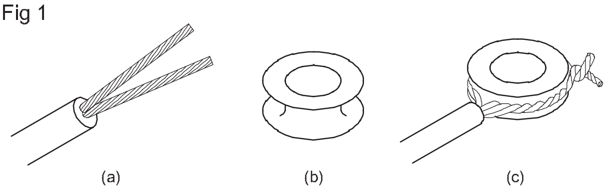
1 Collect the multistrand cable.

2 Split the number of strands into two equal parts and twist them. (Fig 1a)

3 Collect the eyelet. (Fig 1b)

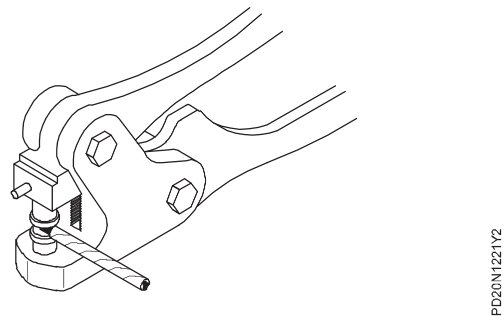
4 Fix the eyelet by placing the eyelet between the grouped strands close to the insulation and twist the free ends of the strands as shown in Fig 1c.

Fig 1



The eyelet is then pressed on to the wire end by the two formers of the eyelet closing pliers. (Fig 2)

Fig 2



5 Trim the excess length of the multi-strand wire after closing the eyelet using side-cutting pliers.

6 Repeat the exercise with different sizes of eyelets for cable end termination.

7 Get it checked by your instructor.

— — — — — —

TASK 3**: Practice on twisting of single strand wires**

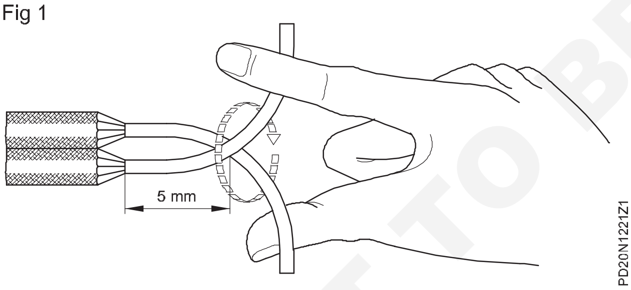
1 Take 300 mm of 1/1.5 mm^2 aluminium wire, or 1/1.2 mm P.V.C copper cable.

2 Cut it into two pieces of 150 mm each.

3 Remove the insulation of 50 mm in each piece by using stripper and clean it with cotton cloth.

4 Cross the bare wires at 45º and at a distance of 45 mm from the cable end. (Fig 1)

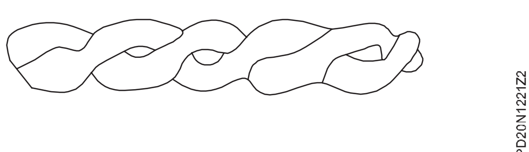
Fig 1



5 Twist the ends tightly at least 6-8 twists. (Fig 2)

While twisting 2 wires together avoid gaps between the twists. If it twisted with gap, it will trigger sparks and overheat as shown in Fig 2.

Fig 2



6 Finish twisting the wires as shown in figure 3 & 4.

Fig 3

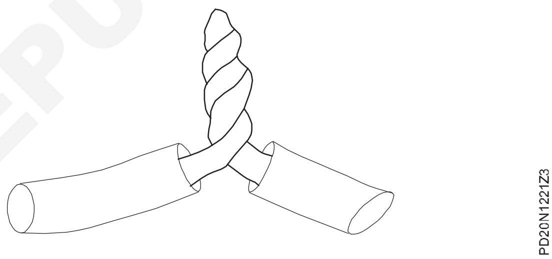
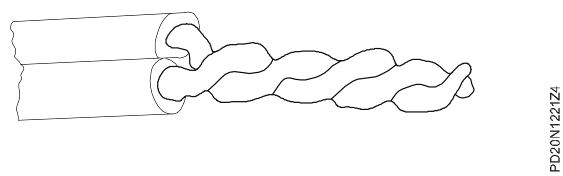


Fig 4

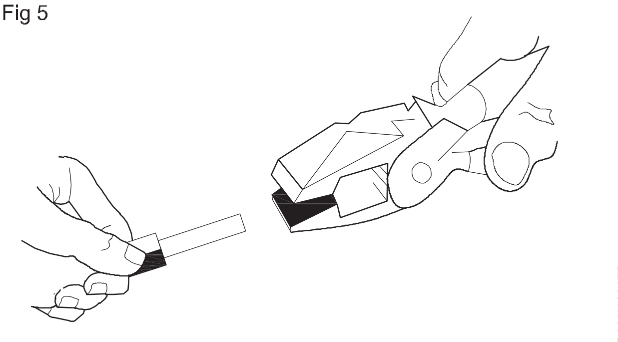


7 Get it checked by your instructor.

Joining of wires by twisting using plier.

8 Hold wires together near the plier. (Fig 5)

Fig 5



9 Grab both the copper ends with pliers.

10 Rotate your wrist while using pressure on pliers.

> **When joining three large wires, strip the insulation more.**

Connecting a stranded wire to a solid wire.

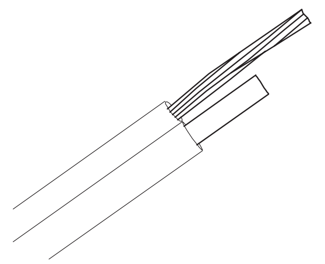
If the stranded wire is thinner than the solid wire

- Strip the stranded wire so that there is more copper visible than solid wires.
- Wrap the stranded wire around solid copper
- Leave the solid wire straight

When connecting two solids to stranded,

- First,twist the solids together
- Wrap the stranded wire around the solids.
- Apply the wire nut tight. (Fig 6)

Fig 6



- Pull the stranded wire to make sure it is tight.

If the surrounded wire is of the same diameter,

- Cut both to the same length.
- Cover the wire with wire nut and twist it. (Fig 7 & 8)

Fig 7

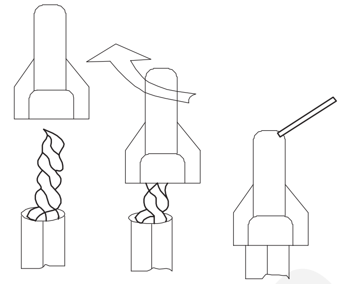
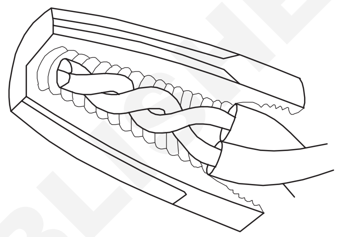


Fig 8



Identify various types of cables and measure conductor size using SWG and micrometer

Objectives: At the end of this exercise you shall be able to
- **identify types of wires and cables**
- **verify their specifications referring to the data book**
- **measure wire sizes using SWG**
- **measure wire size using micrometers.**

Requirements

Tools / Instruments

- Standard Wire Gauge (SWG 0-36) - 1 No.
- Micrometer (0-25) - 1 No.
- Electrician's knife - 1 No.
- Manual wire stripper 150 mm - 1 No.
- Combination pliers 150 mm - 1 No.

Materials

- Wires (assorted size) - as reqd.
- Cables (underground armoured and unarmoured cable) - as reqd.
- Wire/ cable specification data book - 1 No.

PROCEDURE

TASK 1: **Identify types of wires and cables**

The instructor will arrange and provide the various types of cable and wire pieces (assorted sizes) on the table and label them with alphabets and explain them to trainees on, how to identify the types of insulation, conductors, size of wires. Demonstrate how to measure the size of wires using SWG and micrometer.

1 Take any one wire from the table, note down its aplhabet in Table 1.

2 Identify the type of insulation, type of conductor material and size of wires. Note it down in Table 1.

3 Take at least five different types of wires and repeat steps 1 and 2 Note down the details in Table 1.

4 Verify the specifications of the wires by referring with the data book.

5 Take any one cable from the table, note down its alphabet.

6 Identify the type of cable (unarmoured and armoured cable) and note down in Table 1.

7 Identify the type of insulation, core and record in Table 1.

8 Verify the specifications of the cable by referring with the data book.

9 Repeat steps 1 to 8 for various wires and note the data in Table 1.

Table 1

Sl. No.	Alphabet	Type of insulation	Type of conductor material	Type of cable		Type of core single/3/3½	Core size in mm
				Armoured	Unarmoured		
1	A						
2	B						
3	C						
4	D						
5	E						

— — — — — —

TASK 2: **Measuring the wire sizes by SWG in gauge number**

1 Skin the insulation of the cable.

Exercise care to prevent from nicking.

2 Clean the surface of the wire with a cotton cloth. Remove insulation particles and any adhesive coating from the surface of the conductor.

Do not use abrasives to clean the conductor. Use of abrasive material, reduces the size of the conductor.

3 Straighten the end of the conductor to be measured.

Do not straighten conductors by directly using hand tools on them.

4 Insert the conductor in the slot of the wire gauge and determine its close fit. (Fig 1)

5 Read the marking at the slot, Fig 2. It gives the wire size in SWG. The other side will give you the diameter. of the wire in mm.

6 Record the measured size in Table 1.

Fig 1

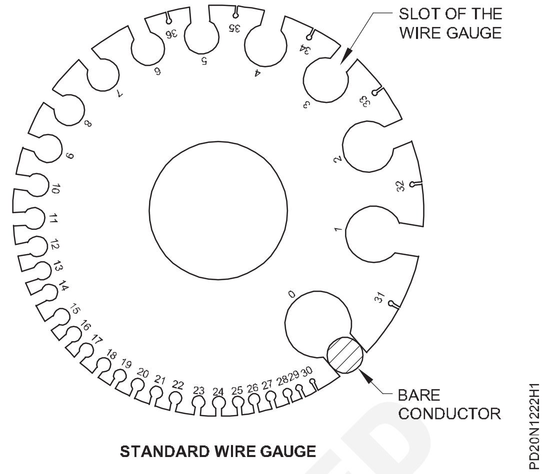
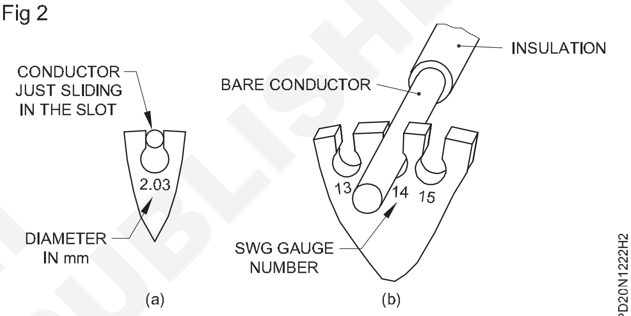


Fig 2



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TASK 3: **Measuring the wire size, using micrometer**

1 Repeat steps 1-3 of TASK 2.

2 Check the micrometer for zero error by operating the spindle.

3 Record the error value with the sign- +ve or –ve.

4 Place the cleaned, straight portion of the conductor between the jaws (anvil and spindle) of the micrometer. (Fig 1)

5 Close the spindle of the micrometer by turning the thimble.

Use the ratchet drive to avoid over tightening.

6 Read and record the diameter in Table 1 after computing zero error.

7 Refer to the conversion table (Table 2) to get the size of the conductor in the standard wire gauge.

8 Repeat the steps to find the measurement for the given cables.

Fig 1

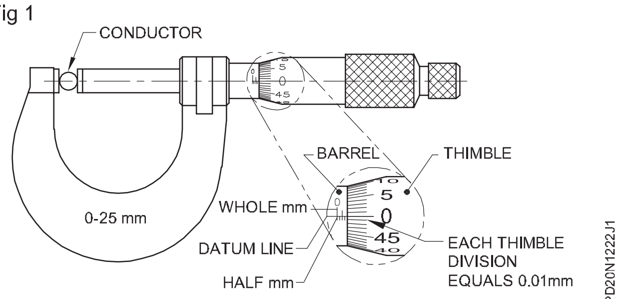

Table 2

Conversion table : SWG to inch/mm

No.	Inch	mm
7/0	0.500	12.7
6/0	0.464	11.38
5/0	0.432	10.92
4/0	0.400	10.16
3/0	0.372	9.44
2/0	0.348	8.83
0	0.324	8.23
1	0.300	7.62
2	0.276	7.01
3	0.252	6.40
4	0.234	5.89
5	0.212	5.38
6	0.192	4.88
7	0.176	4.47
8	0.160	4.06
9	0.144	3.66
10	0.128	3.25
11	0.116	2.95
12	0.104	2.64
13	0.092	2.34
14	0.080	2.03
15	0.072	1.83
16	0.064	1.63
17	0.056	1.42
18	0.048	1.22
19	0.040	1.02
20	0.036	0.91
21	0.032	0.81
22	0.028	0.71

No.	Inch	mm
23	0.024	0.61
24	0.022	0.56
25	0.020	0.51
26	0.018	0.46
27	0.0164	0.42
28	0.0148	0.38
29	0.0136	0.34
30	0.0124	0.31
31	0.0116	0.29
32	0.0108	0.27
33	0.0100	0.25
34	0.0092	0.23
35	0.0084	0.21
36	0.0076	0.19
37	0.0068	0.17
38	0.0060	0.15
39	0.0052	0.13
40	0.0048	0.12
41	0.0044	0.11
42	0.0040	0.10
43	0.0036	0.09
44	0.0032	0.08
45	0.0028	0.07
46	0.0024	0.06
47	0.0020	0.05
48	0.0016	0.04
49	0.0012	0.03
50	0.0010	0.02

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Make simple twist, married, Tee and western union joints

Objectives: At the end of this exercise you shall be able to
- **mark the length of the insulation to be removed**
- **skin the insulation**
- **prepare simple twist joint**
- **prepare married joint in stranded conductor**
- **prepare 'T' joint in multistranded conductor**
- **prepare western union joint in bare conductor.**

Requirements

Tools/Instruments

- Electrician's knife with two folding steel blades of 75 mm and 100 mm - 1 No.
- stainless steel rule 300 mm, with graduations on either edge cm/mm and inches - 1 No.
- Diagonal cutting pliers 150 mm with 660 volts grade insulated handle suitable for cutting hard wires - 1 No.
- Combination pliers 200 mm with 660 volts grade insulated handles with pipe grip, side cutter and two joint cutters - 1 No.
- Wooden mallet 75 mm - 1 No.
- Flat file - bastard 250 mm - 1 No.
- Hard vice 58 mm - 1 No.

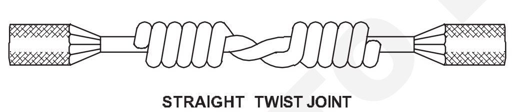
Materials

- PVC insulated copper cable 1/1.12 - 2 m.
- PVC insulated aluminium cable 1/1.40 - 2 m.
- Cotton cloth 30 cm square - 1 No.
- Sandpaper `OO' (smooth) - 1 sheet
- PVC insulated copper cable 7/0.914/600V - 1 m.
- PVC insulated copper cable 3/0.914/250V - 1 m.
- Bare copper wire 4 mm 30 cm - 2 Nos.
- GI wire 4 mm 30 cm - 2 Nos.
- Sand Paper 'O' grade - 1 sheet
- Cotton cloth 30 x 30 - 1 No.
- Sandpaper `o' grade - 1 sheet

PROCEDURE

TASK 1: **Make simple (straight) twist joint as shown in Fig 1**

Fig 1



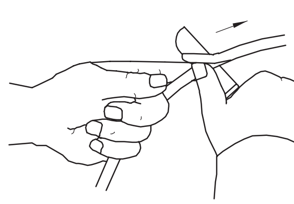
1 Collect 2 pieces of 1/1.12 PVC copper cable of 0.5 m length.

2 Straighten the cables.

3 Mark 80 mm length on one end of each piece of the cable.

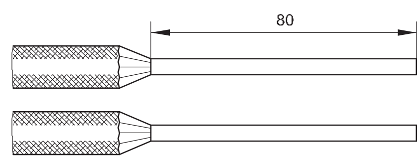
4 Use the knife at 20° as shown in Fig 2.

Fig 2



5 Remove the insulation from each conductor for a length of 80 mm. (Fig 3)

Fig 3



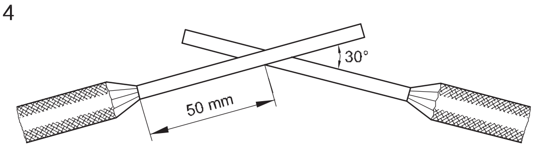
Avoid nicks in the conductor.

6 Clean the ends with the help of a cotton cloth.

Use smooth sandpaper, if necessary, to clean the conductor.

7 Place the conductors together, about 50 mm from the ends. (Fig 4)

Fig 4



8 Twist them tightly around each other in the opposite directions. (Fig 1)

> **Pliers can be used to just grip the crossed conductors.**
>
> **Each side should contain about 6 turns.**
>
> **Each turn of the conductor should closely fit to the adjacent turn.**

9 Cut the excess length of the conductor using side cutters.

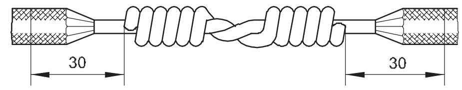
10 Press the sharp edge of the conductor end and smoothen it.

> **Soldering the joint and insulating it with tape should be completed before putting the jointed cable in use.**

11 Show the joint to your instructor.

12 Cut the joint after leaving 30 mm cable from the joint. (Fig 5)

Fig 5



STRAIGHT TWIST JOINT

13 Repeat steps 3 to 9 and make at least 4 more joints for practice, using the remaining cable.

— — — — — —

TASK 2: **Prepare married joint in 7/0.914 stranded conductors as shown in Fig 1**

Fig 1

MARRIED JOINT

1 Collect 2 pieces of PVC sheathed copper cable 7/0.914 0.5 metre in leagth.

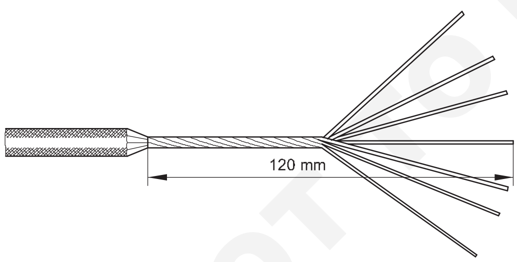
2 Mark both the the cables at 120 mm from the cable ends.

3 Remove the insulation for 120 mm on both the cables.

> **Carefully remove the insulation. Do not nick or shave the conductor.**

4 Open the strands, clean the wires, and re-twist the strands in the original direction up to 50 mm from the cable insulation. (Fig 2)

Fig 2



5 Cut the centre strand of both the cables close to the twist (about 70 mm from the free end).

6 Bind on the twisted part of one cable end as shown in Fig 3.

7 Interlace the strands keeping the centres butt. (Fig 4)

Fig 3

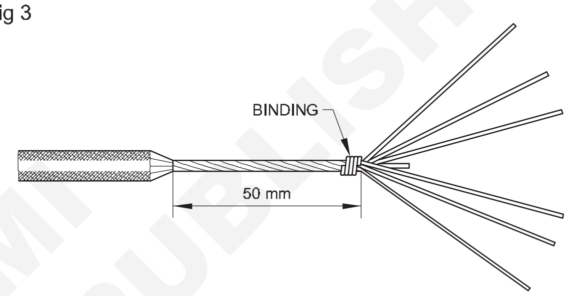
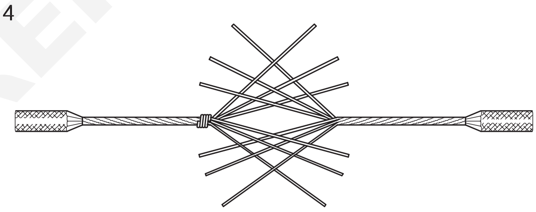


Fig 4



8 Hold the cable end (that is without the binding) in one hand and twist the strands of the other cable end over it, one by one, closely and tightly. Each strand has to be twisted half a turn at a time.

> **The direction of twist to form the shoulder should be the same as that of the cable twist.**

9 Remove the binding made in step 6.

10 Repeat the operation as in step 8 on the other side with the 2nd cable end.

11 Complete the joint as shown in Fig 1 by rounding off the twisted strands with a mallet or pliers, and cut the excess wires.

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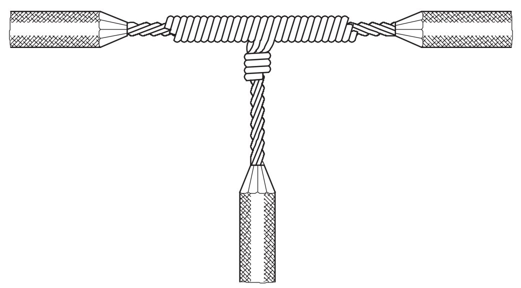
TASK 3: **Prepare 'T' joint in multi-stranded conductor**

Fig 1 shows a completed Tee joint in strandard conductors.

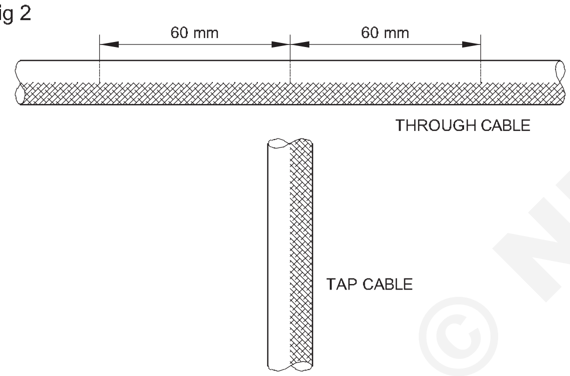
Fig 1



1 Collect two pieces of PVC insulated stranded copper cable 7/0.91. Indicate one piece as `through cable' and the other one as `tap cable'.

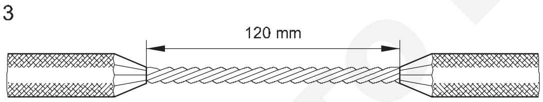
2 Mark the point of tap in the `through cable' and mark 60 mm on either side of the tap point for the insulation to be removed as shown in Fig 2.

Fig 2



3 Remove 60 mm insulation on either side of the `through cable' from the point of tap. (Fig 3)

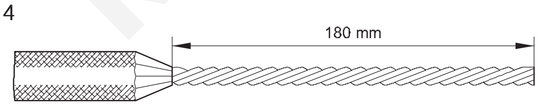
Fig 3



Do not nick or shave the conductor while removing insulation.

4 Remove the insulation for 180 mm at the end of the `tap cable'. (Fig 4)

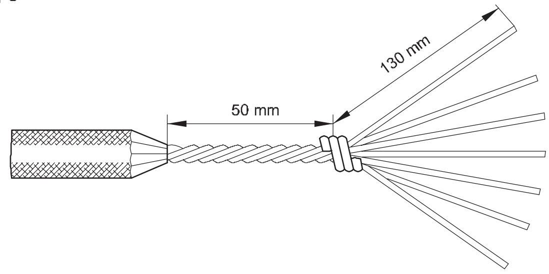
Fig 4



5 Open the strands of the `tap cable' and clean it. Use smooth `00' sandpaper, if necessary.

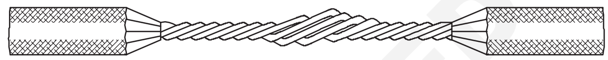
6 Re-twist the strands in the original direction up to 50 mm from insulation, and make a binding on the twisted part of the `tap cable' as shown in Fig 5.

Fig 5



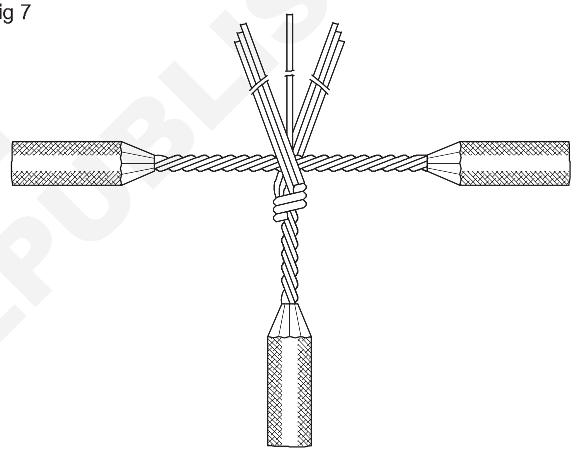
7 Untwist the `through cable' to provide opening at the point of tap. (Fig 6)

Fig 6



8 Insert the centre (middle) strand of the `tap cable' in the opening of the 'through cable' as shown in Fig 7.

Fig 7



9 Wrap 3 strands of the `tap cable' around the `through cable' on either side of the tap point to form shoulder on `through cable'.

10 Wrap the strands up to 50 mm to leave a 10 mm gap between insulation and shoulders (Fig 1) and trim the excess length of strands.

11 Remove the binding from the `tap cable', wrap the centre strand of the `tap cable' around the `through cable' and wrap it in the place of the binding. (Fig 1)

12 Round the ends with the combination pliers or mallet to avoid sharp edges of the strands.

13 Collect two pieces of PVC stranded aluminium cable 19/1.12, or 19/1.63, 500 mm long and repeat working steps 2 to 12.

With 19/1.2, 19/1.63 mm cable, 9 strands of the `tap cable' are to be wrapped on either side of the `through cable'. Insulation that has to be removed is 170 mm on the `through cable' and 250 mm on the `tap cable'.

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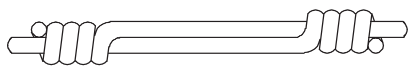
TASK 4: **Prepare western union joint in bare conductor**

(A completed western union joint is shown in Fig 1.)

Fig 1

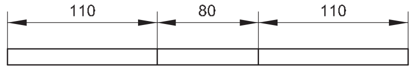


1 Collect two pieces of bare copper conductor of 4 mm diameter. and 30 cm long.

2 Straighten the conductor with a mallet.

3 Mark the conductor as shown in Fig 2.

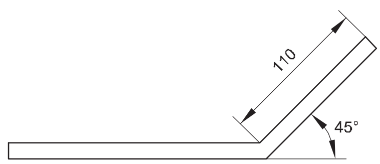
Fig 2



4 Clean both the conductors with `00' grade sandpaper to a length of 250 mm from one end.

5 Bend both the pieces of conductors at a distance of 110 mm from one end to 45^o as shown in Fig 3.

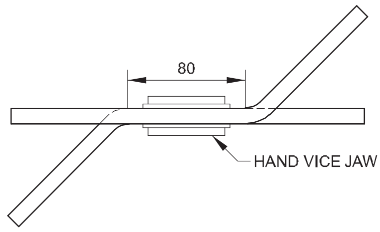
Fig 3



6 Hold the conductors in the hand vice as shown in Fig 4.

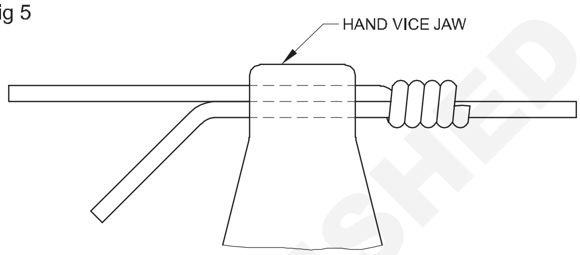
> **To avoid nicks on the conductors while gripping in a hand vice, always use soft materials like aluminium sheets between the jaws.**

Fig 4



7 Wrap one conductor over the other conductor using combination pliers. Make at least 5 to 6 turns as shown in Fig 5.

Fig 5



8 Repeat the same procedure in the other end of the conductor, but wrap the conductor in the opposite direction.

9 Cut the surplus conductor ends with a diagonal cutter.

10 Use a mallet to mesh the ends with the straight conductor.

11 Smoothen the ends of the conductors with a flat file to avoid sharp edges.

12 Repeat the Western union joint with G.I. wire of diameter 4 mm.

Make britannia straight, britannia 'T' (Tee) and rat tail joints

Objectives: At the end of this exercise you shall be able to
- **make britannia straight joint in solid copper conductor**
- **make britannia 'T' (Tee) joint in solid copper conductor**
- **make rat tail joint.**

Requirements

Tools/Instruments

- Steel rule 300 mm - 1 No.
- Diagonal cutting plier 150 mm - 1 No.
- Combination plier 200 mm - 1 No.
- Hand vice 50 mm jaw - 1 No.
- Flat file bastard 200 mm - 1 No.
- Wooden mallet 75 mm diameter. - 1 No.

Materials

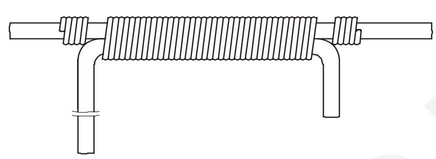
- Hard drawn bare copper wire 4 mm diameter 0.2 metre - 4 Nos.
- Tinned copper wire of dia. 0.91 mm - 4 m.
- Sandpaper `0 0' - 1 sheet
- Cotton cloth 300 x 300 mm - 1 No.
- PVC copper cable 1/1.2 mm 8.5 m - 2 Nos.

PROCEDURE

TASK 1: **Make britannia straight joint**

(A completed brittannia 'T' joint is shown in Fig 1.)

Fig 1



BRITANNIA TEE JOINT

PD20N1224H1

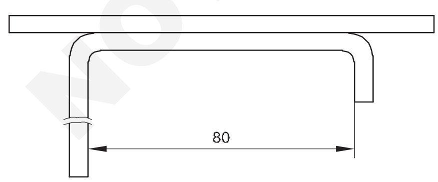
1 Collect two pieces of 4 mm diameter Hard Drawn Bare Copper (H.D.B.C) . wire, 0.2 m long.

2 Straighten the conductors using a mallet and clean it using fine sandpaper and cotton cloth.

> **Use the mallet to make the wires straight. The two pieces should be free from twists over the entire length of the joint.**

3 Bend each piece at one end for about 20 mm length at 90° as shown in Fig 2.

Fig 2



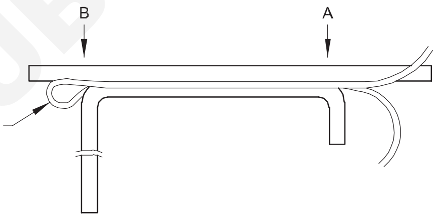
PD20N1224H2

4 Collect the binding wire and straighten it without any kink.

5 Hold the two ends of the bare copper wire to be joined in the hand vice as shown in Fig 2.

6 Form a loop of binding wire leaving one end about 250 mm at the right side of the joint. Place the binding wire in the groove formed in between the main conductors as shown in Fig 3.

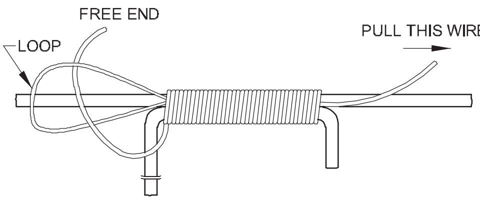
Fig 3



PD20N1224H3

7 Start binding the wire tightly over the joint from position `A' and continue till position `B'. (Fig 4)

Fig 4



PD20N1224H4

8 Insert the free end of the wire inside the loop as shown in Fig 4.

9 Grip the 250 mm loose end of the wire with a pair of pliers, and carefully pull it so that the loop and the free end of the wire go inside the joint.

10 Wrap the free end and the loose end over the conductors as shown in Fig 1.

11 Press the ends of the binding wire to the conductors with pliers .

12 Smooth the sharp edges of the protruding wire ends with a flat file.

13 Repeat the above steps and make two or more joints to get more practice.

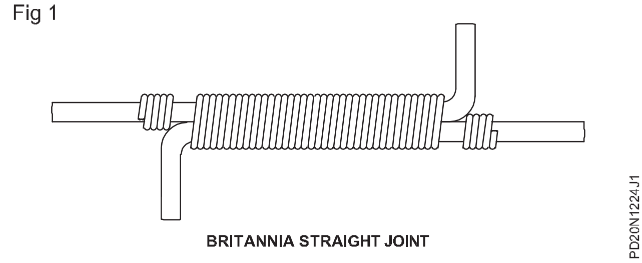
After completion the joint must be soldered before putting it to use.

— — — — — —

TASK 2: **Make britannia straight joint**

(A completed britannia `Tee' joint is shown in Fig 1.)

Fig 1

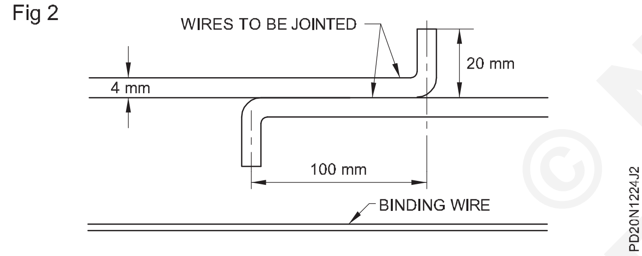


1 Collect two pieces of 4 mm diameter Hard Drawn Bare copper (H.D.B.C) 0.2 m long.

2 Straighten the conductors using a mallet and clean it with fine sandpaper and cotton cloth.

3 Bend and shape of one of the conductors according to the size shown in Fig 2, with the help of combination pliers.

Fig 2



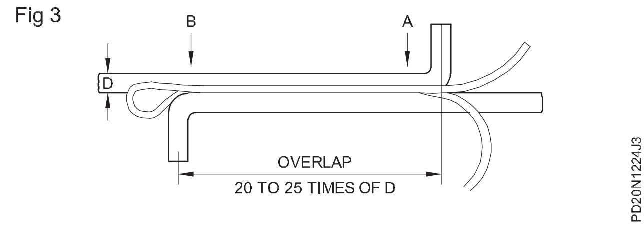
4 Straighten the (0.914 mm diameter.) binding wire.

5 Hold the two copper conductors to be joined with the help of a hand vice as shown in Fig 2 .

6 Form a loop of binding wire leaving one end about 250 mm at the right side of the joint. Place the binding wire in the groove formed between the conductors as shown in Fig 3.

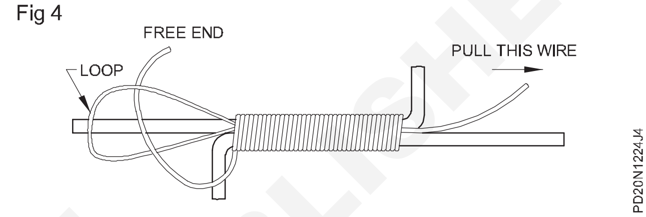
7 Start binding the wire tightly over the joint from position `A' and continue till the position `B'. (Fig 3)

Fig 3



8 Insert the free end of the wire inside the loop as shown in Fig 4.

Fig 4



9 Grip the 250 mm loose end of the wire with a plier, and carefully pull it so that the loop and the free end of the wire go inside the joint.

10 Wrap the free end and the loose end over the conductors as shown in Fig 1.

11 Press the ends of the binding wire to the conductors with plier.

12 Smooth the sharp edges of the binding wire ends with a flat file.

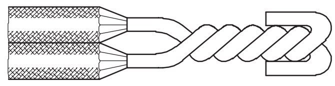
13 Repeat the above procedure to make two or more joints to get more practice.

The joints need to be soldered before putting them into use.

— — — — — —

TASK 3: **Make rat-tail joint (Fig 1)**

Fig 1



1 Collect 2 pieces of 1/1.2 mm PVC copper cable of 0.5 m length.

2 Straighten the cables.

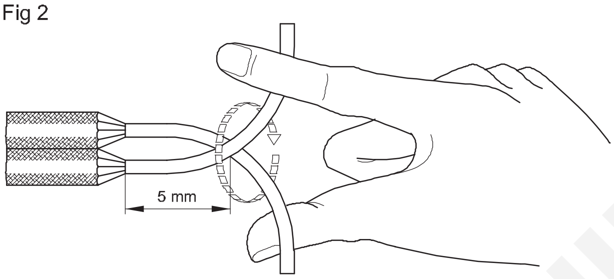
3 Skin both the cable ends for 50 mm.

4 Clean the conductor ends with the help of cotton cloth.

5 Cross the bare wires at of 45° and at a distance of 45 mm from the cable end.

6 Tightly twist the ends as shown in Fig 2.

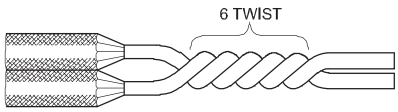
Fig 2



The twist on the wire should be uniform and close.

7 Make at least 6 twists. (Fig 3)

Fig 3



8 Fold the remaining wire back on the twists. (Fig 1)

9 Press the ends of the wire with the help of combination pliers (Fig 1) to avoid sharp ends, and cut the excess wire.

10 Repeat the steps.3 to 8 of TASK 3 for at least 4 more joints for practice, using the remaining cable.

Practice in Soldering of joints/lugs

Objectives: At the end of this exercise you shall be able to
- **solder the copper conductor joints using a soldering iron and rosin solder**
- **solder the lugs in copper conductor with the help of a blow lamp.**

Requirements

Tools/Instruments

• Electrician tool kit	- 1 No.
• Combination piler 200 mm	- 1 No.
• Electric soldering iron 125W, 250V, 50Hz	- 1 No.
• Flat file bastard 250 mm	- 1 No.
• Electrician's knife 100 mm	- 1 No.
• Steel rule 300 mm	- 1 No.
• Diagonal cutting plier 150 mm	- 1 No.
• Blowlamp 1 litre capacity	- 1 No.
• Tongs 300 mm	- 1 No.
• Sheet steel tray 150 x 150 x 20 mm	- 1 No.

Materials

• Finished simple twist joint	- 1 No.
• Sandpaper ‘OO’ grade	- 9 Sq.cm
• Resin-cored solder	- 25 gms
• VIR or PVC copper cable 7/1.06 mm or 7/0.914 - 250 mm long	- 2 pieces
• Lug 30 amperes	- 1 No.
• Resin flux	- 10 gms.
• Solder stick 60/40	- 100 gms.
• Matchbox	- 1 No.
• Cotton tape or cloth	- as reqd.
• Sandpaper `O' grade	- 9 sq. cm.
• Blowlamp pin	- 1 No.
• Kerosene	- 1 litr.

PROCEDURE

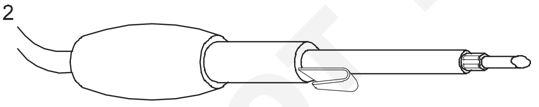
TASK 1: **Solder the copper joints**

(A finished soldered joint will look like Fig 1.)

Fig 1

1 Select a 60W, 240V AC 50 Hz. soldering iron (Fig 2) and check that the iron has no physical damage, the body is well insulated from the element and is of the correct voltage and power rating.

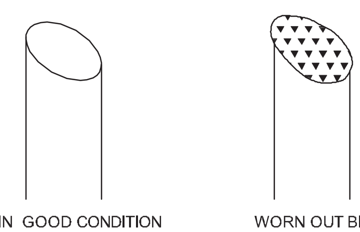
Fig 2



A soldering iron should show continuity between its terminals. Insulation resistance between the terminal and the body should not be less than 2 megohms. Report to your instructor in case the insulation resistance is less than 2 megohms. Do not use the iron unless it is cleared by your instructor.

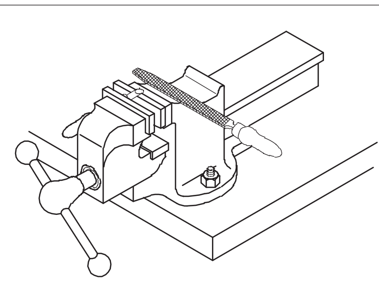
2 Check the bit (Fig 3) to see whether the surface is smooth and clean.

Fig 3



3 If found corroded, file the tip with a flat file, so that the surface is smooth and clean. (Fig 4)

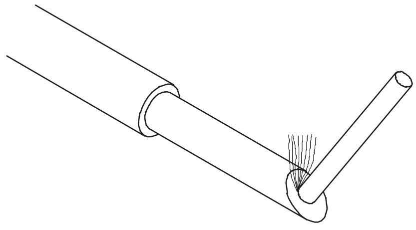
Fig 4



4 Connect the soldering iron to the supply and switch it `ON'.

5 When the bit becomes sufficiently hot, apply a small quantity of rosin-cored solder, and tin the bit. (Fig 5)

Fig 5



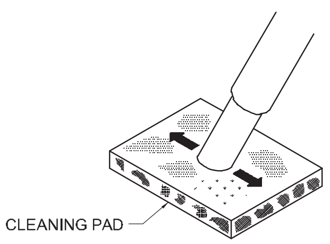
TINNING THE SOLDERING BIT

If the bit is not completely and evenly covered with solder, clean and tin it again.

Never flick excess solder off the bit. The hot solder may cause burns to someone or fall on the work and cause a short circuit.

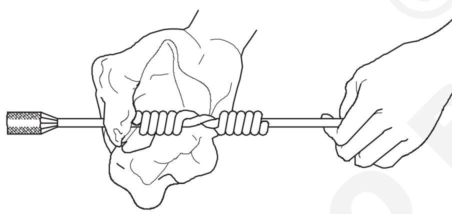
6 Wipe the bit gently on the cleaning pad to remove excess solder as shown in Fig 6.

Fig 6



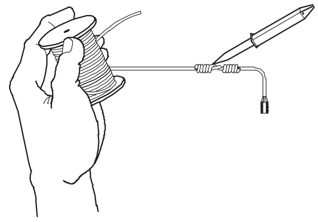
7 Clean the joint to be soldered with the help of sandpaper `0 0', grade as shown in Fig 7, and wipe the dust with a wire brush.

Fig 7



8 Keep the soldering iron bit on the joint and heat it for soldering as shown in Fig 8.

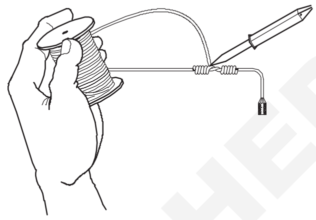
Fig 8



SOLDERING A SMALL SIZED JOINT

9 Keep the rosin-cored solder on the wire joint and allow it to melt as shown in Fig 9.

Fig 9

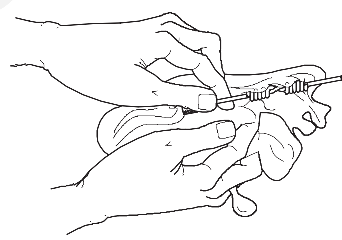


SOLDERING A SMALL SIZED JOINT

10 Melt the solder with the heat of the bit and make sure that the solder flows freely and evenly on the joint.

11 Remove the soldering iron. use cotton cloth to wipe off the excess solder from the surface of the joint when it is still hot as shown in Fig 10.

Fig 10



12 Allow the joint to cool naturally. Do not blow air for cooling.

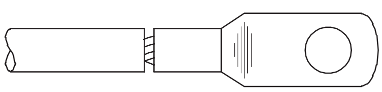
A shining solder surface indicates good soldering. Do not move the joint until the solder solidifies.

— — — — — —

TASK 2: **Solder lug to a copper conductor**

(A soldered lug should look as shown in Fig 1.)

Fig 1



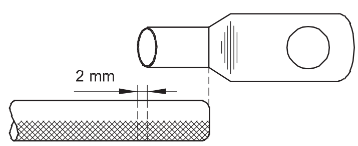
SOLDERED LUG

1 Collect a 30 amps cable lug, copper cable 7/1.06 or 7/0.914(6 sq.mm) of 250 mm length, blowlamp, matchbox, cotton cloth, solder stick, tray and flux.

2 Clean the inner and outer surfaces of the 30 amps cable lug using `00' grade sandpaper.

3 Put the cable lug to one end of the cable and mark the cable according to the depth of the cable lug, as shown in Fig 2.

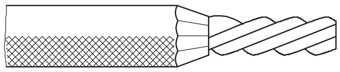
Fig 2



MEASURING CABLE FOR FIXING LUG

4 Add about 2 mm to the marking, remove the insulation from the cable (Fig 3) and clean the strands.

Fig 3



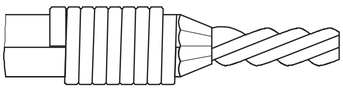
CABLE WITH REMOVED INSULATION

PD20N1225J3

Avoid damage to the strands of the cable while skinning. Clean the tray thoroughly. The tray should be free from dirt and water.

5 Wrap a cloth/cotton tape on the insulation of the cable to a length of 30 mm as shown in Fig 4, and wet it with water.

Fig 4



WRAPPED WITH WET CLOTH

PD20N1225J4

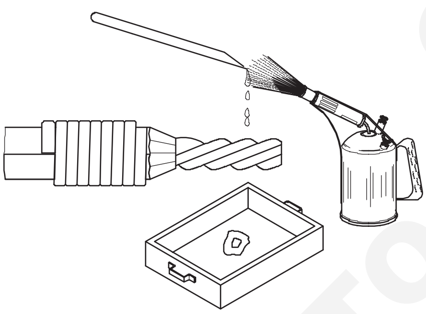
Use minimum water to wet the cloth/tape. Do not allow water to drip.

6 Light the blowlamp and let it emit a blue flame.

7 Apply a thin coat of flux to the cable end.

8 Tin the cable end by monitoring the blowlamp on the solder stick and allowing the molten solder to fall on the bare stranded cable end as shown in Fig 5.

Fig 5



TINNING CABLE END

PD20N1225J5

A thin coating of tin should be on the stranded cable end.

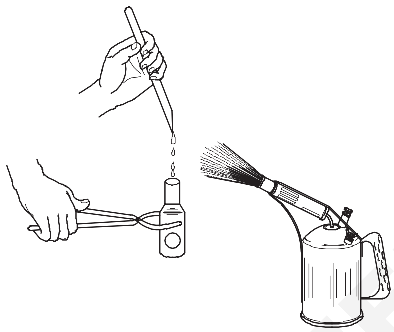
9 Apply a small quantity of flux inside the lug socket. Tin the lug by melting the solder stick to fill the socket and pour the molten solder in the tray.

Pouring out the molten solder from the lug socket a couple of times will make the tinning perfect.

10 Apply some flux to the cable end and the interior of the socket.

11 Fill the socket of the lug with molten solder. (Fig 6)

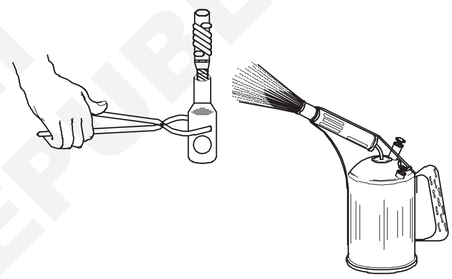
Fig 6



PD20N1225J6

12 Monitor the blowlamp flame on the socket, insert the cable in the socket and hold the cable vertically as shown in Fig 7.

Fig 7



PD20N1225J7

13 Remove the blowlamp and firmliy hold the cable and socket without shaking.

14 Remove the extra solder from the lug and cable by wiping it with a piece of cotton cloth while the solder is still hot.

15 Keep on holding the cable and lug as in Fig 7 and allow the solder to solidify.

Do not use water to cool the lug. This will crystallize the solder and make it weak.

— — — — — —

Practice on measurement of parameters in combinational electrical circuit by applying Ohm's Law for different resistor values and voltage sources

Objectives: At the end of this exercise you shall be able to
- **verify the relation between voltage and current when resistance is constant**
- **verify the relation between current and resistance when keeping voltage is constant**
- **plot the graph in both conditions illustrating the behaviour of current with respect to resistor.**

Requirements

Tools/Instruments

- Screwdriver 150 mm - 1 No.
- MC Ammeter 0 to 500 mA - 1 No.
- MI Ammeter 0 to 1A - 1 No.
- MC Voltmeter 0 15 V - 1 No.

Equipment/Machines

- 12 Volts battery 60 AH capacity OR - 1 No.
- DC variable power supply 0 - 30 V 2 amperes - 1 No.
- Rheostat 20 ohms - 3.7A - 1 No.

Materials

- S.P. Switch, 6A, 250V - 1 No.
- Resistors 10, 20, 50 Ohms 5 watts - 1 each.
- Resistor 20 ohms,2W - 1 No.
- Connecting leads 14/0.2 mm - 1 No.
- P.V.C. insulated copper wires of assorted length - 8 Nos.

PROCEDURE

TASK 1**: Verify the relation between current and voltage when resistance is constant**

1 Check the voltmeter from the dial marking 'V'.

2 Check the ammeter from the dial marking 'A'.

3 Identify the fixed and variable terminals of the rheostat.

4 Connect the circuit elements as shown in Fig 1.

Fig 1

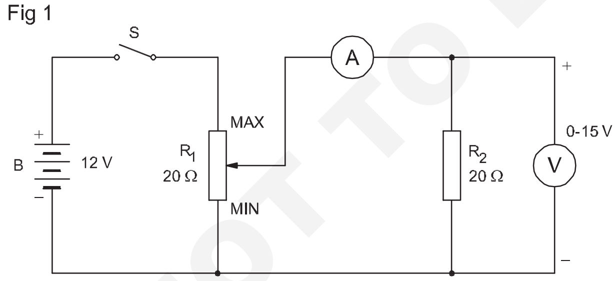


TABLE 1

No.	VOLTAGE (VOLTS)	CURRENT (AMPS)	$I \propto V$ / $I \propto V$

PD20N1326H1

5 Check the value of each major division and minor division of the scales of the meters.

6 Close the switch keeping the variable rheostat at the minimum value of output.

7 Apply different voltages by varying the rheostat arm of the potential divider in succession across the resistance.

8 Measure the voltage and the corresponding current from the instruments.

9 Record the measured values in Table 1.

To avoid parallax error:

Position your eye in line with the pointer and also in front level of the instrument

Position your eye to coincide with the mirror image of the pointer in instruments having anti-parallax mirror.

Conclusion

Write your findings and conclusion by interpreting the current and voltage

____

____

— — — — — —

TASK 2: **Verify the relation between current and resistance: Voltage is constant and resistance is variable.**

1 Connect the circuit elements as shown in Fig 1 with 0 -1A ammeter. Adjust V at 10 volts keep it constant.

2 Close the switch 'S' and measure the current and voltage.

3 Read and record values in the given Table 2.

4 Open the switch (OFF). Change the ammeter to 0-500 mA and repeat steps 2 and 3 by replacing 10 - ohm resistance by 20 and 50 ohms.

5 Refer the recorded value.

Write your findings and conclusion by interpreting the current and resistance.

Conclusion

____

____

Fig 1

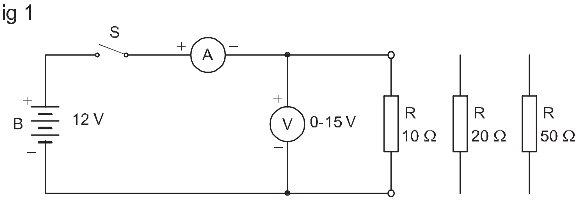


TABLE 2

No.	VOLTAGE (VOLTS)	RESISTANCE (OHMS)	CURRENT (AMPS)	$I \propto R$ / $I \propto R$

PD20N1326J1

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Measure current and voltage in electrical circuits to verify Kirchhoff's Law

Objectives: At the end of this exercise you shall be able to
- **verify Kirchhoff's current Law in two and three branch currents**
- **verify Kirchoff's voltage Law with one voltage and two voltage source.**

Requirements

Tools/Instruments/Equipment

- Trainees kit - 1 No.
- Variable DC power supply unit 0-30V/1A - 2 Nos.
- Milliammeters 0 - 500 mA - 3 Nos.
- Milliammeters 0 - 30 mA - 1 No.
- Power supply unit 0 - 30 V - 1 No.

Materials

- Resistors 1K - 4 Nos.
- Resistors 2.2K - 1 No.
- Resistors 3.3K - 1 No.
- Resistors 4.7K - 1 No.
- Lug board - 1 No.
- Toggle switch, SPST, 1amp. - 2 Nos.
- Patch cords - as reqd.
- SPST switch 6A, 250V - as reqd.

PROCEDURE

TASK 1: **Verify the Kirchhoff's current law with two branch currents**

1 Connect the PSU, milliammeters, SPST switch and resistors as illustrated in the schematic circuit and the layout diagram as shown in Fig 1.

> **Keep the SPST and PSU in the OFF position while making circuit connections.**

2 Switch 'ON' PSU and set output to 12 volts.

3 Simplify the circuit in Fig 1 and calculate the theoretical total circuit current and branch currents of the circuit for a set DC supply of 12 volts. Record values in Table 1.

> **Check if the connected ammeters can measure the calculated current. Change the meter, if necessary.**

4 Get the circuit connections checked by your instructor.

5 Switch ON SPST.

6 Measure and record the total circuit current (I_T) and branch currents I_{B1} and I_{B2} in Table 1.

7 Switch OFF the SPST.

8 Set the output of the RPSU to 9 volts.

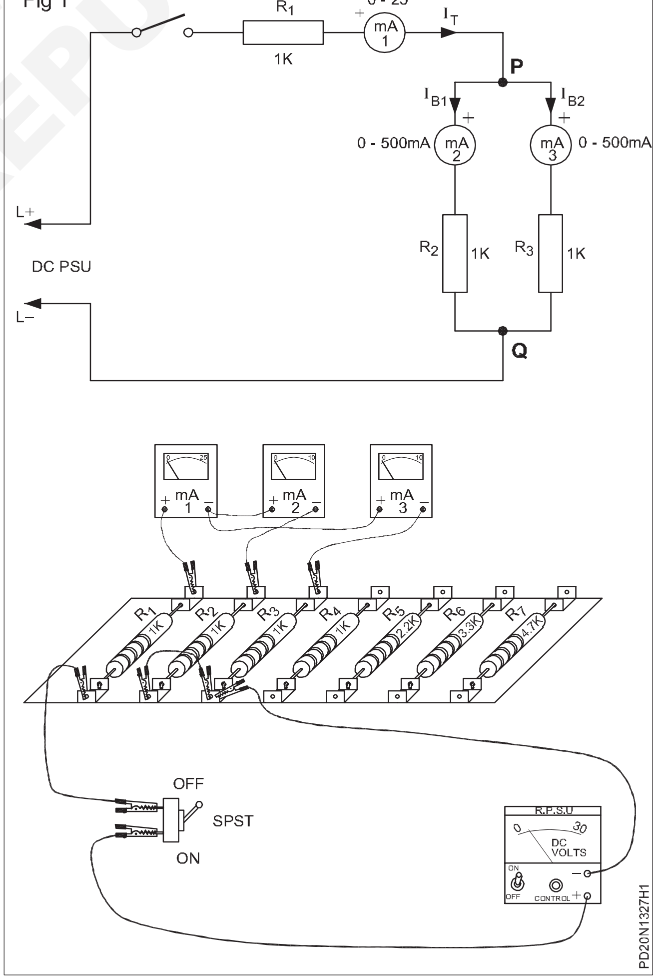
9 Calculate the theoretical circuit currents for the set supply voltage of 9V.

10 Record values in Table 1.

11 Repeat steps 4 and 6.

12 Switch OFF SPST and PSU.

Fig 1



13 Write Kirchhoff's current equations for the nodes P and Q.

14 Verify the equation substituting the measured current values.

15 Get the readings and equations checked by your instructor.

Table 1

Set circuit voltage	Calculated values of circuit current			Measured values of circuit currents		
	Total circuit (I_T) $I_T = I_{B1} + I_{B2}$	I_{B1}	I_{B2}	Total circuit (I_T) $I_T = I_{B1} + I_{B2}$	I_{B1}	I_{B2}

— — — — — —

TASK 2 : **Verify the Kirchhoff's current Law with three branch currents**

1 Make circuit connections on the lug board as per the schematic circuit in Fig 1.

Make it a practice to keep the SPST and PSU switches in the OFF position while making circuit connections.

2 Get the wired circuit checked by your instructor.

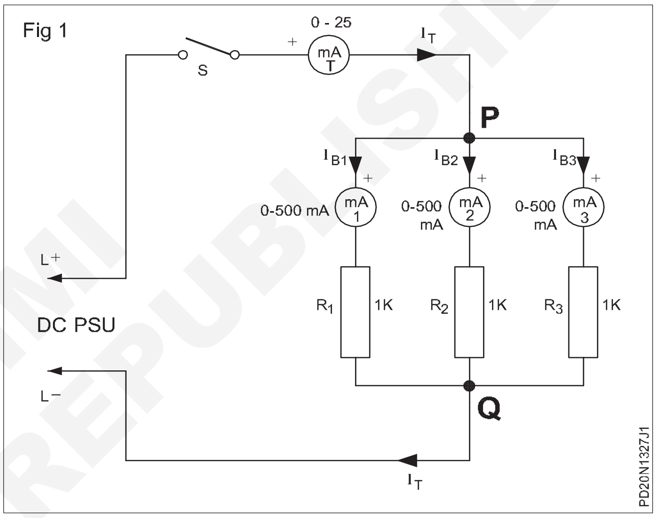
3 With the SPST in OFF position, set the output of PSU to 12 volts.

4 Switch ON the SPST switch. Measure and record currents I_T, I_{B1}, I_{B2} and I_{B3} in Table 2.

5 Switch OFF SPST and PSU.

6 Write Kirchhoff's current equations at nodes P and Q. Verify the equation using measured current values.

7 Get the readings and equations checked by your instructor.



8 Record your findings and conclusions after verifying the recorded and calculated values and check if it is same as per the theoretical conclusions.

Table 2

Set circuit voltage	Total circuit current (I_T)$I_T = I_{B1} + I_{B2} + I_{B3}$	Branch currents		
		I_{B1}	I_{B2}	I_{B3}
12V				

— — — — — —

TASK 3: **Verify the Kirchhoff's voltage Law with one voltage source**

1 Measure and record in Table 3, values of resistors R_4, R_5 and R_6 soldered on the lug board.

2 Make the circuit connections as shown in Fig 1.

3 Mark the polarity of the voltage drops across resistors R_4, R_5 and R_6 in the copy of Fig 1.

4 Get the circuit connections and polarities marked and checked by your instructor.

5 Switch ON PSU and set output to 12V. Switch ON SPST. Following the voltage polarities marked across the resistors, measure and record the drop in voltage across resistors R_4, R_5 & R_6 in Table 3.

6 Switch OFF SPST and PSU.

7 Write Kirchhoff's loop equations for the closed paths a-c-d-b-a, a-e-f-b-a and c-e-f-d-c. Substitute the

voltage readings recorded in Table 3 in the equations for verification.

8 Get your readings and equations checked by your instructor.

Fig 1

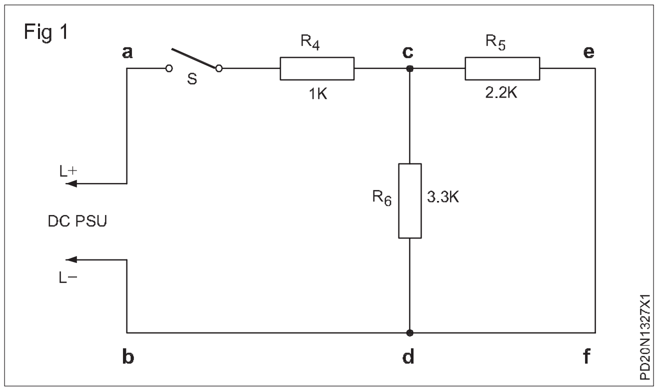


Table 3

Set circuit voltage	Measured values of			Voltage measured across		
	R_4	R_5	R_6	V_{R4}	V_{R5}	V_{R6}

— — — — — —

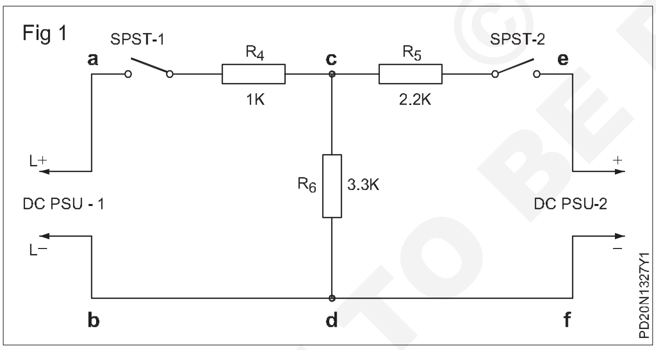
TASK 4: **Verify the Kirchhoff's voltage Law with two voltage sources**

1 Modify the circuit connections made in TASK 3, to obtain a circuit as shown in Fig 1.

Keep both the PSU's and the two SPST's in the OFF position while making circuit connections.

2 Mark the polarity of the voltage drops across the resistors R_4, R_5 and R_6 in the copy of Fig 1.

Fig 1



3 Set the output of PSU-1 to 12 volts and PSU-2 to 6 volts.

4 Switch ON both SPSTs. Following the voltage polarities marked across the resistors, measure and record the voltage drop across the resistors R_4, R_5 & R_6 in Table 4.

Note: While measuring voltage across resistors, if the meter deflects below zero, recheck the polarity marked at step 2 and repeat step 4.

5 Switch OFF the SPSTs and PSUs.

6 Write Kirchhoff's voltage equations for the closed paths a-c-d-b-a, a-e-f-b-a and c-e-f-d-c.

7 Get your readings and equations checked by your instructor.

8 Record your findings and conclusion after verifying the recorded and calculated values and check if it is same as per the theoretical conclusions.

Table 4

Set output of RPSU 1	Set output of RPSU 2	Voltage measured across		
		V_{R4}	V_{R5}	V_{R6}

— — — — — —

Verify law's of series and parallel circuits with voltage source in different combinations

Objectives: At the end of this exercise you shall be able to
- **verify the laws of series circuits**
- **verify the laws of parallel circuits.**

Requirements

Tools/ Instruments

- Electrician tool kit - 1 Set
- Ammeter MC 0-500 mA - 3 Nos.
- Rheostat - 100 ohms, 1A - 1 No.
- Voltmeter MC 0-15V - 1 No.
- Multimeter - 1 No.
- Rheostat 0 - 25 ohm, 2A - 2 Nos.
- Potentiometer 60 ohm, 1A - 1 No.
- Rheostat 0 - 300 ohm, 2A - 2 Nos.
- Rheostat 0 - 10 ohm,5A - 2 Nos.

Equipment/ Machines

- DC source, 0 - 6V/30AH (battery), Battery 12V, 90AH - 1 No. OR DC 0-30V variable voltage supply source with current limiting facility 0-1 ampere - 1 No.

Materials

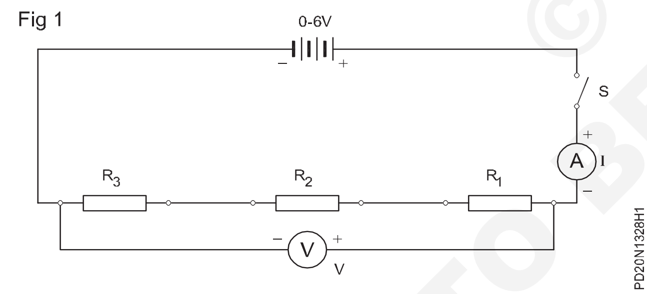
- Switch SPT 6A 250V - 1 No.
- Resistor 10 ohm 1 W - 2 Nos.
- Resistor 20, 30, 40 & 60 ohm 1 W - 1 No. each
- Connecting cables - as reqd.

PROCEDURE

TASK 1: **Verify the characteristics of series circuits**

1 Construct/ assemble the circuit as shown in Fig 1. (R_1 = 10 Ω, R_2 = 20 Ω , R_3 = 10 Ω)

Fig 1

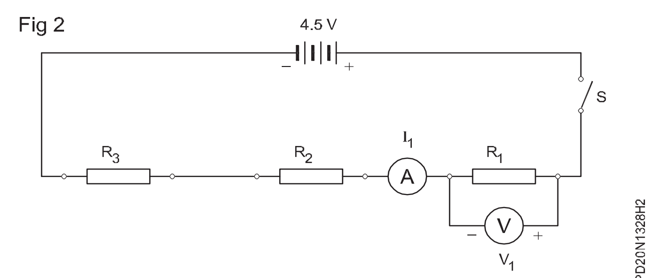


2 Close the switch 'S', measure the current (I) and voltage (V).

3 Enter the measured value in Table 1.

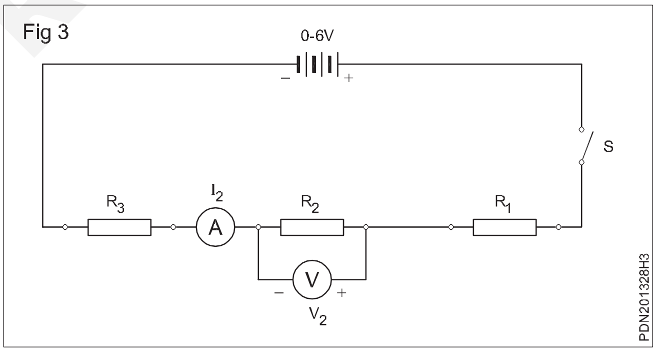
4 Switch OFF the supply. Reconnect the ammeter and voltmeter as shown in Fig 2 and measure voltage (V_1) and current I_1 through R_1.

Fig 2



5 Switch OFF the supply. Reconnect the voltmeter and ammeter as shown in Fig 3 and measure the voltage (V_2) and current (I_2) in R_2.

Fig 3



6 Draw the circuit diagram showing the position of A and V in the circuit to measure the current (I_3) and voltage (V_3) across R_3.

7 Connect and measure the I_3 and V_3 across R_3.

8 Enter the measured values in Table 1.

9 Record the relationship between I_1, I_2, I_3 and I.

____

____

10 Write down the mathematical form of current law of a series circuit.

____

____

11 Record the relationship between V_1, V_2, V_3 and V.

____

____

____

12 Write down the mathematical form of voltage law of a series circuit.

V =

13 Calculate resistance from the measured values, record the results with the values indicated on the resistors.

14 Record the relationship between R and R_1, R_2, R_3.

____

____

____

15 Write down the mathematical form of resistance law of a series circuit.

R =

16 Get it checked by the instructor

Table 1

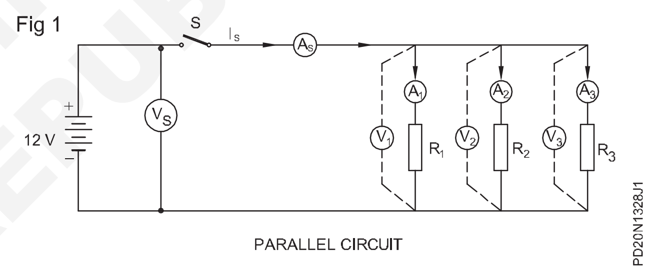
Values	Total	R_1=10	R_2=20	R_3=10
Current	I =	I_1 =	I_2 =	I_3 =
Voltage	V=	V_1 =	V_2 =	V_3 =
Resistance	R = ______ =	R_1=______ =	R_2=______ =	R_3=______ =

— — — — — —

TASK 2: **Verify the characteristics of parallel circuits**

1 Use an Ohm meter to set the values of a rheostat or resistor R_1 = 40 ohms, R_2 = 60 ohms and R_3 = 30 ohms.

While using multimeter to measure resistance values see that the supply is OFF and the supply source is disconnected from the circuit.



2 Connect the resistors (Rheostats) in parallel with the switch S, ammeter A, voltmeter V and battery B as in Fig 1 and measure the current I_s and V_s. Record the valuesin Table 2.

Table 2

Measured Value of R_T = ----------Ohms

Sl.No.	R_1	R_2	R_3	Calculated $R_T = \frac{1}{\frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_3}}$	I_S	V_S	$R_T = \frac{V_S}{I_S}$

3 Get it checked by the instructor

4 Measure the voltages V_S, V_1 , V_2 & V_3 and record them in Table 3.

5 Calculate the current through each resistor taking into consideration V_S, applying Ohm's law and enter the values in Table 3.

6 Measure the currents I_S, I_1, I_2 & I_3 and record them in Table 3.

7 Compare the calculated values with the measured values. Record your observation. ________________

____

Table 3

V_s	V_1 Measured	V_2 Measured	V_3 Measured	Calculated				Measured			
				I_S	I_1	I_2	I_3	I_S	I_1	I_2	I_3

7 Calculate the value of total resistance R_T, from the above measured values.

8 Compare the measured and calculated values of total resistance R_T.

Verification

Current Characteristics $I_S = I_1 + I_2 + I_3$

Voltage Characteristics $V_S = V_1 = V_2 = V_3$

Total Resistance $R_T = \frac{1}{\frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_3}}$

Conclusion

____

____

9 Get the work checked by the instructor.

— — — — — —

Measure the voltage and current against individual resistance in electrical circuit

Objectives: At the end of this exercise you shall be able to
- **connect individual resistor in series and measure current and voltage**
- **connect individual resistor in parallel and measure current and voltage**
- **compare the theoretical values with actuals in the circuit.**

Requirements

Tools/ Equipments

- Cutting plier 150 mm - 1 No.
- Screw driver 150 mm - 1 No.
- Voltmeter MI 0-300V - 1 No.
- Ammeter MI 0 - 1A - 1 No.
- Multimeter - 1 No.
- AC source 240V/6A - as reqd.

Materials

- Connecting leads - as reqd.
- Lamp 250V/ 40W - 2 Nos.
- Lamp 250V/ 60W - 2 Nos.
- Switch 240V/6A - 2 Nos.

PROCEDURE

TASK 1: **Measure the voltage and current of resistors in series**

1 Construct the circuit as shown in Fig 1.

2 Record the cold resistor value of lamps in Table 1.

3 Connect two 40W lamps in series and switch 'ON" AC 240V/6A. Measure and record the current and voltage V_1 and V_2 in Table 1 as per Fig 1A.

4 Switch 'OFF' and replace One 40W lamp and connect 60W lamps in series and repeat the step 3 process after switch 'ON' (Fig 1B).

5 Switch OFF and connect 2 lamps of 60W in series and repeat step 4. (Fig 1C).

6 Get the work checked by the instructor

Fig 1

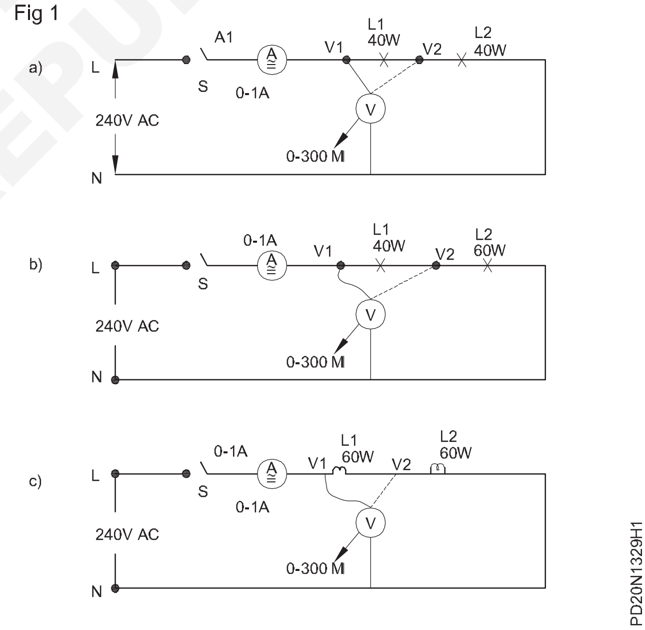


Table 1

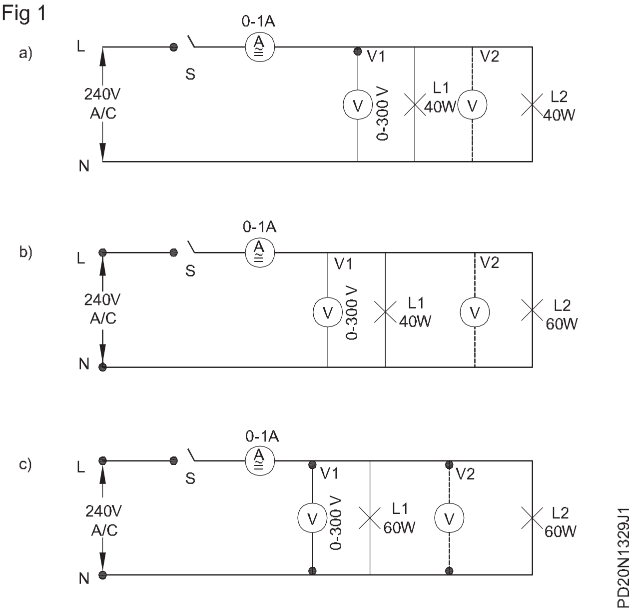
Cold resistor		40W - 40W In series			40W - 60W In series			60W - 60W In series		
40W	60W									
		A	V1	V2	A	V1	V2	A	V1	V2
Value Measured										
Value Calculated										

— — — — — —

TASK 2: **Measure the voltage and current of resistors in parallel**

1 Connect the circuit as shown in Fig 1.

Fig 1



2 Connect two 40W lamps in parallel and switch 'ON' AC 240V/6A. Record the current, voltage V_1 and V_2 in Table 2 as per Fig 1A.

3 Switch 'OFF' and replace one 40W Lamp with 60W Lamp. Switch 'ON'and repeat the step 2 (Fig 1B).

4 Switch OFF and use two 60W Lamps and repeat step 3 (Fig 1C).

5 Record the reading in Table - 2 and write the conclusion.

6 Get the work checked by the instructor.

Table 2

Cold resistor		**40W - 40W In parallel**			**40W - 60W In Parallel**			**60W - 60W In Parallel**		
40W	**60W**									
		A	**V1**	**V2**	**A**	**V1**	**V2**	**A**	**V1**	**V2**
Value measured										
Value calculated										

— — — — — —

Measure current and voltage and analyse the effects of shorts and opens in series and parallel circuits

Objectives: At the end of this exercise you shall be able to
- **examine the effects of short circuited resistors in series circuits**
- **analyse the effects of open circuited resistors in series circuits**
- **examine the effects of short and open circuited resistors in parallel circuits**
- **analyse the effects of short and open circuited resistor in parallel circuits.**

Requirements

Tools/ Instruments

- Screwdriver 150 mm - 1 No.
- Voltmeter MC 0-15V (Sensitivity 20K Ω/V) - 1 No.
- Voltmeter 0 - 15V MC - 1 No.
- Ammeter 0 - 500mA - 1 No.
- Multimeter - 1 No.
- Rheostat 100/120 Ω, 300 Ω,1A - 1 No.
- DC voltage source variable 0-15V, 1 amp or Battery lead acid 12V, 60AH - 1 No.
- Rheostat 0 - 300 Ω, 2A - 1 No.
- DC voltage source variable 0-15V, 1 amp or Battery lead acid 12V, 80AH - 1 No.

Materials

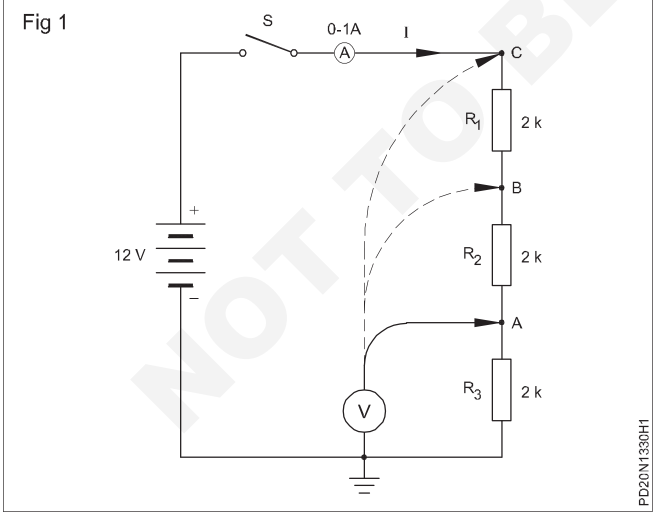
- Resistors 2K, 1 Watt - 3 Nos.
- Connecting leads - as reqd.
- Switch 6A 250V - 2 Nos.
- Resistors, carbon composition 62KΩ 1/4 W, ± 5% - 1 No.
  - 33KΩ - 1 No.
  - 22KΩ - 1 No.
- Resistors, carbon composition
  - 220Ω - 1 No.
  - 1/2 W, ± 5%
  - 330 Ω - 1 No.
  - 470 Ω - 1 No.

PROCEDURE

TASK 1: **Examine the effects of short and open circuited resistors in series circuits**

1 For the circuit in Fig 1, calculate the nominal values for the voltages V_A, V_B and V_C and record them in Table 1.

Fig 1



Note: All voltages are with respect to ground.

2 Considering resistor R_1 as shorted, calculate and record the resulting voltages at A, B and C, if this were to occur.

3 Enter the calculated values in the first column of Table 1 under the heading `Fault conditions'.

4 Repeat steps 2 and 3 for each resistor in turn.

5 Consider now removing R_1, calculate and record the resulting voltages at A, B and C.

6 Enter the calculated values in the fourth column of Table 1 under the heading `Fault conditions'.

7 Repeat this for each resistor in turn.

Note: Only one fault is simulated.

8 Verify your calculations in steps 3 and 6 by connecting a piece of wire across each resistor in turn, simulating a short circuit across that resistor, and then removing each resistor, simulating an open at the location.

10 Measure voltage for each fault condition and be sure to check consistency with the calculated values.

11 Record all measured data in the corresponding columns of Table 1.

12 Analyse the readings in healthy condition (normal condition) and faulty (OC and SC) condition and record the findings.

13 Get the work checked by your instructor.

Table 1

Voltages	Nominal Value	Fault conditions											
		R_1 Cal	S/C Meas	R_2 Cal	S/C Meas	R_3 Cal	S/C Meas	R_1 Cal	O/C Meas	R_2 Cal	O/C Meas	R_3 Cal	O/C Meas
V_A													
V_B													
V_C													

Cal - Calculated S/C - Short circuited

Meas - Measured O/C - Open circuited

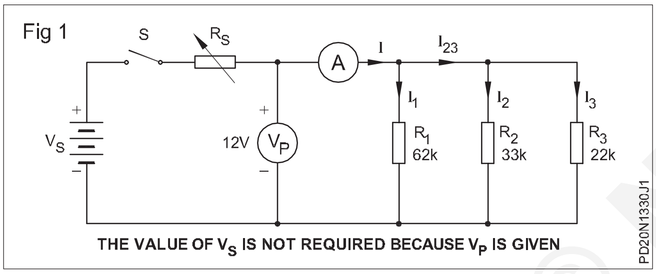
— — — — — —

TASK 2 : **Analyse the effect of short and open circuited resistors in parallel circuits**

1 Calculate the nominal values for the currents I, I_1 and I_{23}, I_2 and I_3 for the circuit in Fig 1 and record them in Table 1.

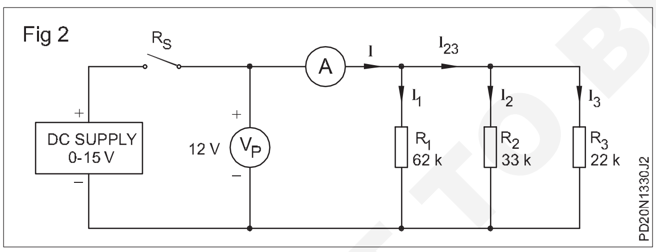
2 Construct the circuit (shown in Fig 1) and adjust R_S, source voltage series resistor, to a value that produces 12 volts across the parallel set of resistors.

Fig 1



3 Set the current limit to 100mA, if the DC power supply with current limiting feature is used as V_s. Omit the series resistor R_S. (Fig 2)

Fig 2



4 Measure and record the values of currents (I, I_1, I_{23}, I_2, and I_3). (Use Multimeter DC milliamperes range). Record them in the 'nominal' column in Table 2.

5 Now consider a shorted R_1. Estimate and record the resulting currents if this were to occur. Enter the calculated values in the first column in Table 1 under the heading `Short resistor'.

6 Repeat step 5 for each resistor in turn.

7 Now consider removing R_1. Calculate and record the resulting currents if this were to occur. Enter the calculated values in the last column in Table 1 under the heading `Open resistor'.

8 Repeat step 7 for each resistor in turn.

Only one fault is simulated.

9 Verify the calculations in steps 5 and 6 by connecting a piece of wire across each resistor in turn to simulate a short circuit across that resistor. Measure and record the current for each fault condition in Table 2.

10 Check the measured value of current consistency with the calculated values in Table 1.

11 Verify the calculation in steps 7 and 8 by removing each resistor in turn to simulate an open circuit at that location.

12 Measure and record the current for each fault condition in Table 2 .

13 Check for the measured value of currents consistency with the calculated values in Table 2.

14 Analyse the readings in healthy condition (normal) and faulty (OC & SC) condition and record the findings.

15 Get it checked and approved by the instructor.

Table 1

Currents	Nominal	Calculated value of current					
		Short resistor			Open resistor		
		R_1	R_2	R_3	R_1	R_2	R_3
I							
I_1							
I_{23}							
I_2							
I_3							

Table 2

Currents	Nominal	Measured value of current					
		Short resistor			Open resistor		
		R_1	R_2	R_3	R_1	R_2	R_3
I							
I_1							
I_{23}							
I_2							
I_3							

— — — — — —

Measure resistance using voltage drop method

Objectives: At the end of this exercise you shall be able to
- **determine unknown high resistance by voltage drop method**
- **test unknown low resistance by voltage drop method.**

Requirements

Tools/Equipments

- Cutting plier 150 mm - 1 No.
- Screwdriver 100 mm - 1 No.
- Ammeter MC 0-500 mA - 1 No.
- Multimeter - 1 No.
- DC power supply unit 0-30V (RPS) - 1 No.

Materials

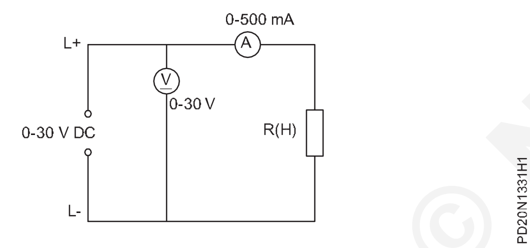
- Resistor high value - 2 Nos.
- Resistor low value - 2 Nos.

PROCEDURE

TASK 1: **Measure the high value resistance by voltage drop method**

1 Construct the circuit as diagram. shown in Fig 1 and connect the high value resistor.

Fig 1



2 Switch ON power supply and adjust the DC volt to 30V.

3 Note the current and record it in Table 1.

4 Replace with another high value resistor and repeat step 3.

The true value and the measured value of R will be equal if we provide "0Ω resistance" ammeter and infinite voltmeter resistance.

Table 1

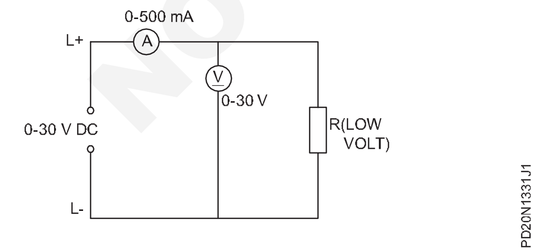
Sl.No.	V	I	$R_m = \frac{V\ reading}{A\ reading}$
1			
2			

— — — — — —

TASK 2: **Measure low value resistance by voltage drop method**

1 Construct the circuit as per shown in Fig 2 and connect the low value resistor.

Fig 1



2 Repeat step 2 in TASK 1.

3 Record the current and voltage in Table 2.

Table 2

Sl.No.	V	I	$R_m = \frac{V\ reading}{A\ reading}$
1			
2			

The true value and measured value of R will be equal if we provide "0Ω resistance" ammeter and infinite voltmeter resistance.

4 Write your conclusion

____

5 Get the work approved by the instructor.

Measure resistance using wheatstone bridge

Objectives: At the end of this exercise you, shall be able to
- **identify the terminals of a Wheatstone bridge**
- **complete the bridge with resistors**
- **operate a wheatstone bridge to get 'Null' deflection**
- **calculate the value of unknown resistance using the wheatstone bridge.**

Requirements

Equipment/Machines

- Wheatstone bridge - 1 No.

Materials

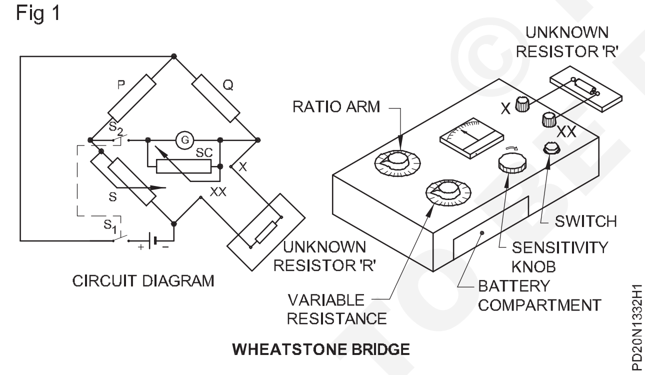
- Resistor 2 ohms 5W - 1 No.
- Resistor 50 ohms 5W - 1 No.
- Resistor 10 ohms 5W - 1 No.
- Resistor 1K ohms 2W - 1 No.
- Resistor 330K ohms 2W - 1 No.
- Torch cells/battery for Wheatstone bridge - as reqd.

PROCEDURE

TASK 1: **Measuring an unknown resistance using Wheatstone bridge**

1 Identify the ratio arm (PQ), variable resistance (S), sensitivity control (SC), switch (S1), galvanometer (G), connecting terminal (x, xx) and battery compartment of the Wheatstone bridge and correlate it with the schematic diagram in Fig 1.

Fig 1



2 Check the battery for its condition.

3 Check the values of the ratio arm.

4 Check the minimum and maximum values of the variable resistance.

5 Connect the unknown resistor across terminals x and xx.

6 Set the ratio arm to the approximate value of the unknown resistor.

7 Set the variable resistor knob in the middle.

8 Set the sensitivity control to `Low'.

9 Close the switch and watch the deflection of the galvanometer.

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

11 Increase the sensitivity and repeat step 10.

12 When `Null' deflection is achieved in the galvanometer, note the value of the ratio arm and position of the variable resistance. Enter the values in Table 1.

13 Apply the formula given below and calculate the resistance.

Unknown resistance in ohms = ____________

Reading of ratio arm setting X value of variable resistance

$$\frac{P}{Q} = \frac{S}{R}$$

$$R = \frac{S}{P} x\, Q$$

14 Enter the values in Table 1.

15 Repeat the procedure for measuring at least four unknown resistors and enter their respective values in Table 1.

16 Get the work approved by the instructor.

Table 1

Sl.No.	Type of resistor	Setting of ratio arm	Value of variable resistance	Resistor value in ohms = Ratio arm x value of variable resistance

— — — — — —

Determine the change in resistance due to temperature

Objectives: At the end of this exercise you shall be able to
- **measure cold resistance of the incandescent lamp using ohmmeter**
- **measure hot resistance of the incandescent lamp with supply by voltmeter and ammeter**
- **identify the colour of the filament with respect to the voltage variation**
- **determine the relation between resistance and changes in temperature.**

Requirements

Tools/Instruments

- Connector screwdriver 100 mm - 1 No
- MI Voltmeter 0-300V - 1 No.
- MC Ammeter 0-1A - 1 No.
- Ohmmeter (shunt type) - 1 No.
- MC Voltmeter - 5 volts or multimeter (digital) - 1 No.

Materials

- Double-pole switch 250V,6A - 1 No.
- Lamp 15W, 250V - 1 No.
- Lamp-holder B.C.batten - 1 No.
- Candle - 1 No.
- Potentiometer 500 ohms, 0.5A - 1 No.
- Iron wire 0.2 mm diameter. - 2.5m.
- Connecting leads - 11 Nos.
- Terminal post 16A - 2 Nos.
- Lamp 40W, 250V - 1 No.

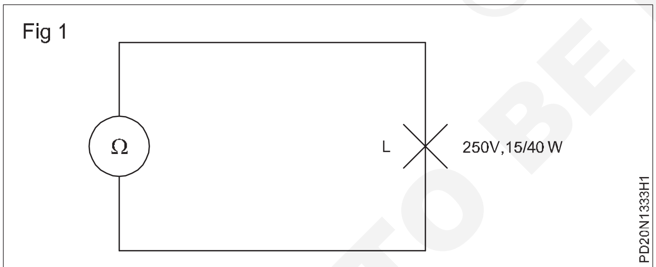
PROCEDURE

TASK 1: **Measuring of cold and hot resistance of the incandescent lamp by using ohmmeter**

1 Set the ohmmeter to 'zero' and touch the two leads on the pins of the lamp.

2 Measure the resistance of the given incandescent lamp using ohmmeter (Fig 1).

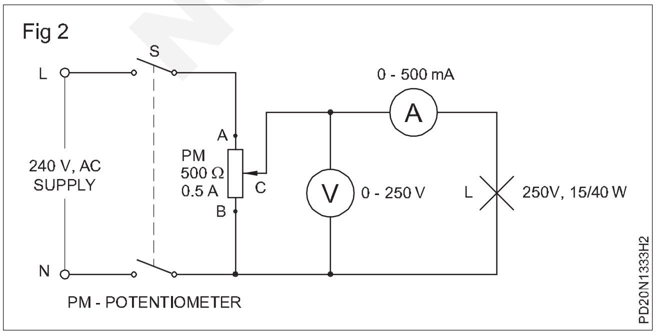
Fig 1



3 Record the value in Table 1.

4 Form the circuit with the lamp-holder, voltmeter, ammeter, potentiometer, D.P.S.T. switch and supply as per the circuit diagram. (Fig 2)

Fig 2



5 Get the circuit checked by the instructor. Keep the potential divider point C at B.

6 Fix the incandescent lamp in the lamp-holder and close the switch.

> **Note: Switch off the supply before fixing the lamp.**

7 Adjust the potentiometer at 50 volts.

8 Close the switch and read the voltmeter and ammeter.

9 Record the values in Table 1.

10 Observe the colour of the filament and feel the temperature on the lamp's glass.

Table 1

Measurement			R in Ω	Colour of filament
1	**Cold resistance of bulb measured by ohmmeter**			
	V in volts	**I in mA**		
2	50 V			
3	100 V			
4	150 V			
5	240 V			

— — — — — —

Verify the characteristics of series parallel combination of resistors

Objectives: At the end of this exercise you shall be able to
- **form series parallel combination circuits**
- **verify characteristics of series and parallel circuits.**

Requirements

Tools/ Instruments

- Electrician tool kit - 1 Set
- MC Ammeter 0-500 mA - 3 Nos.
- Rheostat - 100 ohms, 1A - 1 No.
- MC Voltmeter 0-15V - 1 No.
- Multimeter - 1 No.
- Potentiometer 60 ohm 2A - 1 No.
- Rheostat 25 ohms 2A - 1 No.
- Rheostat - 40 ohms,2A - 2 Nos.
- Rheostat - 300 ohms, 2A - 1 No.

Equipment/ Machines

- DC source,Battery 12V,80AH or DC 0-60V - 1 No.
  variable voltage supply source with current limiting facility 0-1 ampere - 1 No.

Materials

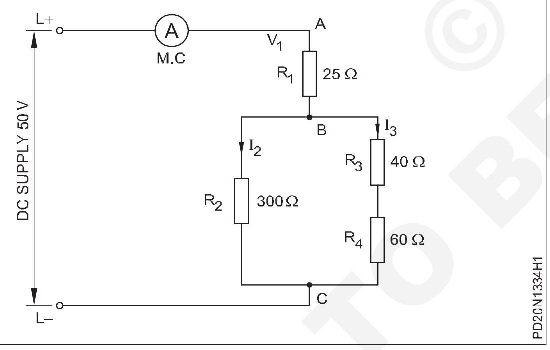
- Switch SPT 6A 250V - 1 No.
- Resistor 22 ohms 1 W - 1 No.
- Resistor 10 ohms 1 W - 1 No.
- Connecting cables - as reqd.

PROCEDURE

TASK 1: **Verify the characteristics of series parallel combination of resistors**

1 Draw the circuit diagram and calculate the voltage and currents for the series parallel circuit shown in Fig 1. Enter the values in Table 1.

Fig 1



2 Calculate the total resistance R_T and total current I_S for V_S = 50V and enter in Table 2.

3 Set the value of the rheostat resistances equal to the values given in Fig 1 (i.e. R_1 = 25 ohms, R_2 = 300 ohms, R_3 = 40 ohms and R_4 = 60 ohms) by measuring the resistance value between one end and the variable point of the rheostat.

4 Form the circuit and measure the voltages and current. Record them in Table 1.

5 Calculate the value of R_T from V_s and I_s and enter in Table 2. Compare with the value obtained in step 2.

Verification

$I_S = I_2 + I_3$; $V = V_R + V_R$; $R_T = R_1 + (R_2/(R_3 + R_4))$.

Table 1

		V_{RI}	I_S	I_2	V_{R2}	I_3	V_{R3}	R_3+R_4	$R_2 \| (R_3+R_4)$
V_S = 50V R_1 = 25Ω R_2 = 300Ω	Calculated Values								
R_3 = 40Ω R_4 = 60Ω	Measured Values								

Table 2

Calculated Values	$R_T = R_1 + \{R_2 \| (R_3 + R_4)\} =$
Measured Values	$R_T = \frac{V_S}{I_S} =$

Determine the poles and plot the field of a magnet bar

Objectives: At the end of this exercise, you shall be able to
- **identify the polarity of the magnetic compass**
- **determine the polarity of a permanent magnet**
- **trace the magnetic field of the given magnetic bar**
- **trace the magnetic lines with the aid of a compass needle and iron filings.**

Requirements

Tools/Instruments

- Bar magnet 12 x 6 x 100 mm - 2 Nos.
- Compass needle 10 mm diameter. - 1 No.

Materials

- M.S.bar 12 x 6 x 100 m or (make a M.S. bar to the size of the bar magnet available) - 1 No.
- Thread (tensionless) - 1 m
- Iron filings - 25 gms
- Iron nails - 25 gms.
- Aluminium wire - a few pieces
- Copper wire - a few pieces
- Cotton thread sleeve - a few pieces
- Wood chips - a small quantity.
- Paper pins - as reqd.

PROCEDURE

TASK 1: **Identify the polarity of the magnetic compass**

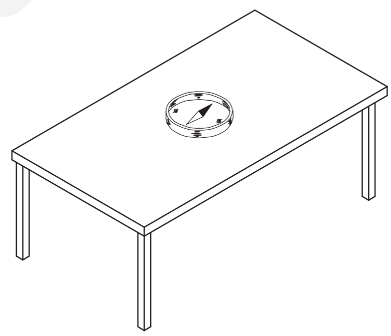
1 Keep the magnetic compass on the table as shown in Fig 1.

2 Observe the needle ends.

3 Turn the position of the compass and observe the position of the needle.

4 Result: The needle end seeking the geometrical north direction is the north seeking pole, or in general called a _________________ pole. The other end is called a ________________ pole.

Fig 1



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TASK 2: **Determine the polarity of a permanent bar magnet**

1 Suspend the magnet as shown in Fig 1 with a tensionless thread.

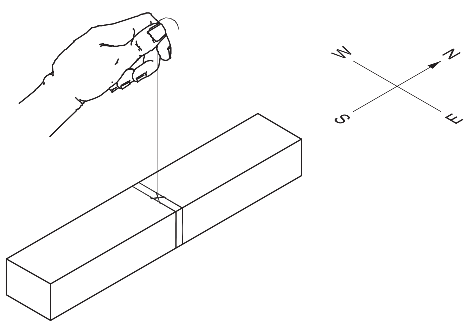
2 Observe the direction of the poles of the suspended magnet.

3 Mark the polarity N on the free end of the suspended magnet that points (seeks) at the north direction of the earth.

4 Reorient the position of the suspended magnet to confirm the polarity.

5 Check the identified polarity with a magnetic compass.

Fig 1



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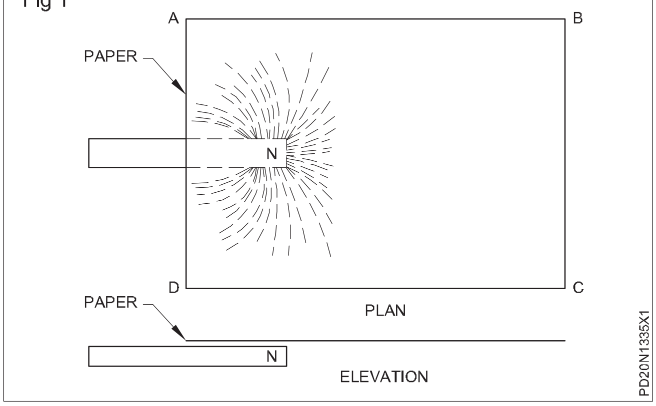
> **The compass needle must not be taken near the poles of the bar magnet.**

— — — — — —

TASK 3: **Trace the magnetic path of the given magnetic bar**

1 Place the bar magnet's north pole underneath the paper as shown in Fig 1. Sprinkle some iron filings on the paper.

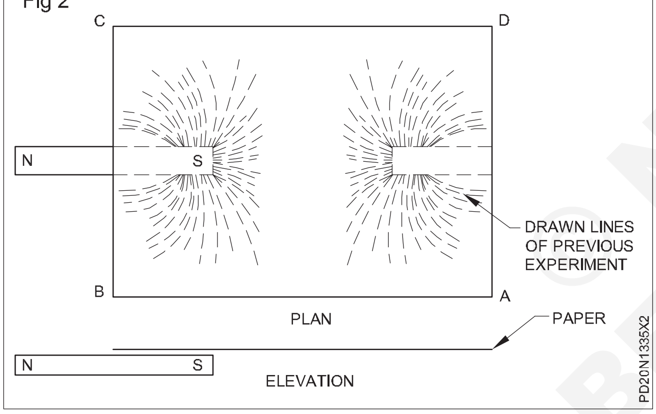
Fig 1



2 Tap the paper gently on all the corners. Observe the random filings getting oriented into a definite pattern.

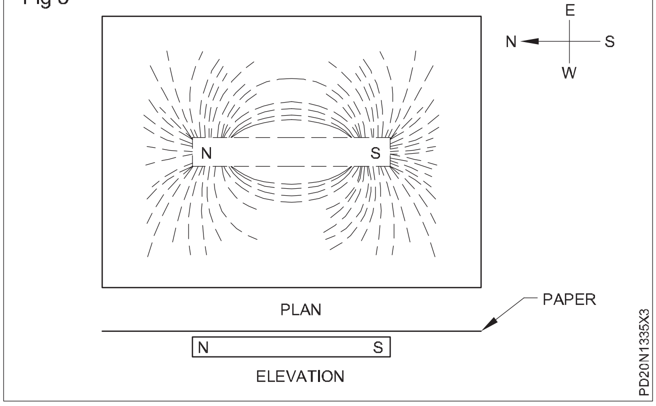
3 Gently draw lines along the orientation of the iron filings with a pencil. Repeat the experiment for the other pole as shown in Fig 2.

Fig 2



4 Place the bar magnet underneath a thin cardboard as shown in Fig 3. Sprinkle some iron filings. Gently tap the paper to orient the iron filings and trace the magnetic path with a pencil.

Fig 3

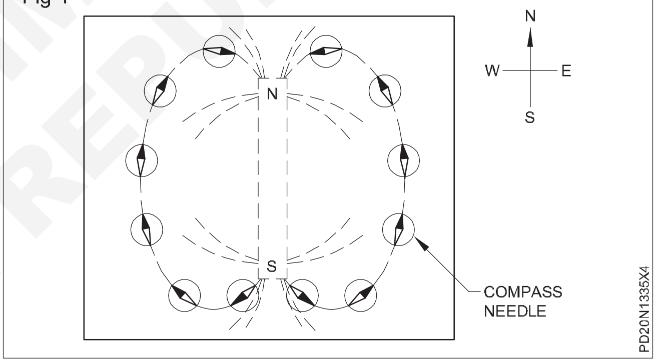


5 Place another thin card over the bar magnet as shown in Fig 4. Trace the magnetic lines using a compass needle by positioning the needle in the required areas.

For steps 4 and 5, the bar magnet should be oriented in the geometrical north-south direction.

Do not use a strong bar magnet for mapping the field with a compass.

Fig 4



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Wind a solenoid and determine the magnetic effect of electric current

Objectives: At the end of this exercise you shall be able to
- **prepare a bobbin**
- **select the suitable wire and make the winding for solenoid**
- **determine the pulling strength of a solenoid.**

Requirements

Tools/Instruments

- Combination pliers 150 mm - 1 No.
- Screwdriver 100 mm - 1 No.
- Screwdriver 150 mm with 3 mm blade - 1 No.
- Magnetic compass 12 mm diameter - 8 Nos.
- Rheostat 10 Ohms, 20A - 1 No.
- MC Ammeter 0-10A - 1 No.
- MC Ammeter 0-30A - 1 No.
- MC Voltmeter 0-15/0-25V - 1 No.

Equipment/Machines

- Battery 12V, 80 or 100AH or variable voltage source DC 0-25V, 30A - 1 No.

Materials

- Iron filings - 50 gms
- Connecting leads - as reqd.
- DPST knife switch 16A/ 250V - 1 No.
- Enamelled copper wire 16SWG - 50 cm
- Paper pins - a few
- Terminal post 16A - 2 Nos
- SPST knife switch 16A / 250V - 1 No.
- PVC insulated cable 4 sq.mm 250V grade - 4 m.
- Barrator resistor 0.48 ohms 250W - 1 No.
- Cardboard A4 (R 48) size - 1 No.
- Bare copper wire 4 sq.mm - 1 m.
- Porcelain connectors 2-way 32A - 2 Nos.
- Transparent sheet of plastic, A4 size, 3 mm thick - 1 No.
- PVC saddles 50mm - 2 Nos.
- PVC pipe 25 mm 100 mm long - 1 piece.
- PVC washer 25mm inner diameter. 50 mm outside dia. - 2 Nos.
- PVC adhesive tape - as reqd.
- Super-enamelled copper wire 22 SWG - 50m.
- 4–way terminal pad - 1 No.
- T W plank 150 mm x 300 mm - 1 No.
- Soft iron piece 22 mm dia 75 mm long with hook on one end - 1 No.
- SPST Knife switch 16A - 1 No.
- Adhesive paste for fixing washers - as reqd.
- PVC/Empire sleeve 2 mm - as reqd.

PROCEDURE

TASK 1: **Make the solenoid and determine its polarity for the given direction of current**

1 Fix the PVC washers at both ends of the PVC pipe to make the bobbin. (Fig 1)

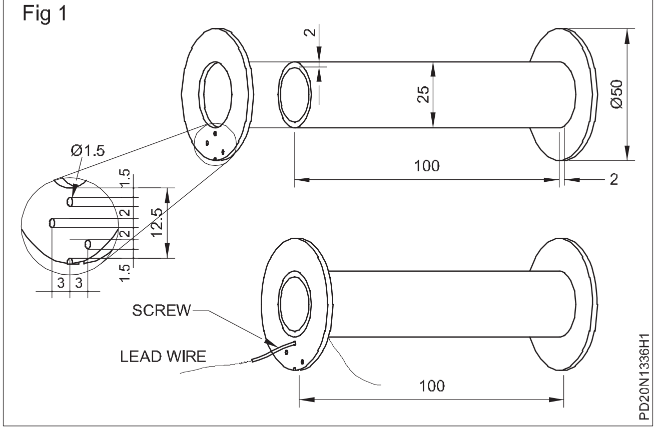
2 Fix the bobbin suitably in a hand drilling machine.

3 Secure the lead-out wire to the bobbin by means of an adhesive tape after inserting the lead wire with sleeve through the hole in the side wall of the bobbin.

4 Find the number of turns wound over the bobbin for one rotation of the drilling machine handle.

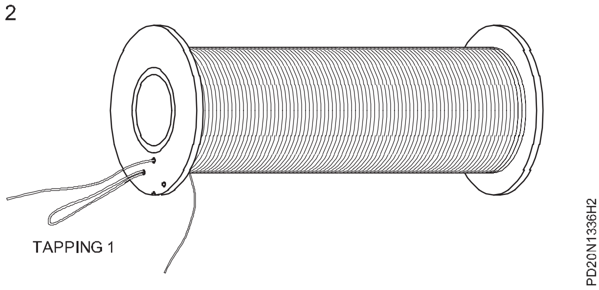
5 Calculate the number of handle rotations required for winding 200, 400 and 600 turns.

Fig 1



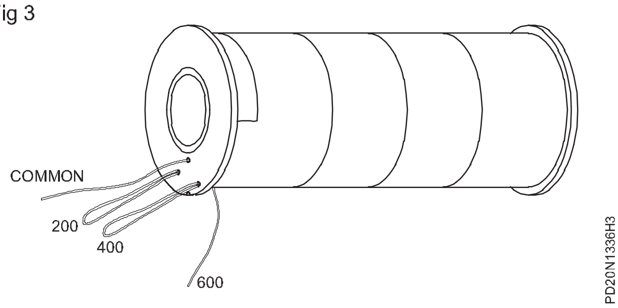
6 Complete the windings by taking tapping at an interval of every 200 turns (200, 400 and 600) such that the common and three terminals are taken out through the holes provided in the side wall (PVC washer). (Fig 2)

Fig 2



7 Insulate the top layer with an adhesive insulation tape. (Fig 3)

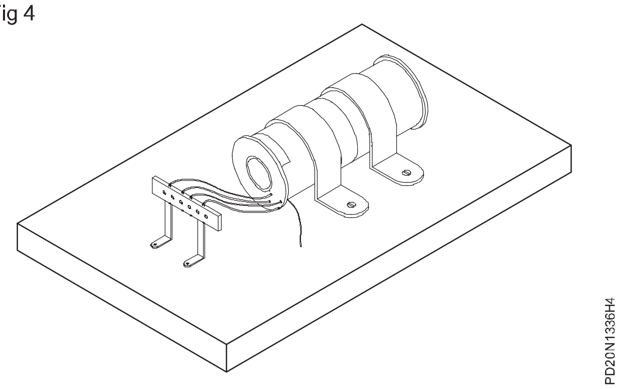
Fig 3



8 Fix the solenoid on a 150 mm x 300 mm wooden board using a plastic saddle. (Fig 4)

9 Connect the drawn out ends with sleeves to the 4-way terminal pad, fixed on the board. (Fig 4)

Fig 4

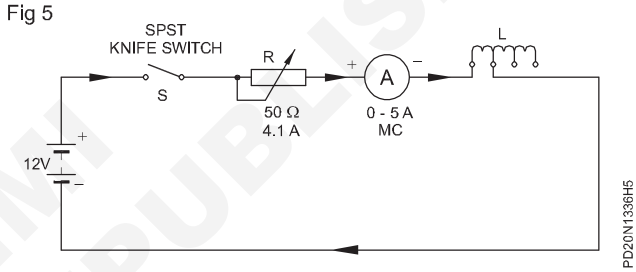


Carefully remove the enamel insulation without damaging the conductor.

10 Check the continuity with an Ohmmeter.

11 Connect the ends of the solenoid to the 12V battery through switch S, variable rheostat and ammeter 0 - 10A. (Fig 5)

Fig 5



12 Close the switch S and test the polarity of the solenoid with a bar magnet which is, suspended with a thread.

— — — — — —

TASK 2: **Determine the magnetic effect of electric current**

1 Vertically mount the coil on a stand.

2 Suspend the spring balance from the stand and hook it vertically to the (plunger) soft iron piece. (Fig 1)

Check for the free movement of the plunger inside the solenoid.

3 Take the initial reading of the spring balance.

4 Connect the solenoid to the first tapping, say 200 turns, through an ammeter, knife switch and rheostat as shown in Fig 5. Get the circuit checked by the instructor.

5 Close the switch and adjust the current to 5 amperes.

6 Note the reading of the ammeter and spring balance and record in Table 1.

7 Open the switch.

8 Repeat operations 4 to 7 for tappings 400 and 600 by keeping the current constant at 5A, adjusting the rheostat.

9 Calculate the pulling power for strength in all the 3 cases.

10 Ascertain the relationship between the number of turns and magnetic strength when the solenoid carries the same current, and record the conclusion accordingly.

11 Connect the coil to 600 turns tappings.

12 Close the switch.

13 Keep the current at 1 ampere by adjusting the rheostat. (Fig 1)

14 Note and record the spring balance readings in Table 2.

15 Repeat step 14 for different current values (in steps of 1 ampere up to 5 amperes).

16 Calculate the pulling power for strength in all the 5 cases.

17 Ascertain the relationship between the current and the magnetic strength when the number of turns of the solenoid is constant. Record the conclusion accordingly.

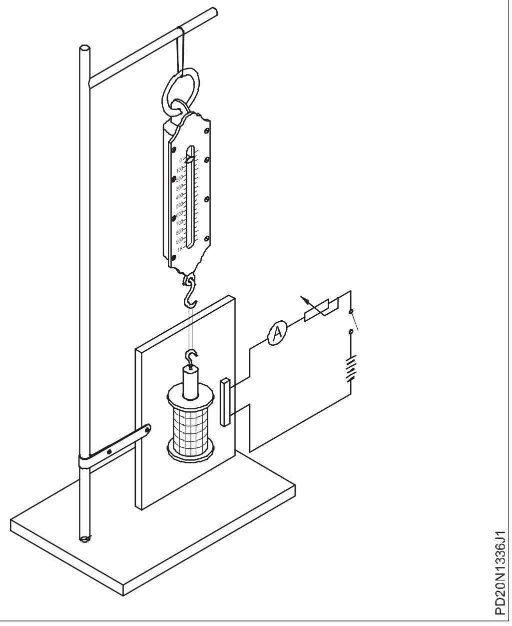


Fig 1

18 Get it checked by the instructor.

Conclusion

____

____

____

Table 1

Magnetic strength with respect to the number of turns (Current kept constant)

Sl.No.	No.of turns	Current	Initial reading of balance W_1	Spring balance reading W_2	Strength of pulling power ($W_3 = W_2 - W_1$)
1	200	5 amps			
2	400	5 amps			
3	600	5 amps			

Table 2

Magnetic strength with respect to the current
(Turns kept constant = 600 turns)

Sl.No.	Current	Initial reading of the balance W_1	Spring balance reading W_2	Strength of pulling power ($W_3 = W_2 - W_1$)
1	1 amp			
2	2 amps			
3	3 amps			
4	4 amps			
5	5 amps			

— — — — — —

Measure induced E.M.F due to change in magnetic field

Objectives: At the end of this exercise you shall be able to
- **test and install a solenoid**
- **select a bar magnet and insert it into the solenoid**
- **measure the e.m.f for the change in magnetic field.**

Requirements

Tools/Equipment

- Voltmeter (100 mv - 0 - 100 mv) (centre zero) - 1 No.
- Bar magnet 100 mm - 1 No.
- Solenoid (Assembled) (prepared in previous exercise) - 1 No.

Materials

- Connecting wires - as reqd.
- Wooden board with stand - 1 No.

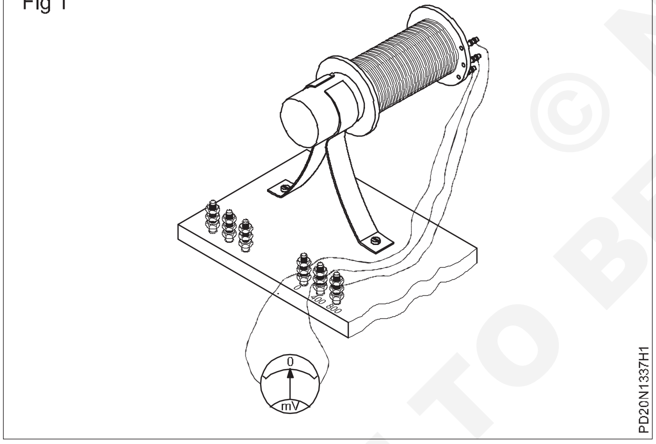
PROCEDURE

1 Check the physical condition of the solenoid and check the continuity of the coil.

2 Fix it on a board on shown in Fig 1.

3 Connect the galvanometer to the solenoid terminals as shown in Fig 1.

Fig 1



4 Insert the bar magnet into the solenoid and slowly initiate to and fro movement as shown in Fig 2.

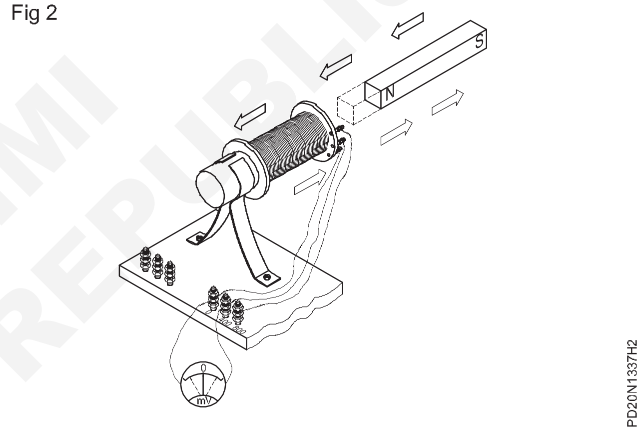
5 Record the corresponding reading in Table 1.

6 Gradually Increase the movement of the bar magnet. (Medium speed)

7 Record the reading in Table -1.

8 Increase the speed of bar magnet to the maximum, to get higher voltage reading.

Fig 2



9 Record the voltmeter reading in Table 1.

10 Tabulate all the readings and show it to the instructor for approval.

Table 1

Sl. No.	Speed of bar magnet	Voltages reading
1.	Slow	
2.	Medium	
3.	High	

— — — — — —

Determine direction of induced E.M.F and current

Objectives: At the end of this exercise you shall be able to
- **determine the direction of e.m.f induced in the circuit**
- **determine the direction of the current by the induced e.m.f.**

Requirements

Tools/Equipment

- Voltmeter (100 mv - 0 - 100 mv) - 1 No.
- Bar magnet 4” - 1 No.
- Solenoid (Assembled) fitted on board - 1 No. (prepared in previous exercise)
- Multimeter - 1 No.
- Magnetic compass - 1 No.

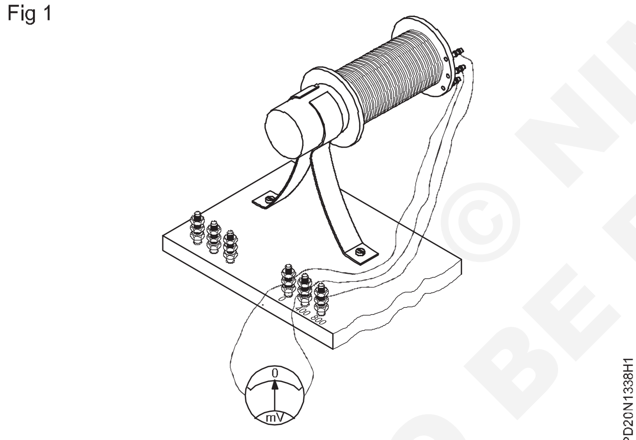
Materials

- Connecting leads - as reqd.
- PVC transparent sheet with drilled holes (4” x 3”) - 1 No.

PROCEDURE

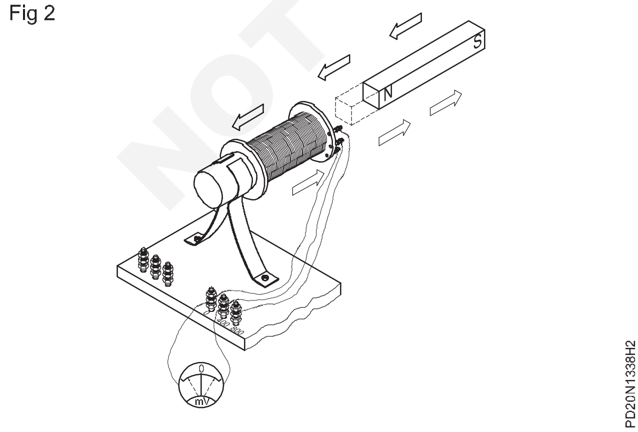
1 Connect the centre zero voltmeter to the solenoid and test the continuity of the coil as shown in Fig 1.

Fig 1



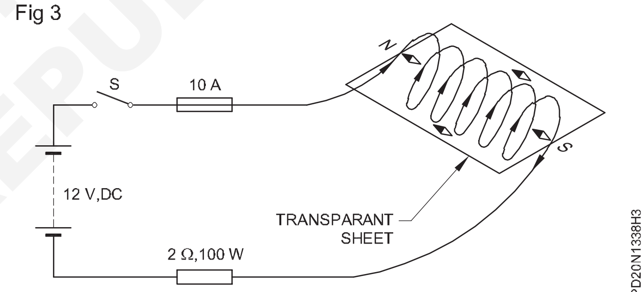
2 Check whether the induced voltage is present in the coil by mounting bar magnet as shown in Fig 2.

Fig 2



3 Extend one end of the coil wire and make 10 turns at equal distance in a drilled hole made on a transparent sheet on it as shown in Fig 3.

Fig 3



4 Place the compass at one entry point of the conductor by pointing ‘N’ to the entry of the coil as shown in Fig 3. Record your findings in Table 1.

5 Insert the magnet into the coil and move the magnet to and fro as in the earlier exercise. Note the deflection in the compass needle.

6 Change the polarity of the magnet and repeat step 4. Note the deflection in the compass needle.

> **The current direction shown in Fig 4 is for your reference.**
>
> **The direction of the current in a conductor’s cross-section is shown by the (+) plus symbol inside a conductor or a (.) dot symbol outside a conductor. (Fig 4)**

7 Interpret your findings and record the conclusion in Table 2. (A sample result is given for reference)

Fig 4

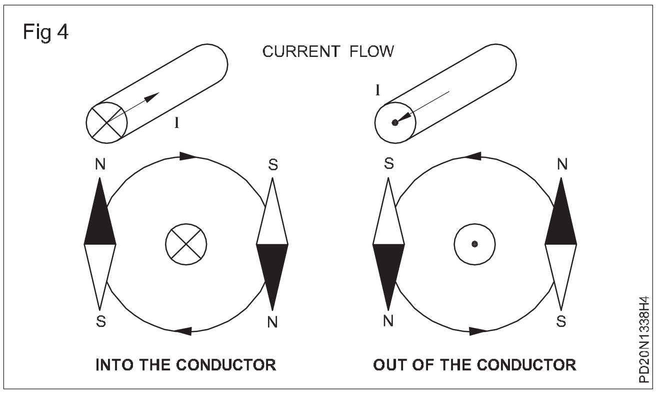
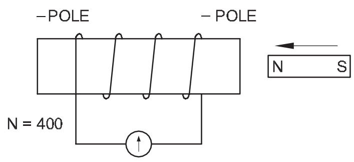
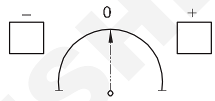
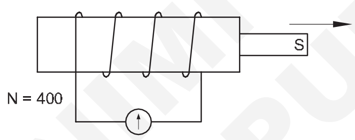
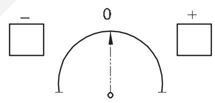
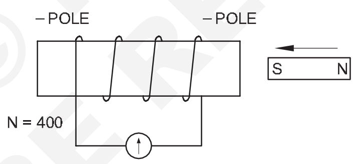
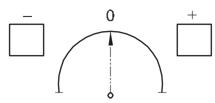
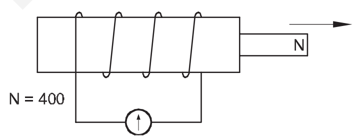
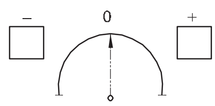


Table 1

Sl. No.	Compass N towards entry	Compass S towards entry
1		
2		
3		

Table 2

(Polarity of Induced EMF)

Case	Operation	Figure	Polarity of induced voltage
1	Magnet is moved inside the coil		
2	Magnet is moving away from the coil		
3	Magnet with changed polarity is moved inside the coil		
4	Magnet with changed polarity is moving away from the coil		

Practice on generation of mutually induced E.M.F

Objectives: At the end of this exercise, you shall be able to
- **prepare a solenoid having two sets of winding**
- **wind the solenoid with both primary and secondary windings**
- **measure the induced voltage in the secondary windings.**

Requirement

Tools/Equipments

- Voltmeter (100 MV - 0 - 100 MV) - 1 No.
- Bar magnet 100 mm - 1 No.
- Solenoid (Assembled) fitted on board (prepared in previous exercise) - 1 No.
- Multimeter - 1 No.
- Magnetic compass - 1 No.

Materials

- Connecting wires - as reqd.
- PVC transparent sheet with drilled holes 100 x 75 mm - 1 No.
- Super Enamelled copper wire 22 SWG - 25 m
- Supporting stand - 1 Pair.

PROCEDURE

> **Use the solenoid, used in exercise 1.3.37 and 1.3.38.**

1 Take the two ends of the coil, and check its resistance using ohmmeter and record in table 1.

2 Wrap the tape over the solenoid from one end.

3 Wind the copper wire (22 SWG) over the solenoid from one end to the half the length of the coil and wrap it with the tape.

4 Take the two terminals of the copper wire and check its resistance and record in table 1.

5 Fix the solenoid, which already has two windings in the board using clamps and screws as shown in Fig 1.

6 Set the secondary winding of step down transformer tapping to 10V.

7 Apply 10V AC to the inner winding (primary) and measure the secondary winding voltage as shown in Fig 1.

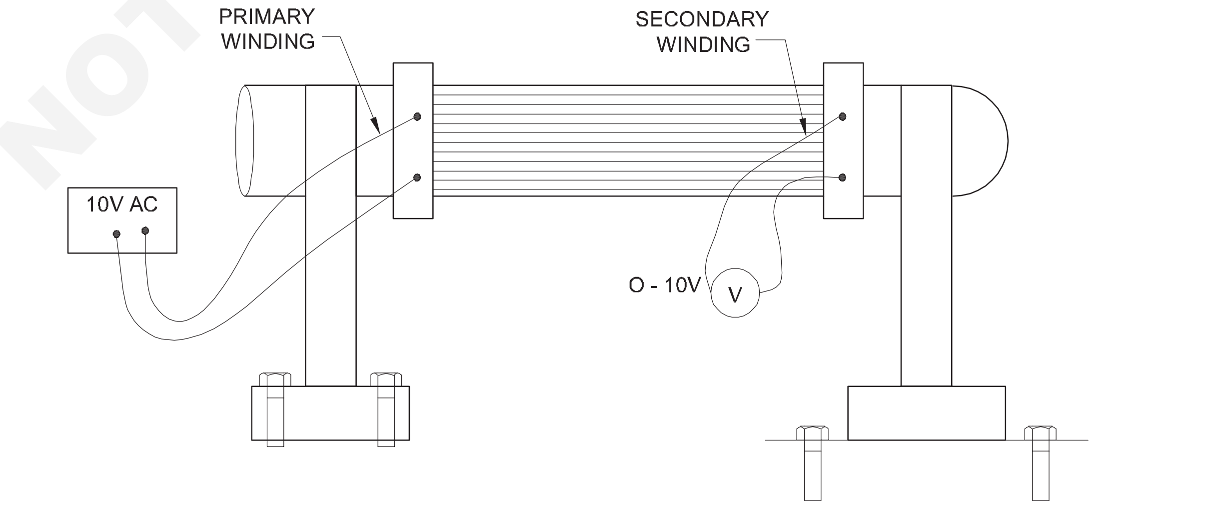
8 Note down the reading of the voltmeter in table 1.

> **The voltmeter may show a very minimal reading. If the reading does not increase when the primary winding is used, set it to the secondary winding**

9 Insert the soft iron core into the solenoid. Now the voltage will increase. Note down the voltage in Table 1.

10 Switch OFF and insert a non-magnetic cylindrical core inside the coil. Switch ON the 10V supply. Note down the voltage in Table 1.

Fig 1



11 Switch OFF and tabulate all the readings.

12 Get the work approved by the instructor.

13 Note down the result and conclusions.

Note down the primary and secondary number of turns in Table - 1 Measure the value of the resistance in primary and secondary windings and record in Table 1.

Table 1

Primary Turn	Secondary Turn	Without soft iron core		With soft iron core		Any other core	
		Primary Voltage	Secondary Voltage	Primary Voltage	Secondary Voltage	Primary	Secondary
		10		10		10	

— — — — — —

Measure the resistance, impedance and determine the inductance of choke coils in different combinations

Objectives: At the end of this exercise, you shall be able to
- **measure the resistance of the coil**
- **measure the impedance in AC circuit using the voltmeter and ammeter**
- **determine the inductance of the coil.**

Requirements

Tools/Instruments

- MC Voltmeter 0-15V - 1 No.
- MI Voltmeter 0-300V - 1 No.
- MC Ammeter 0-500 mA - 1 No.
- MI Ammeter 0 500mA - 1 No.
- Ohmmeter 0 - 2 K ohms - 1 No.

Equipment/Machines

- Potential divider 480 ohms 1A - 1 No.
- 12 volts DC source (RPS)
- 240 volts AC source

Materials

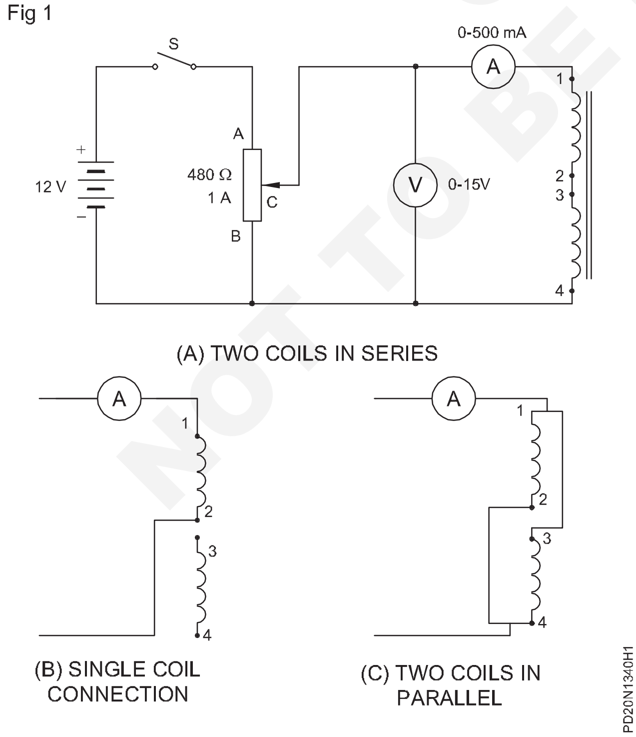
- SPT switch 6A 250V - 1 No.
- Connecting leads - 7 Nos.
- Wound choke (Solenoid coil) - 2 Nos.
- Tube light choke 40W, 240V - 2 Nos.

PROCEDURE

TASK 1: **Measure the resistance of the coil**

1 Connect the elements and form a circuit as shown in Fig 1.

Fig 1



Keep terminal `C' at `B' in the potentiometer/ voltage divider for minimum output voltage

2 Show the connections to the instructor and get it approved.

3 Close the switch `S' and adjust the potentiometer for 100mA current. Record the value of I and V in Table 1.

4 Adjust the potentiometer to obtain the current, 200 and 300mA. Record I and the corresponding voltages.

5 Calculate the resistance of the coil applying Ohm's Law. Record the result in Table 1. Find the average value of resistance in ohms i.e. R = V/I

6 Disconnect one coil i.e. terminals 3 and 4. Repeat the experiment to get the resistance measured for single coil with terminals 1 and 2. (Fig 1b)

7 Connect terminal 3 at 1 and 4 at 2. Read and record the V and I in Table 1. (Fig 1c)

8 **Result:** Resistance of the 2 choke coils in series = ... ohm

Resistance of one choke coil = ... ohm

Resistance of two coils chokes in parallel = ... ohm

....

9 Verify the above results with the help of an ohmmeter.

Table 1

Sl.No.	DC voltatge across coils	current in mA	Resistance R = V/I	Coils connected
1				Two in series
2				
3				One coil only
4				
5				Two in parallel
6				
7				

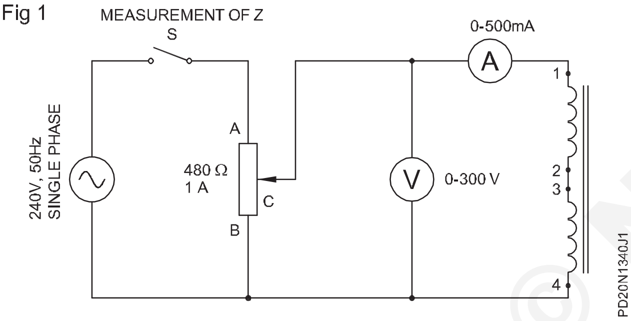
Average resistance of both coils = _______________ ohms
Average resistance of the single coil = _______________ ohms
Average resistance of the parallel coils = _______________ ohms

— — — — — —

TASK 2: **Measure the impedance of the coil in AC supply**

1 Replace the voltmeter and ammeter with MI of type 0-300V and 0.5 ampere respectively. Connect the circuit to AC 240V 50 Hz supply source as shown in Fig 1.

Fig 1



Keep the terminal of the potentiometer `C' at `B' for the minimum output voltage.

2 Show the connections to the instructor and get his approval.

3 Close the switch `S' and adjust the potentiometer to obtain a current of 100mA. Record the I and V in Table 2.

4 Adjust the potentiometer for a current of 200mA. Record the corresponding voltage. Repeat it for 300mA.

5 Calculate the value of R = V/I for each case. Record the value under the column ` impedance ' and find the average value of impedance ___________ohm

6 Disconnect one coil (i.e. terminals 3 and 4). Repeat steps 2 to 4 to determine impedance of one coil.

Conclusion

i) When both coils are in series the impedance is

____

____

____

ii) Impedance of one coil is ____________________ohms.

— — — — — —

TASK 3: **Determine the inductance of the choke**

Calculate the inductance (L) in the method shown below:

Average value of resistance (R) of the choke from Table 1 = ____________________ohms.

Average value of impedance (Z) of the choke from Table 2 =____________________ohms.

Impedance $= Z^2 = R^2 + X_L^2$ ohms

$X_L = Z^2 - R^2$ ohms.

$X_L = 2\pi fL$

$$L = \frac{X_L}{2\pi f}$$

where π = 3.142 (22/7)

f = Frequency of supply in Hz

L = Inductance in Henry

Inductance of the choke coil is $L = \frac{X_L}{2\pi f}$ Henry (H)

L = _________Henry

Table 2

Sl.No.	AC voltage across coils	AC current in mA	Impedance Z = V/I	Coils connected
1				Two in series
2				
3				One coil only
4				
5				
6				

Average value of impedance of both coils = _______________ ohms
Average value of impedance of single coil = _______________ ohms

— — — — — —

TASK 4: **Verify the effect of the direction of the current in coils with a common core**

1 Connect the elements and the terminal of the circuit as shown in Fig 1. Get the approval of the instructor and then close the switch and adjust the potentiometer to get 100mA.

2 Read and record the values for I and V in Table 3. Calculate the impedance and record in Table 3.

3 Switch OFF the supply and interchange the terminals 3 and 4 as shown in Fig 1.

Fig 1

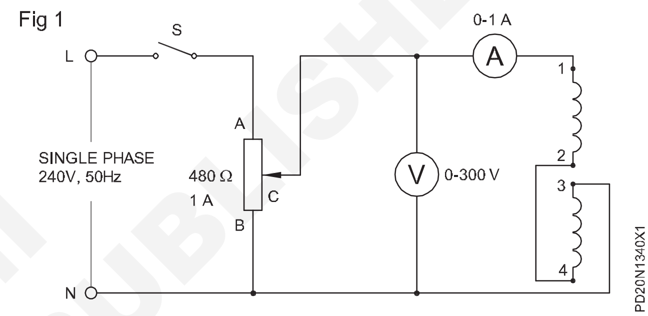


Table 3

Sl.No.	AC voltatge across both the coils	AC current in mA	Impedance Z = V/I	Direction of current
1				Two coils with current in the same direction
2				Two coils with current in the opposite coils

By interchanging the terminal connection, the direction of the current is reversed in the coil.

4 Close the switch `S' and record the new values of I at Sl.No.2. of Table 3.

Ensure that the voltage remains at the set value.

5 Calculate the value of impedance by the formula Z = V/I. Do you observe any change in the value of impedance from the previous value? _______________ Is the value close to the resistance value calculated in Task 1? _____________________.

6 Verify and compare the impedance with the previous values.

7 Compare the impedance values in to following two conditions

– coils carrying current in the same direction
– coils carrying current in the opposite direction.

Conclusion

1 The impedance value when coils carry current in same direction.

____

____

2 The impedance value when coils carry current in the opposite direction.

____

____

— — — — — —

Identify various types of capacitors, charging/discharging and testing

Objectives: At the end of this exercise, you shall be able to
- **identify the type of capacitor by visual inspection**
- **identify the capacitor's value and rating from the marking**
- **test the capacitor with DC supply for insulation and leakage**
- **test the capacitor for charge and discharge.**

Requirements

Tools/Instruments

- Ohmmeter (multimeter - ohms range) - 1 No.
- MC Voltmeter (0 - 15V) - 1 No.
- MC Ammeter (100mA - 0 - 100mA) - 1 No.

Equipment/Machines

- DC source 12 V or 0-30V variable (R.P.S) - 1 No.

Materials

- Capacitors - paper, mica, electrolytic, mylar, tantalum,variable air core and mica – assorted values and different voltage ratings - as reqd.
- Potentrometer 100 k ohm - 1 No.
- Single pole, double throw switch 16A 250V - 1 No.

PROCEDURE

TASK 1: **Identification of capacitors**

1 Look at Figs 1(a) to 1(t). Identify the capacitors and record your observations in Table 1.

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

3 From the capacitor provided by the instructor read the value of the capacitor and identify its type.

Fig 1

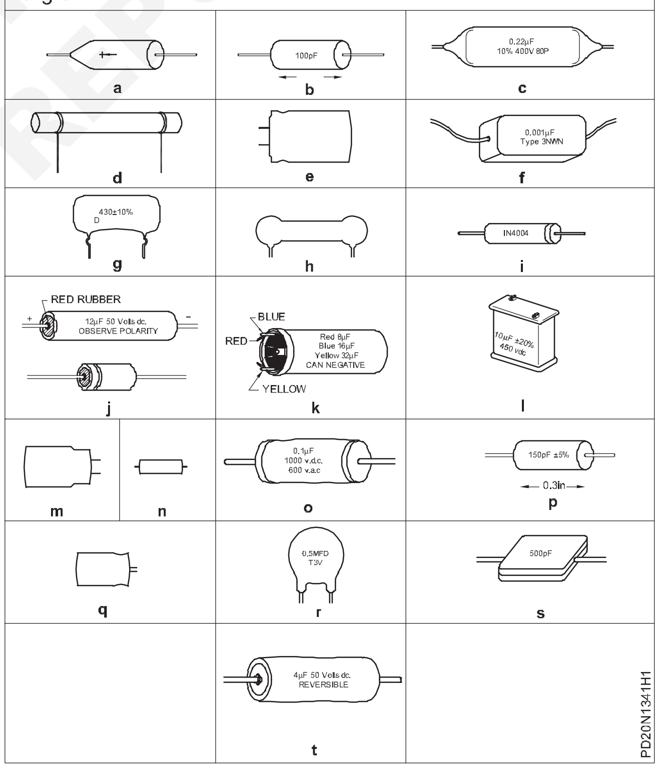


Table 1

Fig.No.	Name of component	Symbol	Type	Capacitance value	Voltage rating

Table 2

Sl.No.	Type	Value of C in μf	Voltage V

— — — — — —

TASK 2: **Test the capacitor for charging and discharging**

1 Initially touch both leads of the capacitor with the voltmeter (suitable range).

> **If there is any deflection, contact both leads through a resistance for sufficiently a long time.**
>
> **Do not touch the capacitor leads by hand. High voltage retained by a charged capacitor will give a severe shock.**

2 Form the 12V circuit for testing the capacitor circuit elements as shown in Fig 1. Keep the switches open.

3 Keep the switch S connected to the battery. Observe the deflection in the ammeter and voltmeter.

4 Record the deflection in the ammeter when the switch S is closed to position 1.

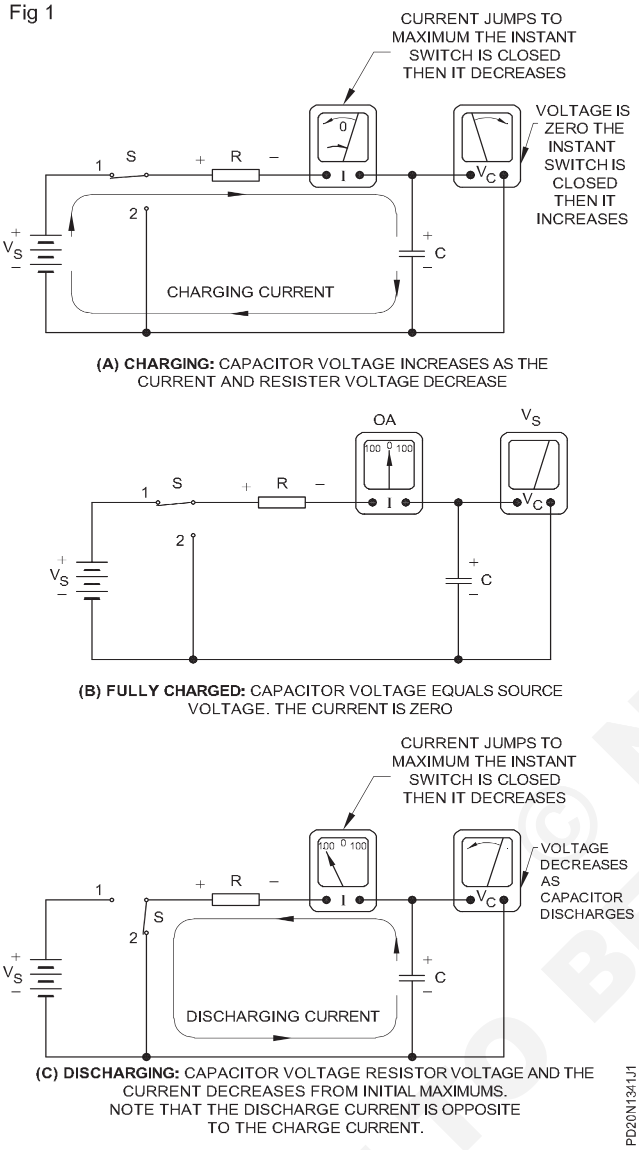
5 Observe the voltmeter reading at equal intervals of time. (At least 4 readings from zero to the maximum deflection.)

6 Record the time and voltage in Table 3.

7 Repeat steps 1 to 5 by changing the value of the series resistor ‘R’ (increasing the value of R increases the time).

8 Open the switch ‘S’ and observe the voltmeter reading for 5 minutes.

Fig 1



(A) **CHARGING:** CAPACITOR VOLTAGE INCREASES AS THE CURRENT AND RESISTER VOLTAGE DECREASE

(B) **FULLY CHARGED:** CAPACITOR VOLTAGE EQUALS SOURCE VOLTAGE. THE CURRENT IS ZERO

(C) **DISCHARGING:** CAPACITOR VOLTAGE RESISTOR VOLTAGE AND THE CURRENT DECREASES FROM INITIAL MAXIMUMS. NOTE THAT THE DISCHARGE CURRENT IS OPPOSITE TO THE CHARGE CURRENT.

9 Result

The voltage across the capacitor remains __________ because of ______________ condition of the capacitor.

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

11 Observe the deflection of the voltmeter:

(a) The voltage of the capacitor gradually decreases.

(b The current shoots to maximum at the instant switch S is closed to position 2, then it decreases gradually, indicating that the capacitor is losing charge.

12 Repeat the test for different values of capacitance rated for different voltages.

The testing voltage should be close to the voltage rating of the capacitor.

Table 3

Sl. No.	Value of		Time in seconds	Voltage volts
	Capacitor μF	Resistor kW		
1	470	500		
2				
3				
4				
5	4370			
6				
7				
8				
9	470			
10				
11				
12				

— — — — — —

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

1 Discharge the given capacitor.

2 Connect the ohmmeter to test the capacitor (Fig 1) and observe the deflection in the meter.

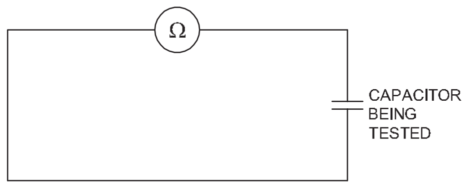
Set the ohmmeter selector switch at a higher range.

While testing with a polarised capacitor, the positive terminal of the capacitor is to be connected to the positive terminal of the ohmmeter and the negative terminal to the negative terminal of the ohmmeter.

While testing with non-polarised capacitor (mica, ceramic, etc) the low values in fractions of micro-farad will not show any deflection in the ohmmeter.

3 Assess the condition of the capacitor under test, using the information available in Fig 1 and record the findings in Table 4.

Fig 1



INDICATION OF TEST INSTRUMENT	CONDITION OF CAPACITOR UNDER TEST
METER INDICATES SOME RESISTANCE	LEAKAGE
NO DEFLECTION	OPEN
DEFLECTS AND RETURN BACK SLOWLY	GOOD CONDITION
CONTINEOUSLY SHOWS ZERO READING	SHORT

TESTING OF CAPACITOR WITH OHMMETER

PD20N1341X1

4 Discharge the capacitor.

5 Perform the test in different capacitors.

Table 4

Sl. No.	Value of Capacitor	Meter reading	Result
1			
2			
3			
4			
5			

For electrolytic capacitor only.

— — — — — —

Group the given capacitors to get the required capacity and voltage rating

Objectives: At the end of this exercise you shall be able to
- **identify the capacitor's value and rating from the markings**
- **test the capacitor with DC supply for its insulation and leakage**
- **determine the capacitive reactance**
- **select capacitors and connect in series**
- **select capacitors and connect in parallel**
- **test combinations of capacitors.**

Requirements

Tools/Instruments

- MI Voltmeter 0 to 300V - 1 No.
- MI Ammeter 0 to 500mA - 1 No.
- Rheostat, about 300 ohms 2A - 1 No.

Equipment/Machines

- 240V AC source.

Materials

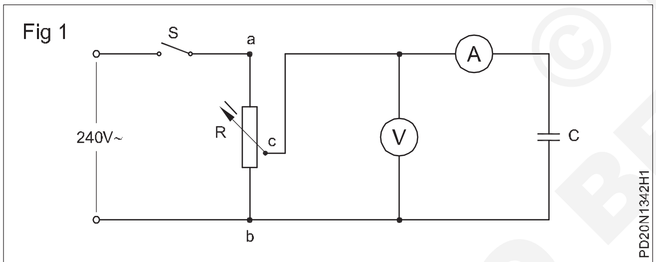
- Switch SPT 6A 250V - 1 No.
- 2 MFD 240V/400V - 2 Nos.
- 4 MFD 240V/400V - 1 No.
- 8 MFD 240V/400V 50 Hz. - 1 No.
- Connecting leads - as reqd.

PROCEDURE

TASK 1: **Measure capacitive reactance (Xc)**

1 Form the circuit as shown in Fig 1 with a 2 - µF capacitor. (Fig 1)

Fig 1



Discharge the capacitor before handling.

2 Close the switch S and adjust the potential divider for the rated voltage of the capacitor (240 V).

3 Note the voltmeter and ammeter readings and record in Table 1.

4 Calculate the reactance and $X_C = \frac{V}{I}$ record the result in Table 1.

Table 1

Sl.No.	Value of Capacitor	Voltage	Current	$X_C = \frac{V}{I}$

5 Compare the calculated value using the formula

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

6 Find the capacitive reactance value for 4 µF repeating steps 1 to 5.

7 **Conclusion**

i When capacitance increases the capacitive reactance ____________

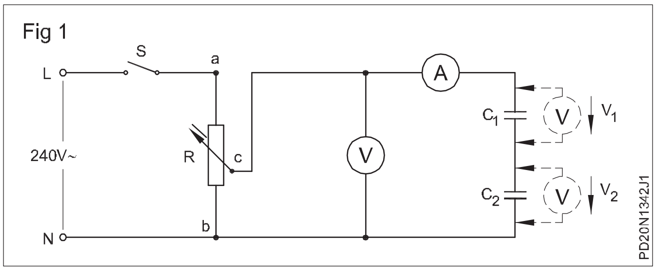
ii Increased reactance means ________ capacitance.

— — — — — —

TASK 2: **Connect capacitors in series**

1 Form the circuit with two capacitors in series as shown in Fig 1. (2 MFD, 2 MFD)

2 Determine the X_C value for the series combination performing steps 2 to 5 of TASK 1. Fill X_C values in Table 2 under the appropriate columns.



3 Calculate the total capacitance C_{total} as

$$\frac{1}{C_{total}} = \frac{1}{C_1} + \frac{1}{C_2}$$

4 Calculate the C_{total} from the X_c. Check for its conformity.

Result

When capacitors are connected in series

i the total reactance ____________

ii the net capacitance value ____________

5 Measure the voltage across each capacitor and record it in Table 2 under column 3.

6 Repeat steps 1 to 5 for series grouping of capacitors.

a) 2 & 4 MFD b) 4 & 8 MFD

7 Get it checked by the instructor.

Conclusion

The voltage across the capacitor and the value of capacitor in series.

____

____

Table 2

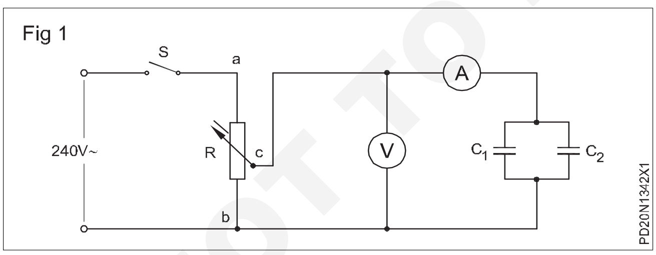
Sl. No.	Value of Capacitor C_1 in μfd	Value of Capacitor C_2 in μfd	Voltage across C_1 V_1	Voltage across C_2 V_2	Current in mA	Voltage V	Total $\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2}$	Capacitive reactance $X_C = \frac{1}{2\pi fC}$
1	2	2						
2	2	4						
3	4	8						

— — — — — —

TASK 3: **Connect capacitors in parallel**

1 Form the circuit with two capacitors in parallel as shown in Fig 3 (2 MFD, 2 MFD).

2 Determine the reactance X_C of the parallel combination performing steps 2 to 5 of TASK 1. Fill up X_C in Table 3.



3 Calculate the total capacitance $C_{total} = C_1 + C_2$. Record C_{total} in Table 3.

4 Calculate the C_{total} from X_C. Check for its confirmity.

Result

In parallel combination of capacitance

i the total reactance ____________

ii the total capacitance ____________.

Discharge the capacitors at the end of each experiment / test

5 Repeat steps 1 to 5 for parallel grouping of capacitors.

Table 3

Sl. No.	Value of Capacitor C_1 in mfd	Value of Capacitor C_2 in mfd	Voltage across C_1 V_1	Voltage across C_2 V_2	Current in mA	Voltage V	Total $C_{total} = C_1 + C_2$	Total reactance $X_C = \frac{1}{2\pi fC}$
1	2	2						
2	2	4						
3	4	8						

— — — — — —

Measure current, voltage and PF and determine the characteristics of the RL, R-C and R-L-C in AC series circuits

Objectives: At the end of this exercise, you shall be able to
- **measure the current, voltage, power and P.F in R-L series circuits**
- **measure the current voltage, power and P.F in R-C, series circuits**
- **measure the current voltage, P.F in R-L-C series circuits**
- **measure the power and P.F. in R-L-C series circuits.**

Requirements

Tools/Instruments

- MI voltmeter 0 - 300 V - 3 Nos.
- MI ammeter 0 - 1.5 A - 1 No.
- Wattmeter 250 V, 2.5 amps - 1 No.
- Power factor meter (0.5 lag to 0.5 lead) 250 volts, 2.5 amps - 1 No.

Equipment/Machines

- Auto transformer 0-270V/8A - 1 No.

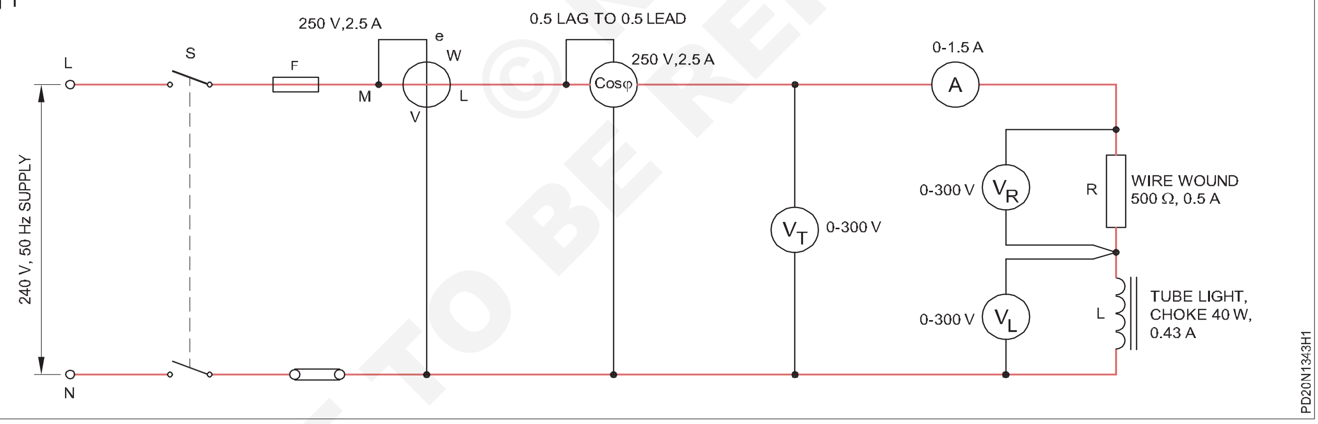
Materials

- Connecting cables - as reqd.
- Choke (tube light) 40 W, 0.43 A, 250 V - 1 No.
- I.C.D.P. switch - 16 amps, 250 volts - 1 No.
- Wire wound resistor 500Ω/0.5A - 1 No.
- Wire wound resistor 100Ω/1.5A - 1 No.
- Electrolytic capacitor 8μFd/400V - 1 No.
- Electrolytic 1μFd, 2μFd, 4μFd/400V - 1 each

PROCEDURE

TASK 1: **Measure the current, voltage, power and P.F in R-L series circuit**

Fig 1



1 Assemble the circuit by connecting instruments, resistor R, inductor L as in Fig 1. Switch ON the supply.

2 Measure the voltage V_R, V_L, supply voltage V_T and the circuit current and record in Table 1.

3 Read power (W_1) and power factor (cos ϕ) and record it in Table 1.

4 Calculate the apparent and the true power consumed in the circuit and compare them.

5 Calculate the power factor and compare it with the measured power factor.

6 Draw the vector diagram to add the voltage drops across R and L.

- Keep current as the reference vector.
- Select a suitable scale for the voltage.
- Draw the voltage vector (V_R) in-phase with current (I).
- Draw the voltage vector V_L leading-current **I** by 90°.
- Add vector V_R and V_L to get V_{T1}

7 Compare the above with the measured supply voltage.

8 Calculate the power factor from the true power and apparent power $\cos\phi_2 = \frac{W}{V_T \times I}$ = ...W

9 Compare the calculated power factor with the measured power factor.

10 Repeat the steps changing two values for the resistor and inductor and record them in Table 1 in columns 2 and 3.

11 Get it checked by the instructor.

Table 1

Measured value							Calculated value			
Sl. No.	Circuit current	Supply voltage	Power consumed (Wattmeter reading)	Voltage across resis- tance	Voltage across induc- tance meter)	Power factor (reading of P.F.	Vector addition of VR and VL	Difference in VT_1 and VT_2	Power consumed in circuit	Difference between measured & calculated power factor
	f	V_{T1}	W_1	V_R	V_L	Cos ϕ_1	V_{T1}	$V_T - V_{T1}$ f $_X$ Cos ϕ_1	W2= $V_{T X}$ Cos ϕ_2	Cos ϕ_1–
1										
Resistance =				Inductance =						
2										
Resistance =				Inductance =						
3										
Resistance =				Inductance =						

Conclusion

The difference between vector addition of V_R and V_L with respect to V_T is due to ______________________

____

— — — — — —

TASK 2: **Measure the current voltage, power and P.F in R-C series circuit**

1 Test the capacitor with an ohmmeter for its condition.

Discharge the capacitor before testing.

2 Check the value of the given resistance with a digital multimeter for its value.

Check the suitability of the selected wattmeter and P.F. meter with respect to the circuit specifications.

3 Construct the circuit as per diagram. (Fig 1) Keep the switch 'S' open.

Set the auto-transformer output to zero voltage.

4 Close switch 'S' and adjust the auto-transformer output voltage to 100V.

5 Measure the circuit current, voltage power consumed and power factor and note the readings in Table 2.

6 Calculate cosϕ and impedance.

7 Compare the calculated P.F with measured P.F.

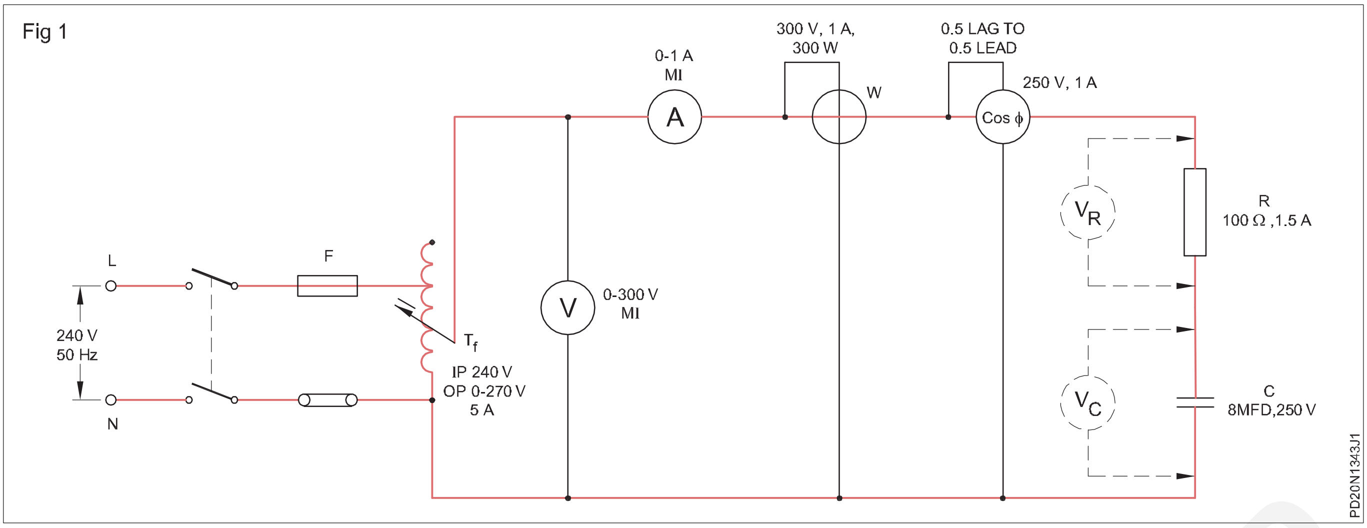
8 Measure the voltages across R and C and note in Table 3.

9 Compare the arithmetical sum of V_R and V_C with the supply voltage and observe that this is a wrong procedure.

10 Add V_R and V_C by the vector method (graphically) selecting a suitable scale and compare with the measured supply voltage.

11 Adjust the output voltage to 200 V and repeat steps 5 to 10.

Fig 1



12 Get it checked by the instructor.

Table 2

Measured				Calculated	
V supply	I	W	PF	$FF = \frac{W}{VI}$	$Z = \frac{V}{I}$
100 V					
200 V					

Conclusion

____

____

____

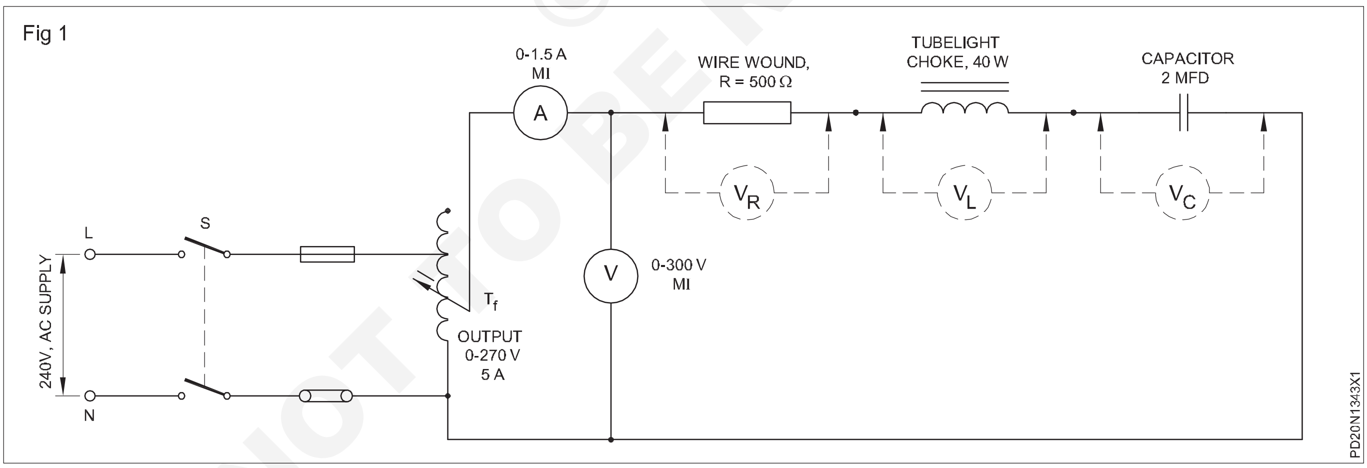
Table 3

V supply	V_R	V_C	$V_R + V_C$ (Arithmetic)	$V_R + V_C$ (Vector)
100 V				
200 V				

— — — — — — —

TASK 3: **Measure the current voltage, P.F, in R-L-C series circuit**

Fig 1



1 Assemble the circuit as per circuit diagram (Fig 1) with the instruments and components collected.

Before forming the circuit, confirm that the capacitor is discharged.

2 Switch 'ON' the supply and adjust the auto-transformer until the voltmeter indicates 240 volts.

3 Measure the voltage across each element and note it in the Table 4.

Table 4

Supply	V_R	V_L	V_C	I
240 v				

4 Measure the current and note the same in Table 4. Switch off the circuit.

5 Draw the vector diagram (say 1cm = 50 V and 1cm = 0.1A) taking the current as the reference vector.

6 Determine the supply voltage from the vector diagram.

Supply voltage (vector sum) =..................V

Assumption: The resistance of the choke is negligible in this case.

7 Compare the value of the resultant vector voltage with reading of the voltmeter across the mains.

If the vector sum of voltages V_R V_C V_L is not exactly equal to the measured supply voltage, it may be due to---

- **observation error**
- **drawing of the vector diagram incorrectly**
- **assumptions made.**

8 Replace the capacitor with another value, say 8.0 MFD and repeat the steps 2 to 7.

9 Replace the capacitor with another value, say 1.0 MFD and repeat the steps 2 to 7.

10 **Result:** Total measured voltage is________________

____

11 Get it checked by the instructor.

Conclusion

A The voltage across individual component and total supply voltage________________

____

B The circuit current________________

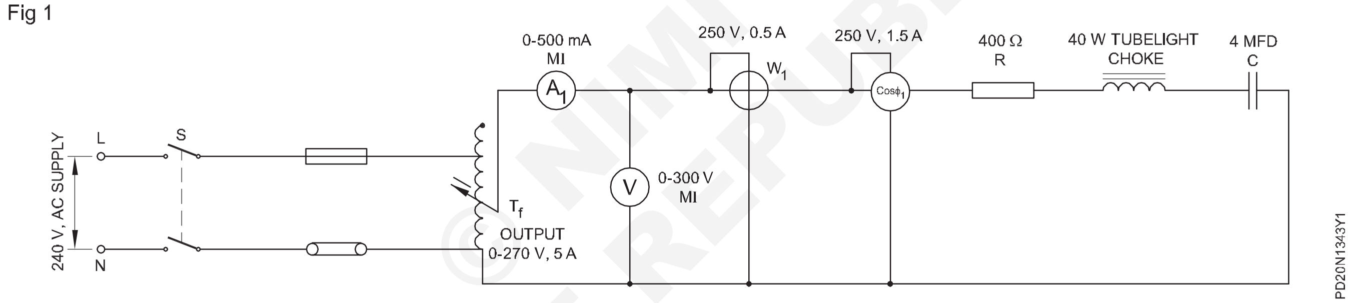
____

C The phase angle of current with supply voltage (from voltage vector) ________________

— — — — — —

TASK 4: **Measure the power and P.F. in R-L-C series circuit**

Fig 1



1 Form the circuit as shown in Fig 1.

Discharge the capacitor. With an ohmmeter check the resistance for its value, the inductor for its continuity and the capacitor for leakage.

2 Set the auto-transformer to have zero output. Switch 'ON' the supply.

3 Gradually increase the output voltage until it is 100V.

4 Measure the corresponding current. Note down the readings in Table 5. Also read the Wattmeter and the power factor meter and record it in Table 5.

5 Calculate the apparent power from voltmeter and ammeter reading.

Apparent power = V x I in volt amp (VA)

6 Determine the power factor by using the formula and record it in Table 5.

$$\text{Cos}\ \phi = \frac{\text{True power}}{\text{Apparent power}}$$

7 Verify the measured power factor with the calculated power factor.

8 Increase the voltage to 200 volts and repeat steps 4 to 7.

Do not increase the voltage beyond 200V for this circuit.

9 Reduce the output voltage back to zero and switch off the supply.

10 Repeat the experiment (steps 2 to 9) with

i) the capacitor removed

ii) a 2 micro-farad capacitor connected

iii) a 8 micro-farad capacitor connected keeping the voltage at 200 V.

11 Compare the readings of the power factor in all the four cases. Record your observation.

12 **Result**

The change of the capacitor in the R-L-C series circuit for given R-L (value)

TABLE 5

Sl. No.	V Volt	I Amp.	W True power	AP = V xI in VA Apparent power	$\cos\phi = \frac{W}{AP}$	P.F. Meter reading	Capacitor value in MFD
1	100 V						4
2	200 V						4
3	200 V						0
4	200 V						2
5	200 V						3

13 Get it checked by the instructor.

— — — — — —

Measure the resonance frequency in AC series circuit and determine its effect on the circuit

Objectives: At the end of this exercise you shall be able to
- **determine the resonance frequency of a given LC series circuit and circuit current**
- **plot a graph of frequency versus circuit current**
- **test the working of a series LC as a wave trap**
- **determine the effect of the resonance on the circuit.**

Requirements

Materials/Components

- General purpose Lug board - 1 No.
- Capacitor 0.1 µF - 1 No.
- Inductor coil, around 40mH (Use the solenoid coil made in Ex. 1.3.36) - 1 No.
- LED with holder - 1 No.
- Hook-up wires - as reqd.

Tools/Equipments/Instruments

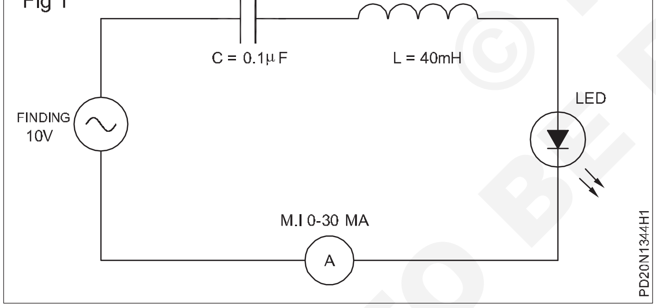
- Trainees kit - 1 No.
- CRO, 20 MHz - 1 No./batch
- Function generator - 1 No./batch
- MI Ammeter 0 - 30 mA - 1 No.

PROCEDURE

TASK 1: **Finding Resonance frequency and circuit current**

1 Solder the components as shown Fig 1 to obtain a simple series resonance circuit. Connect instruments as shown in Fig 1.

Fig 1



The LED in the circuit is to get a visual indication of the current through the circuit at different frequencies.

3 Calculate and record the resonance frequency of the series resonance circuit with known values of L and C.

4 Set the output of the signal generator to $10V_{rms}$ and frequency to 1KHz. Record the current, I through the circuit in Table 1.

LED may not be glow or may be very dim, because the set frequency of 1 KHz may not be the resonance frequency of the circuit.

5 Gradually increase the frequency and record the resonance frequency f_r at which the circuit current becomes maximum (LED glows brightly).

This is the resonance frequency of the series resonance circuit because at series resonance, current I through the LC circuit will be maximum.

6 Compare and record the difference in the resonance frequency calculated in step 3 and that measured in step 5.

7 Vary the input frequency in steps of 500 Hz around the resonance frequency and in each step record the value of circuit current in Table 1.

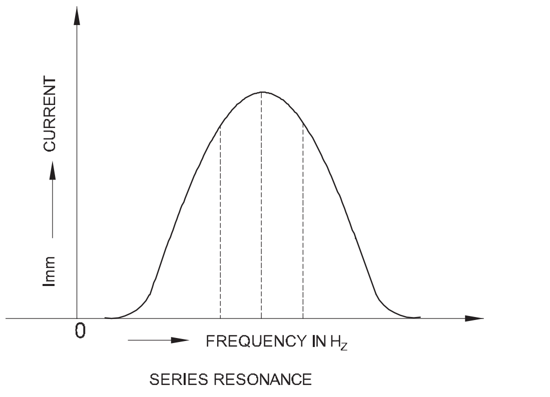
8 From the recorded readings of current in step 6, plot a graph of frequency versus current and mark the resonance frequency of the LC series circuit. (Fig 2)

9 It may appear as in Fig 2 working of the circuit, Record readings and plot the graph and get it checked by the instructor.

Table 1

Frequency	+500HZ	+1KHZ	+1.5KHZ	+2KHZ
Sine wave				

Fig 2



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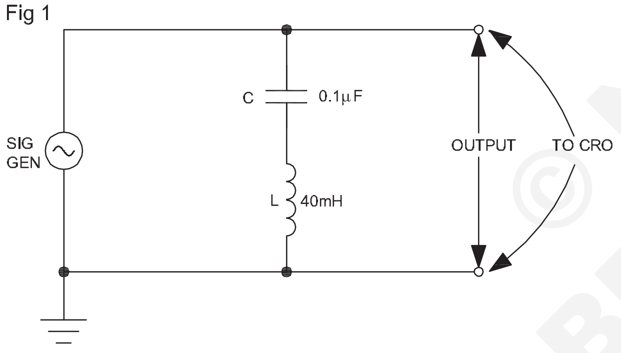
TASK 2: **To use series LC circuit as wave-trap to determine the effect on the circuit**

1 Using known values of L and C, make the circuit connections as in Fig 1.

Fig 1



2 Set the output of the signal generator to 3 volts, 50KHz, sine wave.

3 Increase the frequency till the output of the trap circuit is minimum. Record this frequency as the trap frequency and its the effect on the circuit.

At trap frequency, which is the resonance frequency of the Shunt connected LC circuit, the impedance of the circuit will be minimum and hence the voltage across the circuit will be minimum. Ideally, this should be zero. But, because of the internal resistance of the coil, the output voltage will not be zero but, will be minimum.

4 Get your work checked by the instructor.

LAB ASSIGNMENT: Change the value of the capacitor used in the LC circuit to 0.01μF and redo TASK 2 to find the new wave-trap frequency.

— — — — — —

Measure current, voltage and PF and determine the charactertics of R-L, R-C and R-L-C in AC parallel circuits

Objectives: At the end of this exercise you shall be able to
- **measure the current, voltage in R-L parallel circuit**
- **measure the current and voltage in each branch circuit of R-C parallel circuits**
- **determine the characteristics of R-L-C in parallel circuits.**

Requirements

Tools/Instruments

- Digital multimeter - 1 No.
- MI Ammeter 0 to 2 ampere (0-5A) - 2 Nos.
- MI Ammeter 0 to 3 amperes (0-5A) - 1 No.
- MI Voltmeter 0-250 V - 1 No.
- Frequency meter 50Hz/±5 - 1 No.

Equipment/Machines

- Auto-transformer - input 240 V
  - output 0 to 270 V, 8 amps - 1 No.
- Rheostar 400Ω/1A - 1 No.

Materials

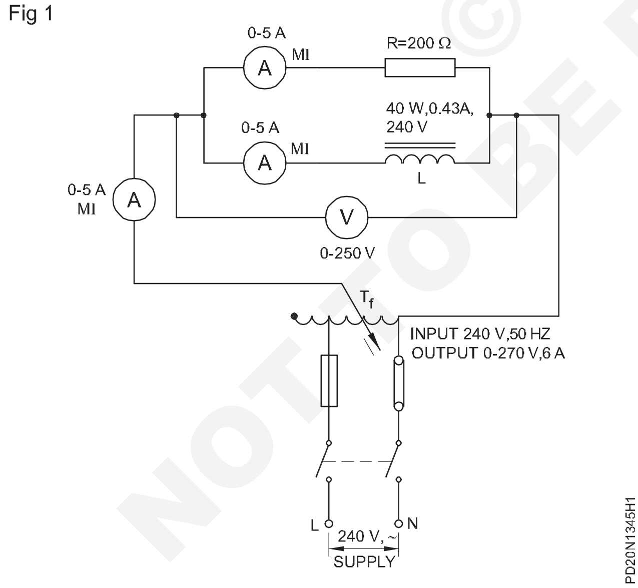
- Connecting cables - as reqd.
- I.C.D.P switch 250V, 16 A - 1 No.
- Wire wound resistor - 200 ohms - 1 No.
- Choke coil of 40 watts, 240V 50 Hz. tube light - 1 No.
- E.capacitor 8μFd/4μFd/400V - 1 each.
- E.capacitor 2μFd/400V - 1 each.

PROCEDURE

TASK 1: **Measure the current, voltage in R-L parallel circuit**

1 Assemble the circuit with the instruments, inductance coil and resistance. (Fig 1)

Fig 1



2 Set the auto-transformer output at zero position.

3 Switch 'ON' the supply and gradually increase the output voltage to 50V.

4 Measure the branch and total currents and record in Table 1. Repeat this step for different voltages say 100V, 125V, 150V, and 175V.

Table 1

Sl.No.	Measured				Graphical
	V	I_R	I_L	I_T	I_T Value
1	50				
2	100				
3	125				
4	150				
5	175				

5 Draw the vector diagram with suitable scale for currents taking voltage as reference vector in your practical record.

6 Determine the total current graphically.

The calculated values of total current and the actual measured value of current may vary due to instrument error, observational error and non-availability of pure inductance. Hence, about 5% error is permissible.

7 Compare the total current measured with the calculated value entered in table 2.

TABLE 2

Sl.No.	Measured value		Calculated value	
	V	I_T	$I_T = \sqrt{(I^2_R + I^2_L)}$	$Z = \frac{V}{I_T}$
1	50			
2	100			
3	125			
4	150			
5	175			

8 Find the Impedance of the circuit from the supply voltage and measured current. Calculate $Z = \frac{V}{I_T}$

Conclusion

Total current in an AC parallel circuit is the vector ______________ of I_R and I_L and not ______________ addition.

— — — — — —

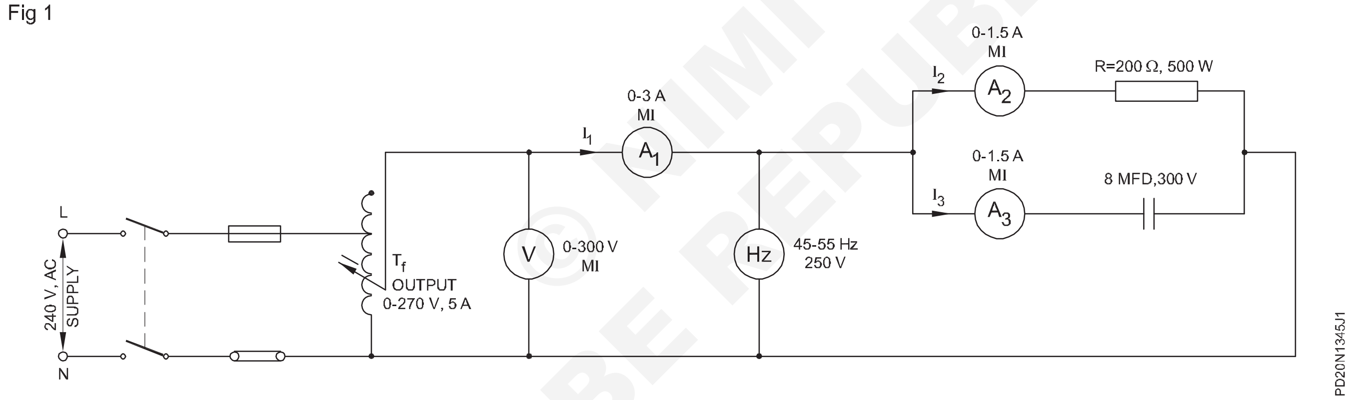
TASK 2: **Measure the current and voltage in each branch circuits of R-C parallel circuits**

1 Test the capacitor with an ohmmeter for its condition.

Discharge the capacitor before testing.

2 Test the resistor with an ohmmeter for its value.

Fig 1



3 Build the circuit as per diagram. (Fig 1) Keep the switch open. Set the auto-transformer to the minimum output voltage.

4 Switch ON the supply. Adjust the auto-transformer for an output voltage of 200V.

5 Record the frequency, voltage and the three ammeter readings in Table 3.

6 Calculate the impedance 'Z' and record in Table 1.

7 Calculate the capacitive reactance ($X_c = V/I_3$) and record your result in Table 1.

8 Calculate the capacitance from the values recorded in Table 3.

9 Establish that the arithmetical sum of the branch current is not equal to the main circuit current.

10 Graphically add the currents I_2 and I_3 and determine the value of I_1. Compare this value with the measured value.

11 Calculate the power factor from the recorded readings and enter the value in the space given below.

Table 1

Sl.No.	V	f	I_1	I_2	I_3	$Z = \frac{V}{I_1}$	$X_C = \frac{V}{I_3}$	$C = \frac{1}{2\pi f X_c}$

12 Adjust the supply voltage to about 100 V and repeat steps 5 to 10.

Discharge the capacitor after the experiment.

13 Repeat the exercise for changed values of R and C in the circuit.

Conclusions

i The calculated value and the indicated value of the capacitor

ii The arithmetic sum of the branch current and the measured value of total current.

iii The vectorial sum of the branch currents and the measured value of the total current.

iv The determination of PF from the vector diagram

$\text{Cos } \phi = \frac{I_2}{I_1} = ... =$

— — — — — —

TASK 3 : **Determine the characteristics of R-L-C in parallel circuits**

1 Form the circuit as shown in Fig 1.

2 Repeat steps 2 to 13 of TASK 2 and record the readings in Table 1.

3 Compare the readings of the power factor in all the cases. Record your observations.

Conclusion

i Effect of change of supply voltage in R-L-C parallel circuit as regards power factor of circuit

ii Effect of change in capacitance in RLC parallel circuit.

Fig 1

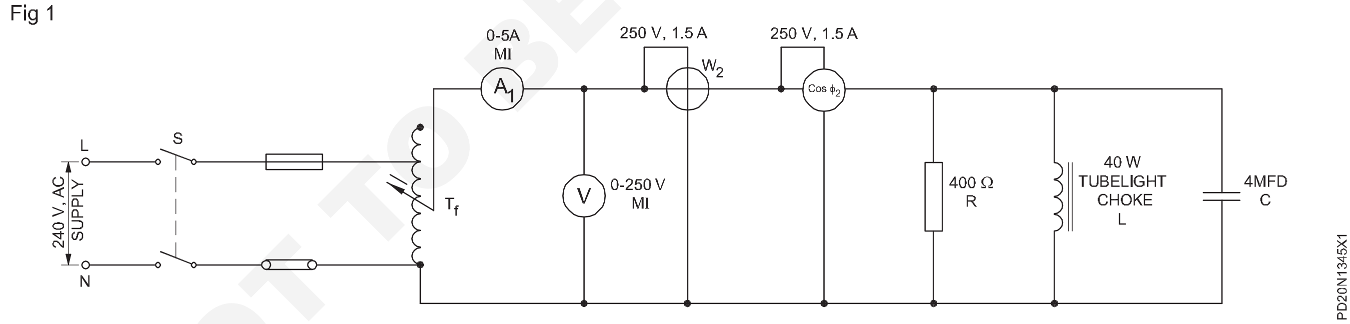


Table 1

Sl. No.	V Volt	I Amp.	W True power in Watt	AP = V xI Apparent power in VA	$\cos \phi = \frac{W}{AP}$	P.F. Meter reading	Capacitor value in μFD
1	100V						4
2	200V						4
3	200V						0
4	200V						2
5	200V						3

— — — — — — —

Measure the resonance frequency in AC parallel circuit and determine its effects on the circuit

Objectives: At the end of this exercise you shall be able to
- **determine the resonance frequency of a given LC parallel circuit**
- **determine the circuit current for different frequencies**
- **plot a graph of frequency versus circuit current**
- **calculate the value of unknown C using LC parallel resonance**
- **determine the effect of LC parallel circuit on the circuit.**

Requirements

Tools/Equipment/Instruments

• Trainees kit	
• CRO, 20 MHz	- 1 No./batch
• Function generator	- 1 No./batch
• MI Ammeter 0-50mA	- 1 No.

Materials/Components

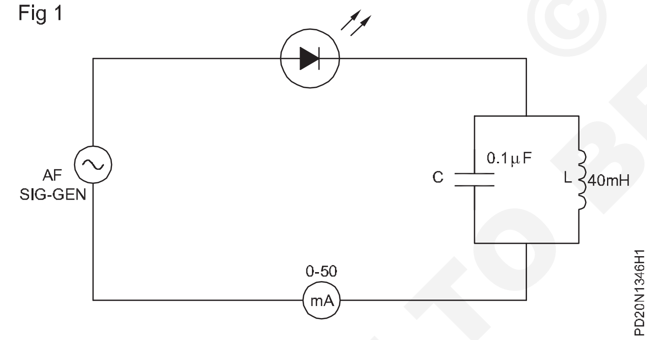
• General purpose Lug board	- 1 No.
• Capacitor 0.1 μF	- 1 No.
• Inductor coil, around 40mH	- 1 No.
(Use the solenoid coil made in unit 5)	- 1 No.
• LED with holder	- 1 No.
• Hook-up wires	- as reqd.

PROCEDURE

TASK 1: **Determine parallel resonance frequency and circuit current**

1 Solder the components as shown Fig 1 to obtain a simple parallel resonance circuit. Connect the instruments as shown in Fig 1.

Fig 1



The LED in the circuit is to get a visual indication of the current through the circuit for different frequencies.

2 Calculate and record the resonance frequency of the parallel resonance circuit from the value of L and C.

3 Set the output of the signal generator to $4V_{rms}$ and frequency to 1KHz in Table 1. Record the current, I through the circuit.

Ensure that the current through the circuit is around 10 to 12 mA and not more. If current flowing is more, reduce the output level of the signal generator. LED will glow at all frequencies except at the resonant frequency.

Table 1

Frequency	+500HZ	+1KHZ	+1.5KHZ	+2KHZ
Sine wave				

4 Gradually increase the frequency and record the resonance frequency f_r at which the circuit current becomes minimum (LED does not glow or glows very dimeter).

This is the resonance frequency of the parallel resonance circuit because at parallel resonance, current I through the parallel LC circuit will be minimum.

5 Compare and record the difference in the resonance frequency calculated in step 2 and that measured in step 4.

6 Vary the input frequency in steps of 500 Hz around the resonance frequency and in each step record the value of circuit current in Table 1.

7 From the recorded readings of current in step 6, plot a graph of frequency versus current and mark the resonance frequency of the LC parallel circuit.

8 Mark the -3dB points on the plotted graph. Find the bandwidth (BW) and quality factor Q.

9 Get the working of the circuit, recorded readings and the graph checked by the instructor.

— — — — — —

TASK 2: **Determine the inductance value of an unknown inductor**

Note : You may use the solenoid coil used by another trainee in Task,1 in Ex. 1.5.46 as an unknown value inductor.

1 Connect the unknown value inductor in the place of the coil.

2 Set the output level of the signal generator around $4V_{rms}$. gradually increase the output frequency from 50 Hz and record the resonance frequency f_r at which the circuit current becomes minimum (LED does not glow or glows very dim).

This is the resonance frequency of the parallel resonance circuit formed by the unknown values of L.

3 Calculate and record the inductance value of the unknown inductor using the formula given below with known values of C.

At resonance, $X_L = X_C$

or $2\pi f_r l = \frac{1}{2\pi f_r c}$ or $L = \frac{1}{4\pi^2 f_r^2 C}$

4 From the found value of L recalculate the resonance frequency f_r to reconfirm the found value of L.

5 Get your work checked by the instructor.

Lab Assignment: Connect a known value inductor in circuit as in Fig 1 and a capacitor of unknown value. Repeat Task 2 to find the value of the unknown capacitor.

Note : The value of an unknown capacitor can be found using series resonance circuit too.

— — — — — —

Measure power, energy for lagging and leading power factors in single phase circuits and compare the characteristics graphically

Objectives: At the end of this exercise you shall be able to
- **measure power and energy for lagging P.F.**
- **measure power and energy for leading P.F.**
- **draw a graph to compare lagging and leading P.F.**

Requirements

Tools and Instruments

- M.I Ammeter 0-5A/10A - 1 No.
- M.I Voltmeter 0-300V - 1 No.
- Wattmeter 250V/5A - 1 No.
- P.F. meter 250V/ 2A - 1 No.
- Variac 0-270/5A - 1 No.
- AC source 0-240V/5A - 1 No.
- Energy meter 5A 250 V - 1 No.
- Stop watch - 1 No.
- Lamp load 240 V/5A - 1KW - 1 No.

Materials

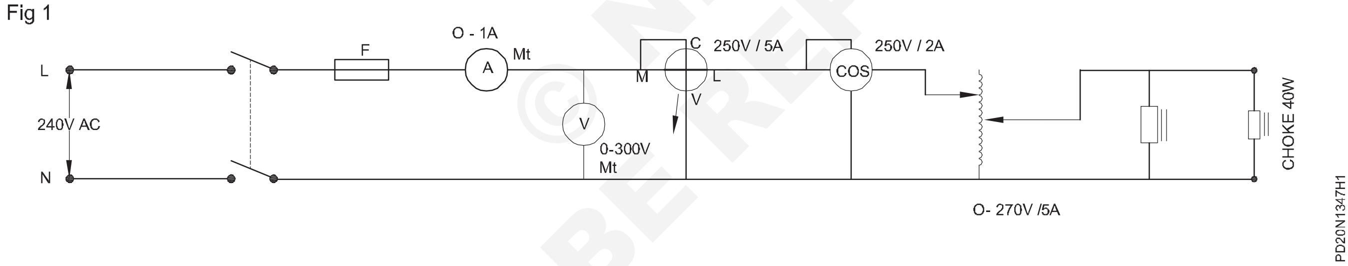
- Choke (T.L) 40W/250V - 2 Nos.
- Electrolytic capacitor, 2.5μFd/415V - 2 Nos.
- Connecting leads - as reqd.

PROCEDURE

TASK 1: **Measure the power for lagging P.F**

1 Assemble the circuit as shown in Fig 1.

Fig 1



2 Before giving supply disconnect one end of both the chokes and set the variac ouput voltage at 250V.

3 Switch ‘ON’ and note down the wattmeter and P.F. meter readings in Table 1.

4 Switch ‘OFF’ and connect one choke and record the readings (W and P.F.).

5 Switch ‘OFF’ and connect the second choke, record the readings in Table 1.

Table 1

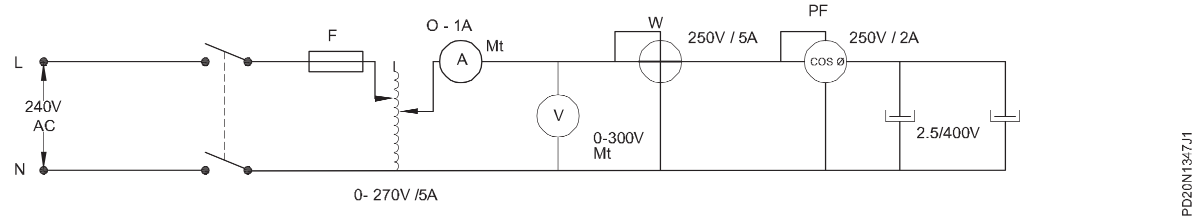
S.No.	Voltage (V)	Current (I)	W (w)	PF +/- Lag/Lead	No. of Chokes
1					With one choke
2					With two chokes

— — — — — —

TASK 2: **Measure the power for leading P.F.**

1 Switch ‘OFF’ and modify the circuit as shown in Fig 1.

Fig 1



2 Disconnect one end of both the capacitor and switch ‘ON’. Record the W and P.F. reading in the Table 2.

3 Switch OFF and connect one capacitor and switch ‘ON’. Record the W and P.F. reading in the Table 2.

4 Switch ‘OFF’ and connect second capacitor and switch ‘ON’.

5 Record the W and P.F. reading in the Table 2.

Table 2

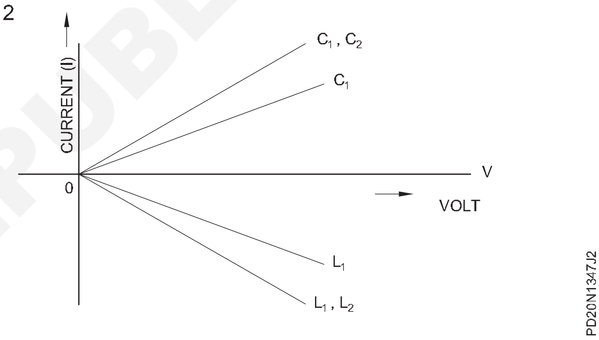
S.No.	Voltage V	Current I	W w	PF +/- lead/lag	Condition
1					With one capacitor
2					With two capacitor

6 Compile all the readings and plot a graph with volt to current for both leading and lagging PF.

Note: A sample graph is shown for reference. in Fig 2.

7 Get your work approved by the instructor.

Fig 2



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TASK 3: **Measurement of energy with lagging and leading P.F.**

1 Identify the energy meter terminals - line and load, after removing the terminal cover.

Always mount the meter vertically.

2 Associate the circuit diagram (inside) with the terminal markings of the instrument.

3 Connect the energy meter terminals (line and load) in the circuit as shown in Fig 1.

4 Note the meter constant from the nameplate of the energy meter. (Fig 2)

5 Record the initial meter readings.

6 Switch ON the circuit with load.

7 Record the reading after 30 minutes in Table 3.

Fig 1

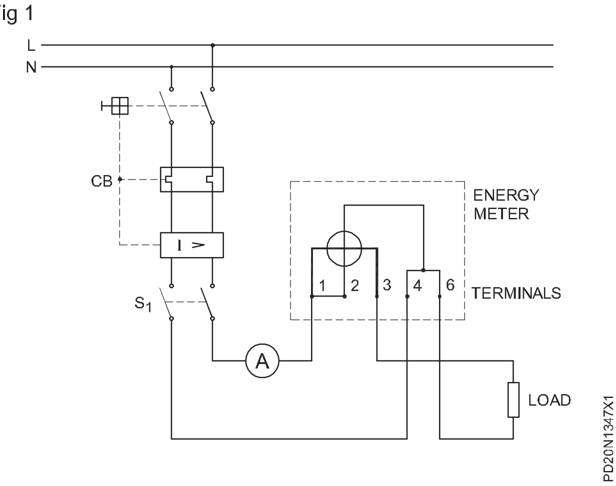


Fig 2

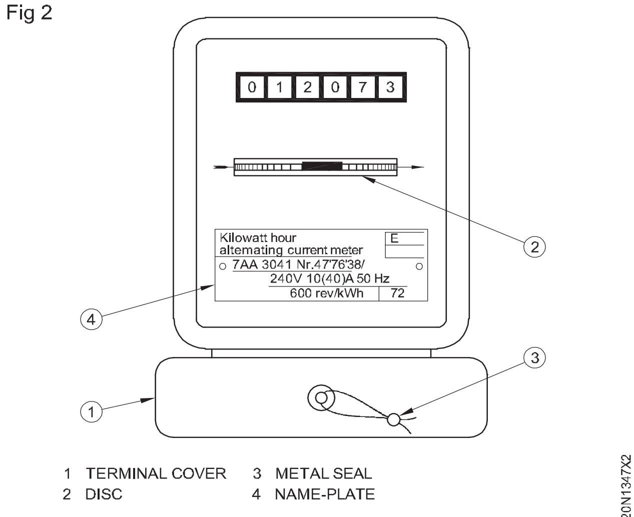


Table 3

Sl. No.	Volt (V)	Current (I)	Meter constant in revolution	Time (Secs)	Energy	
					Wh (Measured)	Wh (Calculated)

8 Connect the inductive load (Lagging power factor) and record the reading (Fig 3) in Table 4

9 Calculate the energy for lagging PF.

Fig 3

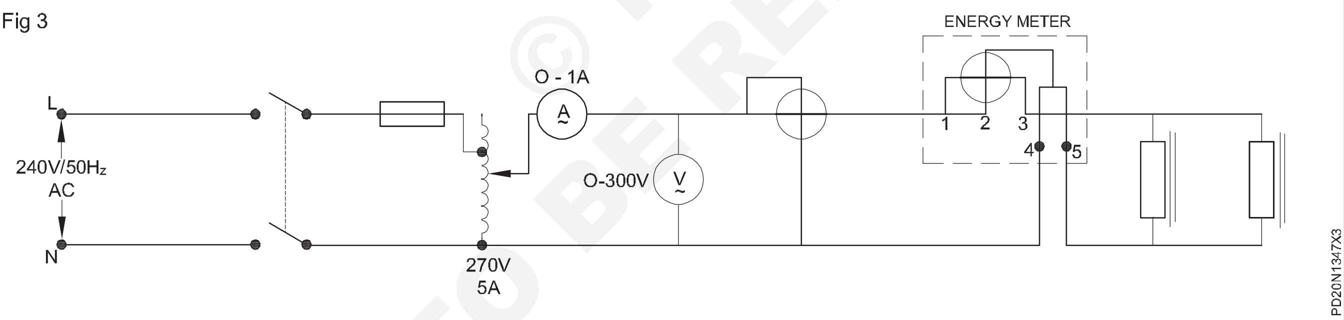


Table 4

Sl. No.	Volt (V)	Current (I)	Meter constant in revolution	Time (Secs)	Energy	
					Wh (Measured)	Wh (Calculated)

10 Switch Off the power and remove the inductive load.

11 Connect the capacitive, reactance (Fig 7) load and record the reading in Table 5.

12 Calculate the energy for leading P.F. compile all the values and record the findings.

13 Plot the graph for lagging and leading P.F. for energy with respect to load current in the space provided

Fig 4

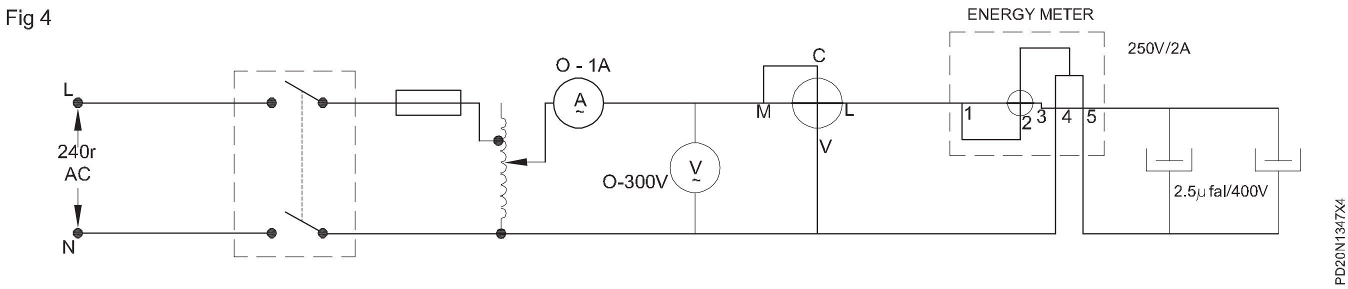


Table 5

Sl. No.	Volt (V)	Current (I)	Meter constant in revolution	Time (Secs)	Energy	
					Wh (Measured)	Wh (Calculated)

14 Get it checked by the instructor.

Result :

Space for Graph

— — — — — —

Measure current, voltage, power, energy and power factor (PF) in 3 phase circuits

Objectives: At the end of this exercise, you shall be able to
- **connect voltmeter, ammeter, wattmeter and power factor meter and 3 phase energy meter in 3 phase circuits**
- **measure the voltage, current, power and power factor and 3 energy in 3 phase circuits with lamp load**
- **measure the voltage, current, power and P.F and energy in 3 phase circuits with inductive lead (Induction motor).**

Requirements

Tools and Instruments

- Insulated screw driver 200 mm - 1 No.
- Insulated cutting plier 150 mm - 1 No.
- M.I Voltmeter 0-300V/600V - 1 No.
- M.I Ammeter 0-5A/10A - 1 No.
- Wattmeter 250V/500V, 5A/10A - 1 No.
- Power Factor meter 415V/20A - 1 No.
- 3 phase 4 wire energy meter 415V/20A - 1 No.

Equipment/Machines

- 3-phase induction motor 415V, 50 Hz, 5 HP (3.75 KW) - 1 No.
- 3-phase lamp load 100 W - 6 Nos.

Materials

- PVC insulated copper cable 2.5 mm^2 650V grade TPIC 16A/500V - 20 m.
- 200 Watt/250V, lamps - 6 hrs.

PROCEDURE

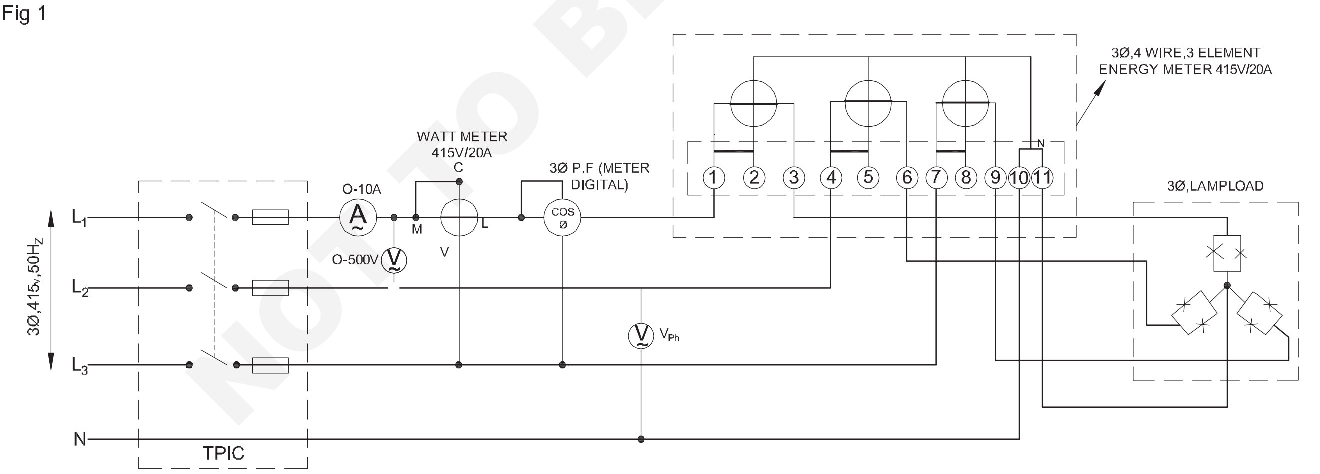
TASK 1: **Measure three phase current, voltage, power and power factor in 3** phase **circuit with lamp load**

1 Select and collect the proper range of meters and lamp load for 3 phase circuit.

The lamp load should have equal wattage in all three phases

3 Switch 'ON' the power supply momentarily after getting the approval of the instructor and observe all themeter deflections. Keep the switch closed if nothing is abnormal.

Fig 1



CIRCUIT DIAGRAM FOR MEASURING OF VOLTAGE, CURRENT,POWER,ENERGY AND P.F IN 3 PHASE CIRCUIT

2 Make the connections of the meters and load as per the circuit diagram (Fig 1).

Connect the current coils of wattmeter, energy meter and P.F meter in series with the load.

4 Note down the initial reading of the energy meter.

5 Note down the meter readings and enter in Table 1.

6 Keep the load in 'ON' position for at least 10 minutes and then note and record the final reading and calculate the energy consumption (i.e) F.R - I.R.

Table 1

Load	Line Voltage	Phase Voltage V_L	Line Current V_{ph}	Phase Current I_L	Power in I_{PH}	Power factor Watt	Initial reading in energy meter	Final reading after 10 min in energy meter F.R	Energy consumption F.R - I.R in KWh
Lamp load for 100W									
Lamp load for 200W									
3 ϕ Ind. meter load									

7 Swtich 'OFF' the power supply.

8 Replace the 100 Watt lamp with 200W lamp load.

9 Repeat steps 3 to 6 and record the readings in Table 1.

10 Switch 'OFF' power supply and disconnect the lamp load and connect 3 phase induction motor 3.75 KW/4.5V/50 Hz to the circuit.

11 Repeat steps 3 to 6 and record the readings in Table 1.

12 Get it checked by the instructor.

— — — — — —

Practice improvement of PF by use of capacitor in three phase circuit

Objectives: At the end of this exercise you shall be able to
- **connect 3 phase balanced inductive load and measure the P.F.**
- **connect 3 phase capacitor bank to inductive load and measure the P.F.**
- **calculate and record the improvement of P.F, after connecting the capacitor bank.**

Requirements

Tools and Instruments

- Insulated combination pliers 200 mm - 1 No.
- Insulated screwdriver 200 mm - 1 No.
- 3 ϕ P.F. meter 240V/440V ; - 1 No.
- Wattmeter 250/500 V, 5A/10A - 2 Nos.
- M.I Ammeter 0-5A/10A - 1 No.
- M.I Voltmeter 0-300V/600V - 1 No.
- Power factor improving capacitor bank 3 phase 415V, 1.5 KVAR - 1 No.

Equipment/Machines

- 3-phase induction motor 415V, 2.25 KW (with loading arrangement) - 1 No.
- 3-phase lamp load 0-3KW - 1 No.

Materials

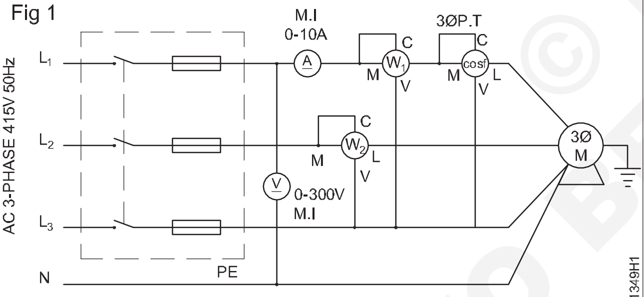
- PVC insulated copper cable 2.5 Sq, MM, 650V grade - 20 m.
- T.P.I.C.Switch 16A, 500V - 2 Nos.

PROCEDURE

TASK 1: **Connect 3 phase unbalanced inductive load and measure the P.F.**

1 Connect two Wattmeters to 3 phase P.F. meter, voltmeter and ammeter to 3 phase motor with load as shown in Fig 1.

Fig 1

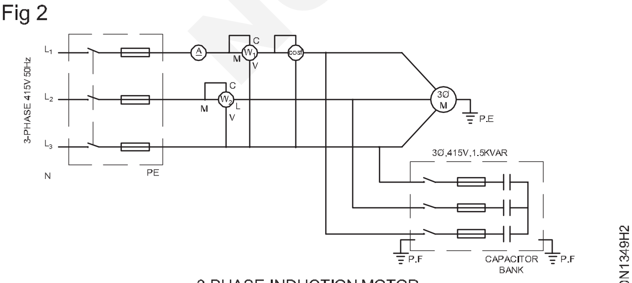


3 PHASE INDUCTION MOTOR WITHOUT CAPARITOR BANK

2 Get the connection checked by the instructor.

3 Switch 'ON' and load the motor to 60% of its load capacity and note the readings in Table 1.

Fig 2



3 PHASE INDUCTION MOTOR WITH CAPACTOR BANK

4 Switch OFF and connect the capacitor bank as shown in Fig 2.

5 Switch ON and adjust 60% of the load and verify the readings as in step 3. The readings will be same.

6 Switch ON the capacitor bank and record the readings in Table 1 for the load conditions.

7 Calculate the P.F. in each case using the following formula.

a) P.F. calculated 1 = cos φ = $\dfrac{W_1 + W_2}{3E_{PH} I_{PH}}$

b) P.F. calculated 2 = Cos θ where the angle θ is derived from the formula $\tan\theta = \sqrt{3}\,\dfrac{W_1 - W_2}{W_1 + W_2}$

8 Enter the values in Table 1. Determine the percentage of error.

$$\%\ \text{error} = \frac{(\text{Calculated P.F.} - \text{Measured P.F.}) \times 100}{\text{Calculated P.F}}$$

Write your conclusion and reasons for if any.

9 Get it checked by your instructor.

Table 1

Condition	Ammeter reading I_{PH}	Voltmeter reading E_{PH}	3-phase apparent power in volt amperes $3 \times E_{PH} \times I_{PH}$	Wattmeter reading W_1 watts	Wattmeter reading W_2 watts	3-phase true power $W_1 + W_2$	P.F. Calculated 1 Cos φ (P.F) $= \frac{W_1 + W_2}{3E_{PH} I_{PH}}$	P.F. Calculated 2	P.F. measured	Percentage of error
Motor with load										
Motor with load and capacitor bank										

Conclusion:

After connecting the capacitor bank, the effect in value of P.F. is ____________________

Measure power factor in three phase circuit by using power factor meter and verify the same with voltmeter, ammeter, wattmeter readings

Objectives: At the end of this exercise you shall be able to
- **connect a single phase P.F. meter in 3-phase balanced load and read the P.F**
- **verify the P.F. by voltmeter, ammeter and wattmeter readings and determine the error**
- **connect the capacitor bank in the 3-phase circuit and measure the P.F.**

Requirements

Tools / Instruments

- Single phase P.F. meter 250V/ 500V; 5A/ 10A - 1 Set
- Wattmeter 250/500V, 5A/10A 1500W - 1 Nos.
- M.I Ammeter 0-5 A/ 10A - 1 No.
- M.I Voltmeter 0-300V/ 600V - 1 No.
- Insulated combination plier 200mm - 1 No.
- Insulated screwdriver 200mm - 1 No.

Equipment / Machines

- 3-phase induction motor 415V 2.25 KW (with loading arrangement) - 1 No.
- Power factor improving capacitor bank single phase 250V, 50 Hz 1kvar - 1 Set
- 3 Phase lamp load 3 KW 415 V 50 Hz - 1 No.

Materials

- PVC insulated copper cable 2.5 sq. mm 650 V - grade - 20 m
- T.P.I.C. switch 16A, 500V - 2 Nos.

PROCEDURE

1 Collect the meters and the 3-phase lamp load.

The lamp load should have equal wattage in all the three phases.

2 Make necessary connections of the meters and load as per circuit diagram - Fig 1.

Connect the current coils of wattmeter and P.F. meter in series with load.

3 Get the circuit approved by the instructor.

4 Switch 'ON' the power supply momentarily observe deflections of all the meters. Keep the switch closed if nothing is abnormal.

5 Equally load all the three phases and note down the meter readings and enter in Table 1.

6 Switch 'OFF' the power supply.

If P.F. meter shows leading P.F. for inductive load, switch 'off' the supply and interchange current coil connections of the P.F. meter.

Fig 1

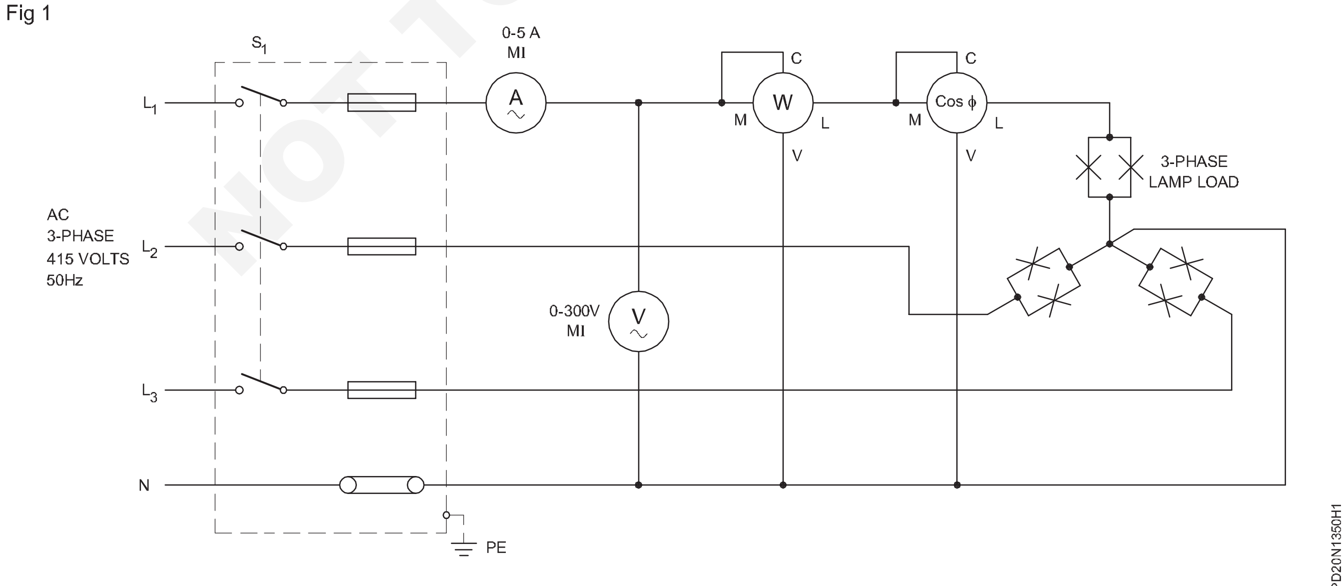


Table 1

Load condition	Ammeter reading in Amps. (I_{ph})	Volt-meter reading in Volts (E_{ph})	3-phase apparent power in watts $3xE_{ph}xI_{ph}$	Wattmeter reading in Watts W	3-phase power W x 3	Calculated value of P.F. $P.F.=\frac{W\times 3}{3\times E_{Ph}\times I_{ph}}$	P.F. measured value	Remarks
Resistive load								
Motor without load								
Motor without load but with capacitor								
Motor with load								
Motor with load and with capactior								

7 Determine the power factor by using the formula,

$$P.F.=\frac{W\times 3}{3\times E_{Ph}\times I_{ph}}$$

Where W- Wattmeter reading (power in one phase)

E_{ph}- Phase voltage

I_{ph}- Phase current (Also equal to line current)

8 Compare the calculated power factor and power factor meter reading and write your observation.

Observation ______________________

____

____

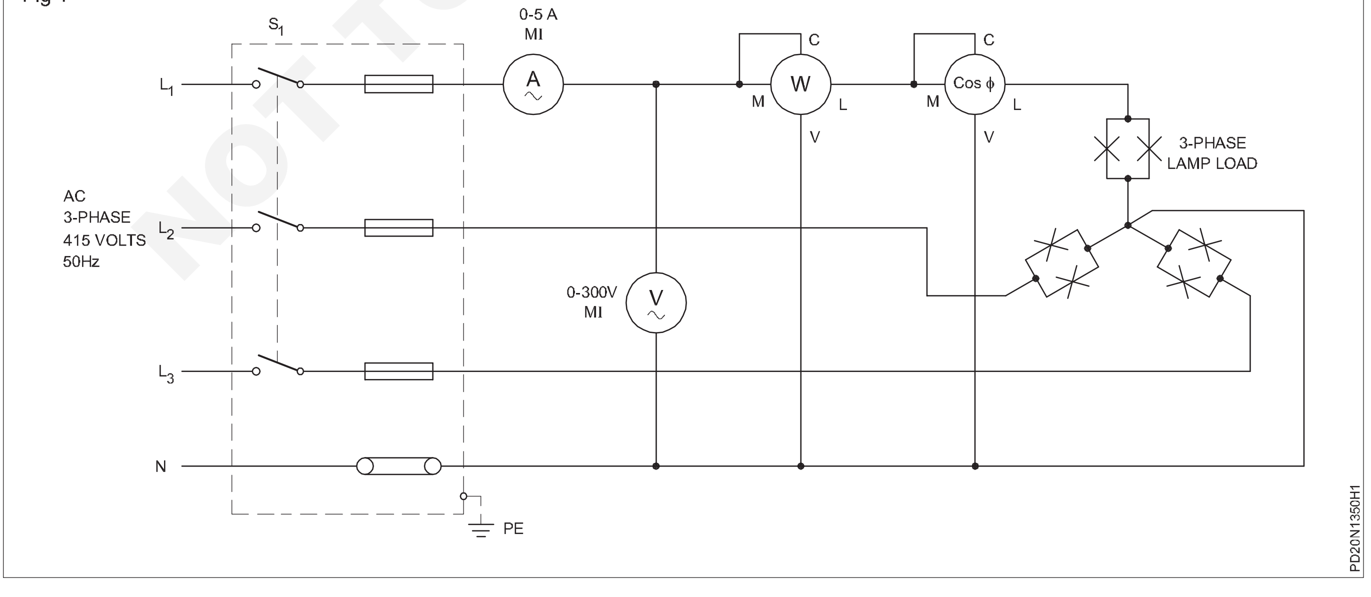
9 Show the readings to your instructor for approval.

10 Disconnect the lamp load and connect the 3 phase induction motor with P.F. improving capacitor as shown in Fig 2.

11 Ensure that the range of current coil in wattmeter and P.F. meter are well higher than the load current of the connected load.

12 Keep the capacitor switch in OFF condition. Switch ON the power supply and observe the deflection of the meters.

Fig 1



13 Record the meter readings in Table 1 for the load conditions shown in Table 1.

14 Switch 'OFF' the power supply and disconnect the connection.

15 Calculate the power factor in each case and compare with the measured P.F.

Consider the multiplying factor of the wattmeter which depends on the range of watt meter with respect to current and voltage ranges and C.C. and P.C. range selected. The reading of the wattmeter should be multiplied with the multiplying factor to get the actual power.

16 Observe the P.F. each load condition and write your observations.

Observation ______________________________

____

____

17 Show the readings and observation to your instructor for approval.

— — — — — —

Ascertain use of neutral by identifying wires of a 3-phase 4 wire system and find the phase sequence using phase sequence meter

Objectives: At the end of this exercise, you shall be able to
- **test the phase wire and identify neutral with the use of test lamp**
- **identify, check and confirm the neutral wire with a meter**
- **connect and verify the phase sequence with 3-phase sequence meter.**

Requirements

Tools and Equipment

- Connector/Screw driver 100 mm - 1 No.
- Combination plier 150 mm - 1 No.
- Test lamp (40W/250V) - 2 Nos.
- Voltmeter 0-600V M.I. - 1 No.
- Phase sequence meter - 1 No.

Materials

- Connecting wires - as reqd.

PROCEDURE

TASK 1: **Test the phase line and identify the neutral with the use of test lamp**

1 Prepare a line test lamp by connecting two lamps in series.

2 Mark the terminals as 1, 2, 3 and 4 and connect one lead of lamp to the marked 1 and other lead to the earth point provided in the frame as shown in Fig 1 and record the condition of lamp in Table 1.

Fig 1

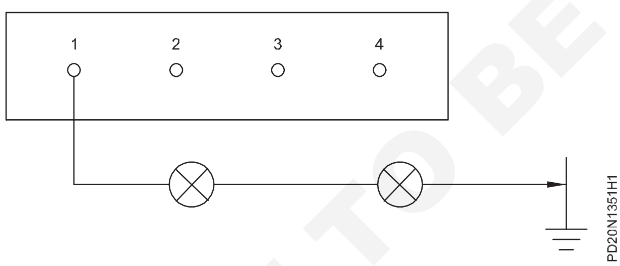


Table 1

Terminals	Glowing	Not glowing
1 to E		
2 to E		
3 to E		
4 to E		

3 Repeat the above step for other terminals 2, 3 and 4 and record the conditions in Table 1.

4 Mark the terminal where the lamp is not glowing as neutral. (N)

The three terminals at which the test lamp glows are the phase leads.

5 Connect one lead, No:4 (Identified as N) and connect the other lead of test lamp to 1, 2, 3. (Fig 2). Record the glow condition of the lamp in Table 2.

Fig 2

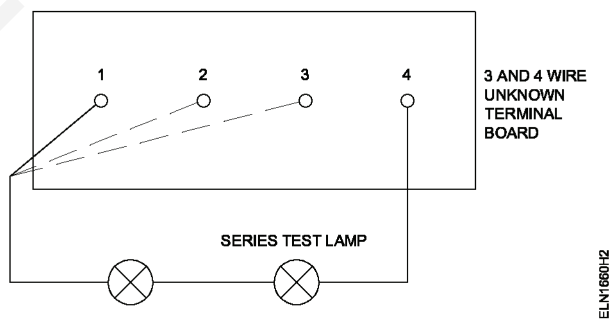


Table 2

Sl.No.	Terminals	Lamp condition	
		Glowing	Not glowing
1	4 - 1		
2	4 - 2		
3	4 - 3		
	1 - 2		
	1 - 3		
	2 - 3		

6 Refer to Table 2, mark the terminals where the lamp is glowing dim as neutral. If the lamp glows bright in the other three terminals i.e. 1-2, 1-3, 2-3 are phase terminal

7 Repeat steps 1 to 5 by replacing lamps in series by connecting the voltmeter (0-600v) and record the readings in Table 3 as shown in Fig 3.

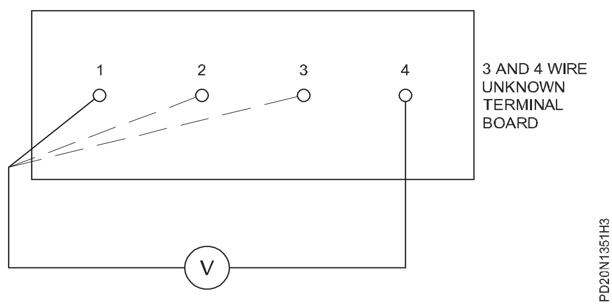


Fig 3

Table 3

Sl.No.	Test terminals	Voltage	
		High	Low
1	4 -1		
2	4 - 2		
3	4 - 3		
4	1 - 2		
5	1 - 3		
6	2 - 3		

— — — — — —

TASK 2: **Identify the phase sequence in 3-phase 4 wire system by using phase sequence meter**

1 Read and record the marking of the phase sequence indicator direction: (Fig 1)

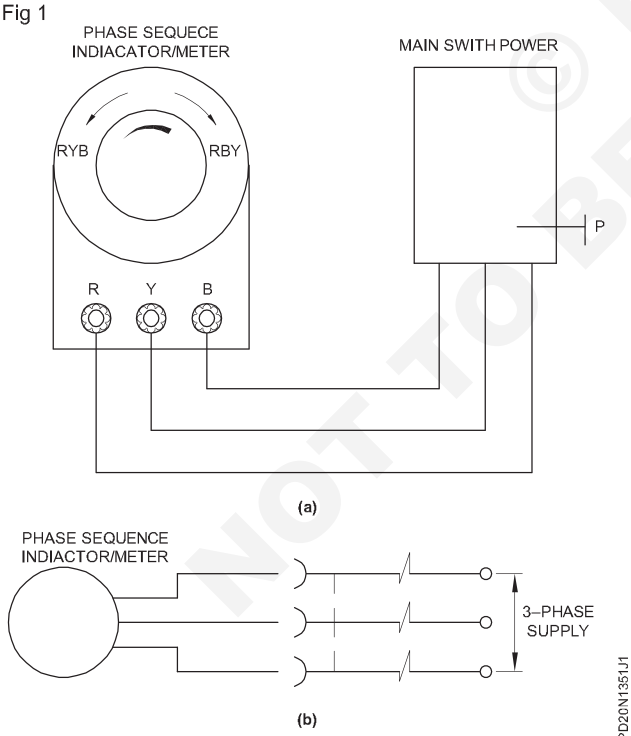


Fig 1

Rotation	Remarks
Same as arrow of the disc Opposite to the arrow of disc	

RYB Sequence } Arrow marking to be indicated

RBY Sequence }

Arrow in clockwise - ↱

Arrow in anti-clockwise - ↶

2 Switch 'OFF' the supply and connect the corresponding terminals (R, Y & B) to the phase sequence Indicator .

3 Mark leads as I, II, III. Connect them, such that I is connected to R, II to Y, III to B,

You can connect any lead (phase) to any terminal in the sequence indicator.

4 Switch 'ON' and observe the rotation of the disc and record the direction of rotation.

5 If the direction is anticlockwise switch 'OFF' the supply and interchange the terminals 1 and 2. Switch 'ON' and see that the rotation is reversed.

6 Mark the leads corresponding to the letters on the Phase Sequence Meter. (PSM)

If you connect any wire to any terminal, the disc will rotate anticlockwise if the RYB sequence is reversed, and it will be in the clockwise direction when RYB is connected in sequence.

7 Get it checked by your instructor.

— — — — — —

Determine effect of broken neutral wire in three phase four wire system

Objectives: At the end of this exercise you shall be able to
- **test a healthy neutral wire in the 3-phase 4 wire system**
- **check the effect of broken neutral wire in 3-phase 4 wire system.**

Requirements

Tools and Instruments

- Combination plier 150 mm - 1 No.
- Connector screw driver 150 mm - 3 Nos.
- Three phase test board with netural link - 1 No.
- Lamp 40/240 V - 3 Nos.
- M.I Voltmeter 0-600V - 1 No.
- M.I Ammeter 0-5A - 3 Nos.
- Line tester 500V/5A - 1 No.

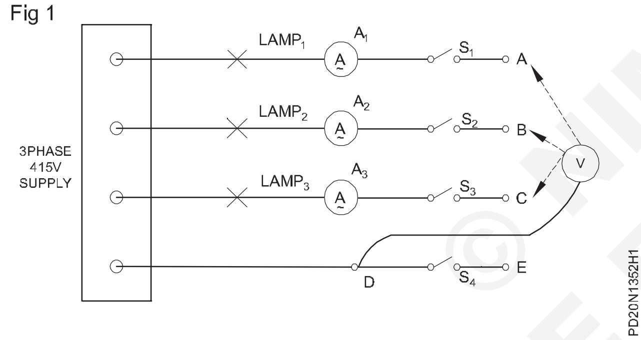
Materials

- Connecting wires - as reqd.
- ON-OFF switch - 4 Nos.

PROCEDURE

1 Connect the circuit as shown in Fig 1.

Fig 1



2 Switch 'OFF' all the switches S_1, S_2,S_3,S_4 and switch ON the 3-phase supply.

3 Check whether the lamps are glowing. Lamps do not glow

4 Switch 'OFF' 3-phase supply. Connect the terminal 'B to D', 'C to D' and 'A to E'

5 Switch 'ON' 3-phase supply. Switch 'ON' S_1, S_2, S_3. Switch 'OFF' S_4. Check if the lamps are glowing. Record all the readings in the Table 1. (L_1 will not glow L_2 and L_3 will glow - Step 2)

6. Switch 'OFF' 3-phase supply. Link 'B-E'. Follow the step 3 in Table - 1. Record the readings

7. Repeat the above step while linking 'C-E' (step 4 in Table 1). Record all the readings

It is evident that when neutral is broken the current does not flow So lamp will not glow, even though supply is available.

Table 1

S. No.	Switch position	A_1	A_2	A_3	V_1	V_2	V_3	Links	Links
1	**S_1,S_2, S_3, S_4 OFF**	0	0	0	0	0	0	–	–
2	**S_1,S_2, S_3 ON S_4 OFF**	0			0			A - E	B to D C to D
3	**S_1,S_2, S_3 ON S_4 OFF**		0			0		B - E	A to D C to D
4	**S_1,S_2, S_3 ON S_4 OFF**			0			0	C - E	A to D B to D

Determine the relationship between Line and Phase values for star and delta connections

Objectives: At the end of this exercise you shall be able to
- **verify the relationship between Line and Phase values in star connection**
- **verify the relationship between Line and Phase values in delta connection.**

Requirements

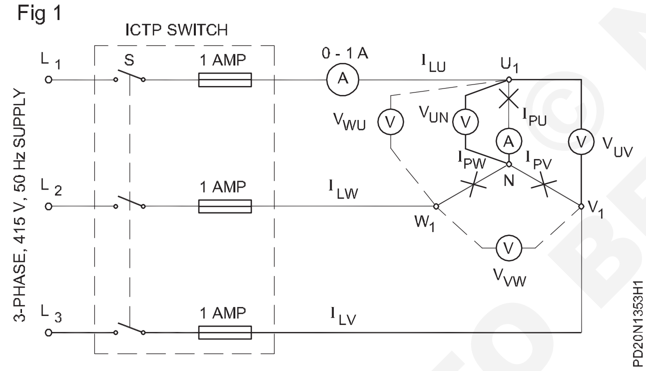
Tools/Instruments		Materials	
• Screw driver 150 mm	- 1 No.	• Connecting leads	- as reqd.
• Combination plier 150 mm	- 1 No.	• Lamp BC - 40W 240V	- 6 Nos.
• M.I Ammeter type 0-1 amp	- 2 Nos.	• 100W 240V	- 6 Nos.
• M.I Voltmeter type 0-500V	- 2 Nos.	• 200W 240V	- 6 Nos.
• ICTPN switch 16A 500V	- 1 No.		

PROCEDURE

TASK 1: **Verify the relationship between Line and Phase values in star connection of three phase system**

1 Form the circuit as per the given circuit diagram. (Fig 1) with one lamp each connected to all the 3 phases (40/100/200 W).

Fig 1



2 Identify the 3-phase (L_1, L_2, L_3) and neutral (N) of supply terminals.

3 Switch 'ON' the 3-phase supply.

4 Measure the line voltage V_{UV} by placing the voltmeter leads between the two lines and enter the reading in Table 1.

5 Repeat for the other line voltages V_{VW}, V_{WU}.

6 Measure the phase voltages by placing the voltmeter leads between one line and star point N, and enter the readings in Table 1.

7 Measure the Line and Phase current and enter the readings in Table 1.

> **Switch 'OFF' supply before effecting any change in load.**

8 Repeat steps 3 to 7 for different loads.

9 Calculate the ratio between the Line voltage and Phase voltage.

$$\frac{V_{UV}}{V_{UN}} =$$

$$\frac{V_{VW}}{V_{VN}} =$$

$$\frac{V_{WU}}{V_{WN}} =$$

10 Verify the ratio between Line current and Phase current, i.e.

$$\frac{I_{LU}}{I_{PU}} = \frac{I_{LV}}{I_{PV}} = \frac{I_{LW}}{I_{PW}} =$$

11 Get it checked by the instructor.

Table 1

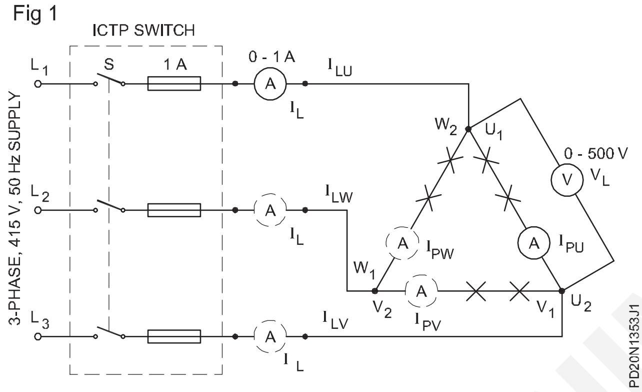
Sl. No.	Load in watts per phase	Line voltage			Phase voltage			Line current			Phase current		
		V_{UV}	V_{VW}	V_{WU}	V_{UN}	V_{VN}	V_{WN}	I_U	I_V	I_W	I_{UN}	I_{VN}	I_{WN}
1	40W												
2	100W												
3	200W												

— — — — — —

TASK 2: **Verify the relationship between Line and Phase values in delta connection in three phase system**

1 Form the circuit as per the given circuit diagram. (Fig 1) Two lamp in series to be connected between two phases of same voltage.

Fig 1



2 Switch ON the 3-phase supply. Measure the line voltages by connecting the voltmeter leads between two of the terminals U_1, V_1, W_1.

3 Measure the phase voltage by placing the voltmeter leads across the lamps, i.e. U_1, U_2 or V_1, V_2 or W_1, W_2.

4 Record the Line voltages and Phase voltages measured, under the appropriate column in Table 2.

5 Measure the Line and Phase currents and enter the readings in Table 1.

An ammeter connected between supply and load indicates Line current. An ammeter connected in series with single load (two lamps in series) indicates Phase current.

6 Repeat steps 2 to 5 for different loads.

Switch off the supply before effecting any change in the load.

7 Verify the relationship between Line and Phase value of current and voltage. Enter in Table 2.

Result

In star : Line current and Phase current are __________
whereas Line voltage =__________ x Phase voltage.
In delta :Line voltage and Phase voltages are __________
whereas Line current =__________ x Phase current.

8 Get it checked by the instructor.

Table 1

Sl. 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_U	I_V	I_W	I_{U1U2}	I_{V1V2}	I_{W1W2}
1	40W												
2	100W												
3	200W												

Table 2

Load	$\frac{V_{U_1V_1}}{V_{U_1U_2}}$	$\frac{V_{V_1W_1}}{V_{V_1V_2}}$	$\frac{V_{W_1U_1}}{V_{W_1W_2}}$	$\frac{I_{LU}}{I_{PU}}$	$\frac{I_{LV}}{I_{PV}}$	$\frac{I_{LW}}{I_{PW}}$
40W						
100W						
200W						

Measure the power of 3-phase circuit for balanced and unbalanced 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, balanced 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.**

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.

Equipment/Machines

- 3-phase, 415V AC induction motor 3 HP coupled with DC generator - 1 No.

Materials

- 200W, 250V lamps - 3 Nos.
- 100W, 250V lamps - 3 Nos.
- Capacitor 400V AC 4 MFD - 2 Nos.
- Connecting leads - as reqd.
- Pendent-holders 6A 250V - 6 Nos.

PROCEDURE

TASK 1: **Connect balanced load in star and measure the power with one single element Wattmeter.**

1 Form 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 turns and record the redings.

4 Total the readings of the wattmeters and check its conformity with the calculated total power.

5 Repeat steps 1 to 4 for different load conditions.

Fig 1

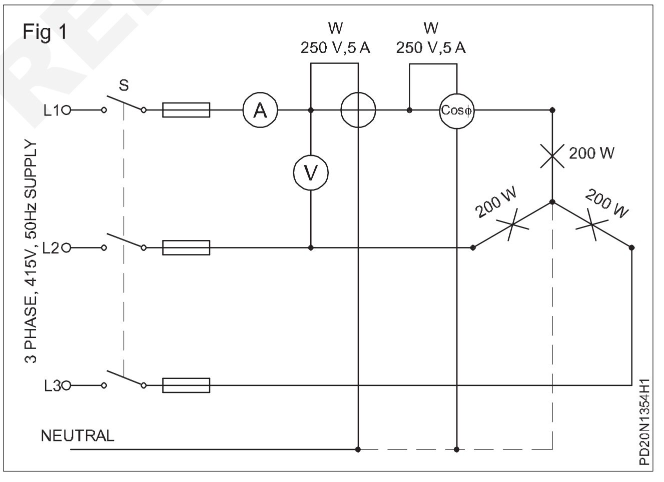


Table 1

Type of Load	Wattmeter connected in the line			V_L	I_L	P.F	Calculated Total power	Total power = Total of three wattmeter readings
	W_{L1}	W_{L2}	W_{L3}				$W=\sqrt{3}\,V_L I_L \cos\theta$	$W_{L1} + W_{L2} + W_{L3} = W$
1								
2								
3								
4								

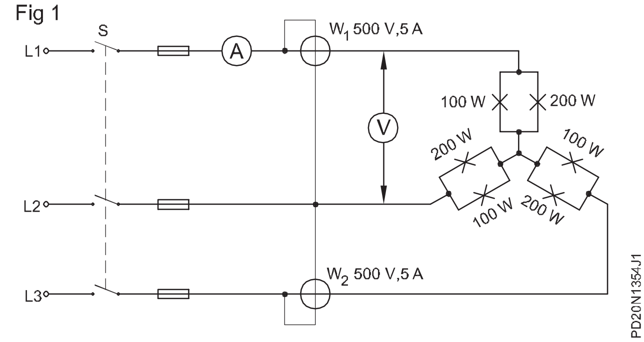
— — — — — —

TASK 2: **Power measurement by two-wattmeter method in 3-phase load**

1 Form the circuit as per the given circuit diagram. (Fig 1)

Connect proper ranges of meters suitable for the given load.

Fig 1



2 Switch 'ON' the 3-phase supply and check whether the deflection of wattmeter is correct. 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 potential coil of the reverse deflection wattmeter. Go to step 5.

4 Read the wattmeters W_1 and 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 and W_2. Record the values in the Table. Record the readings of the wattmeter with the changed potential coil as negative quantity.

6 Measure the 3-phase power for different load conditions specified below:

a) L_1 = 400 W bulb

L_2 = 400 W bulb parallel 4 MFD capacitor

L_3 = 200 W bulb

b) Water load to take a current maximum of 3 amps.

c) Induction motor 3 HP on no load

d) Induction motor 3 HP with load

The instructor may connect the three-phase motor to ensure it is running properly.

7 Calculate the power factor in all the above cases and enter them in Table 2.

8 Get it checked by the instructor.

Table 2

Type of Load	**Wattmeter W_1**	**Wattmeter W_2**	**Total $W_1 + W_2$**	**Calculated Power factor Cos θ** $\tan\theta = \sqrt{3}\dfrac{W_1 - W_2}{W_1 + W_2}$ **Determine Cos θ**
1				
2				
3				
4				
5				

Conclusion : ______________________________

— — — — — —

Measure current and voltage of two phases in case of one phase is short-circuited in three phase four wire system and compare with healthy system

Objectives: At the end of this exercise, you shall be able to
- **connect and test the circuit**
- **measure the current and voltage in healthy conditions**
- **check the condition of the two phase, when one phase is overloaded/short-circuited**
- **record the current and voltage in both conditions.**

Requirements

Tools/Instruments

- M.I Ammeter 0-10A - 2 Nos.
- M.I Ammeter 0-20A - 1No.
- M.I Voltmeter 0-300V - 3 Nos.
- Load 1500W/ 240V - 4 Nos.
- 3 Phase supply board 3φ, 4 wire - 1 No.

Materials

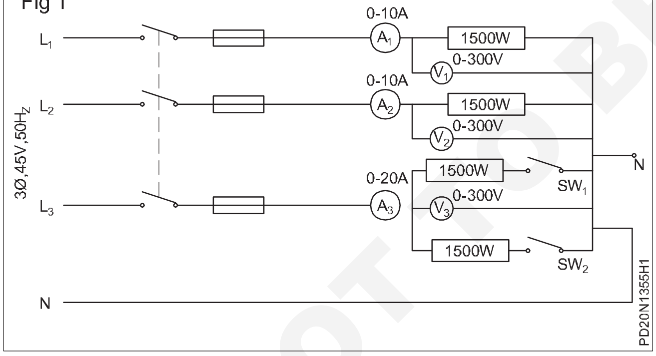
- S.P. switch 240V/16A - 2 Nos.
- Connecting wires - as reqd.
- TPIC - 415V/16A - 1 No.

PROCEDURE

We cannot manually make a short circuit in the phase line as it is dangerous and it may trip the circuit. In order to make a short circuit condition load current is doubled in one phase.

1 Connect the circuit as per the diagram shown in Fig 1.

Fig 1



2 Switch 'ON' the 3 Phase supply and ON the switch SW_1. Record the current and voltage the tabular column.

3 Switch 'OFF' the 3 Phase in supply and SW_2 switch 'ON'.

4 Switch 'ON' the 3 Phase supply and record the readings of the current and voltage in the tabular column.

5 Switch 'OFF' all the supply lines, and disconnect the wiring and return all the materials and equipment.

6 Get it checked by the instructor.

Conclusion : ____________________________

Table 1

Sl.No.	SW_1 - ON				SW_1 - ON & SW_2 ON			
1	A_1		V_1		A_1		V_1	
2	A_2		V_2		A_2		V_2	
3	A_3		V_3		A_3		V_3	

— — — — — —

Measure electrical parameters using tong tester in three phase circuit

Objectives: At the end of this exercise you shall be able to
- **select a sutiable range in tong testers to measure the different Power parameters**
- **measure the AC volt, DC volt and frequency**
- **measure the AC and DC current**
- **measure kw, KVA, PF and phase angle in AC circuit**
- **measure resistance**
- **measure capacitance**
- **measure AC and DC micro ampere.**

Requirement

Tools / Instruments

- Tong - tester - 1 No.

Equipment / Machines

- Single phase lamp load - 1 Set
- Welding Transformer - 1 No.
- 3 phase Induction motor 3 HP 440V, with suitable load - 1 Set

PROCEDURE

TASK 1 : **Measure the AC and DC voltage and frequency**

The operating instruction given below is for one particular tong Tester. Some other model Tong Testers are also be available in market. Follow the operating instructions accordingly.

1 Set the rotary switch to the 'V' Position.

2 Insert the test leads into the input Jack (Black to COM and Red to V)

3 Connect the test leads in parallel to the measured circuit.

4 The meter will automatically switch to ACV or DCV display.

5 The meter will automatically select the appropriate range.

6 Read the voltage and frequency values displayed on the LCD and note down in Table (Fig 1)

— — — — — —

TASK 2 : **Measurement of current in AC circuit**

1 Set the rotary switch to the 'A' position.

2 Press the trigger to open the jaw and fully enclose the conductor to be measured.

No gap is allowed between the two half Jaws.

3 The clamp will automatically select the appropriate range

4 Read the current values displayed on the LCD and note down in Table (Fig 1).

— — — — — —

TASK 3 : **Measurement of AC kW, KVA, PF and ∅ (phase angle)**

1 Set the rotary switch to the KW / KVA Position

2 Insert the test leads into the input Jack. (Black to COM and Red to V)

3 Connect the Black lead COM to the neutral line.

4 Connect the Red lead 'V' to power line and clamp the same conndu ctor where V (red) terminal is connected.

5 The power clamp will automatically select the appropriate range.

6 Read the watt and HP values displayed on the LCD and note down in Table.

7 Press range button to display required parameters.

$$PF = \frac{KW}{KVA} = \cos\theta$$

8 For 3 phase 3 wire balanced load system, insert 3 plug in adapter in terminals " COM" and "V". Connect three crocodile clips to appropriate phase (R, Y and B) 3 phase power = 3 x meter indication (Fig 1).

— — — — — —

TASK 4 : **Measurement of Resistance**

1 Before taking resistance measurement, make sure the circuit is not live and discharge any capacitor present in the circuit.

2 Set the rotory switch to the Ω or M Ω range.

3 Insert the test leads into the input jack. (Black to com and red to Ω)

4 Connect the test leads to the circuit being measured and read the displayed value.

5 Note down the reading in Table.

— — — — — —

TASK 5 : **Measurement of capacitance**

1 Insert the test leads into the input Jacks (Black to COM and Red to

2 Set the rotary switch to the "   " Positon.

3 Connect the rotary test lead to the anode side and black test lead to the cathode side of the capacitor being tested

4 Read capacitance value on LCD and note it in Table.

— — — — — —

TASK 6 : **AC + DC Micro Ampere measurement**

1 Set the rotary switch is " ≂μA" position.

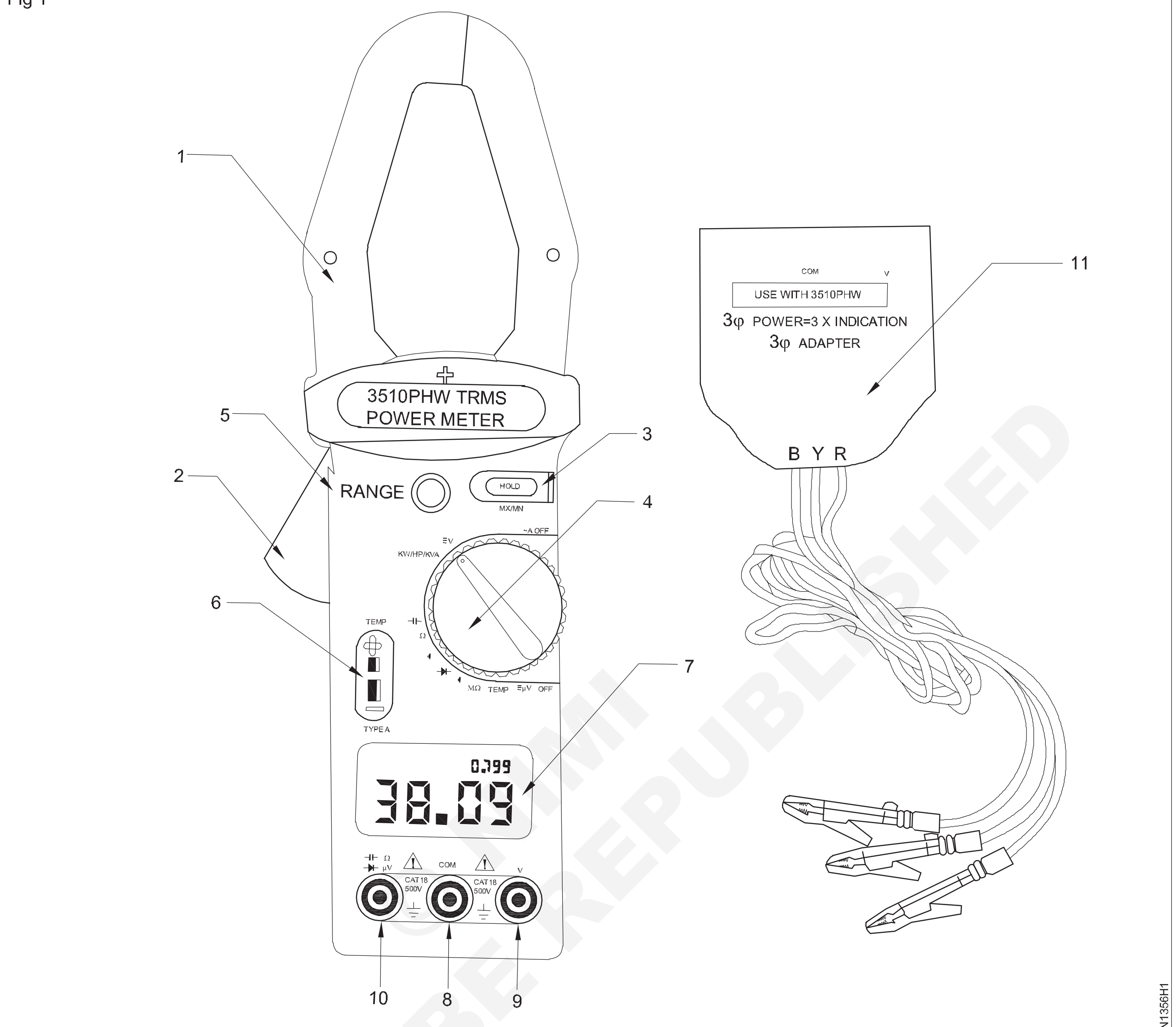
2 Insert the test leads into the input Jack (Black to COM and Red to/μA) (Fig 1)

3 Connect the meter in series the with the circuit being measured and read the displayed value and note down the reading in Table.

Table

Sl. No.	Measurement	Reading 1	Reading 2
1	AC voltage		
2	DC voltage		
3	Frequency		
4	KW		
5	KVA		
6	PF		
7	Phase angle		
8	Resistance		
9	Capacitance		
10	AC Micro Ampere		
11	DC mircro Ampere		

Fig 1



TONG-TESTER

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Measure various electrical parameter using digital multifunction meter

Objectives: At the end of this exercise you shall be able to
- **connect Digital multimeter**
- **measure currect, voltage, power factor,frequency and energy.**

Requirement

Tools / Instruments
- Insulated screw driver 200mm - 1 No.
- Insulated combination plier 200mm - 1 No.
- MFM 384 3 phase multifunctional meter - 1 No.

Equipment / Machines
- Connecting cables

Materials
- ICTP switch 16A, 500V

PROCEDURE

1 Collect tools, equipments/machines and materials.

2 Make necessary connections of the Digital multifunctional meter and load as per circuit diagram in Fig 1.

3 switch 'ON' 3 ϕ supply and observe reading from display of multifuction meter (Shown in Fig 2).

4 Record the readings of voltage, current, powerfactor, frequency and energe as in Table 1.

Fig 1

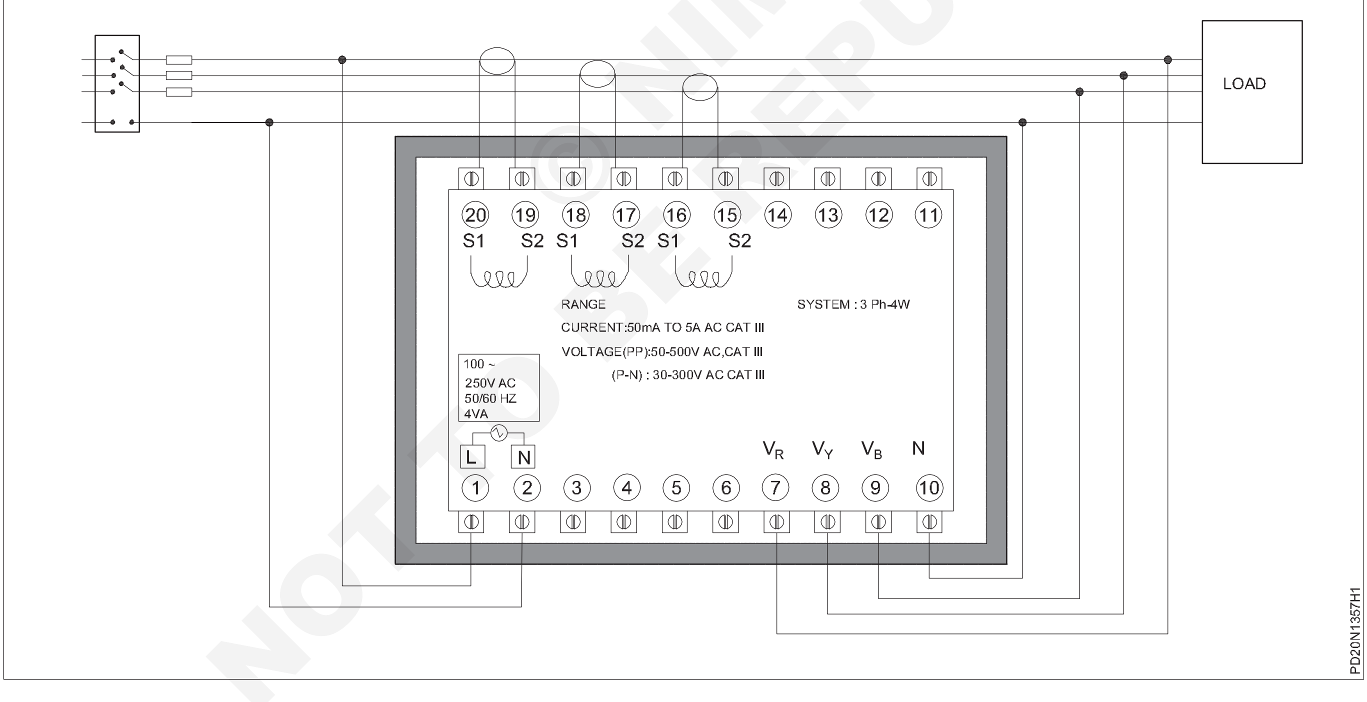
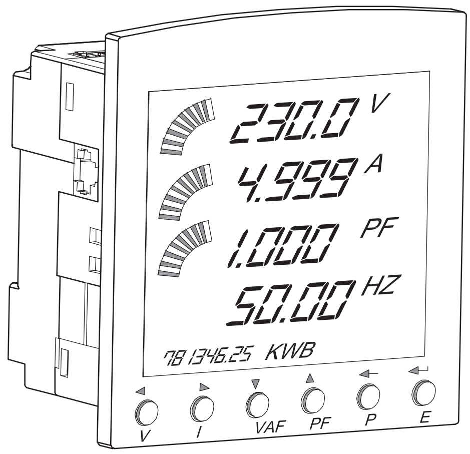


Fig 2



PD20N1357H2

Table 1

S.No.	V	I	Power Factor	Frequency	Energy
1					
2					

— — — — — —

Determine the value of resistance by colour code and identify types

Objectives: At the end of this exercise you shall be able to
- **identify the types of resistors by referring to the pictorial representation**
- **identify the colour bands, and decode the resistance value**
- **calculate the tolerance value by the colour band**
- **measure the actual value with an ohmmeter verify with calculated value.**

Requirements

Tools/Instruments		Materials	
• Multimeter/Ohmmeter	- 1 No.	• Various types of resistors (assorted values) including potentiometers of carbon track and wire-wound type.	- as reqd.

PROCEDURE

TASK 1: **Identify the type of resistor from pictorial representation**

1 Identify the resistor's type by referring Fig 1 and write the type in Table 1.

2 Sketch the I.S. symbol for the identified resistor in Table 1.

Fig 1

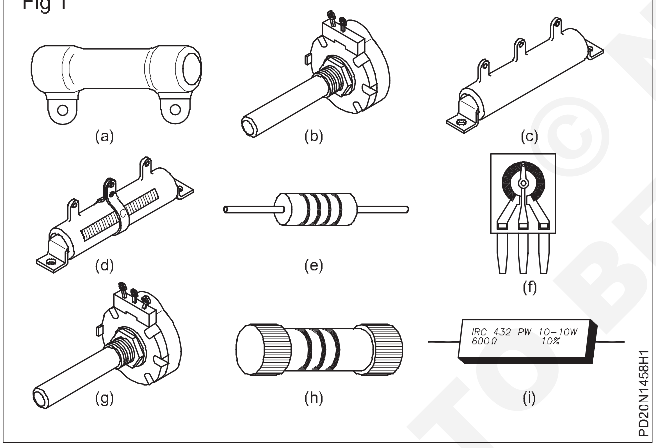


Table 1

Sl. No.	Sketch reference	Type of resistor	Symbol
1	A		
2	B		
3	C		
4	D		
5	E		
6	F		
7	G		
8	H		
9	I		

— — — — — —

TASK 2 : **Identify the colour band and decode the resistance value**

1 Identify the value of resistors shown in Fig 1 from the colour bands and enter Table 2.

2 Identify the first two colour bands of the resistors given by the instructor (in sequence commencing from the 1st colour band closer to one end of the resistor - Refer Fig 2.

3 Write the 1st number and 2nd number in Table 2.

4 Identify the colour of the 3rd band and write the multiplier value in the respective column in Table 2.

5 Compute the value of the resistor and record in Table 2.

6 Identify the 4th band colour and fill up the tolerance in Table 2.

7 Determine the resistance value and the tolerance for the another given resistors and record in your note book by repeating the above steps 1 to 6.

8 Measure the value of the resistors by using a multimeter/ohmmeter and enter the values in your note book by following the procedure given below.

Fig 1

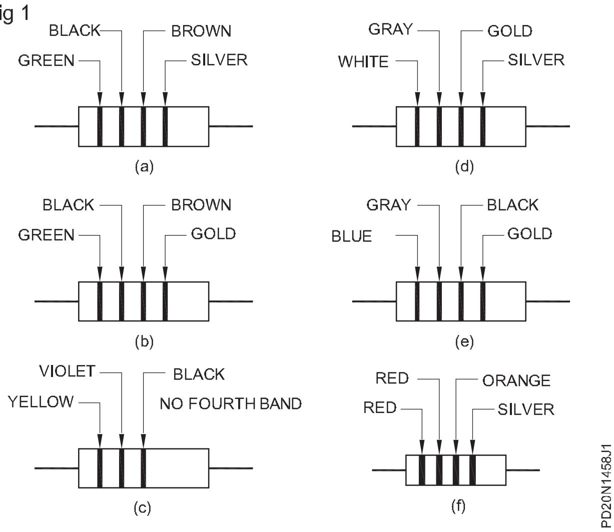


Fig 2

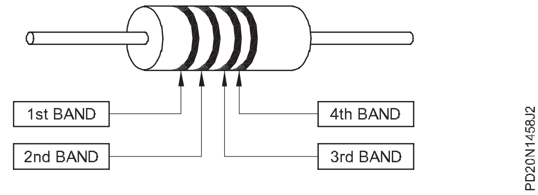


Table 2

Theoretically calculated values										Practically measured value	Tolerance
Sl.No.	Colour				1st No.	2nd No.	3rd No.	Multiplier	Resistance value		Tolerance limit (±) in percentage
	1st Band	2nd Band	3rd Band	4th Band							
A											
B											
C											
D											
E											
F											

— — — — — —

Test active and passive electronic components and its applications

Objectives: At the end of this exercise you shall be able to
- **identify the electronic components - diode, diode bridge, transistor, SCR, IC by referring to the pictorial representation**
- **identify the given electronic components- diode, diode bridge, selenium bridge, transistor, IC, by visual inspection**
- **identify the passive components by visual inspection**
- **interpret the coding and marking on the components**
- **test the components for its working conditions.**

Requirements

Tools/Instruments

- Multimeters/Ohmmeter - 1 No.

Materials/Components

- Capacitors, inductors, resistors (assorted size, shape and values) - as reqd.
- Assorted components of diodes, transistors, SCRs, DIACs, TRIACs, UJTs, FETs bridge diodes etc of different types with semi-conductor data manual - as reqd.

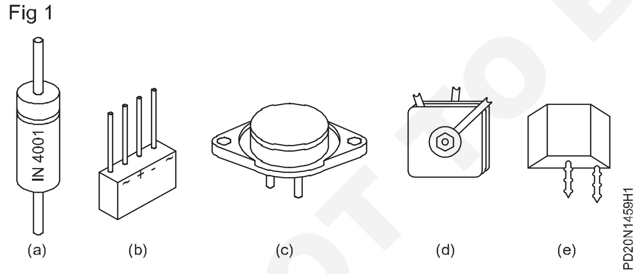
PROCEDURE

TASK 1: **Identify the active components**

Assumption: Given components have their code number, lead identification marks are available in data book.

1 Look at the Fig 1. Identify the component from the pictorial representation. Give your response in Table 1.

Fig 1



2 Write the figure Nos. that indicate the components given in Fig 2, in Table 2

Fig 2

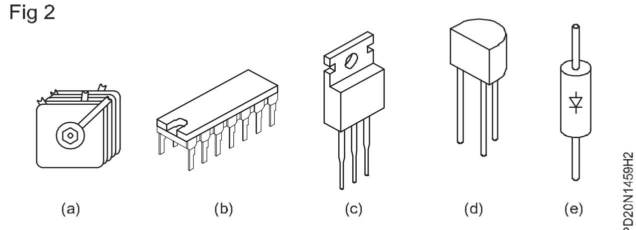


Table 1

Sl.No.	Figure number	Component's name
1	Fig 1 a	
2	Fig 1 b	
3	Fig 1 c	
4	Fig 1 d	
5	Fig 1 e	

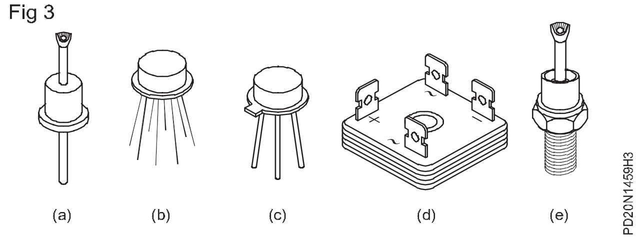
Table 2

Sl. No.	Figure number	Component's name
1		Transistor with heat sink
2		Diode bridge
3		Integrated circuit
4		Diode
5		Transistor

3 Match the names and pictorial representations of the active components (Fig 3).Record your response in the space provided.

4 Collect the electronic (ACTIVE) components from your instructor. Identify the components and record your response in your record book along with sketches of the components. (Refer Fig 3 for guidance)

Fig 3



5 Get it checked by your instructor.

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TASK 2 : **Identify and check the passive components**

> **Instructor shall select the resistors, inductors and capacitors so that, few can be visually identified and other can be identified by coding only.**

1 Identify the passive components referring to Fig 1 and write the type of passive component in Table 1.

2 Sketch the appropriate symbol against the corresponding type of passive components in Table 1.

3 Get your result corrected by your instructor.

4 Collect assorted size, shape and type of passive components from your instructor.

5 Divide the passive components into separate groups as resistor, inductor and capacitor by their appearances (or) code references.

6 Interpret, the code references of resistor and list them in Table 2.

7 Measure the value of resistance of each by multimeter and record in Table 2.

8 Interpret the code references of capacitor and list them in Table 3.

9 Check the capacitor for charge and discharge by multimeter, and record the condition in Table 3 by referring Fig 1.

Table 1

Sl. No.	Fig alphabets	Components identified as	Reasons for identifications	Symbols	Remarks
1	A				
2	B				
3	C				
4	D				
5	E				
6	F				
7	G				
8	H				
9	I				
10	J				
11	K				
12	L				
13	M				
14	N				
15	O				
16	P				

Table 2

Sl. No.	Coded reference	Type of resistors and other details	Measured value of resistor
1			
2			
3			
4			
5			
6			

In case of very low value of capacitors, multimeter may not show any deflection during charge or discharge. Anyhow if the multimeter reading is infinity the capacitor has to be considered as good in case of non electrolytic capacitors.

10 Interpret the code references of inductors/ coils / transformers and list them in Table 4.

11 Check the continuity of the coil and its tapping with the multimeter and record the condition in Table 4.

There should not be any continuity between coil and the core

12 Get the above observation approved by your Instructor.

Table 3

Sl. No.	Coded reference	Type of capacitors and other details	Condition of capacitor
1			
2			
3			
4			
5			
6			

Table 4

Sl. No.	Coded reference	Type of inductors /coils transformers and other details	Condition of coil
1			
2			
3			
4			
5			
6			

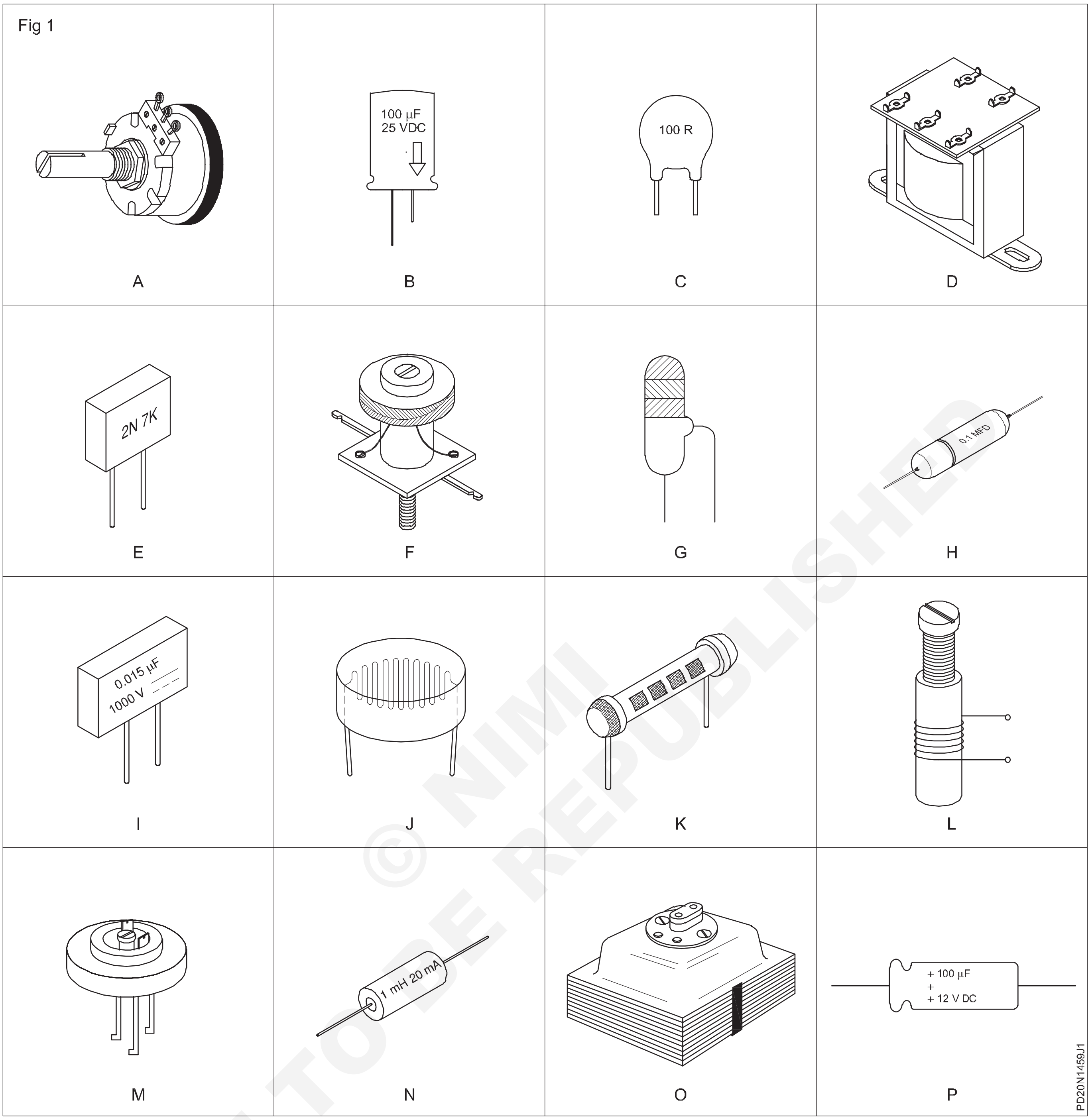


Fig 1
100 µF
25 VDC
100 R
A
B
C
D
2N 7K
0.1 MFD
E
F
G
H
0.015 µF
1000 V
I
J
K
L
1 mH 20 mA
+ 100 µF
+
+ 12 V DC
M
N
O
P
PD20N1459J1

— — — — — —

Determine the V-I characteristics of semi conductor diode

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

- **refer data book and**
  - **a) identify the diode is Ge, Si etc**
  - **b) verify operating voltage and current rating**
  - **c) list the application of the diode**
- **identify the terminals of a diode and test the diode for its condition**
- **plot the forward characteristics, determine the forward resistance of the diode and the barrier potential**
- **plot the reverse characteristics of the diode and determine the minority carrier current.**

Requirements

Tools/Instruments

- Multimeter (Digital) - 1 No.
- Voltmeter MC 0-1 V - 1 No.
- Milliammeter MC 0-25 mA - 1 No.
- Voltmeter MC 0-30 V - 1 No.
- Micro ammeter MC 0-100 Micro Amp - 1 No.
- Semi conductor diode data book - 1 No.

Equipment/Machines

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

Materials

- Assorted types of diodes including IN 4001 or IN 4007 - as reqd.
- 570 Ω, 5W potentiometer - 1 No.
- SPST switch 6A 250V - 1 No.
- Bread board 150 x 150 mm - 1 No.
- Suitable connecting wires for bread board - as reqd.
- Patch cords with clips - 2 sets
- 100Ω 1/4 W resistor - 1 No.
- 10 Ω 1/4 W resistor - 1 No.

PROCEDURE

TASK 1: **Refer the diode with data book**

1 Select any one of the given assorted diodes. Record the type number printed on the diode.

2 Refer diode data book and search for the type number of the selected diode.

3 Look in the data book for the column which indicates Rated peak reverse voltage abbreviated as V_R or V_r or PIV against the referred diode. Find and record the indicated value of rated peak reverse voltage.

4 Get as done in step 4 and record the following specifications of the referred diode from the data book:

- I_F of I_f - Maximum average forward current
- V_F of V_f - Forward voltage drop at specified I_F
- I_s - Maximum forward surge current
- I_{VT} - Maximum reverse current at V_R
- Function - Normal use/application of the diode.

  The coding used for Function differs from data book to data book. Consult instructor in case of difficulty.

5 Repeat steps 1 to 5 for atleast ten different types of given diodes.

6 Refer diode data book or diode equivalents data book and identify one or two equivalent diode types for each diode. For those diodes you collected the specification.

7 Get your work checked by your instructor.

— — — — — —

TASK 2 : **Identify the terminal leads of a given diode**

1 Set the multimeter in ohms range (W x 1). Connect its leads to a M.C. voltmeter (0-3V), to find out the polarity of multimeter output voltage.

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

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

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

4 Connect the +ve marked terminal for the multimeter to one terminal of the diode and other to the -ve and observe the reading.

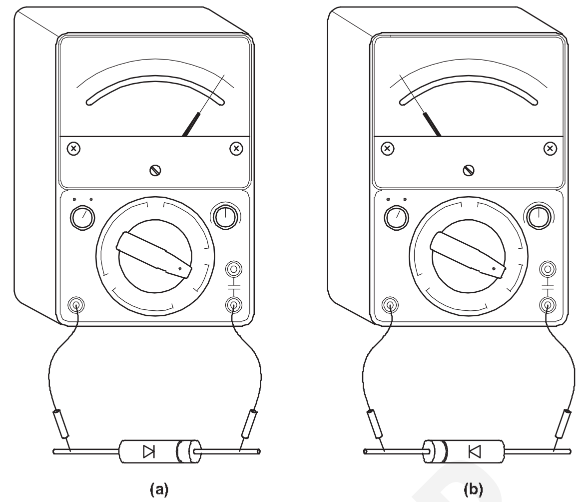
a) If the meter reads low resistance then the lead of the diode connected to +ve marked terminal of the meter is the ANODE and the other is cathode. (Fig 1a)

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

If the meter reads low resistance for both polarities the diode is short.

If the meter reads high resistance for both polarities the diode is open.

Fig 1



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TASK 3 : **Determine the forward V-I characteristic of the diode**

1 Construct the circuit in the bread board as in Fig 1.

2 Set initially V_B = 0 and switch ON the power supply.

3 Set V_B= 5V, set the potentiometer to minimum position.

4 Close the switch S and adjust potentiometer to increase the voltage across the diode in steps of 0.1 V as per the Table.1

5 Record the corresponding values of current read by the ammeter in the Table.1.

Fig 1

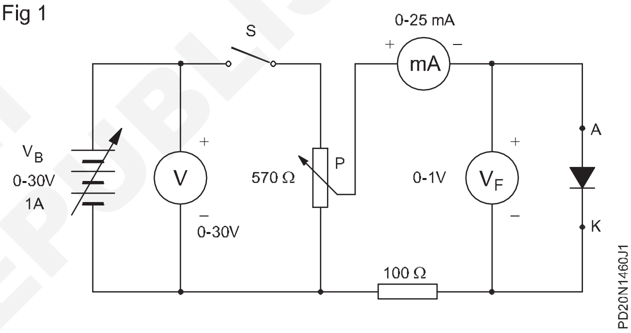

Table 1

V_F Volt	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	2.0
I_FmA	0											

6 Check the value of voltage across the diode at which the current starts increasing and remain constant at later.

7 Switch OFF the supply

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

9 Determine the forward resistance.

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

From the graph determine the knee point voltage at which large quantity of current starts flowing. Enter the value below.

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

Note : Increase the voltage beyond 2.0V as indicated in case diode is not reached in saturation current.

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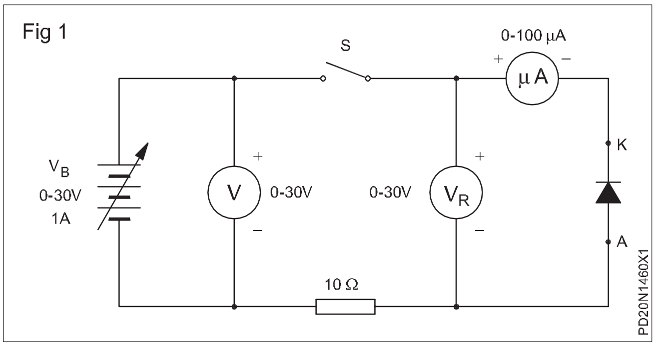
TASK 4 : **Determine the reverse V-I characteristic of a diode**

1 Construct the circuit in a bread board as in Fig 1. (Reverse the Diode terminals with respect to previous task)



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

3 Increase the voltage gradually across the diode by operating the power supply as per Table 1 and note down the corresponding current read by the ammeter in Table 1.

4 Switch OFF the power supply.

5 Plot the graph on the same graph sheet (Task 3) with V_R on x-axis and I_R on Y-axis.

6 Determine the minority carrier current from the graph.

If the reverse voltage becomes equal to the PIV of the diode then the diode starts conducting and not to increase the voltage beyond PIV of the diode.

7 Repeat the experiment for different type of diodes.

Table 1

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

— — — — — —

Construct half-wave, full wave and bridge rectifiers using semi conductor diode

Objectives: At the end of this exercise you shall be able to
- **construct a half-wave rectifier and test**
- **construct and test a full-wave rectifiers using two diodes**
- **construct and test bridge type, full wave rectifiers using four diodes.**

Requirements

Tools/Instruments

- Trainees kit - 1 No.
- Voltmeter MC 0-30V - 1 No.
- Multimeter (Digital) - 1 No.

Materials/Components

- Bread board - 1 No.
- Diode IN4007 - 4 Nos.
- Resistor 470Ω (Ohm) - 1 No.
- Step-down transformer, 240V/12.0.12, 500mA - 1 No.
- Multi strand wire, red, blue 23/0.2 of 650V grade - as reqd.
- Mains cord 3 core cable 23/0.2 of 650V grade - 1 No.
- 3 Pin plug 6A 250 V - 1 No.

PROCEDURE

TASK 1: **Construct half-wave rectifier and test it**

1 Test the continuity of the primary and secondary windings of the given transformer. Record the specifications of the given transformer.

2 Follow the order of steps given below by referring Fig 1.

- Mount the rectifier diode on bread board.
- Connect three core power cord to the transformer.

3 Connect AC mains to the board and switch ON mains. Measure and record the mains voltage and transformer secondary voltage $V_{S(rms)}$ (AC input to rectifier) in the Table 1.

4 Calculate and record the calculated DC voltage across load R_L using the formula,

$V_{dc} = 0.45\ V_{S(rms)}$

where, $V_{S(rms)}$ is the AC input to the rectifier.

5 Measure and record the rectified DC voltage V_{dc} across load R_L using multimeter.

6 Record the difference in the calculated and measured values.

7 Get it checked by your instructor.

Transformer specifications

Rated primary voltage	
Rated secondary voltage	
Secondary current or VA rating of transformer	
Type of transformer step-up/ step down	
No. of windings in secondary	

Fig 1

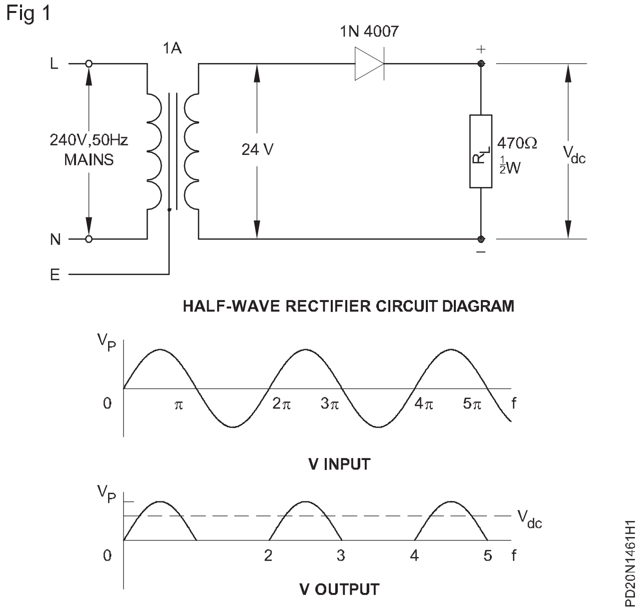


Table 1

Readings of single diode half wave rectifier

$V_{s(rms)}$ (1)	Calculated V_{dc} volts (2)	Measured V_{dc} volts (3)	Difference of (2) & (3) (4)	Peak value of V_s (5)	Frequency of V_s (6)

— — — — — —

TASK 2 : **Construct full wave rectifier with centre tap transformer**

1 Check to confirm good condition of the given components. Record specifications of the transformer.

2 Construct a full wave rectifier circuit as shown in the schematic and layout diagram at Fig 1.

Transformer specifications

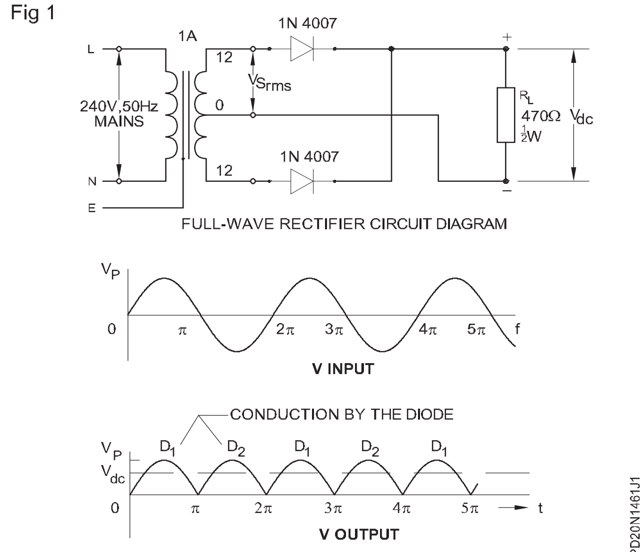
1	Rated primary voltage	------
2	Rated secondary voltage between centre tape and one end	------
3	Rated secondary current or VA rating transformer	------

3 Switch ON the circuit. Measure the AC input voltage $V_{s(rms)}$ to the rectifier across the center-tap and any one end of the transformer and record it in Table 1.

4 Calculate the expected DC voltage V_{dc} across load R_L using the formula given below;

In full wave rectifier, $V_{dc} = 0.9\ V_{s(RMS)}$ where, $V_{s(rms)}$ is the voltage across the centre-tap and any one end terminal of secondary. Record the value in Table 1.

Fig 1



5 Measure the rectified output V_{dc} across load R_L and record it Table 1.

6 Calculate and record the difference in the calculated and measured V_{dc} values. Get it checked by your instructor.

Table 1

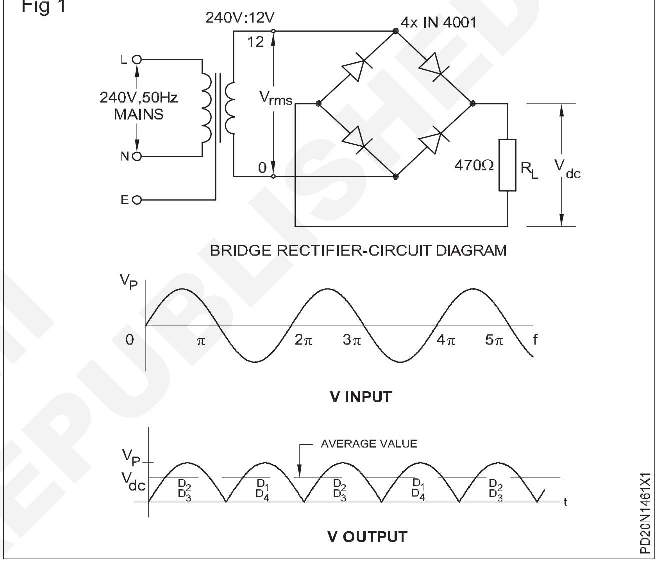
Readings of two-diode full-wave rectifier

$V_{s(rms)}$ V_{dc} (1)	Calculated volts (2)	Measured V_{dc} volts (3)	Difference of (2) & (3) (4)	Peak value of V_s (5)	Frequency of V_s (6)

— — — — — —

TASK 3 : **Construct bridge rectifier**

Fig 1



1 Modify the two diode full wave rectifier wired in Task 2 to construct a bridge rectifier, referring to the schematic and layout diagrams (Fig 1).

2 Switch On the circuit. Measure and record the AC input $V_{s(rms)}$ to the rectifier in Table 1.

3 Calculate the expected output DC voltage V_{dc} across load R_L using the formula, In a bridge rectifier.

$V_{dc} = 0.9\ V_{s(rms)}$ where, $V_{s(rms)}$ is the AC input to the rectifier (refer Fig 1). Record the value in Table 1.

4 Measure the DC output V_{dc} across the load R_L and record it in Table 1.

5 Record the difference in the calculated and measured values in Table 1.

6 Report and get it checked by your instructor.

Table 1

Readings of bridge rectifier

$V_{s(rms)}$ V_{dc} volts (1)	Calculated V_{dc} volts (2)	Measured (2) & (3) (3)	Difference of (4)	Peak value of V_s (5)	Frequency of V_s (6)

— — — — — —

Check transistors for their functioning by identifying its type and terminals

Objectives: At the end of this exercise you shall be able to
- **identify a transistor from its type-number the following information referring to a data book;**
  a) silicon or germanium
  b) PNP or NPN
  c) package type
  d) base, emitter, collector pins.
- **test the condition of a given transistor using ohmmeter/multimeter.**

Requirements

Tools/Instruments
- Trainees kit - 1 No.
- International transistors data book - 1 No.
- Ohmmeter/multimeter - 1 No.

Materials/Components
- Assorted type of transistors - 10 Nos.
- Sleeve wires of red, yellow, blue and black colours 1 mm dia - as reqd.

PROCEDURE

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

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

2 Refer to transistor data manual, find and record the following details of the transistor in Table 1
- Whether silicon or germanium
- Whether NPN or PNP
- Type of packaging or case outline (Example: TO5, TO7 etc.)

Fig 1

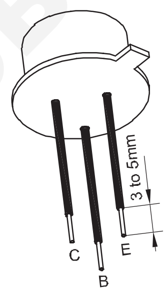


Table 1 (With sample data)

Label No.	Transistor type No.	Semi-Conductor	Type of package /type	Pin Diagram	E- B Junction resistance B-C	
					in forward bias E-B	in reverse bias (E-B & B-C)
Sample	BC107	Si/NPN	T018		Low	Very High

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

4 Put sleeves of suitable length (Fig 1) to the identified pins of the transistor using the colour scheme given below:

Base : Blue colour sleeve
Emitter : Red colour sleeve
Collector : Yellow colour sleeve
Shield : Black colour sleeve

In power transistors, the metal body itself will be the collector. In such cases, mark 'C' on the metal body using a pencil. All transistors will not have shield pin.

5 Repeat steps 1 to 4 for atleast five transistors of different types in the given lot and get your work checked by your instructor.

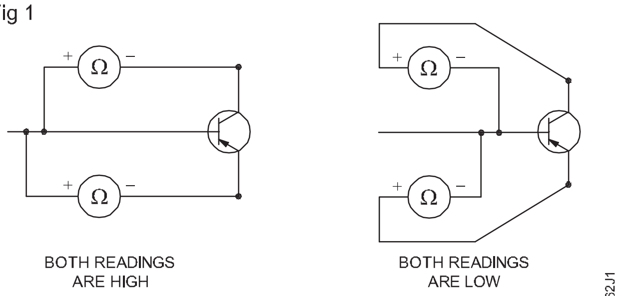
TASK 2 : **Check the transistor for PNP or NPN type**

Referring a data book with respect to transistor number gives the information whether transistor is PNP or NPN. In the absence of data book this test will be useful.

1 Ascertain the +ve and -ve polarity of the ohmmeter leads.

2 Hook the negative lead of the ohmmeter test prod to the base and the positive lead of the ohmmeter to emitter of the transistor.

Fig 1



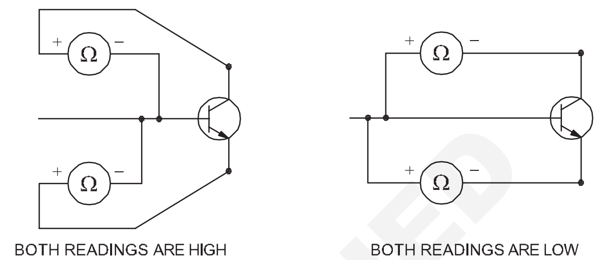
RESULTS OF THESE OHMMETER TESTS PROVE THAT TRANSISTOR IS THE PNP TYPE

3 Read the resistance value.

A low reading shows the transistor is PNP and the high reading shows the transistor is NPN provided the condition of the transistor is good. Refer Fig 1 and 2.

4 Record your findings in Table 1 and mark the identified type and condition.

Fig 2



RESULTS OF THESE OHMMETER TESTS PROVE THAT TRANSISTOR IS THE NPN TYPE

Table 1

Transistor	Forward bias No.		Ohmmeters	Reverse bias reading		Ohmmeters	Transistor reading	Remarks Type
	+Ve	-Ve		+Ve	-Ve			
AC128	E	B	Low	C	B	Low	PNP	Good
	B	E	High	B	C	High		

— — — — — —

TASK 3 : **Test transistor for its working condition**

1 Identify which terminal of the ohmmeter being used is connected to the +ve terminal of the internal battery of the meter. Set the meter range to RX100Ω.

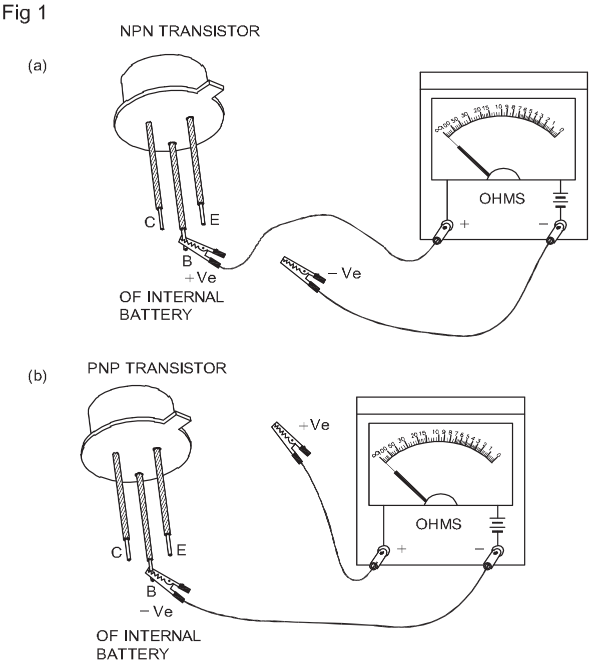
Ohmmeters in very low or very high ohms range can produce excessive current/voltage and may damage low power transistors while testing.

2 Take a transistor whose pins are identified and sleeved at Task 1. Depending on whether the chosen transistor is NPN or PNP, clip/hold the +ve or -ve of the meter prod to the base of the transistor as shown in Fig 1a and 1b.

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

4 Reverse the polarity of the prod connected across the base-emitter and check if the base-emitter junction diode of transistor shows low resistance or very high resistance. Record your observation in Table 1.

Fig 1



5 From the recorded observations in steps 3 and 4, and referring to the table given below, conclude and record, the condition of the base-emitter junction diode of the transistor as GOOD, open or shorted in Table1.

> **If the resistance of the junction measured in both directions is high, in addition to the condition of the junction given in table, an other possibility is, your identified base pin may be wrong. You may be measuring resistance across emitter-collector. In case of doubt, recheck the identified pins of the transistor and repeat steps 2,3 and 4.**

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

7 Measure the resistance across the emitter-collector and record the observation as V-HIGH (> 1MΩ) or LOW (<500Ω).

> **In a good transistor the resistance between the emitter and collector will be very high. A low resistance indicates that the transistor is leaky.**

8 Clip the meter across the emitter-collector with correct polarity as in Fig 2. Touch the base-collector with moist finger as in Fig 2 and check if the resistance shown by the meter decreases indicating that the transistor is turning ON. Record your observation as YES or NO in Table 1.

9 From the observations recorded at steps 5,6,7 and 8, give your conclusion on the overall condition of the transistor under test. Refer Table 1.

10 Repeat the steps 1 to 9 for at least five more transistors of different types.

11 Report and get your work checked by your instructor.

Fig 2

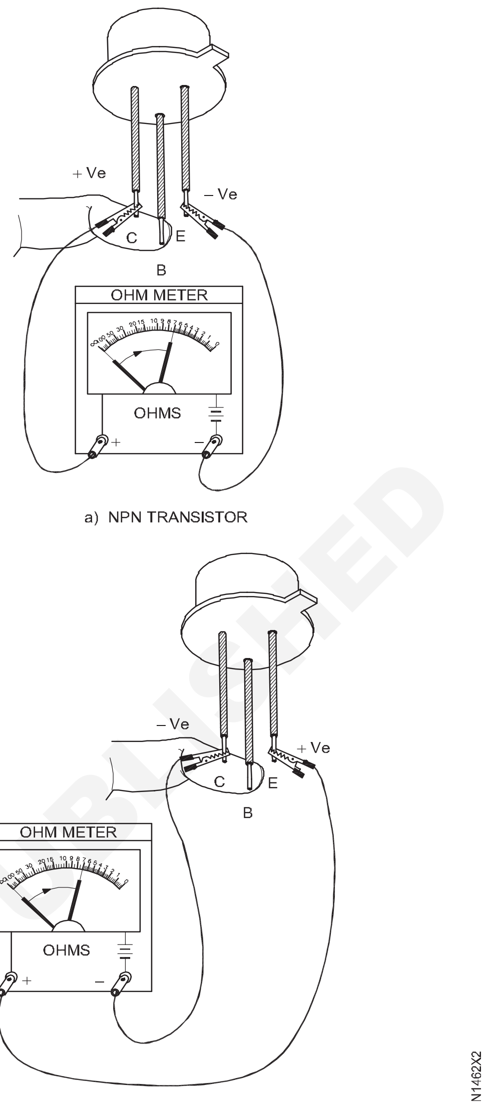


Table 1

Resistance of P - N junction with meter prods in one direction	Resistance of P - N junction with meter in reversed direction	Condition of P - N Junction
Low	Very High	Good
Low	Low	Shorted
Very High	Very High	Open (see Note above)

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Use transistor as an electronic switch and series voltage regulator

Objectives: At the end of this exercise you shall be able to
- **determine the minimum forward bias current required to switch the transistor from OFF to ON condition**
- **construct transistorised series voltage regulator and test**
- **measure ripple at input and out put of the regulator and find ripple factor.**

Requirements

Tools/Instruments

- Ammeter MC - (0-100 milliamp) - 1 No.
- Ammeter MC (0-100 microamp) - 1 No.
- Voltmeter MC (0-15 V) - 1 No.
- Trainees Kit
- Unregulated DC power supply 0-30VDC/1A - 1 No.
  CRO, 20 MHz - 1 No./ batch

Equipment/Machines

- DC regulated power supply; 0-30 V 1 amp - 1 No.

Materials

- Transistor BC 107 - 1 No.
- Lamp 6V, 150 mA - 1 No.
- Variable resistor 250K 1 W - 1 No.
- Bread board - 1 No.
- Connecting leads - as reqd.
- Dry cell 1.5 V - 1 No.
- Tag board (Code no. 111-01-TB) - 1 No.
- Transistor SL 100 or equivalent - 1 No.
- Zener diode, 12V, 1/4W - 1 No.
  180Ω - 1 No.
  1KΩ - 2 Nos.
  220 Ω - 1 No.
  330 Ω - 1 No.
- Capacitor, 10µF, 25V - 1 No.
- LED, Red colour - 1 No.
- Hook up wires (Red and Black) each - 1 Meter
- Rosin core solder - 20 cms.

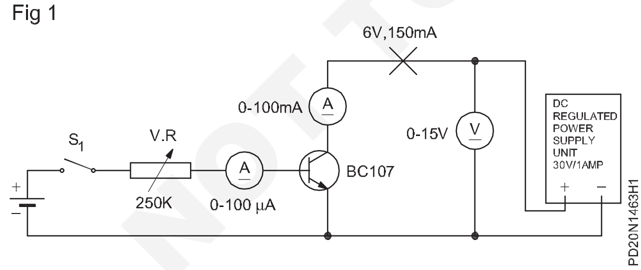
PROCEDURE

TASK 1: **Perform the using of the transistor as an electronic switch**

1 Collect the specifications from the data book for the transistor used in the circuit diagram. (Fig 1)

2 Form the circuit as per the given circuit diagram (Fig 1)

Fig 1



> **Check for the specific range of instruments and correct polarity.**
>
> **Keep the supply OFF and the voltage knob of power supply unit at 0V.**

3 Switch ON the power and set the collector supply to 10V by operating the voltage knob.

4 Switch ON the battery supply by closing the switch S_1 to the base-emitter circuit.

5 Adjust VR for base current of 5 microamps and note the collector current and record it in Table 1.

6 Change I_b to 90 microamps insteps as in the Table 1.

Table 1

Base current in micro-ampere	5	10	20	30	40	50	60	70	80	90
Collector current in milliampere										
State										

7 Check the value of I_b for which I_c has not changed, (i.e. I_c is saturated).

8 Vary the I_b base current between the two readings to find the exact value of I_b at which I_c reaches saturation.

9 Set the I_b to a value just above minimum to cause I_c saturation and check for 'ON' 'OFF' action by operating switch S_1. Switch OFF power supply.

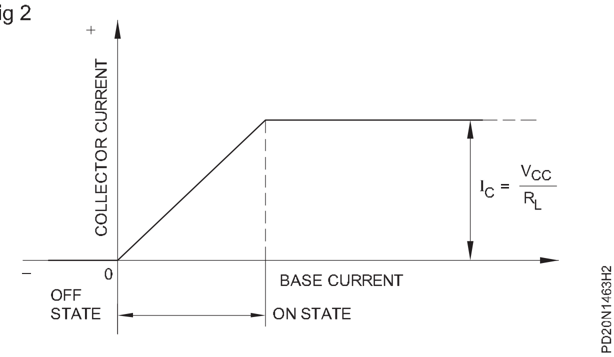
10 Connect a lamp 6V, 150 mA in the collector circuit as in Fig 1 and switch 'ON' the power supply.

11 Check lamp glowing; if not slightly adjust the base current to increase till the lamp 'ON'.

12 Confirm the lamp operation by operating base current of Transistor.

13 Draw the base to the collector current graph, and mark the states of the transistor. (Fig 2)

Fig 2



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TASK 2 : **Construct transistorised series voltage regulator**

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

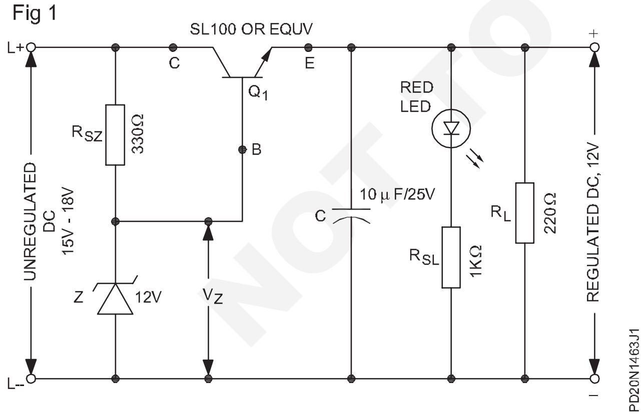
Table 1

Sl.No.	Input P.S voltage in volts	O/P P.S voltage in volts	Remarks
1	6		
2	8		
3	10		
4	12		
5	14		
6	16		

2 Test to confirm the condition of the given components.

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

Fig 1



4 Connect an unregulated DC voltage of 0 - 30V to the input terminals of the wired series regulator board.

5 Get the interconnections made checked by your instructor.

6 Switch on the AC mains supply to the unregulated DC supply.

7 Measure and record the input voltage and output voltage of the series regulator.

8 Measure and record the following voltage levels in observation and tabulation sheet .

a) Voltage across zener, V_Z

b) V_{CE} of the transistor Q_1

c) V_{BE} of the transistor Q_1.

9 Keep input P.S Voltage 2V and measure O/P voltage and record in Table 1.

10 Increase the voltage steps of two and record the corresponding O/P voltage in Table 1.

11 Increase the voltage steps up to 16V and record.

Beyond 12V in the output voltage, any increase in input voltage beyond 12V, 14V or 16V will not make any change in output voltage.

12 Switch 'OFF' & Connect to the CRO to the I/P side and O/P side of P.S. (using dual trace CRO) measure and record the ripple presentation the circuit. Record it in Table 1.

13 Calculate the ripple factor in Table 1.

— — — — — —

Operate and set the required frequency using function generator

Objectives : At the end of this exercise you shall be able to
- **identify the various controls of the function generator**
- **operate the equipment and set the required frequency and wave form**
- **measure the time and frequency of the set waveform using CRO.**

Requirements

Tools/Instruments

- 10 MHz oscilloscope dual Trace - 1 No.
- Function generator - 1 No.
- AF oscillator 20 kHz - 1 No.

Materials

- Patch cords - 1 Set

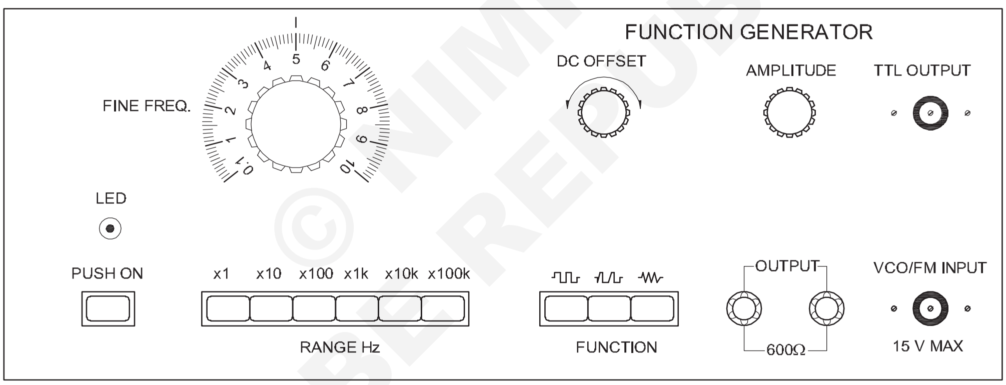
PROCEDURE

TASK 1: **Practice using of a function generator**

1 Locate the various control of the function generator on its front panel which may look like Fig 1. (Some other model have few changes)

2 Keep the amplitude adjustment knob to a minimum position.

Fig 1



FRONT PANEL OF FUNCTION GENERATOR

3 Connect B & C cable to CRO and set CRO working/ measuring conditions.

4 Using patch cords connect the output terminals of the function generator to the input terminals of the CRO. Keep both the instruments in OFF position.

5 Press the function switch to select sine wave.

6 Select 10 Kilo Hertz Range by pressing the range switch marked 'X 10 K'

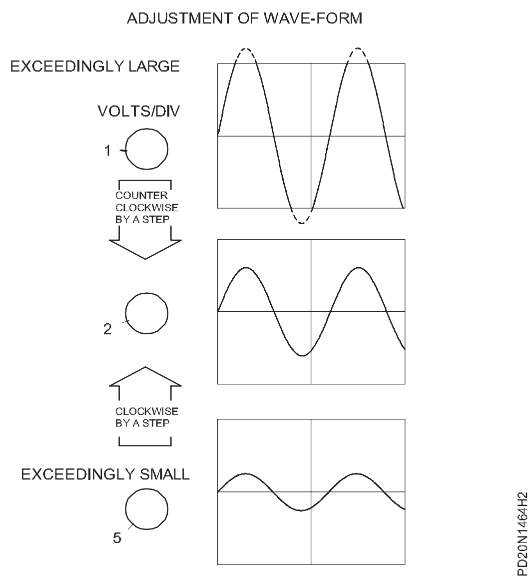
7 Keep the fine frequency dial to position 2 (Fig 1).

8 Set AC-DC switch to AC position (out) in the CRO.

9 Switch 'ON' the power of both function generator and the CRO. Adjust the trace to be on the centre of the screen.

10 Adjust the amplitude knob of the function generator and the Volts/DIV on the CRO To get a clear sine wave on the screen follow the illustration (Fig 2).

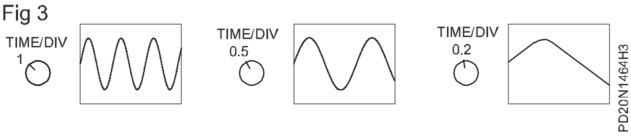
Fig 2



11 Adjust the TIME/DIVISION knob to get adequate number of peaks on the screen.

> **Relationship between TIME/DIV. (sweep time) and No. of peaks.**
>
> **When the TIME/DIV. switch is turned clockwise, the time per one period of saw-tooth wave will become small and the wave-form part is stretched. (Fig 3)**

Fig 3



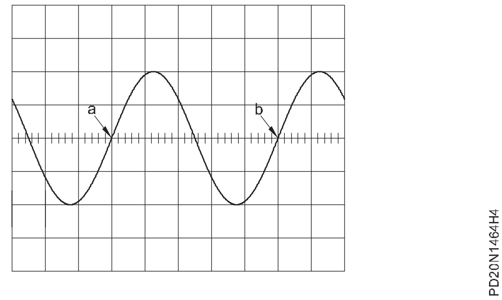
12 Adjust the X-shift control to move the start of the measurement period to a convenient reference point (intersecting point of vertical and horizontal lines). (Fig 4)

13 Check the time period of the wave form. The time between a and b can be determined by counting the no. of horizontal divisions and multiplying it with time base range.

Example

If the time base is set to 0.01 millisecond. There are 5 divisions between 'a' and 'b'.

Fig 4



therefore time period t = 5 x 0.01 = 0.05 ms

therefore frequency of the wave form

$$'f' = \frac{1}{T} = \frac{1}{0.05 \times 10^{-3}}$$

$$= 20 \text{ kHz.}$$

14 Vary the frequency range settings on the functions generator (follow the Table.1) and verify the output frequency using oscilloscope.

15 Set the function switch to some other wave (e.g. square, triangular etc.,) and repeat the steps 9 to 13 (Note to record the readings in Table 1). Only sine wave entry is needed in Table 1.

Table 1

Trial No.	Range switch position	Fine freq. dial position	Set frequency	Measured frequency using CRO	Remarks
1	x 1	10	10 Hz	—-	
2	x 10	5	50 Hz	—-	
3	x 100	3.5	350 Hz	—-	
4	x 1K	5	5 kHz	—-	
5	x 10K	0.1	1 kHz	—-	
6	x 100K	2	200 kHz	—-	

— — — — — —

Make a printed circuit board for power supply

Objectives: At the end of this exercise you shall be able to
- **transfer the layout on to a copper clad board**
- **punch component mounting holes**
- **paint the pattern using etch-resist ink pen, Indian ink or enamel paint**
- **etch a painted copper clad board**
- **trace the component side pattern and make the components**
- **drill holes on the PCB**
- **rivet tags/terminals at input and output points.**

Requirements

Tools/Equipments/Instruments

- Centre punch, sharp tip - 1 No./batch
- Wooden mallet - 1 No./batch
- Trainee's Kit - 1 No./each
- Hand drill/Push-type drill gun - 1 No./batch
- Drill bit, 0.8 m - 1 No./batch
- Drill bit, 2 mm - 1 No./batch
- Bench vice/Table vice - 1 No./batch
- Wooden block (of PCB size) - 1 No./batch
- Glass rod, 30 cm long - 1 No./batch

Materials/Components

- Detergent soap powder - 10 gms.
- White cotton cloth - 1/4 mt.
- Carbon paper, A4 size - 1 No.
- Adhesive tape - as reqd.
- Etch-resist ink pen, black or Indian ink & fine brush No.6 - 1 No.
- Copper clad, 1 oz, 75 x 60 mm (Phenolic) single side - 1 No.
- Copper clad board - as reqd.
- $FeCl_3$ in liquid or powder form - 50 ml.
- Detergent soap powder - 10 gm.
- Thinner/Alcohol/Petrol - 100 ml.
- Post-type termination tags, riveting type - 4 Nos.
- Turret type termination tags, riveting type - 2 Nos.
- Carbon paper, A4 size - 1 No.
- Plastic tray, 30 cm x 15 cm aprox. - 1 No.
- Plastic hand gloves - 1 pair
- Glass rod, 30 cm - 1 No.
- Plastic table spoon, 10 ml - 1 No.
- Painting brush, fine, No. 6 - 1 No.
- Permanent marker, blue, fine tip - 1 No.

PROCEDURE

TASK 1: **Prepare the tracks on copper clad board**

1 Clean the copper side of the 75 mm x 60 mm single side copper clad board using soap and water. Dry it using a piece of cloth.

> **Presence of oil or dust on the clad hinders transferring of the layout on the board.**

2 Take a fresh carbon paper of 85 x 70 mm and fix it on the copper clad board. (Fig 1)

3 Take out the PCB circuit pattern diagram of power supply, prepared for making power supply.

4 Fix the circuit pattern over the carbon paper (fixed on the copper clad board at step-2) as in Fig 2. Get it checked by your instructor.

> **Use adhesive tapes at several places such that the layout drawing sheet does not slip off while tracing.**

Fig 1

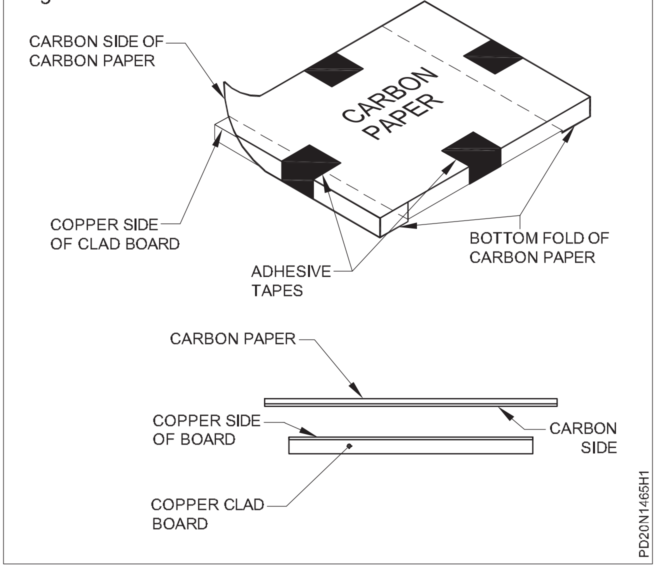
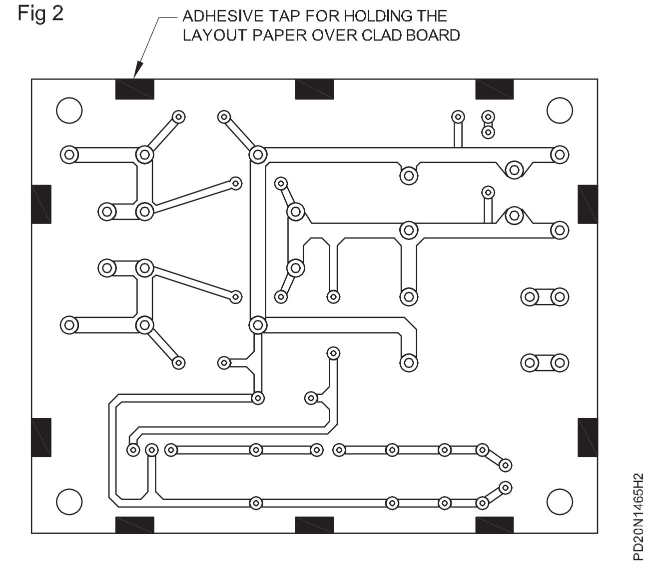


Fig 2



5 Make punch marks using a centre punch, at the centres of all inner circles and the mounting hole circles.

The punching is only to make a mark on the copper clad and not to make a hole on the clad. So, do not hit very hard.

6 Trace all the pads and connecting tracks using a 2H pencil.

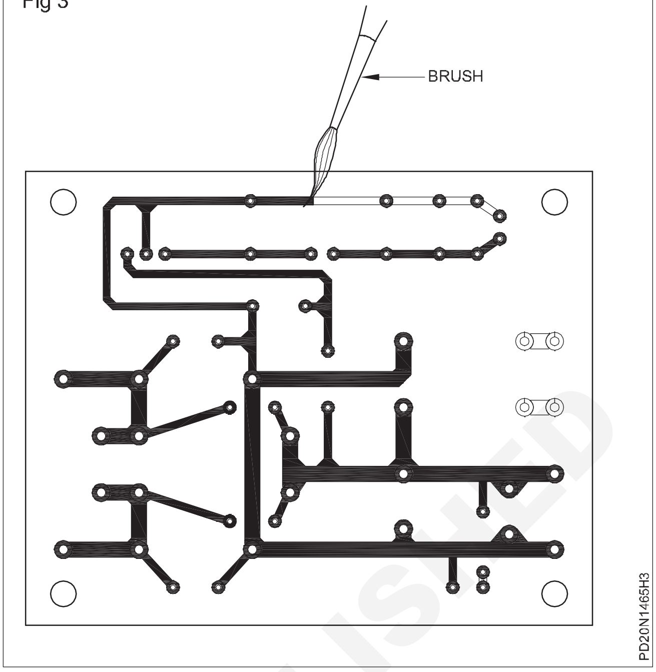
Do not use excessive force while tracing, as this may tear off both the layout and carbon paper. At the same time, do not trace with very little force as this may not transfer the pattern on the copper clad.

7 Take out both the circuit pattern diagram sheet and the carbon paper fixed on the clad.

8 Check if the all traced impression of the pattern on the copper clad is clearly visible. If not touch up using a sharp tip 2B pencil such that the impression is clearly visible.

9 Using etch-resist ink pen or a fine painting brush and Indian ink/ enamel paint, ink the pattern as in Fig 3.

Fig 3



If the ink flows slightly beyond the traced pattern circles and lines, do not try to correct it.

10 Allow the ink to dry for 5 to 10 minutes.

11 Correct the excessive paint flows outside the intended pattern by using a sharp tip knife or half shaving blade. Allow the pattern to dry up in sunlight for atleast 3 to 4 hours.

The drying period depends on the ink/paint used. Consult your instructor.

12 Get your work checked by your instructor.

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TASK 2: **Etch the painted laminate board and drill holes on PCB**

1 Take about half litre of luke warm water in a plastic tray of approximately 30 cm x 15 cm.

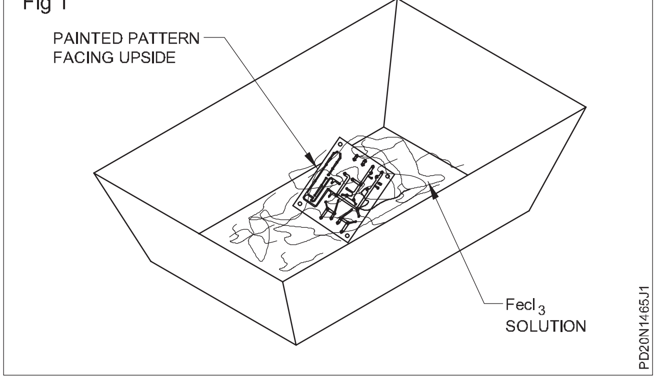
Do not take an excessively large tray as you may have to make large quantity of etching solution which has to be thrown once the etching is completed.

2 Put on hand gloves. Add three spoonful of $FeCl_3$ etchant to water and stir the solution using a glass rod.

$FeCl_3$ solution is injurious to bare skin.

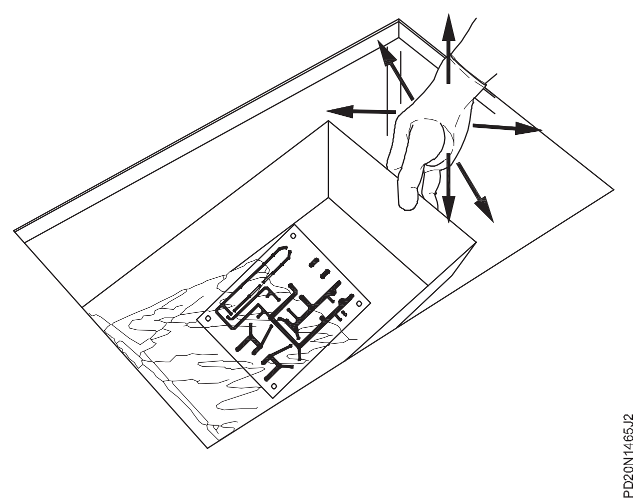
3 Slide the painted copper clad board PCB-1 (made in Task 1) into $FeCl_3$ and water solution with the copper clad side facing upward and visible. (Fig 1)

Fig 1



4 Move the tray up and down, left and right (Fig 2) such that the solution is agitated adequately in increasing the etching process.

Fig 2



Do not agitate the solution very fast as this may sometimes peel off the paint and etch the required patterns also.

5 Repeat step 4 for 10-15 minutes and observe the unpainted portion of the copper clad getting etched OFF.

Once the etching is complete the unpainted portion of the board looks brown or the colour of the board.

6 Take out the board from the $FeCl_3$ solution and check visually if the unpainted copper is completely etched. If not, put the board back into solution and allow the board to remain in the solution for 5-10 minutes.

Depending on the concentration of the $FeCl_3$ solution, the etching time may vary from 10 to 30 minutes.

7 Take out the board from the $FeCl_3$ solution and wash the board thoroughly in running water.

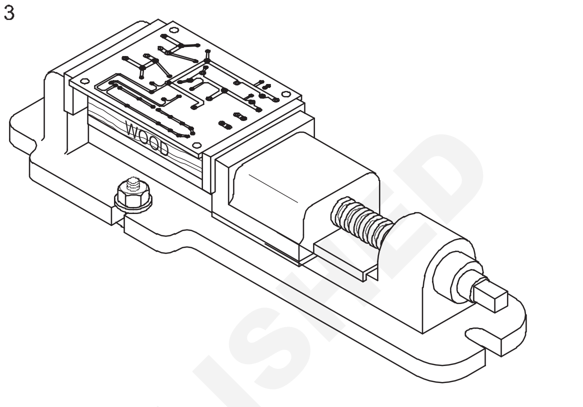
8 Apply a small quantity of detergent powder and wash it again in running water.

9 Allow the board to dry in open air or by placing it in front of a fan.

10 Using a thick brush apply thinner or alcohol or petrol on the painted side of the board and remove the ink using a dry cloth.

11 Repeat step 10 till the paint is completely removed and the copper pattern is clearly visible.

Fig 3



12 Wash the printed circuit board with water and dry it using a piece of cloth.

13 Fix the board with a wooden block on a vice as shown in Fig 3.

14 Using a hand-drill/push-drill-gun fitted with a 0.8 mm drill bit, drill holes at the punched points at the centre of circular patterns.

Drill slowly and steadily. Careless drilling may pull the complete circular copper pattern away.

15 Drill holes at the corner mounting points by use a drill bit of 2 mm.

16 Clean the drilled board from burn and other dirt using cloth or a brush.

17 Get your work checked by your instructor.

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Construct simple circuits containing UJT for triggering and FET as an amplifier

Objectives: At the end of this exercise you shall be able to
- **construct UJT relaxation oscillator for triggering and test**
- **identify the terminals with specification of JFET and test a N-channel JFET**
- **construct an AC voltage amplifier using JFET and find the gain**
- **plot the graph of gain of the amplifier at different frequencies.**

Requirements

Tools/Equipments/Instruments

- Trainee tool kit - 1 No.
- Dual channel oscilloscope 20 MHZ - 1 No.
- Power supply unit 0-30V 2A variable - 1 No.
- Function generator 2 to 200Hz - 1 No.

Materials/Components

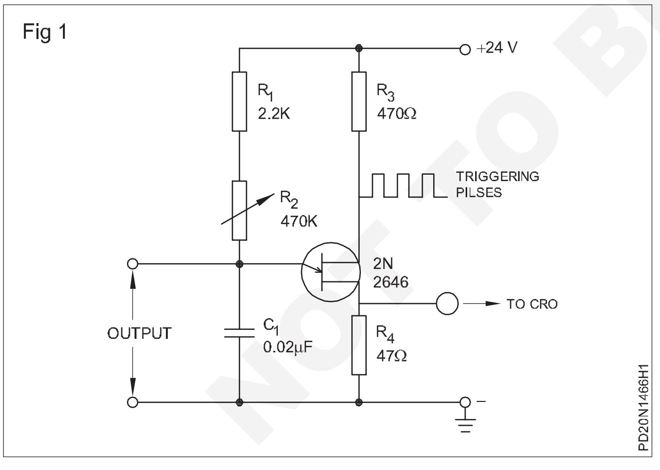
- General purpose PCB (4 x 8) cm - 1 No.
- UJT 2N2646 - 1 No.
- Carbon resistors - 1/4 watt
  47Ω - 1 No.
  470Ω - 1 No.
  2.2 KΩ, 470 KΩ - 1 No.
- Potentiometer 1/2 w, 470 KΩ - 1 No.
- Capacitor 0.02 μf, 25V - 1 No.
- Hookup wires - as reqd.
- Solder - as reqd.
- Assorted types of N-channel, JFET (JFET - BF 245 B/BFW 10) - 4 Nos.
- Sleeves - Red, Green, Yellow, Black (2 cm length each) - 4 Nos.
- Capacitors : 5.6 ηF -Disc type - 1 No.
  270 ηF - 1 No.
  6.8 μF/24V electrolyte - 1 No.
- Resistors - Carbon Film - 1/4 W
  1MΩ, 47KΩ, 10KΩ, 12 KΩ - 1 No. each

PROCEDURE

TASK 1: **Construct UJT relaxation oscillator for triggering and test it**

1 Assemble the relaxation oscillator on the general purpose PCB by referring the circuit diagram (Fig 1)

Fig 1



2 Get the wired oscillator checked by your instructor.

3 Energise the circuit with the stipulated DC.

4 Check the triggering pulses by using CRO between emitter and base and sketch these wave forms in Table 1.

5 Calculate the frequency from the reading taken at Table 1 and apply formulae given below. Keep the potentiometer at minimum, maximum and middle position, record the details of wave forms on Table 1.

Frequency = 1/t where 't' is the time period in seconds.

Time period (Condition 1) t = when C = 0.02 μFD and R_2 is at one extreme end (R_2 = 0)

Time seconds = (R_1 + R_2) x C

where R_1 & R_2 are in ohms

C in Farad

R_1 = 2K2 ohms and R_2 = 470 K ohms variable

Value of R_2 at middle = 235 K ohms

R_2 at other end = 470 K ohms

6 Get the work checked by your instructor.

Table 1

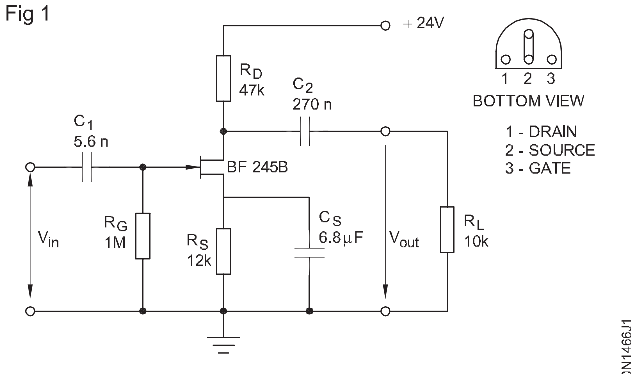
Sl. No.	Waveform at the output terminals	Amplitude	't' time period	Frequency
1	POT at one extreme end			
2	POT at middle position			
3	POT at other extreme end			

— — — — — —

TASK 2 : **Construct and test an AC/FET amplifier and plot the graph**

1 Refer Fig 1 and construct an AC voltage amplifier using a N-channel FET.

Fig 1



AC VOLTAGE AMPLIFIER CIRCUIT

Construct the circuit on a bread board or on a GPCB. If you are wiring the circuit on a GPCB use base for the FET to ensure that it does not get damaged.

2 Get the wired circuit checked by your instructor.

3 Power ON wired circuit. Feed input, at 10 kHz and level from 1mV to 1V in steps of 100mV. Measure the corresponding output levels by using CRO and record in Table 1.

4 From the recorded readings at step 3, calculate and record gain of the amplifier.

5 Get the recorded readings checked by your instructor.

6 Calculate the gain of the amplifier with an input of 400 mV at frequencies 40 KHz, 80 KHz, 100 KHz, 120 KHz and at 150 KHz in Table 2.

7 Get the work checked by your instructor.

Table 1

Input frequency : 10 KHZ			Gain = $\frac{\text{Output voltage}}{\text{Input voltage}}$
Sl. No.	**Input voltage**	**Output voltage**	
1	100 mV		
2	200 mV		
3	300 mV		
4	400 mV		
5	500 mV		
6	600 mV		
7	700 mV		
8	800 mV		
9	900 mV		
10	1V		

Table 2

Input volt	Gain = $\frac{\text{Output voltage}}{\text{Input voltage}}$
Frequency kHz	
40	
80	
100	
120	
150	

8 Plot the graph input/output voltage vs gain as in the first case and frequency vs gain in the second case.

9 Get the graph approved by instructor.

— — — — — —

Troubleshoot defects in simple power supplies

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

Requirements

Tools/Equipments/Instruments

- Trainees kit - 1 No.

Materials/Components

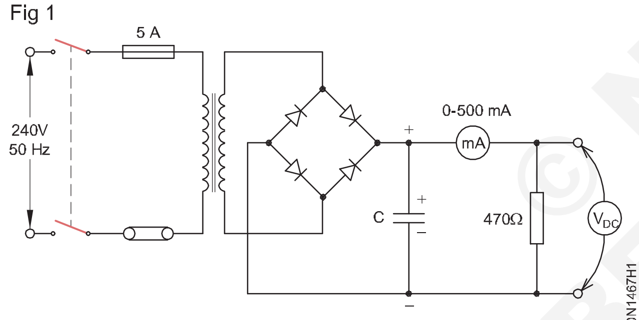
- Bridge rectifier power supply circuit with filter - 1 No.
- Spare components - as reqd.

PROCEDURE

TASK 1 : **Troubleshoot defects in bridge rectifier power supply**

1 In the given power supply board, refer Fig 1. Check for any one of the physical defects listed below; Record the observed defect(s) in Table 1. Service the defect(s).

Fig 1



POWER SUPPLY HAVING BRIDGE RECTIFIER AND FILTER CAPACITOR

- Loose/open wire connections.
- Loose/open component lead connections.
- Dry solder points.
- Shorting of terminals due to solder spray or bad skinning/bending of wire ends or component leads.

2 Trace the circuit wiring and check the correctness of the following.

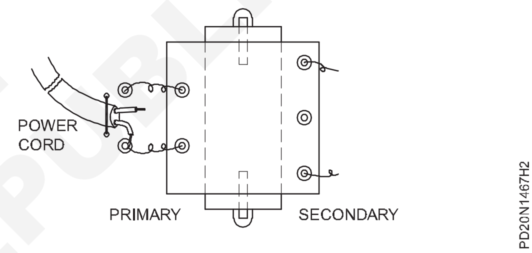
- Polarity of diodes
- Polarity of polarized capacitors.

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

3 Open one of the wire ends of the power cord connected to the power supply. (Fig 2)

This will disconnect the transformer primary from the power cord.

Fig 2



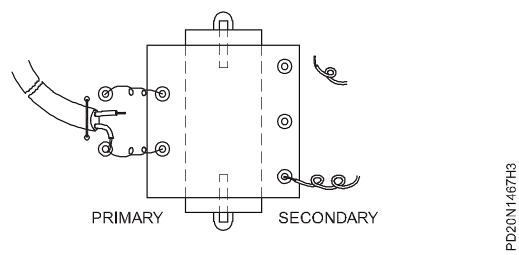
4 Using a continuity tester, check the power cord for any one of the following defects and record the defect observed if any;

- Open or shorted wires in the plug.
- Open or shorted wires in the 2-core cable.

5 Check the continuity of transformer primary winding. If found open or short the coils record defect.

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

Fig 3

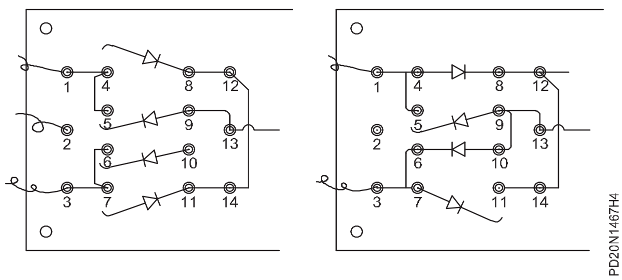


7 Open one lead of each diode (Fig 4). Check the condition of the diodes. Record your observation in Table 1.

Table 1

Sl.No.	Name of the defective component	Nature of defect observed	Specification the component to be replaced	Equivalents, if any, for the components to be replaced	Specification of the component to be replaced
Sample	Soldered point	Dry solder	....	....	De-soldered

Fig 4



8 Open one of the leads of the capacitor. Check the condition of the filter capacitor by carrying out the capacitor action test. Record your observation in Table 1.

9 Check the condition of the bleeder/load resistor. Record your observations in Table 1.

10 Get the defects recorded in steps above, checked by your instructor. Get his approval to replace the components found defective.

11 Collect and test the new components to replace the identified defective components.

12 Replace the defective components with the new components and solder back all connections opened while testing.

13 Connect serviced power supply to AC mains and switch ON mains supply. Check and record the output condition in Table 2 under the heading final condition after servicing.

If there is no output from the PSU even after carrying out the laid procedure of servicing, consult your instructor.

The output may have problems other than the one for which it is serviced. Record the problem as it is observed.

14 Get the work checked by your instructor.

Final condition of power supply after servicing

a) Output voltage level

b) Ripple voltage $V_{r(p-p)}$ in output DC

— — — — — —

TASK 2 : **Troubleshoot defects in power supply using shortcut/logical approach method**

1 Switch 'ON' the given defective power supply unit and record the identified defect in record sheet.

2 Refer the problem tree corresponding to the identified defect.

3 Refer the service flow sequence (SFS-1) or (SFS-2) depending on the identified defect of power supply. Follow the logical sequence to service the defective power supply.

4 Record the identified component defects and remedial measure taken in Table 1 of record sheet.

Whenever any component is found defective, record its type, cause of defect and other details in the Table 1 of record sheet.

Whenever any component is replaced, record the specification of the replaced component in Table 1 of the record sheet.

5 Get your work checked by your instructor.

6 Final condition of power supply after servicing.

a) Output voltage level :

b) Ripple voltage $V_{r(p-p)}$ in output DC :

7 Refer service flow chart 1 & 2 and follow the sequence of approach.

8 Interpret the problem Tree-Chart 1 & 2 (PTC-1 & PTC -2) and locate the exact fault / repair.

Table 1

Sl. No.	Name of the defective component	Nature of defect observed	Possible cause(s) of the defect	Specification of the component to be replaced	Equivalents, if any, for the components replaced	Specification of the component replaced

— — — — — —

Construct power control circuit by SCR, DIAC, TRIAC and IGBT

Objectives: At the end of this exercise you shall be able to
- **assemble and test a lamp dimmer-cum-fan speed regulator using TRIAC and DIAC**
- **construct and test a power control circuit using SCR**
- **construct and test a power control circuit using IGBT.**

Requirements

Tools/Instruments/Equipments

- Soldering iron - 25W/240V - 1 No.
- Trainees tool kit - 1 No.
- Lamp load (60 watts 240V) - 1 No.
- Table fan, 80 watts 240V - 1 No.
- Hand drilling machine with bit (8 mm) - 1 No.
- Universal motor 500W/240V - 1 No.

Materials

- Triggering pulse module for pulse generator - 1 No.
- Printed circuit board - 1 No.
- Resistors
  – 180 ohms 1w ±5% - 1 No.
  – 4K7 12 w 5% - 1 No.
  – 470 K Ohms 1/4w 5% - 1 No.
- Potentiometer linear 250K, 16 mm plastic shaft - 1 No.
- Capacitor 0.1 μF 415 Volts - 4 Nos.
- Solder (Resin) 60:40 - as reqd.
- Soldering flux (Resin) 60:40 - as reqd.
- IGBT - HGTG 12N 60- (pack) - 1 No.
- General purpose PCB - 1 No.
- TRIAC BT 136 or equivalent - 1 No.
- DIAC D3202 or equivalent - 1 No.
- Inductor (25 SWG, 40 turns on 10 mm ferrite rod with former made of leatheroid paper) - 1 No.
- Resistors - 10K, 2W - 1 No.
  470 Ω - 1 No.
  1 KΩ - 2 Nos.
- Pot Meters, 1KΩ, 1W - 1 No.
- Capacitors - 2.2 K PF Disc - 1 No.
  100 PF
- SCR - C 106D or equivalent - 1 No
- Transistor - BD 135 - 1 No.
  BD 136 - 1 No.
- Diode - 1 N 4007 - 6 Nos.
- Connecting cables - 1sq.mm/650V - as reqd.

PROCEDURE

TASK 1: **Construct power control circuit using TRIAC and DIAC**

1 Clean the Printed Circuit Board (PCB). Check the circuit components and confirm their working condition.

2 Assemble the control circuit referring to the circuit schematic diagram shown in Fig 1a & 1b and PCB layout diagram. (Fig 2)

> **Use multi strand flexible insulated wire for these connections as these wires will carry A.C mains voltage and large current of the order of a few hundred milli amperes.**

3 Keep the PCB on any insulated material. Keep the Potentiometer (POT) in mid position. Put AC mains Single Pole Single Throw (SPST) switch mounted on the gang box to 'OFF'.

4 Connect a test lamp at the mains output socket (mounted on the gang box).

5 Connect AC mains supply to the wired circuit. Put the SPST switch mounted on the gang box to ON. Check if the lamp glows.

Fig 1

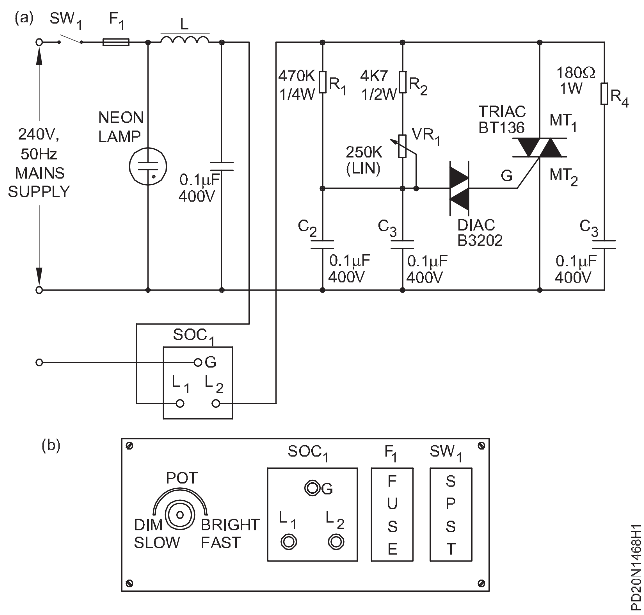
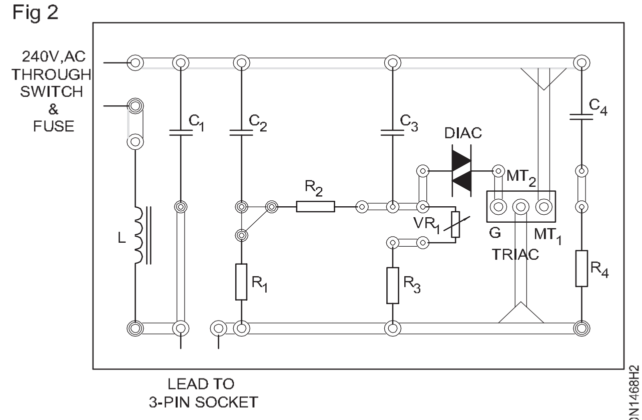


Fig 2



COMPONENT SIDE LAYOUT

If the lamp is not glowing, switch off mains supply and consult your instructor.

6 Vary POT position such that, the light intensity of the output lamp gradually decreases and becomes minimum/zero. Record the status of the lamp intensity at one extreme position of the POT. (Refer Table 1)

Table 1

Status of the lamp intensity when the POT (VR_1) is at one extreme position ________________
Light intensity may be recorded as very dim, off or such

7 Increase the intensity of lamp gradually by turning the POT from minimum position to maximum position. Check and record the light intensity at other extreme position of the POT. (Refer Table 2)

Table 2

Status of the lamp intensity when the POT VR,is at other extreme position ________________
Light intensity may be recorded as very dim, off or such

8 Repeat steps 6 and 7 a few more times to confirm that the wired lamp dimmer circuit is working satisfactorily. Get it checked by your instructor.

9 Remove the lamp load connected at the controlled output of the lamp dimmer circuit. Connect a table fan to the controlled AC output of the wired circuit.

10 Switch 'ON' AC mains supply to the circuit. Vary the POT from one end to the other. Observe and record the speed of the fan at minimum, middle and maximum position of the POT.

The Lamp dimmer-cum-fan speed controller is a very versatile and very useful gadget. You can make use of this project constructed for any useful purpose and assembled in a suitable box with all mandatory control and protecting devices.

11 Get your work checked by your instructor.

— — — — — —

TASK 2: **Construct power control circuit using Silicon Controlled Rectifier (SCR)**

1 Prepare a PCB for the given dimensions. Check the sizes of the components with the soldering position on the PCB. If necessary slightly alter the dimensions of the PCB track.

2 Check the PCB tracks and clean PCB.

3 Test the components to confirm its working condition.

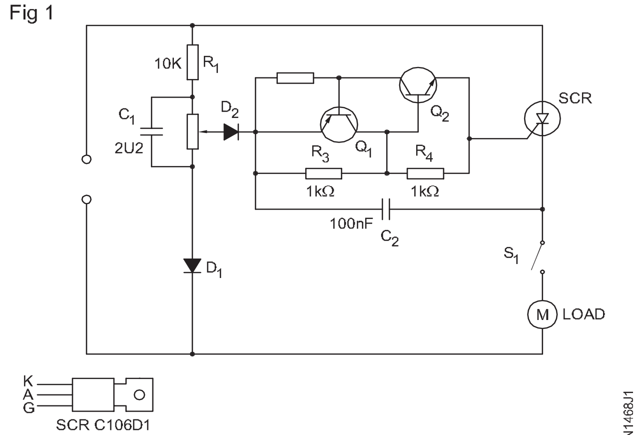
4 Wire the power control circuit on the PCB referring to the circuit schematic (Fig 1) and the PCB layout diagram. Get the wired circuit checked by your instructor.

5 Using suitable wires make connections for the POT, switch, 6A flush type socket, 3 core cable mains 3-pin top with the wired circuit on PCB. Get the wiring checked by your instructor.

The wire connections made is to test the wired power control circuit. Keep sufficient wire lengths in all connections made for the purpose of safety and ease of testing.

6 Test the working of wired circuit by connecting a test lamp load at the output of the speed controller circuit. Find the lamp glow bringing the two extreme positions of the speed.

Fig 1



CIRCUIT DIAGRAM OF THE DRILL POWER CONTROLLER

7 Test the speed controller using table fan as load and record your observation.

8 Assemble the PCB and other associated items, so that the wired speed controller is ready for use. Get it checked by your instructor.

This wired circuit can be effectively used for a control circuit to use for any speed control purpose. Kept in a box with all mandatory controlling and protecting devices.

9 Get your work and recorded readings checked by your instructor.

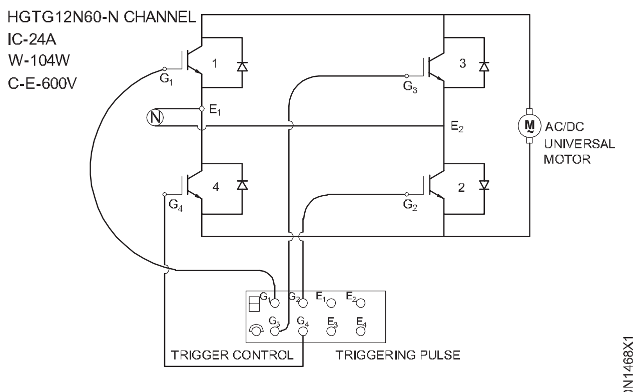
The wired and tested universal speed controller can be effectively used for any practical applications. So, preserve the project work made and use it whenever required.

— — — — — —

TASK 3: **Construct power control circuit using Insulated Gate Bipolar Transistor (IGBT)**

1 Wire the circuit as per the diagram. (Fig 1)

Fig 1



UNIVERSAL MOTOR CONTROL USING IGBT

Solder the components on a general purpose PCB and connect the cables for connection.

2 Set the input AC single phase supply to 120V and connect to the supply points E_1 & E_2 through a various.

3 Switch 'ON' the triggering pulse generator and set the pulse control minimum position.

4 Switch 'ON' the variac.

5 Increase the triggering pulse control to rotate the AC/DC motor.

Universal motor rotates slowly with abnormal sound.

6 Switch 'OFF' both the control circuit and triggering pulse circuit.

7 Set the variac voltage 240V and switch 'ON' the triggering pulse.

8 Reduce the speed by controlling trigger control knob. If motor rotates with high speed.

Switch OFF both the circuits. Universal motor not allow to run without load.

Ensure the motor rpm varies as per the variation of trigger pulse control.

9 Get it checked with your instructor.

— — — — — —

Construct variable DC stabilized power supply using IC

Objectives: At the end of this exercise you shall be able to
- **construct and test a variable IC regulated power supply**
- **test the voltage regulation at various load and ripple rejection.**

Requirements

Tools/Equipments/Instruments

- Trainees kit - 1 No.
- Soldering iron 25W/250V - 1 No.
- Digital multimeter - 1 No.

Materials

- General purpose PCB - 1 No.
- Step down transformer, 240 V : 24 V, 12-0-12, 24VA - 1 No.
- Diodes, 1N4002 or BY127 or equivalent - 6 Nos.
- Capacitors
  - 2200 µF, 50V, electrolytic - 1 No.
  - 25 µF, 50V, electrolytic - 1 No.
  - 10 µF, 50V, electrolytic - 1 No.
  - 100 µF, ceramic disc - 1 No.
- LED, Red - 1 No.
- Resistors
  - 4K7, potentiometer, carbon, rotary - 1 No.
  - 2K2, carbon, 1/2W - 1 No.
  - 220W, carbon, 1/4W - 1 No.
- 3-terminal voltage regulator, LM317T, To - 220 package - 1 No.
- 1A, slow blow fuse with fuse holder - 1 No.
- Hook up wires - as reqd.
- Resin cored solder - 20 cms.
- Heat sink for TO-220 package - 1 No.
- Rheostat 100Ω 1 A - 1 No.

PROCEDURE

1 Test all the components to confirm their good working condition. Record the specifications of IC LM317T.

2 Check the given general purpose PCB for the following defects and correct them or take a new board;

- Broken tracks
- Joined tracks
- Closed holes

3 Clean the copper side of the PCB using alcohol or other cleaning agents. Wash, wipe and dry the PCB.

4 Construct a variable regulated output power supply on the given general purpose PCB, referring to the circuit schematic shown in Fig 1.

> **All components except the transformer to be mounted on GEN-PCB. Use suitable heat sink with IC 317 T.**

> **Note : Solder all components except the fuse and transformer on the given PCB**

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

6 Connect the secondary of (240:24V) transformer to the wired circuit. Switch ON mains supply.

> **Switch OFF main supply immediately if burning, smoking overheating, sparks are observed in any of the components, and report to your instructor. Check the IC and ensure that it is not heated-up.**

7 Measure and record the unregulated DC input and the minimum, maximum variable voltage of the regulator under no-load condition.

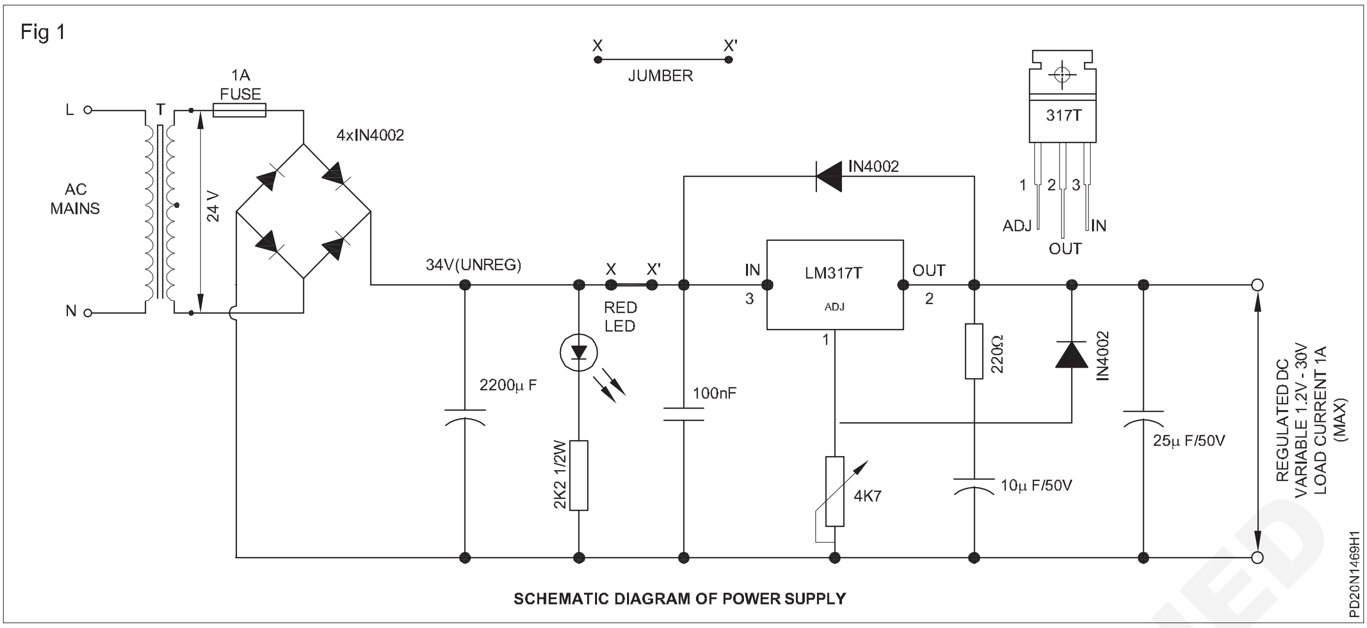
8 Set the output to +15 volts and load the output using a loading rheostat in steps of 200 mA up to 600 mA. In each step measure and record the output voltage and the ripple voltages.

> **Load current is restricted to 600 mA as heat-sink is provided to the IC may not be the ideal one.**

9 Calculate and record the output regulation and ripple rejection of the regulator.

10 Short the load terminals momentarily by using a DC current meter (0-1A range) and record the short circuit fold back protection current level.

11 Get the readings checked by your instructor.



Observation & tabulation sheet

1 Specification of the given 3-terminal regulator IC

Type number	Package type	Output voltage		Max. output current
		Min.	Max.	

— — — — — —

Practice on various logics by use of logic gates and circuits

Objectives: At the end of this exercise you shall be able to
- **construct an OR gate using lamp and switches and verify its truth table**
- **construct an OR gate using IC-7432 and verify its truth table**
- **construct AND gate using lamps and switches**
- **construct AND gate using IC-7408 and verify its truth table**
- **construct NOT gate and verify truth table using transistor.**
- **construct NOT gate using IC 7404 and verify its truth table.**

Requirements

Tools/Equipments/Instruments

- Trainees kit - 1 No.
- Regulated DC power supply unit 5V/500mA - 1 No.
- DC voltmeter (MC) 0-10V/multimeter - 1 No.
- Data Manual - 1 No.
- Digital IC tester - 1 No.

Materials/Components

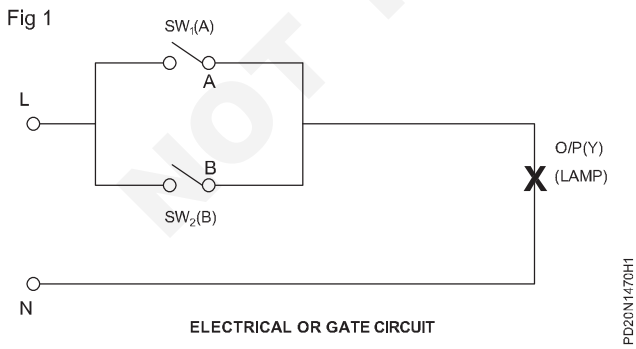
- Single pole switch any type/ Toggle switch 240V/6A - 2 Nos.
- Lamp - 250V/100W - 1 No.
- LED, Red (5 mm) - 2 Nos.
- ICs
  7408 QUAD AND gate - 1 No.
  7432 - 1 No.
- Connecting wires - as reqd.
- Solder, flux - as reqd.
- IC base, 14 pin - 2 Nos.
- DC power supply 5V - 1 No.
- SPDT switches (miniature toggle) - 2 Nos.
- General purpose IC test board/Pin Board - 1 No.
- Transistor BC 147 - 1 No.
- Resistors, carbon film, 1/4w
  1KW - 2 Nos.
  330W - 2 Nos.
- LED (t5mm)
  Green - 2 Nos.
- IC 7404 (Hex inverter) - 1 No.
- IC 4049 (Hex inverter) - 1 No.
- IC base 14-pin - 2 Nos.
- Hookup wire
  Red 50 cm - as reqd.
  Black 50 as reqd.cm - as reqd.

PROCEDURE

TASK 1: **Construct an OR gate using two switches with lamp and verify its truth table**

1 Refer Fig 1 and wire an OR gate circuit on a test board/pin board.

Fig 1



ELECTRICAL OR GATE CIRCUIT

2 Apply logic level inputs to A and B of the circuit as given in Table 1. Record the output lamp condition in each case and verify its truth table.

3 Get the recorded readings checked by your instructor.

Table 1

Truth table of OR-gate using switches and lamp

Logic input		Logic output
A SW1	**B SW2**	**Y = A + B lamp**
0	0	
0	1	
1	0	
1	1	

— — — — — —

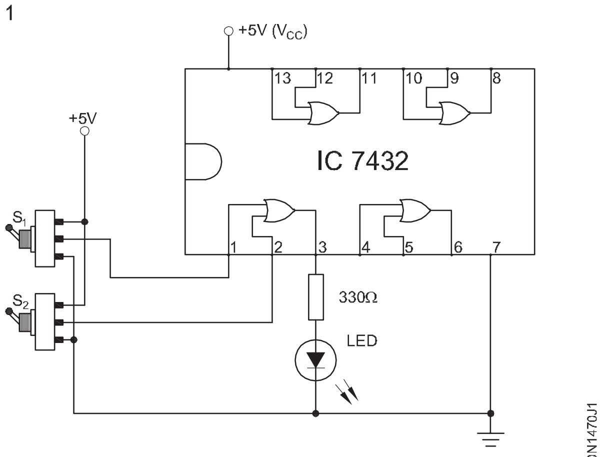
TASK 2 : **Construct a Quad two input OR gate using IC-7432**

1 Record the details of the given IC-7432 in Table 1 of record sheet referring to data manual.

2 Insert the IC-7432 into the IC base of the general purpose IC test board.

3 Make other circuit connections to the IC in Fig 1.

Fig 1



OR GATE CIRCUIT USING IC7432

4 Set switches SW_1 and SW_2 to apply input logic levels as in Table 3 to the first OR gate (Fig 1). Record the output logic level and verify its truth Table 2.

5 Repeat step 4 for the other three OR gates of the IC.

6 Write your conclusion about the condition of each OR gate in Table 3 based on the recorded output of gates.

7 Get the recorded readings checked up by your instructor.

Disconnect connections made at input and output of the gates. Allow the IC 7432 to remain plugged on the board for subsequent tasks.

Table 2

Truth table of OR-gate using IC7432

Logic Input		Output logic at Pin No.			
A	B	3 Gate-1	6 Gate-2	8 Gate-3	11 Gate-4
0	0				
0	1				
1	0				
1	1				
Condition of gate in the IC :					

Table 1

I.C No.	Type of package	Total no. of pins	Input voltage		Output voltage		V_{CC}/V_{DD}		Status	Temperature of IC range
			Logic- 0	Logic- 1	Logic- 0	Logic - 1	max.	min.		
7432										
7402										

— — — — — —

TASK 3 : **Construct AND gate using two switches with lamp and verify its truth table**

1 Refer Fig 1 and construct the AND gate circuit using on a board switches and lamp test.

2 Get wired circuit checked by your instructor.

3 Apply different logic levels to the inputs A & B as given in Table 4 . Record the corresponding output logic level and lamp status.

4 Get the work checked by your instructor.

Fig 1

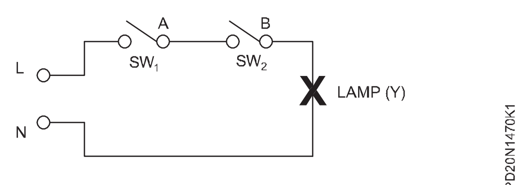


Table 1

Truth table of AND gate using switches and lamp

Input				Output			
Logic level		Equivalent voltage level given as inputs		Logic level	Voltage level	LED status (ON/OFF)	
A	B	A	B				
0	0						
0	1						
1	0						
1	1						
open	open						

— — — — — —

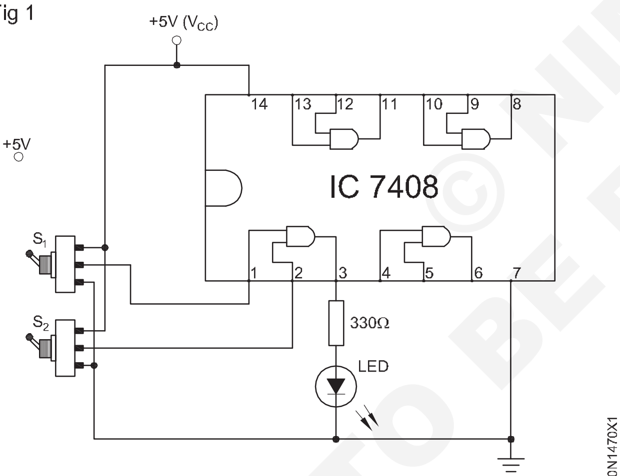
TASK 4 : **Construct and test an AND gate using IC (7408)**

1 Make circuit connections (Fig 1) using IC 7408 (AND).

2 Apply different logic levels to the inputs A and B to gate-1 (between pins 1 & 2) and record output (pin 3).

3 Repeat step 2 for the other AND gates in the IC 7408 by suitably modifying the circuit at input & output.

Fig 1



AND GATE CIRCUIT USING IC7408

4 Conclude the condition of the IC in sheet after verifying truth table at Table 1.

5 Get the work checked by your instructor.

Table 1

Truth table of AND gate IC-7408

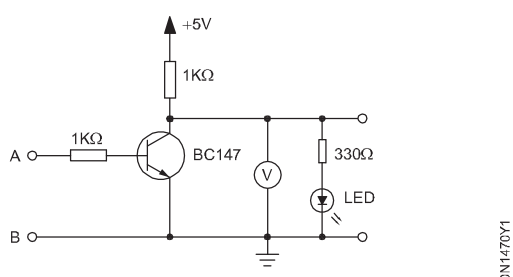
Input		Output Y = A·B			
Logic level A	B	Y_1 (pin 3)	Y_2 (pin 6)	Y_3 (pin 8)	Y_4 (pin 11)
0	0				
0	1				
1	0				
1	1				
Condition of gate					

— — — — — —

TASK 5 : **Construct a NOT gate using discrete components and verify its truth table**

1 Construct the NOT gate using discrete components as shown in Fig 1 on the general purpose PCB. Get it checked by your instructor.

Fig 1



TRANSISTORISED 'NOT' GATE CIRCUIT

2 Power ON the circuit, by applying 5V Fig 1. Apply logic level-0 to the input (see note below) and record the voltmeter reading, its equivalent logic level and the status of LED.

When the input terminal of the circuit is grounded, it is equivalent to applying logic 0. Note that keeping input terminals open is not equal to logic 0 level.

3 Apply logic level-1 to the input (see note below) and record the voltmeter reading, its equivalent logic level and the status of LED.

When the input of the circuit is connected to +5V, it is equivalent to applying logic 1.

4 Repeat steps 3 & 4 a few times to confirm the recorded values and to have a clear understanding of the logic levels and concept of inversion logic.

5 Get the working of the NOT gate and confirm the recorded readings (Table 1) checked by your instructor.

Table 1

Input		Output		
Logic level	Voltage level	Logic level	Voltage level	LED status ON/OFF

— — — — — —

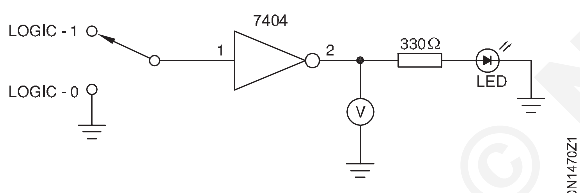
TASK 6 : **Verify the truth table of a Transistor-Transistor Logic (TTL) NOT gate IC 7404**

1 Record the following details for the given IC 7404.

- Manufacturer's name
- IC number
- Type of package
- IC family type
- Internal connection diagram with pin numbers.

Referring to Fig 1 of exercise and IC data book, note down the following readings in Table- 6

Fig 1



IC 7404 **NOT** GATE CIRCUIT

2 Construct the NOT gate test circuit shown in Fig 1 on the general purpose IC test board/pin board. Get the constructed circuit checked by your instructor.

3 Insert the IC in the IC base of the wired circuit. Make sure IC inserted as per circuit.

4 Switch on the DC supply (+ 5V) to the wired circuit and check if the IC is getting excessively heated-up. If the IC is getting heated up, switch-off power supply and consult your instructor.

5 Measure voltage level at V_{CC} and GND pins at the IC to confirm that supply is reaching the IC.

6 Apply Logic 0 (Low/Ground/ 0 volt) to the input of the inverter 1 of wired IC NOT circuit. Record the output voltage, corresponding logic level and status of LED.

7 Give logic 1 (High/+ 5V) at the input of the same inverter and record the outputs as done in step 8.

8 Get the recorded readings checked by your instructor.

9 Modify the wiring of the circuit to test the next NOT gate between pins 3 & 4. Get it checked by your instructor.

10 Repeat steps 8, 9 and 11 to test other NOT gates of the IC.

If any gate is found to be defective, record it and consult your instructor.

11 Get your work checked by your instructor.

Do not dismantle the circuit. This is required for next exercise.

12 Repeat steps 1 to 11 for the CMOS NOT gate IC, CD4079 following the instructions given below;

– Construct the circuit in a different place on the same board.

– After setting up the circuit get it checked before proceeding further.

– Use 12 volts DC for V_{CC}.

– For CMOS ICs, Logic-1 can be equal to V_{CC}.

The minimum logic-HIGH input voltage should be = 2/3 V_{CC}. and, maximum logic-LOW input voltage can be = 1/3 V_{CC}.

13 Get the work checked by your instructor.

— — — — — —

Generate and demonstrate wave shapes for voltage and current of rectifier, single stage amplifier and oscillator, using CRO

Objectives: At the end of this exercise you shall be able to
- **construct a bridge rectifier test the output wave form**
- **test the wave shape without RC filter and with filter and calculate ripple factor**
- **test the wave shapes of a common smith amplifiers and distinguish with the input & output waves**
- **test the hartley oscillator output wave shape and identify the frequency.**

Requirements

Tools/Instruments

- Trainees kit - 1 No.
- Oscilloscope, 20MHz, dual trace - 1 No.
- Voltmeter MC 0-30V - 1 No.
- Multimeter - 1 No.
- Function generator - 1 No.
- Regulated DC power supply 12V/1A - 1 No.

Materials/Components

- Bread board - 1 No.
- Diode IN4007 - 4 Nos.
- Resistor 470Ω - 1 No.
- Step-down transformer, 240V 24V 500mA - 1 No.
- Multi strand wire, red, blue 19/0.3 of 600V grade - as reqd.
- 3 Pin plug 6A 250V - 1 No.
- Electrolytic capacitor 10 μFD/25V - 1 No.
- Resistor 10K/1W - 1 No.
- Transistor BF 195 - 1 No.
- Capacitors - 0.01and 0.1μfd - 3 Nos.
- Gang capacitor 25-2J - 1 No.
- Resistors - 82K, 18K, 3.9K, 390Ω/1/4W - 1 each
- Medium wave oscillator coil - 1 No.
- Transistor, SL 100 or equivalent Diode IN914/OA79 - 1 No.
- Capacitor, 100 μF/25 V, electrolytic, axial - 1 No.
- Capacitor, 25 μF/25 V, electrolytic, axial - 2 Nos.
- Resistors 1/4 W, carbon
  - 120 Ω - 1 No.
  - 470 Ω - 1 No.
  - 1.2 KΩ - 1 No.
  - 5.6 kΩ - 1 No.
- Hook-up wires - 20 cms.

PROCEDURE

TASK 1:

For TASK 1 - Refer Exercise No 2.7.155.

— — — — — —

TASK 2: **Measure of ripple and calculate ripple factors in bridge rectifiers with RC filter**

1 Construct the filter circuit in the bridge rectifies already constructed. (Fig 1)

2 Repeat the steps 2 to 6 of task 1. Enter the measured values in Table 1 and 2.

Fig 1

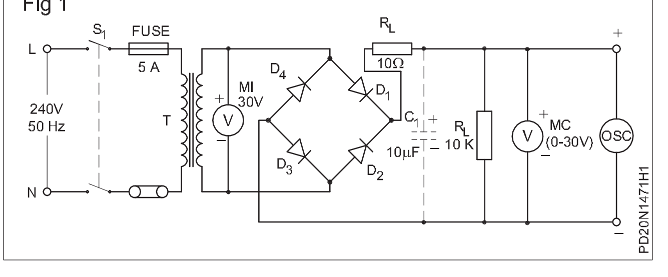


Table 1

Condition	Input AC	Output DC	AC ripple	Ripple factor $= \frac{\text{AC ripple voltage}}{\text{DC voltage}}$
Without RC filter				
With RC filter				

Table 2

Condition		
Output wave form without capacitor		
Output wave form with capacitor		

— — — — — —

TASK 3 : **Determine the voltage gain A_2 of CE amplifier and distinguish input and output wave shapes**

1 Construct the circuit of CE amplifier in Fig 1.

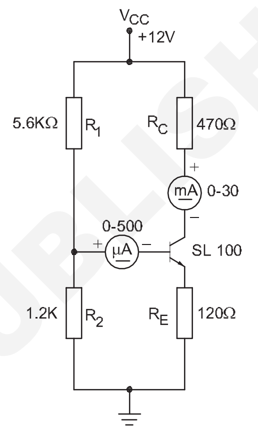
2 Apply V_{cc} measure and record I_c and I_B in Table 1.

3 Apply input sinewave from function generator and measure voltage gain of using CRO. Observe the input and output waves.

4 Record the input and output wave shapes of the CE amplifiers.

5 Get it checked with your instructor.

Fig 1



DC CONDITION OF CE - AMPLIFIER

Table 1

Transistor Number	Collector I_C current	Base current I_B	V gain	Input wave shapes	Output wave shapes	Relation between input & output wave

— — — — — —

TASK 4 : **Assemble a hartley oscillator and test the waves, find frequency with different capacitor values**

1 Test the components to confirm their good working condition.

2 Assemble the Hartley oscillator circuit referring to Fig 1.

3 Connect and switch ON + 12V-DC supply to the wired circuit. Check to ensure that the transistor is not getting heated-up.

If the transistor is getting heated-up, switch-OFF supply and consult your instructor.

4 Connect the secondary terminals of the MW OSC coil, to CRO set to measure the frequency.

5 Adjust CRO time-base to get a clear sinusoidal wave on the screen. Measure the amplitude and frequency of oscillations and record the observations below:

i) amplitude of oscillations

ii) Frequency of oscillations

If oscillations are not seen, tune the gang capacitor. If oscillations are still not seen, consult your instructor.

6 Get the working of the oscillator checked by your instructor.

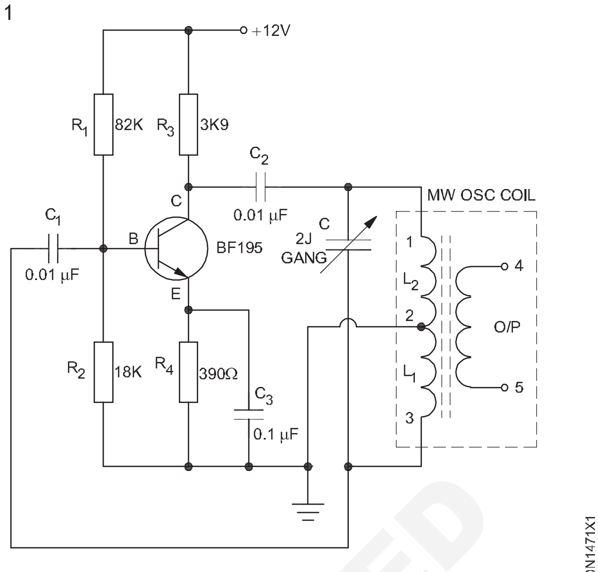
7 Set the gang capacitor to one extreme end. Measure the amplitude and frequency of oscillations and enter in Table 1.

8 Set the gang capacitor to the other extreme end. Measure the amplitude and frequency of oscillations and enter in Table 1.

9 Set the position of the gang capacitor to approximately mid-position. Measure the amplitude and frequency of oscillations and enter in Table 1.

10 Get the recorded reading checked by your instructor.

Fig 1



HARTLEY OSCILLATOR CIRCUIT SCHEMATIC

Table 1

Position of gang capacitor	Amplitude in volts peak to peak	Frequency in Hz
At one extreme end		
At other extreme end		
Mid position		

— — — — — —

Construct 1 Φ and 3 Φ bridge rectrifier/Inverter/logic gate measure input and output voltage and analyse wave form by using osicilloscope

Objective: At the end of this exercise you shall be able to
- **construct and test bridge type full wave rectifiers using from diodes.**

Requirements

Tools/Equipments/Instruments/Materials

- Trainees kit - 1 No.
- Oscilloscope, 20 MHz, dual trace - 1 No.

Equipments/Machines

- Log board general purpose 5 points - 2 Nos.
- Diode IN4007 - - 4 Nos.
- Resistor 470 Ω - 1 No.
- Step down transformer 240 V/12-0-12-500mA - 1 No.

Materials

- Multi strand wire, red, blue, 23/0.2 of 650 v grade - as reqd.
- Base board (Laminated board 30x15x3mm) - as reqd.
- Nuts, bolts and washer - as reqd.
- 3 pin plug 6 A 250V - as reqd.
- Resin core Salder 60/40 - as reqd.
- Main Cord 3 Core Cable 23/0.2 of 650V Grade - 1 No.

PROCEDURE

TASK 1: **Construct bridge rectifier**

1 Construct a bridge rectifier, referring to the schematic and layout diagrams (Fig 1(a) & Fig 1(b)).

2 Switch On the circuit. Measure and record the AC input $V_{s(rms)}$ to the rectifier in Table 1.

3 Calculate the expected output DC voltage Vdc across load RL using the formula, In a bridge rectifier.

$V_{dc} = 0.9\ V_{s(rms)}$ where, $V_{s(rms)}$ is the AC input to the rectifier (refer Fig 1). Record the value in Table 1.

Table 1

Readings of bridge rectifier

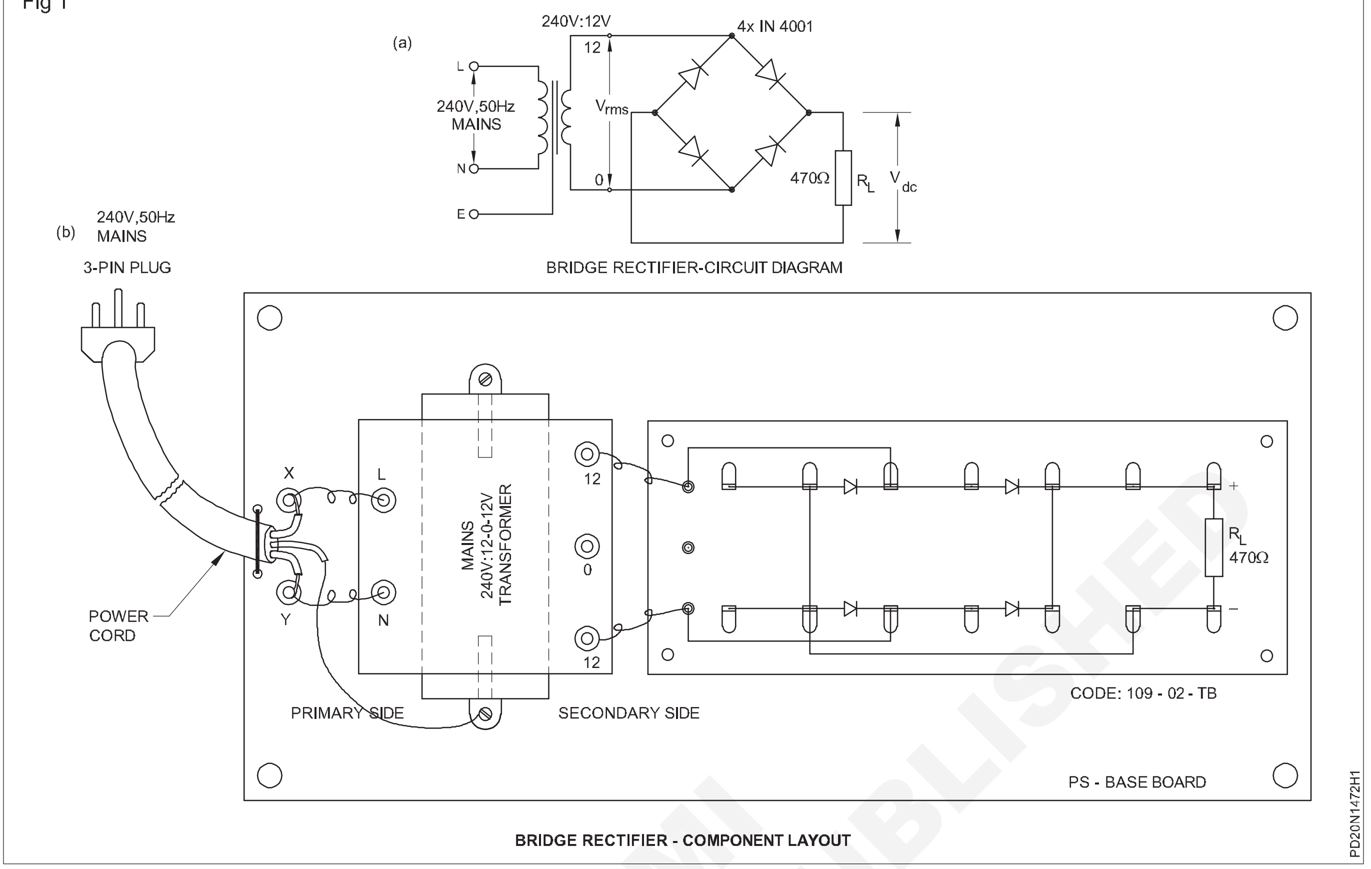
Vs(rms) (1)	Calculated Vdc volts (2)	Measured Vdc volts (3)	Difference of (2), (3) & (4)	Peak value of Vs (5)	Frequency of Vs (6)

4 Measure the DC output Vdc across the load RL and record it in Table 1.

5 Record the difference in the calculated and measured values in Table 1.

6 Report and get it checked by your instructor.

Fig 1



BRIDGE RECTIFIER - COMPONENT LAYOUT

Identity and use of various types of cell

Objectives: At the end of this exercise you shall be able to
- **read and interpret the different type of cells from the chart or physically available cells**
- **name the cells, parts and uses.**

Requirements			
Equipments		**Materials**	
• Different types of cells	- 1 each	• Chart showing different types of cells	- 1 No.

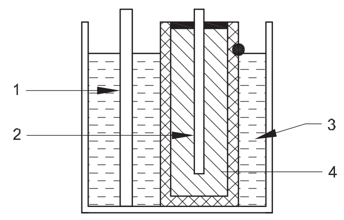
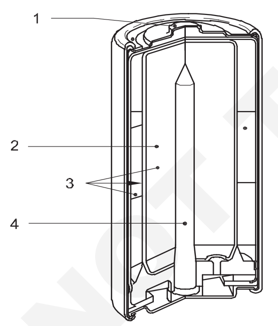
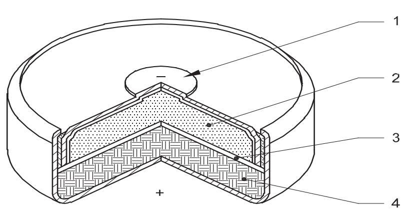
PROCEDURE

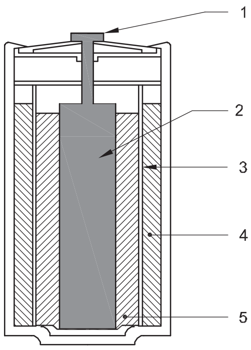
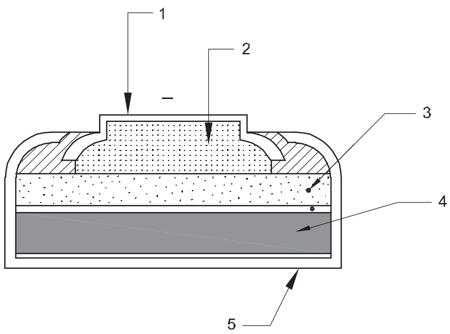
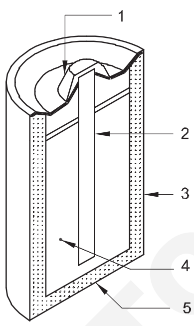
Instructor may arrange the available different types of cells on the table. Explain the types of cells and their uses

1 Identify the type of cell and write their names to corresponding cell placed on the table or by referring from chart as in Table 1 (Fig 1 to Fig 6)

2 Write the name of the parts against the number and uses in the blank space provided against each cell in table 1.

Table 1

Sketches	Name of Cell	Parts of cell	Uses
Fig 1 		1 2 3 4	
Fig 2 		1 2 3 4	
Fig 3 		1 2 3 4	

Sketches	Name of Cell	Parts of cell	Uses
Fig 4 		1 2 3 4 5	
Fig 5 		1 2 3 4 5	
Fig 6 		1 2 3 4 5	

3 Get it checked by your instructor.

— — — — — —

Measure voltage of different Cell and Batteries in Substation

Objectives: At the end of this exercise you shall be able to
- **measure the voltage of the battery**
- **measure the voltage of the cell with multimeter.**

Requirements

Tools and Instruments/equipment

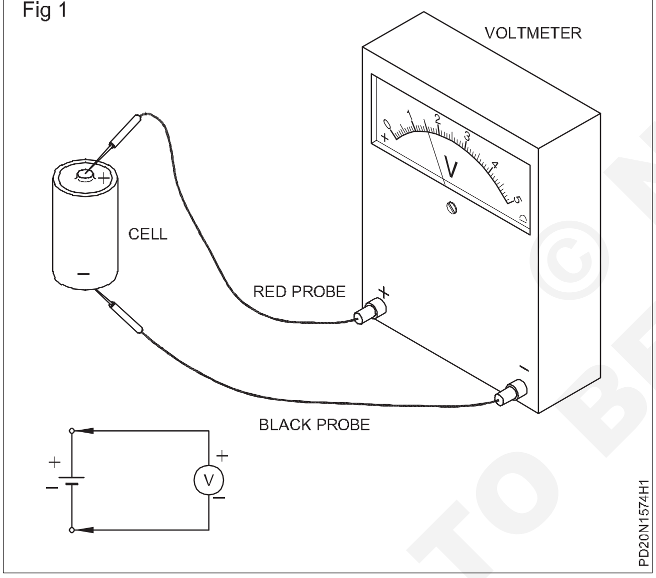
- Digital multimeter (or) Analog D.C. voltmeter (0-50V) - 1 No.
- Cell and Batteries in Substation different types - 1 No each.

PROCEDURE

1 Select the range of 0-1000V D.C in digital multimeter/ D.C analog voltmeter.

2 Touch the positive probe (Red colour) at carbon rod and negative probe (Black colour) at zinc container as shown in Fig 1.

Fig 1



3 Take the readings of the meter which shows the actual voltage of the assembled dry cell.

Multimeter shows 1.5V

4 The same procedure repeated and measure the voltage in batteries.

SI No.	Cell/Battery	Voltage Reading

Practice on grouping of cells for specified voltage and current under different conditions and care

Objectives: At the end of this exercise you shall be able to
- **make grouping of cells in series connection**
- **make grouping of cells in parallel connection**
- **make grouping of cells in series and parallel connection.**

Requirements

Tools/Instruments

- MC Ammeter 0-1A - 1 No.
- MC Voltmeter 0-15V - 1 No.
- MC Ammeter 500 mA - 1 No.
- Multimeter - 1 No.
- Rheostat 20 ohms 3.7A - 1 No.

Materials

- Cells 1.5V - 8 Nos.
- SP Switch 6A, 250V - 4 Nos
- Connecting leads - as reqd.
- Resistor 5 Ω , 10W - 1 No.
- 4 Cell battery pack - 2 Nos.
- miniature lamp 6V / 9V, 300 mA - 1 No.
- Resistor 10 Ω , 10W - 1 No.

PROCEDURE

TASK 1 : **Grouping of cells in series connection**

1 Check the individual cells for their condition.

- Select 500 mA DC current range in mulimeter or 500 mA DC ammeter.
- Connect the cell across the meter in series with a 3 ohm resistor.
- Watch the deflection.

Full deflection shows good condition of cell. Low deflection shows discharged condition of the cell.

Cells having a higher internal resistance should not be used for series connection.

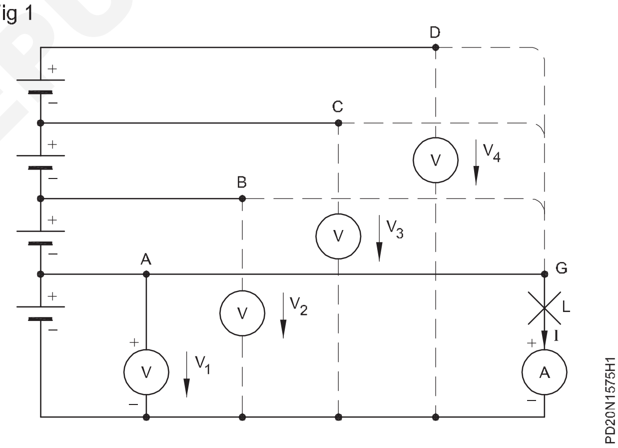
Care should be taken for the cells polarity.

2 Connect the cells as shown in Fig 1.

3 Measure the voltage of one cell V_1, two cells V_2, three cells V_3 and four cells V_4 connected in series.

4 Record your observations in the first and second columns of Table 1.

Fig 1



5 Connect the terminal 'G' to the terminal A and observe the ammeter reading and the glow condition of the lamp.

6 Change the contact of terminal ' G' terminals B,C and D in succession.

7 Record your observations under the columns 3 & 4 in Table 1

Table 1

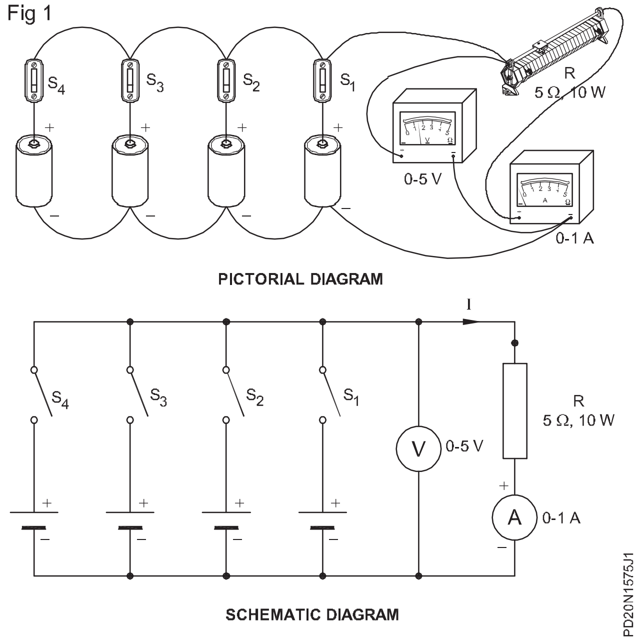
Sl No.	No. of cells in series	Voltmeter reading	Ammeter reading	Glow
1				
2				
3				
4				

TASK 2: **Grouping of cells in parallel connection**

1 Check the voltage of each cell.

2 Form the circuit as shown in Fig 1.

Fig 1



3 Close the switch S_1 and measure voltage and current. Record the values in Table 2, under columns 2, 3 and 4.

Table 2

Sl. No.	No. of Cells in Parallel	V	I

4 Check and record the readings of V and=f after closing switch S_2, then S_3, and S_4 in succession.

Unequal voltage cells cannot be connected in parallel.

Conclusion

When cells of equal voltage are connected in parallel the terminal voltage is equal to ______________

As the load current is shared by the cells in parallel, the terminal voltage across the load is ____________ when compared to a single cell supplying current to the same load.

The effect of a number of cells in parallel to a given load.

____

____

____

— — — — — — —

Measure specific gravity of electrolyte and determine correction factor

Objectives: At the end of this exercise you shall be able to
- **measure specific gravity**
- **determine correction factor.**

Requirements

Tools/ Instruments

- Screw driver 300 mm with 6 mm blade - 1 No.
- Rubber gloves - 1 Set
- Safety goggles - 1 Set

Equipment/Machines

- 12V Lead acid battery - 1 No.
- Hydrometer - 1 No.

PROCEDURE

1 Put on eye protection and rubber gloves.

2 It is recommended to disconnect the battery especially if on a high rate of charge/discharge.

3 Remove vent cap. Carefully insert the hydrometer into the cell, not pushing down on the top of the plates.

4 Carefully draw liquid into the hydrometer and avoid “bumping” the hydrometer. Be careful the float is not flooded (too much liquid) or sticking to the sides of the glass tube.

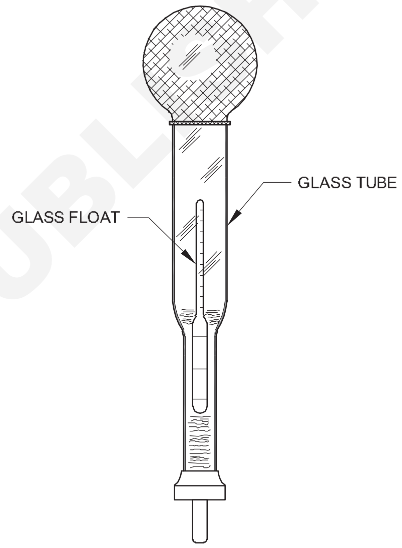
5 Obtain a reading by looking directly at the float.

6 Repeat steps 3-5 to reconfirm reading.

7 RECORD the cell number and result.

8 If it is very warm or very cold correct the specific gravity for temperature. If the ambient temperature is fairly consistent and original gravities are taken when the batteries are put into service temperature correction is not as critical and only necessary if problems arise. Make sure the electrolyte is not hot if just taken out of service. Let it reach room temperature.

Fig 1



HYDROMETER

Charged	Measured SP. Gravity	Standard SP. Gravity	Correcting Factor

Note: The correction factor is calculated by subtracting the observed specific gravity from the predicted specific gravity.

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Identify various components of battery charger used in substation

Objective: At the end of this exercise you shall be able to
- **identify various components of battery charger used in substation.**

Requirements

Tools/ Instruments		Equipment/Machines	
• Personal protective equipment	- 1 No.	• A4 Paper	- 2 Nos.
		• Scale 300	- 1 No.

Instructor may take trainee to nearest substation with permission from Engineer-in-charge and help to identify various components of battery charger.

PROCEDURE

A battery charger consists of a rectifier circuit, power circuit, ripple monitoring, control circuit, regulator circuit, and fault detection circuit. This charger can also be used as a DC source for a control and protection circuit of a substation during normal operation, or to charge the battery in floating mode. (Figs 1,2 & 3)

Fig 1

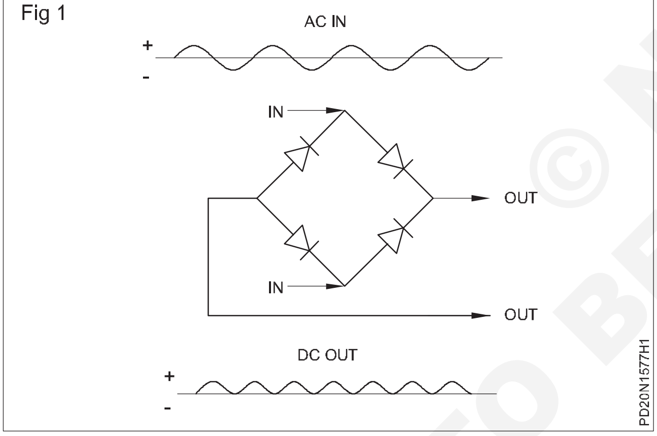


Fig 2

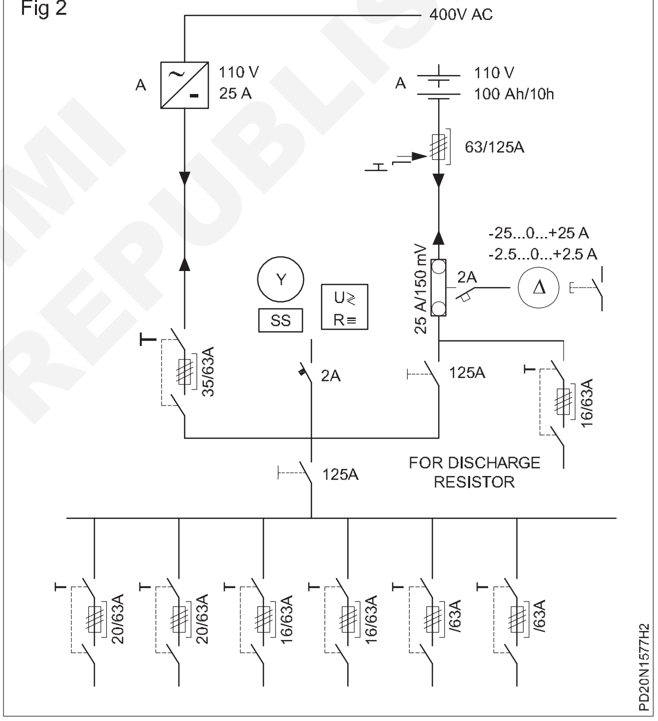
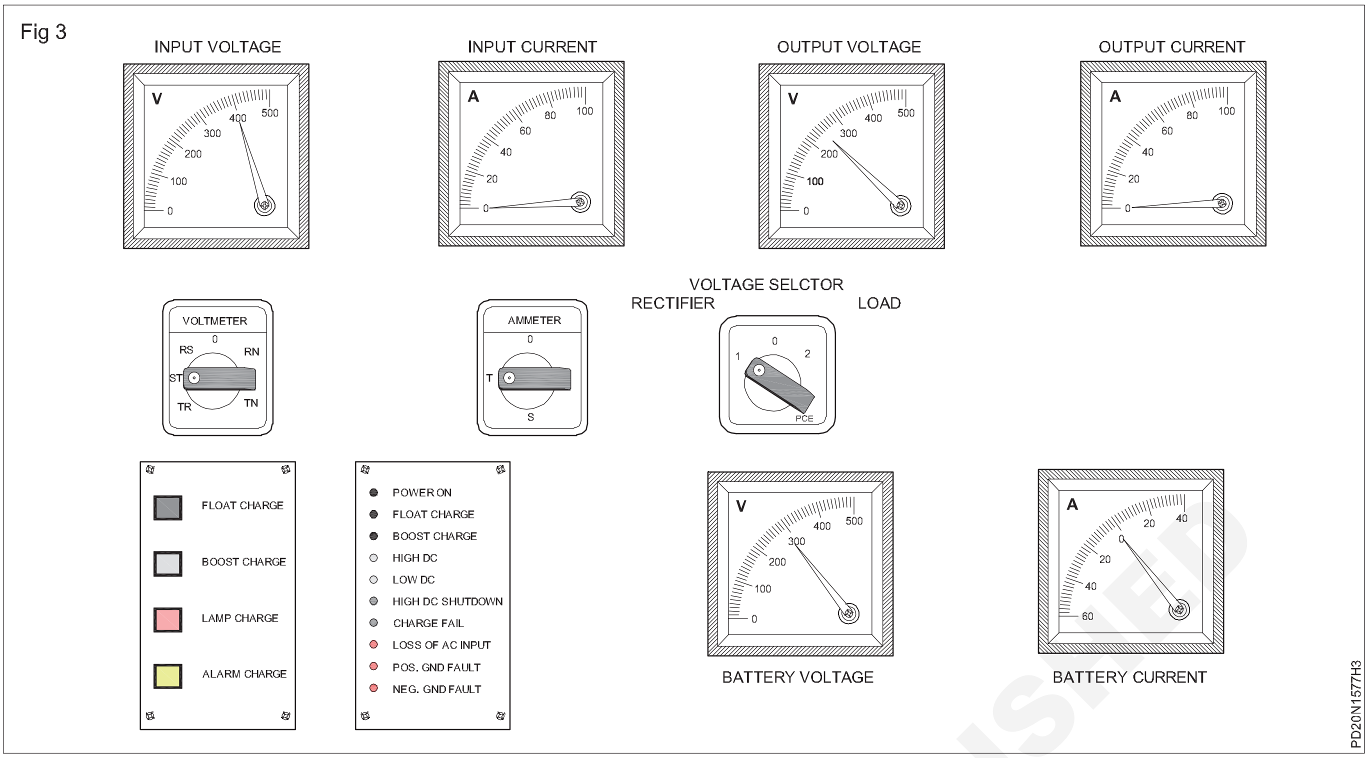


Fig 3


INPUT VOLTAGE
INPUT CURRENT
OUTPUT VOLTAGE
OUTPUT CURRENT
VOLTMETER
AMMETER
VOLTAGE SELCTOR
RECTIFIER
LOAD
FLOAT CHARGE
BOOST CHARGE
LAMP CHARGE
ALARM CHARGE
POWER ON
FLOAT CHARGE
BOOST CHARGE
HIGH DC
LOW DC
HIGH DC SHUTDOWN
CHARGE FAIL
LOSS OF AC INPUT
POS. GND FAULT
NEG. GND FAULT
BATTERY VOLTAGE
BATTERY CURRENT
PD20N1577H3

— — — — — —

Perform proper setting of voltage according to mode of charging and practice on battery charging

Objectives: At the end of this exercise you shall be able to
- **connect and charge the battery by using a battery charger**
- **connect and charge the battery by the constant current method**
- **connect and charge the battery by the constant potential method.**

Requirements

Tools and Instruments

- Cutting plier 150 mm - 1 No.
- Screw driver 150 mm - 1 No.
- MC Voltmeter 0-15V - 1 No.
- MC Ammeter 0-10A - 1 No.
- Hydrometer - 1 No.
- High rate discharge tester - 1 No.

Equipment/Machines

- Battery charger for 12V - 1 No.
- Low voltage DC power supply 0-30 volts 10A. - 1 No.
- Variable resistor 10 ohms, 5A capacity - 1 No.
- Battery 12V lead acid type - 1 No.

Materials

- Distilled water - 1 bottle (450ml)
- Petroleum jelly - as reqd.
- Sandpaper (Smooth 120) - as reqd.
- Test leads with crocodile clips - 1 Pair
- Clips - 1 Pair
- Concentrated sulphuric acid - 100 ml
- Clean jar for mixing 1 litre capacity - 2 Nos.
- Cotton Waste - as reqd.
- Soda bi-carbonate - as reqd.

PROCEDURE

TASK 1: **Prepare the battery for charging**

1 Clean the battery terminals, if corroded, with sandpaper : if sulphated, clean with wet cotton waste or with soda bicarbonate.

Do not damage the battery terminal by scraping with any metal strip.

2 Unscrew all the vent plugs and check the level of the electrolyte.

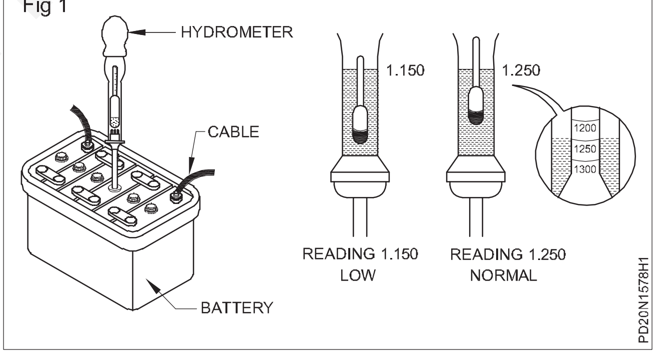
Do not clean the battery top surface keeping the vent plugs open. The accumulated dirt may fall inside the cells and form sediments.

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

No electrolyte to be used to top up battery.

4 Check the initial specific gravity of the electrolyte of each cell using a hydrometer (Fig 1) and record in Table 1.

Fig 1



5 Measure the cell voltage and the battery voltage with a voltmeter and record in the Table 1.

Do not use a high rate discharge tester for measuring voltage.

Table 1

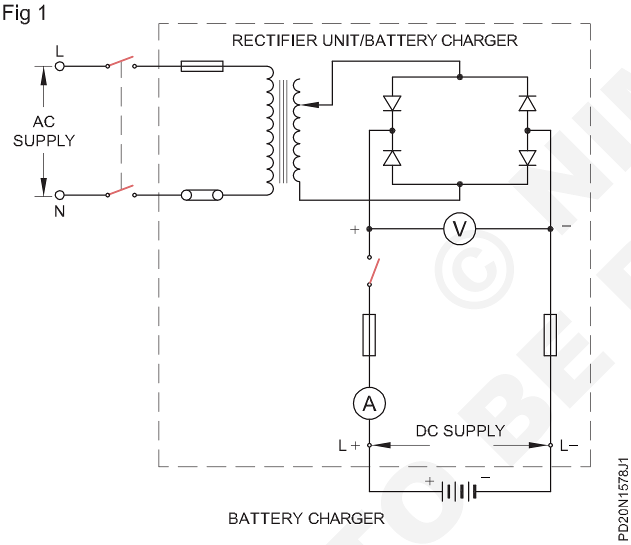
Cell No.	Initial condition		Charged condition after									
	Specific gravity	Voltage	1 Hr		2 Hrs		3 Hrs		4 Hrs		5 Hrs	
			SP	V	SP	V	SP	V	SP	V	SP	V
1												
2												
3												
4												
5												
6												

— — — — — —

TASK 2: **Practice on battery charging using battery charger**

1 Connect the battery charger's +ve lead to the +ve terminal of the battery and the -ve lead of the charger to the -ve terminal of the battery. (Fig 1)

Fig 1



2 Adjust the battery charger output voltage equal to or a little higher than the voltage of the battery to be charged.

3 Set the charger voltage to produce the determined value of initial charging current.

Follow the manufacturer's recommendation for current setting for charging as well as discharging.

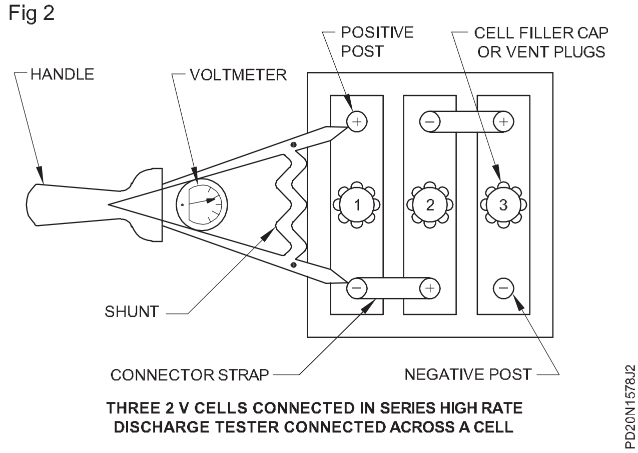
4 Check the voltage of each cell of the battery and specific gravity of the electrolyte at regular intervals (say ONE hour).

Remove the vent plug to enable the gas to escape.

5 Disconnect the battery when fully charged. Fit the vent plugs, clean the outer surface with wet cloth. Apply petroleum jelly to the terminals.

6 Check the battery for its working voltage under load using a high rate discharge tester for a short period. (Fig 2)

Fig 2



Do not keep a high rate discharge tester for a long period, say more than five seconds.

— — — — — —

Perform setting and carryout trickle charging of battery

Objectives: At the end of this exercise you shall be able to
- **set connection for trickle charging**
- **carryout trickle charging of battery.**

Requirements

Tools/ Instruments

- Insulated cutting plier 150 mm - 1 No.
- Screw driver 150 mm - 1 No.
- Soldering iron - 1 No.
- Heavy duty screw driver 300 mm - 1 No.
- IN4007 PN jn diode - 4 Nos.
- Ammeter 0-20A - 1 No.
- 12V battery - 1 No.
- 220V AC supply - 1 No.

Equipment/Machines

- 220V/14V step down transformer - 1 No.

Materials

- Sand paper grad '0' - 1 Sheet
- Flexible cable 14/0.2 - 5 m

PROCEDURE

Procedure for Trickle Charging

Trickle charging is a method of charging a battery slowly to maintain its charge without overcharging it. Here's a general procedure for trickle charging:

1 Set a trickle charger as in fig ensure you have a compatible trickle charger for your battery and check its voltage and current rating to match your battery's requirements.

2 Work in a well-ventilated area, away from flammable materials, and follow all safety guidelines provided.

3 Disconnect the negative (black) terminal first, and then the positive (red) terminal of battery.

4 Inspect the battery terminals for any corrosion, and if necessary, clean them with a mixture of baking soda and water. Rinse with clean water and dry thoroughly.

5 Attach the charger's positive (red) lead to the positive terminal of the battery and the negative (black) lead to the negative terminal. Make sure the connections are secure.

6 Set the charger to the appropriate voltage and current for your battery type. Ensure that the charger is in "trickle" or "maintenance" mode to prevent overcharging.

7 Plug the charger into a standard electrical outlet and turn it on. The charger will supply a low and steady current to the battery to maintain its charge.

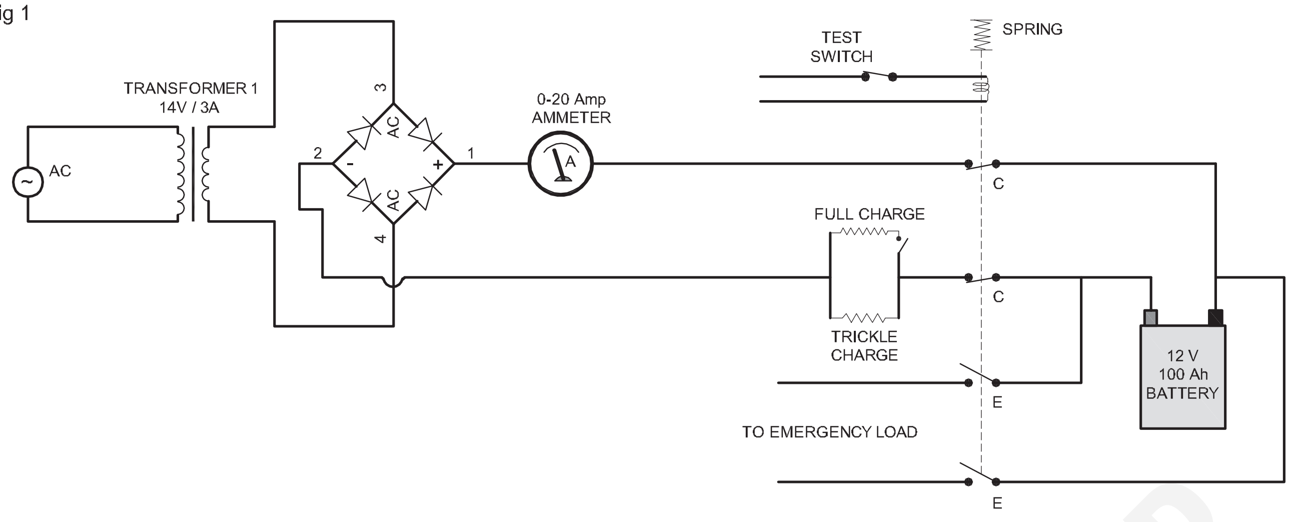
8 Monitor the charging process: Keep an eye on the charger and battery while it's charging to ensure everything is functioning correctly. If you notice any issues or abnormalities, stop the charging process immediately.

9 Trickle charging is a slow process and may take several hours or even days to complete. It's designed to maintain the battery charge, so you can leave it connected for extended periods.

10 Once the battery is fully charged or if you want to use the battery again, disconnect the charger first (unplug it from the electrical outlet) and then remove the charger leads from the battery terminals.

Remember, trickle charging is ideal for keeping batteries at their optimal levels during storage or infrequent use, but it's essential to use the correct charger and follow safety guidelines to avoid any potential hazards.

Fig 1



Trickle Charging

1 While charging a battery, technically charging stops when full battery voltage reached. However, in that case, the battery starts self discharging due to its intended resistance same batteries like emergency batteries are required to be fully charged all the time.

2 In order to keep it in a fully charged position it is practice to keep a small current just enough to balance the discharge. This small curent is the trickle current. A charging current is designed to maintain this trickle current once fully battery voltage is reached.

3 If the batteries are in stand by mode, with the charging switches C closed and the emergency load switches E open the positioner of these switches are held with the help of an electro magnetic coil againt spring tension.

— — — — — —

Practice charging and discharging of NiCd battery

Objectives: At the end of this exercise you shall be able to
- **connect a NiCd battery for charging as per the circuit diagram**
- **charging of NiCd battery**
- **discharging of NiCd battery.**

Requirements

Tools/ Instruments

- Ring spanner (6 mm - 25 mm) - 1 No.
- Combinations plies 150 mm - 1 No.
- Insulated screw driver 20 mm - 1 No.

Equipment/Machines

- Step down transformer (0-12VAC) - 1 No.
- Bridge reclifier module or (in 4007x4) - 1 No.

Materials

- Regulater IC Lm 3/7 - 1 No.
- Resistors 1K-2, 120 Ω , 510 Ω - 1 No.
- Resistors 10-21W - 1 No.
- Capacitor 47M/16V - 1 No.
- LED - 1 No.
- Multimeter - 1 No.

PROCEDURE

1 For charging Ni-cd battery connection are done as in connection diagram.

2 Disconnect the power supply alter completion of charge.

3 Test the battery if fully charged with multimeter.

Nickel Cadmium battery system has a nominal voltage of 1.2V/cell.

4 The typical end voltage for charging in PV system varies between 1.45V and 1.6V/cell. Depending on battery controller and system type.

Fig 1

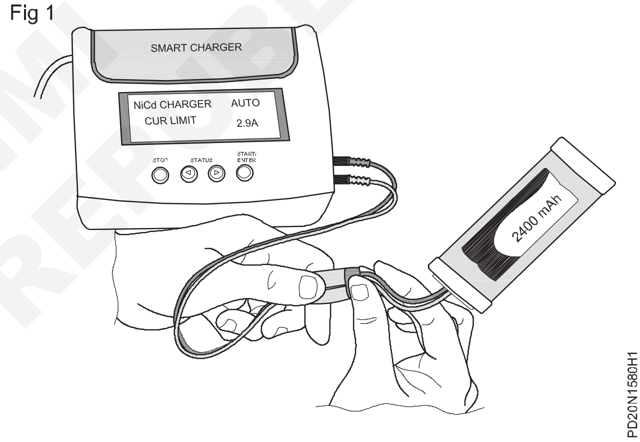
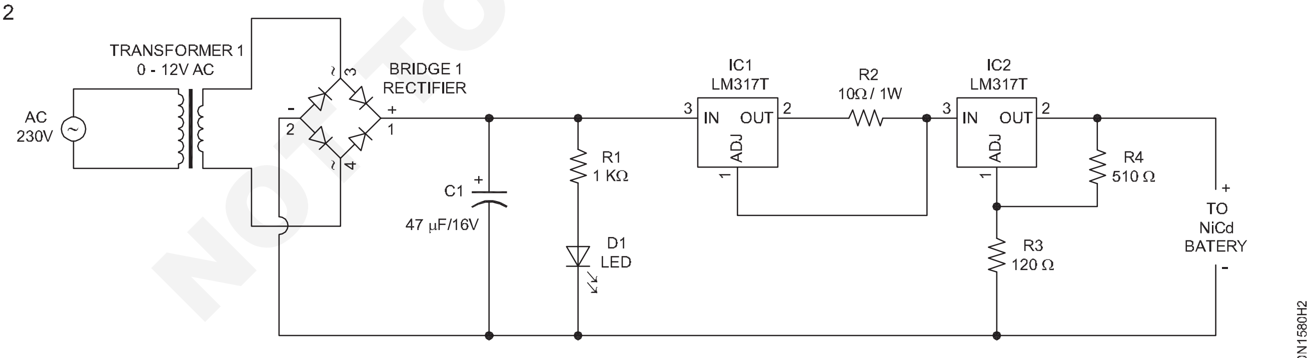


Fig 2



NiCd BATERY CHARGER CIRCUIT

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Charge batteries by using float and boost charger

Objectives: At the end of this exercise you shall be able to
- **charger battery by boost charger**
- **charge battery by float charger.**

Requirements

Tools/ Instruments

- Multimeter - 1 No.

Equipment/Machines

- Boost charger - 1 No.
- Float charger - 1 No.
- Battery set - 1 No.
- DC Load and connecting accessaries - 1 No.

PROCEDURE

Charger batteries by using float and boost charger

1 Connect the boost charger as in circuit diagram. If the battery's charge is significantly low or depleted, start by connecting the boost charger. The boost charger provides a higher current to charge the battery quickly.

2 Adjust the boost charger to the appropriate voltage and current settings for your battery. Refer to the battery manufacturer's guidelines to ensure safe and efficient charging.

3 Attach the positive (red) lead of the boost charger to the positive terminal of the battery and the negative (black) lead to the negative terminal. Double-check the connections for accuracy.

4 Charge the battery: Turn on the boost charger and allow the battery to charge until it reaches a suitable level, but be cautious not to overcharge it.

5 Monitor the charging process: Keep a close eye on the battery and charger while it's charging. Look for any signs of excessive heat or bubbling, as these may indicate potential issues.

6 Once the battery has reached an acceptable charge level, switch to the float charger. The float charger provides a low and steady voltage, preventing overcharging and maintaining the battery at its fully charged state.

7 Set the float charger: Adjust the float charger to the appropriate voltage for your battery type. The float voltage should be lower than the battery's maximum voltage to avoid damage.

8 Connect the float charger: Attach the positive (red) lead of the float charger to the positive terminal of the battery and the negative (black) lead to the negative terminal.

Fig 1

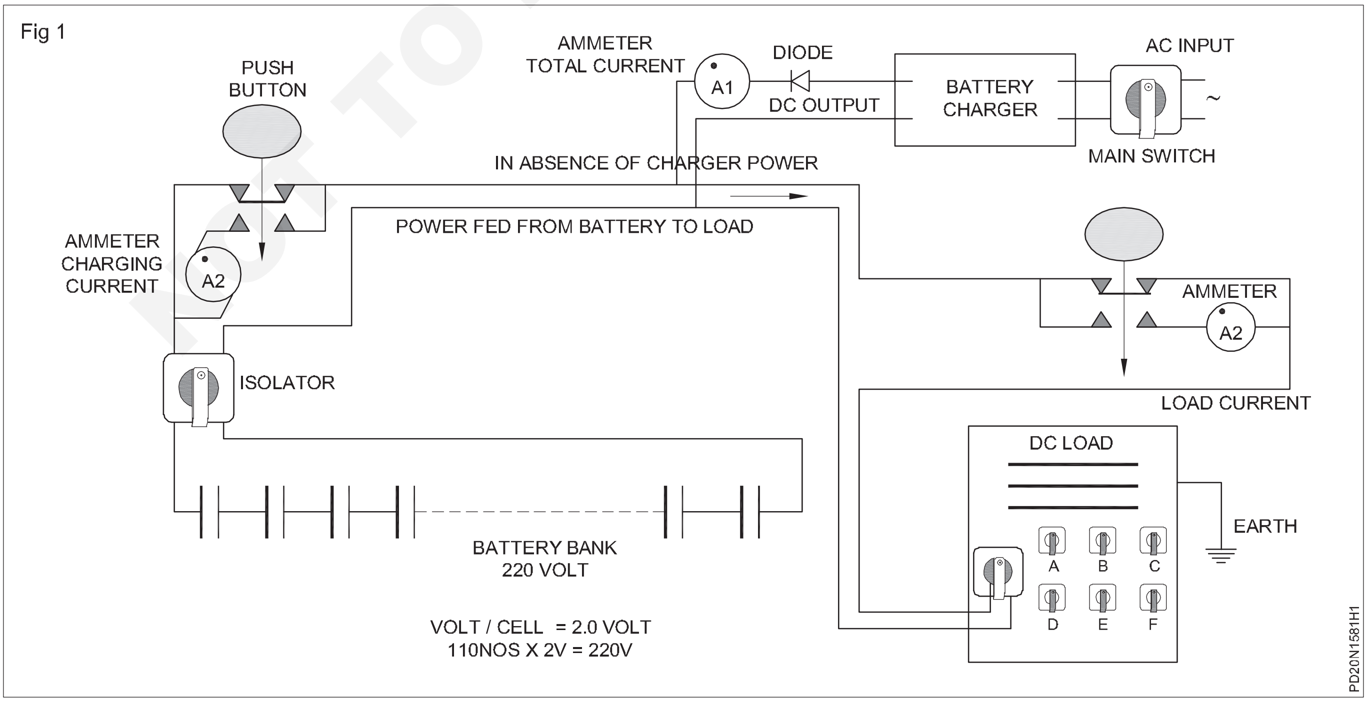
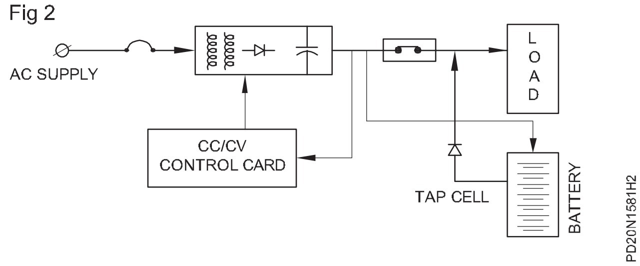


Fig 2



9 The float charger will continuously provide a small current to keep the battery fully charged without causing harm.

10 The duration of both boost and float charging will depend the battery's capacity, initial charge level, and the charger specifications. Follow the recommended charging times provided by the charger and battery manufacturers.

11 Ensure you are working in a well-ventilated area, away from flammable materials, and follow all safety guidelines provided by the charger manufacturers.

12 Disconnect and store: Once the battery is fully charged or if you plan to store it for an extended period, disconnect the chargers first (unplug them from the electrical outlet), and then remove the charger leads from the battery terminals.

13 Boost Charging Phase: During the boost charging phase, the charger supplies a constant current to the battery to rapidly charge it. This phase is used when the battery's voltage is significantly lower than its recommended fully charged voltage. The boost charging phase aims to replenish the battery's charge quickly until it reaches a certain voltage level.

14 After the boost charging phase, the charger switches to the float charging phase. In this phase, the charger provides a lower voltage, which is typically the battery's recommended float voltage. The float voltage is lower than the boost voltage and is designed to maintain the battery at a fully charged state without overcharging it. Float charging prevents the battery from losing charge over time and ensures it remains ready for use whenever needed.

15 Here's an outline of the typical battery charging process using a float and boost charger:

Boost Charging

Apply a constant current to the battery until it reaches the boost voltage level (usually around 2.4 to 2.45 volts per cell for lead-acid batteries)

The charger monitors the battery's voltage to determine when to switch to the float charging phase.

Transition:

1 Once the battery voltage reaches the boost voltage level, the charger transitions from boost charging to float charging. Float Charging:

2 Apply a constant voltage to the battery at the float voltage level (usually around 2.25 to 2.3 volts per cell for lead-acid batteries).

3 This voltage level is lower than the boost voltage and is safe for long-term battery maintenance.

4 The charger continuously monitors the battery voltage and adjusts the charging current as needed.

5 If the battery's voltage drops below a certain threshold, the charger will switch back to the boost charging phase until the battery is adequately charged again.

6 It's essential to use a charger specifically designed for float and boost charging or a charger that has both modes available. Also, it's crucial to follow the manufacturer's guidelines and recommendations for your specific battery type to ensure safe and effective charging. Overcharging or charging with incorrect voltage levels can lead to damage or reduced battery life.

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Check DC leakage and practice for its protection

Objectives: At the end of this exercise you shall be able to
- **clean battery case**
- **check DC leakage**
- **practice for protection from DC leakage.**

Requirements

Tools/ Instruments

• Multimeter	- 1 No.
• Plier	- 1 No.
• Soft brush	- 1 No.

Equipment/Machines

• Paper towels	- 1 No.
• Distilled water	- 1 No.

PROCEDURE

DC leakage, also known as ground leakage or ground fault, occurs when an unwanted current flows from a DC power source to the ground or other unintended conductive paths. This can be hazardous and can cause damage to equipment or pose a safety risk. Here are some steps to check for DC leakage and practices to protect against it.

Check for DC Leakage

- Before you begin, make sure the DC power source is disconnected, and all equipment is powered off.
- Use a multimeter or a ground leakage tester designed for DC systems.
- Connect the negative (black) lead of the tester to the negative terminal of the DC power source.
- Touch the positive (red) lead of the tester to various parts of the system, including equipment chassis, exposed conductive surfaces, or any areas where current might unintentionally flow to the ground.
- If the tester detects any current flow, it indicates DC leakage.

Identify and Fix the Issue

- Once DC leakage is detected, inspect the DC system and equipment for damaged insulation, loose connections, or other issues that might cause leakage.
- Fix any identified problems promptly to eliminate the leakage. Use Ground Fault Circuit Interrupters (GFCIs):
- Install Ground Fault Circuit Interrupters (GFCIs) in the DC circuit. GFCIs are designed to detect even small imbalances in current flow and shut off power quickly to prevent shocks or damage.

Isolate DC Power Sources

- When possible, isolate DC power sources to prevent leakage from affecting other parts of the system. Use separate circuits or isolated power supplies when necessary.

Insulate Conductive Surfaces

- Ensure that all conductive surfaces are well-insulated to prevent unintended current paths to the ground. Use appropriate insulating materials and cover exposed conductors.

Regular Maintenance

- Conduct regular maintenance and inspections of the DC system and equipment to identify and fix potential issues before they lead to DC leakage.

Use Safety Labels and Warnings

- Clearly label hazardous areas or equipment where DC leakage might be present, and provide appropriate warnings for users and maintenance personnel.

Follow Safety Guidelines

- Always follow safety guidelines and best practices when working with DC power systems. Use proper personal protective equipment (PPE) and ensure that personnel are trained in safe handling procedures:
- By following these practices and being vigilant about potential DC leakage issues, you can help ensure the safety and reliability of your DC power systems. If you encounter significant leakage or are unsure how to handle the situation, it's best to consult with a your instructor.

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Carryout testing of Batteries

Objectives: At the end of this exercise you shall be able to
- **test a battery and verify whether the battery is ready for use**
- **verify whether battery needs recharge.**

Requirements

Tools/Equipments/Instruments

- Trainees tool kit - 1 Set
- High rate discharge tester - 1 No.
- Hydrometer - 1 No.
- MC voltmeter 0-15V - 1 No.
- Lead acid type 12V - 1 No.

Materials/Components

- Cotton waste - as reqd.
- Test probes with crocodile clip - 1 Pair

PROCEDURE

TASK 1: **Testing the a battery and verifying whether battery is ready for use**

1 Clean the terminals; measure the cell voltage and battery voltage using voltmeter; record the observations in Table 1.

2 Check the level of the electrolyte in the battery

3 Measure the specific gravity of electrolyte of each 3 cell with hydrometer and record the observations in Table 1.

4 Observe whether the specific gravity is 1.28.

5 See whether the level of electrolyte is above the level of eletroplate.

6 If all the above test results are satisfied, then the battery is ready for use.

Fig 1

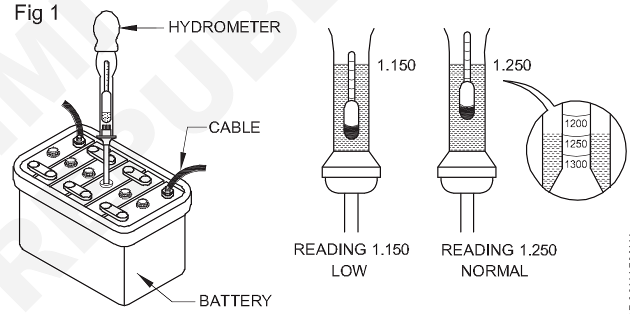


Table 1

Cell No.	Measured voltage	Specific gravity	Condition	Remarks
1				
2				
3				
4				
5				

— — — — — —

TASK 2: **Verifying whether battery needs recharge or not**

1 Check the battery for its working voltage under load using a high rate discharge tester for a short period say within 5 seconds.

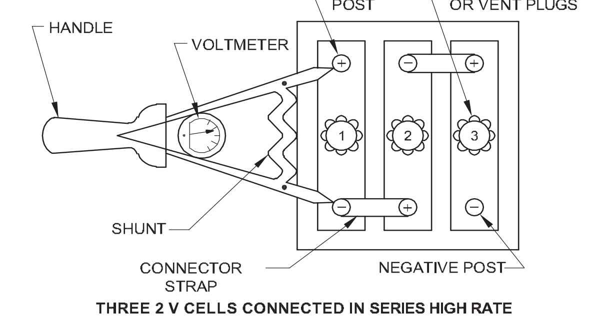
2 Observe whether each cell voltage is below 1.8V.

3 Measure the specific gravity of electrolyte of each cell with a hydro meter.

4 observe whether the specific gravity is below 1.24.

5 If all the test results are in the above condition then the battery needs recharge.

Fig 1



THREE 2 V CELLS CONNECTED IN SERIES HIGH RATE DISCHARGE TESTER CONNECTED ACROSS A CELL

Practice on routine, care / maintenance and testing of batteries

Objectives: At the end of this exercise you shall be able to
- **prepare and follow the routine care/maintenance schedule chart for batteries**
- **carry out the general procedure and maintenance for batteries.**

Requirements

Tools/ Instruments

- Ring spanner (6 mm - 25 mm) - 1 Set
- Combination pliers 150 mm - 1 No.
- Insulated screw driver 200 mm - 1 No.
- Hydrometer - 1 No.
- High rate discharger tester - 1 No.

Equipment/Machines

- Lead acid battery 12V / 60 AH - 1 No.

Materials

- Banian cloth - as reqd.
- Distilled water - as reqd.
- Sodium bicarbonate solution - as reqd.

PROCEDURE

TASK 1: **Prepare and follow the routine care/maintenance schedule chart for batteries**

1 Collect the care/maintenance activities required for lead acid batteries.

2 Make a care/maintenance chart for daily, weekly, monthly, six monthly maintenance schedule as in Chart - 1.

3 Perform the routine care/maintenance activities of battery by referring the following Chart 1.

Routine Care/ Maintenance Schedule Chart-1

Sl.No.	Routine	Activities to be done	Remarks
1	Daily	• Inspect the batteries visually. • If it is found abnormal, report and do necessary action.	
2	Weekly	• Inspect all batteries visually • Clean surface, check tightness of connectors and vent plugs • Check supporting clamps	
3	Monthly	• Check level of electrolyte • Do charging of battery, if not been automatically charged • Clean terminals, reconnect, apply protection jelly. • Clean top surface by sodium bi-carbonate solution in water. • Wipe surface for dryness. • Check that other materials surface should not have contact with batteries and top surface of battery	
4	Six Monthly	• Check level and specific gravity, charging rate, charging hours, voltage cell	

(Life of well maintained lead acid battery can be about five to six years)

— — — — — —

TASK 2 : **Carry out the general preventive maintenance of lead acid battery**

1 Perform the following steps for the preventive maintenance of battery.

Steps to be followed for preventive maintenance of battery

- Maintain the level of the electrolyte 10 to 15 mm above the plates (or) as per manufacturer's manual.
- Add the distilled water to the acid; and do not add acid to water.
- Connect the positive terminal of the battery to the positive terminal of the supply, and connect the negative terminal of the battery to the negative terminal of the supply while charging the battery.
- Keep the vent plug open for the liberation of gases during charging.
- Clean the vent plugs holes for proper discharging of gas.
- Keep the battery terminals always cleaned.
- Apply a thin layer of Vaseline (or) petroleum jelly over them to prevent corrosion.
- Do not charge or discharge the battery in higher rate continuously.
- Remove the lead sulphate which is formed due to over charge after four months.
- Maintain well-ventilated room for battery charging.
- Use high rate discharge tester only for charged battery not for discharged battery.
- Check the specific gravity of the electrolyte before charging and discharging.

— — — — — —

Determine the number of solar cells in series / Parallel for given power requirement

Objectives: At the end of this exercise you shall be able to
- **determine the number of solar cells required for a series group for a given voltage requirement**
- **determine the number of group of solar cells in parallel for a given ampere hour capacity**
- **calculate the total number of solar cells required for a given power requirement**
- **connect the given cells in series and parallel groups to charge the battery.**

Requirements

Tools/Instruments

Cutting pliers 200 mm	- 1 No.
Screw driver 250 mm	- 1 No.
Connector screw driver 100 mm	- 1 No.
Voltmeter MC type 0 - 15V	- 1 No.
Ammeter 0-500 mA - MC	- 1 No.
Soldering Iron 35W 240V 50 Hz	- 1 No.

Materials/Components

Solar cells 125 mW/cm^2, 0.45 V, 57 mA	- 87 cells
Connecting wires 3/0.91 mm PVC insulated cable	- 20 m
Insulation tape 30 cm long	- 1 No.
Miniature bulb B.C Type 3W 12 V with holder	- 1 No.
‘On’ and ‘Off’ flush mounting switch 6A 240 Volts	- 2 Nos. - 2 Nos
Resin core solder 60:40	- as reqd.

PROCEDURE

TASK 1: **Determine the number of cells required for a series group**

A village panchayat office requires a light of 12V 3 Watts for display purpose for four hours which has to be energized through a battery. The battery is to be charged through an array of solar cells having 125 mw/cm^2 capacity. The light from sun expected to be available for 8 hours a day. Calculate the number of solar cells in series group and the number of groups in parallel to charge the battery and wire up the solar cells accordingly.

1 Determine the number of solar cells in series group.

$$\text{No. of cells in series group} = \frac{\text{Total required voltage}}{\text{Volt per cell}}$$

Assuming charging voltage is equal to battery voltage + 1 volt = 12 + 1 = 13 V

$$\text{No. of cells in series group} = \frac{13}{0.45} = 29 \text{ cells}$$

Calculate the ampere hour requirement

The current required

$$\text{The current required} = \frac{\text{Power}}{\text{Voltage}} = \frac{3 \text{ watts}}{12 \text{ volts}} = \frac{1}{4} \text{amps}$$

say 250 mA

The charge taken from the batteries at the rate of 250 mA for 4 hours

$$\text{Hence ampere hour requirement} = \frac{250}{1000} \text{X} 100$$

= 1 AH

Charging current rating

$$= \frac{\text{amphere hour lost in actual usage}}{\text{No. of possible charging hours}}$$

$$= \frac{1\text{AH}}{8}$$

= 0.125 amperes

Total No. of cells in parallel group

$$= \frac{\text{Output current}}{\text{Cell current}}$$

$$= \frac{0.125 \text{ amp}}{57 \text{ mA}}$$

$$= \frac{125}{57}$$

= say 3 cells/group

Hence total number of cells required = 29 x 3

= 87 cells

— — — — — —

TASK 2: **Connect the given 87 cells in series parallel groups to charge the 12 v battery**

1 Connect 29 cells in a series group and solder the points.

2 Make 3 groups of 29 cell series groups.

3 Connect the three series groups in parallel and solder the connections ends.

4 Connect the series parallel group of cells with a voltmeter, an ammeter, battery and a 6A Switch as shown in the Fig 1.

5 Measure the voltage across the groups with the help of 0-15 V M.C. voltmeter and enter the values in Table 1.

6 Close the switch and measure the charging current and enter the values in Table 1.

Fig 1

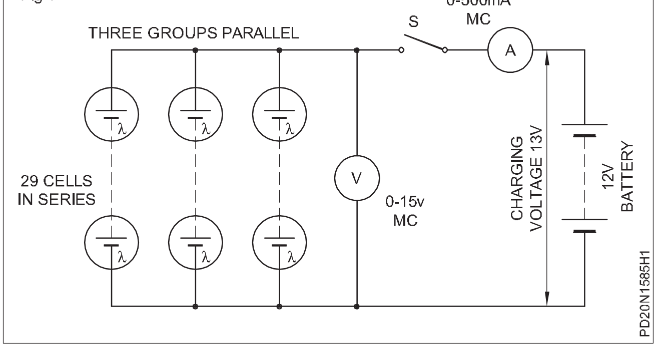


Table 1

Open circuit voltage of coils	Load voltage	Charging current

Identify various conduits and different electrical accessories

Objectives: At the end of this exercise you shall be able to
- **identify and name the conduits and conduit accessories and write their specification and uses.**
- **identify and name the electrical accessories**
- **write the specification and uses of the electrical accessories**
- **draw the electrical accessories IE symbols.**

Requirements

Tools/Instruments

- Insulated screw driver 4 mm x150 mm - 1 No.
- Insulated connector screw driver 4 mm x100 mm - 1 No.
- Tray 60x30x4 cm - 1 No.
- I.S. books on graphic symbols (B.I.S 2032 all parts) - 1 No.

Materials

- PVC conduit pipe - 19 mm and 25 mm - 3M long - 1 No. each
- GI conduit pipe - 19 mm and 25mm - 3 m long - 1 No. each
- PVC Channel - 20mm and 25mm - 1M long - 1 No. each
- PVC pipe coupling - 19mm & 25mm - 1 No. each
- PVC junction box - 1,2,3 and 4 way -19mm & 25mm - 1 No. each
- PVC bend - 19 mm & 25mm - 1 No. each
- PVC Elbow - 19 mm & 25 mm - 1 No. each
- PVC Tee - 19mm & 25mm - 1 No. each
- GI conduit coupler & Inspection Coupler - 19mm & 25mm - 1 No. each
- GI Elbow & Inspection Elbow - 19mm & 25mm - 1 No. each
- Tees & Inspection Tee - 19mm & 25mm - 1 No. each
- GI junction box -1,2,3 & 4 way square type 19mm & 25mm - 1 No. each
- S.P. switch 6A 250V flush type, single way - 1 No.
- S.P. switch 6A 250V flush type two way - 1 No.
- S.P. switch 6A 250V mounting type single way - 1 No.
- S.P. switch 6A 250V mounting type two-way - 1 No.
- Tube light starter holder 6A - 1 No.
- Combined tube and starter holder 6A - 1 No.
- Tube light holder - 6A - 1 No.
- Brass batten-holder 6A 250V - 1 No.
- Bakelite batten-holder 6A 250V - 1 No.
- Brass pendent-holder 6A 250V - 1 No.
- Bakelite pendent-holder 6A 250V - 1 No.
- 3-pin 6A wall socket, mounting type - 1 No.
- 3-pin 16A wall socket, mounting type - 1 No.
- 3-pin 6A wall socket, flush type - 1 No.
- 3-pin 16A wall socket, flush type - 1 No.
- 2-pin 6A wall socket, flush type - 1 No.
- 2-pin 6A mounting type - 1 No.
- Ceiling rose 6A 250V 2 plate - 1 No.
- Ceiling rose 6A 250V 3 plate - 1 No.
- Fan regulator - 1 No.
- Kit-kat fuse 16A 250V - 1 No.
- Intermediate switch 6A 250V - 1 No.
- 3-pin 6A 250 V plug - 1 No.
- 3-pin 16A 250 V plug - 1 No.
- Terminal plate 16A 250 V 3- way - 1 No.
- I.C.D.P. switch 16A 250V - 1 No.
- I.C.T.P. switch 16A 400V - 1 No.
- Neutral link 16 amps - 1 No.
- I.C. cutouts 16A 250V - 1 No.
- Distribution box 4-way - 1 No.
- Bell-Push/switch 6A, 250V flush type - 1 No.
- Bell-Push/switch 6A, 250V mounting type - 1 No.
- HRC Fuse - 16A - 1 No.
- Iron connector - 5A - 1 No.
- Toggle switch 6A - 1 No.
- MCB 1,2 & 3 Pole - 1 No. each

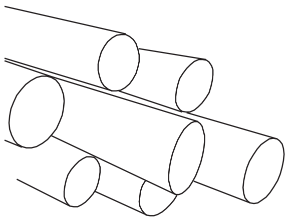
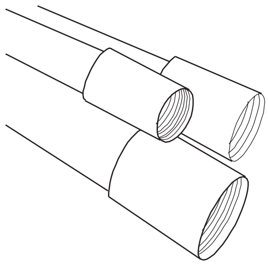
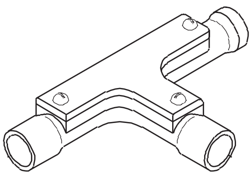
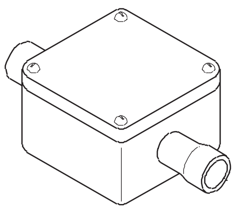
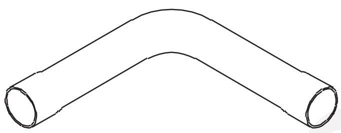
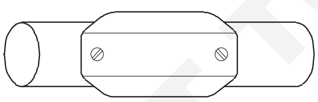
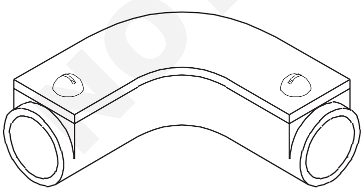
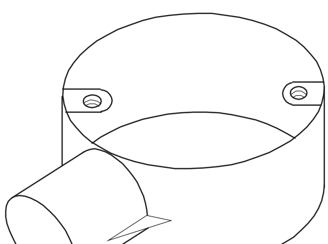
PROCEDURE

TASK 1 : **Identify various conduit and conduit accessories**

1 Identify each items and write the name in the table. (Fig 1 to Fig 10)

2 Write the specification and use of each conduit & conduit accessory in the column given.

Conduit Pipe & Conduit accessories

Sketch	Name	Specification	Use
			
			
			
			
			
			
			
			

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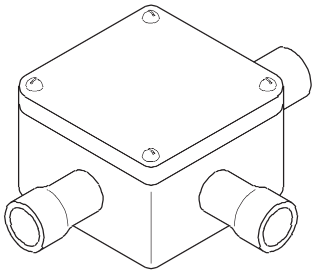			
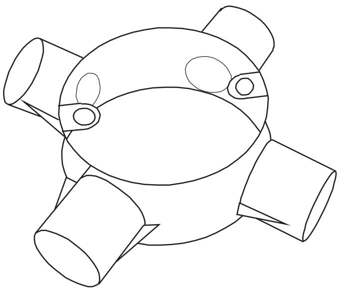			

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TASK 2 : **Identify electrical accessories and write their names**

1 Identify each accessory and write the name in the table 2 (Fig 11 to 28)

> **Different manufacturers design the outline of accessories differently to suit various conditions. However, the Power contact positions of the accessories remain the same. As such there should not be much difficulty in identifying the accessories.**
>
> **On the other hand, single way and two-way switches as well as two and three plate ceiling roses look alike. A careful look at the rear of the accessory will make the identifying process much easier.**

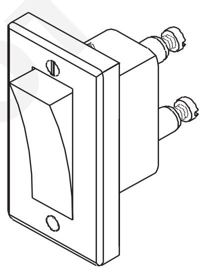
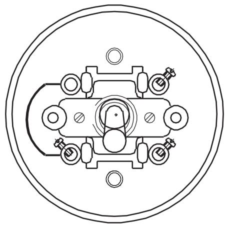
2 Write the specification of each accessory in the column given by the side of each (accessory) figure.

> **Most of the specifications can be collected from the markings on the accessory itself. Otherwise try to get them from an approved catalogue or approach the instructor for guidance.**

3 Identify the I.E symbols used for the accessory from the related theory or B.I.S.books and sketch the symbols in the columns/spaces provided.

4 Show the completed sheets of specifications, identification and symbols to the instructor and get his approval.

Table 2 **- Electrical accessories**

Sketch	Name	Specification	Use	IE Symbol
				
				

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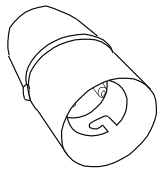				
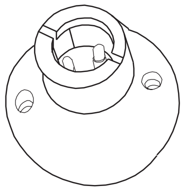				
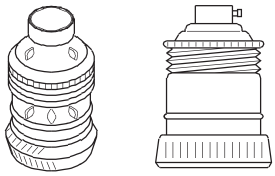				
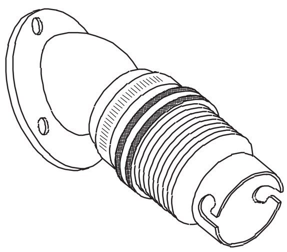				
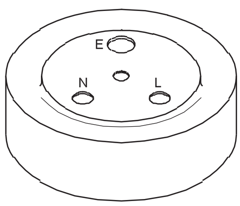				
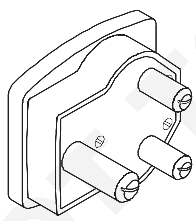				
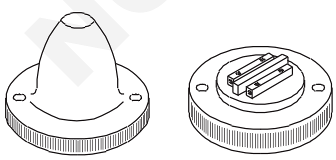				
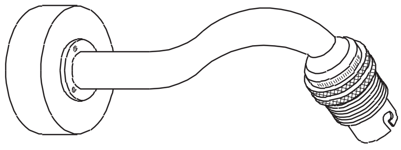				

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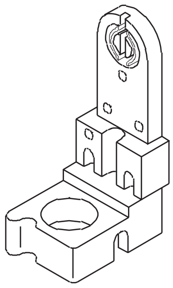				
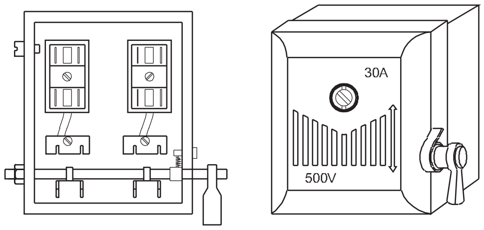				
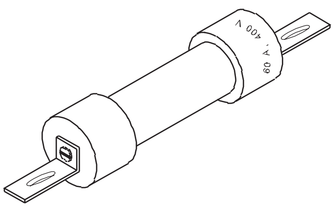				
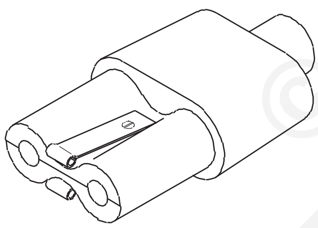				
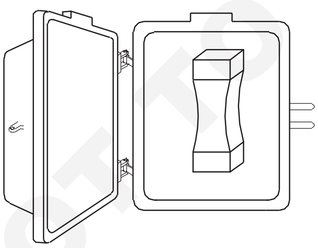				
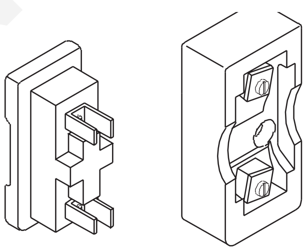				

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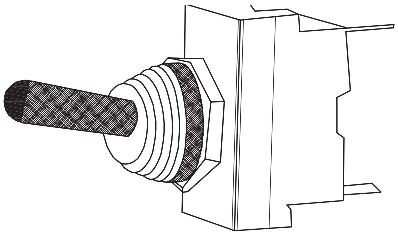				
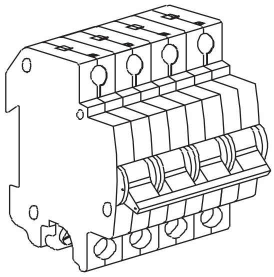				

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Practice cutting, threading of different sizes of conduits and laying installations

Objectives: At the end of this exercise you shall be able to
- **cut metal conduit pipes of heavy gauge to the required dimensions**
- **fasten the conduit pipe in the pipe vice and prepare the conduit ends for threading**
- **cut the threads on heavy gauge metal conduit,according to requirements using a conduit die set**
- **fix the conduit accessories to the pipes according to the pipe size using the threaded method**
- **fix the conduit with the necessary clamps and spacers on surface installation in accordance with the B.I.S.recommendations**
- **draw cables in the metallic conduit pipes**
- **bond the conduit pipes at joints and junctions**
- **earth the conduit as per B.I.S. recommendations**
- **prepare metal boxes and fix Power accessories**
- **terminate the cable ends at the accessories according to the wiring diagrm**
- **test the wiring.**

Requirements

Tools/Instruments

- Screwdriver 200mm with 5mm blade - 1 No.
- Connector screwdriver 100mm with 3mm blade - 1 No.
- Pipe vice 50 mm - 1 No.
- Steel rule 300 mm - 1 No.
- Hacksaw with a blade of 24 teeth per 25 mm (25 TPI) - 1 No.
- Flat file bastard 250 mm - 1 No.
- Half round file 2nd cut 200 mm - 1 No.
- Reamer 16 mm - 1 No.
- Oil can 250ml - 1 No
- Conduit stock and dies for 19 mm & 25 mm conduit - 1 Set
- Wire brush 50 mm - 1 No.
- Plumb bob with thread - 1 No.
- Electrician's knife DB 100 mm - 1 No.
- Poker 200 mm - 1 No.
- Ball peen hammer 500 grams - 1 No.
- Hand drilling machine 6 mm capcity with 4 mm drill bit - 1 Set
- Scriber 200 mm - 1 No.
- Combination pliers 200 mm - 1 No.

Materials

- Conduit pipe, heavy gauge 19 mm dia. - 6 m
- Conduit pipe,heavy gauge 25 mm dia - 3 m
- Metal Box 90 mm Square of hexagonal type with top cover - 4 Nos.
- Conduit pipe inspection Tee 19 mm - 3 Nos.
- Conduit elbow 19 mm - 4 Nos.
- Conduit bend 19 mm - 1 No.
- Conduit junction box 3-way 19 mm - 4 Nos.
- T.W. spacers 60mm long 19 mm width and 12mm thick - 25 Nos.
- Tinned copper wire 14 SWG - 12 mts.
- Earth clamps, tinned copper suitable for 19 mm pipe with bolt, nut and washers - 3 doz.
- G.I. saddles 19 mm - 25 Nos.
- Wood screws and machine screws assorted - as reqd.
- P.V.C. aluminium cable 1.5 sqmm 250 V grade - 18 mts.
- S.P.T. switch 6A 250V - 1 No.
- Two-way Flush type switch 6A 250V - 3 Nos.
- Ceiling rose 2-way 6A 250V - 4 Nos.
- Pendent-holder, bakelite 6A 250V - 4 Nos.
- B.C. bulbs 40W, 230V - 4 Nos.
- Colour chalk - 1 piece
- Terminal plate 16 amps 3-way - 1 No.
- G.I. wire as fish wire 14 SWG - 6 mts.
- P.V.C. bushes suitable for 19 mm pipe - 40 Nos.
- Conduit check-nut 19 mm - 8 Nos.
- Lubricant coconut oil - 100 gm
- Cotton Waste - as reqd.

PROCEDURE

TASK 1: **Preparation of conduit pipe for cutting**

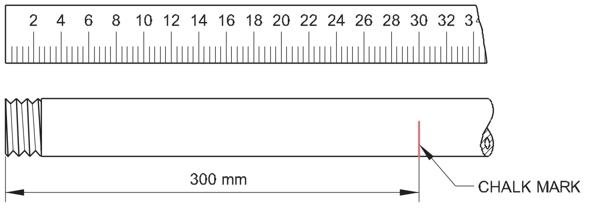
Assume the job needs a 300 mm long conduit drop but a standard length pipe of 3000 mm is only available. Normally both the ends of a standard length pipe will have threads.

To make the required conduit drop, the standard length 3000 mm pipe is to be cut for a length of 300 mm and threaded again at one end.

Cutting could be done either by pipe cutters or with hacksaws. In practice, cutting with a hacksaw is popular, and the method is explained below.

1 Measure 300mm from the threaded end of the 19 mm pipe and mark it with chalk as shown in Fig 1.

Fig 1

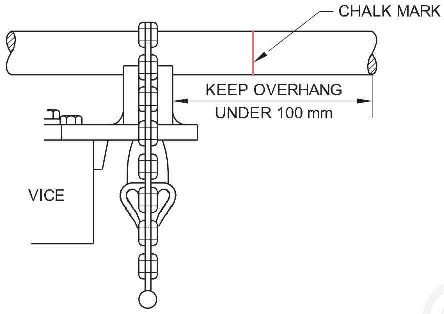


MEASURE THE PIPE LENGTH

2 Open the jaw of the vice and insert the pipe so that it is horizontal and parallel to the jaw serrations.

3 Keep the chalk mark of the pipe within 100 mm of the vice as shown in Fig 2.

Fig 2

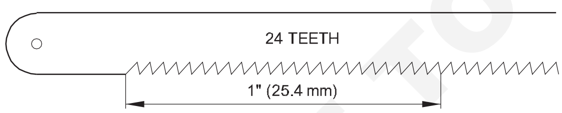


GRIP THE PIPE IN THE VICE FOR SAWING OPERATION

4 Close and tighten the vice jaw.

5 Select a hacksaw with a blade having 24 teeth per 25mm (25 TPI), as shown in Fig 3.

Fig 3



HACK SAW BLADE

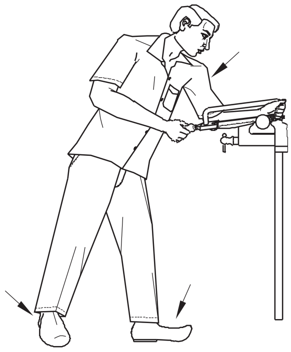
Ensure that the hacksaw blade is firmly tightened in the frame and that the teeth point in the forward direction.

6 Take up the hacksaw and position yourself, as shown in Fig 4, with your left shoulder pointing in the direction of the cut.

7 Grip the hacksaw handle with the right hand and position the hacksaw blade on top of the cutting line.

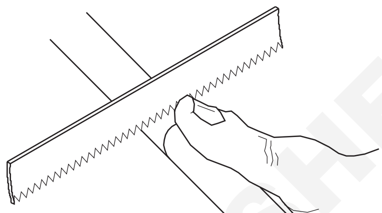
8 Prepare to cut by guiding the blade with the thumb of your left hand exactly on the cutting line against the saw blade as shown in Fig 5.

Fig 4



HACK SAWING - POSITION OF SAWING

Fig 5

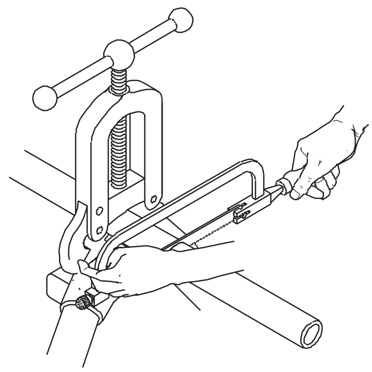


USE THUMB AS A GUIDE INITIALLY

9 When the initial cut has been made, move the left hand to the front end of the hacksaw frame and use both hands for the cutting operation as shown in Fig 6.

10 When sawing, use the full length of the blade, increasing gradually the pressure on the forward stroke, and releasing the pressure as the blade is drawn back. (Fig 6)

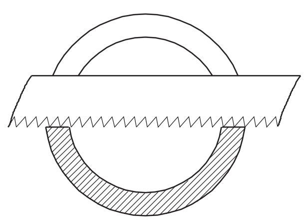
Fig 6



HOLDING SAW WHILE SAWING

11 Saw with steady, even strokes, keeping the blade upright and square to the cut as shown in Fig 7.

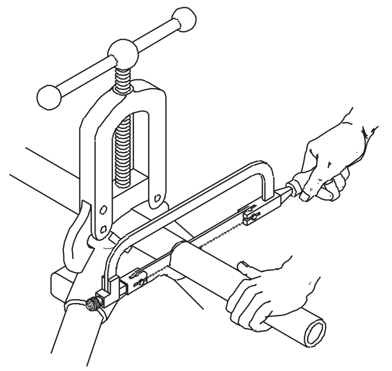
Fig 7



HOLD THE STRAIGHT

12 When getting near to the end of the cut, the conduit must be supported with your left hand as shown in Fig 8. Finish the cut.

Fig 8



END OF SAWING

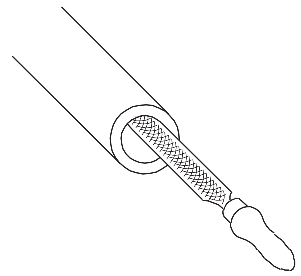
Support the free end of the conduit to prevent the blade of the hacksaw from being damaged.

13 Use a reamer or half round file to remove the inside burrs as shown in Fig 9.

14 Use the flat portion of the half round file to smoothen the sharp edges. (Fig 10)

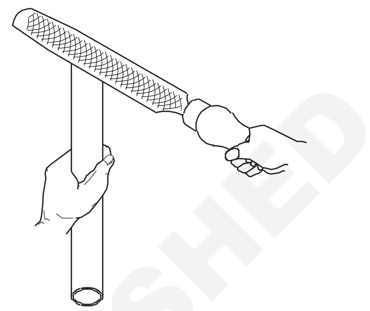
15 Again follow the steps 2 to 14 for cut the 300 mm long from the threaded end of 25 mm dia. 3 m long pipe.

Fig 9



REMOVAL OF BURRS

Fig 10



REMOVAL OF SHARP EDGES

16 Clean the hacksaw and vice after the end of the work and keep them in their respective places.

— — — — — —

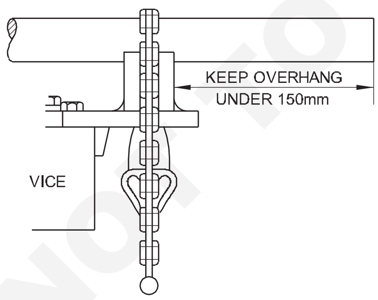
TASK 2 : **Preparation of conduit pipe for threading**

1 Open the jaw of the vice and insert the 19 mm dia pipe so that it is horizontal and parallel to the jaw serrations.

2 Keep the end of the tube within 150 mm of the vice.

3 Close and tighten the vice as shown in Fig 1.

Fig 1



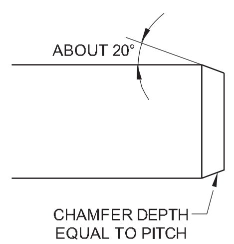
HOLD THE PIPE IN THE PIPE VICE FOR THREADING OPERATION

4 File the end of the tube flat and chamfer the outer edge to an angle of about 20° as shown in Fig 2.

Make the depth of the chamfer equal to the pitch of the thread (1.5 mm for conduit).

5 Choose the correct dies and stock suitable for the pipe to be threaded. (Fig 3 shows the conduit stock and dies set)

Fig 2



BEFORE THREADING, CHAMFER THE EDGE OF THE PIPE

Assembly drawing for the quick cut stock and dies is given in Fig 13. The die size is engraved on the die itself. Check the size with that of the pipe. The handle of the stock is not shown in the picture for clarity.

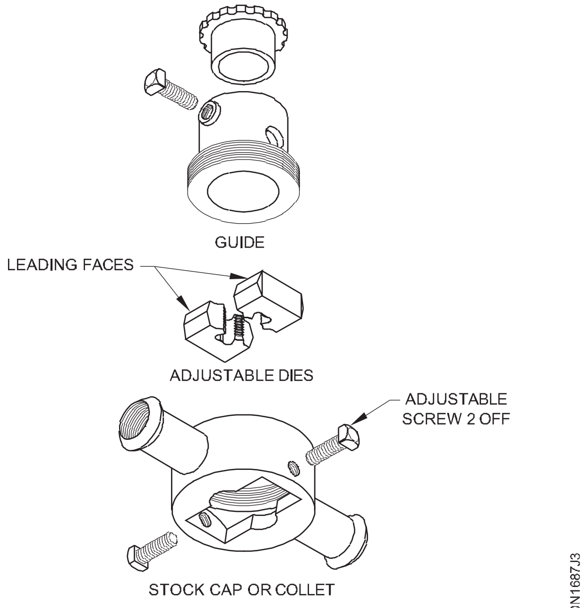
6 Insert each half of the die in the cap(stock) with the chamferred threads (leading faces) being adjacent to the guide.

7 Screw the guide into position.

8 Adjust each adjusting screw equally to make the die halves centralized to the pipe axis.

9 Slide the stock guide over the end of pipe, adjust the adjusting screws such that the dies just grip the pipe evenly on both sides.

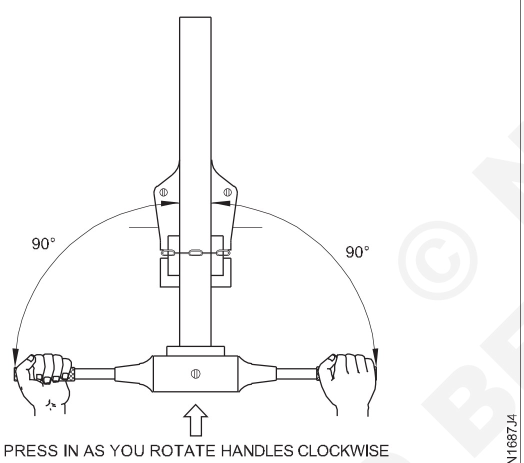
Fig 3



DIE SET (HANDLE NOT SHOWN)

10 Apply pressure to the stock and keep the handles at right angles to the pipe as shown in Fig 4.

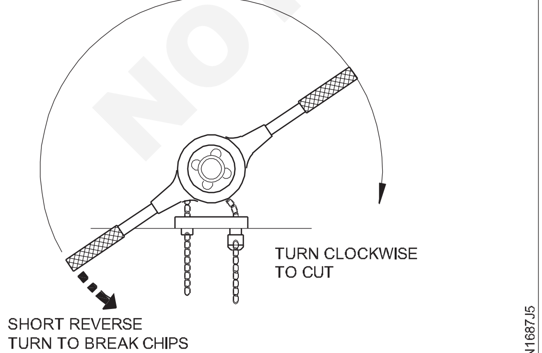
Fig 4



MOUNTING THE DIE SET IN THE CONDUIT

11 Rotate the handles clockwise in a plane at right angles to the pipe axis as shown in Fig 5.

Fig 5



THREADING PROCESS

12 Apply the lubricant to the part to be threaded after the thread has been started.

The lubricant allows the die to cool off the heat developed and thereby helps the edges to stay sharp and to produce a better thread finish.

13 Make one or two complete turns in a clockwise direction.

Check whether the stock is at right angle to the pipe axis.

14 As indicated by the increased resistance of rotation, ease the handle as frequently as necessary, back in an anticlockwise direction for half a turn.

Reverse turning is necessary to break off long cuttings and to clear the cutting edges of the die.

15 Apply the lubricant at frequent intervals.

Use a brush to remove the metal burrs from the die.

16 Remove the stock. Check the length and fit of the thread by screwing on the female fittings (coupling etc.).

The length of the thread should be sufficient to fit half way into the couplings and fully into the other fittings.

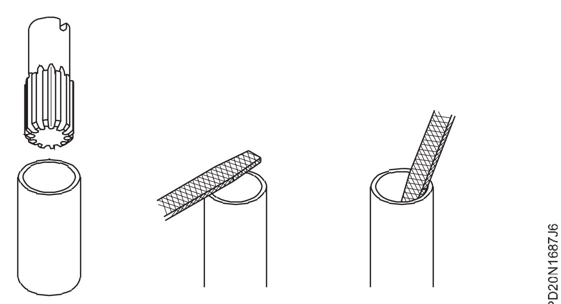
17 If the thread is not smooth (i.e.tight in the fittings) mount the stock and tighten the adjusting screws by half turn evenly and repeat working steps 10 to 16.

18 Remove any burrs or sharp edges from inside the end of the pipe with a reamer or half round file as shown in Fig 16, and file off the sharp edges, if any.

19 Again follow the steps from 2 to 18 in the task-2 for thread the 25 mm dia conduit pipe.

20 Clean the die stock and vice. Keep them in their respective places.

Fig 6



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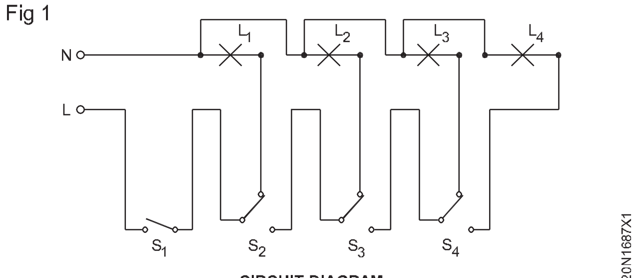
TASK 3 : **Install and wire up in metal conduit in the lighting circuit for godown**

1 Form the circuit with the required wiring accessories as per circuit diagram (Fig 1) on the workbench.

Fig 1



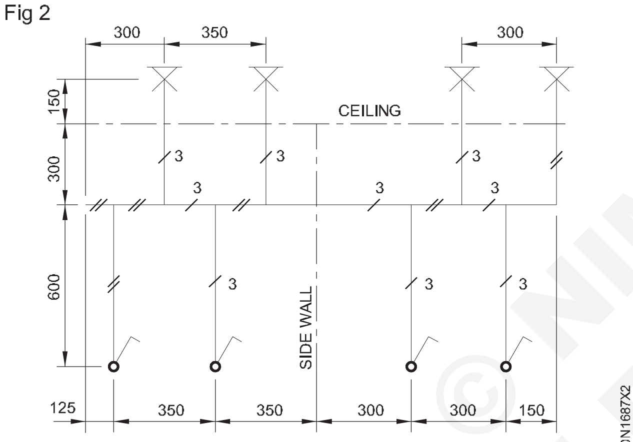
CIRCUIT DIAGRAM

2 Get the circuit approved by the instructor.

> **If it is incorrect, trace the circuit and correct it.**

3 Mark the layout on I.P.C. (Installation Practice Cubicle) as per the layout given in Fig 2

Fig 2



LAYOUT DIAGRAM

4 Select the required conduit fittings as per the layout.

5 Measure the length of the conduit pipes required for each run as per the layout.

> **Take into consideration the length of accessories to be used in various places along with the conduit threads while taking conduit measurements.**

6 Cut the length of the conduit as per markings and remove the burrs.

> **While marking on the conduit pipe for cutting, consider the economical way to utilize the pipes without much wastage in the lengths.**

7 Cut threads in the pipes and remove the burrs.

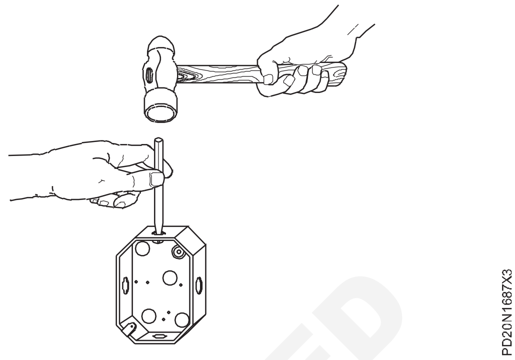
8 Prepare the T.W. spacers with through holes for fixing on the I.P.C. and pilot holes to fix the saddles.

9 Fix the T.W. spacers as per the layout.

10 Fix the conduit pipe and conduit accessories as per the layout by means of saddles.

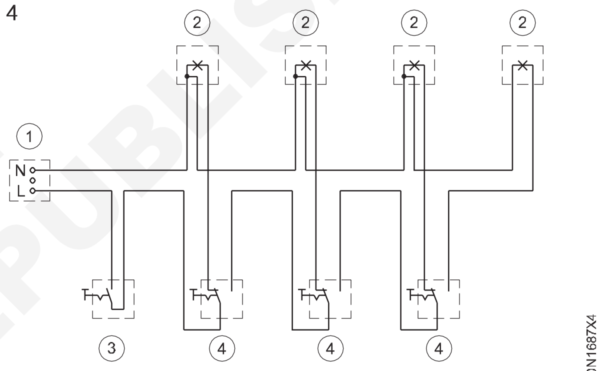
> **Knock out the holes in the square/hexagonal metal boxes for conduit pipe terminations as shown in Fig 3.**

Fig 3



11 Measure and cut the cables as per the cable route given in the wiring diagram. (Fig 4)

Fig 4



WIRING DIAGRAM

> **Make an allowance in cable lengths for terminations.**

12 Provide bushes in the conduit ends.

13 Insert the given fish wire in the pipe run for drawing cables.

> **Drawing of cables should be done stage by stage, taking each run one by one, and consolidating the number of cables in each run.**

14 Skin the cables and mark each cable legibly at both ends.

15 Group the cables as per cable route and cable runs and fasten them to the fish wire as shown in Fig 5.

> **Check the continuity of cables before fastening the cables to the fish wire.**

16 Pull the cables by means of the fish wire, and, at the same time push the cables from the other end as shown in Fig 6.

Fig 5

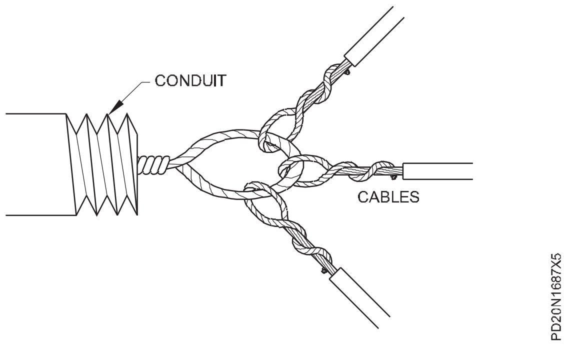
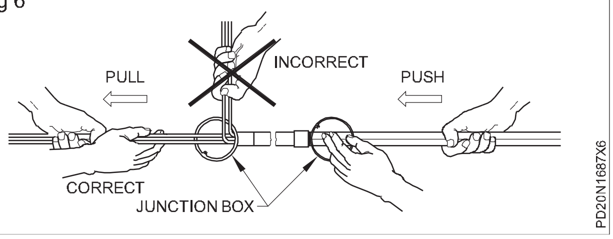


Fig 6



You may require a helper while drawing cables. There should not be any kink or twist in the cables while drawing the cables through the conduit pipe. For long conduit runs, it is better, the drawing of the cables is done in stages, firstly from one end to the inspection type accessory, and then from the inspection type accessory to the end of the conduit, and so on.

17 Prepare top covers of the square metal boxes for fixing the accessories by drilling through holes for cable entry and accessory fixing.

18 Fix the ceiling roses on the one-way junction boxes.

Ceiling roses can be fitted directly on the one-way junction boxes, using the machine screws provided for fixing the cover.

19 Prepare the cable ends and terminate them in the accessories as per Fig 1 and 4, and cable markings done as per step 14.

20 Fix the accessories with machine screws.

21 Close the top covers of the metal boxes.

22 Close the inspection windows of the inspection type accessories.

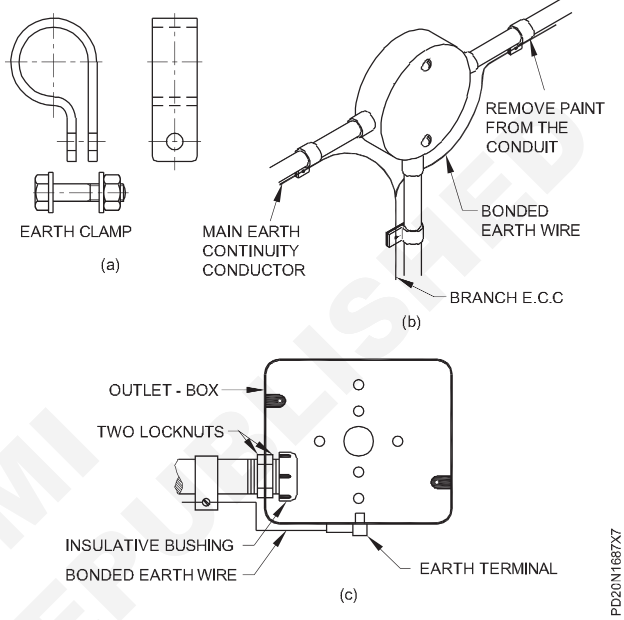
23 Run the given earth wire along the conduit pipe by means of earth clamps and terminate at the junction boxes and metal boxes. (Fig 7)

It is necessary to follow the looping system to avoid joints in the earth wire runs.

As an alternate to the looping method, the bonding system could be used. Wherever accessories are used, bonding by earth clamps and earth wire as shown in Fig 7 is recommended.

Remove the paint on the surface of the conduit, the copper wire and the clamps before fixing.

Fig 7



24 Prepare the pendent-holders and connect the cables to the ceiling roses.

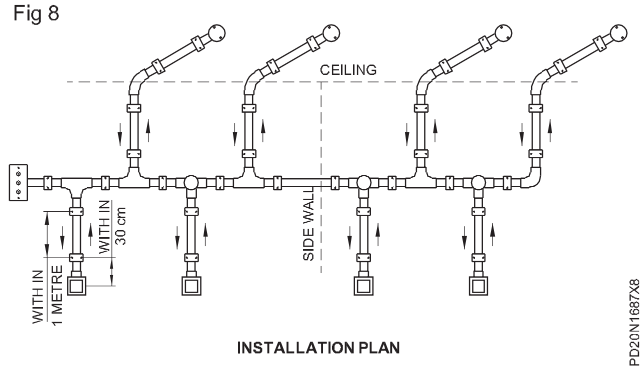
25 Fix the bulbs.

A completed installation looks as shown in Fig 8.

26 Get the wiring checked by the instructor.

27 Connect the supply and test the wiring.

Fig 8



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Prepare test boards/extension boards and mount accessories like lamp holders, various switches, sockets, fuses, relays, MCB, ELCB, MCCB etc.

Objectives: At the end of this exercise you shall be able to
- **identify and use Power accessories like double-pole switch and indicating neon lamp**
- **select the correct size of board to mount specified accessories**
- **position the accessories and mount them on the T.W. board**
- **wire up and test the test board. / Extension Board.**

Requirements

Tools/Instruments

- Combination pliers 200 mm - 1 No.
- Screwdriver 200 mm with 5 mm blade - 1 No.
- Screwdriver 150 mm with 3 mm blade - 1 No.
- Poker 200 mm - 1 No.
- Firmer chisel 12 mm - 1 No.
- Try square 150 mm - 1 No.
- Tenon-saw 300 mm - 1 No.
- Gimlet 5 mm dia. 200 mm - 1 No.
- Ball peen hammer 250 gms - 1 No.
- 4 mm drill bit - 1 No.
- Connector screwdriver 100 mm - 1 No.
- Hand drilling machine 6 mm capacity - 1 No.
- Mallet 75 mm dia. head with handle - 1 No.
- Steel Rule 30 cm - 1 No.
- Key hole saw 200 mm - 1 No.

Materials

- T.W. hinged box 375x250x80 mm - 1 No.
- B.C. batten lamp-holder 6A 250V - 2 Nos.
- Flush mounting 250V 6A 3-pin socket - 3 Nos.
- Flush mounting 250V 6A S.P.T. switch 250V, 6A - 2 Nos.
- PVC copper cable 3/20 - 2 m
- 14 SWG G.I. wire - 1 m
- 12 mm No.5 wood screws - as reqd.
- 20 mm No.6 wood screws - as reqd.
- 25 mm No.6 wood screws - as reqd.
- Neon lamp flush-mounting 250V with holder 6A - 1 No.
- BC bulb 60W, 250V - 1 No.
- Kit-kat fuse-carrier with base flush-type 16A 250V - 1 No.
- Insulated terminals non-detachable 4 mm plug entry - 3 Nos.
- Flush mounting type D.P. switch 250V 20A with neon indicator - 1 No.
- Twin twisted flexible wire 23 / 0.2 mm - 5 metre

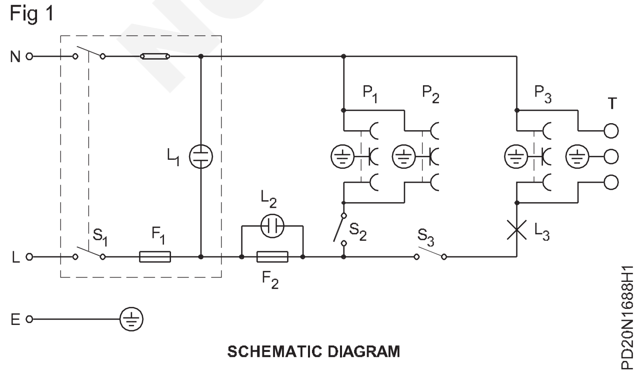
PROCEDURE

TASK 1 : **Prepare the test board / Extension board**

1 Identify the D.P. switch, its incoming/outgoing terminals and its operation. Identify a neon lamp and its connection.

2 Form the circuit as per the schematic diagram Fig 1, using a flexible wire for the testing circuit.

Fig 1



3 Get the formed circuit checked by the instructor.

If incorrect, make necessary changes.

4 Effect supply and test the circuit.

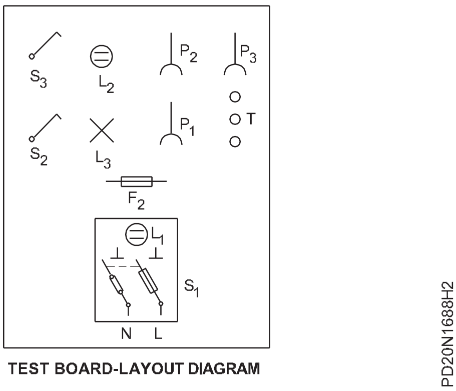
5 Place the accessories on a cardboard to suit the technical and aesthetic aspects and draw a layout. Select the size of the T.W. board accordingly.

6 Compare the layout drawn by you with the layout given in Fig 2 and discuss with your co-trainees about their merits and de-merits.

7 Mark the position of the double-pole switch and other accessories on the T.W. board as per the given layout (Fig 2) and the supplied drawing of the front panel. (Fig 3)

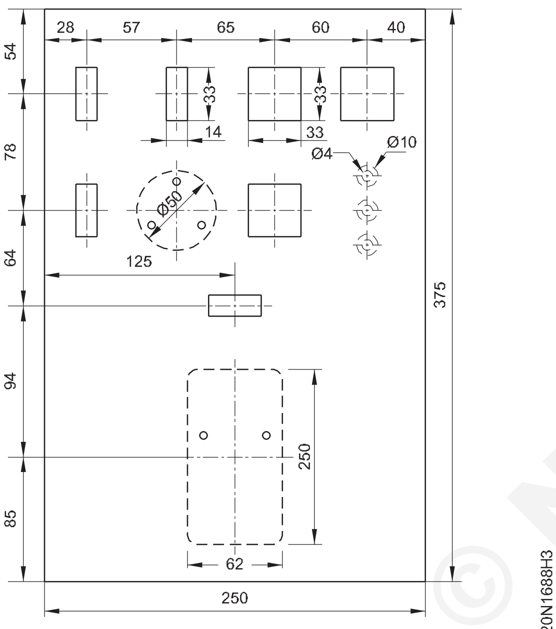
8 Cut profiles for fixing the accessories to the T.W. board and drill holes for cable entries, insulated terminals and fixing screws, and make pilot holes wherever necessary.

Fig 2



TEST BOARD-LAYOUT DIAGRAM

Fig 3



TEST BOARD FRONT PANEL DRAWING SHOWING THE PROFILE

9 Fix the Power accessories on the T.W. board.

10 Fix three numbers of insulated terminals.

11 Measure and cut cables for harnessing, according to the circuit diagram. (Fig 1)

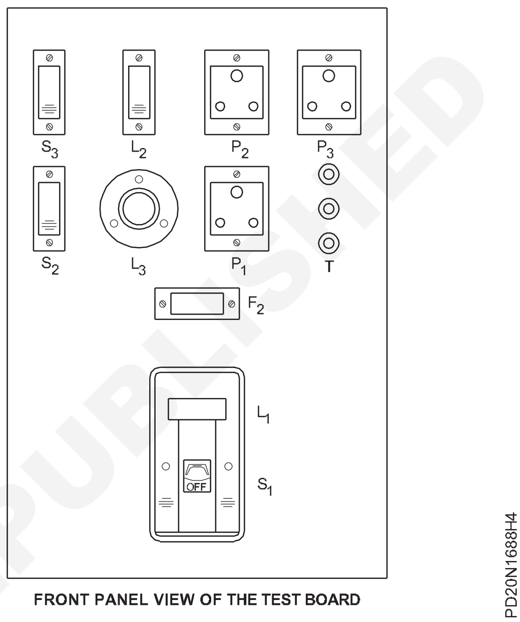
Use the B.I.S. recommended colour code for cable connections within the test board.

12 Route the connecting cables between accessories neatly, harness (strap - bunch) the cables.

13 Connect the accessories and the insulated terminals after identifying phase and neutral.

14 Connect the earth wire with earthing terminals of socket outlets, one of insulated terminals and the double pole switch. A completed test board will look as shown in Fig 4.

Fig 4



FRONT PANEL VIEW OF THE TEST BOARD

15 Provide bulbs in the lamp-holders.

16 Get the approval from your instructor and test the test board.

— — — — — —

Draw layouts and practice in PVC casing - capping, conduit wiring with minimum to more number of points of minimum 15 metre length

Objectives: At the end of this exercise you shall be able to
- **mark the layout on the work station/location**
- **prepare PVC channel as per the marked layout**
- **fix the PVC channel and other PVC accessories**
- **run the cable as per the circuit diagram**
- **fix the top cover on the casing**
- **prepare & fix the PVC boxes**
- **mount the switches, fan regulator, socket on the switch board**
- **connect the end terminals to load as per the circuit diagram & test it.**

Requirements

Tools and Instruments

- Electrician tool kit - 1 No.
- Hacksaw frame with blade - 1 No.
- Rawl jumper No.14 - 1 No.
- Screw driver 100 mm - 1 No.
- Steel tape 5 m - 1 No.
- Steel Rule 300 mm - 1 No.
- Electric/Hand drilling machine (capacity 6 mm) - 1 No.
- Twist drill bit 5 mm - 1 No.

Material required

- PVC casing and capping 25 mm x 10 mm - 20 mtrs
- PVC round block - 90 mm x 40 mm - 3 Nos.
- T.W. box 250 mm x 100 mm with Sunmica cover - 1 No.
- Terminal plate 16 Amps - 3 way - 1 No.
- Single pole one way switch-6A, 230V Flush type - 4 Nos.
- Electronic fan regulator - socket type - 1 No.
- 3 Pin socket - 6A 250V Flush type - 1 No.
- Batten lamp holder - 6A, 250V - 2 Nos.
- Ceilling rose 6A, 250V - 1 No.
- PVC insulated aluminium cable 1.5 sq. mm - 100 mtr.
- Wood Screw No. 6 X12 mm - 20 Nos.
- Wood Screw No.6 X 20 mm - 7 Nos.
- PVC Casing and capping Elbow -25 mm - 1 No.
- PVC casing and capping Tee (3 way) - 2 Nos.
- PVC Casing and capping internal coupler - 3 Nos.
- Colour chalk / pencil - 1 No.
- PVC insulation tape roll 20 mm - 1 Roll

PROCEDURE

1 Analyze the layout diagram Fig 1 showing the location of fittings, accessories and their distances.

2 Draw the wiring diagram for the given circuit as per layout plan. Check the correctness of the wiring diagram with the help of Fig 1 (supplied by the instructor).

3 List out the materials required for this wiring along with complete specifications and quantity required for this wiring .

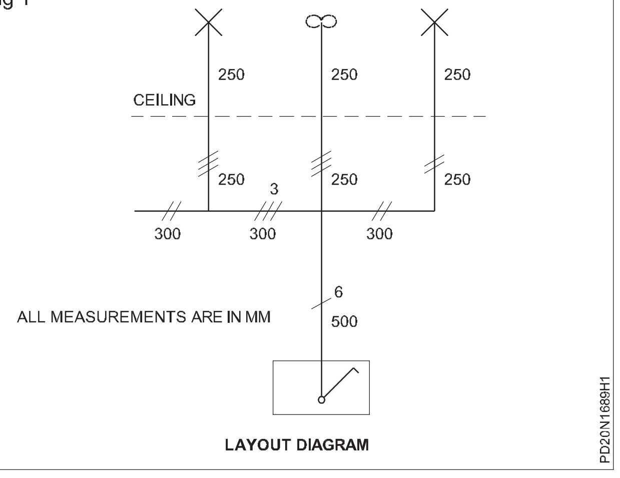
4 Check your material list with that of supplied list.

> **Hand over the list to the instructor for checking and get the approval.**

5 Collect the materials as per the list.

6 Mark the layout as per the work station/location. Cut and prepare the casing as per the installation plan diagram.

Fig 1



7 Drill holes in the PVC channel for fixing with a gap of 60 cm using drilling machine.

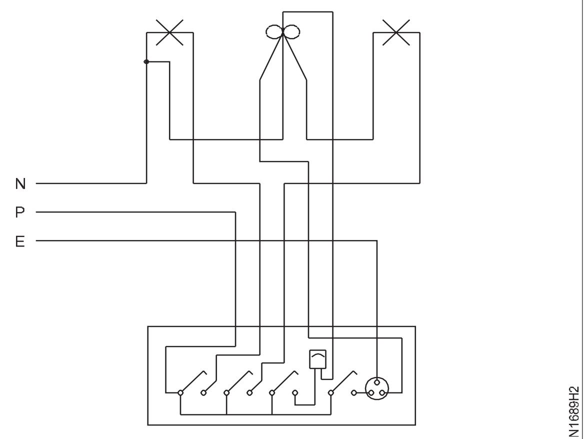
8 Place the PVC channel in the route mark coinciding with the jumper holes for fixing.

9 Prepare the joints on PVC channel (refer layout).

10 Fix the PVC channel on the work station as per the layout.

11 Run the cable into the PVC channel as per wiring diagrams (Fig 2)

Fig 2



WIRING DIAGRAM

12 Fix the cover on the channel.

13 Mark and cut the PVC boxes for the channel entries.

14 Drill holes for cable entry and take out cables as per installation plan.

15 Terminate the cable in accessories and mount the switches, regulator & socket over the switch box.

16 Test the circuit for insulation resistance, continuity test & polarity.

Only after obtaining satisfactory results of the above test, circuit to be energised.

17 Connect the circuit with supply and test it.

18 Repeat the wiring steps using PVC conduit pipe for a 15 meter length.

— — — — — —

Wire up PVC Conduit wiring to control one lamp from two different places

Objectives: At the end of this exercise you shall be able to
- **form the circuit using two-way switches to control one lamp from two different places**
- **cut the profiles in a wooden board according to marking for flush-type accessories**
- **wire up a circuit in PVC conduit pipe to control one lamp from two different places.**

Requirements

Tools/Instruments

- Cross Peen hammer 250 gms - 1 No.
- Insulated screwdriver 200 mm width 5 mm blade - 1 No.
- Insulated screwdriver 150 mm width 5 mm blade - 1 No.
- Electrician's knife (100 mm) - 1 No.
- Connector screwdriver 100 mm - 1 No.
- Mallet 5 cm dia. -500 gram - 1 No.
- Gimlet 5 mm dia. 200 mm long - 1 No.
- Hand drilling machine 6 mm capacity - 1 No.
- Drill bit 3 mm to 5 mm - 1 each
- Try square 150 mm - 1 No.
- Bradawl 150 mm - 1 No.
- Insulated combination pliers 200 mm - 1 No.
- Hacksaw frame with blade (24 TPI) - 1 No.
- Steel rule (300 mm) - 1 No.

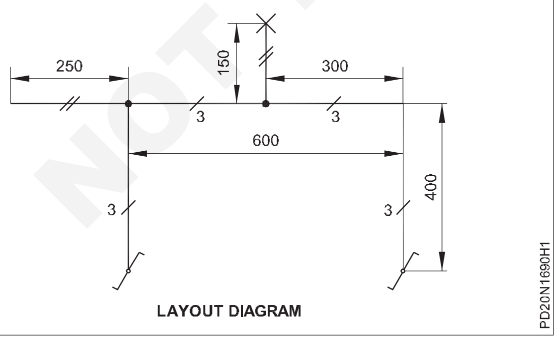
Materials

- PVC conduit pipe -19 mm dia. - 2 mtrs
- PVC terminal box - 1 No.
- Wood screws No.6x12 mm - 3 Nos.
- Wood screws No.6x20 mm - 4 Nos.
- PVC--Insulated aluminium cable 1.5 sq mm. 250V grade - 6 m
- Flush mounting two-way switch 6A, 250V - 2 Nos.
- Batten lamp-holder, 6A, 250V - 1 No.
- Terminal plate 3-way - 1 No.
- Bulb 40W, 250V, BC type - 1 No.
- PVC round block (90mm x 40 mm) - 1 No.
- PVC box 100 mm x 100 mm - 2 No.
- PVC 'Tee' 19 mm - 2 Nos.
- Marking Pen/Pencil/Chalk - as reqd.
- Marking thread - as reqd.
- PVC Insulation tape - 1 Roll
- Self tapping screw (20 mm) - as reqd.
- PVC bend 19mm - 2 mtrs

PROCEDURE

1 Estimate the tools and materials required for the job according to the layout (Fig 1) and the wiring diagram. (Fig 3) Compare the list with the given list. Discuss with your co-trainees/instructor about the variations between the two lists.

Fig 1



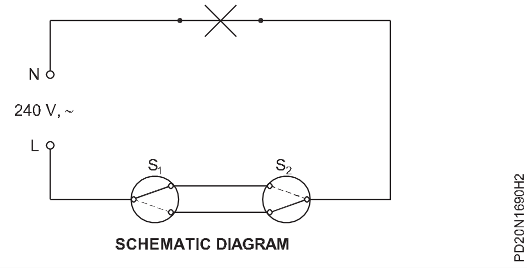
2 Collect materials as per the list.

3 Identify and confirm the switches received are two-way switches only.

4 Identify the terminal points, cable entry holes and fixing holes of the switches and batten lamp-holders.

5 Form the circuit as per the schematic diagram shown in Fig 2.

Fig 2



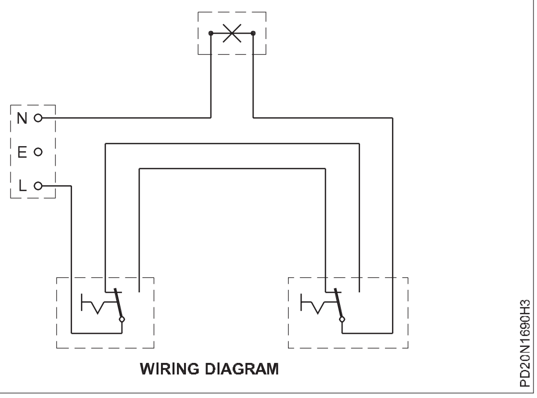
Get the approval of the instructor. If necessary, make alterations in the connections.

6 Connect the supply, check the function of the circuit and note the results in Table 1.

TABLE 1

S_1,S_2 position up	____________
S_1,S_2 position down	____________
S_1 up and S_2 down	____________
S_1 down and S_2 up	____________

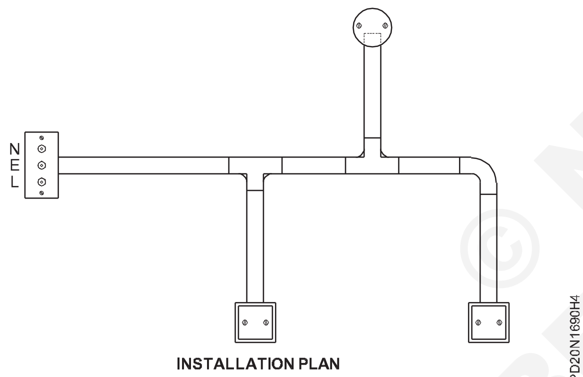
Fig 3



WIRING DIAGRAM

7 Mark the layout points on the building as per the installation plan (Fig 4)

Fig 4



INSTALLATION PLAN

8 Cut the required length of PVC pipes as per the layout marking.

Take into consideration the length of bends, tees and corners in appropriate places to reduce the measured length of the P V C conduits.

9 Mark the posistion of the saddles on the building and fix them loosely on one side only.

Observe the N.E. Code for the distance between saddles. In the case of brick/concrete walls, the wooden plugs (gutties) are to be fixed flush with the walls, cemented and cured.

10 Fix the PVC pipe and accessories in the saddle and tighten the saddle screws. Cut the cables according to the wiring diagram (Fig 2)

Keep an extra 200 to 300 mm for termination

11 Insert the cables in the pipes and fittings and push / draw the cables to the other end of the pipes according to the wiring diagram (Fig 3)

For longer lengths of PVC conduit runs, use fish wire/curtain spring to pull the cables through the conduits.

12 Mark the entry profile of the conduit in the round block and boxes. Based on the conduit entry position, position the accessories on the round block, mark the through holes for cable entry, and the pilot holes for fixing the accessories.

13 Prepare the conduit entry profile, drill/make through and pilot holes in the round block and boxes.

14 Insert the cables through the cable entry holes of the round blocks and boxes and fix the round block and boxes on the building.

15 C onnect the cable ends to the accessories according to the wiring diagram and fix the accessories on round blocks and boxes.

The completed installation should look as per the installation plan shown in Fig 4

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

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Wire up PVC conduit wiring to control one lamp from 3 different places

Objectives: At the end of this exercise you shall be able to
- **verify and draw the intermediate switch connections in alternate positions of the knob**
- **draw a schematic diagram to show one lamp being controlled from 3 different places based on the I.M. switch connections**
- **form the given circuit with the intermediate switch**
- **cut and lay the PVC pipes as per dimensions with the required number of bends, elbows and different types of junction boxes in the ceiling and the wall**
- **draw the cables through pipe according to the wiring diagram**
- **fix the accessories on boards and terminate the cables in accessories**
- **test the circuit.**

Requirements

Tools/Instruments

- Hacksaw frame 300 mm with 24 TPI blade - 1 No.
- Steel tape roll 5 Meter - 1 No.
- Insulated Screwdriver 250 mm with 4mm blade width - 1 No.
- Insulated Screwdriver 150 mm with 3 mm blade width - 1 No.
- Insulated Connector screw driver 100 mm with 3 mm blade width - 1 No.
- Plumb bob with thread - 1 No.
- Try square 250 mm - 1 No.
- Ball peen hammer 250 grams - 1 No.
- Poker 4 mm dia. 200 mm - 1 No.
- Gimlet 4 mm dia. 200 mm - 1 No.
- Electrician's D.B knife 100 mm - 1 No.
- Cutting pliers, insulated 200 mm - 1 No.
- Hand drilling machine, 6 mm capacity - 1 No.
- S.S. drill bit 3mm and 4 mm - 1 each
- Side cutting pliers 150 mm - 1 No.
- Firmer chisel 12 mm - 1 No.

Materials

- PVC pipe 20 mm dia. - 4 mtrs
- PVC bend 20 mm dia. - 2 Nos.
- PVC elbow 20 mm dia. - 1 No.
- PVC Tee 20 mm dia. - 3 Nos.
- Saddles 20 mm dia. heavy gauge - 10 Nos.
- Wood screws No.6 12 mm - 40 Nos.
- Wood screws No.6 18 mm - 8 Nos.
- PVC cable 1.5 sq.mm 250V grade - 15 m
- T.W. round blocks with box 90 x 40 mm - 4 Nos.
- Terminal plate 3-way - 1 No.
- S.P.switch 2-way Flush type 6A 250V - 2 Nos.
- Intermediate switch 6A 250V - 1 No.
- Bakelite batten-holder of B.C. type 6A 250V - 1 No.
- B.C. lamp 40W 250V - 1 No.

PROCEDURE

TASK 1 : **Ascertain the connections of an intermediate switch**

1 Collect the accessories and materials for the exercise.

2 Identify the mode of connections to the terminals with respect to the position of the knob and draw the connection diagram in your record book.

3 Keeping the above connections as the base, draw a schematic diagram to control one lamp from three different places, in your record book.

4 Show the connections to your instructor and get his approval.

— — — — — —

TASK 2 : **Form the circuit on the workbench/trainer board**

1 Form the circuit according to the approved diagram on the workbench/trainer board.

2 Show the circuit to the instructor and get his approval.

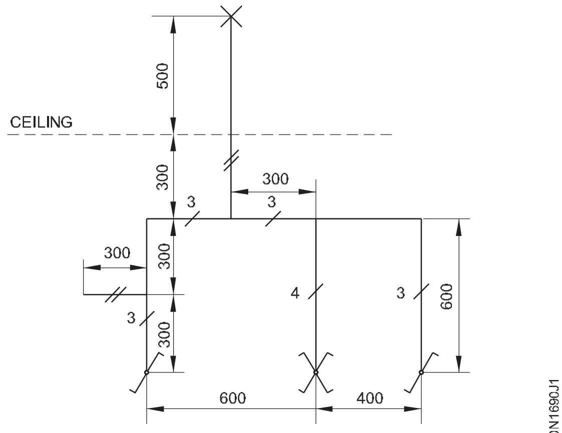
3 Operate the switches as given in Table and note down the results in Table.

Position of S_1 knob	Position of S_2 knob	Position of S_3 knob	Condition of lamp
↑	↑	↑	ON/OFF
↓	↑	↑	
↓	↓	↑	
↓	↓	↓	
↑	↓	↓	
↑	↑	↓	
↓	↑	↑	
↓	↑	↓	

TASK 3 : **Execute PVC conduit wiring**

1 Mark the layout on the installation practice cubicle as per the layout given in Fig 1.

Fig 1



LAYOUT DIAGRAM

2 Cut the required length of P V C pipes as per the layout marking.

> **Take into consideration the length of bends, tees and corners in appropriate places to reduce the measured length of the P V C conduits.**

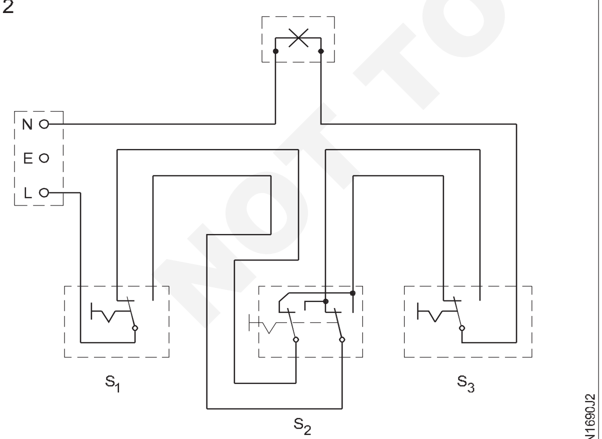
3 Mark the position of the saddles in the I.P.C. and fix them loosely on one side only.

> **Observe the N.E. Code for the distance between saddles. In the case of brick/concrete walls, the wooden plugs (gutties) are to be fixed flush with the walls, cemented and cured.**

4 Fix the PVC pipe and accessories in the saddle and tighten the saddle screws.

5 Cut the cables according to the wiring diagram.(Fig2)

Fig 2



WIRING DIAGRAM

> **Keep an extra 200 to 300mm for termination.**

6 Insert the cables in the pipes and fittings and push/ draw the cables to the other end of the pipes according to the wiring diagram. (Fig 2)

> **For longer lengths of P V C conduit runs, use fish wire/curtain spring to pull the cables through the conduits.**

7 Mark the entry profile of the conduit in the round block.

8 Based on the conduit entry position, position the accessories on the round block, mark the through holes for cable entry, and the pilot holes for fixing the accessories.

9 Prepare the conduit entry profile, drill/make through and pilot holes in the round block.

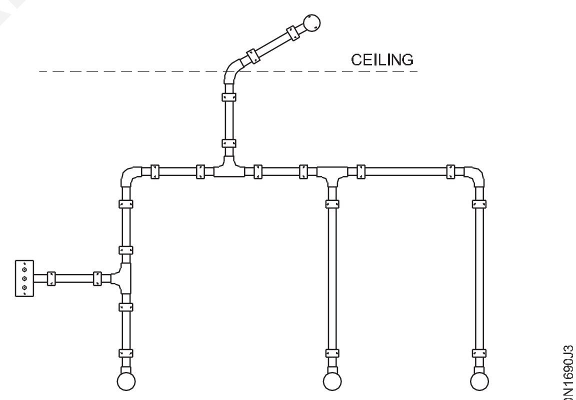
10 Insert the cables through the cable entry holes of the round blocks and fix the round block on boards.

11 Connect the cable ends to the accessories according to the wiring diagram and fix the accessories on the T.W. round blocks.

> **The completed installation should look as per the installation plan shown in Fig 3.**

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

Fig 3



INSTALLATION PLAN

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Wire up PVC Conduit wiring and practice control of sockets and lamps in different combinations using switching concepts

Objectives: At the end of this exercise you shall be able to
- **determine the size of the cable for power wiring**
- **cut non-metallic conduit pipes**
- **fix the accessories to the pipes according to the pipe size with the tight grip method**
- **fix conduit with the necessary clamps and spacers on surface installation in accordance with I.S. recommendations**
- **draw wires with non-metallic conduit pipes**
- **wire up the power circuits in P.V.C. conduit**
- **test the circuit.**

Requirements

Tools/Instruments

- Insulated combination pliers 200 mm - 1 No.
- Insulated screwdriver 200 mm width 4 mm blade - 1 No.
- Insulated side cutting pliers 150 mm - 1 No.
- Electrician's knife 100 mm - 1 No.
- Bradawl 150 mm - 1 No.
- Ball peen hammer 250 grams - 1 No.
- Hacksaw with 24 TPI blade - 1 No.
- Firmer chisel 6 mm x 200 mm - 1 No.
- File rasp half round 200 mm basted with handle. - 1 No.
- Flat file rasp 200 mm - 1 No.
- Neon tester 500V - 1 No.
- Drill bits 6mm, 3mm - 1 No. each
- Hand drilling machine 6mm capacity - 1 No.

Materials

- PVC pipe 20 mm dia. - 11 mts
- 3-way junction box 25 mm - 3 Nos.
- 20mm sadles - 19 Nos.
- TW Box 200 x 150 x 40mm - 4 Nos.
- PVC sheathed aluminium cable 4 sq mm. 250 V - 52 mts
- Copper wire 14 SWG - 13 mts
- SPT switch 16A 250V - 2 Nos.
- 3-pin socket 16A 250V - 2 Nos.
- 3-pin socket with switch 16A 250V - 2 Nos.
- T.W. wooden spacers - 20 Nos.
- Terminal plate 16 A 6-way - 1 No.
- Wood screws No. 6 x 25 mm - 20 Nos.
- Wood screws No. 6 x 12 mm - 40 Nos.
- PVC elbow 20 mm - 1 No.
- Surface-mounting type Kit-kat fuse 16A, 250V - 2 Nos.

PROCEDURE

TASK 1: **Determine the size of cable for power wiring**

1 Ascertain the load particulars of each socket, assuming each socket is feeding one room air-conditioner of 1.5 ton capacity.

2 Determine the number of circuits, the size of cables for the circuit and branch circuits.

Refer to I.E. regulations, NE code and I.S. recommendations regarding socket connections, loading and maximum number of sockets per circuit.

— — — — — —

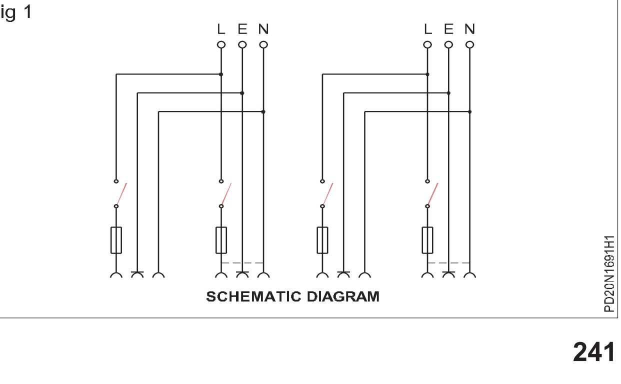
TASK 2: **Form the circuit and test it**

1 Form the circuit on the workbench/trainer board with the required accessories as per schematic diagram. (Fig 1)

2 Get the approval from your instructor.

3 Effect supply and test the circuit.

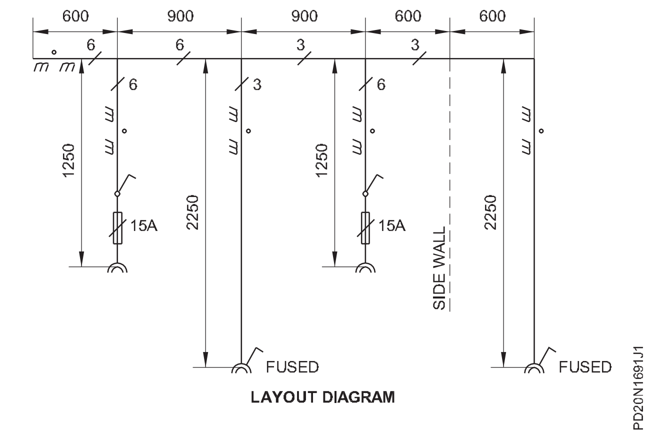
Fig 1



TASK 3 : **Wire the power circuit with P V C conduit**

1 Mark the layout on I.P.C. as per the layout diagram. (Fig 1)

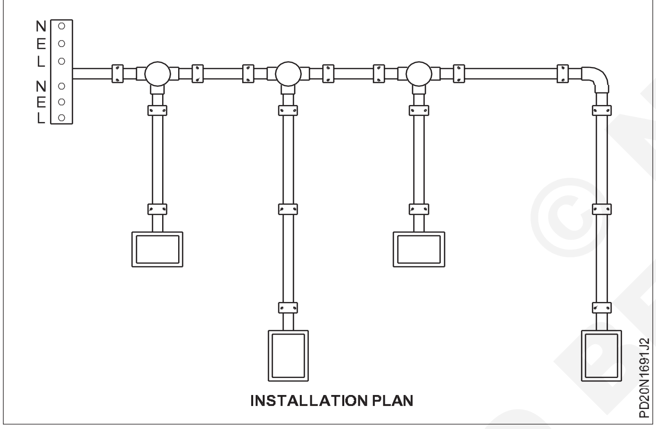
Fig 1



2 Cut the PVC conduit according to the layout by taking the length of the fittings into consideration.

3 Fix the wooden spacer on the layout marking as per installation plan shown in Fig 2, with the help of 25mm wood screws.

Fig 2

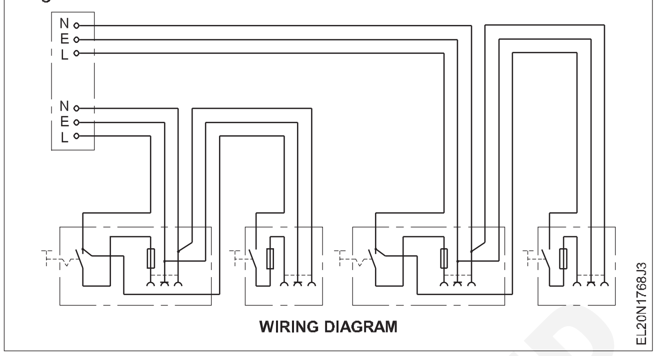


4 Fix the saddles on one side only on the wooden spacers.

5 Cut the cable length according to the route length taking into consideration the layout diagram, Fig 1 and the wiring diagram, Fig 3.

Keep an extra length of 200 to 300 mm in each cable run.

Fig 3



6 Fix the PVC conduits and accessories in the saddles and tighten the saddles by means of wood screws.

7 Insert the cables and the earth wire in the pipe and fittings, and push the wires to the other end of the pipe.

8 Prepare wooden boxes for conduit terminations, for fixing accessories and for taking cable terminations.

9 Fix the base of the boxes on the I.P.C. and fix the cover on the boxes after inserting the cables in the respective holes.

Expansion of the acronym I.P.C. is Installation Practice Cubicle/Wiring cabin/Wiring booth.

10 Connect the cable ends to the accessories and fix the accessories to the boxes with screws.

11 Connect the earth wire. (The completed installation should look as shown in Fig 3.)

The minimum size of earth wire, 14 SWG, tinned copper must be used.

12 Get the approval of the instructor.

13 Test the circuit.

— — — — — —

Wire up the consumer's main board with ICDP switch MCB & DB'S and switch and distribution fuse box

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

- **place the MCB switch and distribution fuse box on the board as per the given layout observing the standard code of practice**
- **mark on the board to drill holes for the purpose of drawing wires and for fixing the accessories**
- **drill suitable holes to fix accessories and for cable entry**
- **fix the accessories**
- **identify and earth the metal parts**
- **identify the cable to be connected for phase and neutral according to the colour of insulation**
- **select and confirm the size of the cables according to the capacity of the main switch and D.B.**

Requirements

Tools/Instruments

• Steel rule 300 mm	- 1 No.
• Insulated Side cutter 150 mm	- 1 No.
• Combination pliers 200 mm	- 1 No.
• Hand drilling machine 6 mm capacity with 3 mm,6 mm bits	- 1 Set
• Poker 200 mm	- 1 No.
• Insulated Screwdriver 200 mm with 4mm blade	- 1 No.
• Insulated Screwdriver 150 mm with 3mm blade	- 1 No.
• Connector screwdriver 100 mm	- 1 No.
• Neon tester 500V	- 1 No.
• Wooden mallet 7.5cm dia.500 g	- 1 No.
• Electrician's knife DB 100 mm	- 1 No.
• Tenon-saw 300 mm	- 1 No.
• Gimlet 200mm with 4 mm dia. stem	- 1 No.
• Firmer chisel 12 mm	- 1 No.
• Wood rasp file 200 mm flat	- 1 No.

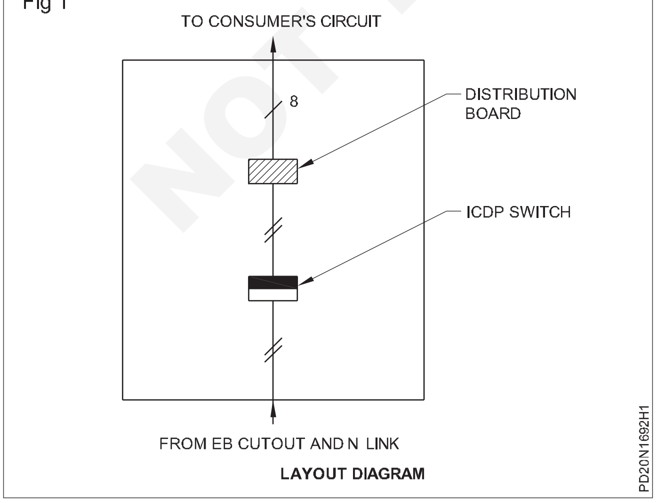
Material

• 2 pole MCB 16A	- 1 No.
• Distribution fuse box 4-way 16A 250V	- 1 No.
• Wood screws No. 25 x 6 mm	- 4 Nos.
• Wood screws No. 20 x 6 mm	- 4 Nos.
• Wood screws No. 15 x 6 mm	- 2 Nos.
• PVC aluminium cable 2.5 sq mm in red and black colour	- 1.5 m each.
• Tinned copper wire 14 SWG	- 3 m
• T.W. hinged box 300 x 250 x 80 mm	- 1 No.
• 3mm dia. 25 mm long full-threaded G.I bolt, nut and washer	- 10 Nos.
• PVC Cable clips 10 mm wide 2 mm thick	- 300 mm

PROCEDURE

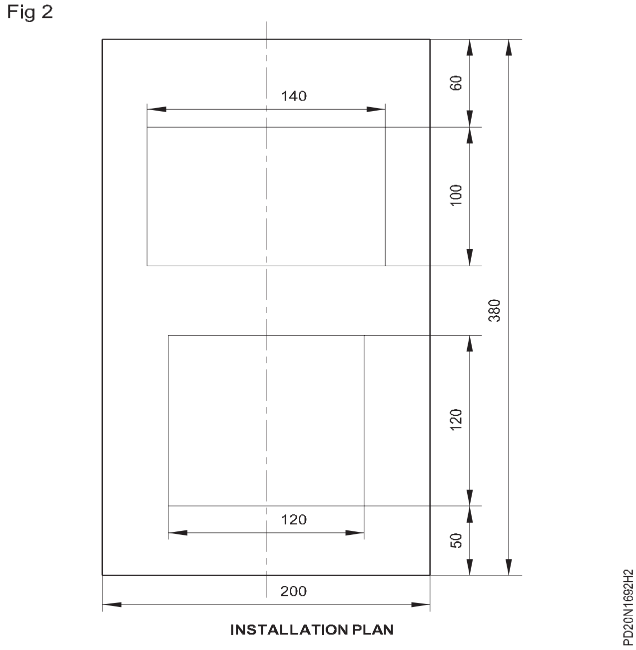
1 Mark the position of the given MCB and DB on the top surface of the T.W. board as shown in Figs 1 and 2.

Fig 1



2 Mark the position of through holes for cable runs and earth conductor.

Fig 2



3 Drill suitable holes (either pilot or through) in the T.W. board to fix MCB and DB.

4 Drill holes for cable entry.

5 Provide holes in the top and bottom of the base T.W. board for the supply and outgoing cables.

6 Fix MCB and DB using wood screws/other fasteners.

7 Select and confirm the size of the cables according to the ratings of the main switch and DB.

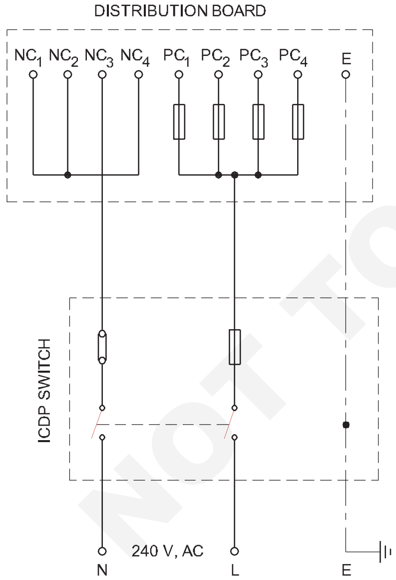
8 Connect the supply leads to the MCB through the T.W. board. Mark the end of the phase cable.

While connecting the incoming and outgoing cables to the MCB and D.B. they should pass through the holes in the top board and then through the holes provided in the top and bottom sides of the base board.

In both cases sufficient allowance of length should be given in the cables such that the hinged top board could be opened at an angle of 120° from the base board. Harnessing of the cables inside the board should be done with the P.V.C. cable clips, and the cables should pass in or out from the MCB and D.B. through the P.V.C. bushed holes.

9 Interconnect the MCB and DB as shown in Fig 4. Provide 4 pairs of outgoing cables from the D.B. for four branch circuits. Compare the wiring diagram (Fig 4) with the Circuit diagram (Fig 3).

Fig 3



CIRCUIT DIAGRAM

While using connecting cables observe the colour code. Phase:red, Neutral:black.

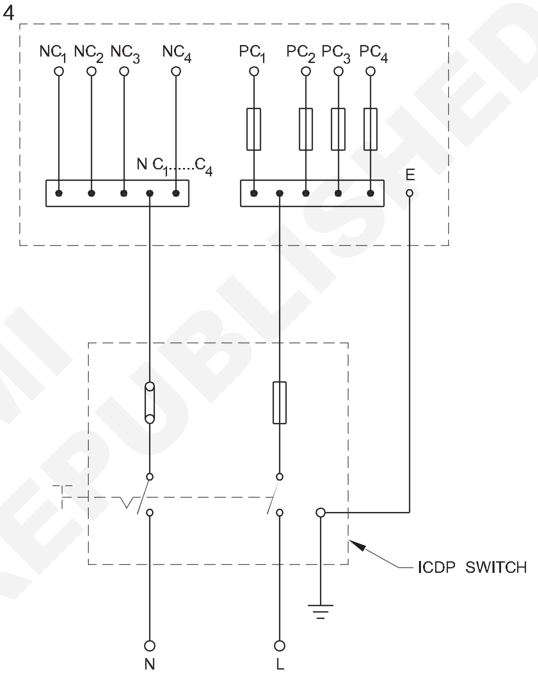
10 Locate the earth connecting points on the DB and drill suitable holes for the earthing leads in the T.W. board.

11 Connect the earth wire to the DB and then connect the E.C.C. to the meter board earth plate.

12 Fix the fuses in the DB and main switch according to the circuit/main loads.

Individual circuit loads have to be indicated in amperes by fixing labels on the D.B

Fig 4



WIRING DIAGRAM

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Prepare and mount the energy meter board

Objectives: At the end of this exercise you shall be able to
- **make holes on the wall according to requirement with a rawl jumper and hammer**
- **fill the holes with filling material**
- **make recess holes for fixing wooden gutties**
- **fix wooden gutties (wooden plugs) in the wall**
- **use a pipe jumper for making holes through the masonry wall**
- **mount the given energy meter, iron-clad cut out and the neutral links on the meter board**
- **connect the meter, iron-clad cut out and the neutral link as per regulations**
- **mount the meter board on the wall.**

Requirements

Tools/Instruments

- Insulated Steel rule 300mm - 1 No.
- Insulated Side cutter 150mm - 1 No.
- Combination pliers 200mm - 1 No.
- Hand drilling machine with 3mm and 6mm drills - 1 No.
- Insulated Screwdriver 200mm with 4mm blade - 1 No.
- Insulated Connector screwdriver 100mm - 1 No.
- Poker 200mm long with 4mm dia. stem - 1 No.
- Electrician's knife DB 100 mm - 1 No.
- Firmer chisel 12mm wooden handle - 1 No.
- Rawl jumper No.8 with holder and bit - 1 No.
- Cold chisel 200mm long with 12mm edge - 1 No.
- Ball peen hammer 500 gm. - 1 No.
- Tenon-saw 250mm - 1 No.
- Mallet with 7.5cm dia. head 500 gm - 1 No.
- Neon tester 500 V - 1 No.
- Scriber 200mm with 3mm dia. stem - 1 No.
- Mason's trowel - 1 No.
- Tray for cement mortar - 1 No.

Equipment Machines

- Single phase energy meter 10/15A 250V

Materials

- PVC insulated copper cable 2.5 square mm - 3 m
- Tinned copper wire 14 SWG - 1 m
- Iron-clad cut out 16A - 1 No.
- Neutral link 16A - 1 No.
- T.W. board 250x250x40mm - 1 No.
- Porcelain spacers - 4 Nos.
- Teak wood gutties (wooden plugs) 40mm square x 60mm long x 30mm square - 4 Nos.
- Wood screws No.4 x 25 mm - 3 Nos.
- Cement - 1/2 kg.
- River sand - 2 kgs
- Rawl plug No.8 - 4 Nos
- Rawl plug Compound - 25 gms.
- Chalk piece (colour) - 1 No.
- G.I. pipe 20mm - 400 mm.
- Wood screws No. 50 x 8 mm - 4 Nos.

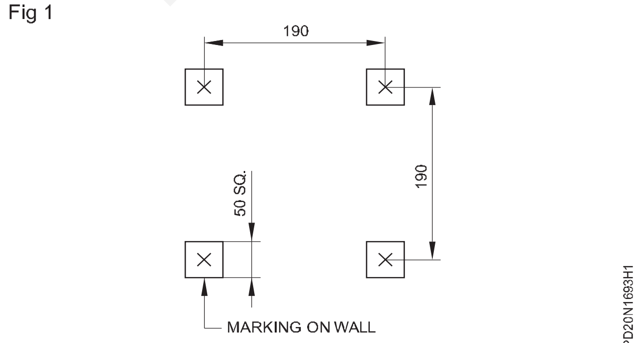
PROCEDURE

TASK 1 : **Prepare wall for mounting meter board**

If the wall is not too rigid, follow this method.

1 Mark 50mm square around the marking as shown in Fig 1.

Fig 1



2 Remove the plaster and the brick at the marked surfaces to a depth of 70 mm from the wall surface with the help of a cold chisel and hammer.

3 Prepare cement and sand mortar in the ratio of 1:4.

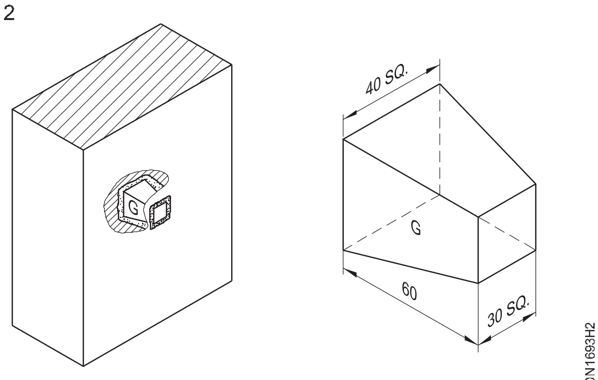
Let the mortar be in a semi-solid condition.

4 Sprinkle water in all the pits.

5 Insert a small quantity of cement mortar inside the pit with the help of a mason's trowel.

6 Insert the wooden gutties inside the hole pit such that the broad portion is inside and the narrow portion is outside and is just flush with the surface of the wall. (Fig 2)

Fig 2



7 Apply the cement on all sides of the gutty such that the gutty remains in the centre of the square hole.

8 Smoothen the surface of the wall with a mason's trowel.

> **Allow the cement to dry for 4 hours and sprinkle water on the cement every one hour so that the cement settles. The gutties become rigid after approximately 24 hours. Then only the boards could be fixed on to the gutties.**
>
> **Now the wall is ready for fixing the T.W. board.**

9 Fix the T.W. board with the help of 45mm long wood screws.

> **Trainees are required to identify the relationship between the stem thickness of 45mm long wood screws and the respective designation numbers.**

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TASK 2: **Preparation of wall for drawing the service connection**

> **Sometimes the service connection wires need to be taken through the wall using a G.I. pipe. There is then the necessity of making a hole through the wall with the help of a pipe jumper. The method to do it is as explained below. The diameter of the pipe jumper depends on the diameter of the service connection pipe and the length of the pipe jumper depends upon the wall thickness.**

1 Take a 20mm dia. G.I. pipe of 400mm length.

2 Make serrations by cutting at one end of the pipe as shown in Fig 1 using a hacksaw.

> **This type of pipe jumper is also called crown jumper, due to its very look.**

3 Inspect the wall and mark a place on the wall considering the nearest point to the electric service pole.

> **The marking should be close to the meter terminals. It should not be on the R.C. . beam or granite stone embedded in the wall.**
>
> **In the case of an old building check whether any concealed wiring is running through the wall at the place of marking. In such cases the marking should be done at a different place. However, in buildings, where wiring exists, switch `off' the mains, remove the fuse-carrier and keep it under your custody.**

4 Keep the pipe jumper on the mark and hammer it lightly.

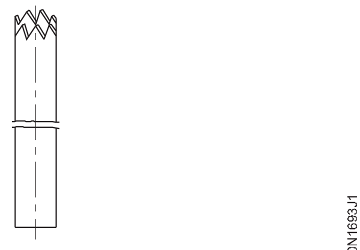
5 Rotate the pipe jumper for every stroke of hammer.

> **This process removes the broken masonory and allows free movement of the pipe jumper.**

> **Take care to keep the pipe jumper perpendicular to the wall surface.**

6 Slow down the hammer strokes when the pipe jumper reaches near to the other end of the wall.

Fig 1



> **Hitting hard on the hammer at the end of a hole will make a larger sized plaster to fall out at the other end of wall.**

7 Clear the hole.

8 Insert the G.I. pipe for the service cable in the hole and plaster around the pipe with cement.

Wiring up a meter board

1 Confirm the capacity of the energy meter.

2 Select and confirm the size of the cable as per the meter rating.

> **Follow the standard colour code for phase and neutral.**

3 Position the meter, I.C. cut-out and earth-plate as per layout (Fig 4) and mark their position as per layout on the T.W. board.

4 Mark the cable entry positions and mounting screw positions.

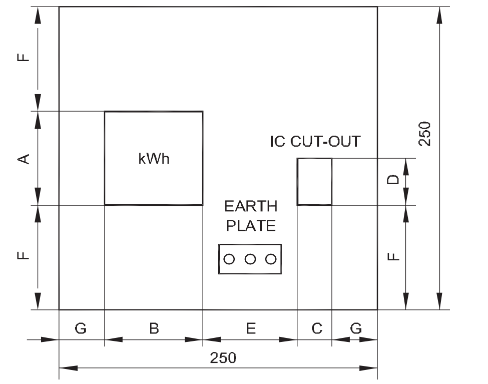
5 Select the drill bit according to the cable size.

6 Drill through holes in the T.W. board for cable entry and pilot holes for fixing the meter, I.C. cut out and the earth plate.

7 Fix the meter, I.C. cut out and the earth plate.

8 Determine the length of the cables according to the layout and cut them with reference to Figs 2 and 3.

Fig 2



A-B OUTSIDE MEASUREMENTS OF ENERGY METER

$F = \frac{250-A}{2}$

C-D OUTSIDE MEASUREMENTS OF METAL CLAD (IRON CLAD) CUT - OUT

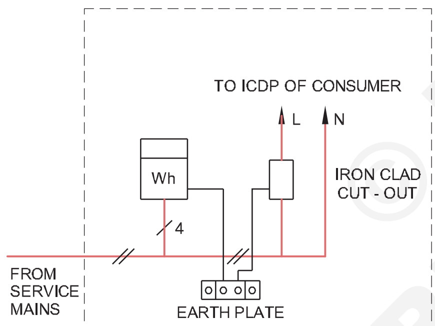
E = 50mm

$G = \frac{250-B-C-E}{2}$

INSTALLATION PLAN

PD20N1693J2

Fig 3



ENERGY METER SINGLE PHASE (6-16A-240V)

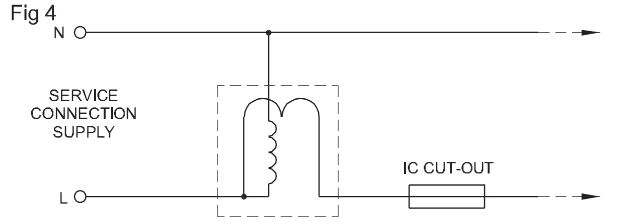
LAYOUT DIAGRAM

PD20N1693J3

9 Connect the supply leads and the outgoing phase wire to the I.C. cut–out. Pass the neutral directly as per the wiring diagram. (Figs 4 and 6)

10 Earth the casing of the meter and the I.C. cut out body to the earth plate.

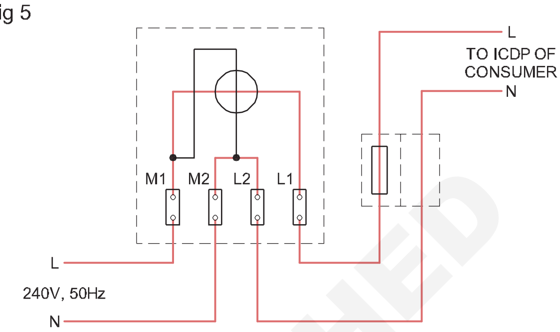
Fig 4



CIRCUIT DIAGRAM

PD20N1693J4

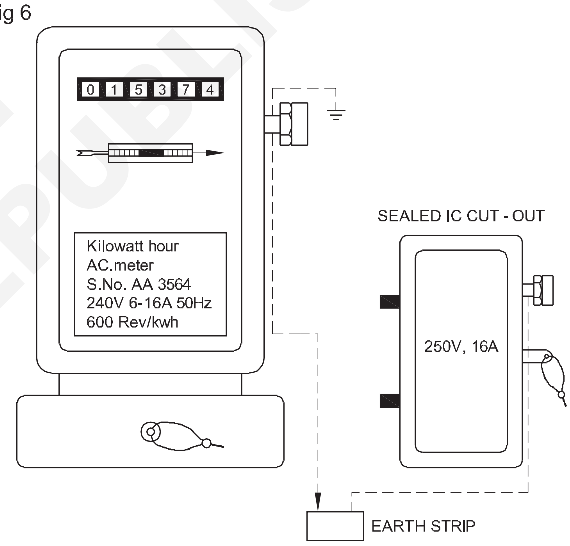
Fig 5



WIRING DIAGRAM

PD20N1693J5

Fig 6



METER BOARD WITH MOUNTED ACCESSORIES

PD20N1693J6

11 Keeping the meter board in a vertical position, test the circuit after getting the approval of the instructor.

12 Mount the meter board on the previously prepared wall with the help of 45mm wood screws.

The completed work should look as shown in Fig 6.

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Estimate the cost/bill of material for wiring of hostel/residential building and workshop

Objectives: At the end of this exercise you shall be able to
- **calculate the total load in sub-circuit**
- **select the size of cable in the sub circuits**
- **estimate the quantity of materials**
- **estimate the cost of wiring.**

Requirements

Tools/Instruments

- Measuring tape 0-25 m - 1 No.
- SWG - 1 No.
- Steel rule 300 mm - 1 No.
- Micrometer 0-25 mm - 1 No.

Materials

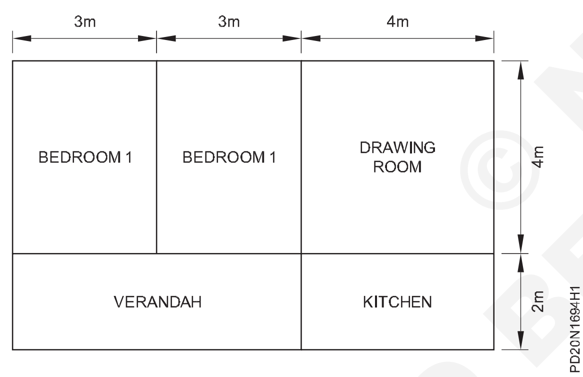
- A-4 Paper - as reqd.
- Pencil/HP - 1 No.
- Eraser - 1 No.

PROCEDURE

TASK 1: **Estimate the cost/bill of material for wiring of hostel / residential building**

1 Obtain the building plan as shown in Fig.1

Fig 1



2 Collect the requirements of lights, fans, lighting and power sockets etc.

3 Mark the location of switch board, Power loads and DB in the plan.

The type and quantity of loads depend upon the customer's requirement. Hence, complete data are to be collected before starting estimation. A sample requirements is given for the trainee's reference.

The wall thickness	- 40 cm
The height of roof from ground	- 3.5 m
Height of conduit run	- 3 m
Height of main board	- 2.5 m
Height of switch	- 1.5 m
Height of light brackets	- 3 m
Height of main board	- 3 m

The details of standard requirement of Power loads are given in Table 1.

Table 1

Location	Light (60 W)	Fan (80 W)	6A Plug Point (80 W)	16A Power Plug (1000 W)
Verandah	1	1	1	1
Kitchen	1	1	Nil	1
Bedroom	2 +2	1 + 1	1 + 1	Nil
Drawing Room	2	1	1	Nil

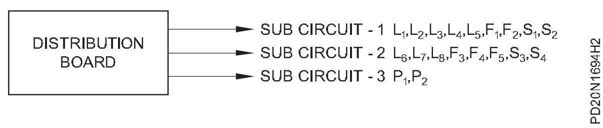
4 Calculate the number of sub circuits required for the above load as per IE rules.

Indian electricity rule states that there should be separate sub circuits for light/fan loads and power loads. Therefore 6A plug points (Sockets) are considered as light / fan load points as they are meant for connecting table fan /table lamp etc. 16A power plug are considered as power points as they are used for connecting heavy loads like heaters, kettles etc.

Total wattage of light points	= 8 x 60 = 480 W
Total wattage of fan points	= 5 x 80 = 400 W
Total wattage of (6A) sockets	= 4 x 80 = 320 W
Total 17 Nos	= 1200 W

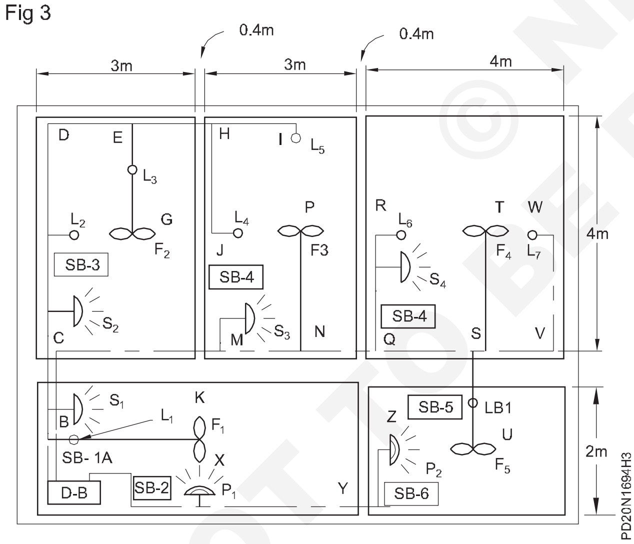
As there are 17 points, we need two sub - circuits. The division of outlets on each sub circuit is made more or less uniform, i.e., 8 & 9. Refer Fig 2

Fig 2



5 Draw the layout of conduit, switch board, loads and DB as shown in Fig 3.

Fig 3



6 Calculate the size of each cable as shown below.

i current through subcircuit - 1

$$= \frac{(5x60)+(2x80)+(2x80)}{230}$$

= 2.696 A

ii Current through subcircuit - 2

$$= \frac{(3x60)+(3x80)+(2x80)}{230}$$

= 2.522 A

iii Current through sub circuit 3 $= \frac{2000}{230} = 8.696A$

Total current = 2.696+2.522+8.696 = 13.9 A

16A, 250V flush type DP main switch is sufficient

7 Calculate the length of PVC conduit and cable as shown below.

19mm conduit can be used up to ABC length and for remaining length, 12mm conduit is sufficient.

Horizontal runs

19mm conduit for length ABC	= 2.4 m
19mm conduit for length at C (wall thickness)	= 0.4 m
Total	**= 2.8 m**
12 mm Conduit	
Length CDEHI (4 + 3 + 1.5)	= 8.5 m
Length EG	= 2.0 m
Length HJ	= 2.0 m
Length CMNQSVW (3+3+4+2)	= 12.0 m
Length MS3	= 1.5 m
Length NP	= 2.0 m
Length QR	= 2.0 m
Length ST	= 2.0 m
Length SV	= 1.0m
Length BK	= 3.0 m
Length AXYZ (6+1)	= 7.0 m
Length (wall thickness) at C, H, M, Q, S & Y (6x0.4)	= 2.4 m
Total	**= 45.4 m**

Vertical down drops (horizontal run to SB's) :

19 mm conduit	
Length B to roof	= 0.5 m
Length E to roof	= 0.5 m
Length N to roof	= 0.5 m
Length S to roof	= 0.5 m
Total	**= 2.0 M**

Total 19 mm conduit required	= 2.8+1.5+0.5 = 4.8 m
Wastage 10%	= 0.48 m
Total	= 5.28 m (Take 6m)
Total 12mm conduit required 45.4+10.50	= 55.9 M
Wastage 10%	= 5.59 m
Total	= 61.49 m (Take 62m)

Cable for (power) sub circuit -3 (1/1.8m Al)

= 3 x (6+1+1.5+1.5) = 30 m

Cable for subcircuit 1 & 2 (1.0 mm^2 copper)

= 3 x (6+62-10) = 174 m

Trainee shall select the cable size by refering the table given in related theory

8 Calculate the labour cost.

Meter board	= 2 Points
Distribution board	= 2 Points
Light / fan	= 17 Points
Power	= 2 Points
Total points	**= 23 Points**

Labour cost / point should be taken by referring the local rate list.

For example, take the labour cost is Rs.100/point

Then, total labour cost is 23 x 100 = Rs. 2300/-

9 Prepare a list of "material of schedule and cost" as shown in Table 2.

Table 2

Material of schedule and cost

Sl.No.	Material Specification	Rate Cost				Remarks
		Qty.	Rs. Ps.	Per	Rs. Ps.	Remarks
1	D.P Main switch 10A, 240V flush type	1 No	....	each	....	For M.B For power load
2	I.C cut out 16A, 240V	1 No	....	each	....	
3	Flush type fuse unit 16A	1 No	....	each	....	
4	Flush type fuse unit 6A	2 Nos	....	each	....	
5	PVC conduit 19 mm (heavy guage)	6 m	....	length	....	1 length = 3 m
6	PVC conduit 12 mm (heavy guage)	62 m	....	length	....	1 length = 3 m
7	1.0mm^2 multistrand copper, VIR cable	174 m	....	100m	....	
8	1/1.8 mm aluminium VIR cable	30 m	....	100m	....	
9	1/1.8m copper VIR cable	2 m	....	100 m	....	From M.B to D.B
10	Switches 6A, 240V one way flush type	17 Nos	....	each	....	
11	2-pin sockets 6A, 240V	4 Nos	....	each	....	
12	3 -pin sockets 16A, 240V with switch and neon	2 Nos	....	each	....	
13	Ceiling rose 2 - plate 6A 240V	5 Nos	....	each	....	
14	Lamp holders brass batten type	8 Nos	....	each	....	
15	PVC junction boxes 25 mm 4 - way	1 No	....	each	....	
	12 mm 3-way	7 Nos	....	each	....	
	12 mm 2-way	5 Nos	....	each	....	
16	PVC bends 12 mm	4 Nos	....	each	....	
17	PVC reducers (25 mm to 12 mm	1 No	....	each	....	
18	Saddles 25 mm	24Nos		Doz	....	
	12 mm	144No		144 Nos	....	
19	Wooden boards (a) 30 x 30 Cm	2 Nos	....	each	....	For M.B & D.B For S.D's
	(b) 18x10 Cm	7 Nos	....	each	....	
20	Round blocks	5 Nos	....	each	....	
21	Wooden gutties/plugs 9cm2 x 4 cm^2 x50 mm	3 doz		doz	......	For boards
22	Nails 25 mm	1 kg		kg		Per conduit
23	Wooden screw 60 mm	25 Nos		100		For boards
	Wooden screw 12 mm	25 Nos		100	....	Forholders
24	Copper wire (16SWG) for earth	1 Kg		kg	.....	
	(GI WIRE 14 SWG)	1 Kg		kg		
25	Earth set (Pipe, salt, coal)	1 set		...	......	
26	Cement	2 kg		kg		
27	Labour cost	2 kg			......	For 4 gutties
	Total				......	
	Contingency 10%				....	
	Grand Total					

The rate of each material shall be obtained from the price list of the branded items

— — — — — —

TASK 2 : **Estimate the cost / bill of materials for wiring of workshop**

1 Obtain the floor plan of the workshop.

2 Mark the positions of motors on the floor plan with the consultation of the customer.

A sample requirement is given below for trainee's reference

1 One 5HP, 415V 3 phase motor

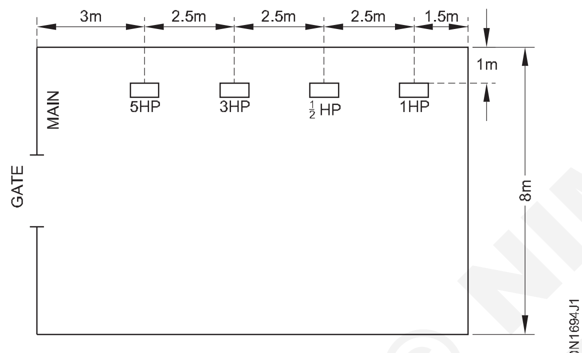
2 One 3HP, 415V 3 phase motor

3 One ½ HP, 240V 1 phase motor

4 One 1HP, 415V 3 phase motor

The motors are to be arranged as shown in Fig 1.

Fig 1



FLOOR PLAN

The main switch, motor switch and starters are assumed to be mounted at a height of 1.5m from the ground level.

Height of horizontal run from ground level will be 2.5 m

The cost of motors and starters are not to be included in the estimate.

3 Calculate the size of cable

Assuming the motor efficiency to be 85% power factor to be 0.8 and supply voltage is 400 V for all the motors.

FL current of 5HP motor $= \frac{5 \times 735.5}{\sqrt{3} \times 400 \times 0.85 \times 0.8} = 7.806$ A

FL current of 3HP motor $= \frac{3 \times 735.5}{\sqrt{3} \times 400 \times 0.85 \times 0.8} = 4.68$ A

FL current of ½ HP motor $= \frac{0.5 \times 735.5}{240 \times 0.85 \times 0.8} = 2.25$A

FL current of 1HP motor $= \frac{1 \times 735.5}{\sqrt{3} \times 400 \times 0.85 \times 0.8} = 1.56$ A

The main switch and the cable from meter to main switch should be capable of handling starting current of one motor of high rating plus full load current of the all other motors.

i.e, 15.6+4.68+2.25+1.56 = 24.9A

4 Prepare a table showing cable size of each motors to be installed as shown in Table 3.

Table 3

Sl. No.	Motor	FL current I_L (A)	Starting current $I_s = 2I_L$(A)	Recommended cable size
1	5HP motor	7.5	15.0	2.0mm^2 copper conductor cable (17A) or 2.5mm^2 aluminium conductor cable (16A)
2	3HP motor	4.68	9.36	2.0mm^2 copper conductor cable (17A)
3	1/2 HP motor	2.25	4.5	1.0mm^2 copper conductor cable (11A) minimum recommended cable
4	1HP motor	1.56	3.12	1.0mm^2 copper conductor cable (11A) minimum recommended cable

The type and gauge of cable shall be selected by referring the table given in related theory

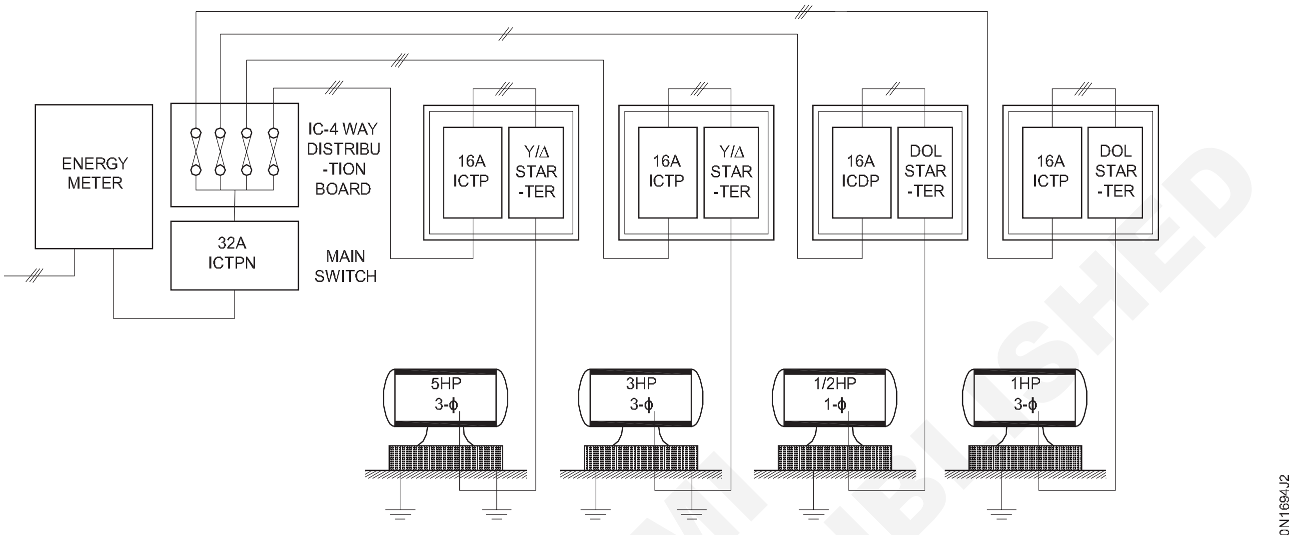
5 Select the suitable switches and distribution board

- 32A, 415V ICTP switch with fuses can be used as main switch.
- 16A, 415V, ICTP switches with fuses can be used for 5HP, 3HP, & 1HP motors.
- 16A, 240V, ICDP switch with fuses can be used for ½ HP motor.
- 415V, 4 way, 16A per way IC distribution board with neutral link can be used for power distribution.

6 Draw the single line diagram of power wirings as shown in Fig 2.

7 Calculate the size and length of conduit.

Fig 2



SINGLE LINE DIAGRAM OF POWER WIRING IN WORKSHOP

19mm heavy gauge conduit should be used for 3 cable runs and 25 mm heavy gauge conduits should be used for 6 cable runs.

- 19 mm heavy gauge conduit

Length from main board of 5HP motor starter

= 1+1+3+1 = 6.0m

Length from main board to 3HP motor starter

= 1+1+5.5+1 = 8.5m

Length from main board to ½ HP motor base

= 1+1+8+1+1.5+1.5 = 14.0m

Length from main board to 1HP motor base

= 1+1+10.5+1+1.5+1.5 = 16.5m

Total = 45.0 m

10% wastages = 4.5m

Total length = 49.5m, say 50.0m

- 25.4 mm heavy gauge conduit.

Length from meter to main switch = 0.75 m

Length from 5HP motor starter to 5HP motor base

(1.5 +1.5) 3.0 m

Length from 3HP motor starter to motor base = 3.0 m

Total = 6.75 m

10% wastage = 0.67 m

Total = 7.42m, Say 8.0m

- 25 mm flexible conduit for 5HP & 3 HP motor (0.75+0.75) = 1.5, Say 2.0m

8 Calcualte the length of cables.

2.0mm^2 copper conductor from main board to 5HP motor terminals = 3(1+1+3+1) + 6(1.5+1.5+0.75) = 40.5m

15% wastages & end connections = 7.2 m

Total = 55.2m , Say = 56.0m

1.0mm^2 copper conductor from main board to 1/2 HP motor terminals = 2(1+1+8+1+1.5+1.5+0.75) = 29.5 m

15% wastages & end connections = 7.76m

Total = 59.51m, Say 60.0m

9 Calculate the labour cost as per the local rate and rules for calcualting number of points.

10 Prepare "Schedule of material and cost as shown in Table 4.

Table 4

Material of schedule and cost

Sl.No.	Specification of material		Rate	Cost		Remarks
		Qty.	Rs. Ps.	Per	Rs. Ps	
1	32A, 415V- Iron -clad triple - pole (ICTPN) switch with fuses	1 No.	......	each	......	
2	16A, 415V, Iron- clad triple -pole switch with fuses	3 Nos.	......	each	......	
3	16A, 240V, Iron -clad double - pole switch with fuses	1 No.	......	each	......	
4	4-Way distribution box, 415V, 16A	1 No.	......	each	......	
5	Conduit heavy gauge .... 19 mm	50 m	......	m	......	
	25mm	8 m	......	m	......	
6	Flexible conduits .... 19 mm	2 m	......	m	......	
	25 m	2 m	......	m	......	
7	2.0 mm^2 copper conductor single core (17A)	47 m	......	100 m	......	
8	1.0mm^2 copper conductor single core (11A)	56 m	......	100 m	......	
9	1.0mm^2 copper conductor single core (11A)	34 m	......	100 m	......	
10	1.0mm^2 copper conductor single core (11A)	60 m	......	100 m	......	
11	Angle iron frame 50 x 30 m	5 Nos.	......	each	......	For M.B & D.B
12	Conduit bends 19mm	10 Nos.	......	each	......	
	25 mm	2 No.	......	each	......	
13	Saddles .... 19 mm	150 Nos.	......	100	......	
	25 mm	25 No.	......	100	......	
14	Conduit couples 19mm	6 No.	......	each	......	
	25 mm	1 No.	......	each	......	
15	Wooden gutties	120 No.	......	doz	......	
16	Earth wire, GI, 8 SWG	40 m	......	kg.	......	1kg. ≃ 10 m
17	Lugs for connecting leads to motors	17 No.	......	each	......	(6+6+2+3)
18	Earthing pipe perforated 25.4mm dia	2.5 m	......	m	......	Two earths
19	Coal	40 kg.	......	kg.	......	
20	Salt	40 kg.	......	kg.	......	
21	Funnel with wire mesh	1 No.	......	each	......	
22	Labour charges for earthing (Civil work)	2 Nos.	......	pit	......	
23	Caution plate	1 No.	......	each	......	
24	Nails 25.4 mm	2	......	kg.	......	
25	Shock treatment chart	1	......	each	......	
26	Labour cost	-	......	point	......	
	Total	......	......	......	......	
	Contingency 10%	......	......	......	......	
	Grand total	......	......	......	......	
	Say	......	......	......	......	

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Practice wiring of hostel and residential building as per IE rules

Objectives: At the end of this exercise you shall be able to
- **read and interpret the circuit diagram of a bank/ hostel/ jail**
- **mark the layout of the wiring scheme**
- **prepare and install a conduit frame as per layout**
- **draw the cables through the conduit**
- **connect the accessories as per circuit**
- **test the circuits.**

Requirements

Tools /Instruments

• Combination pliers 200 mm	- 1 No.
• Screw driver 200 mm with 4 mm blade	- 1 No.
• Side cutting pliers 150 mm	- 1 No.
• Electrician's knife 100 mm	- 1 No.
• Bradawl 150 mm	- 1 No.
• Ball peen hammer 250g	- 1 No.
• Hacksaw with 24 TPI blade	- 1 No.
• Firmer Chisel 6 mm	- 1 No.
• Flat rasp file 200 mm	- 1 No.
• Neon tester 500V	- 1 No.
• Electirc drilling machine 6 mm capacity with 5 mm drill bit.	- 1 No.

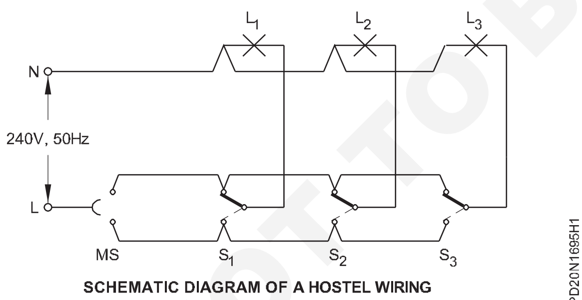
Materials

• 2 way switch 6A 250V	- 4 Nos.
• Batten holder 6A 250V	- 4 Nos.
• PVC switch box 100 X 100 X 40 mm	- 4 Nos.
• PVC Cable 1.5 sq mm, 660 V	- as reqd.
• Saddle 19 mm	- 20 Nos.
• Wooden gutties	- 20 Nos.
• Conduit bend 19 mm	- 20 Nos.
• Fish wire	- as reqd.
• PVC Conduit 19 mm	- 50 m
• Flexible conduit 19 mm	- 2 m
• Conduit coupler 19 mm	- 6 Nos.
• Earth wire G1, 8 SWG	- 20 m
• Wood Screw 25 x 6 mm	- 1 box
• Wood Screw 12 x 6 mm	- 1 box

PROCEDURE

1 Read and interpret the schematic diagram (Fig 1) and the layout diagram (Fig 2).

Fig 1



SCHEMATIC DIAGRAM OF A HOSTEL WIRING

2 Draw the wiring diagram based on Figs 1 and 2 and compare with the given wiring diagram. (Fig 3).

3 Draw your own wiring diagram according to the layout.

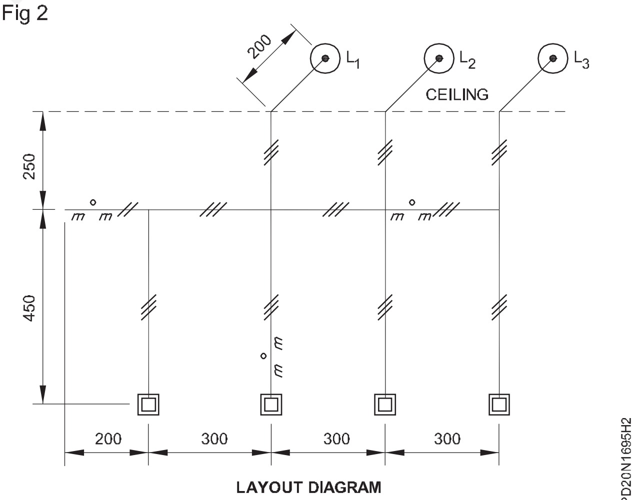
4 Estimate the material required for wiring installation referring to the layout as well as the wiring diagrams.

5 Mark the layout on the Installation Practice Cubicle (IPC).

6 Prepare the PVC conduit frame as per the layout plan.

7 Mark the saddles position and fix them loosely as per the layout plan.

Fig 2



LAYOUT DIAGRAM

8 Fix the conduit pipe on the IPC with the help of saddles.

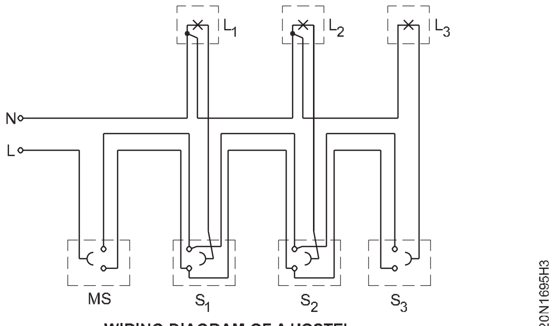
9 Insert the fish wire into the conduit pipe.

10 Draw the cable as per the wiring diagram. (Fig 3)

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

11 Fix the batten holders as per the Fig 2 and terminate the cable ends.

Fig 3



WIRING DIAGRAM OF A HOSTEL

12 Fix the switches on the PVC switch boxes.

13 Prepare the end termination of cables and connect the accessories as per the circuit.

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

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Practice wiring of Institute and workshop as per IE rules

Objectives: At the end of this exercise you shall be able to
- **read and interpret the floor plan of a workshop**
- **mark the single line diagram of power wiring in workshop**
- **prepare and install a conduit frame as per line diagram**
- **draw the cables through the conduit**
- **connect the accessories as per circuit**
- **test the circuits.**

Requirements

Tools/Instruments

• Power drilling machine 6 mm with 5 mm drill bit	- 1 No.
• Combination pliers 200 mm	- 1 No.
• Side cutting pliers 150 mm	- 1 No.
• Electrician's knife	- 1 No.
• Bradawl 150 mm	- 1 No.
• Ball peen Hammer 250 gm	- 1 No.
• Hacksaw with 24 TPI blade	- 1 No.
• Firmer Chisel 6 mm	- 1 No.
• Neon Tester 500V	- 1 No.
• 3ϕ Energy meter 30A, 440V	- 1 No.

Equipment / Machines

• 5 HP 3ϕ 440V AC motor	- 1 No.
• 3 HP 3ϕ 440V AC motor	- 1 No.
• 1/2 HP 1ϕ 240V AC motor	- 1 No.
• 1 HP 1ϕ 240V AC motor	- 1 No.
• Star Delta starter 4, 5V 50 Hz	- 2 Nos
• DOL starter 1ϕ, 10A, 250 V	- 2 Nos.

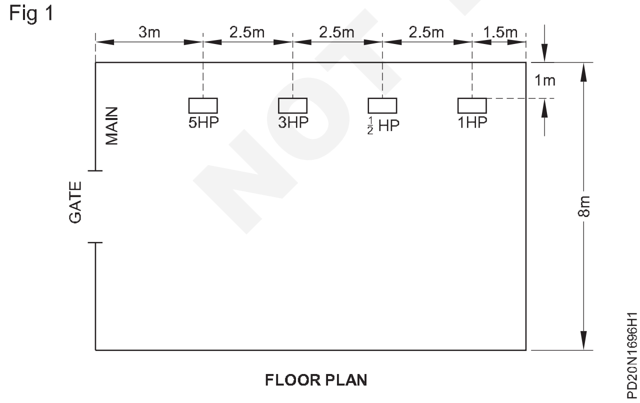
Material

• Metal conduit pipe 20 mm	- 10 m
• Conduit junction box	- 20 Nos.
• TW box 200 x 150 x 40 mm	- 3 Nos
• TW box 300 x 200 x 40 mm	- 4 Nos.
• TPIC 16A - 415V	- 2 Nos.
• DPIC 16A, 250V	- 2 Nos.
• Saddles 19 mm	- 50 Nos.
• Wooden gutties	- 50 Nos.
• Conduit bend 19 mm	- 10 Nos.
• Angle Iron frame 50 x 30mm	- 5 Nos.
• Fish wire	- as reqd.
• PVC sheathed aluminium cable 4 Sq mm 250 V	- 60 m
• Copperwire 14 SWG	- 15 meter
• Metal conduit Elbow 20 mm	- 25 Nos.
• Distribution box 4 ways 200x150x40mm	- 1 No.
• TW wooden spacer	- 30 Nos.
• Wood screws 25 x 6 mm	- 1 Box
• Wood screws 12 x 6 mm	- 1 Box
• Surface mounted kit kat fuse 16A 250V	- 4 No.

PROCEDURE

1 Obtain the floor plan of the work shop (Fig 1).

Fig 1



2 Mark the position of motors on the floor plan with the consultation of the customer.

A Sample requirement is given below for trainees reference.

1 One 5 HP, 415V 3 phase motor.

2 One 3 HP, 415V 3 phase motor.

3 One 1/2 HP; 240V, 1 Phase moor

4 One 1 HP, 240V, 1 Phase motor

The motors are to be arranged as shown in Fig 1.

> **The main switch, motor switch and starter are assumed to be mounted at a height of 1.5 m from the ground level.**
>
> **Height of horizontal run from ground level will be 2.5 m**

3 Draw the wiring diagram based on Fig 1.

4 Mark the layout based on Fig 2.

5 Prepare the PVC coduit frame as per layout.

6 Mark the sadles position an dfix them loosely as per the layout plan.

7 Fix the conduit pipe with the help of saddles

8 Insert the fish wire in the conduit pipe.

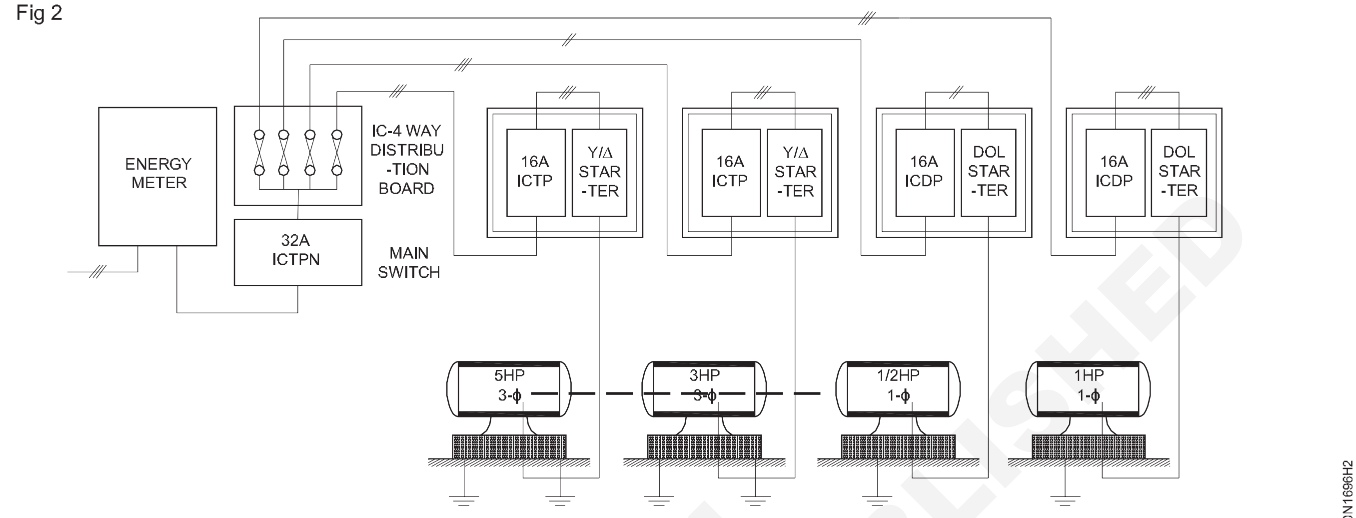
9 Draw the cable as per the wiring diagram as shown in Fig 2.

10 Fix the switches energy meter and starter on the box.

11 Prepare the end terminate of cables and connect the loads as per the circuit.

12 Test the circut after getting the approval of the instructor.

Fig 2



SINGLE LINE DIAGRAM OF POWER WIRING IN WORKSHOP

Practice testing /fault detection of domestic and industrial wiring installation and repair

Objectives: At the end of this exercise you shall be able to
- **detect and repair open circuit fault in domestic and industrial wiring**
- **detect and repair shortcircuit fault in wiring**
- **detect and repair earth fault in wiring**
- **prepare the flow chart for location rectification of fault in domestic wiring installation.**

Requirements

Tools/Instruments

- Connecting screw driver 100 mm - 1 No.
- Cutting plier 150 mm - 1 No.
- Screw driver 200 mm - 1 No.
- Neon tester 500 V - 1 No.
- D.E. Electrician knife100 mm - 1 No.
- Multimeter - 1 No.
- Megger 500V - 1 No.

Materials

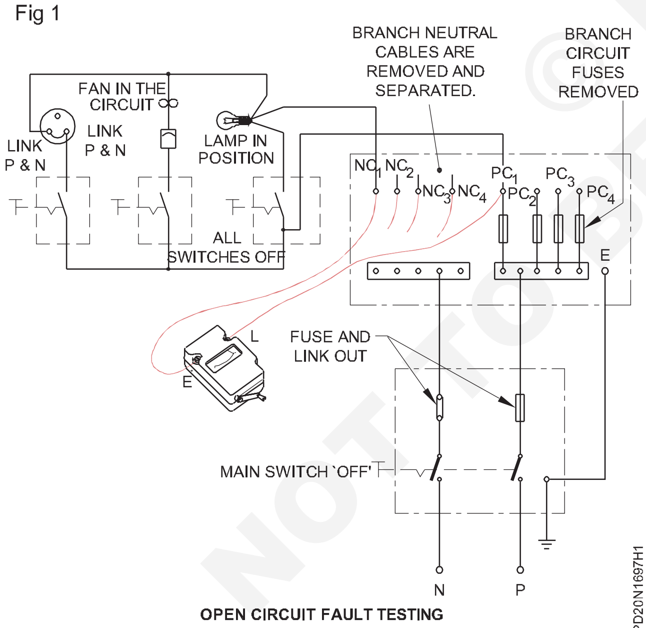
- Test lamp 100W, 240 V - 1 No.
- Crocodile clip 15A - 2 sets
- PVC flexible cable 1.5 sq.mm, 660 V - 10m

PROCEDURE

Open Circuit Fault

1 Consider the circuit as shown in Fig 1 in a domestic installation.

Fig 1



OPEN CIRCUIT FAULT TESTING

For open circuit fault removal of fuses, etc are to be done before doing the test by using megger.

2 Check whether the cables used in an installation have proper continuity or not using megger.

3 Check circuit fuses whether in order or not, if not, rewire the fuses.

4 Check one circuit at a time and then proceed step by step.

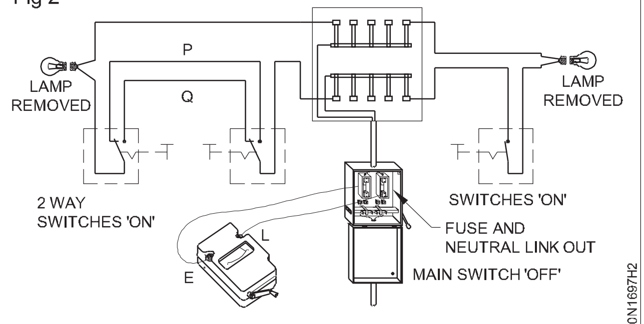
5 Check the circuits having 2 way switches, the concerned switches may be operated alternately to ensure the correct test result.

6 Check the defective fan, regulators or lamps by shorting the suspected appliance if necessary and then retest it.

Short circuit fault

1 Make the circuit as shown in Fig 2 and connect the megger, if it shows continuity in both ON and OFF positions of the switch, this indicates short in circuit.

Fig 2



SHORT CIRCUIT FAULT

2 Check insulation resistance between the cables of the installation and earth.

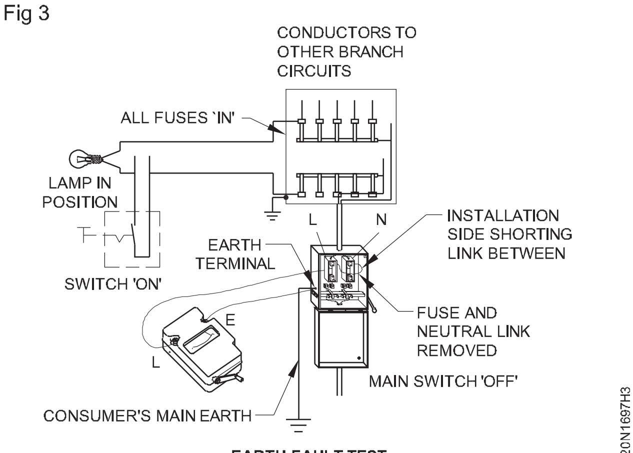
3 Connect the megger terminal ‘E’ to the live wire and L to the corresponding neutral wire, the megger will read zero or very low value of insulation resistance and confirms the short circuit.

4 Repeat the test procedures in each and every circuit and locate the shorting point of the live and neutral wire by inspection and remove it by insulating the bare conductors.

Earth fault

1 As per the circuit as shown in Fig 3 keep all the fuses, switches bulbs etc in closed position as indicated in the figure.

Fig 3



EARTH FAULT TEST

> **Isolate the live conductor from neutral, remove all other lamps and other equipments connected with wiring.**

2 Switch 'ON' all the switches.

3 Using Insulation resistance Tester, terminal 'E' of the megger connect to the earth point of the system provided at the Meter Board and Terminal 'L' of the megger with each conductor in turn at the main board cut-out terminal and rotate the handle of the megger to send current through closed circuit formed between conductor and earth.

4 Note down the reading of the meter which gives directly the insulation resistance between the conductor and earth.

5 Repeat the step 3 and 4 for other circuits, subcircuits, live conductors and main switch board etc.

— — — — — —

Group different wattage lamps in series for specified voltage

Objectives: At the end of this exercise you shall be able to
- **read and interpret the data stamped on a given lamp**
- **measure the voltage drop across the lamp when unequal wattage lamps are connected in series to the supply**
- **state the reasons for the behaviour/condition of glow of unequal wattage lamps in series.**

Requirements

Tools/Instruments

- Multimeter - 1 No.
- Voltmeter MC 0-15V - 3 Nos.
- Ammeter MC 0-500 mA - 1 No.

Equipment/Machines

- DC variable source 0-24 volts, 5 amps with output current & voltage indicator - 1 No.

Materials

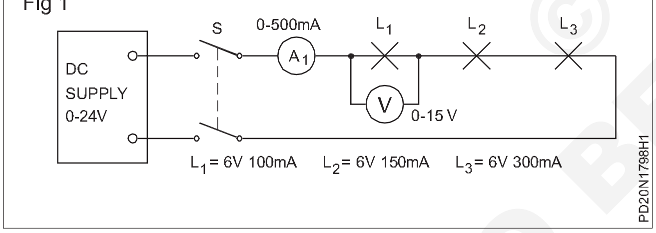
- Bulbs screw cap - 6V 100 mA - 10 Nos.
- Bulbs screw cap - 6V 150 mA - 6 Nos.
- Bulbs screw cap - 6V 300 mA - 4 Nos.
- Bulb-holders - 20 Nos.
- Connecting leads - as reqd.
- Knife switch DPST 16A - 1 No.

PROCEDURE

TASK 1 : **Connect 3 lamps of 6 volts in series across 18 volts supply (unequal wattage) and test it**

1 Connect the three lamps with ammeter A in series to the variable voltage DC supply source Fig 1a.

Fig 1



Keep the output of DC source at minimum, say 0 volts.

2 Connect a MC voltmeter (0-15 V) across L_1 (i.e low current rating/low wattage bulb). Close the switch S.

3 Gradually increase the supply voltage from 0 volts, observing ammeter, voltmeter and lamp L_1.

4 Increase the voltage upto 18 volts. Record your observations.

____

____

____

5 Does the lamp L_1 fuse? If yes, give your reasons, stating the observation made just before fusing.

____

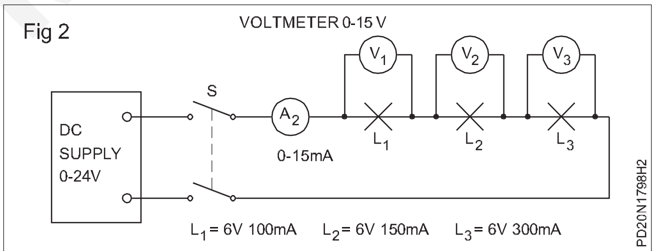
____

____

6 Open the switch S and reset the supply voltage to OV. Replace the bulb L_1.

7 Form the circuit Fig 1(b) with 3 voltmeters 0-15 volts connected across each lamp.

Fig 2



8 Close the switch S and increase the supply voltage until the current reaches 100 mA., (i.e. rated current of low wattage bulb in the series circuit).

9 Read the voltages V_1, V_2 & V_3 and record in Table 1.

Table 1

Supply Voltage	V_1	V_2	V_3

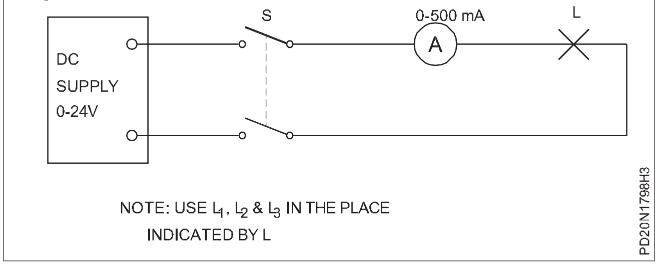
10 Give your reasons for the unequal distribution of supply voltage.

11 Connect each lamp L_1, L_2 & L_3 independently in the circuit Fig 2 and record the value of current and voltage when the supply voltage is 6 V in Table 2.

Table 2

Lamp in circuit	Supply voltage	V	I	V/I
L_1 6 V 100 mA	6 V			
L_2 6 V 150 mA	6 V			
L_3 6 V 300 mA	6 V			

Fig 3



Conclusion

The voltage across each of the lamps connected in series varied because of

____

____

____

The stamped value of voltage and current on the lamp means that the specified __________________ when applied will cause a __________________ to flow.

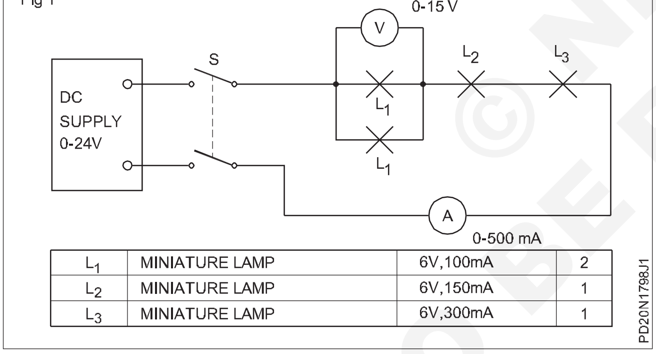
Resistance of lamp varies because of different __________________ of lamp.

— — — — — —

TASK 2 : **Connect two low wattage L_1 lamps in parallel as in Task 1 and test it**

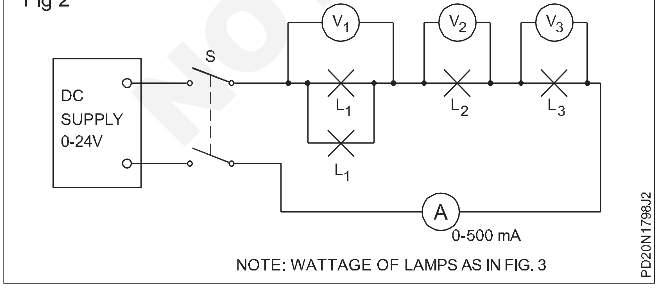
1 Form the circuit as per the diagram, Fig 1.

Fig 1



2 Observe the effect of increasing the supply voltage from 0 to a value that causes 6 volts across low wattage lamps L_1.

Fig 2



3 Does the lamp L_2 fuse? If yes, give your reasons stating observations made just at the time of L_2 fusing.

____

____

____

4 Open the switch S, connect the 3 voltmeters as shown in Fig 2.

5 Replace the lamp L_2 and reset the DC source at OV. Close the switch S. Increase the supply voltage until a current of 150 mA flows in the circuit.

6 Read and record the voltages V_1, V_2 & V_3 in Table 3.

Table 3

Supply Voltage	V_1	V_2	V_3

Conclusion

The voltage is V_2 is greater than V_1. Also $V_2 > V_3$, because

____

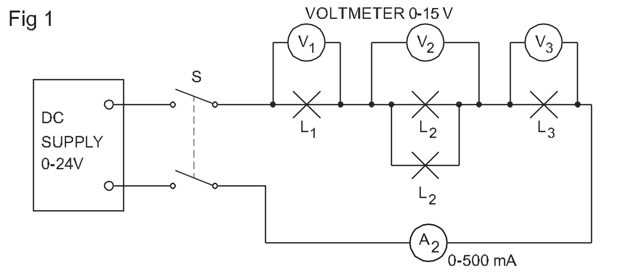
____

____

TASK 3: **Connect two (L_2 lamps) in parallel as in task 1 and test it**

1 Form the circuit as shown in Fig 1.

Fig 1



L_1	MINIATURE LAMP	6V,100mA	1
L_2	MINIATURE LAMP	6V,150mA	2
L_3	MINIATURE LAMP	6V,300mA	1

2 Gradually increase the supply voltage up to 18V after closing the switch S. Observe the voltage V_1, current and glow of lamp L_1.

3 Does the lamp L_1 fuse again? What are the conditions at the time of fusing?

______________ V_1

______________ DC supply voltage

______________ current

4 Is there any difference in the values as compared with the one in Task 1? Give your response.

5 Open the switch S. Replace the fused lamp L_1. Reset the supply voltage to 0V. Close the switch S and increase the current through the circuit to 100 mA. Record the voltages V_1, V_2 & V_3 in Table 4.

Table 4

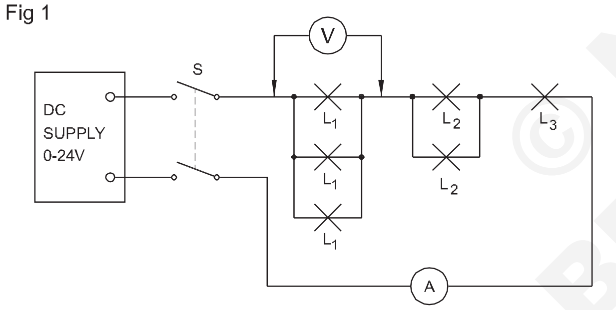
Supply Voltage	V_1	V_2	V_3

— — — — — —

TASK 4: **Connect three L_1 lamps connected in parallel and the whole in series with one lamp L_3 two L_2 lamps in parallel as in task 1**

1 Form the circuit as shown in Fig 1.

Fig 1



L_1	MINIATURE LAMP	6V,100mA	3
L_2	MINIATURE LAMP	6V,150mA	2
L_3	MINIATURE LAMP	6V,300mA	1

2 Close the switch S. Increase the supply voltage gradually to 18 V. Observe the lamps, ammeter and measure the voltage across the lamp group L_1, lamp group L_2 and L_3.

3 Now all the lamps glow with their normal brightness. No lamp fused. Why?

____

____

____

Conclusion

In a serial set of lamps, while replacing a fused lamp the lamps voltage and also ______________ or ____________ should also ______________ wattage lamp, replacement should be

— — — — — —

Practice installation of various lamps eg. fluorescent tube, HP mercury vapour, LP mercury vapour, HP Sodium vapour, LP Sodium vapour, Metal halide etc.

Objectives: At the end of this exercise you shall be able to
- **connect a flourescent tube with accessories, install and test it**
- **connect a H.P. M.V lamp with acccessories, install and test it**
- **connect a H.P.S.V lamp with accessories install and test it**
- **connect a L.P.S.V lamp with accessories install and test it**
- **connect a metal halide lamp with accessories install and test it.**

Requirements

Tools/Instruments

- Insulated combination plier - 150 mm - 1 No.
- Insulated screwdriver - 200 mm x 4 mm - 1 No.
- Insulated connector screw driver - 100 mm - 1 No.
- Long round nose plier - 150 mm - 1 No.
- D.B. Electrician's knife 100 mm - 1 No.
- Test lamp 100 W, 250 V - 1 No.

Materials

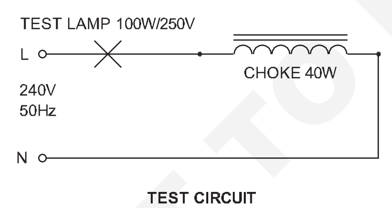
- Tube light fitting 1200 mm - single patti - 1 No.
- Choke 40w, 250V - 1 No.
- Tube light starter - 40W,250V - 1 No.
- Tube light holder plain - 2 Nos.
- Starter holder - 2 Nos.
- MV lamp holder suitable for 240W, 250 V lamp (Goliath screw type) - 2 Nos. single patti - 1 No.
- MV lamp choke - 240 Watts, 250 V - 1 No.
- Capacitor 4 MFD / 380 U - 1 No.
- L.P.M.V lamp 40 W, 250 V - 1 No.
- MV lamp 240W, 250V - 1 No.

PROCEDURE

TASK 1: **Assembling of a fluorescent lamp (LPMV lamp) with its accessories**

1 Check the choke for its short and open with a test lamp as shown in Fig 1.

Fig 1



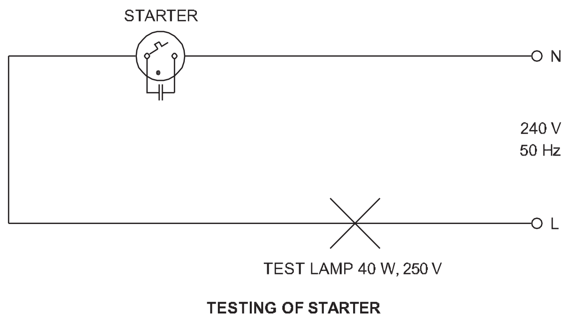
2 Check the starter with a series test lamp as shown in Fig 2. Observe the flickering of the lamp which indicates good condition of the starter.

3 Assemble the following fluorescent tube accessories in the fitting base. Refer to the sketch. (Fig 3)

1) Holders for tube 2) Starter-holder 3) Choke.

4 Connect the accessories as shown in Fig 4 (for a single tube light). Also install the tested starter.

Fig 2

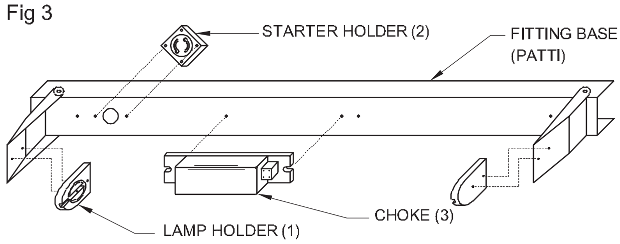


5 Test the filament on both sides of the fluorescent tube for its continuity as shown in Fig 5. Discard the fluorescent tube with open or fused filament in either side.

6 Fix the bulb in the holder.

Firstly, you have to make sure that the slot in the inner parts of the holder is turned to the proper position.

Fig 3



ASSEMBLY OF ACCESSORIES

Fig 4

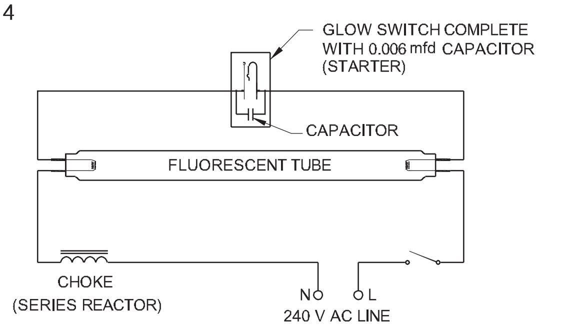
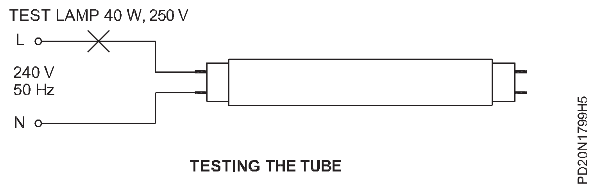


Fig 5



TESTING THE TUBE

7 Test the tube light assembly for its working.

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TASK 2: **Installation of tube light fitting**

1 Follow the recommended method and procedure depending on the type of wiring.

The fixing of the tube to the wall, ceiling or tubular post should be strong enough to support the weight of the fitting.

The installed fitting must be below the level of the ceiling fan to avoid the flickering effect of the shadow.

2 Connect the tube light fitting to the ceiling rose.

Check the supply at the ceiling rose. Switch off the supply before making any connection.

3 Fix the fluorescent tube in the fitting.

Use a stable ladder and a helper to hold the ladder while you are working on the ladder.

4 Switch `ON' the supply and observe the glow of the tube. If the tube is not glowing, check for proper housing of starter and tube.

— — — — — —

TASK 3: **Install and test the H.P.M.V (High Pressure Mercury Vapour) lamp with accessories**

1 Read the specification of the mercury vapour lamp and the choke from the markings. (Fig 1)

2 Connect the H.P.M.V. lamp in series with the 60W 240V bulb and test in 240V AC supply. Check whether the series test lamp glows.

3 Test the choke for its working condition.

4 Assemble the accessories (choke, holder and capacitor) in the fitting, following the manufacturer's instructions.

5 Connect the accessories as per circuit diagram, Fig 2 (Pictorial diagram Fig 3) using the recommended type of termination.

Choose the tapping of the choke suitable to the rated supply system voltage.

6 Fix the bulb in the holder and test the working of the lamp with the supply voltage.

Ensure the fitting is properly earthed at the earthing terminal provided, before testing.

7 A modern M.V. lamp with a built-in resistor needs no external accessories to be connected as discussed above. It can be connected as we do an incandescent lamp.

Installation of the M V lamp fitting

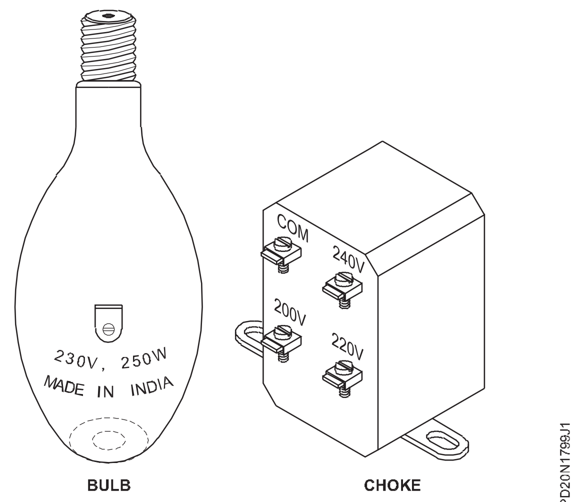
8 Assemble, connect and test the M.V. lamp fitting on a table, for its working. Then remove the cover and bulb.

Mount at the location

9 Observe the recommended method and procedure specified by the manufacturer in the installation leaflet.

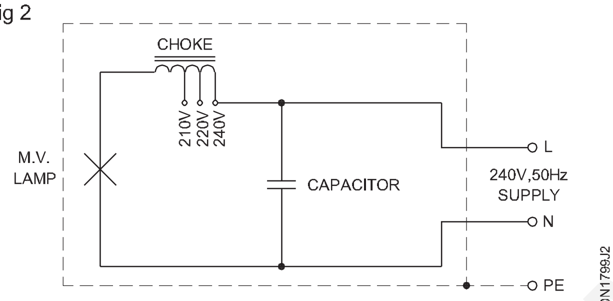
Do not alter the specifications recommended by the manufacturer because it should be strong enough to support the weight of the fitting.

Fig 1



BULB CHOKE

Fig 2



CIRCUIT DIAGRAM OF HPMV LAMP

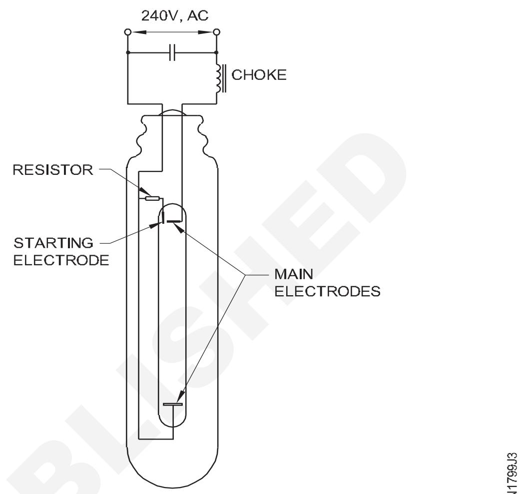
10 Connect the M.V. lamp fitting to the supply. The method depends on the system of wiring, location of fitting etc.

Ensure that the supply line is dead (not live), before making the connections.

11 Fix the bulb in the holder securely and refit the cover.

12 Switch on the supply and wait until the high pressure mercury vapour lamp glows with its full brightness. then switch off the supply.

Fig 3



PICTORIAL DIAGRAM OF A HPMV LAMP

— — — — — —

TASK 4: **Install and test H.P.S.V. (High Pressure Sodium Vapour) and LPS lamp with accessories**

1 Read the specification from the markings on the leak transformer, choke and bulb.

2 Check the transformer and choke with a test lamp for shorts and open.

3 Assemble the accessories (choke, leak transformer and lamp-holder) in the fitting.

Follow strictly the manufacturer's instructions.

4 Give connections as per diagram shown in Fig 1.

Use the recommended type of termination only.

5 Choose the appropriate voltage tapping suitable to the supply voltage. (Fig 1)

6 Fix the bulb in the holder.

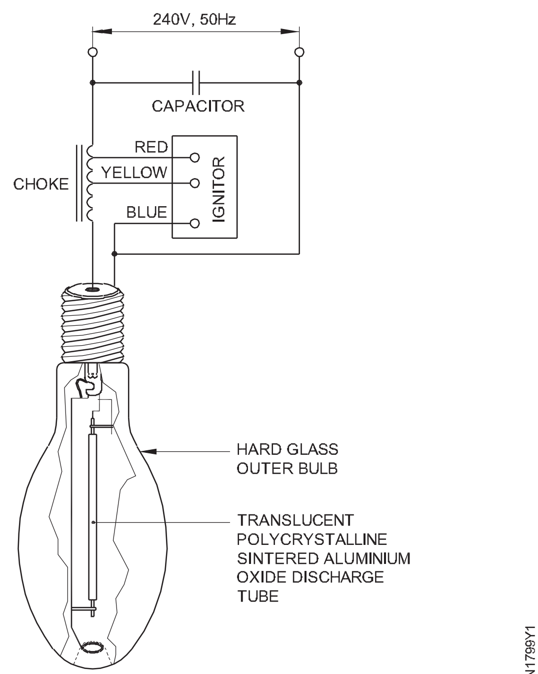
Ensure the fitting is properly earthed.

7 Test the working of the assembled fitting by connecting it to the mains.

8 Note the time taken for the bulb to give full illumination.

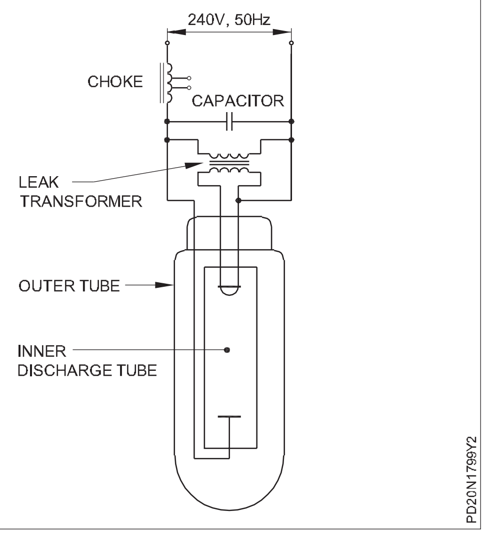
9 Repeat the above steps for a high pressure sodium vapour lamp. Connect as per the diagram shown in Fig 2.

Fig 1



HIGH PRESSURE SODIUM VAPOUR LAMP

Fig 2



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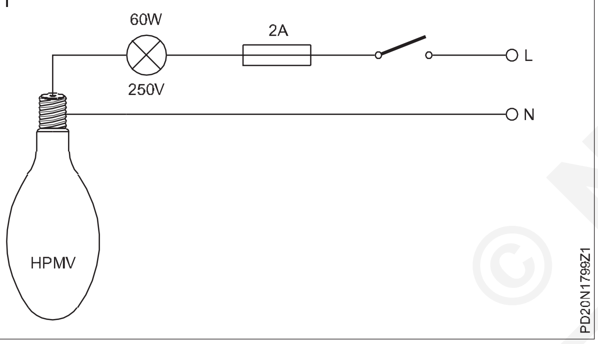
TASK 5: **Testing of High pressure metal Halide**

1 Read the specifications of the given Halide lamp as Fig 1 collect the required accessories.

Fig 1



2 Connect the HPMV lamp in series with a 60W. 250V incandescent amp as shown in Fig 1 and test with 240V AC supply. Check whether the series test lamp glows. If the test lamp flows it means that HPMV lamp in good codition.

3 Connect as the circuit diagram and test with 240V supply.

4 Measure the current and test with 240V supply.

Measure the current and voltage. Calculate the power and verify with the rated values.

Voltage :______________________________Volt

Current : ______________________________ Amp

Power : ______________________________ Watt

— — — — — —

Prepare a decorative lamp circuit

Objectives: At the end of this exercise you shall be able to
- **determine the number of lamps to be connected in series for a particular supply voltage**
- **design the circuit for a given decoration, where the total number of low voltage bulbs to be used**
- **use of an electronic flasher or glow starter.**

Requirements

Tools/Instruments

- Insulated plier 150mm - 1 No.
- Insulated screwdriver 100mm - 1 No.
- Insulated screwdriver 150mm - 1 No.
- Side cutting pliers 150mm - 1 No.
- Multimeter - 1 No.

Materials

- Miniature screw cap bulbs 6V, 150mA - 40 Nos.
- Holder for the 6V screw cap bulb - 40 Nos.
- Connecting lead flexible 13/0.2mm twin core cable - 20m.
- Insulating tape (steel grip) PVC 20m - 1Roll 5m
- Flasher lamp or glow starter - 1 No.
- Electro mechanical flasher 3 points 5 amps rating - 1 No.
- Glass fuse with holder 500mA - 1 No.

PROCEDURE

TASK 1: **Serial lamp set for 240V**

1 Determine the No. of lamps to be connected in series in a branch. 5% extra to be calculated i.e.100+ 5 = 105.

$$\text{No. of bulbs} = \frac{\text{Supply voltage}}{\text{Bulb voltage}} \times \frac{105}{100}$$

$$\text{No. of bulbs} = \frac{240}{6} \times \frac{105}{100} = 42 \text{ Nos.}$$

2 Connect the holders and the fuse in series (screwing or soldering) with suitable lead lengths.

3 Test all bulbs and fix them in the holder.

4 Effect supply and test for their glow across the 240V AC supply.

5 Switch 'off' the supply and add a flasher unit in series and check for its working. (Fig 2)

Fig 1

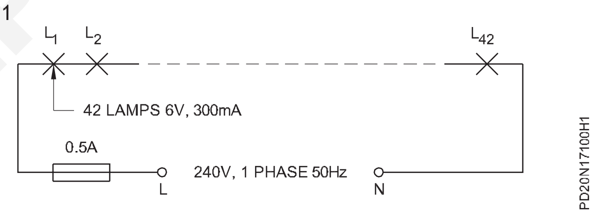
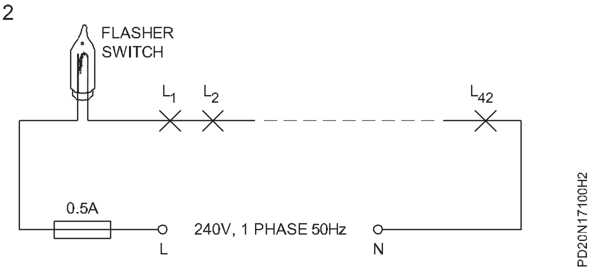


Fig 2



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TASK 2: **Serial lamp set of a given pattern**

1 Collect the pattern of design from the instructor (it should contain a minimum of three branches).

2 Mark the layout of bulbs to be fixed on the pattern.

3 Count the number of bulbs in the layout.

4 Determine the number of branches to be formed based on the number of bulbs required in each branch (Refer to Task 1).

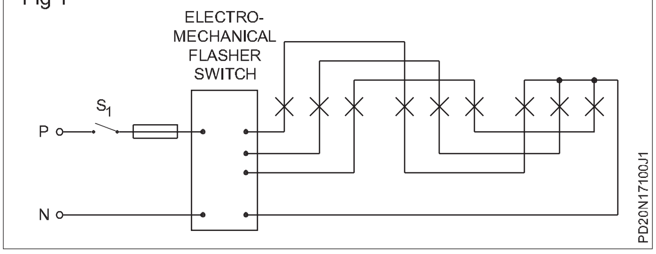
5 Readjust the bulb layout to suit the total number of bulbs. Also readjust the number of bulbs in each branch, if required.

6 Form the bulb-holders into the required branches and connect them in parallel.

7 Insert the flasher in the circuit. (Fig 1)

8 Mount the bulbs and test for the working of the decorative board.

Fig 1



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Prepare a decorative lamp circuit to produce rotating light effect/ running light effect

Objectives: At the end of this exercise you shall be able to
- **select lamps/sequential control for light decoration**
- **design lighting layout for running light**
- **design layout for rotating light**
- **connect the motor for 3-point running light (sequential control motor)**
- **connect lamp circuits in the electronic sequential controller.**

Requirements

Tools/Instruments

• Multimeter	- 1 No.

Equipment/Machines

• Single phase motor FHP with reduction gear	- 1 No.
• 240V operation output load 5 to 10 A with speed and intensity control	- 2 Nos.

Materials

• Cams	-3 Nos.
• Brushes	- 3 Nos.
• Connection leads flexible	- as reqd.
• Cam drive arrangement with shaft	- 1 No.
• Lamps 240V, 15W, BC	- 54 Nos.
• Batten Lamp holder 6A, 250 V	- 54 Nos.
• DPST knife switch 16A 250V	- 2 Nos.
• Electronic sequential controller	- 1 No.

PROCEDURE

TASK 1 : **Prepare a rotating lamp circuit**

1 Connect the lamps, switches and the flasher motor. (Fig 1).

2 Keep the D.P.S.T switches S_1 & S_2 Open.

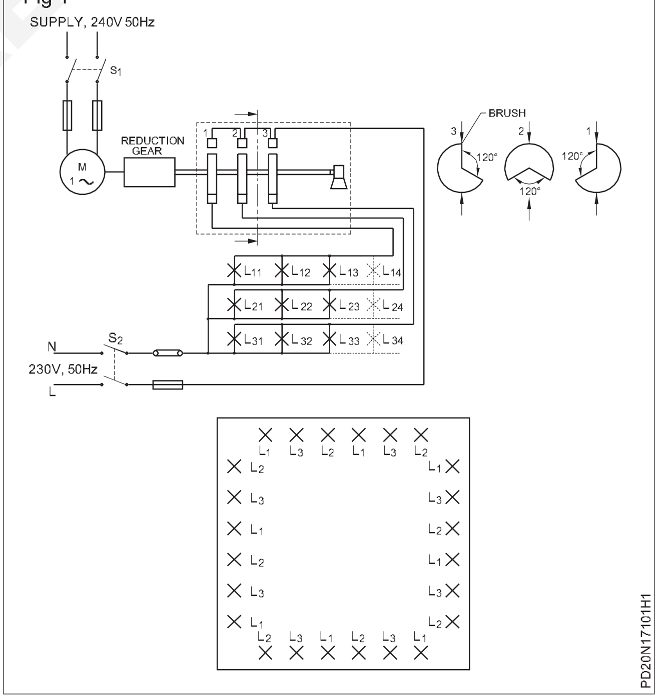
3 Close the D.P.S.T switch S_1 and start the flasher motor (sequential light controller.

4 Close the D.P.S.T Switch S_2 and observe the make and break contacts 1,2,3 and “ON” “OFF” operations of the 3 lamp banks.

Do not touch live wires

6 Open the D.P.S.T. switch S_1 and S_2

Fig 1



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TASK 2 : **Prepare a running light effect**

1 Prepare the lighting design as shown in Fig 1.

2 Close the D.P.S.T. switch S_1 and observe the lighting.

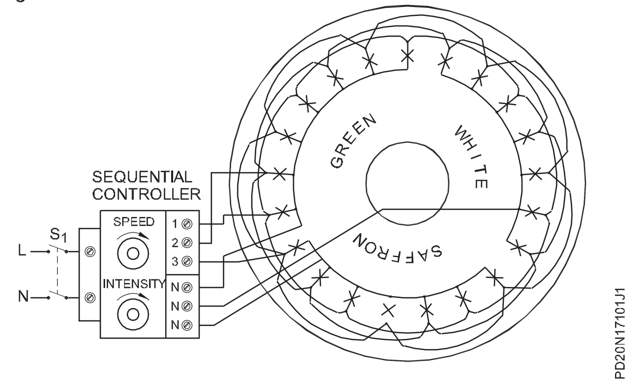
3 Increase the speed of operation by operating the speed control.

4 Adjust the intensity of light-adjusting the knob on the electric sequential controller.

5 Reduce the speed and intensity of the lighting system.

6 Open the D.P.S.T. switch S_1.

Fig 1



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Install light fitting for show case lighting

Objectives: At the end of this exercise you shall be able to
- **install and wire up the show case window lighting for tie rack**
- **wireup a show case window lighting to display clothes.**

Requirements

Tools and Instruments

- Insulated cutting pliers 150 mm - 1 No.
- Screw driver set of five - 1 Set
- Line tester 500V - 1 No.
- Electric hand drilling machine 6 mm capacity - 1 No.

Materials

- Complete set of circline tube light 30 cm 32 watts 250V 50 Hz with suitable shade and stand - 1 No.
- Complete set of 1200 mm fluorescent lamp fitting 40 watts 250V 50 Hz - 4 Nos.
- Wiring materials - as reqd.

PROCEDURE

TASK 1 : **Install and wire up the show case window lighting for tie rack**

1 Place a suitable sized plywood board in the base of the window with spacers.

2 Locate the circline tube fitting with its stand in proper position in the show case so that complete stand is visible from the window. Refer Fig.1.

3 Wire up in such a way that a 3 pin 5 amps socket is fitted in the inner side of the window.

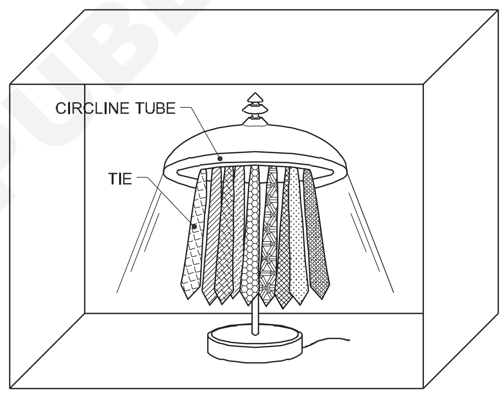
4 Mark the position of stand base and drill a hole in the marked centre to allow the circline tube cable to pass.

5 Draw the cable through the hole and connect a 3 pin plug at the cable ends.

6 Check the connections and connect the plug to the socket.

7 Give supply and check the lighting for the tie rack.

Fig 1



SHOWCASE WINDOW LIGHTING FOR TIE RACK

— — — — — —

TASK 2 : **Wire up the show case window lighting for a mannequin (dummy figure used for to display clothes)**

The show case needs four (400mm) tube light fittings to be wired in parallel and the tubes are hidden behind the frame. Refer Fig 2. Draw the connection diagram and wire up the fluorescent tubes in concealed wiring.

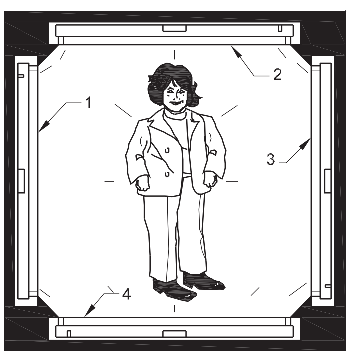
1 Prepare suitable frame for 4 tube light fittings which are to be hidden behind the frame (Fig 1)

2 Draw the connection diagram and wireup the 4 tube lghts in parallel.

3 Place the dummy figure at the centre used to display the clothes

4 Get the supply and check for its functioning.

Fig 1



1,2,3 AND 4 TUBELIGHTS
TUBES AND WIRING ARE CONCEALED IN THE FRAME

INDIRECT LIGHTING OF SHOWCASE WINDOW

— — — — — —

Install light fitting's with various types of LED and fixtures

Objective: At the end of this exercise you shall be able to
- **install light fitting's with various types of LED and fixtures.**

Requirements

Tools and Instruments

• Ladder	- 1 No.
• Sheet rock saw	- 1 No.
• Line man plier	- 1 No.
• Assorted screw drivers	- 1 No.
• Putty knife	- 1 No.
• Scraper	- 1 No.

Materials

• NM type cable (a.k.a. "Romese")	- 5m
• Snake or Fish tape	- 1 No.
• Wiring materials	- 2 Nos.
• Switch boxes	- 2 Nos.
• Switches	- 2 Nos.
• Fixture	- 2 Nos.
• Fasteners	- 1 Pack
• Wire rut assortment	- 1 Pack
• Speaker other patching compound	- 1 Bottle

PROCEDURE

1 Check your local wiring codes and schedule inspections.

2 Decide what type of fixture will work best in the area you're trying to illuminate.

3 Decide what kind of bulb you want for your fixture.

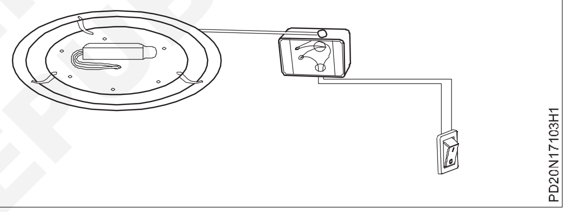
4 Determine voltage and current requirements for the fixture.

5 Locate a suitable power source.

6 Plan the wiring route.

7 Prepare a complete circuit diagram for the installation model given in Fig.

Fig 1



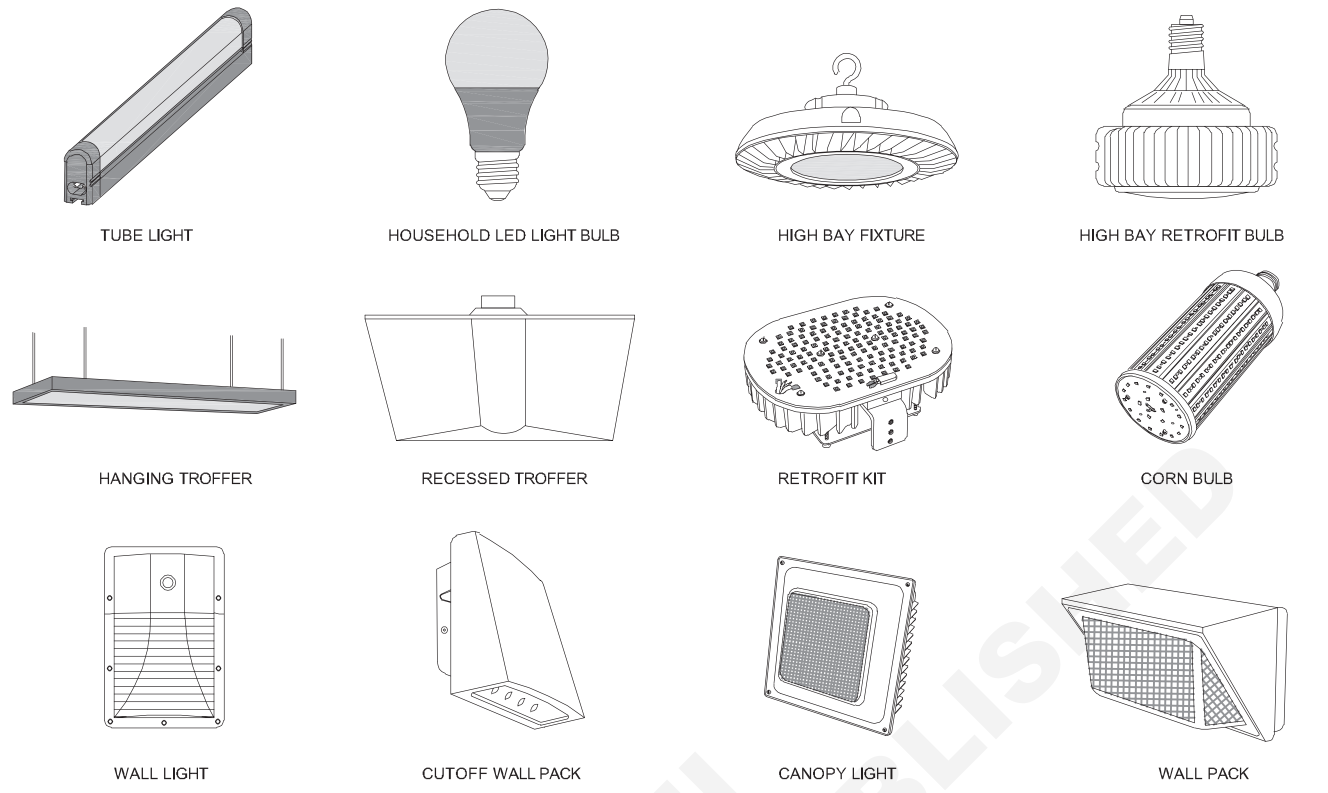
8 Cut openings for the wiring.

9 Install the wiring.

10 Make sure your wiring is up to code.

11 Connect the devices as shown in the diagram that matches your application.

Fig 2



DIFFERNT TYPES OF COMMERICAL LED LIGHT BULBS AND FIXTURES

— — — — — —

Identify parts and terminals of three phase AC motors

Objectives: At the end of this exercise you shall be able to
- **read and interpret the name plate details of the given 3 phase squirrel cage induction motor and slip ring induction motor**
- **identify their parts and write their names**
- **test the 3 phase squirrel cage induction motor for continuity test**
- **identify the terminals of 3-phase squirrel cage and slip ring induction motors.**

Requirements

Tools/Instruments

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

Equipments/Machinery

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

Materials

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

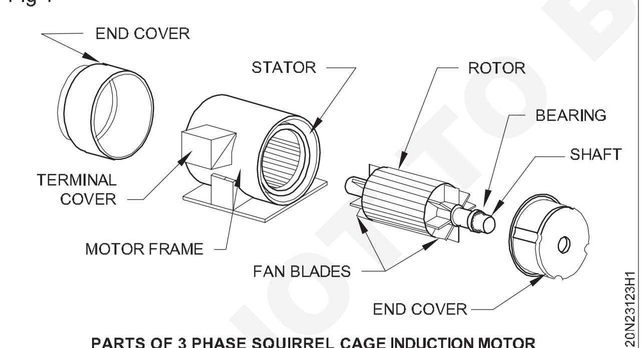
PROCEDURE

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

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

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

Fig 1



PARTS OF 3 PHASE SQUIRREL CAGE INDUCTION MOTOR

3 Label the each identified parts with number tags.

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

Table 1

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

5 Get it checked with your instructor.

— — — — — —

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

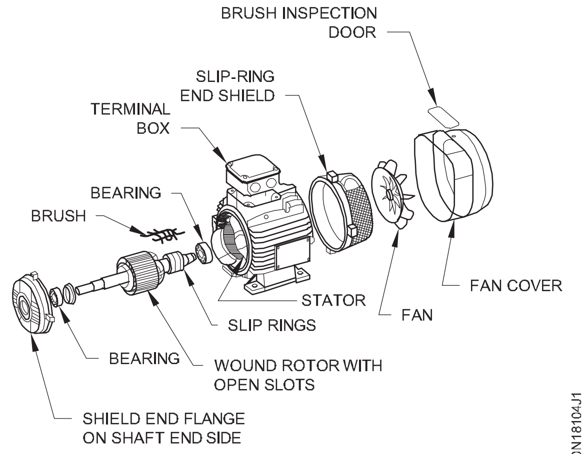
1 Read and interpret the name plate details of the 3 Phase slip ring induction motor.

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

3 Label the each identified parts with number tags

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

Fig 1



PARTS OF 3 PHASE SLIP RING INDUCTION MOTOR

Table 1

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

5 Get it checked with your instructor.

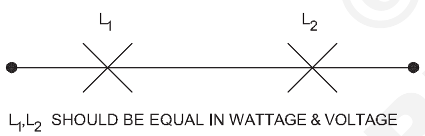
— — — — — —

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

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

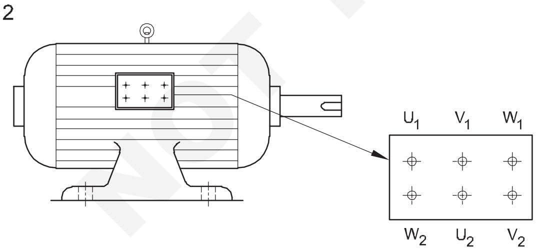
Lamps should be equally rated both in voltage and wattage. (Fig 1)

Fig 1



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

Fig 2

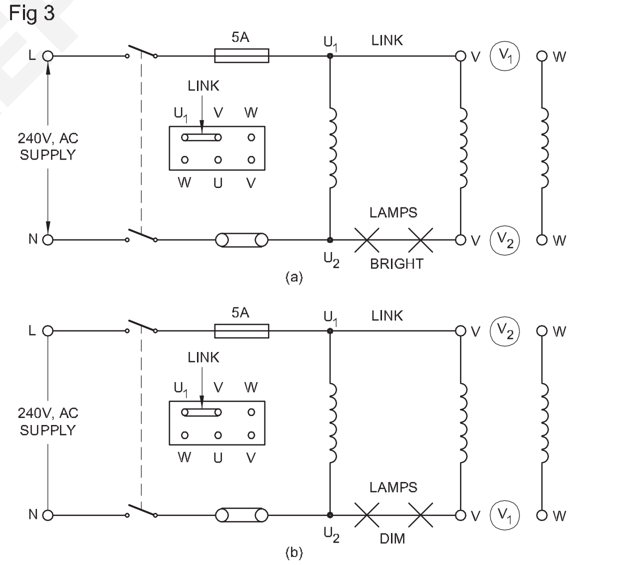


3 Identify the 3 pairs of terminals, name them as 'U' coil, 'V' coil and 'W' coil.

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

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

Fig 3



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

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

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

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

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

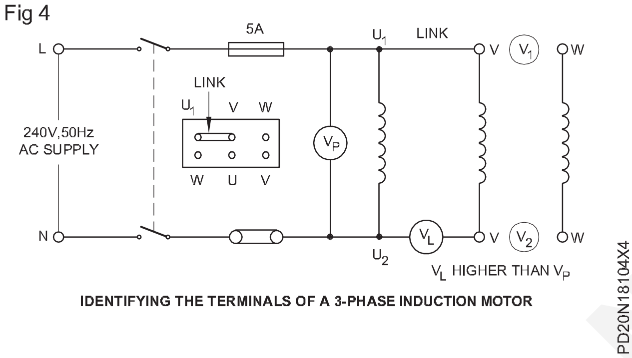
7 Test in the same way for the remaining terminals of coil ‘W’ and mark them as W_1W_2.

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

1 Repeat the steps 1 to 4 of Method 1.

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

Fig 4



IDENTIFYING THE TERMINALS OF A 3-PHASE INDUCTION MOTOR

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

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

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

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

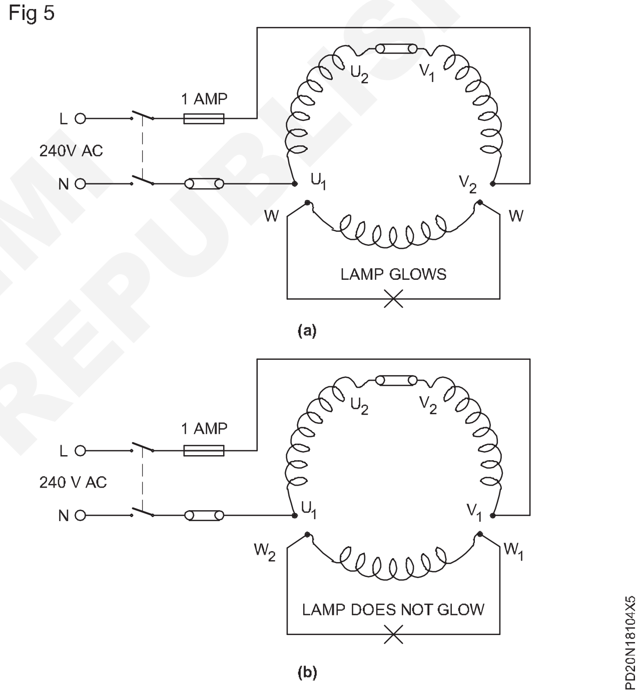
1 Connect the terminals as shown in Fig 5a. Connect it to a 240V AC supply and switch on the supply.

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

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

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

Fig 5



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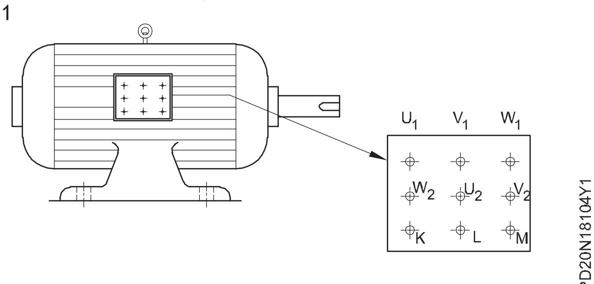
TASK 4: **Identify the terminal of a slip ring induction motor**

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

Fig 1



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

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

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

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

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

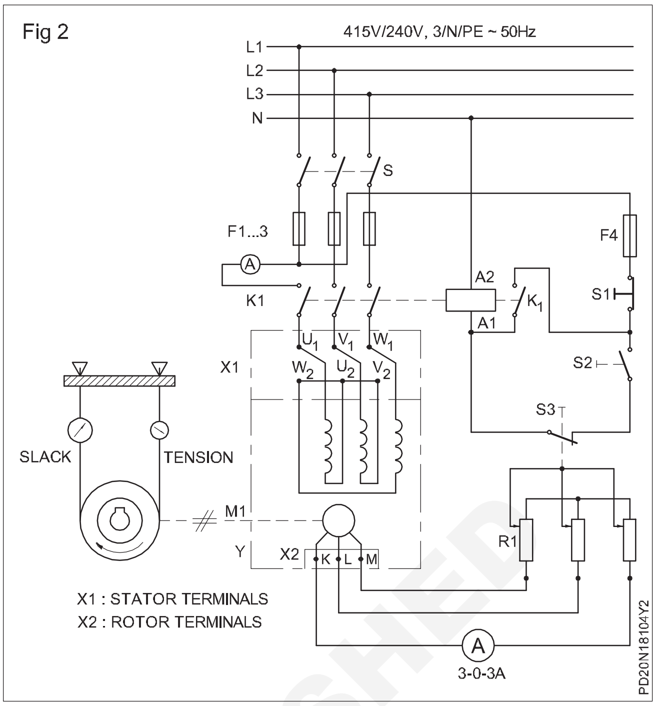
The above test will not be valid until and unless the following conditions are observed.

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

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

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

Fig 2



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Practice control of a AC motors

Objectives: At the end of this exercise you shall be able to
- **interpret the name-plate details of an ac series motor and determine full load current**
- **select a suitable variable resistor**
- **connect, run and measure the speed for different settings of the resistor.**

Requirements

Tools/Instruments

- Electrician tool Kit - 1 No.
- Voltmeter 0-300 V - 2 Nos.
- Ammeter 0 - 5A - 1 No.
- Tachometer 3000 rpm - 1 No.

Equipments/Machines

- AC series motor 240V 1/2 HP - 1 No.
- Rotary switch 6A, 250.4 position - 1 No.

Materials

- Connecting cable - as reqd.
- ICDP switch 16A 250V - 1 No.
- Wire wound enamel insulated resistor 10 ohms 100 W - 2 Nos.

PROCEDURE

TASK 1 : **Connect, run and control speed at a AC single phase motors**

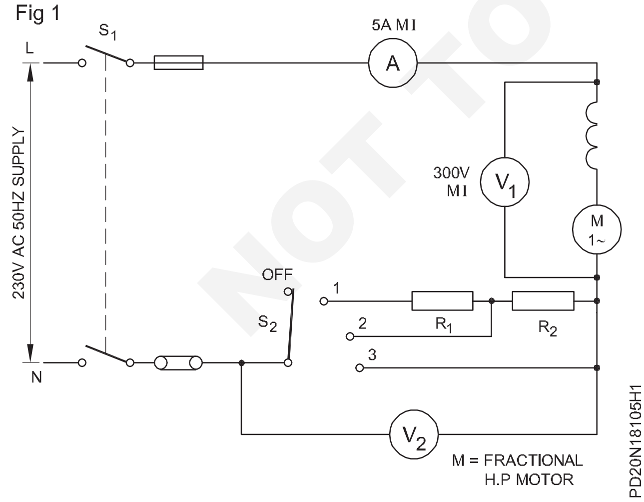
1 Read the name-plate details and record in Table 1.

2 Determine the load current from the name plate

To drop 80 V at position 1 and to drop 40 V at position 2. Calculate the required series resistors R_1 and R_2 and also determine their wattage (see example given)

3 Make the connections as per diagram (Fig 1) and make necessary arrangements to load the motor through prony brake.

Fig 1



4 Close the switch S_1.

5 Set the switch S_2 in position 1 and observe the starting of the motor.

6 Measure the current, voltages V_1 & V_2 and the speed. Record the values in Table 2.

7 Set the switch S_2, in position 2 and repeat the step 6.

8 Set the switch in position 3 and repeat the step 6.

Table 1

Menufacturer's name	
HP/KW	R.P.M.
Current	Voltage
Type	
Sl.No.	Insulation

Table 1

Switch S_2 Position	**Current**	**V_1**	**V_2**	**Speed**

9 Write the conclusion based on the following questions.

a What is the relation between V1 and the speed of the motor?

____

____

b V_2 is the drop across series resistance. What happens to the speed if it increases when the supply voltage is constant ?

____

____

____

c Can you find some approximate relation between V2 and fall in speed ?

____

____

____

d Calculate the value of resistance R_1 and R_2 by repeating V_1 & V_2 measurement at the loaded condition of the series motor.

____

____

____

Example

Calculation steps

Motor voltage V_1 = 175 V

Supply voltage V = 230 V

Voltage to be dropped $V_2 = V - V_1$ = 55 V.

Full load current of motor = I = ________

Resistance value = $R = \frac{V_2}{I} = \frac{5}{I}$

Calculated resistance= ______________ ohms.

Nearest standard resistance value is ____________

The resistance should carry full load current, I = __________________ A.

Therefore resistor selected is ______________ ohms ____________ amps ______________ watts.

— — — — — —

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

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

Requirements

Tools/Instruments

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

Equipment/Machines

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

Materials

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

PROCEDURE

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

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

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

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

Refer and recapitulate the connection diagram

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

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

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

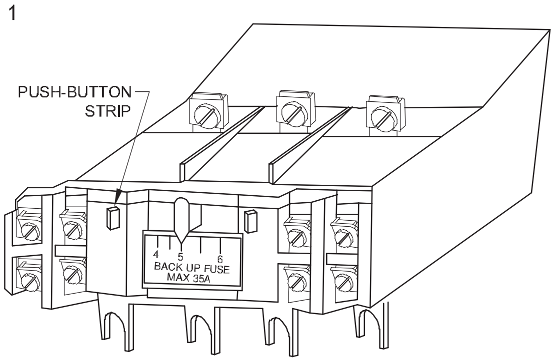
Fig 2 shows Contactor with no-volt coil.

5 Get the approval instructor for diagram.

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

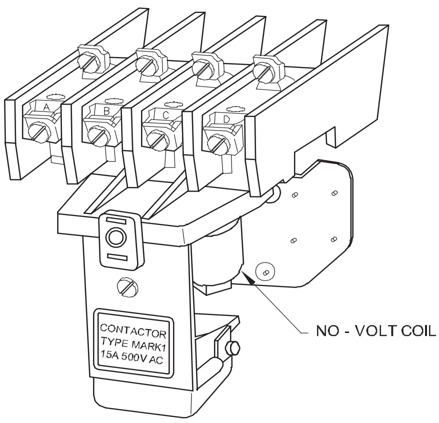
Do not tighten the screws more than necessary as too much tightening of screws will break the PVC casing of the contactor and OL relay.

Fig 1



OVERLOAD RELAY

Fig 2



CONTACTOR

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

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

9 Get the wiring approved by your instructor.

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

11 Mount the starter vertically on the wall/frame.

> **The position of the starter should be such that the no-volt coil mechanism works properly, taking advantage of the gravitational pull while disengaging.**
>
> **Use a plumb bob or spirit level to check the verticality.**

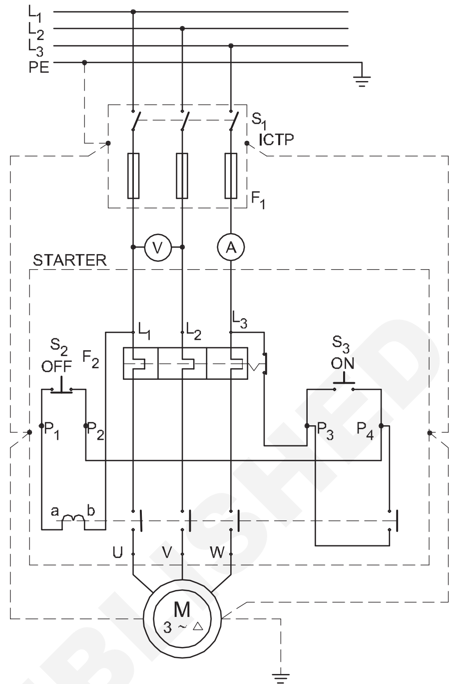
12 Connect the main supply to the starter incoming terminals through the I.C.T.P switch. (Fig 3)

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

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

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

Fig 3



CIRCUIT DIAGRAM OF DOL STARTER WITH PROTECTIVE DEVICE

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

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

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

18 Switch on the ICTP.

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

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

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

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

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

24 Show the readings to your instructor.

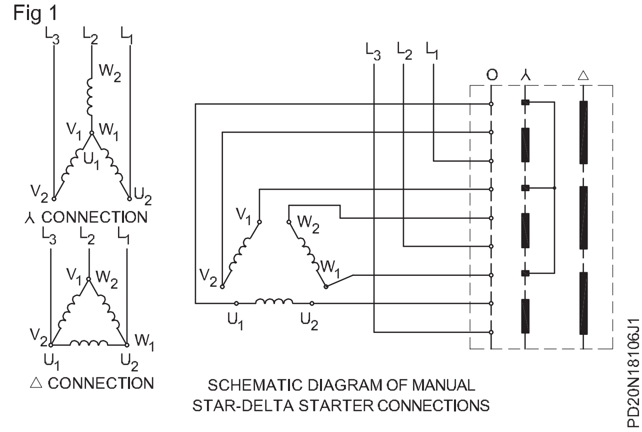
— — — — — —

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

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

2 Identify the parts of the given star-delta starter, trace the connections and verify its operation. Draw the traced out circuit and get it approved by the instructor. (Fig 1)

Fig 1

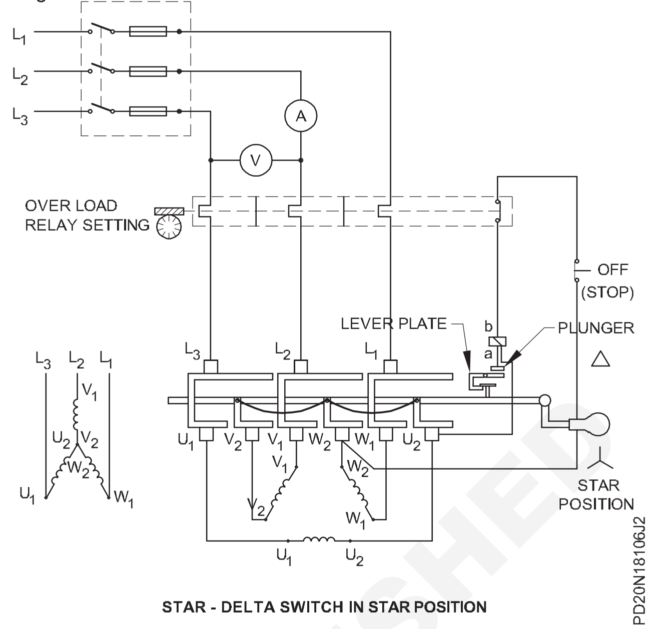


3 Make the connections of the motor, starter and the ICTP switch as per the approved diagram.

4 Connect three cables from supply L_1L_2 & L_3 to the main switch. (Fig 2)

5 Insert the ammeter in series with one of the line cables from the main switch and a voltmeter across two line cables. (Fig 2)

Fig 2

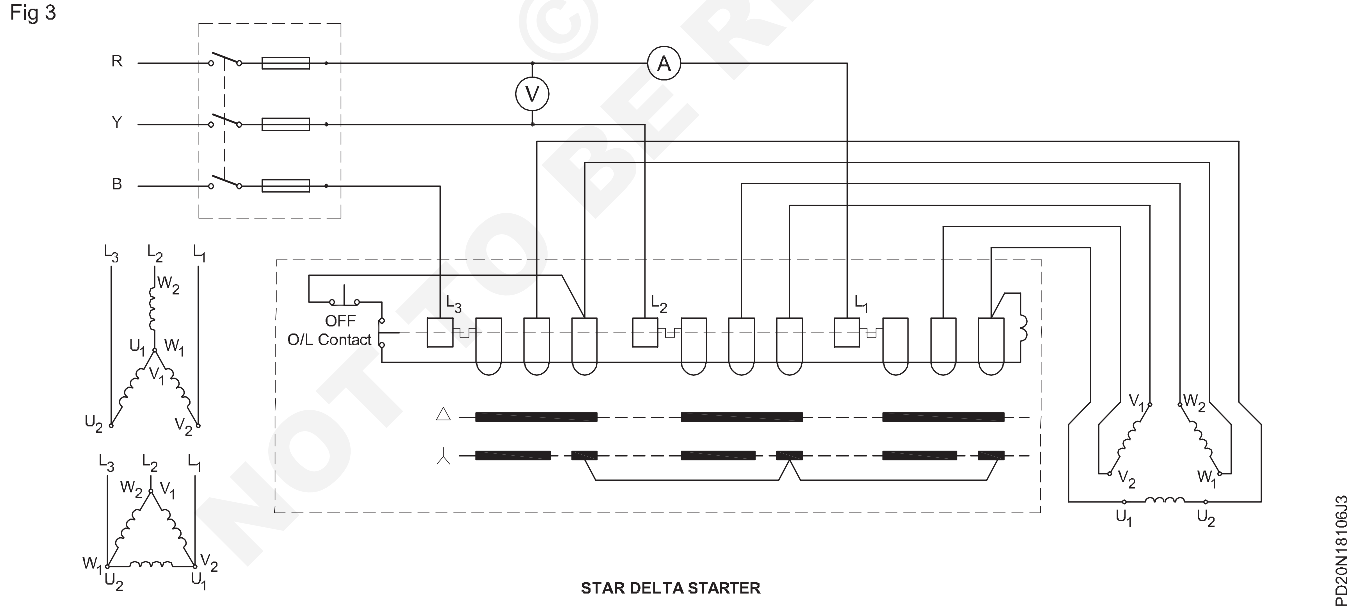


6 Wire the proper fuse element according to the given motor rating in the fuse-carrier and insert the carriers in the main switch.

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

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

Fig 3



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

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

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

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

Table 1

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

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

Table 2

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

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

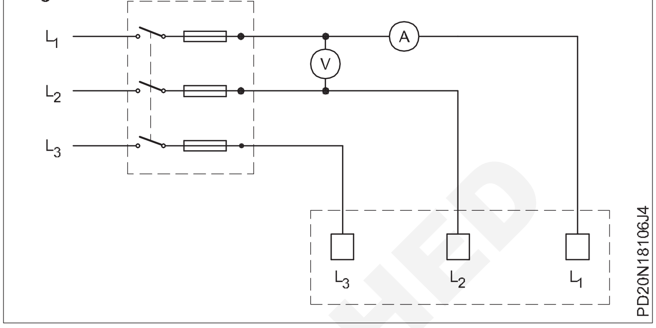
14 Switch 'OFF' the main switch and remove the fuses.

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

16 Insert the fuse-carriers in the main switch.

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

Fig 4



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

19 Insert the fuse-carriers in the main switch.

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

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

____

____

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

— — — — — —

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

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

2 Check the earthing connection for its effectiveness.

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

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

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

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

Get the circuit checked by the instructor before proceeding.

7 Make connections as per diagram.

8 Switch on S1. Switch on the contactor.

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

10 Measure rpm of the induction motor.

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

Fig 1

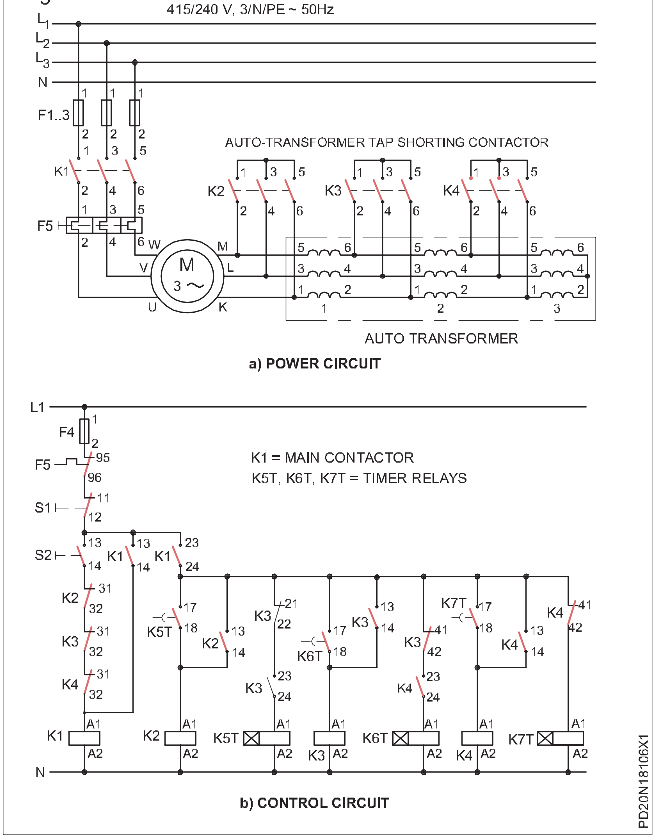
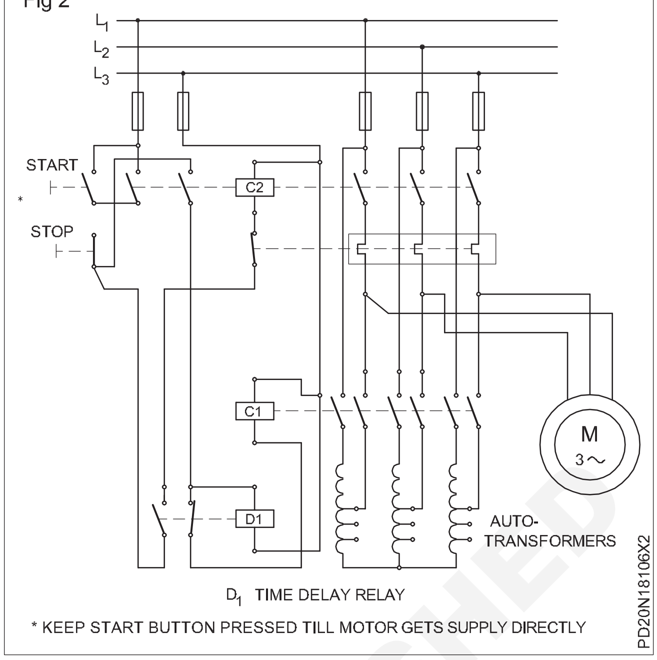
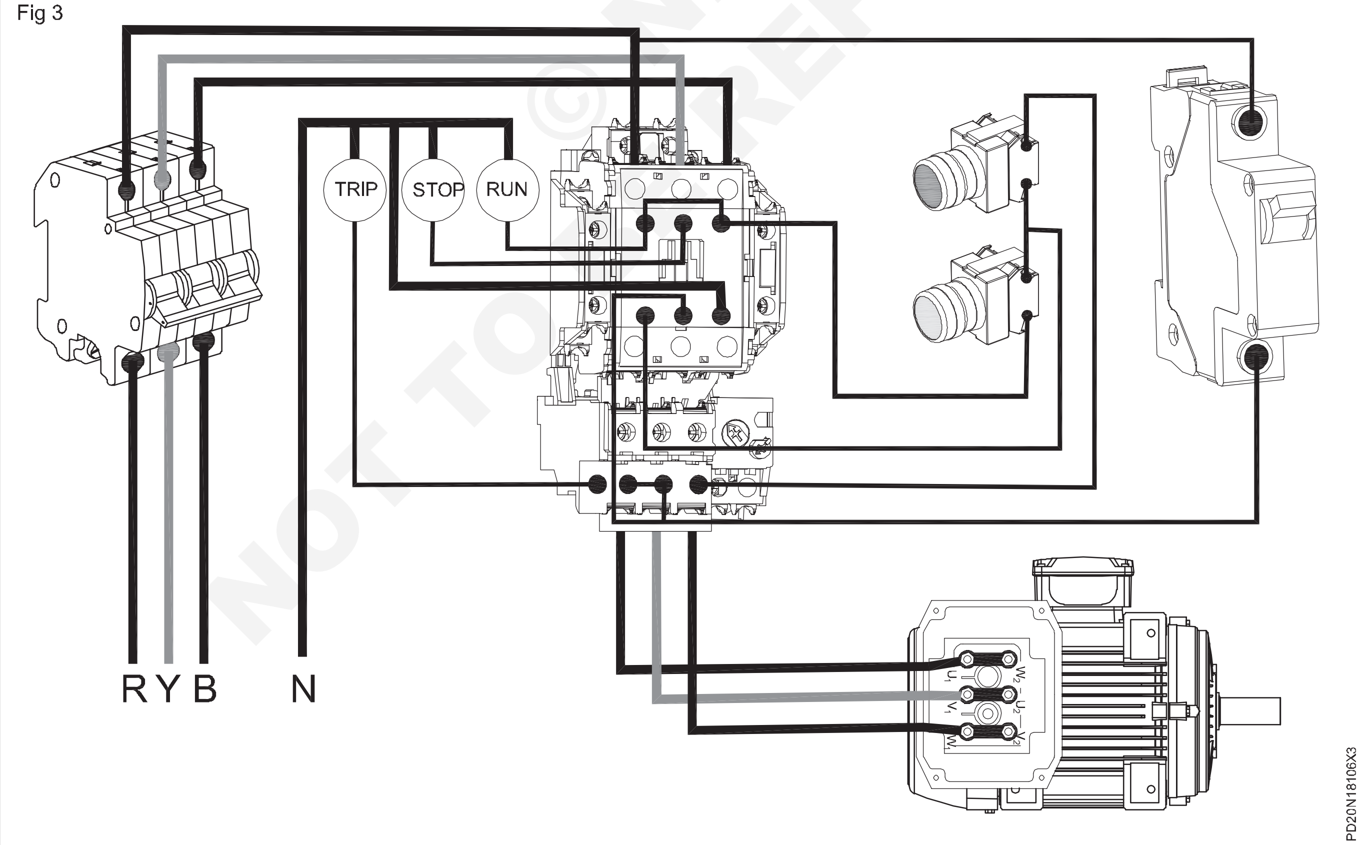


Fig 2



A New type of starter is given below for trainees reference (Fig 3)

Fig 3



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

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

Requirements

Tools/Instruments

• Insulated cutting pliers 200mm	- 1 No.
• Connector screwdriver 100mm	- 1 No.
• Electrician's knife 100mm	- 1 No.
• Screwdriver 200mm	- 1 No.
• MI Voltmeter0-500V	- 1 No.
• Tachometer 300 r.p.m to 3000 r.p.m	- 1 No.
• MI Ammeter 0-20A, 0-10A	- 1 each
• Megger 500V	- 1 No.
• MI Ammeter centre zero 5-0-5A	-1 No.
• Rotor resistance starter, complete set, suitable for 5HP 415V 3-phase slip-ring induction motor	- 1 Set
• Mechanical loading arrangement complete set	- 1 Set

Equipment/Machines

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

Materials

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

PROCEDURE

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

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

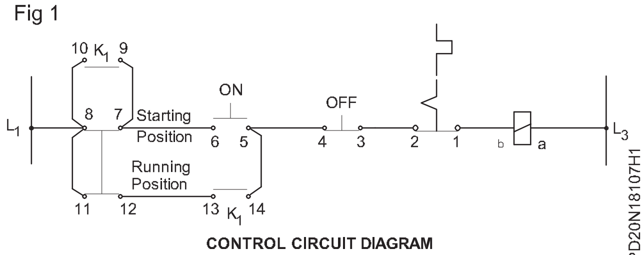
2 Identify the terminals of the 3-phase, slip-ring induction motor.

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

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

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

Fig 1



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

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

To start and run the motor

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

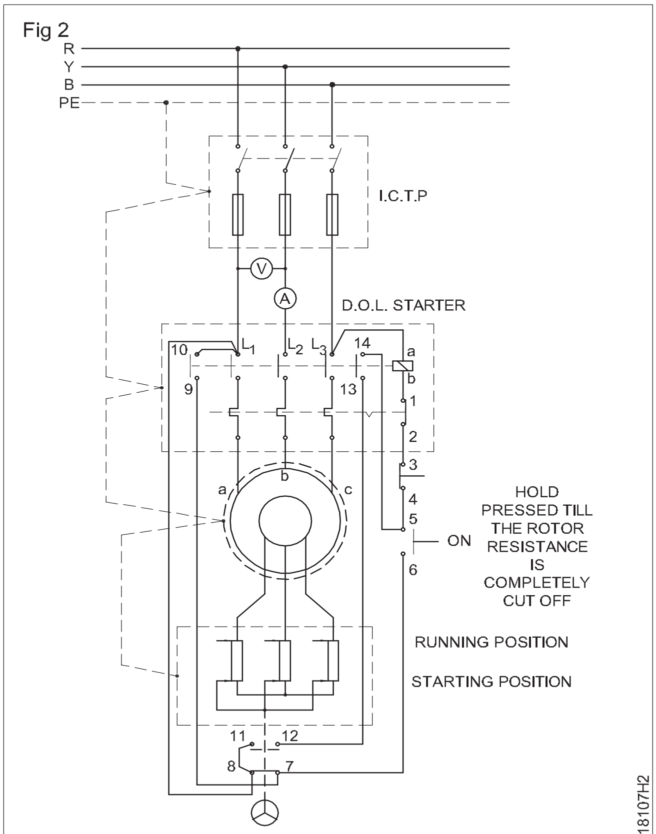
8 Press the start-push button of the starter. While pressing the start-push button, slowly move the handle of the rotor resistance from the starting position towards the running position till it settles down at 'run' position.

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

10 Release the pressure from the start-push button.

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

12 Measure the speed and enter in Table 1.



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

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

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

Investigate the following:

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

Write your conclusion.

____

____

Table 1

(L-with air gap)

Measured resistance = ...ohms

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

Change DOR

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

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

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

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

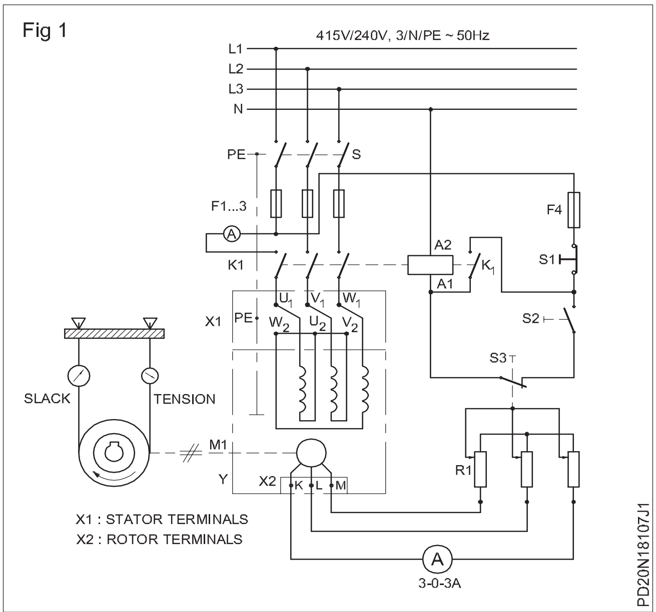
18 Stop the motor, switch 'off' the mains, remove the fuses and disconnect the cables.

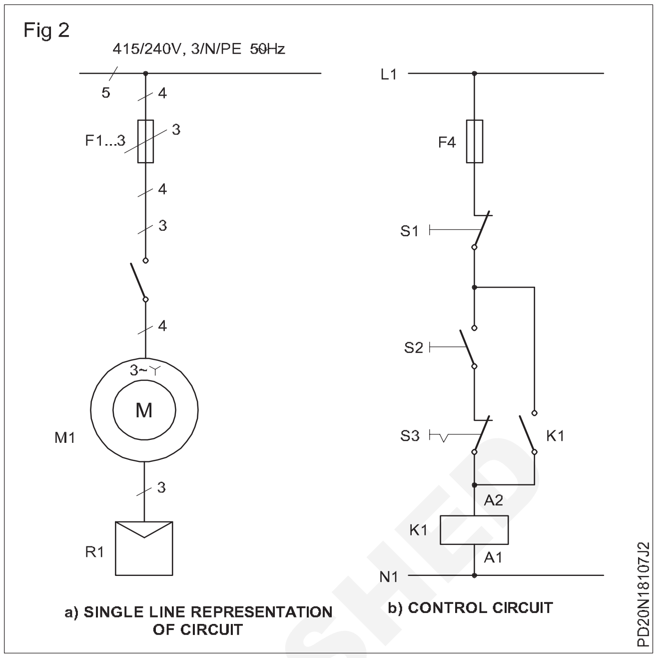
— — — — — —

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

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

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





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

4 Start the motor on no-load.

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

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

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

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

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

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

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

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

10 Apply the formula

$$\text{Slip} = \frac{f_r}{f}$$

Table 2

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

— — — — — —

Practice on connection and setting of soft starters

Objectives: At the end of this exercise you shall be able to
- **connect soft starter**
- **know wiring diagram of soft starter**
- **start and stop the motor through soft starter.**

Requirements

Tools/Instruments

- Combination piler 200mm - 1 No.
- Screwdriver 300mm - 1 No.
- Connecting Screw driver 100 mm - 1 No.

Equipment/Machines

- 3 Phase Supply - 1 No.
- 3 Phase Motor - 1 No.
- Circuit breaker - 1 No.
- Bypass contactor - 1 No.

Materials

- PVC insulated, Single stand
- Copper Wire 0.5 m - 0.5 m

PROCEDURE

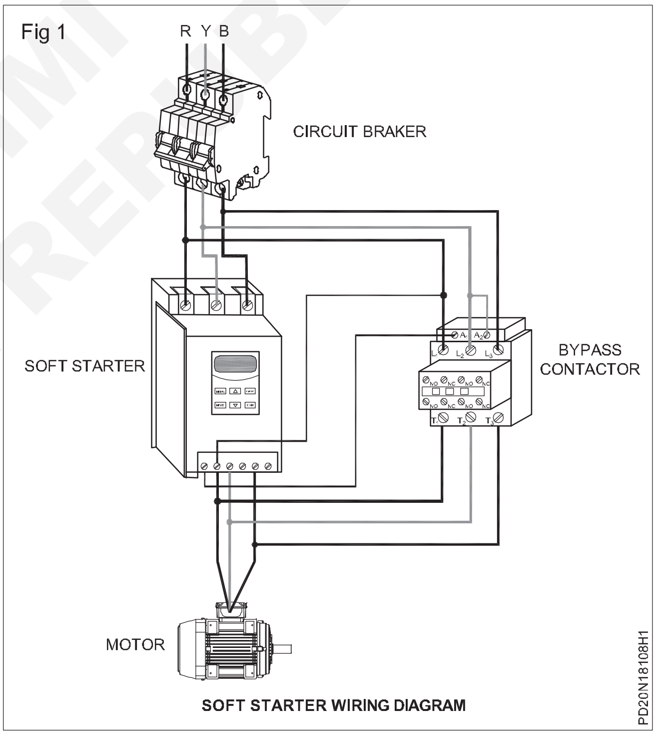
1 Connect the incoming power supplies at the top side as in Fig 1.

2 Connect the outgoing terminals of at the bottom side. Must check the identification on the soft starter for an incoming and outgoing connection.

3 Connect the bypass contactor in parallel to the soft starter with main power supply.

4 Find out the bypass out put terminal on the soft started and connect the contactor coil terminals to the bypass output of the starter. Generallty it is normally opened (NO).

Fig 1



SOFT STARTER WIRING DIAGRAM

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

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

Requirements

Tools/Instruments

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

Equipment/Machines

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

Materials

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

PROCEDURE

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

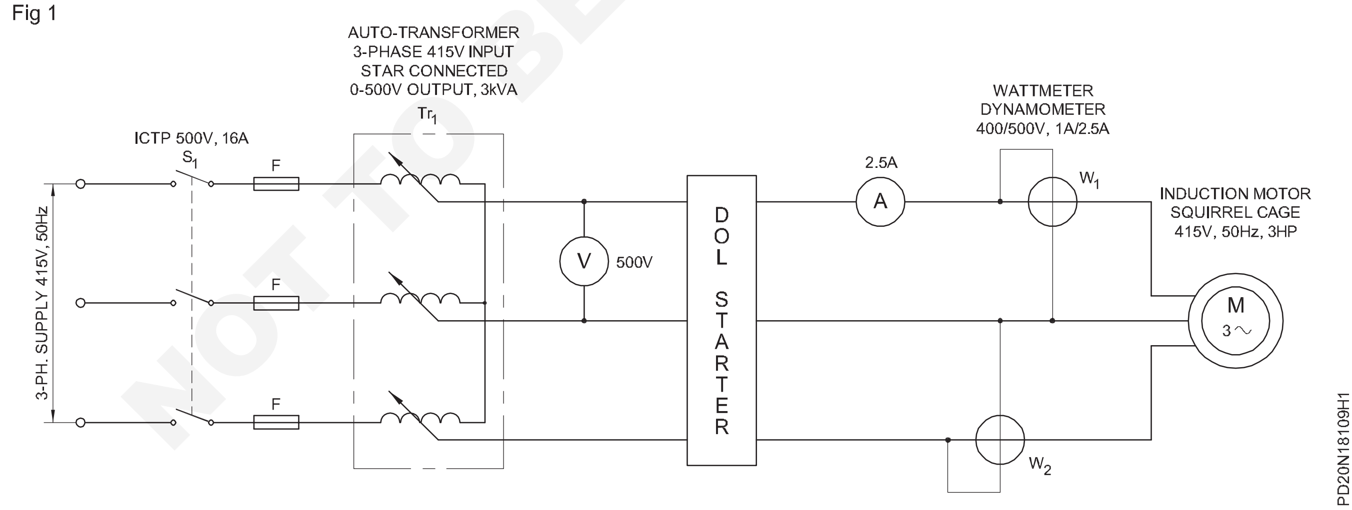
1 Record the name-plate details of the induction motor.

2 Collect all the required instruments for the circuit. (Fig 1)

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

4 Check the supply for the rated value and switch 'ON' the ICTP switch (S_1) (If the value is not correct adjust by auto transformer)

Fig 1



5 Start the motor without any load.

6 Read and record the wattmeter, ammeter and voltmeter readings in Table 1.

7 Switch 'OFF' the supply and disconnect all connections of the meters, and the motor.

Table 1

Input voltage	Power input $W_O = (W_1 + W_2)$	No-load current I_O

8 Check the connections of the 3-phase supply leads to the motor terminals. If six terminals are available identify each phase winding.

9 Measure the resistance of the stator using DC low voltage supply, ammeter and voltmeter. Record the reading in Table 2.

Table 2

DC supply voltage	Ammeter reading	Resistance of stator (one phase)

10 If the motor has only 3 terminals, and the internal connections are marked on the name plate, make calculations as below.

For star connection

Resistance per phase $R_P = \frac{V}{I} \times \frac{1}{2}$

Therefore $R_P = \frac{R}{2}$

For Delta connection

Resistance between two terminals $R = \frac{V}{I}$

Let the resistance per phase = R_P

$R = R_P \parallel 2R_P$ (R_P parallel to $2R_P$)

i.e $\frac{1}{R} = \frac{1}{2R_P} + \frac{1}{R_P}$

Resistance measured $= \frac{2}{3} R_P$

Therefore R_p (resistance per phase of stator) is $= \frac{2}{3} R$

Calculations

The no-load input: W_o = No load copper loss

$= (I^2_{oph} R_P) \times 3$

(I_{oph} = no load phase current)

For star connected motor $I_O = I_{oph}$

For delta connected motor $I^2_{oph} = \frac{I_0}{\sqrt{3}}$

The losses at no load are

- I^2R loss in the stator winding
- Core losses in the stator and rotor
- friction and windage losses

Core losses and friction and windage losses practically remains constant in induction motor.

Constant losses = $W_o - (I_{oph})^2 R.3)$

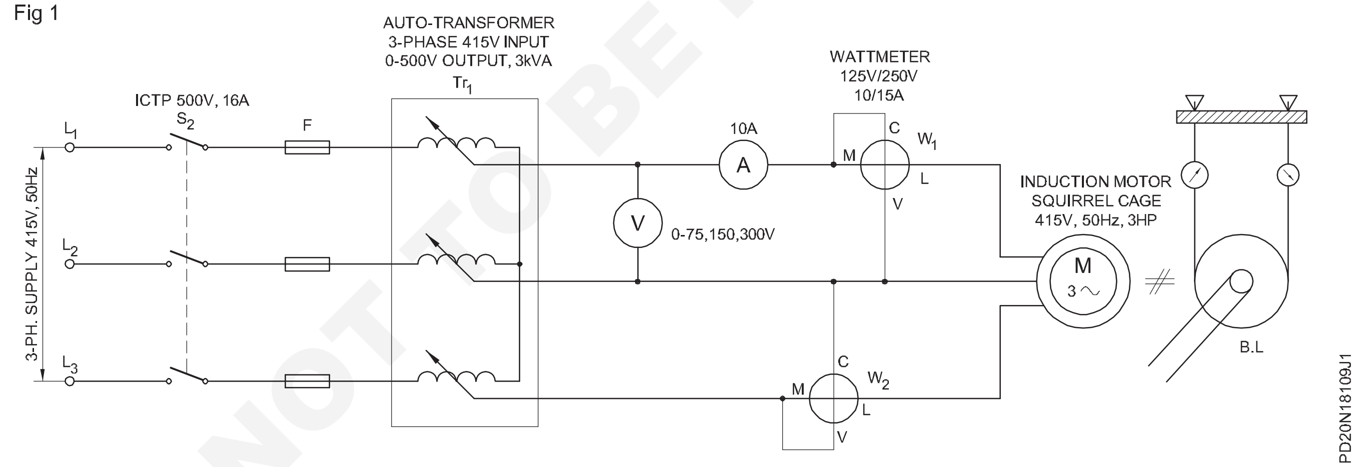
— — — — — —

TASK 2: **Conduct blocked rotor test**

1 Collect the instruments to form circuit as per diagram. (Fig 1)

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

Fig 1



Keep the auto-transformer at zero output voltage position.

3 Switch on ICTP switch 'S_2'.

4 Increase the output of the auto-transformer voltage gradually, watching the ammeter, till the current is equal to full load current.

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

Table 3

Input voltage V	Power input W	Blocked current I

Calculation

Wattmeter reading = full load I^2R loss.

= $3I^2_PR_e$,

where R_e = Resistance of stator winding per phase

Wattmeter reading= $3I_P^2R_e$,

I^2R at no load = $3I_o^2R_e$

Magnetic losses = No load input – copper loss.

Total loss = full load I^2R loss + Magnetic losses

= Block rotor wattmeter reading + Magnetic losses

$$\text{Efficiency} = \frac{\text{Output}}{\text{Input}} = \frac{\text{Input - Losses}}{\text{Output + Losses}}$$

Determine the efficiency of the motor at full load.

Constant losses

= Copper loss at full load = $3I^2_pR_e$ watts

where R_e – equivalent resistance/phase

I_P – full load current/phase

Copper loss at full load = _________ watts.

Input

= $\sqrt{3}$ x v x I x pf = ___________ watt.

Total losses = constant losses + copper loss

Therefore, efficiency = ____________

6 Determine the efficiency when the input current is 0.7 full load and p.f is 0.8.

Conclusion

____
____
____
____
____
____

— — — — — —

Test for continuity and insulation resistance of three phase induction motors

Objectives: At the end of this exercise you shall be able to
- **perform insulation resistance test between phase windings**
- **perform insulation resistance test between winding and body.**

Requirements

Tools/Instruments

- D.E spanner 5 mm to 20 m - 1 Set
- Cutting pliers 150 mm - 1 No.
- Screwdriver 200 mm - 1 No.
- Megger 500V - 1 No.
- Ohmmeter low range 0-10 Ohm - 1 No.
- Test lamp 240V, 60W - 1 No.
- Earth tester with spikes and connecting lead - 1 Set
- Hammer straight peen 1.5kg - 1 No.
- M.C voltmeter 0-10V - 1 No.
- M.C ammeter 0-20A - 1 No.
- Calibrated rheostat 0.1 ohm, 10 amp - 1 No.
- Battery 6V, 60 A - 1 No.
- M.I voltmeter 0-50V - 1 No.
- M.I voltmeter 0-25A - 1 No.

Equipment/Machines

- AC 3-phase, 415V / 3 H.P. squirrel cage induction motor - 1 No.

Materials

- Connecting cables 2.5 mm^2 of length 40m - 1 No.
- Connecting cables 2.5 mm^2 of length 10m - 1 No.
- Testing prods - 1 Pair

PROCEDURE

TASK 1 : **Test the continuity of 3 phase induction motor**

1 Note the name-plate details of the induction motor.

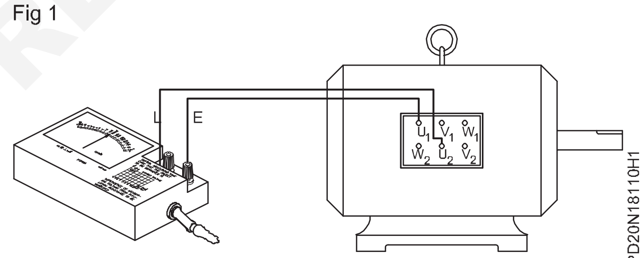
2 Identify the terminals of the given AC induction motor from the markings.

3 Connect the test loads of the megger to the terminals U_1 and U_2. (Fig 1)

4 Rotate the megger at its rated speed and note down the readings in Table 1.

5 Repeat the steps 3 and 4 by connecting the megger terminals between V_1 and V_2 and also between W_1 and W_2. Record the finding in Table 1.

Fig 1



The megger reading should be zero, if the winding of the motor is having continuity.

The megger reading should be high or infinity (∞) if the winding of the motor is open.

Table 1

Continuity test for 3 phase induction motor

Sl.No	Between terminals	Meter reading	Remarks
1	U_1 and U_2		
2	V_1 and V_2		
3	W_1 and W_2		

— — — — — —

TASK 2: **Measure the insulation resistance value between the windings**

1 Connect the test leads of the megger to the terminals U_1 and V_1. (Fig 1)

2 Rotate the Megger at its rated speed and note down the readings in Table 1.

Fig 1

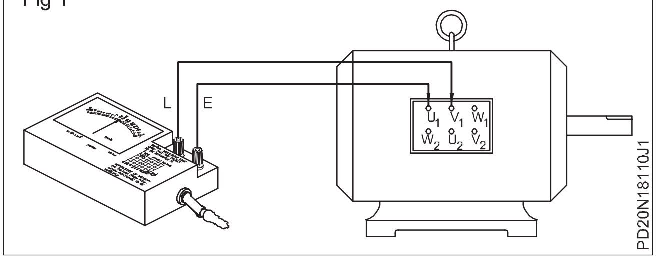


Table 1

Insulation resistance of 3-phase induction motor

Sl. No	Between terminals	Insulation resistance	Remarks
1	U_1 and V_1		
2	U_1 and W_1		
3	V_1 and W_1		
4	U_1 and frame		
5	V_1 and frame		
6	W_1 and frame		

3 Repeat the steps 1 and 2 by connecting the Megger terminals between U_1 and W_1, and also between V_1 and W_1. Record the findings in Table 2.

Recommended standard insulation resistance

$R_1 = \frac{20 \times E_n}{1000 + 2P}$ in megohm .

where

R_1 = insulation resistance in megohms at 25^0C.

E_n = rated phase-to-phase voltage

P = Rated power in kW.

If the resistance is measured at a temperature different from 25°C, the value shall be corrected to 25°C.

The equation given here is used to calculate the insulation resistance as a standard value. However the accepted insulation value should not be less than 1 megaohms.

— — — — — —

TASK 3 : **Measure the insulation resistance between each winding and body or frame**

1 Connect the test leads of the Megger to the frame of the motor and terminal U_1. (Fig 1)

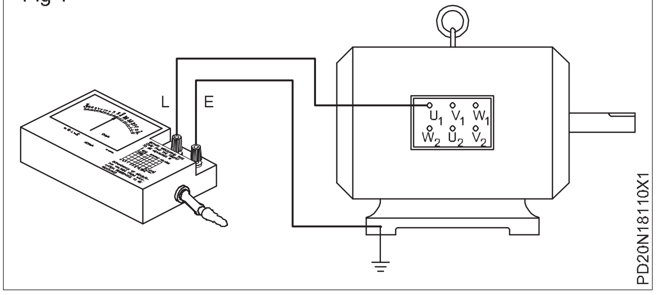
The Megger connection to the frame should be done at the earthing stud of the frame. Before connecting, remove the varnish, dust, dirt and grit thoroughly at the earthing stud.

2 Rotate the Megger at its rated speed and note down the readings.

3 Repeat steps 1 and 2 for the other two windings (V_1 and W_1).

4 Compare the measured value with the standard value.

Fig 1



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Perform speed control of 3-phase induction motors by various methods like rheostatic control, auto transformer etc.

Objectives: At the end of this exercise you shall be able to
- **connect the 3 phase slip ring induction motor through rotor resistance starter**
- **control the speed of a 3-phase slip ring motor by rotor resistance starter**
- **connect a 3 phase induction motor to an auto transformer starter**
- **control the speed of a 3 phase induction motor by auto transformer starter.**

Requirements

Tools/Instruments

- Insulated cutting pliers 200 mm - 1 No.
- Connector screw driver 100 mm - 1 No.
- Electrician's knife 100 mm - 1 No.
- Screw driver 200 mm - 1 No.
- MI Voltmeter - 0-500 V - 1 No.
- Tachometer 300 rpm to 3000 rpm - 1 No.
- Megger 500V - 1 No.

Equipment/Machines

- AC 3 Phase slip ring induction motor 415V 3HP - 1 No.
- Rotor resistance starter complete set suitable for 3HP - 1 No.
- AC 3 phase squirrel cage induction motor 500V, 5 HP - 1 No.
- Auto - transformer starter complete set suitable for 5 HP - 1 No.

Materials

- PVC Insulated flexible cable 2.5 sq mm - 20 m
- IC TP switch 10A 500V - 2 Nos.
- Test Lamp 40 W 250V - 1 No.

PROCEDURE

TASK 1 : **Control the speed of a slip ring Induction motor by a rotor resistance starter**

1 Check the Insulation and continuity of the motor winding.

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

3 Check the supply and provide proper rating fuses in the main switch according to the motor rating.

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

> **Cut in position of the rotor resistance is generally indicated in the starter as starting position or off position.**

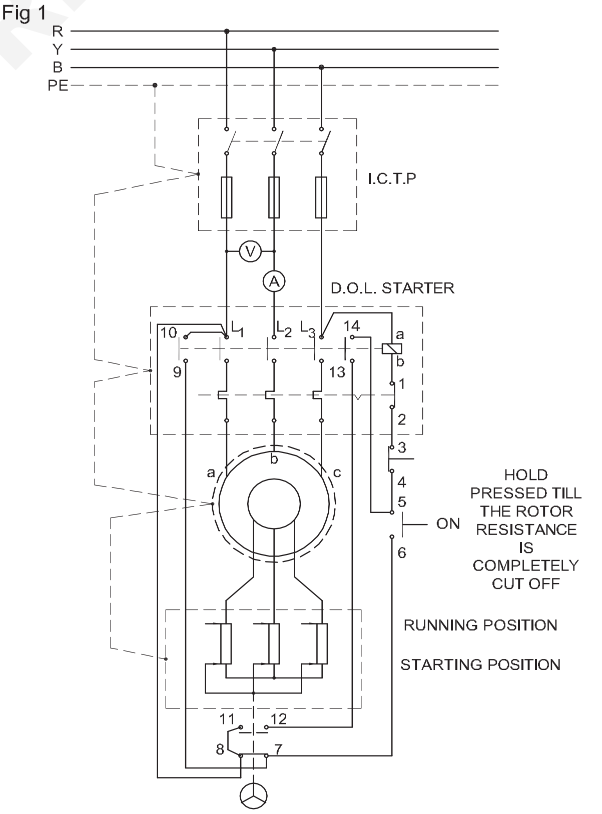
5 Press the start button of the starter, while pressing the start push button, slowly move the handle of the rotor resistance from the starting position towards the running position step by step till it settles down at run position.

6 Measure the speed at every step of rotor resistance and record them in Table 1.

Table 1

S.No.	Rotor Resistance Handle position	Speed in RPM

Fig 1



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

PD20N18111H1

7 Release the pressure from the start push button.

8 Press the off button of the starter to stop the motor.

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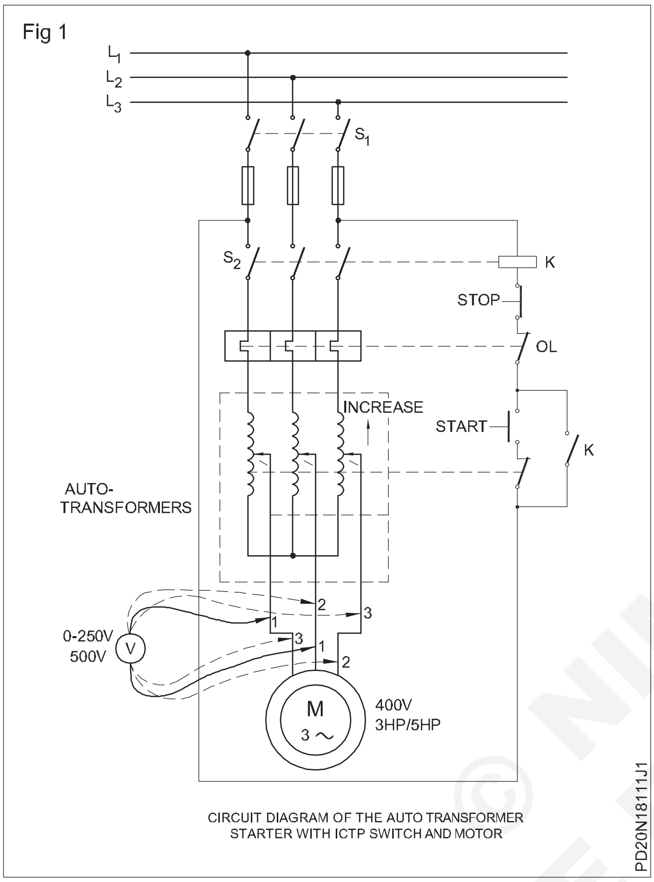
TASK 2: **Control the speed of 3-phase Induction motor by an auto transformer starter**

1 Check the insulation and continuity of the motor winding.

2 Make connections as per diagram. (Fig 1)



Get the circuit checked by the instructor before proceeding.

3 Switch on the main switch 'S1' and then press start push button. (keep auto-transformer for 100V output)

4 Start moving the auto transformer starter contacts such that the induction motor will start getting more voltage in stages upto full voltage.

5 Note the speed and voltage at every stage.

6 Reduce the applied voltage to the induction motor by resetting the auto-transformer contacts.

7 Measure the rpm of the induction motor at every stage and note in Table 2.

Table 2

Sl.No.	Line voltage (V1)	rpm

8 Switch off by pressing stop button and then switch off the main switch (S1)

Conclusion

State in what proportion the speed changes with respect to applied voltage to induction motor.

— — — — — —

Identify parts and terminals of different types of single phase AC motors

Objectives: At the end of this exercise you shall be able to
- **read and interpret the name plate details of the given single phase AC motors**
- **identify their parts and write their names**
- **identify the pairs of two windings of 3 terminals & four terminals of single phase motor**
- **measure the resistance of each winding by an ohmmeter.**

Requirements

Tools/Instruments

- Trainee's tool kit - 1 No.
- Ohmmeter/ Multimeter - 1 No.

Equipments/Machines

- Induction start induction run motor 1/2 HP, 240V, 50Hz - 1 No.
- Single phase capacitor start induction run motor 1HP,240V,50Hz - 1 No.
- Universal motor 240V, 50Hz,0.5HP - 1 No.

PROCEDURE

TASK 1: **Identify the parts of single phase induction start motor / split phase motor**

1 Read and interpret the name plate details of the single phase induction start induction run motor and note down in Table 1.

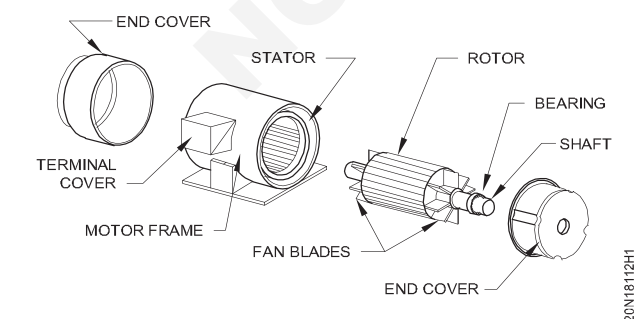
Table 1

Name-plate details

Manufacturer, Trade mark	Rated frequency ....
Type, model or serial number	Rated power ....
Type of current	Rating class ....
Function	Insulation class ....
	Rated current ....amp
	Rated speed ....r.p.m
Rated Voltage ....Volts	Protection class ....

2 Identify the parts of single phase induction start induction run motor from the real objects or from the exploded view chart. (Fig 1).

Fig 1



PARTS OF 3 PHASE SQUIRREL CAGE INDUCTION MOTOR

3 Label the each identified parts with number tags.

4 Write the name of the parts of each labelled numbers tag in Table 2.

Table 2

S.No.	Label No.	Name of the parts
1		
2		
3		
4		
5		
6		
7		
8		

TASK 2: **Identify the parts of capacitor start induction run motor**

1 Read and interpret the name details of the capacitor start, induction run motor

2 Identify the parts of the capacitor start, induction run motor from the real objects (or) from the exploded view Fig 1&2 and note down each labelled number in Table 1.

Fig 1

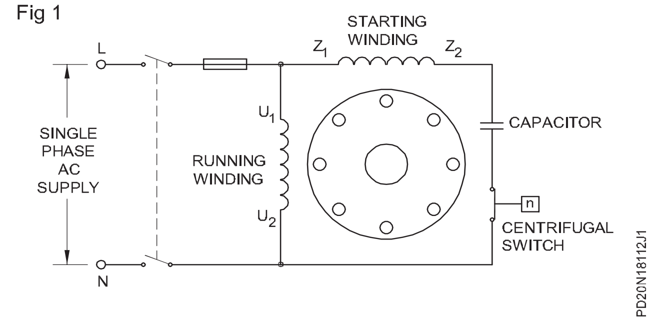
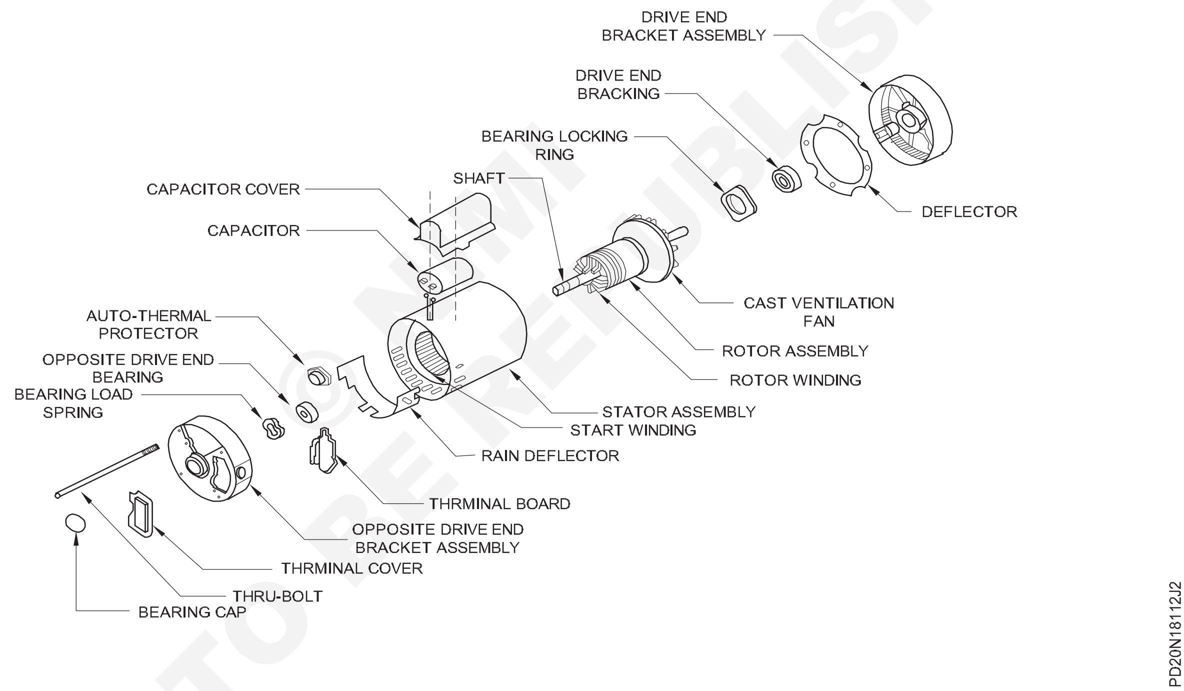


Table 1

S. No.	Label No.	Name of the parts
1		
2		
3		
4		
5		
6		
7		
8		

Fig 2



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TASK 3: **Identify the parts of single phase capacitor start capacitor run motor/permanent capacitor motor**

1 Read and interpret the name plate details of permanent capacitor motor.

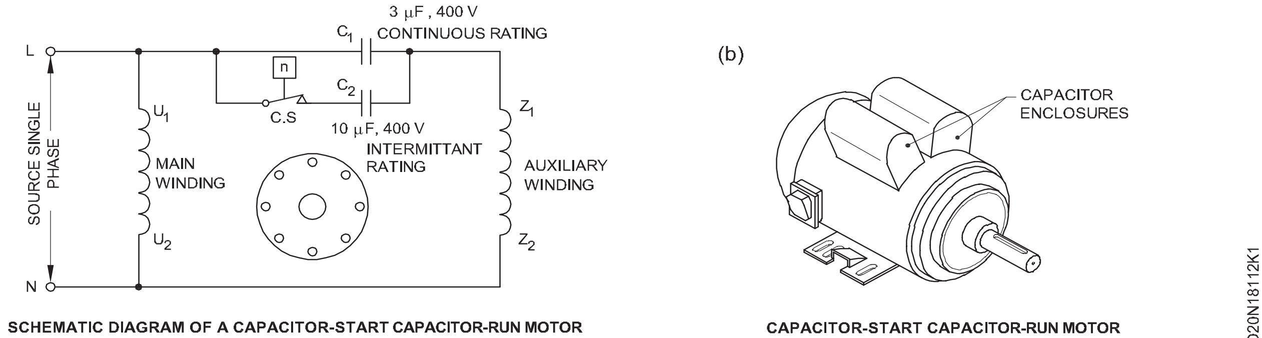
2 Identify the parts of the permanent capacitor motor from the real objects (or) from the exploded view of Fig 1a and 1b and note down each labelled number in Table 1.

3 Get it checked with your instructor.

Table 1

SI No.	Label No.	Name of the parts
1		
2		
3		
4		
5		
6		
7		
8		

Fig 1



SCHEMATIC DIAGRAM OF A CAPACITOR-START CAPACITOR-RUN MOTOR

CAPACITOR-START CAPACITOR-RUN MOTOR

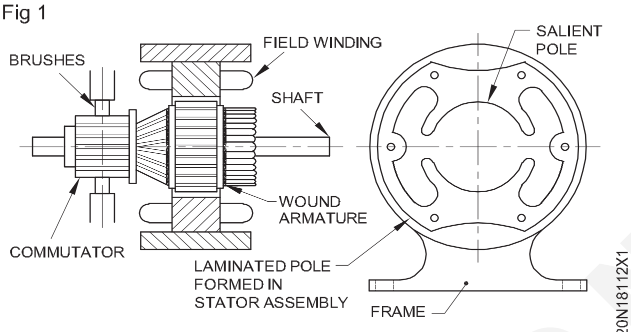
— — — — — —

TASK 4 : **Identify the parts of universal motor**

1 Read and interpret the name plate details of the universal motor.

2 Identify the parts of the universal motor from the real objects (or) from the exploded view.(Fig 1)

Fig 1



PARTS OF A UNIVERSAL MOTOR

3 Label the each identified parts with number tags.

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

Table 1

S.No.	Label No.	Name of the parts
1		
2		
3		
4		
5		
6		
7		
8		

5 Get it checked with your instructor.

— — — — — —

TASK 5 : **Identify 3 terminals of the pair of two windings of single-phase split phase induction motor**

1 Remove the terminal cover. Make connection using a piece of cable and short circuit two terminals at a time to discharge the capacitor.

2 Remove the capacitor if any and test the capaicator for insulation and leakage.

3 Measure the resistance in between pairs of terminals by an ohmmeter. (Fig 1)

4 Mark the terminals between which you get maximum reading as 1 and 3. Mark the unmarked terminal as 2.

5 Record the resistance values in Table 1 according to your terminal marking made.

The reading between the pair of terminals 1 & 2 and 1 & 3, whichever is greater is considered as the terminals of starting winding and the other is considered as terminal of running winding.

Fig 1

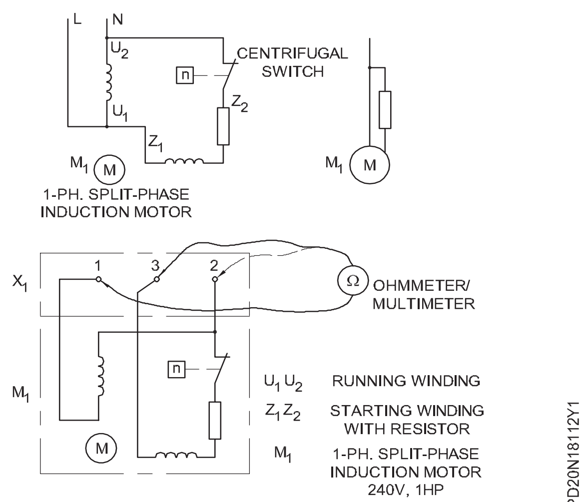


Table 1

Resistance between 1 & 2	Resistance between 2 & 3	Resistance between 1 & 3

— — — — — —

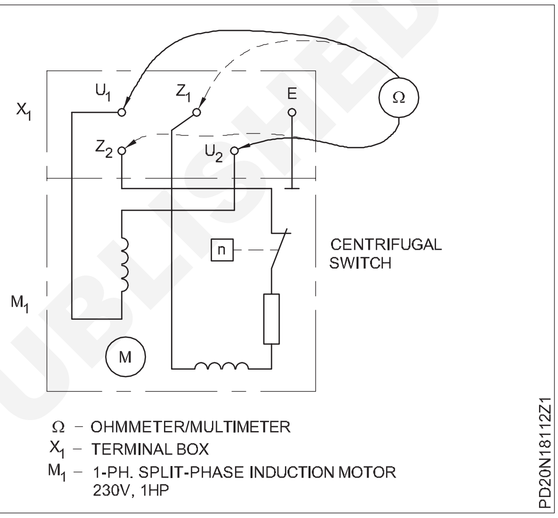
TASK 6 : **Identify 4 terminals of the pair of two windings of single phase split phase induction motor**

1 Repeat the steps 1 and 2 of Task 5.

2 Find out the pairs of terminals and number one pair of terminals as 1 and 2. The other pair is numbered as 3 and 4 (Fig 1)

3 Measure the resistance between U1 and U2 and Z1 and Z2..

Fig 1



Conclusion

1 Higher resistance is between ____________________ terminals.

2 Lower resistance is between the terminals marked as ____

Therefore the starting winding is connected between ____

Resistance between 1 & 2 = ________________ohms

Resistance between 3 & 4 = _________________ohms

— — — — — —

Install connect and determine performance of single phase AC motor

Objectives: At the end of this exercise you shall be able to
- **read the manufacturer's installation instruction and follow the same**
- **transfer the template measurements to the mounting base**
- **make the template of the base (mounting) of the given motor**
  - **frame (wooden)making**
  - **marking**
  - **drilling**
  - **selecting hole size.**

Requirements

Tools/Instruments

- Masonry tools like travel spirit level etc - 1 Set
- Drilling machine Electric 12.7 mm capacity with drills - 1 No.
- Measuring tape 3 meters - 1 No.
- Electrician hand tool kit - 1 Set
- Spanner set 5 mm to 30 mm - 1 Set
- Ball pein hammer 500 g - 1 No.

Equipments/Machines

- A.C Single phase motor 0.5 HP 240V - 1 No.

Materials

- Connecting cables - as reqd.
- Plywood 8 mm thick 40 x 30 cm - 1 No.
- Nuts, grouting bolts - as reqd.
- GI wire 14 SWG - 6 m

PROCEDURE

TASK 1: **Installation of single phase AC Motors**

1 Read the name plate details and record in the motor maintenance card (Table 1)

Table 1

Name-plate details

Voltage _________ Phase _________ Type ________	
Rating _______________ Speed _______________	
Power factor ___________ Current _____________	
SL No. _________________________	

2 Make necessary arrangements at the place where the motor is to be installed as per manufacturer's nuts and bolts or / and R.C.C. foundation etc.

3 Determine the size of the connecting cable and fuse from the rating of the motor. (Table 2)

Fuse current rating will be 3 or 2 times more than running current. If it has the dual function of overload protection also, the rating should be as recommended by the manufacturer or as per I.S recommendations.

4 Cut two straight pieces and two cross pieces of plywood as shown in Fig 1 and mark the holes accordingly to the size of the holes of the base of the motor on the wooden frame planks (Fig 1)

Table 2

Calculating fuse ratings of motors

Motor type	Multiply the running current of the motor by
Single phase	3
Squirrel-cage, full voltage start	3
Squirrel-cage, reduced voltage start or high - reactance type (if motor is rated at 30 ampere's or less)	

5 Select the size of the drill according to the size of the mounting bolt as recommended by the manufacturer.

6 Drill the holes according to the size mentioned.

7 Make use of the template measurements on the mounting base and get the base mounting ready for installing the motor. (Fig 2)

a) Fix the planks with a grouting bolt.

b) Check for level using the spirit level.

c) Fill the space around the bolts with thin coarse cement mortar.

Fig 1

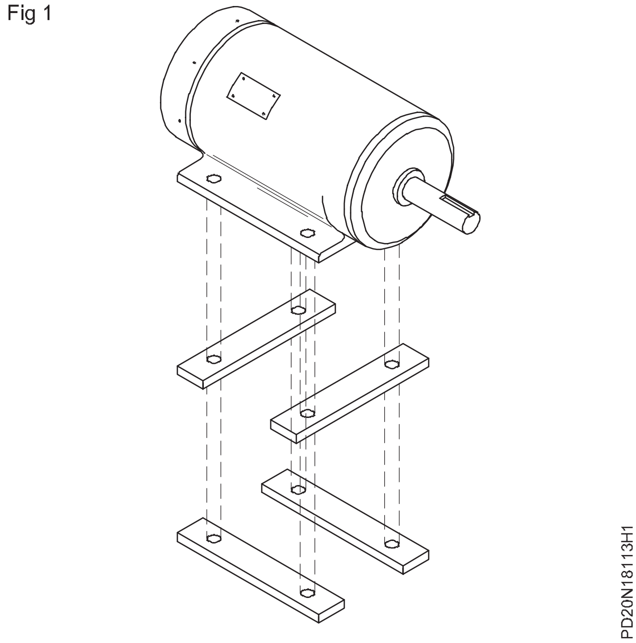
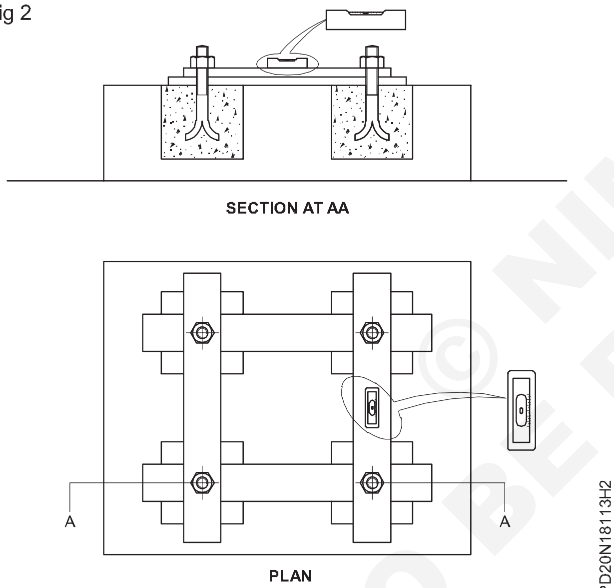


Fig 2



In the training institute use clay mortar instead of cement to facilitate repetition easily by every trainee in a batch.

d) Allow it to settle down for 8 to 12 hours, then remove the template planks.

e) Cure the cement mortar with water for a minimum of 2 days

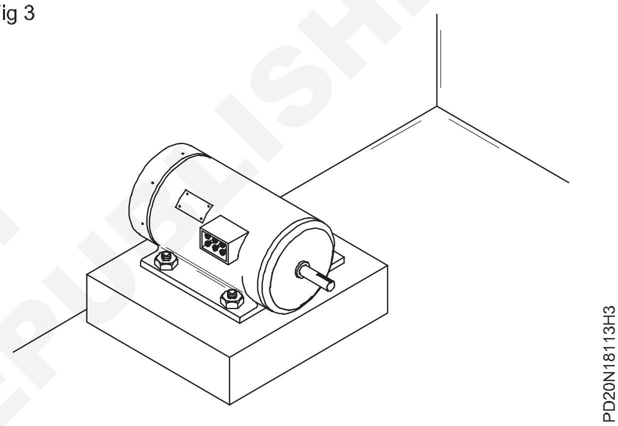
f) Finish the surface by plastering neatly.

Include vibration arresting devices as per the manufacture's instructions such as spring washers etc.

8 Install the motor and fix it with nuts (Fig 3)

9 Make double earthing in accordance with I.E. regulations and I.S. recommendation.

Fig 3



10 Start the motor and observe any mechanical vibrations are there or not.

11 If any mechanical vibrations is there, then stop the motor and tighten nuts properly.

— — — — — —

Start run and reverse the direction of rotation of single phase AC motors

Objectives: At the end of this exercise you shall be able to
- **start run and reverse the D.O.R of induction start, induction run motors through DOL starter**
- **start run and reverse the D.O.R of capacitor-start, induction run motors**
- **start run and reverse the D.O.R of capacitors start, capacitor - run motor.**

Requirements

Tools/Instruments

- Trainee's tool kit - 1 No.
- Pulley puller 15 cm - 1 No.
- MI Voltmeter 0-300V - 1 No.
- MI Ammeter 0-10 A - 1 No.
- Megger 500 V - 1 No.
- Ohmmeter - 1 No.

Equipment/Machines

- Single phase induction start, induction run motor 1/2HP, 250V, 50Hz - 1 No.
- D.O.L starter for single-phase motor 10A, 250V - 1 No.
- Capacitor start , induction run motor 250v, 50Hz, 1Hp - 1 No.
- Capacitor start, capacitor run motor 250V, 0.5 HP, 50Hz - 1 No.
- Regulated power supply (0.30v) - 1 No.

Materials

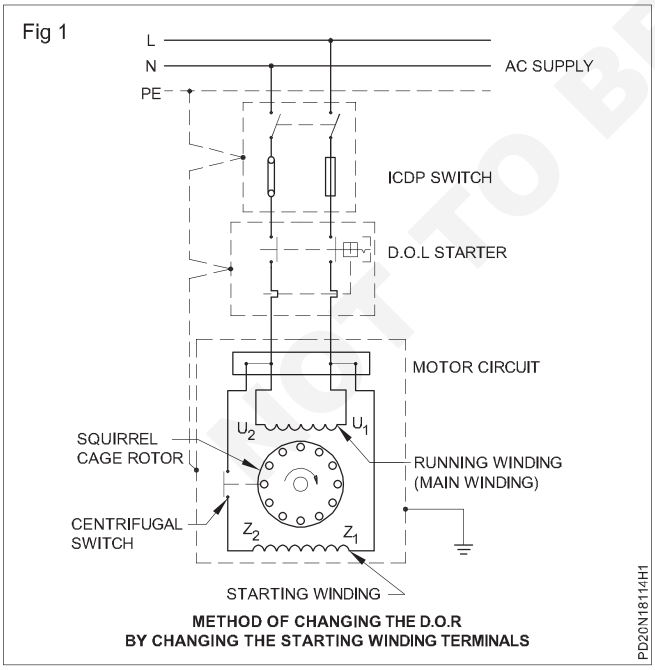
- GI wire 14 SWG - 6 m
- 2.5 sq. mm. PVC copper wire 250 V grade - as reqd.
- I.C.D.P. switch 16 A,250V - 1 No.
- Fuse wire 10A - 10 gm

PROCEDURE

TASK 1 : **Start , run and reverse the D.O.R of Induction start induction run motor through D.O.L Starter**

1 Draw the complete connection diagram of the given motor, starter and I.C.D.P. (Fig 1)

Fig 1



METHOD OF CHANGING THE D.O.R BY CHANGING THE STARTING WINDING TERMINALS

2 Get the diagram approved by your instructor.

3 Connect the motor through the I.C.D.P. switch and starter as per the approved diagram across the AC rated voltage supply. Provide earth connection to the motor, the starter and the switch.

4 Replace with a fuse of proper capacity according to the motor rating and set the overload relay of the D.O.L. starter to the current rating of the motor.

5 Switch on the I.C.D.P. switch and press the start-button of the starter.

6 Check the direction of rotation and record it below. The direction of rotation is ....

7 Stop the motor by pressing the stop-button; switch `off' the I.C.D.P and remove the fuses.

The I.C.D.P. switch must be switched off and the fuses removed before any modification in the circuit is carried out.

For changing the direction of rotation

8 Change the connection of the starting winding (Fig 2) and record it below. Direction of rotation is ....

9 Stop the motor and interchange the connection of the main field winding.

The D.O.R is ....

10 Stop the motor and switch off the supply.

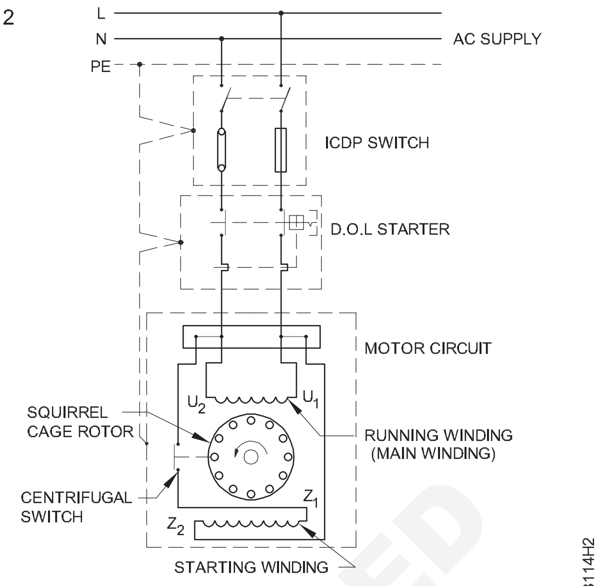
Conclusion

____

____

____

Fig 2



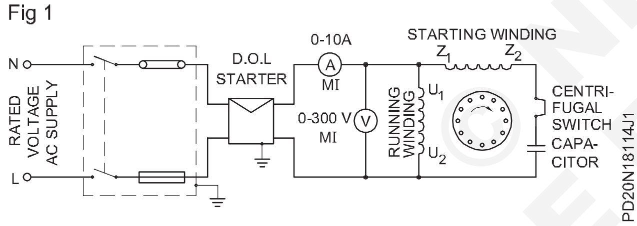
METHOD OF CHANGING THE D.O.R BY CHANGING THE STARTING WINDING TERMINALS

— — — — — —

TASK 2 : **Start run and reverse the D.O.R of single phase capacitor start induction run motor**

1 Make the connection as per the circuit diagram. (Fig 1) Earthing the I.C.D.P. switch, starter and motor is most essential.

Fig 1



2 Provide fuse-wire, according to the rating of the motor, in the I.C.D.P. switch and set the overload relay ampere in the D.O.L. starter to the rated value of the motor.

3 Switch `ON' the I.C.D.P.

4 Start the motor with the help of the starter and note the starting current, normal running current and the direction of rotation, and enter the details in Table 1.

Table 1

Sl.No.	Reference circuit diagram	Starting current	Running current	Direction of rotation
1				
2				
3				

For changing the direction of rotation

5 Stop the motor by the starter and switch `off' the I.C.D.P, and remove the fuse-carrier.

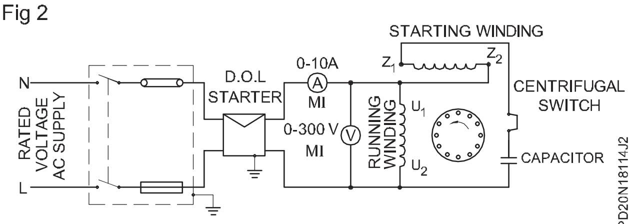
6 Interchange either the starting winding or the running winding terminals for changing the direction of rotation. Fig 4 illustrates the changing of the starting winding.

7 Replace the fuse-carrier, and then switch on and start the motor. Note down the direction of rotation in Table 1.

Effect of changing the supply leads

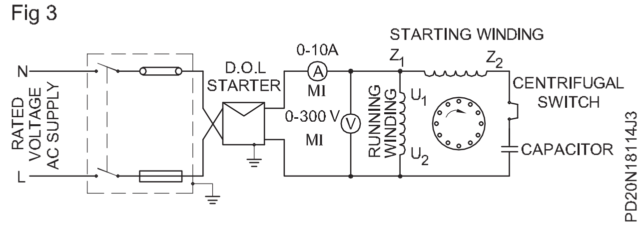
8 Switch off the motor and reconnect the winding. (Fig 1) Interchange the supply terminals as per circuit diagram. (Fig 2). Switch `ON' the motor. Check the effect on the direction of rotation and record the result in Table 2.

Fig 2



The D.O.R changed / did not change with respect to the condition as per circuit (Fig 3). (Strike out that part of the sentence which is not applicable).

Fig 3



Conclusion

____

____

____

Table 2

Sl.No.	Reference circuit diagram	Starting current	Running current	Direction of rotation
1				
2				
3				

— — — — — —

TASK 3 : **Start, run and reverse the direction of rotation of capacitor start capacitor run motors**

1 Identify the starting and running condensers and check their condition and data. Enter them in Table 3. Compare and analyse the data also relating to the starting and running condensers.

2 Show the readings to your instructor and get his approval.

3 Check the condition of the centrifugal switch, and ensure it is working.

Table 3

Sl.No.	Component part	Type	Value in micro-farad	Voltage		Duty Cycle	Condition
				Working	maximum		
1	Running capacitor						
2	Starting capacitor						

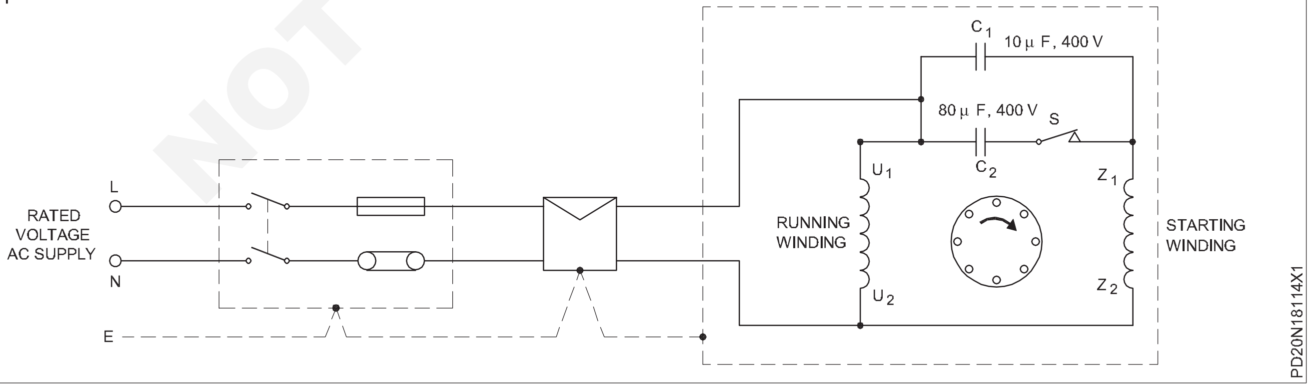
4 Connect the motor to the 240V AC supply through the switch and starter as per the circuit diagram. (Fig 1)

5 Insert a suitable size of fuse in the I.C.D.P switch and set the overload relay according to the rating of the motor.

6 Get the approval of your instructor for starting. Switch on the I.C.D.P and start the motor by pressing the start- button of the starter.

7 Check the direction of rotation and record the D.O.R below. Direction of rotation - clockwise/ anticlockwise.

Fig 1

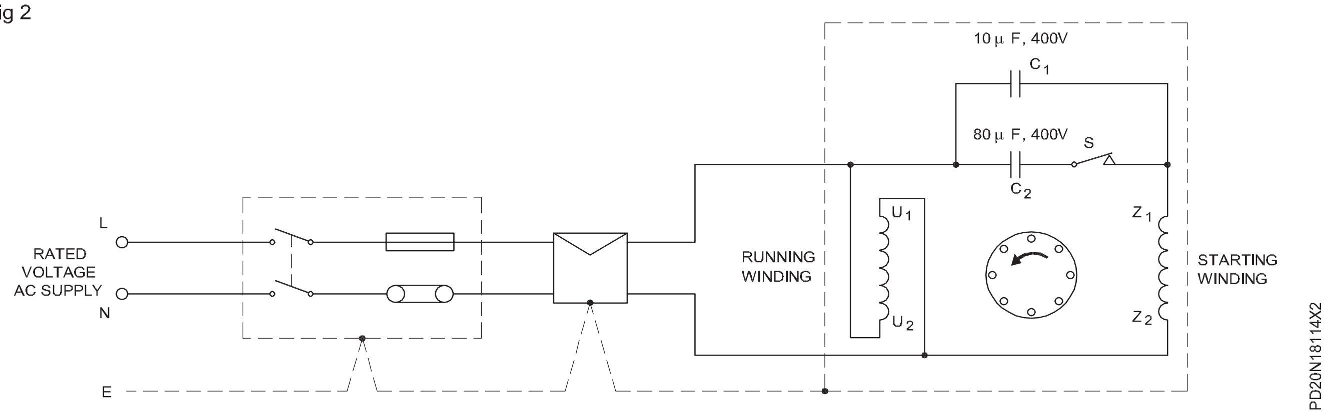


Change the direction of rotation of an AC single -phase capacitor, start capacitor-run motor.

For changing the direction of rotation

8 Stop the motor, switch off the I.C.D.P. Remove the fuse and interchange the running winding terminals. (Fig 2)

Fig 2



9 Repeat the steps 6 and 7 of task 3.

The direction of rotation could be changed either by changing the running winding terminal connections or by changing the starting winding terminal connections whichever is easier. The schematic diagram shown in Fig 8 is for a four terminal machine. For a ten terminal machine only the terminal U_1 and U_2 can be changed easily.

10 Stop the motor, interchange the starting winding terminal connections as shown in Fig 3. Keeping the running winding connection as in Fig 1 and repeat the steps 5 to 6 of task 1.

11 Check the D.O.R is clockwise/ anticlockwise.

12 Stop the motor, reconnect the starting and running winding as in Fig 1. Only interchange the supply terminal connections at the starter outgoing side as shown in Fig 4 and repeat the steps 8 and 9 of Task 1.

13 The D.O.R. is clockwise /anticlockwise.

14 Stop the motor. Switch off the ICDP. Remove the fuses. Disconnect the cables. Write your observation regarding the method of changing the direction of rotation and show to your instructor.

Conclusion

____

____

Fig 3

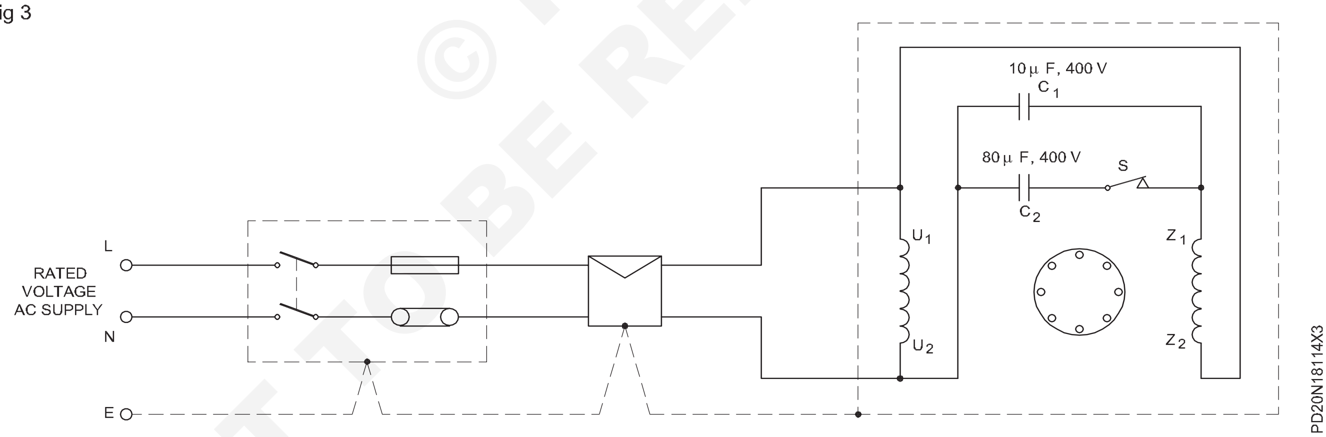
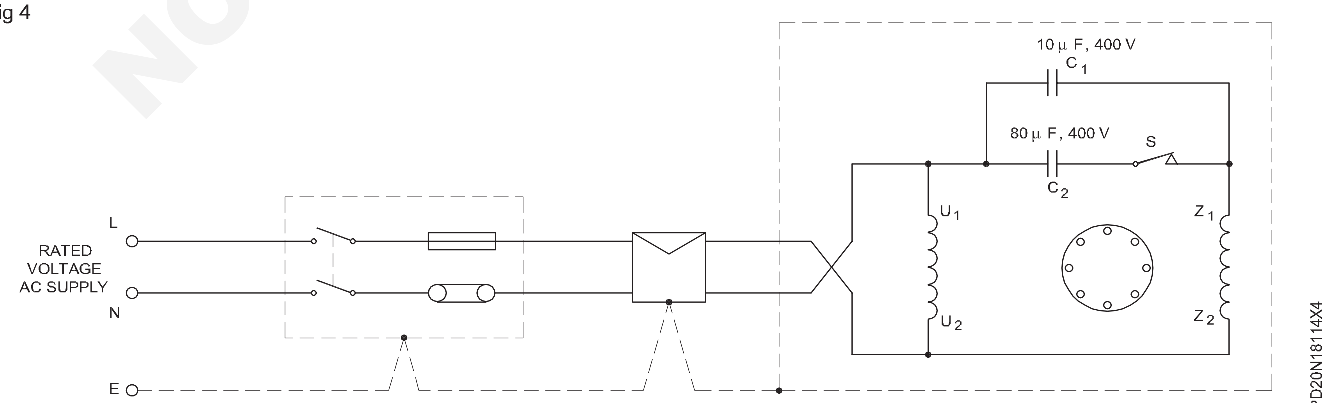


Fig 4



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Practice on speed control of a single phase AC motors

Objectives: At the end of this exercise you shall be able to
- **interpret the name-plate details of an ac series motor and determine full load current**
- **select a suitable variable resistor**
- **connect, run and measure the speed for different settings of the resistor.**

Requirements

Tools/Instruments

- Electrician tool Kit - 1 No.
- Voltmeter 0-300 V - 2 Nos.
- Ammeter 0 - 5A - 1 No.
- Tachometer 3000 rpm - 1 No.

Equipments/Machines

- AC series motor 240V 1/2 HP - 1 No.
- Rotary switch 6A, 250.4 position - 1 No.

Materials

- Connecting cable - as reqd.
- ICDP switch 16A 250V - 1 No.
- Wire wound enamel insulated resistor 10 ohms 100 W - 2 Nos.

PROCEDURE

TASK 1 : **Connect, run and control speed at a AC single phase motors**

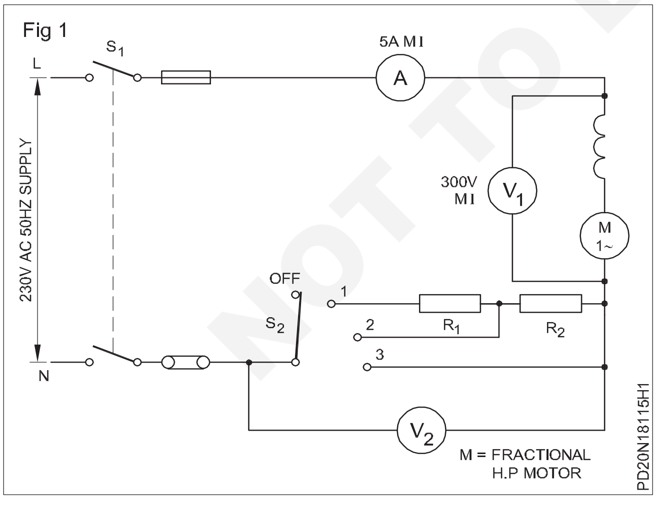
1 Read the name-plate details and record in Table 1.

2 Determine the load current from the name plate

To drop 80 V at position 1 and to drop 40 V at position 2. Calculate the required series resistors R_1 and R_2 and also determine their wattage (see example given)

3 Make the connections as per diagram (Fig 1) and make necessary arrangements to load the motor through prony brake.

Fig 1



4 Close the switch S_1.

5 Set the switch S_2 in position 1 and observe the starting of the motor.

6 Measure the current, voltages V_1 & V_2 and the speed. Record the values in Table 2.

7 Set the switch S_2, in position 2 and repeat the step 6.

8 Set the switch in position 3 and repeat the step 6.

Table 1

Manufacturer's name	
HP/KW	R.P.M.
Current	Voltage
Type	
Sl.No.	Insulation

Table 2

Switch S_2 Position	Current	V_1	V_2	Speed

— — — — — —

Practice maintenance and repair of AC single phase motors

Objectives: At the end of this exercise you shall be able to
- **follow general maintenance and service procedure**
- **test the single phase motor prior to dismantling**
- **dismantle, identify faults and rectify them**
- **assemble and test the motor**
- **identify the general causes of failure and trouble shoot them.**

Requirements

Tools/Instruments

- Electrician kit - 1 No.
- Set of D.E. spanners 8 to 22 mm - 1 Set
- Pulley puller 100 mm and 150 mm - 1 No. each
- Nylon hammer 1/4 kg - 1 No.
- Ohmmeter 0 - 1 kilo ohms - 1 No.
- Industrial, thermometer, metric, 0 to 300° - 1 No.
- Megger 0-500 V - 1 No.
- Voltmeter M.I. type 0-300 V - 1 No.
- Ammeter M.I. type 0-5 amps - 1 No.

Equipments/Machines

- Fraction horse power AC single phase (split phase) motor - 1 No.

Materials

- ICDP switch 16A 250V - 1 No.
- Test lamp - 1 No.
- Test prods 500V - 1 Set
- PVC insulated copper cable 2.5 sq mm 250 V grade - 10 m
- Fuse wire 5 amps capacity - as reqd.
- PVC insulation tape 20 mm size - as reqd.
- Bearing - Grease - 200 gms.
- Kerosene oil - 1 litre.
- Cotton waste - 100 gms
- Shellac varnish - 1/4 litre
- Sandpaper `O' - as reqd.

PROCEDURE

TASK 1: **Perform maintenance and service as per the following procedure**

1 Read the name-plate details of the motor and record in Table 1.

Table 1

Name-plate details of the motor

Make____ Frame____ No. _____ Model _____

Type _______ HP _________ Volts __________

Amperes _______ Phase ______ Cycles______

2 Switch 'OFF' the respective I.C.D.P. main switch.

3 Remove the fuses and keep in safe custody.

Remove the sub-circuit fuses which supplies power to the ICDP.

4 Clean the main switch with a brush.

5 Check the incoming and outgoing leads of the I.C.D.P. main switch for discolouring.

Discolouring normally indicates loose terminal connection.

6 Check the cable terminal connection screws and tighten them with the help of a screw driver.

7 Open the starter cover and clean the parts with a brush.

8 Check the leads and the terminal screws. Tighten the screws, if found loose.

9 Check the overload setting and if necessary, set it to the rated current of the motor.

10 Check the contact points of the starter for pittings.

If the contact points are lightly pitted, use a sandpaper to clean them. Badly pitted or damaged contacts need to be replaced.

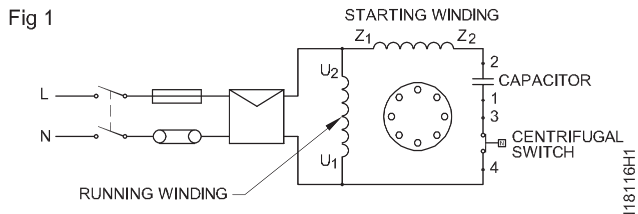
11 Clean the external surface of the single phase motor using brush, a piece of the cloth and a blower.

12 Open the terminal cover.

13 Note the incoming, starting winding, running winding, capacitor and centrifugal switch connections and draw a diagram in your record. Indicate the colour of cables in the diagram.

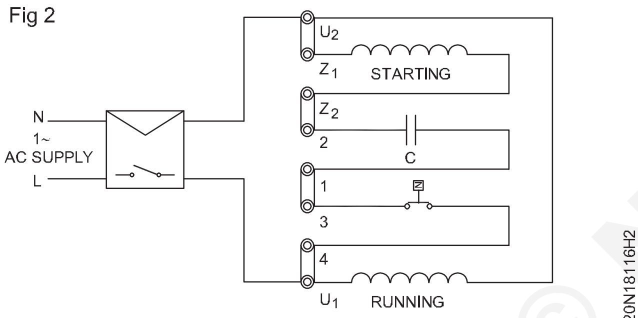
Normally some letter markings are found in the terminal plate. Some manufacturers give the schematic diagram on the back side of the cover. In case no diagram or marking were there wire clearly the colour of the cables connected to the terminal plate. Fig 1 is the schematic diagram of a particular single phase motor and Fig 2 shows the terminal connections with the simplified internal connections. These diagrams are given for your guidance. Draw the required diagrams to show the connections of the motor for which maintenance is required.

Fig 1



SCHEMATIC DIAGRAM OF THE CAPACITOR START SINGLE PHASE MOTOR

Fig 2



TERMINAL CONNECTION OF A CAPACITOR START SINGLE PHASE MOTOR

14 Open the shorting loops and incoming connections.

15 Check the continuity a) main winding b) starting winding c) centrifugal switch.

16 Record the finding in Table 2

17 Measure the resistance value of the windings and contact resistance value of the centrifugal switch with an ohmmeter and record it in Table 2.

18 Check the capacitor and the centrifugal switch for its condition with an ohmmeter and enter the result in Table 3.

A capacitor when tested with a Megger or multimeter, the meter needle will show short indicating the capacitor is charged. When the capacitor terminals are shorted by a cable, a spark will be noticed indicating the capacitor is discharged and in good condition. However whether the capacity is charged or the capacitor able to hold the charge for a specified time cannot be checked by this test.

19 Check the insulation value of the windings with the help of a Megger and enter the result in Table 4.

20 Dismantle the motor following the procedural steps.

21 Clean the stator and rotor with a brush and blower.

22 Clean the bearings and grease cups with kerosene and check the bearing.

23 Identify the bearing which is found worn out replace it with a similar type.

24 Check the internal connections and lead insulations.

If necessary reinsulate the leads.

25 Check the rotor bars.

If any loose bar is found, it has to be brazed.

26 Check the rotor and stator surface for rubbing marks.

Rubbing marks indicate either worn out bearing or wrong alignment in assembly. Correct them.

27 Check the centrifugal switch for its tension and perfect contact between the points of contact.

If the switch is in a bad shape it should be replaced with a similar switch. Dressing of contact could be done with the help of sandpaper.

28 Identify the insulation resistance value measured earlier. If found to be less than 1 megohm, dry the winding in an oven or with incandescent lamps and varnish it.

29 Assemble the motor following procedural steps.

30 Perform the earlier test and enter the results in Tables 2 and 4.

The test result should not vary too much. Rather it should show improvement. Discuss with your instructor regarding the test results.

31 Connect the shorting loops and incoming leads as per your diagram.

32 Replace the fuses of correct value in the fuse grip and replace the carrier in the holder of the I.C.D.P. mains.

33 Check the earth connections to the motor starter and switch correct them if necessary.

34 Start the motor and test run for about 30 minutes.

35 Check the frame temperature of the motor and satisfy yourself that the temperature is within the reasonable limits.

36 Check for any undue noise or vibrations.

37 Stop the motor and write your observations in the maintenance card.

If any undue noise or vibrations is found stop the motor and recheck the tightness of the end plate bolts and frame bolts.

Table 2

Sl.No.	Description	Continuity check		Resistance value		Remarks
		Before dismantling	After assembling	Before dismantling	After assembling	
1	Main winding					
2	Starting winding					
3	Centrifugal switch					

Table 3

Sl.No.	Description	Condition
1	Capacitor	
2	Centrifugal switch	

Table 4

Sl.No.	Description of the test	Test result in megohms		Remarks
		Before dismantling	After assembling	
1	Between main winding and starting windings (auxiliary)			
2	Between main winding and the body/frame			
3	Between starting winding and the body/frame			
4	Between centrifugal switch and the body/frame			
5	Between centrifugal switch and the winding (both the windings shorted)			

— — — — — —

TASK 2: **Trouble shooting procedure**

1 Follow the troubleshooting charts No.1 to 5 to identify the symptom and rectify the fault. (Refer trade theory)

— — — — — —

Identify part and terminals of alternator

Objectives: At the end of this exercise you shall be able to
- **read and Interpret the name plate details of alternator set**
- **identify their parts and write their names**
- **identify the terminals of alternator.**

Requirements

Tools/Instruments

- Right spanner set 5 mm to 25 mm - 1 Set
- DE spanner set 5 mm to 25 mm - 1 No.
- Ball pein hammer 1 Kg - 1 No.
- Cold chisel 19 mm dia 200 mm long - 1 No.
- Lead hammer 1 Kg - 1 No.
- Screwdriver 300 mm with 6 mm blade - 1 No.

Equipments/Machines

- 3 Phase Alternator 3KVA 500V 50 Hz coupled to suitable motor - 1 No.
- Ohm meter - 1 No.

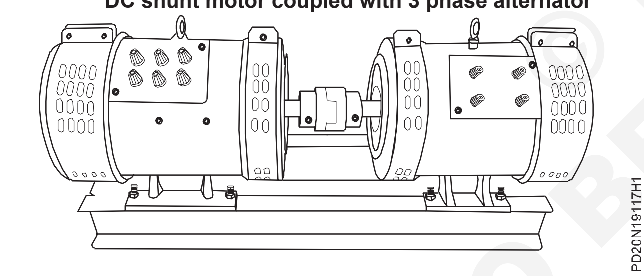
PROCEDURE

TASK 1: **Identify the parts of alternator**

1 Read and interpret the name plate details of the given alternator.

2 Identify the parts of the alternator from the real object or form the exploded view chart (Fig 1)

Fig 1



3 Label the each part with number and write the name of the parts in Table 1.

Table 1

S No.	Label No.	Name of the part
1		
2		
3		
4		
5		
6		
7		

— — — — — —

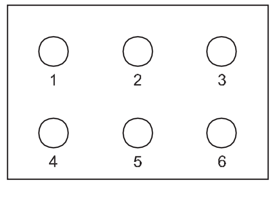
TASK 2: **Identify the terminals of a 3 phase, star connected alternator**

In a 3-phase, star-connected alternator three windings are internally connected in the star and four terminals are brought out to the terminal block. These four terminals consist of three beginning ends of the 3-phase winding and one neutral.

1 Check there is any marking on the terminals and note it down also. If not, give your own marking as 1,2,3 etc as shown in Fig 1.

2 Identify the terminals which show the internal connection, following the procedure stated in the above working steps and also as shown in Fig 2a. Measure the resistance in between them and record the readings in Table 1.

Fig 1

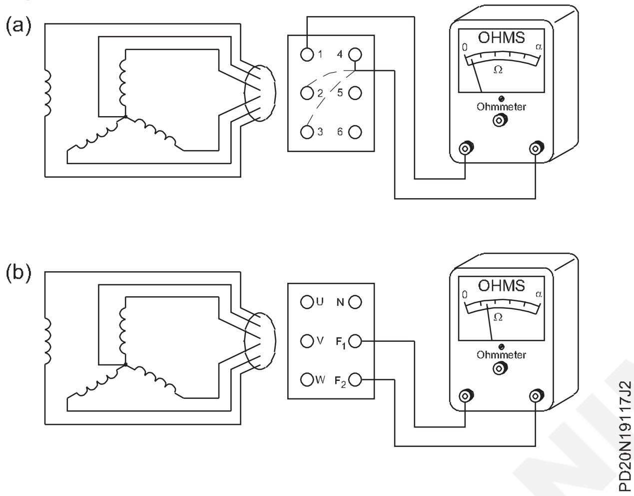


3 Identify the field winding from the terminal block (Fig 2b)

Only one pair will be independent with marginally high resistance. This pair belongs to the field winding. The other four terminals which show continuity between them belong to the star-connected, main winding terminals.

Out of the four terminals, three terminals will give comparatively high resistances between them. These are the ends of the three coils called UVW terminals. However, the left out terminals out of the four will give half the value of resistance when measured between any one terminal of UVW and that terminal. This terminal is the neutral and has to be marked as 'N'. The marking of the 3-phase terminals as UVW is tentative. The correct phase sequence is to be checked with the help of a phase-sequence meter, then only the terminals could be marked as UVW.

Fig 2



4 Mark the terminals accordingly.

5 Show your making to your instructor and get his approval.

Table 1

S.No.	Between in ohms	Resistance value	Remarks
1	1 - 2		
2	2 - 3		
3	3 - 4		
4	1 - 3		
5	1 - 4		
6	2 - 4		
7	5 - 6		

— — — — — —

Test for continuity and insulation resistance of alternator

Objectives: At the end of this exercise you shall be able to
- **test the alternator windings for continuity**
- **test the insulation resistance between the stator and rotor windings.**

Requirements

Tools/Instruments

- Cutting pliers 200 mm - 1 No.
- Spanner set 5 mm to 200 mm - 1 Set
- Screwdriver 200 mm - 1 No.
- Screwdriver 100 mm - 1 No.
- Megger 500 V - 1 No.

Equipment/Machines

- Alternator, 3-phase, 3 KVA 415 V - 1 No.

Materials

- P.V.C. insulated copper wire 23/0.2 mm size - 5 m
- Insulation tape - 1 m.
- Test lamp 60W / 240V - 1 No.

PROCEDURE

TASK 1: **Read and interpret the name plate details of an alternator**

1 Read and interpret the name-plate details of the 3-phase alternator.

2 Identify the terminals of the alternator as you did in Exercise No.2.5.143. Task : 3.

— — — — — —

TASK 2: **Conduct continuity test by using a lamp**

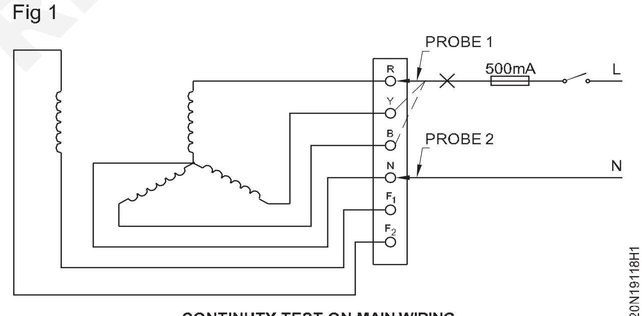
1 Take the test lamp and identify the cable to which the S.P. switch and the fuse are connected in series with the lamp. Use this as Probe 1.

2 Connect Probe 2 to terminal `N' and touch the terminals R, Y and B alternatively by Probe 1. (Fig 1) Observe the lamp condition and enter the same in Table 1.

The phase wire should be identified in the test lamp as Probe 1, and should be connected through the switch and fuse to the test lamp. Care should be taken to see that the phase wire does not touch the body or frame of the alternator. Do not touch any terminal while testing with AC supply.

3 Check the continuity between F_1 and F_2 and enter the finding in Table 1.

Fig 1



CONTINUTY TEST ON MAIN WIRING

Table 1

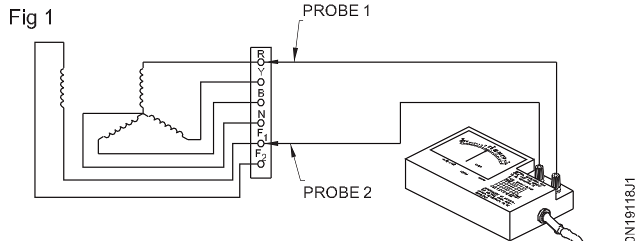
S.No.	Connection between	Condition of lamp
1	R and N	
2	Y and N	
3	B and N	
4	F_1 and F_2	

— — — — — —

TASK 3: **Measure insulation resistance between windings**

1 Connect one prod of the Megger to any one of the terminals R,Y,B,N and the other prod to the terminal F1 or F2 as shown in Fig 1.

Fig 1



INSULATION TEST BETWEEN WINDINGS

You can connect to any one of the terminals R, Y, B and N as all of them are having continuity as ascertained earlier.

2 Rotate the Megger at its rated speed and measure the insulation value and record it in Table 2.

The measured value should not be less than 1 megohm.

Table 2

S. No.	Insulation resistance between windings	Value in megohms
1	Between RYBN and field winding F_1 & F_2	

— — — — — —

TASK 4: **Measure the insulation resistance between the windings and the body**

1 Connect one of the prods of the Megger to any one terminal, RYBN and the other prod to the body/frame of the alternator.

2 Rotate the Megger at its rated speed and measure the insulation resistance. Record it in Table 1.

Table 1

S. No.	Insulation resistance between winding and the body	Value in MΩ
1	Between armature winding R/Y/B/N and the body	
2	Between field winding F_1 & F_2 and body	

3 Connect the Megger probe to terminal F_1 or F_2 and the other probe to the body.

Rotate the Megger at its rated speed and measure the insulation resistance value, and record it in Table 1.

The measured insulation value should not be less than 1 megohm.

4 Compare these values of insulation resistance with those entered in the alternator maintenance card available in the section, and discuss the variations in the reading with your instructor.

— — — — — —

Connect, start and run an alternator and build up the voltage

Objectives: At the end of this exercise you shall be able to
- **read and interpret the name-plate details of an alternator**
- **test and identify the terminals of an alternator**
- **connect, start, run, adjust the speed and frequency of the alternator**
- **adjust and set the rated voltage of an alternator.**

Requirements

Tools/Instruments

- Insulated cutting pliers 200 mm - 1 No.
- Screwdriver 150 mm - 1 No.
- Screwdriver 100 mm - 1 No.
- Voltmeter AC 0 to 500 volts - 1 No.
- Ammeter DC 0 to 5 amps - 1 No.
- Tachometer 0 to 3000 r.p.m. - 1 No.
- Single phase frequency meter 250V - 45 to 55 Hz. - 1 No.

Equipment/Machines

- 3-phase alternator 3KVA 415V 50 Hz. coupled to a suitable DC motor. - 1 Set
- Rheostat 480 ohms 2 amps - 2 Nos.
- 4-point starter 30 amps 250V - 1 No.

Materials

- PVC insulated copper cable 2.5 sq mm 600 V grade - 10 m.
- Insulation tape - 30 cm.
- Fuse wire 5A, 15A - as reqd.
- T.P.I.C. switch 16 amps 500V - 1 No.
- D.P.I.C. switch 32 amps 250V - 2 Nos.

PROCEDURE

TASK 1: **Connect, start, run, adjust the speed and frequency of an alternator**

1 Read and interpret the name-plate details.

2 Test and identify the terminals of the alternator.

3 Test the alternator for insulation resistance between the windings, the winding and the ground, and record the values separately.

> **The insulation resistance value should not be less than one megaohm**

4 Select a suitable range of rheostats, ammeters, voltmeters, switches and cables according to the specification of the available alternator.

> **You may have to change the ranges of the meters and rheostat according to the rating of the available alternator with respect to Fig 1.**

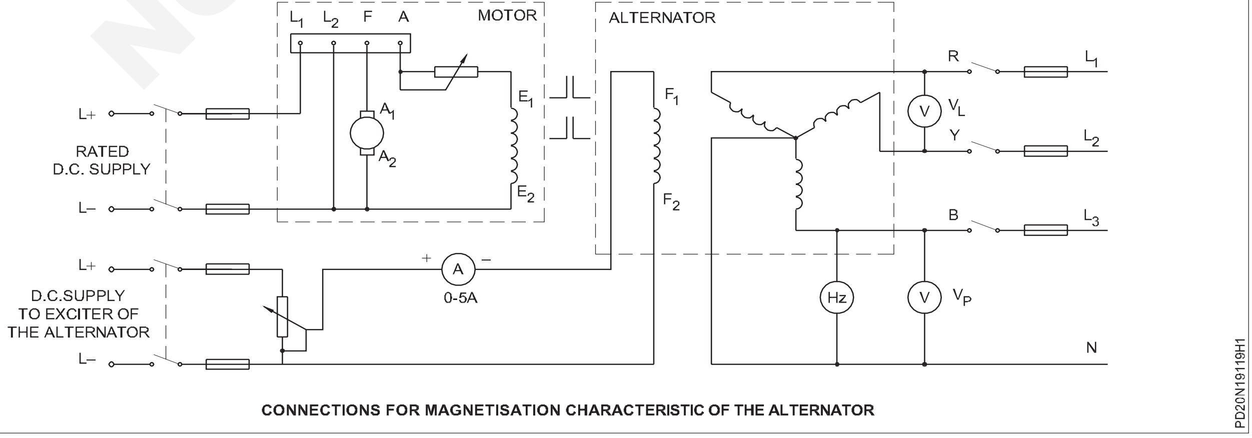
5 Make the connections as per the circuit diagram.

6 Adjust the field rheostat of the prime mover to cut out position, and the field rheostat of the exciter in the minimum voltage position.

7 Check the couplings.

8 Switch `ON' the DC supply to the prime mover (DC motor) and start the prime mover through the 4-point starter.

Fig 1



CONNECTIONS FOR MAGNETISATION CHARACTERISTIC OF THE ALTERNATOR

9 Adjust the speed of the prime mover through its field rheostat to the rated speed of the alternator.

10 Switch `on' the DC supply to the exciting winding of the alternator. Note down the field current, line voltage and phase voltage of the alternator in Table.

11 Note down the frequency (if possible, for the frequency meter may not read at a low voltage) in Table.

12 Increase the field current in 10 to 12 equal steps. For each step measure the phase voltage, line voltage, frequency and field current and enter the values in Table until the alternator output voltage reaches its rated value.

The field current should be varied gradually in equal steps in the ascending order. Otherwise it will disturb the shape of the plotted curve.

13 Increase the excitation current such that the alternator line voltage is about 10% above the rated value.

14 Draw the curve I_F versus V_P taking I_F on the `X' axis and $V_P$ on the `Y'axis. The curve shows the O.C.C. or the magnetisation characteristic of the alternator.

15 Write your conclusion regarding the relation between the field current and phase voltage as well as the line voltage and phase voltage.

Conclusion

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Table

S.No.	Field current I_F	Line voltage V_L	Phase voltage V_P	Frequency V_F	Remarks

— — — — — —

Determine the load performance and voltage regulation of a 3-phase alternator

Objectives: At the end of this exercise you shall be able to
- **connect, start, run, and build up the voltage of an alternator**
- **determine the voltage regulation of an alternator.**

Requirements

Tools/Instruments

• Combination pliers 200 mm	- 1 No.
• Round nose pliers 150 mm	- 1 No.
• Electrician's knife	- 1 No.
• M.I. ammeter 0 to 20 amps	- 3 Nos.
• M.I. voltmeter 0 to 500 volts	- 1 No.
• M.C. voltmeter 0-300V	- 1 No.
• M.C. ammeter 0-5A	- 1 No.
• Frequency meter 500V, 45 to 50 Hz.	- 1 No.
• Power-factor meter 500V, +0.5 to -0.5 P.F.	- 1 No.
• Tachometer 300 to 3000 r.p.m.	- 1 No.

Equipment/Machines

• 3-phase alternator 500V 5/10 kW coupled with DC shunt motor having facility for speed control	- 1 Set
• 3-phase lamp load 415/400V 5 KW	- 1 No.
• 3-phase squirrel cage motor 500V 50HZ, 3 HP with DOL starter and switch	- 1 No.

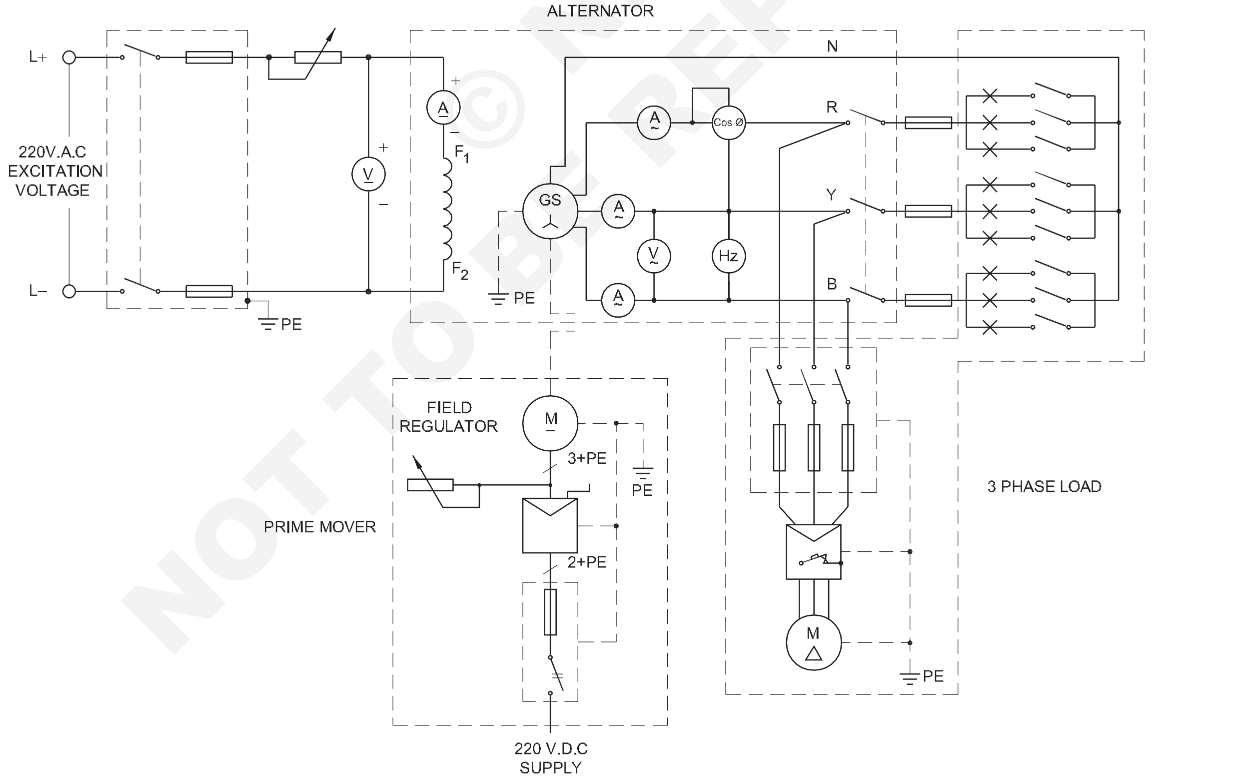
Materials

• P.V.C. insulated stranded aluminium cable	-10 m
• T.P.I.C. switch 32 amps 500v	- 2 Nos.

PROCEDURE

TASK 1 : **Connect, start, run, and build up the voltage of an alternator**

Fig 1



CONNECTIONS OF 3 - PHASE ALTERNATOR WITH LOAD

PD20N19120H1

1 Note down the name-plate details of the given alternator in Table 1. (As per exercise 2.5.144 Task : 1)

2 Select proper sizes of cables, fuse wires, switches etc., as per the name-plate ratings (rated capacity) of the given 3-phase alternator.

3 Connect the exciter output terminals to the field of the alternator with the rheostat, ammeter and voltmeter. (Fig 1)

The exciter output voltage is shown in Fig 1 as 220V DC. Different manufacturers choose different exciter voltages suitable for their alternators. You may have to select the voltmeter and ammeter ratings according to the voltage rating of the field of the available alternator.

4 Connect the alternator terminals RYB and N to the load as per the circuit diagram (Fig 1). Keep the load switches and also all the lamp switches of the lamp load in the `off' position.

Check the voltage rating of the power factor and frequency meters whether they are for phase voltage or line voltage. Connect accordingly. Do not forget to connect the star point of the lamp load to the neutral point of the alternator. The bulb wattage rating should be equal in all lamps.

5 Show the connection to your instructor and obtain his permission to start the prime mover.

6 Run the alternator at its rated speed. Measure and record the speed. Speed.............. r.p.m.

7 Build up its voltage by adjusting the field rheostat to the rated voltage of the alternator. Read and record it. Voltage ....volts.

— — — — — —

TASK 2: **Determine the voltage regulation of an alternator**

1 Close the T.P.I.C. switch of the motor load and start the motor by the D.O.L starter.

2 Close also the T.P.I.C. switch of the lamp load and increase I_L up to the alternator's rated value in steps of one ampere. Read and record the values of I_L, V_L & P.F. frequency in Table 1.

3 Reduce the load and switch off the alternator.

4 Draw the three curves for the 3 sets of reading showing the terminal voltage versus load current. Keep the terminal voltage in the Y axis and load current in the X-axis.

5 Calculate the voltage regulation for the above different loads at 5 and 10 amperes by using the formula:

Percentage voltage regulation ($\%V_R$)

$$\%V_R = \frac{\text{No.load voltage - Full load voltage}}{\text{Full load voltage}} \times 100$$

6 Based on steps 5 and 6 write your conclusion in the space given below.

Conclusion 1

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Conclusion 2

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Table 1

S. No.	Load current equal in all the three phases I_L	Terminal Voltage V_L	Frequency kept constant	Power Factor cos Ø	Power = $\sqrt{3}\, E_L I_L \cos Ø$	Remarks

— — — — — —

Parallel operation and synchronization of three phase alternators

Objectives: At the end of this exercise you shall be able to
- **read and interpret the name plate details of the two 3 phase alternators**
- **synchronise the two 3 phase alternators by dark lamp method and test it**
- **synchronise the two 3 phase alternators by dark and bright lamp method and test it**
- **synchronise the two 3 phase alternators by synchroscope method and test it.**

Requirements

Tools/Instruments

• Trainees tool kit	- 1 No.
• MI Voltmeter 0-500V	- 2 Nos.
• Frequency meter (45 - 50 - 55 Hz)	- 1 No.
• Phase sequence indicator	- 1 No.
• Synchroscope	- 1 No.

Equipments/Machinery

• 3 Phase alternators 5 kVA/500V 50 Hz coupled with prime mover (/adjustable speed control)	- 2 Nos.
• Rheostat 150 ohms/1A	- 1 No.

Materials

• TPIC switch 16A, 500V	- as reqd.
• ICDP / Knife switch 16A, 250V	- 1 No.
• ICTP / Knife switches 16A, 500V	- 2 Nos.
• 100W/250 V lamps	- 6 Nos.
• Connecting wires	- as reqd.

PROCEDURE

TASK 1: **Read and interpret the name plate details of the alternators**

1 Read and interpret the name plate details of the 3 phase alternators.

The voltage rating of two alternators must be same. Rating of alternators (kVA), not necessary must be same. The load can be shared according to the rating of alternators.

— — — — — —

TASK 2: **Synchronise the two 3 phase alternator by dark lamp method and test it**

For connecting two alternators in parallel they must fulfil the following conditions.

1 Terminal voltage of both the alternators must be same

2 Supply frequency of both alternators must be equal

3 Phase sequence of both the alternators must be ideal

1 Check the phase sequence of the main bus bar line by using phase sequence indicator/meter

2 Connect and set the arrangement of incoming alternator and outgoing alternator with prime mover coupled, TPIC main switch, voltmeters and frequency meters and lamp connection in series. (Fig 1).

While connecting the alternators, care should be taken, that corresponding phase lines must be connected of both alternators. (i.e.) 1st alternator is connected to L1, L2 and L3 then the 2nd alternator must also be connected to same L1, L2 and L3.

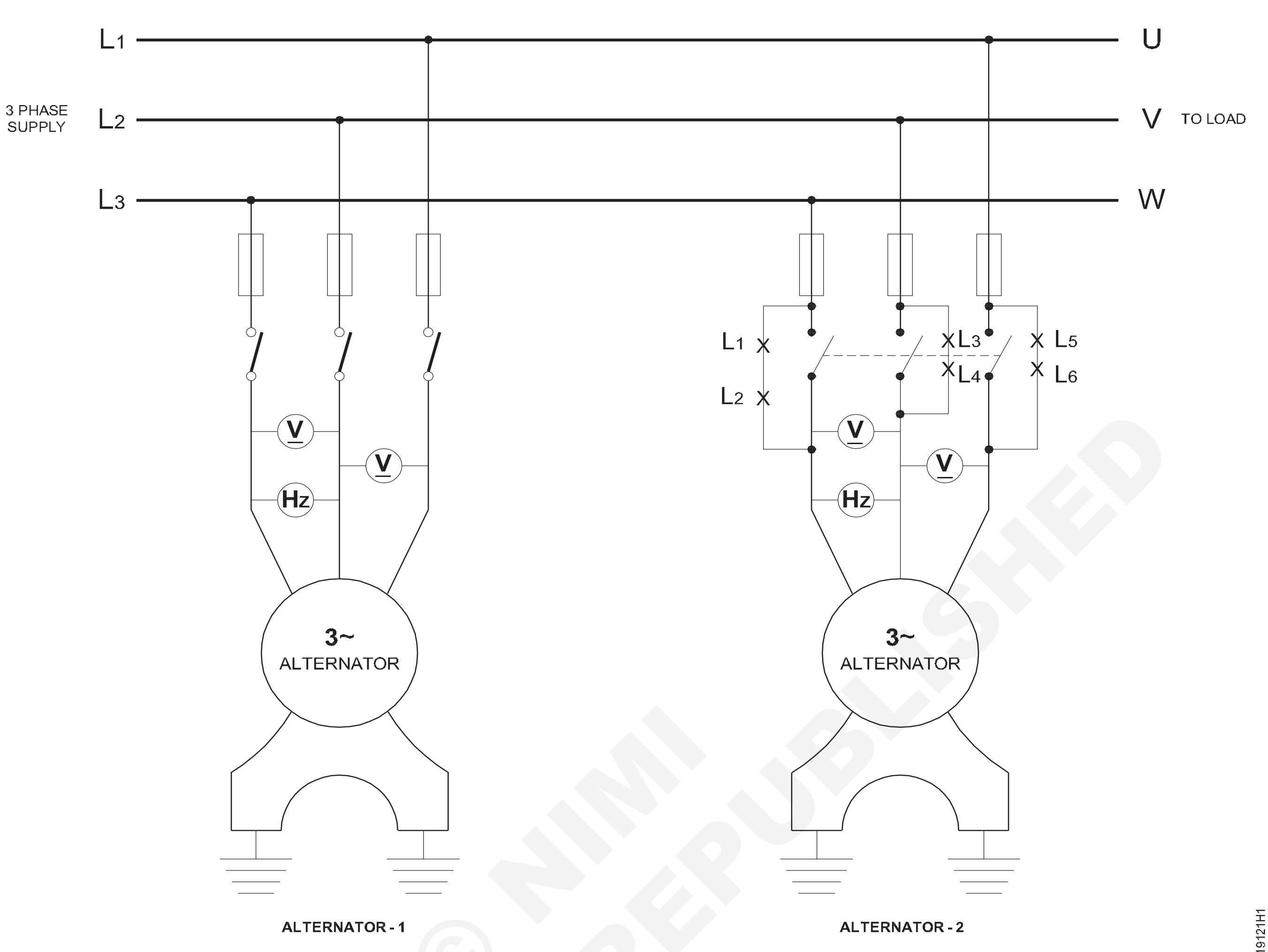
3 Keep the main switch of incoming alternator -1 in closed position after ensuring the phase sequence are correct.

4 Keep the main switch of alternator - 2 in opened position.

5 Start and run the first alternator and build up the rated voltage

6 Measure the line voltage between phases, then measure the frequency of an alternator-1 and note down the readings of voltmeter and frequency meters in Table 1.

Fig 1



PARALLEL OPERATION OF 3 PHASE ALTERNATIVES BY DARK LAMP METHOD

Table 1

Alternator 1

S.No.	Voltage reading in Volt	Frequency in Hz
1	L1 - L2	L1 - L2
2	L2 - L3	L2 - L3
3	L3 - L1	L3 - L1

7 Start, run and build up the rated voltage

8 Measure the line voltages and frequency in alternator 2 and note down the readings in Table 2.

Table 2

Alternator 2

S No.	Voltage reading in Volt	Frequency in Hz
1	L1 - L2	L1 - L2
2	L2 - L3	L2 - L3
3	L3 - L1	L3 - L1

9 Check the condition of the two lamp.

If the voltage and frequency are equal the lamps will becomes dark and then becomes bright. If the voltage and frequency of the both alternators are not same, the lamps will flicker.

10 Adjust the field excitation current in the alternator 2 and bring the voltage to the same value of the alternator 2.

11 Check the condition of lamps brightness.

If the lamps are flickering still now, then the frequency may not be equal, it must be brought to same equal frequency value of alternator 1

12 Adjust the speed of the prime mover of alternator 2 and bring the frequency as same as in alternator 1

Now, all the lamps are bright and then become dark at a time, it indicates all the conditions are fulfilled for synchronising.

13 Close the main switch of alternator - 2 when all the lamps are in dark condition.

Now the alternators are synchronised (parallel) and ready for sharing the load.

14 Switch 'ON' common load for both the alternators.

15 Check the loads are shared equally by the two alternators.

16 Get it checked with your instructor.

— — — — — —

TASK 3: **Synchronise the two 3 phase alternators by dark and bright lamp method**

1 Check the phase sequence of the main bus bar lines by using phase sequence indicator

2 Connect and set up the arrangement of the alternator - 1 and alternator - 2 with prime mover, TPIC switch, lamp connection. (2 pairs of lamp are connected across two phases, In one phase, the pair of the lamps are in series with voltmeters and frequency meters. (Fig 1)

3 Repeat the working steps from 3 to 8, in Task - 2

4 Note down the readings in table - 3 & Table - 4

Table 3

Alternator - 1

S. No.	Voltage reading in Volt	Frequency in Hz
1	L1 - L2	L1 - L2
2	L2 - L3	L2 - L3
3	L3 - L1	L3 - L1

Table 4

Alternator - 2

S. No.	Voltage reading in Volt	Frequency in Hz
1	L1 - L2	L1 - L2
2	L2 - L3	L2 - L3
3	L3 - L1	L3 - L1

5 Look at the condition of the lamps.

If the voltage and frequency are equal then one pair of the lamp will be dark and other two pair will be bright.

If the voltage and frequency of the both the alternators are not same, then the lamp will flicker not giving standstill lighting.

6 Check the voltage and frequency are not equal repeat the steps from 10 to 12 of task 2and bring the same value of voltage and frequency as in alternator - 1.

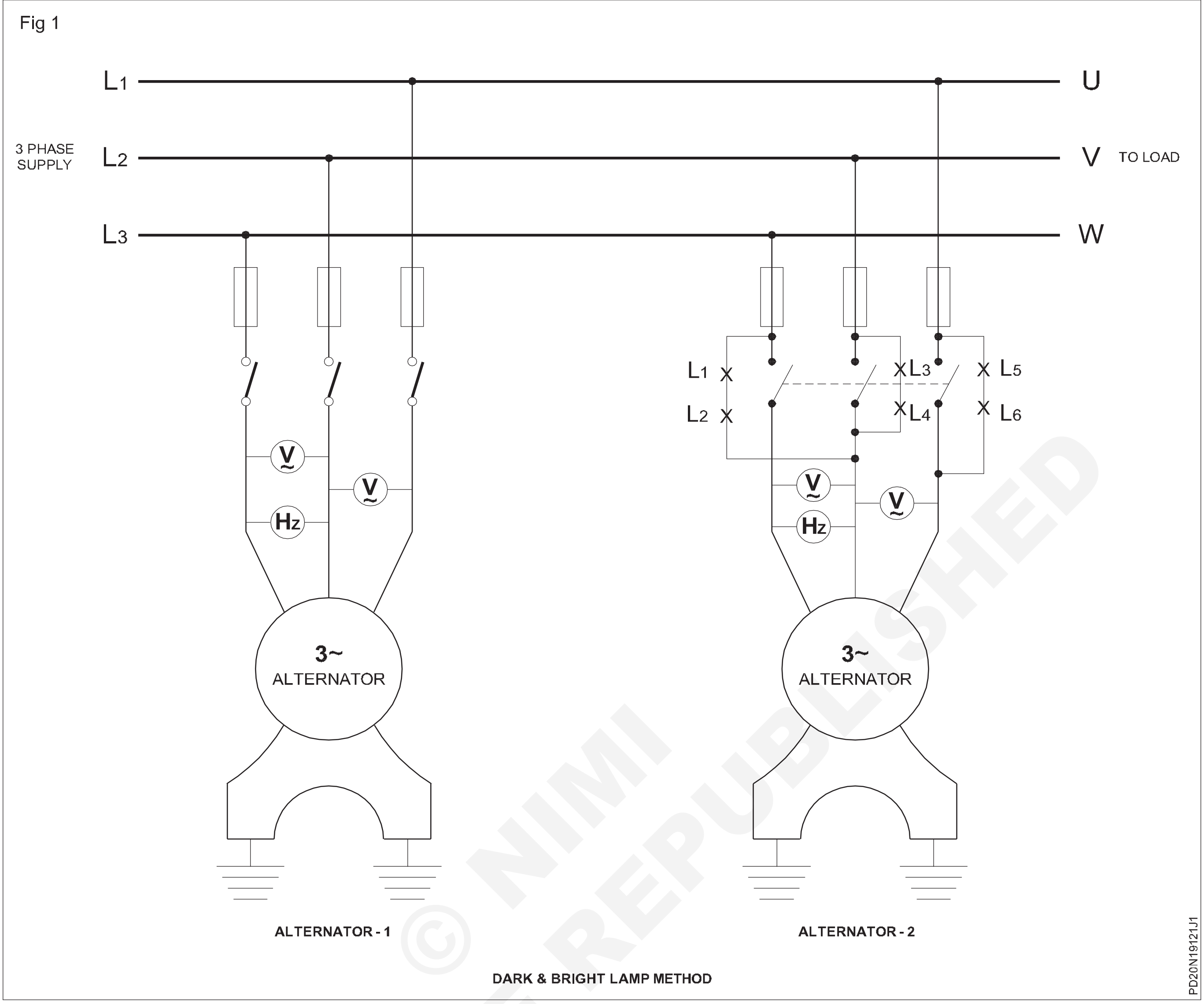
If all the condition are fulfilled, then all the lamps will not flicker and one pair of the lamp will be dark and other two pair lamps will be bright at a time.

7 Close the main switch of alternator - 2 when the lamps are bright condition.

Now the 2 alternators are synchronised (parallel) and ready for sharing the load.

8 Switch 'ON' the common load for both alternators.

9 Check the loads are shared equally by the two alternators.



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TASK 4: **Connect two alternators in parallel by using synchroscope**

1 Collect the instruments as shown. (Fig 1)

2 Connect the equipment and instruments. (Fig 1)

> **Keep `open' the bus-bar switch S_1 and synchronising switch S_2.**

3 Start the incoming alternator (Alternator-2) with low excitation.

4 Close the bus-bar switch S_1.

> **One alternator (Alternator-1) is connected to the bus-bar that produces the rated V.**

5 Observe the bus-bar voltage V_1 and incoming voltage V_2.

6 Adjust the excitation of the incoming alternator till $V_1 = V_2$. The voltage of incoming and exciting machine should be equal.

7 Check the pointer in the synchroscope.

8 Adjust the speed of the alternator. If it is indicating fast, reduce the speed of the incoming machine gradually observing the synchroscope pointer.

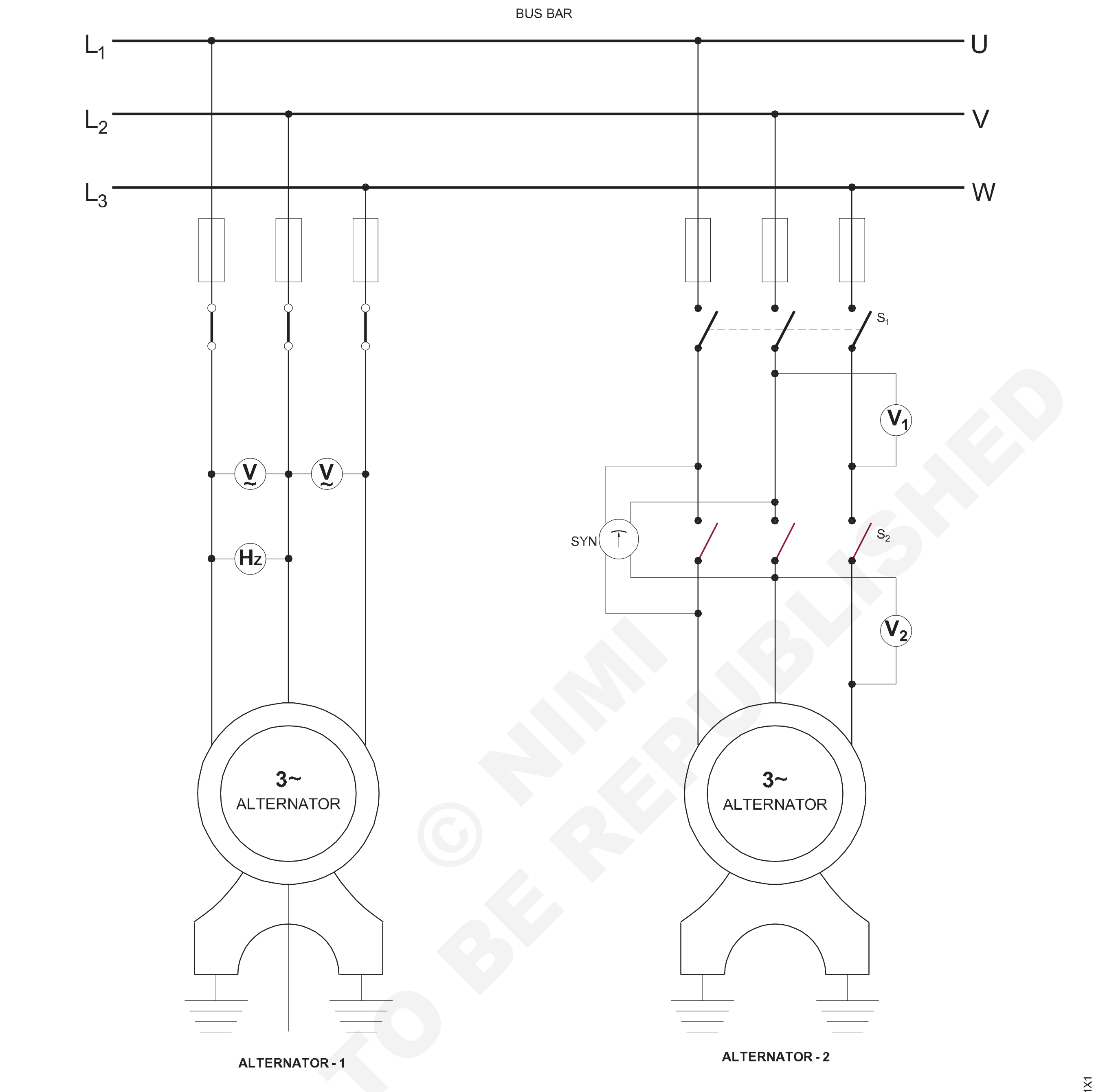
> **If it indicates slow, increase the speed of incoming machine slowly. The result should be slow movement of the pointer to 0.**
>
> **When the pointer comes to zero position very slowly, the bulb behind the dial will glow bright.**

9 Adjust the speed of the incoming alternator for minimum oscillation of the synchroscope pointer.

10 Close the synchronising switch `S_2' at zero, and the steady position of the synchronising pointer.

> **When the two voltages of the incoming and existing machines are the same in magnitude and phase, synchroscope pointer will be at zero.**

Fig 1



TWO ALTERNATORS IN PARALLEL BY USING SYNCHROSCOPE

— — — — — —

Identify parts and terminals of a synchronous motor

Objectives: At the end of this exercise you shall be able to
- **read and interpret the name plate details of given shynchronous motor**
- **read the manufacturers installation instruction and follow the same**
- **identify parts and terminals.**

Requirements

Tools/Instruments
- Electrician hand tool kit - 1 Set

Equipment/Machines
- Synchronous motor 3 KVA, 500V. 3 phase 50Hz with suitable starter - 1 No.

Materials
- Connecting cables - as reqd.

PROCEDURE

TASK 1: **Identify the parts and terminals of synchronous motor**

1 Identify the parts of the synchronous motor from the real object or from the exploded view chart.

2 Label the each identified parts with number tags.

3 Write the name of the parts of each labelled number in the table.

4 Identify the terminals which shown in fig 1. Following the exercise no: 2.5.143 Task 3 for starter terminals.

5 Identify the exciter terminals.

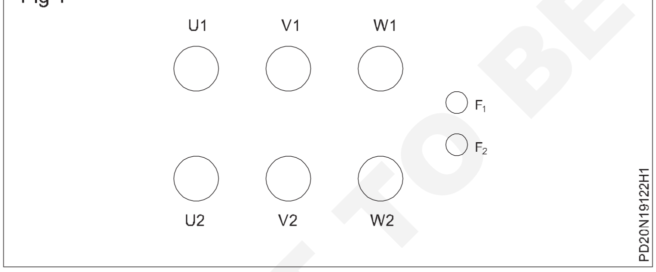
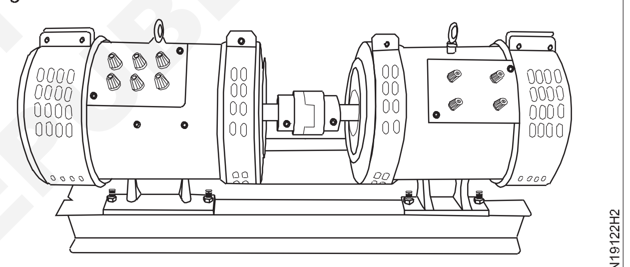
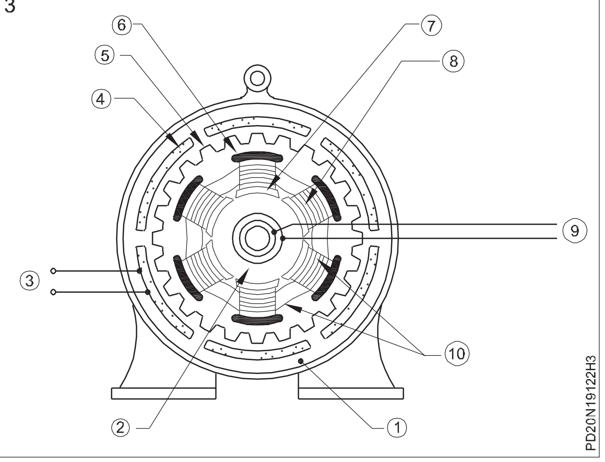
Fig 1


Fig 2


DC SHUNT MOTOR COUPLED WITH 3 PHASE ALTERNATOR

Fig 3


Table

S. No.	Label No.	Name of Part

— — — — — —

Connect start and plot V-curves for synchronous motor under different excitation and load conditions

Objectives: At the end of this exercise you shall be able to
- **connect the synchronous motor with its starter**
- **start and run the sychronous motor with its starter**
- **plot the 'V' curve.**

Requirements

Tools/Instruments

- Trainees tool kit - 1 No.
- MI Ammeter 0-10 A - 1 No.
- MC Ammeter 0-1 A - 1 No.
- MI Voltmeter 0-500 V - 1 No.
- Frequency meter (45-50-55Hz) - 1 No.
- Tachometer 0-10000 rpm - 1 No.
- DC source/rectifier suitable for above motor - 1 No.
- TPIC switch 32A, 500V - 1 No.
- DPIC switch 16A 250V - 1 No.
- Field rheostat suitable for above motor - 1 No.

Equipment/Machines

- Synchronous motor 3 KVA, 500V 3 phase 50Hz with suitable starter - 1 No.

Materials

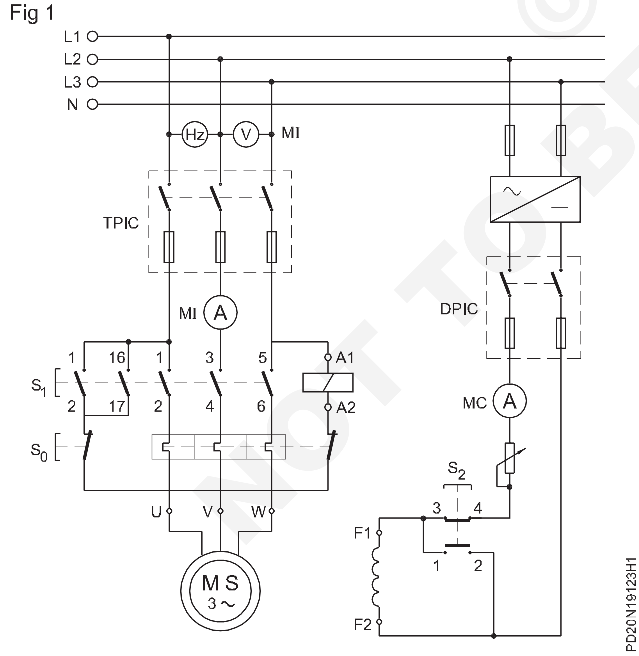
- Connecting leads - as reqd.

PROCEDURE

TASK 1: **Connect the synchronous motor, start, run and test it**

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

Fig 1



2 Show the connections to your instructor and get his approval.

3 Close TPIC switch and DPIC.

4 Adjust the field current to its rated value as per name plate detail.

5 Hold push button S_2 depressed, and start the motor by operating switch S_1.

> **Make sure that push button S_2 is pressed before energising the motor at the time of starting.**
>
> **When S_2 is depressed DC supply to field is disconnected and field winding terminals F1 and F2 are shorted.**

6 After the rotor attains maximum speed say 95% of the synchronous speed release push button S_2 i.e. field winding is excited by DC supply.

> **With field winding excited the motor gets pulled into synchronism and runs at synchronous speed.**

7 Measure speed, supply voltage, frequency, line current, and field excitation current and record in Table 2.

Table 2

Line voltage	:	________________	Volt
Line current	:	________________	amp
Excitation current	:	________________	amp
Speed	:	________ _______	r.p.m
Frequency	:	_________________	Hz

8 Calculate the synchronous speed of the motor by using the formula.

$$N_S = \frac{120f}{p}$$

Synchronous speed N_s =... rpm.

9 Compare the synchronous speed with the measured speed, and ensure measured speed is equal to synchronous speed.

— — — — — —

TASK 2: **Plot the V-Curve for synchronous motor under different excitation and load condition**

1 Start and run the synchronous motor to its maximum speed without load.

2 Adjust the field current by adjusting the field rheostat (Fig 1) and take the readings of armature current (I_a) and field current (I_f)

3 Note down the readings in Table 1 and plot the 'V' curves for synchronous motor under different excitation and load conditions in a separate graph sheet. The same Procedure has to be repeated for loaded condition.

Table 1

S. No.	Without Load		With Load	
	Armature Current (I_a)	Field Current (I_f)	Armature Current (I_a)	Field Current (I_f)

— — — — — —

Carryout maintenance of alternator and synchronous motor

Objectives: At the end of this exercise you shall be able to
- **read and interpret the name plates details of alternator**
- **identify terminals of 3 ϕ alternator**
- **study maintenance of alternators and synchronous motor.**

Requirement

Tools/Instruments

- Spanner set 5 mm to 25 mm - 1 Set.
- Cutting pair 200 mm - 1 No.
- Screw driver 200 mm - 1 No.
- Adjustable Spanner - 1 No.

Equipment/Machines

- Alternator 3 ϕ 3 KWA 415 - 1 No

Materials

- PVC insulated copper wire 23/0.2 mm size - 5 m
- Insulation Tape - 1 No.

PROCEDURE

TASK 1: **To maintain an alternator**

1 Clean inside the alternator winding with approved non - informatic solvent to improve the insulation and remove dust.

2 Check for abnormal temperature and vibration.

3 Check for all wiring to the alternator, tighten of this terminal connection and condition of cable insulation.

4 For air cooled alternators check the vents for observations and the external for (If installed) is in good condition.

Name plate details

Manufacturer, Trade mark	:		
Type, model or list number	:		
Type of current	:	Fabrication or serial number	: ....
Function	:	Alternator	: ....
Type of connection	:	P.F	: ....
Rated voltage	:	Rated current	: .... amp
Frequency	:	Rated speed	: .... r.p.m
Rated power	:	Rated exc.current	: .... amps
Related exc.Voltage	:	Direction of rotation	: ....
Rating class	:	Protection class	: ....
Insulation class	:		

Example of preventive maintenance recommendations for AMS synchronous motors and generators variations may occur for other types

Maintenance level	**Level 1 (L1)**	**Level 2 (2)**	**Level 3 (L3)**	**Level 4 (L4)**
Interval	Max.10,000 to 20,000 equivalent hours of operarion	Max.20,000 to 40,000 equivalent hours of operation. or max.3 years	Max. 50,000 to 70,000 equivalent of operation or max.6 years	Max.80,000 to 102,000 equivalent hours's of operation . or max. 12 years
Main customer preparations prior to maintenance	Disconnect motor/ generator electrically Connect outgoing lines to the earth	L1 Give access to terminal connection	L2 Block cooling and oil system Disconnect pping from motor/generator Drain water coolers and bearing house	L3 Split shaft couplings Prepare for rotor removal
Measurements tools and special instruments		IR/PI[2] of stator, statror diagnostic measurement IR of rotor	IR/PI[2] of stator, statror diagnostic measurement IR of rotor, impedance measurement of rotor coils Bearing and exciter removal tools Optional ABB Air Gap inspector or video borescope Rectifier test equipment	IR/PI[2] of stator, statror diagnostic measurement IR of rotor, impedance measurement of rotor coils Rotor, bearing, exciter removal tools Rectifier test equipment
Maintenance parts	L1 preventive maintenance kit	L2 preventive maintenance Kit Parts recommended in previous preventive maintenance	L2 preventive maintenance Kit Parts recommended in previous preventive maintenance	L2 preventive maintenance Kit Parts recommended in previous preventive maintenance

Expected duration	**Approx.1 woriking days**	**Approx. 2. woriking days**	**Approx. 5 woriking days**	**Approx.10 woriking days**

Equivalent hours of operation number of starts x20 , or 12 x actual operating hours for vaiable speed motors
IR[2] = insulation resistance PI = polarization index
Option Diagnostic insulation of the stator winding (ABB Ability[IM] LEAP)
Depending on the accessibility of the motor/generator and infiting equipment

Example of maintenance shedule for AMS motors and generators									
Interval (Approx. Years)	1	2	3	4	5	6	7	8	9
Interval (hours x 100)	10	20	30	40	50	60	70	80	90
Level	L1	L2	L3	L4	L5	L6	L7	L8	L9

Fig 1

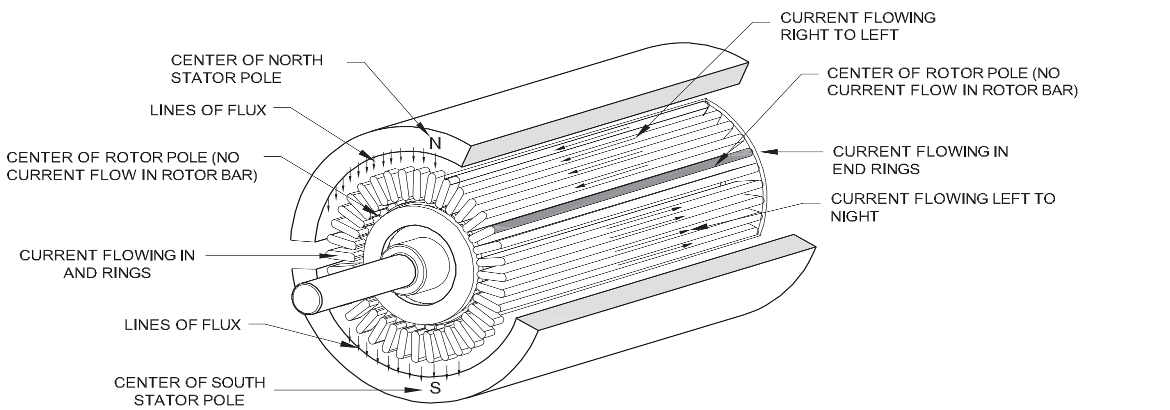
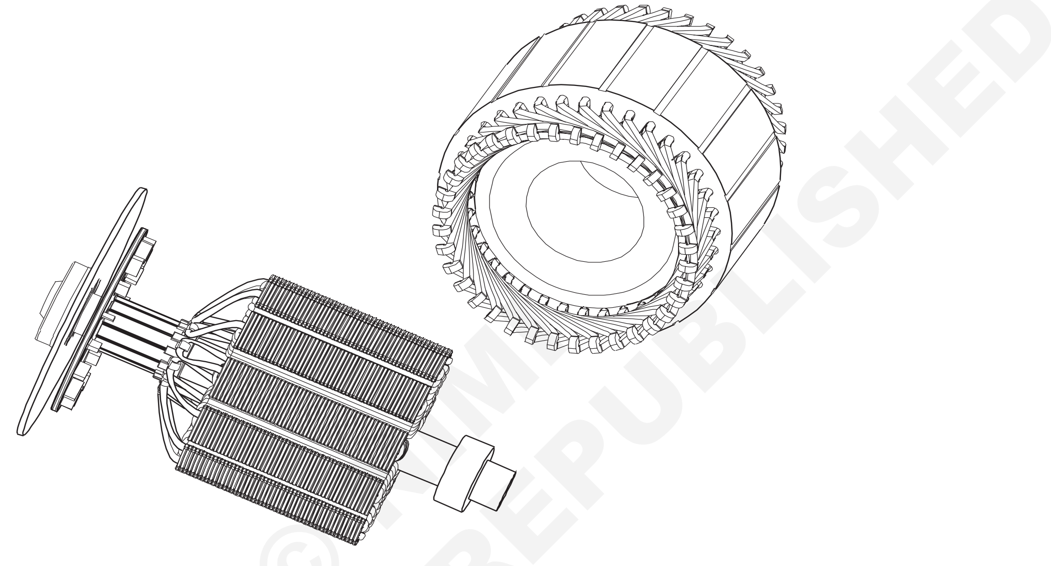
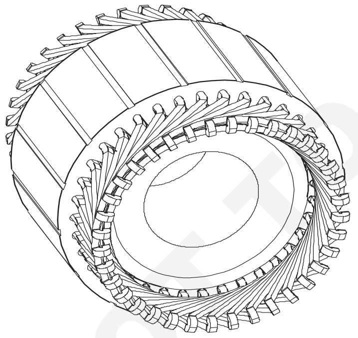


Fig 2



ROTOR

Fig 3



STATOR

Fig 5

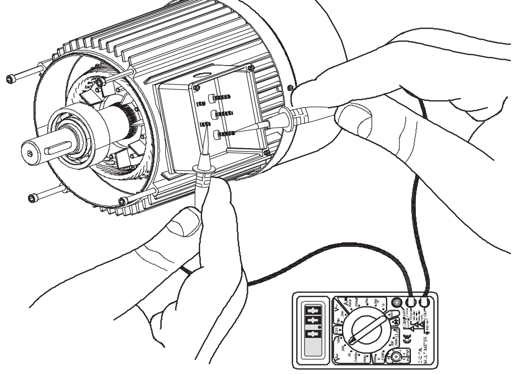
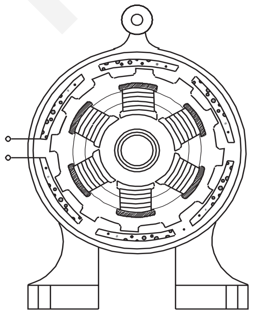


Fig 4



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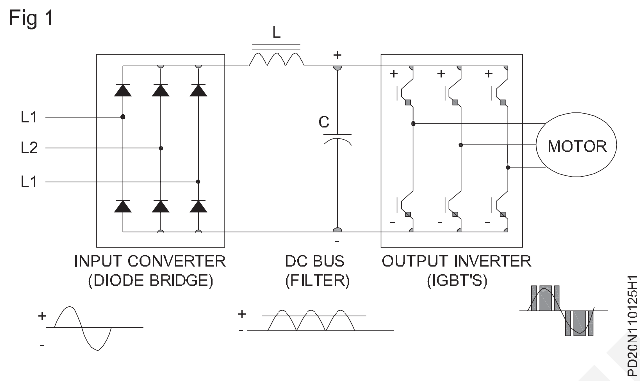
Enter motor data and perform auto turning on thyristors/AC drives

Objectives: At the end of this exercise you shall be able to
- **enter data of motor**
- **perform auto turning on thyristors.**

PROCEDURE

- For understanding the basic principles behind AC drive operation requires understanding three basic section of AC drive the Rectifier unit, DC Bus and the Inverter unit.



- The supply voltage is firstly pass through a rectifier unit where in gets converted into AC to DC supply, the three phase supply is fed with three phase full wave diode where it gets converts into DC supply The DC bus comprises with a filter section where the harmonics generated during the AC to DC conversion are filtered out. The last section consists of an inverter section which comprises with six IGBT where the filtered DC supply is being converted to quasi sinusoidal wave of AC supply which is supply to the AC motor connected to it.

Result

The simulation result is being calculated from a 4 pole AC motor of 3 HP and the Harmonics analysis using FFT tool of simulation of maximum frequency 5000 Hz.

Fundamental Frequency	Speed (RPM)	Order of Harmonics	THD of Voltage	THD of Current
80	2400	62.5 (even)	106.25%	30.49%
75	2250	66.66 (even)	81.86%	19.65%
70	2100	71.42 (odd)	67.89%	14.91%
65	1950	76.92 (even)	55.46%	12.20%
60	1800	83.33 (odd)	78.59%	11.46%
55	1650	90.90 (even)	55.85%	18.72%
50	1500	100 (even)	76.85%	32.86%
45	1350	111.11 (odd)	126.29%	37.35%

Data analysis of Frequency

- It is clear that THD (V) level increases with as the value of fundamental frequency increases from 70Hz and also the fundamental frequency decreases 45 Hz or balow. Thus the range of variations of fundamental frequency should be kept in betwean 70 to 45 Hz. It is also seen that the values of THD (V) in case of 70Hz, 60Hz and 45Hz is quit high as compared to other frequency presents in between them, this is because of presence of ODD Harmonics in these frequencies, as we know that the ODD harmonics is more harmful for the promotion of Distortion in the circuit than the EVEN Hammonics Since the maximum frequency is set as 5000Hz therefore it can be easily calculated the order of Harmonics. Thus the consumption of electrical energy is depends on the load requirement However the variation of frequency leads to the harmonics distortion which can be mitigate by several techniques of harmonics mitigation.

- The variation of THD in between the fundamental frequencies is keep changing therefore there are variation for distortion which leads to the calculation of energy savings is quite possible as well as speed control of the ac motor Further the introduction of filter techniques can lead to the mitigation of harmonics level in the circuit. Basically the application of Band Pass Active Filter is quite suitable for mitigation of harmonics in this level It can be introduced as a future research work of this article.

Conclusion

- Thus from the analysis of table it is clear that the frequency variation leads to the harmonics change in the machine also as the speed decreases the Total Harmonics Distortion in voltage as well as in current increases and THD in voltage is lower than THD in current. It is also to be noted that too much variation in frequency also leads to increase in the THD voltage as well as THD current levels Thus the VFD can make the ac motor work at variable speed as well as energy savings.
- For high performance providing by the VFD for maximum process productivity always required complex engineering consideration.

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Perform reversing the direction of rotation of AC motors by using thyristors/ AC drive

Objectives: At the end of this exercise you shall be able to
- **read and interpret the name plate details of AC drive**
- **connect the input / output terminals of AC drive through AC motor**
- **identify the operating buttons on AC drive**
- **control the motors speed by using AC drive**
- **reverse the directions of rotation of 3 phase induction motor by using AC drive.**

Requirements

Tools/Instruments

- Insulated combination pliers 150 mm - 1 No.
- Screw driver 200 mm - 1 No.
- Connector 100 mm - 1 No.
- Electrician's knife 100 mm - 1 No.
- Round nose plier 150 mm - 1 No.

Equipments/Machines

- 3 Phase induction motor 5 H.P/415V - 1 No.
- AC drive 3 phase 415V, 2HP - 1 No.

Materials

- PVC insulated standard copper cable 1.5 sq.mm - 15 m
- PVC insulated flexible cable 14/0.2 mm - 2 m
- Insulated tape - 1 m
- Fuse wire - as reqd.

PROCEDURE

TASK 1: **Connect the input/output terminals of AC drive through AC motor**

1 Note down the name plate details of the given motor and AC drive and enter them in Table 1 & 2.

2 Identify the terminals of the 3 - phase induction motor.

Table 1

AC motor name plate - details

Manufacturer	______________	Rated frequency	______________ Hz
Model	______________	Speed	______________ RPM
Power	______________ KW/HP	Insulation class	______________
Voltage	______________ Volt	Rated current	______________ A

Table 2

AC drive name plate - details

Manufacturer	______________ Model : ______________
I/P voltage	______________ V
I/P frequency	______________ Hz
O/P frequency	______________ Hz
Serial Interface type	______________
Output voltage	______________ V
Power range	______________ HP/KW
Control type	______________
Braking type	______________

3 Identify and trace the internal circuit of AC drive and get it approved by the instructor.

4 Check the switch /MCB , cables and fuse - wire rating and match with motor rating.

5 Draw the connection diagram of ICTP, drive, motor and get it approved by the instructor.

6 Connect the motor, AC drive, main switch as per approved diagram and get it checked the instructor. (Ref. Fig 1)

7 Connect double earth independently for the main switch, AC drive and the motor.

Improper connection of AC drive results shock and material damage.

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TASK 2: **Connect, run the motor and setting the parameter of different speed**

1 Select the suitable type of model AC drive.

2 Connect and wire the AC drive input power supply with terminals R/L1, S/L2, T/L3, when the output terminals U/T1, V/T2, W/T3, are connected to the motor. (Fig.1)

3 Switch ON the power supply main.

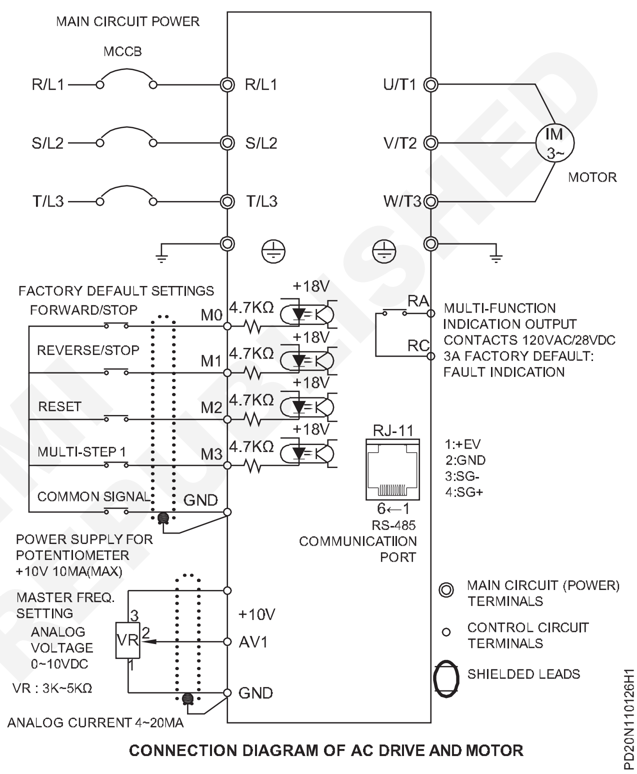
4 Press RUN/STOP button. The motor will run. (Ref. Fig 1 Measure the speed of motor by using the Tachometer and record it_______RPM.

5 Increase and decrease the frequency and check the change in speed of the motor.

6 Press ‘STOP’ button and turn ‘OFF’ main power supply to disconnect the supply.

Improper connection of AC drive results shock and material damage.

Fig 1



CONNECTION DIAGRAM OF AC DRIVE AND MOTOR

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TASK 3: **Reverse the direction of rotation in AC motor by setting in AC drive**

1 Switch ON the power supply main.

2 Press key RUN/STOP button (Ref.Fig 1). The motor will run in forward direction.

3 Set the parameter for reverse direction. (Ref.Fig 1)

4 Press RUN / STOP, button key, The motor will run in reverse direction.

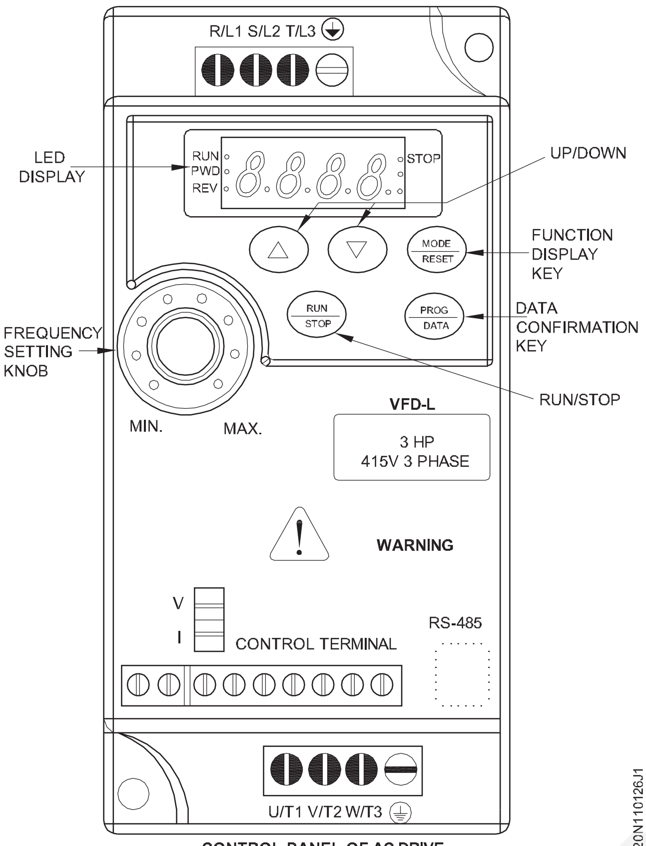
5 Press the STOP button to stop the motor.

Improper connection of AC drive results shock and material damage.

The motor will run as you press the key and will stop as you leave the key.

6 Turn ‘off’ the power supply and disconnect the drive.

Fig 1



CONTROL PANEL OF AC DRIVE

Do not run the motor at low speed for longer time. Because the motor cooling will not be effective due to low fan speed. So motor will heat up.

The programming procedure /keys may differ according to the make model of the drive in your institute. Refer to the drive instruction manual and take help of your instructor.

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Perform connections and identify parameters of AC drives

Objectives: At the end of this exercise you shall be able to
- **perform connections of AC drives**
- **identify parameters of AC drives.**

PROCEDURE

Block Diagram of VFD

To understand the working principle of a variable frequency driver, it is important to know what it is composed of In other words, you need to know what leads the currents passing through a VFD of a 3-phase motor, for instance, to be changed from AC to DC and then back to AC again.

VFD comprises three main sections Rectifier, Filters, and Inverter.

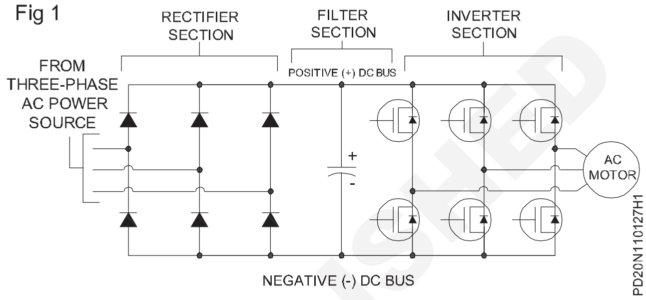
1 **Rectifier:** The first stage of VFD. It converts AC power fed from the mains to DC power. It mainly utilizes diodes that are connected in parallel to convert AC power into DC.

2 **Filter:** A capacitor that is used to smooth the rectified DC power.

3 **Inverter:** Transistors (IGBTS) used to work to be switched on and off rapidly to create a pulse width modulation which creates an AC-like wave that will allow the VFD to control the speed of the motor.

The following diagram shows the circuit diagram of a variable frequency drive (VFD).

Fig 1



VFD Parameters

After we have reminded ourselves how VFDs work by looking at their waveform when the current passes, we will start looking at the practical side of it, which is more critical for installation, configuration, and troubleshooting on-site.

For a VFD to properly and safely control an electric motor, the drive must 'know' specific data about the connected electric motor and its intended application. AC motors have voltage, current, frequency power ratings, etc. These ratings are typically found on a **metal nameplate affixed to a motor frame** where they can be easily read.

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Identify and assemble circuits of voltage stabilizer and UPS

Objectives: At the end of this exercise you shall be able to
- **construct voltage stabilizer circuit on PCB**
- **test the stabilizer for its low and high cut-off ranges**
- **assemble 'ON' line UPS with assembled PCB modules/circuit boards**
- **test the 'ON' line UPS for its function.**

Requirement

Tools/Instruments

- Trainees tool kit - 1 No.
- Multimeter - 1 No.
- AC Voltmeter 0-300 V - 1 No.
- Variac 0-300V/1A - 1 No.

Materials

- General purpose PCB - 1 No
- Transistors - BC 147/157 - 2 Nos.
  CL 100 - 2 Nos.
- Diode IN 4007 - 2 Nos.
- Zener diode 6V/0.5A - 1 No.
- LED, red & green - 1 No. each
- Inductor - 21 SWG
  Ferrite core 100 turns - 2 Nos.
- Capacitor - 330 μFd/12V - 3 Nos.
  100 μFd/12V - 4 Nos
- Resistors carbon film 1/2 W
  1K5, 3K3, 1K - 2 Nos. each
  560Ω, 100Ω - 2 Nos. each
  4K7, 47K - 3 Nos. each
  1K Pot - 1 No.
- Electronic relay - 170V - 270 V/6V moulded type : 3 pin - 2 Nos. each
  Buck - boost mains transformer 170V - 270V - 1 KVA 0-6 A, 0-6 V AC - 1 No.
- Assembled modules or PCBs of a ON line UPS - 1 Set
- Incandescent lamps fitted in pendent holders - 1 No.
- Connecting wires/cables - as reqd.
- Solder; flux etc. - as reqd.

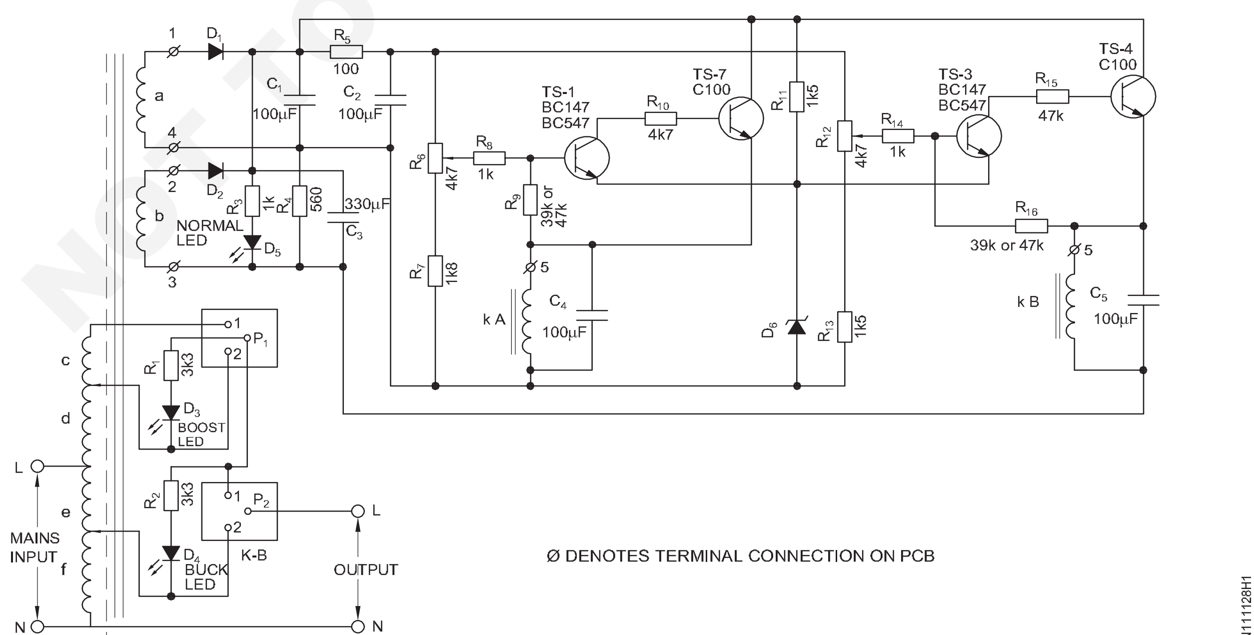
PROCEDURE

TASK 1: **Construct voltage stabilizer circuit on PCB**

1 Solder the components on general purpose PCB as per the circuit (Fig 1). Do not fix the transformer on PCB.

2 Connect the wires or cables from the PCB to connect with transformer winding terminals.

Fig 1



VOLTAGE STABILIZER 835 / VS

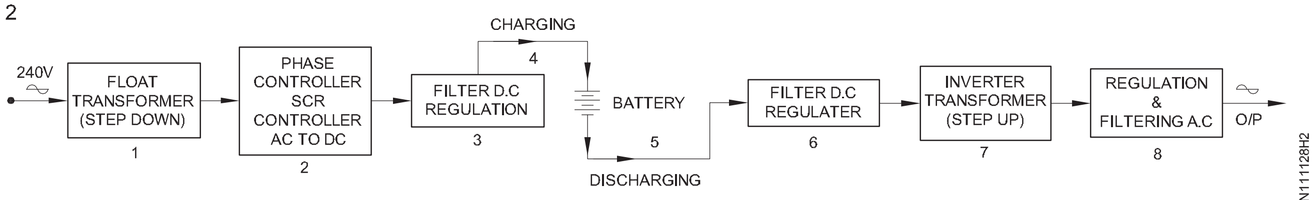
3 Finish the wiring and clean the PCB; check the wiring for its correctness.

4 Connect the transformer input wires to the Variac for testing the circuit. Connect the incandescent lamp in the output of stabilizer. (Fig 2)

5 Switch 'ON' the supply to Variac and slowly increase the voltage till normal LED glow and output lamp glow.

6 Switch 'OFF', remove the lamp and connect the voltmeters. Do not change the variac position.

Fig 2



BLOCK DIAGRAM OF 'ON' LINE UPS

7 Switch 'ON' the supply and note down the voltage in Table 1.

8 Test the bulk-boost action by increasing and decreasing of Variac voltage increase the variac voltage.

9 Check the voltmeter, starts to show increase in voltage initially; but drops to normal voltage. Note down both the voltage; Voltage in output and Voltage at Variac terminals. Record in the Table 1.

10 Reduce the voltage of Variac and note the voltmeter reading. The voltmeter voltage will decrease but regains its normal position.

11 Note this time voltage : Voltage at output and variac terminal voltage in the Table 1.

If the voltage is not changing when changing variac volt ; consult your instructor.

12 Remove all connections and get your voltage readings approved by your instructor.

Table 1

Sl. No.	Variac voltage position	Variac terminal voltage (Volt)	Output voltage (Volt)
1	Variac knob in Middle Position		
2	Increase from Middle Position		
3	Decrease from Middle Position		

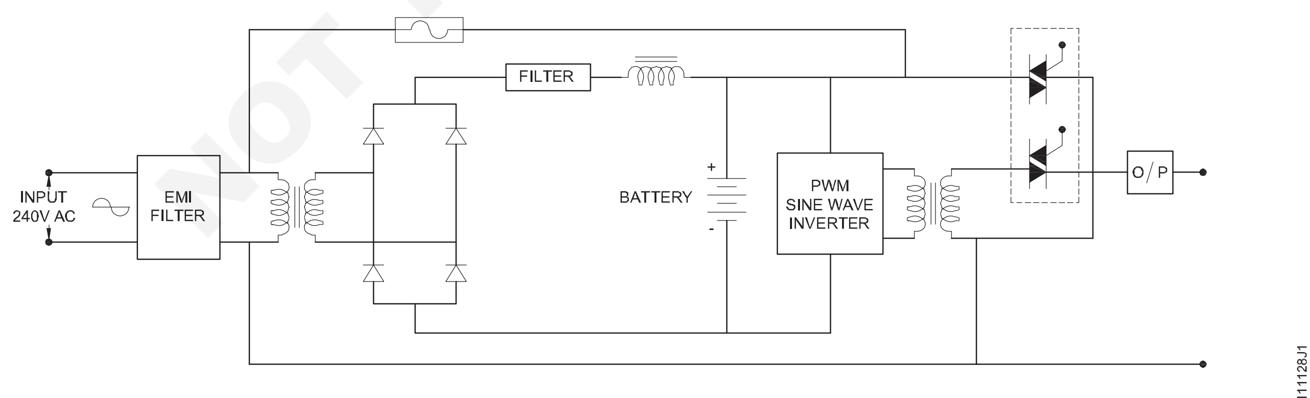
— — — — — —

TASK 2: **Assemble of 'ON' line UPS using wired PCB modules**

1 Refer the block diagram in Task 1 and arrange the PCB wired modules.

2 Wire the PCB modules as per the block diagram in Fig 2 in Task 1 and check the sequence as per the Fig 1.

Fig 1



ON LINE UPS CIRCUIT

3 Connect the charged battery without shorting the battery terminals. Connect one single pole switches initially with battery circuit.

4 Connect the input to EMI filter. Check for any circuit problems. Switch 'ON' the circuit 240V AC. Check the output with Voltmeters. Record the meter reading in Table 1.

If it is not indicating any voltage and consult with your Instructor.

5 Switch 'ON' the battery. Check the voltage in the output and record the reading in Table 1.

6 Switch 'OFF' the Mains 240V and check the voltage in output, record the voltage in Table 1.

If no voltage consult with your instructor.

7 Connect the incandescent lamp in the output. Repeat steps 4 to 6.

8 Note the lamp brighten while input supply 220V. Switched 'ON' & 'OFF'.

If lamp is not glowing or dim consult with your Instructor.

9 Get your readings approved by your instructor.

Table 1

Sl. No.	Input supply voltage	Output voltage (Volt)
1	'ON'	
2	'OFF'	

— — — — — —

Assemble circuits of battery charger and inverter

Objectives: At the end of this exercise you shall be able to
- **assemble the battery charging circuit wired on PCB and test it**
- **construct and test inverter.**

Requirements

Tools/Instruments

- Trainees tool kit - 1 Set
- soldering iron 35W/250V - 1 No.
- De soldering gun 65W/250V - 1 No.
- Star screw driver set (set of 6 Nos) - 1 Set
- Ammeter 0-10 A M.C - 1 No.
- Voltmeter 0-50V M.C - 1 No.
- Digital multimeter (31/2 digits) - 1 No.

Equipments/Machinery

- Auto transformer 0-270 V-5A - 1 No.
- Step down transformer 240/40V, 300VA - 1 No.
- Charger transformer with centre tapping 6V-0-6V,500mA - 1 No.
- Sealed maintenance Free battery 6V/120AH - 1 No.
- Relays double pole -3 Nos.

Materials/Components

- PCB -115 -General purpose -2 Nos.
- Push button switches - 2 Nos.
- Toggle switches 250V/6A - 2 Nos.
- Diodes 1N4002 - 4 Nos.
- Diodes for bridge 1N112 - 4 Nos.
- Capacitors -250µf /12V - 1.No.
- Resistors,10Ω, 1W - 1 No.
- Pot 1.5Ω/10W - 1 No.
- Low voltage lamp 6.3V - 1 No.
- Fuse 250 mA - 3 Nos.
- Neon lamp - 1 No.
- Buzzer 250V - 1 No.
- Soldering flux and 60/40 solder - as reqd.
- Diode IN 5402 - 3 Nos.
- LED : Red and Green - 1 No.
- Transistor - 2N 3055 - 1 No.
- Resistor : 2.2Ω, 22Ω, 50Ω, - 1 No. each
  1K (1 Watt) - 2 Nos.
- Electrolytic capacitors
  1000 µfd/25V, 10 µfd, 25V- 2 Nos. each
- 2.2 µfd/250V - 1 No.
- Relay NC/No 6V - 1 No.
- Transformer 240V/7.5 - 0 - 75V, 2A - 1 No.
- Inverter transformer- iron core laminated
  21 SWG - 25 turns,
  29 SWG - 15 turns - Primary
  36 SWG - 285 turns - Secondary - 1 No.
- Fuse 2.5A, 0.5A - 1 No. each
- SP Switches (Toggle - 6V) - 2 Nos.

PROCEDURE

TASK 1: **Assemble the battery charging circuit**

1 Select suitable PCB (wired PCB)and other components

2 Check all components i.e. transformer, relays, battery for their good condition

3 Construct the transformers relays, and other components on PCB. (Fig 1)

4 Connect the charger Transformer (X1)to the auto transformer (X2).

5 Connect the secondary of charger transformer (X1) to the full wave bridge rectifier which supplies rectified voltage to the battery under charge through ammeter, voltmeter and potentiometer.

Step down transformer (X3) keeps the cut off relay in energised condition when the main AC supply is cut off to the charger circuit. Relay (RL1) is used to cut off the AC main supply to the charger circuit.

6 Connect the pole (P1) of relay (RL1)to A.C main supply and connect pole (P2) is cut off circuit.

7 Connect the poles (P1 & P2) to normally open (N/O) pin, which will switch 'OFF' AC Main supply to the circuit.

8 Connect the test switch (S3) to check battery polarity.

Reset switch (S4) is used to reset the charger, when any fault occurs and the charger is cut off. The switch (S1) for ON/OFF.

9 Connect the ON/OFF switch (S1) to the input of AC main supply.

Normally a fully charged lead acid battery voltage 2.1 V/cell, During on charge ,and can be increased up to 2.7 V/cell .The voltage of a battery is multiple of the number of cells in that battery .The voltage on Fully discharged condition is 1.8 V.

10 Connect the diodes neon lamps, fuses, capacitor, resistor, buzzer, low voltage lamp in correct position as in the circuit.

11 Solder all PCB connection neatly and clean the PCB, without making any short circuit.

12 Set the auto transformer (X2) is in zero level position, before charging the battery.

13 Keep the switches S1,S2 & S5 on open position .

14 Connect the battery to the charger output terminal (positive terminal to the battery positive pole and negative terminal to the battery negative pole)and close the switch S3.

15 Check the readings in voltmeter which is connected through diode D9 and switch S3.

If the battery is connected in wrong/reverse polarity, then the diode will block the battery voltage and no reading in voltmeter. Correct the battery polarity by charging the connection to read the volt meter.

16 Close the main ON/OFF switch (S1) by keeping the zero position of an autotransformer (X2) and neon lamp (N1) and Lamp (L1) will indicate 'ON'.

17 Vary the setting of Auto transformer slowly from zero position until the voltmeter shows the reading nearer to the voltage of battery to be charged.

18 Switch 'ON' the charging switch (S2) and increase the voltage by varying auto transformer till, the required charging current (5 Amp) is displayed by the ammeter.

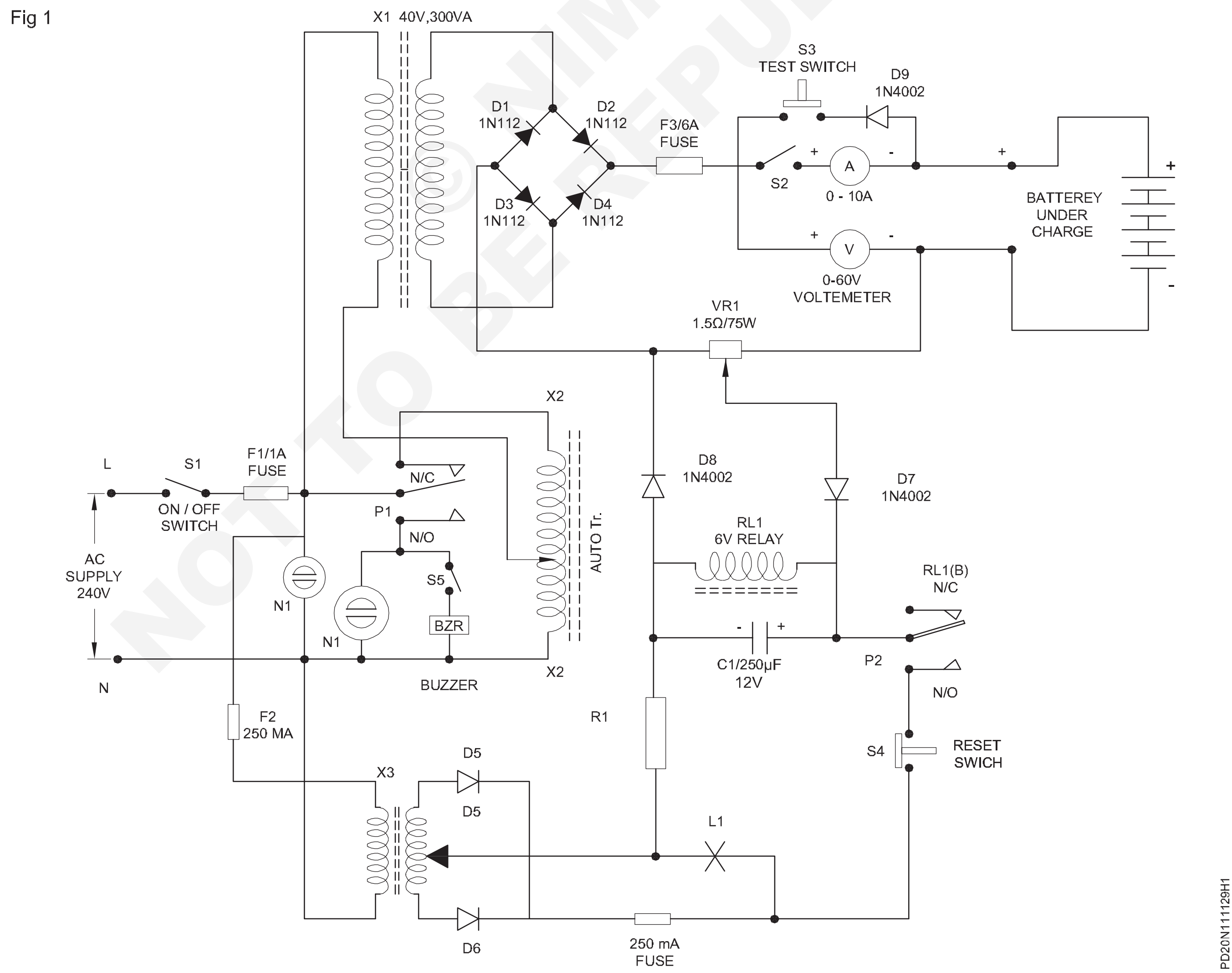
19 Leave the charger on to charge the battery to the required level.

If the battery is fully charged automatic cut-off circuit will switch 'OFF' the supply to the battery, and automatically switch 'OFF' the charging current which flows through potentiometer VR1 , to cut off relay RL1.

When the battery is fully charged the current through the potentiometer increases and relay RL1 is energised through diode D7 and D8, and the pole of relay RL1 (ca) is connected to N/O contact which will cut off main A.C supply to auto transformer X2 and switch on the error indicator buzzer and the warning neon 'N2' lamp.

20 Switch 'OFF' the buzzer by the switch (S5).

Fig 1



The error indicator neon lamp (N2) and the buzzer stays on till the charger is reset.

21 Press the reset switch (S4), only, if the process to be continued once again.

If the reset switch is pressed without correcting the problem which activated the cut off and again it will operate instantly. To reset the charger, the reset button (S4) to be pressed for about one second, only to let the capacitor C1, discharge.

The following precautions to be followed when charging the battery.

1 The level of electrolyte should be about 1.2 cm above the plates.

2 Add distilled water to electrolyte if the level of electrolyte is low (acid should not be added to the electrolyte).

3 Charge the battery continuously unless the battery temp. exceeds 37° C stop charging for some time to cool down the battery.

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TASK 2: **Construct and test inverter circuit**

The inverter made for emergency light (Ex. No.2.10.176) can be utilised for this exercise.

1 Collect the inverter circuit assembled in the emergency light. (Fig 1) (Ex. No.2.10.176)

2 Remove the tube light and make the terminals free.

3 Connect the terminals of mains to the supply and switch 'ON'.

4 Check the corresponding LED's are glowing and measure the output voltage.

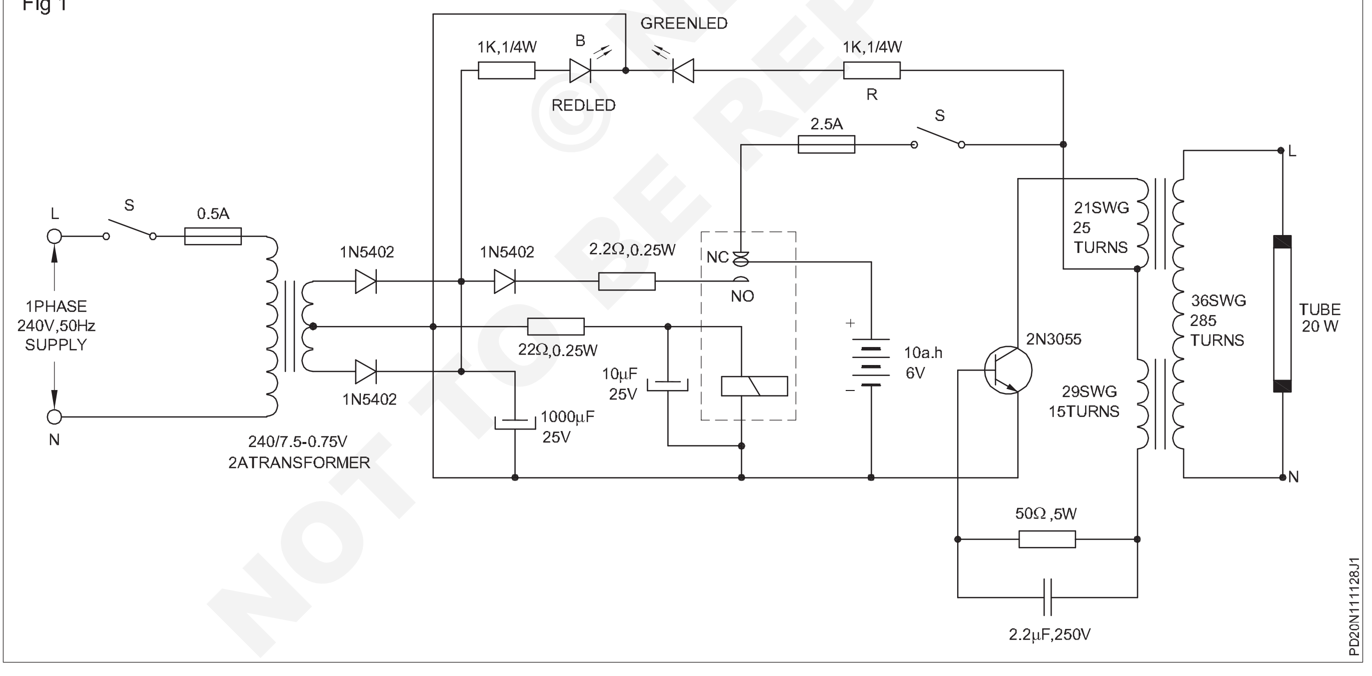
5 Connect the inverter circuit with supply. Disconnect the main AC supply and test the output of inverter by connecting load and note the performance.

____

6 Report your instructor and get his approval.

Check the backup time of the inverter and verify the same with manufacture's manual.

Fig 1



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Test analyse, defects and repair voltage stabilizer, emergency light and UPS

Objectives: At the end of this exercise you shall be able to
- **analyse the defect and repair voltage stabilizer**
- **repair and maintenance of emergency light**
- **analyse the fault and repair the defects in UPS.**

Requirements

Tools/Instruments

- Trainees Tool kit - 1 Set
- Connector screw driver set - 1 Set
- Line /Neon tester 500 V - 1 No.
- Soldering iron 35 W/250V - 1 No.
- Desoldering gun - 1 No.
- Multimeter (analog (or) digital) - 1 No.
- Clamp on meter - 1 No.

Equipments

- Common UPS 625 VA/12 V - 1 No.
- Sealed lead acid battery with operation manual (maintenance free battery) 12 V/120AH - 1 No.
- CRO 20 MHz/dual trace - 1 No.
- Assembled circuit of voltage stabilizer
- Assembled circuit of emergency light
- Assembled circuit of 'ON Line' UPS

Materials/Components

- Spare components - as reqd.
- Solder 60/40 - as reqd.
- Soldering flux - as reqd.
- Connecting wires - as reqd.

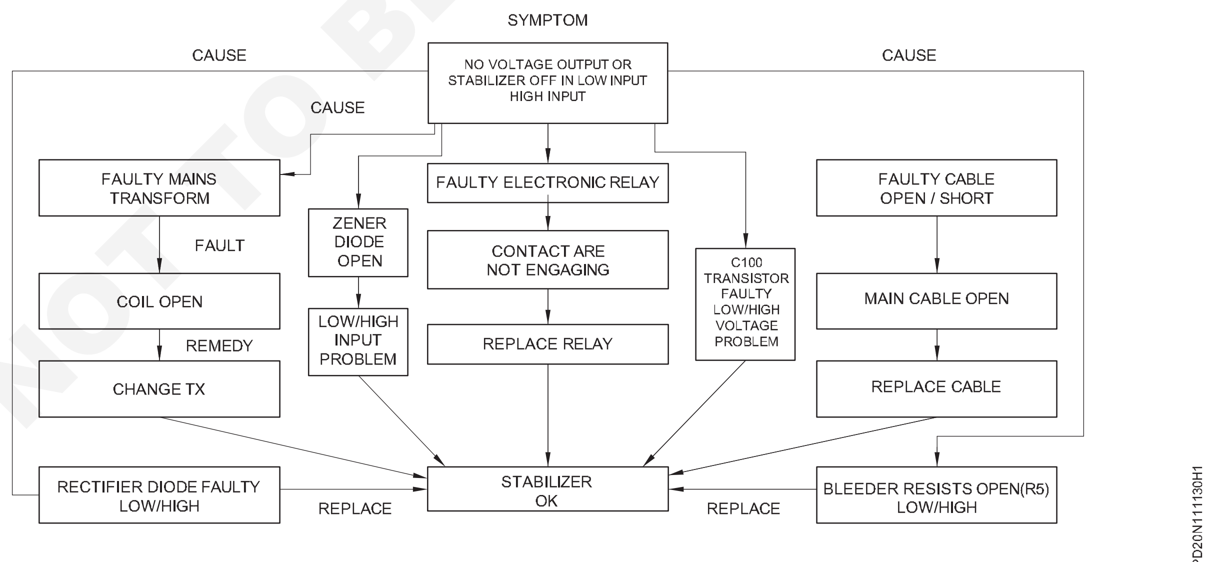
PROCEDURE

TASK 1: **Analyse the fault and repair of voltage stabilizer with the help of a Service Flow Sequence (SFS)**

1 Check the circuit carefully before connecting the supply for any short circuit in the components/parts in the stabilizer.

2 Connect the main supply cable into ohm meter and check the resistance by switch 'ON' the circuit (note to be connect with AC mains)

Fig 1



> **If it shows '0' resistance, it indicates a dead short. Consult your instructor.**

3 Check for any open circuit visually or by ohm meter after testing for short circuit.

> **If the meter shows infinity i.e. open circuit. Otherwise, if it is a healthy circuit it will show some resistance reading.**

4 Analyze the status of the circuit by the meters reading.

5 If the stabilizer is without short circuit fault, connect it to the supply mains and switch ‘ON’. Check the symptoms of the unit, and record the symptoms. Analyze the fault with the help of service flow sequence.

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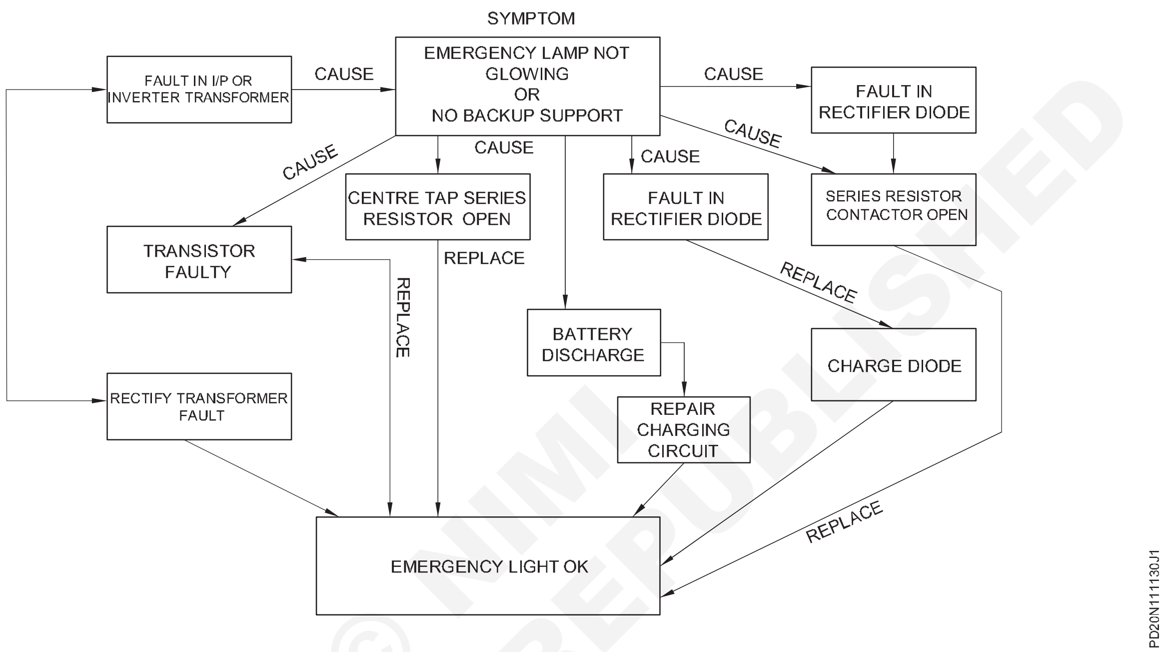
TASK 2: **Repair and maintenance of emergency light with the help of trouble shooting sequence block**

1 Steps 1 to 5 on as same as follow in Task 1. Refer the service flow sequence diagram and solve it. (Fig1)

There may be single fault or multi fault involving more components. A visual check will help in to find burning of components, dry soldering, loose connection, etc. A careful visual check is very much essential.

Fig 1



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TASK 3: **Test UPS and identify the faults and rectify**

1 Read and interpret the name plate details of the given UPS

Type of UPS.....................ON line/OFF line

Model ....

Power rating ....VA

Change over time ....m sec

Battery rating ....

Back up time ....Hours

2 Switch ‘ON’ the UPS, with UPS. ‘Plugged in’

3 Press and hold the ON/OFF /test /silence button for more than one second until “Line normal ‘LED green lights up. (i.e U.P.S .’ON’ and ready for use)

If green LED does not light up, the possible causes may be (i) button not pressed (or) pressed to short (ii) voltage of battery less than 10V (iii) PCB - failure and (iv) load may be less than 20 W at battery mode.

4 Identify the problem by self testing UPS., and rectify this fault by referring the trouble shoot sequence block diagram (Fig 1)

5 To switch ‘OFF’ the UPS press and hold the ON/OFF/ test/ silence button for more than 3 seconds until the “Line normal” or “backup” LED ‘OFF’.

6 Check the condition of switch, (or) back up LED (yellow LED) (or) press the switch for more than 3 seconds and rectify the problem, if the UPS not switched ‘OFF’.

To de-energise the UPS properly in emergency, the right way is to switch ‘OFF’ the output switch to ‘OFF’ position and disconnect the power cord from the main supply.

7 Press the ON/OFF/test/silence switch, more than 3 seconds, to switch ‘OFF’ the UPS and battery.

8 Check the back up (LED yellow).

If the yellow LED (back up) lights 'OFF', the UPS and battery is on 'OFF' position. If the back LED is not 'OFF', it indicates UPS always at battery mode. The causes for this fault may in power cord, fuse or up normal voltage.

9 Check the condition of power cord, A.C fuse, abnormal voltage and PCB.

10 Rectify problem by referring the trouble shooting sequence block diagram (Fig 1)

11 Press the ON/OFF/TEST silence button less than one second, when A.C mains supply is available observe the operation UPS

If the UPS operates on load on battery mode, then battery LED lights up, it indicates UPS is in 'ON' line operation.

If the UPS does not operate on load on battery mode and immediately returns to 'ON' line operation and lights up the RED-LED ,It indicates that the back up time is too short the battery is to be replaced (or) to be recharged.

12 Recharge the battery immediately for atleast four hours.

13 Check and test UPS with recharged battery and rectify the fault by referring Fig 1,Trouble shooting sequence block diagram.

If the "replace battery" (red LED) is still on, replace the battery.

14 Press the ON/OFF/test/silence button for less than 1 sec in 'Backup' mode ,observe the audible alarm, It should be 'silence.

If does not function under 'Low battery (or) over load conditions.

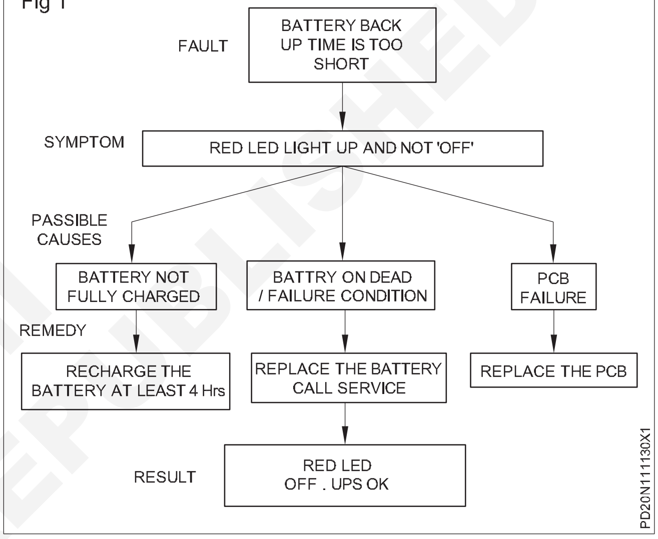
15 Check the beeping alarm ,when pressing the silence button to stop the operation of UPS.

If it is stopped in back up mode it indicates UPS is in normal . But, If the beep sound alarms continuing, It indicates that UPS is over loaded.

16 Press the button (ON/OFF)during alarms to stop the beeping when yellow LED (backup) lights up.

17 Check for the maximum connected load to UPS and rectify this fault by disconnect the excess until the beep alarm is not available.

Fig 1



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Maintain service and troubleshoot battery charger and inverter

Objectives: At the end of this exercise you shall be able to
- **carryout service and troubleshoot a battery charger**
- **troubleshoot and repair a inverter.**

Requirements

Tools/Equipments

- Trainees kit - 1 No.
- Multimeter - 1 No.

Material

- Collect the circuits already constructed in Ex.No. 1.11.129

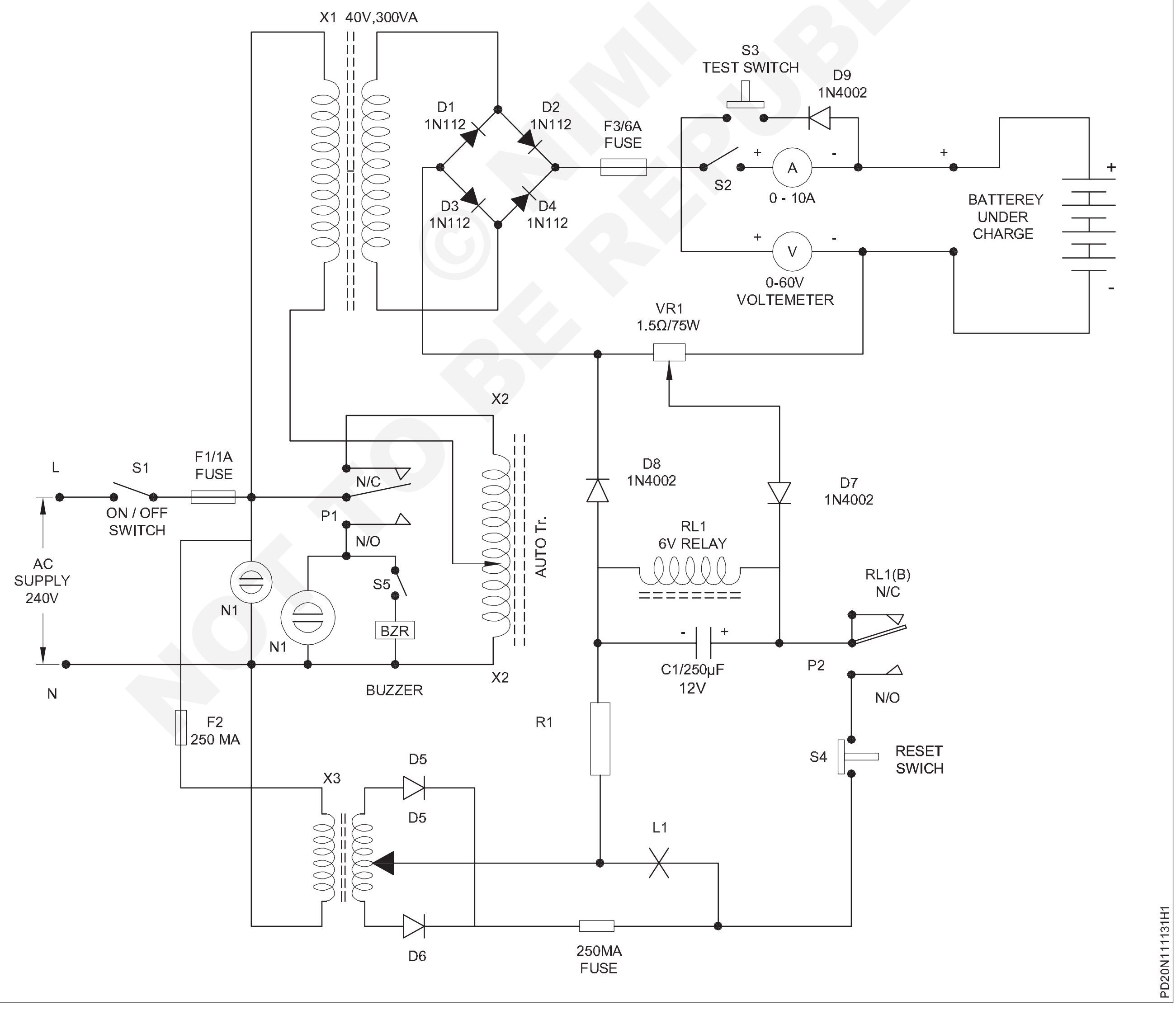
PROCEDURE

TASK 1: **Service and troubleshoot of battery charger**

1 Trace the battery charger circuit made in Ex.2.10.177 as in Fig 1.

2 Check the circuit for an availability of charging volt at battery connecting terminals.

Fig 1



3 Check the fuse provided in the fuse carrier. If the voltage is not available.

4 Test the voltage output at the bridge rectifier output with multimeter.

5 Check the conditions of bridge rectifies diodes if found defective replace. If no voltage available.

6 Check the AC input to Bridge network. If the diodes are OK.

7 Check the relay contacts and; ensure supply is available at primary of the auto transformer. If the AC is not available

8 Check the charging control circuit for normal working after the charging circuit is repaired.

9 Check that auto cut-off of AC Mains is 'OFF' the battery is fully charged.

10 Check the diode connected to potentiometer and voltage at relay terminals, If auto cut-off is not working or functioning, and if the voltage is present at relay terminal (pole) Auto cut-off is OK.

11 Check the conditions of the battery, fully charged battery will show DC Voltage in no load about 20% more than the rated voltage.

Do not allow the battery Voltage (no-load) drop below 70% of the rated voltage. If it is so revival of the battery is difficult.

12 Check while charging battery; ensure that it is topped-up with distilled water and caps are removed for easy gaseous out from the cells.

13 Complete the work and show to your instructor for approval.

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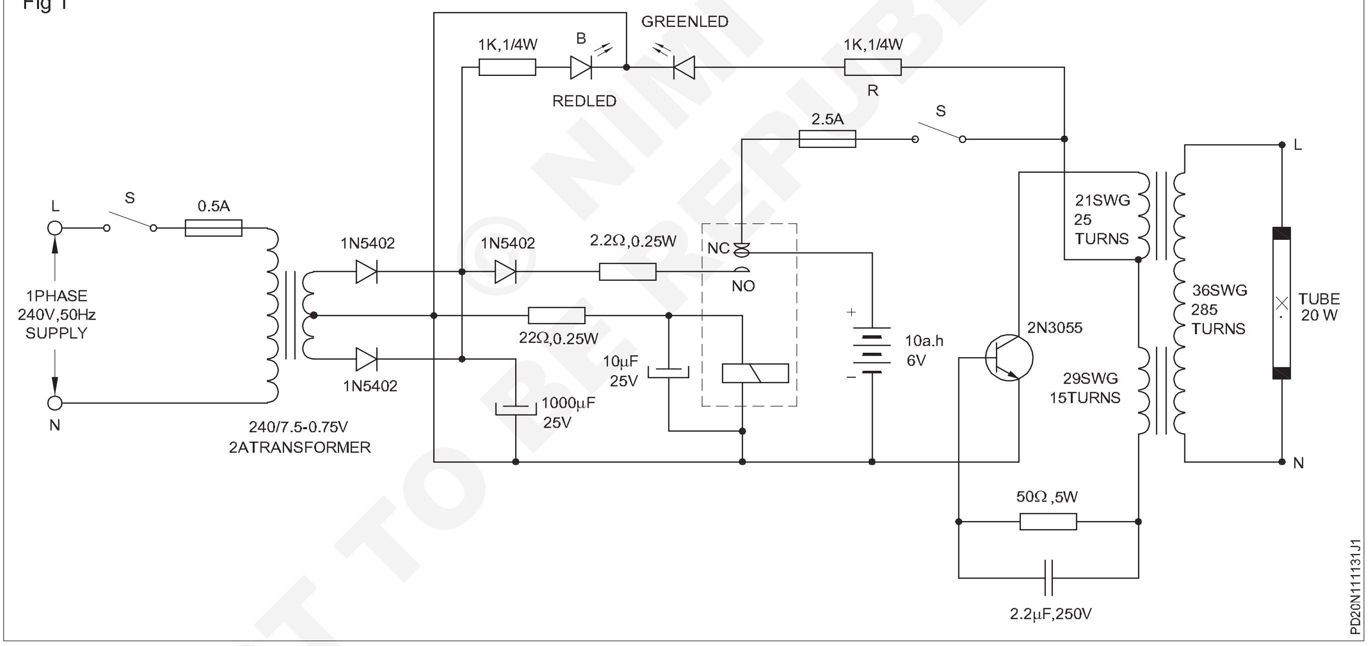
TASK 2: **Service and troubleshoot of inverter circuit**

1 Trace the circuit made in Ex. No.2.10.177 (Inverter circuit) and locate the Active Components. (Fig 1)

2 Carry out short circuit and open circuit test.

Fig 1



3 Remove the battery connect to AC Voltage check the inverter output with mains 'ON'.

4 Check the continuity of inverter transformer primary and secondary windings. If then is no output.

5 Check the transistor 2N3055 and the base supply. If the transformer is OK,

6 Check the fuse provided with NC of relay and check the conditions of relay contacts.

7 Check the rectifier diodes and bleeder resistor connections secondary to the Mains transformer.

8 Check the mains transformer primary and secondary windings. Check the main fuse.

9 Once the repair is completed check the output voltage without battery connections.

10 Connect the charged battery if output is available and operate it and ensure its working. Maintenance of battery is explained in the Task 1 and follow the same.

11 Complete the work and show to your instructor for approval.

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Install an inverter with battery and connect it in domestic wiring for operation

Objectives: At the end of this exercise you shall be able to
- **select the proper rating of inverter to install**
- **select suitable place for the inverter in the house**
- **select a correct rating of battery and the place to keep with inverter**
- **install the inverter and make connection to the load**
- **test the inverter for its good performance in 'OFF' and 'ON' supply mains.**

Requirements

Tools/Instruments

- Trainees kit - 1 Set
- Portable electric drilling machine 6mm - 1 No
- Star head screw driver set (set of 6mm)- 1 No.
- Rawl jumper No.8 - 1 No.
- Cutting plier 150mm - 1 No.
- D.E spanner set 6mm-25mm - 1 Set
- Ballpein hammer 0.75 kg - 1 No
- Single phase energy meter 250V/15A - 1 No
- Multi pin socket 3/5 pin 250V/6A - 1 No.

Equipments/Machinery

- 200W/250V/6A -inverter - 1 No.
- Battery 12V/120AH - 1 No.

Materials/Components

- 4 way MCB -20A - 1 No.
- 1.5mm^2 P.V.C. copper (1/18)wires - as reqd.
- Auto wires (stranded) - as reqd.
- I.C.D.P switch 16A/250V - 1 No.
- 4 way MCB/ICDP20 A switch - 1 No
- Power socket 250 V/16A - 1 No
- Multi pin wall socket 250V/6A (2 in one)with switch - 1 No
- Grease/Vaseline - as reqd.

PROCEDURE

TASK 1: **Select, install inverter with battery to connect in domestic wiring**

1 Select the suitable rating of the Inverter considering the total connected load in that house, like fan, lamp etc.

> **The rating of the inverter should not exceed 60% capacity of the inverter key. (for a 100w inverter, total load should not be more than 60W).**

2 Select the right place to install the inverter, where good ventilation is available.

> **The place for installation for inverter should be nearer to the D.P switch and the energy meter position.**

3 Select the correct place to install battery, which is nearer to the inverter and to the ventilation.

4 Install the inverter and battery close to each other.

> **Do not provide the battery away from inverter. If should be closed to the inverter because it helps in reducing the current loss due to resistance of wire.**

5 Make wiring connection to the inverter with 1.5 mm^2 wire.

6 Connect the three pin output socket from the mains supply (Fig 1)

7 Connect the positive terminal of the battery (i.e red wire) to the place provided for the positive terminal on the Inverter.

8 Connect the negative terminal of the battery (i.e black wire) to the place provided for the negative terminal of the inverter.

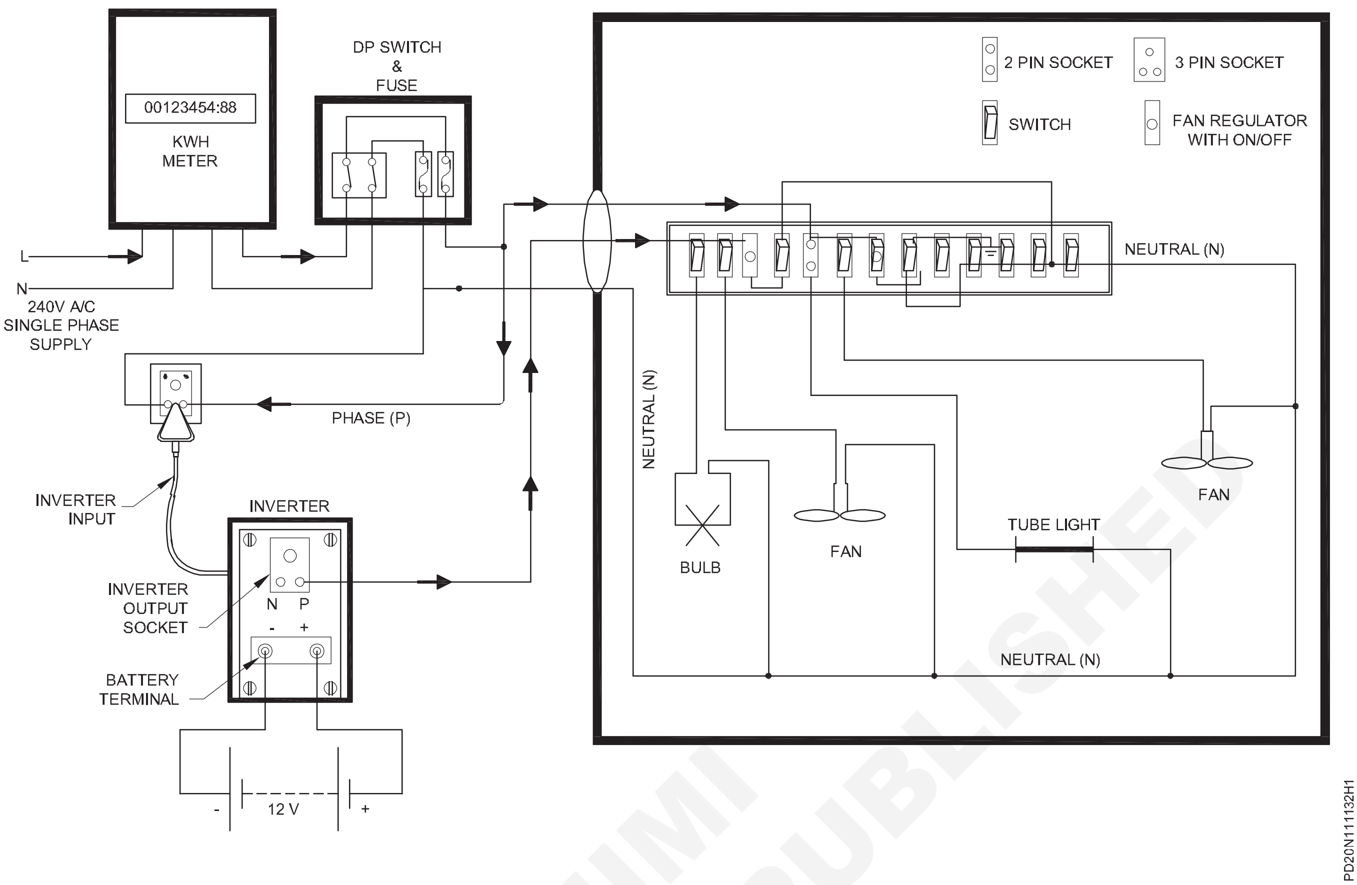
> **When connecting battery terminals to the inverter use special auto wires, do not use common 3/20 (or)7/20 wires and ensure that the battery is fully charged.**

9 Put grease (or) vaseline on the battery terminals for reducing the terminal corrosion.

10 Complete the connection Take the output from the inverter output socket and use it to power the load.

> **To connect the inverter output to the load use only 1/18 wire, and do not use 3/20 or 7/20 wires.**

Fig 1



11 Connect the ON/OFF switch on the wall panel from the phase output pin of inverter output socket (Fig 1)

12 Connect one common Neutral line of both inverter output and mains AC supply.

13 Connect only one wire for the phase line from the inverter output socket to the switches.

14 Give connection to one bulb, one fan (A) and 2 pin socket only to the inverter output as in Fig 1.

15 Connect the other devices in the room i.e the tube light, fan (B) and 3 pin socket directly to the mains AC line.

Low wattage load only to be connected on the two pin socket during the power 'OFF' time. Heavy load should not be connected to this socket., such as heater, geyser, motors in HP etc.

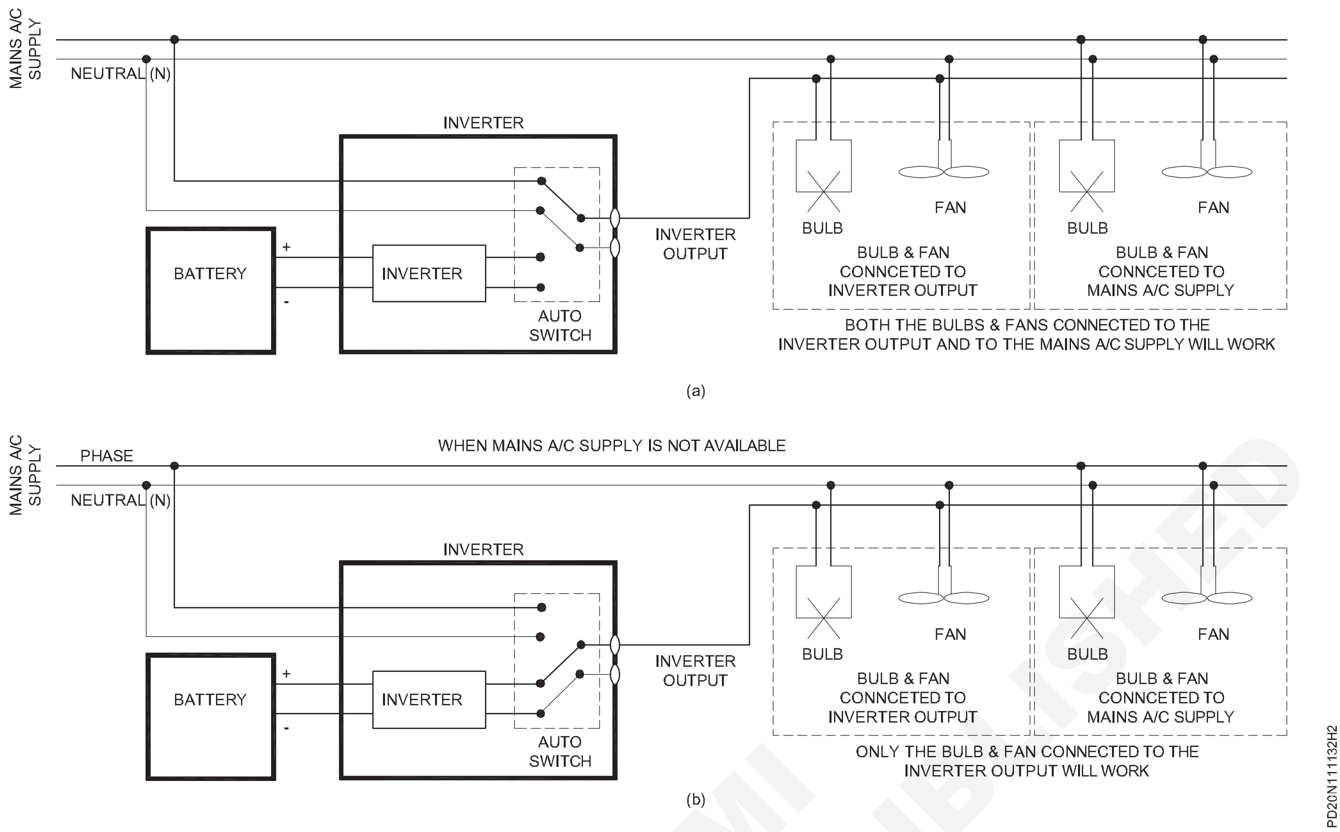
16 Show the connection and get it approved by your instructor.

17 Check the operation of inverter during power 'OFF' and then power returns.

If the main supply is 'ON' the load connected to the inverter will get the main AC supply and the other devices which are directly connected to the mains AC supply will also work on the main supply. (Fig 2a)

During power shut down, the devices which are directly connected to the mains AC will stop functioning and the devices connected to the inverter will keep on working on the inverter output . when the mains AC supply returns the inverter will again connect the load to its output. (Fig 2b)

Fig 2


MAINS A/C SUPPLY
NEUTRAL (N)
INVERTER
BATTERY
+
-
INVERTER
AUTO SWITCH
INVERTER OUTPUT
BULB
FAN
BULB
FAN
BULB & FAN CONNCETED TO INVERTER OUTPUT
BULB & FAN CONNCETED TO MAINS A/C SUPPLY
BOTH THE BULBS & FANS CONNECTED TO THE INVERTER OUTPUT AND TO THE MAINS A/C SUPPLY WILL WORK
(a)
MAINS A/C SUPPLY
PHASE
WHEN MAINS A/C SUPPLY IS NOT AVAILABLE
NEUTRAL (N)
INVERTER
BATTERY
+
-
INVERTER
AUTO SWITCH
INVERTER OUTPUT
BULB
FAN
BULB
FAN
BULB & FAN CONNCETED TO INVERTER OUTPUT
BULB & FAN CONNCETED TO MAINS A/C SUPPLY
ONLY THE BULB & FAN CONNECTED TO THE INVERTER OUTPUT WILL WORK
(b)
PD20N11132H2

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Project Works

Objectives: The Trainees/Participants shall be able to
- **select a project work of their choice**
- **prepare the list of materials required and collect them**
- **list out the tools required**
- **prepare a brief note on the project**
- **complete the project and submit the project report with all the details.**

Note: Instructor has to explain in detail regarding the project works to be carried out in the section. The trainees may be divided in groups according to the strength available in section and give all details how to prepare and finish the work with complete workmanship and accuracy.

- Step to start and follow the project work
- Motivate the group by emphasising the technical work involved and its future influences.
- Divide the work equally and make sure all are participating with full interest.
- Start the project work, test it stage by stage and complete it.
- Test the completed project job for its functional and its utility.
- Prepare a project report containing its technical parameters, specification, material requirement and its cost, operational procedure, maintenance, utility and marketting etc.
- Indicate scope of future expansion, easy conversion to other project for advanced version in the report.
- Get it checked with your instructor.
- The project must be complete with all operational instructions with necessary procedure labels and symbols etc. and further use.
- Safety devices has to be placed according to the project and its functions.
- Maintenance and repair instructions has to be indicated clearly.

Note : Instructor has to evaluate the project work with all records and reports. Marks to be awarded for the Project working, Accuracy, Workmanship, Safety features and its work performance related to the viva question.

Project work

1 Prepare and assemble a test board with switches plug socket, lamp holder etc.

2 Temperature controlled system for switchning 'ON 'and 'OFF' of any circuit using bi-metallic strip.

3 Series/Parallel combinational circuits.

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