SOLAR TECHNICIAN (ELECTRICAL)

NSQF LEVEL - 3

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 : 1 - Year

Trade : Solar Technician (Electrical) - Trade Practical - NSQF level - 3 (Revised 2022)

Developed & Published by

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First Edition : November 2022 Copies : 1000

Rs.350/-

FOREWORD

The Government of India has set an ambitious target of imparting skills to 30 crores people, one out of every four Indians, by 2020 to help them secure jobs as part of the National Skills Development Policy. Industrial Training Institutes (ITIs) play a vital role in this process especially in terms of providing skilled manpower. Keeping this in mind, and for providing the current industry relevant skill training to Trainees, ITI syllabus has been recently updated with the help of Mentor Councils comprising various stakeholder's viz. Industries, Entrepreneurs, Academicians and representatives from ITIs.

The National Instructional Media Institute (NIMI), Chennai has now come up with instructional material to suit the revised curriculum for **Solar Technician (Electrical) - Trade Practical - NSQF Level - 3 (Revised 2022) in Power Sector under Yearly Pattern.** The NSQF Level - 3 (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 - 3 (Revised 2022) trainees will also get the opportunities to promote life long learning and skill development. I have no doubt that with NSQF Level - 3 (Revised 2022) the trainers and trainees of ITIs, and all stakeholders will derive maximum benefits from these IMPs and that NIMI's effort will go a long way in improving the quality of Vocational training in the country.

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

Jai Hind

Addl. Secretary/ Director General of training
Ministry of Skill Development & Entrepreneurship,
Government of India.

New Delhi - 110 001

PREFACE

The National Instructional Media Institute (NIMI) was established in 1986 at Chennai by then Directorate General of Employment and Training (D.G.E & T), Ministry of Labour and Employment, (now under Directorate General of Training, Ministry of Skill Development and Entrepreneurship) Government of India, with technical assistance from the Govt. of the Federal Republic of Germany. The prime objective of this institute is to develop and provide instructional materials for various trades as per the prescribed syllabi 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 organisations to bring out this Instructional Material **(Trade Practical)** for the trade of **Solar Technician (Electrical)** under **Power** Sector for ITIs.

MEDIA DEVELOPMENT COMMITTEE MEMBERS

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

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

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

INTRODUCTION

TRADE PRACTICAL

The trade practical manual is intended to be used in practical workshop. It consists of a series of practical exercises to be completed by the trainees during the course of the **Solar Technician (Electrical)** 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 -3 (Revised 2022) syllabus are covered.

Module 1	-	Safety practice and hand tools
Module 2	-	Basic Workshop Practice
Module 3	-	Electrical wire joints, Soldering and Crimping
Module 4	-	Measuring instruments and power, energy, calculation of electrical circuits
Module 5	-	Natural planetary movements and sunlight's path
Module 6	-	Characteristics of Photovoltaic cells, Modules, Batteries & Charge controllers and DC appliances of solar PV
Module 7	-	Connect, test, under take maintenance and disposal of solar batteries
Module 8	-	Basic circuits of solar panel, Charge controller,Battery bank and Inverter
Module 9	-	Connect and Test Solar Panel
Module 10	-	Bill of Materials for Solar PV Projects
Module 11	-	Tests and Measurement of PV Modules and Installation
Module 12	-	Installation Solar PV Plant and Hybrid Plant
Module 13	-	Operation & Maintenance of PV System
Module 14	-	Manufacturing of Solar Panel

The skill training in the shop floor is planned through a series of practical exercises centered 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 Course of the **Solar Technician (Electrical)** Trade Practical NSQF Level - 3 (Revised 2022) in Power . The contents are sequenced according to the practical exercise contained in NSQF LEVEL - 3 (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 indications about the corresponding practical exercises are given in every sheet of this manual.

It will be preferable to teach/learn trade theory connected to each exercise at least 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 for 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	1.1.01 - 10
2	Prepare electrical wire joints, carry out soldering and crimping.	1.2.11 - 14
3	Construct and test various characteristics of electrical and magnetic circuits.	1.3.15 - 28
4	Assemble, install and test wiring system	1.3.29 - 37
5	Use instruments for measurement of various electrical parameters.	1.4.38 - 40
6	Perform basic electric energy calculations and understand transmission and distribution of electrical power.	1.4.41 - 46
7	Verify natural planetary movements and sunlight's path.	1.5.47 - 57
8	Demonstrate characteristics of Photovoltaic cells, Modules, Batteries and Charge controllers.	1.6.58 - 82
9	Construct and demonstrate Solar DC appliances.	1.6.83 - 88
10	Connect, test, under take maintenance and disposal of solar	1.7.89 - 96
11	Connect and test solar panel, Charge controller, Battery bank and Inverter.	1.8.97 - 104 1.9.105 - 110
12	Prepare Bill of materials for small, medium and mega solar PV projects	1.10.111 - 116
13	Perform various tests and measurement pertaining to PV Modules and their installation as per IEC standards.	1.11.117 - 121 1.12.122
14	Assist in Installation and commissioning of Solar PV plant and Hybrid plant.	1.12.123 - 157 1.13.158
15	Perform Operation & Maintenance of PV system with best practices.	1.13.159 - 163
16	Perform manufacturing of solar panel, prepare and commission marketable solar products.	1.13.164 - 169 1.14.170 - 176

SYLLABUS

1st Year (Vol II of II) **Duration: Six months**

Duration	Reference Learning Outcome	Professional Skill (Trade Practical) (With inidcative hour)	Professional Knowledge (Trade Theory)
Professional Skill 60 Hrs; Professional Knowledge 15 Hrs	Prepare profile with an appropriate accuracy as per drawing following safety precautions	1. Visit of various sections of the institutes and identification of danger, warning, caution & safety signs. (05 hrs) 2. Preventive measures for electrical accidents and use of fire extinguishers.(05hrs) 3. Practice elementary first aid and artificial respiration. (06hrs) 4. Disposal procedure of waste materials. (03hrs) 5. Use of personal protective equipments. (05hrs) 6. Familiarization with signs and symbols of electrical Accessories. (04hrs)	Scope of the trade. Safety rules and safety signs. Types and working of fire extinguishers. First aid safety practice. Hazard identification and prevention. Response to emergencies, e.g. power failure, system failure and fire etc. (05 hrs)
		7. Workshop practice on filing and hacksawing.(07hrs) 8. Practice sawing, planing, drilling and assembling formaking a wooden switchboard. (07hrs) 9. Workshop practice on drilling, chipping, internal and external threading of different sizes. (12hrs) 10. Prepare an open box from metal sheet. (05hrs)	Concept of Standards and advantages of BIS/ISI. Trade tools specifications. Electrical symbols. Introduction to National Electrical Code-2011. (10 hrs)
Professional Skill 25 Hrs; Professional Knowledge 05 Hrs	Prepare electrical wire joints, carry out soldering and crimp-ing.	11. Practice on skinning, twisting and crimping. (06 hrs) 12. Identify various types of cables and measure conductor size using SWG and micrometer. (06hrs) 13. Make joints on single strand conductors. (06 hrs) 14. Practice in crimping and soldering of joints / lugs. (07 hrs)	Fundamentals of electricity. Concept of current, voltage, power, resistors and capicitors. Generation of DC electricity. Electrical conductors and insulators. Differentiate between AC and DC current. Types of joints and techniques of soldering. (05 hrs)
Professional Skill 60 Hrs; Professional Knowledge 12 Hrs	Construct and test various characteristics of electrical and magnetic circuits	15.Measure parameters in combinational DC circuits by applying Ohm's Law for different resistor values and voltage sources. (05 hrs) 16. Measure current and voltage in DC circuits to verify Kirchhoff's Law. (04 hrs)	Ohm's Law; Simple electrical circuits and problems. Kirchoff's Laws and applications. Series and parallel circuits. Open and short circuits in series and parallel networks.

		17. Verify laws of series and parallel circuits with voltage source in different combinations. (04 hrs) 18. Measure current and voltage and analyse the effects of shorts and opens in series and parallel circuits. (05 hrs) 19. Verify the characteristics of series parallel combination of resistors. (04 hrs) 20. Determine the poles and plot the field of a magnet bar. (04 hrs) 21. Identify various types of capacitors, charging / discharging and testing. (04 hrs) 22. Test AC circuit with resistive load like lamp, heater, etc. (04 hrs) 23. Test AC circuit with inductive load like fan, pump, etc. (04 hrs) 24. Measure power, energy for lagging and leading power factors in single phase circuits. (04 hrs) 25. Measure Current, voltage,power, energy and power factor in three phase circuits. (05 hrs) 26. Ascertain use of neutral by identifying wires of a 3- phase 4 wire system and find the phase sequence. (04 hrs) 27. Determine the relationship between Line and Phase values for star and delta connections. (04 hrs) 28. Measure the Power of three phase circuit for balanced and unbalanced loads. (05 hrs)	Series and parallel combinations of resistors. Magnetic terms, magnetic materials and properties of magnet. Electrostatics: CapacitorDifferent types, functions, grouping and uses. Inductive and capacitive reactance and their effect on AC circuit. Comparison and Advantages of DC and AC systems. Sine wave, phase and phase difference. Related terms frequency,Instantaneous value, R.M.S. value Average value, Peak factor, form factor, power factor and Impedance etc. Active and Reactive power Single Phase and threephase system. Advantages of AC polyphase 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. (12 hrs)
Professional Skill 45 Hrs; Professional Knowledge 07 Hrs	Assemble, install and test wiring system.	29. Identify various conduits and different electrical accessories. (04 hrs) 30. Practice cutting, threading of different sizes & laying Installations. (05 hrs) 31. Prepare test boards / extension boards and mount accessories like lamp holders, various switches, sockets, fuses, relays, MCB, ELCB, MCCB etc. (05 hrs) 32. Drawing layouts and practice in PVC Casingcapping, Conduit wiring with minimum to number of points as per IE rules. (06 hrs) 33. Wire up PVC conduit wiring to control one lamp from two different places using two way switch. (06 hrs)	I.E. rules on electrical wiring. Types of domestic and industrial wirings. Study of wiring accessories e.g. switches, fuses, relays, MCB, ELCB, MCCB, switchgears etc. Grading of cables and current ratings. Principle of laying out of Domestic wiring. Voltage drop concept. PVC conduit and Casing-capping wiring system. Different types of wiring Power, control, Communication and entertainment wiring.

		34. Practice testing / fault detection of domestic and industrial wiring installation and repair. (05 hrs) 35. Practice control panel wiring using wiring accessories and mounting of control elements, e.g. meters, fuses, relays, switches, push buttons, MCB, ELCB etc. (05 Hrs) 36.Prepare different types of earthing and measure earth resistance by earth tester / megger. (05 hrs) 37. Practice Installation of lightening arrestor. (04 hrs)	Wiring circuits planning, permissible load in subcircuit and main circuit. Importance of Earthing. Plate earthing and pipe earthing methods and IEE regulations. Earth resistance and earth leakage circuit breaker. Lightening arrestor. (07 hrs)
Professional Skill 25 Hrs; Professional Knowledge 05 Hrs	Use instruments for measurement of various electrical parameters.	38.Identify and practice of various analog and digital measuring Instruments. (05 hrs) 39.Practice on measuring instruments in single and three phase circuits e.g. multi-meter, Wattmeter, Energy meter, Phase sequence meter and Frequency meter etc. (15 hrs) 40.Test single phase energy meter for its errors. (05 hrs)	Classification of electrical instruments and essential forces required in indicating instruments. PMMC and Moving iron instruments. Range extension Wattmeter, PF meter, Energy meter, Megger, Earth tester, Frequency meter, Phase sequence meter, Multimeter, Tong tester etc. Instrument transformers – CT and PT. (05 hrs)
Professional Skill 45 Hrs; Professional Knowledge 10 Hrs	Perform basic electric energy calculations and understand transmission and distribution of electrical power	41. Measure power consumption for different loads with various times of use and calculate watthour. (07 Hrs) 42. Find out power ratings from product label and prepare a load calculation chart. (06 hrs) 43. Verify terminals, identify components and calculate the transformation ratio of single phase transformers. (04hrs) 44. Perform OC and SC test to determine and efficiency of single phase transformer. (05 hrs) 45.Visit to transmission / distribution substation. (15 hrs) 46.Draw actual circuit diagram of substation visited and indicate various components. (08 hrs)	Calculation of total watt hour of all loads per day and daily average watt hour from twelve months electricity bill. Working principle of transformer. Electric power demand, supply and gap in city, state and national level. Conventional energy Generation by thermal (coal, gas diesel) and hydel power plant. (small and large) Advantages of high voltage transmission. Transmission network of India. Study of distribution of power and substation. Overhead v/s underground distribution system. (10 hrs)

Professional Skill 60 Hrs; Professional Knowledge 12 Hrs	Verify natural planetary movements and sunlight's path.	47. Plot sun chart and locate the sun at your location for a given time of the day. (04 hrs) 48. Find out relations between sunlight and earth motion by globe model. (04 hrs) 49. Observe and compare sunlight and angle of inclination during 12 hours of a day on different days. (13 hrs) 50. Locate magnetic poles (North and South) with the help of magnetic compass. (05 hrs) 51. Observe on Globe, which countries are in the Northern hemisphere and which on the Southern hemisphere. (05 hrs) 52. Prepare a list of places around India, their latitude and longitude. (05 hrs) 53.Measure intensity of solar radiation using Pyranometer and radiometers. (05 hrs) 54.Analyse shadow effect on incident solar radiation and find out contributors. (05 hrs) 55.Plot curve of radiation measured with respect to time for a location. (05 hrs) 56.Draw a solar map by collecting data of solar radiation in a location for one year. (05 hrs) 57. Compare the effects of direct radiation, diffused radiation and reflected radiation and prepare reports. (04 hrs)	Non-renewable and Renewable energy concept. Advantages over non renewable energy; brief discussion main renewable energy resources viz. solar (PV and thermal), wind, Biofuel, Biomass, small hydro, Tidal power, Wave power, Geo thermal energy etc. Solar energy fundamentals. Study of Sun path (east to west, North to south and south to north movement). Study of daily and seasonal changes of sunlight. Angle of inclination of radiant light and its relation with latitude and longitude of different locations on Earth. Definition of key earth-sun angles. Equation of time, solar constant etc. Definition of GHI & DNI Definition of tracking (single axis and double axis) Solar radiation over India (measurements, satellite data and maps) (10-12 years historical data) Application of sunchart on shadow identification. Sunlight spectrum. (12 hrs)
Professional Skill 100 Hrs; Professional Knowledge 19 Hrs	Demonstrate characteristics of Photovoltaic cells, Modules, Batteries and Charge controllers.	58. Test an LED and a Photodiode to verify the photo emitting effect and light sensitivity. (04 hrs) 59. Test a Photo voltaic cell for different illumination levels and verify photovoltaic property. (04 hrs) 60. Plot I-V curve for photovoltaic cell based on the illumination at constant temperature. (04 hrs) 61. Plot I-V curve for photovoltaic cell based on temperature at constant illumination. (04 hrs) 62. Test photovoltaic cell in sunlight at various angles of inclination and direction. (04 hrs) 63. Test different rated Photovoltaic modules (Panels) and plot I-V curve. (04 hrs)	Semiconductor properties and types. P-type and N-type semiconductors, PN junction, etc. Conversion of solar radiation to electricity. Main materials used to develop solar cells (Silicon, Cadmium tellurides, etc.) Light sensitive properties of PN junction. Difference of photo electric and photo voltaic effects of a PN junction. PV cell characteristics, I–V curve, effects of temperature. Photovoltaic effect. Photo voltaic module: minimal functional

		64. Record specification of different solar panels and compare specifications to select a panel. (04 hrs) 65. Test different types of PV panels such as, mono crystalline, poly crystalline, amorphous silicon and thin film modules. Prepare a report on panels. (04 hrs) 66. Determine the relation between number of cells and maximum voltage per module. (04 hrs) 67. Connect suitably rated wires in the terminal box of a solar panel and connect end terminals using MC 4 connectors. (04 hrs)	specification, cells per module, max watts per module, maximum voltage at max power, maximum current at max power. Standard test conditions (STC) of a PV module. Terminal box and connectors of a Solar PV module. Identification of various test standards of PV module. Measurement of area of the cells and compare with the module area in data sheet. Identification of faulty PV module. (14 hrs)
		68. Connect solar panels in series and measure voltage and current. Repeat with different rated panels. (04 hrs) 69. Connect solar panels in parallel and measure voltage and current. Repeat with different rated panels. (04 hrs) 70. Shift the panels to rooftop or the place of installation using safe handling practices. (03 Hrs) 71. Check the structural and area requirement for installation of 1 KW solar panel. (04 hrs) 72. Identify different solar panels as per specification. (04 hrs) 73. Compare different types of solar panels and prepare a report. (04 hrs) 74. Charge a solar battery rated 12V, 100 Ah using Battery charger by CV and CC method and Tabulate the observations during charging cycle. (05hrs) 75. Discharge a solar battery rated 12V, 100 Ah using DC load under Constant Current and tabulate the observations during discharging cycle. (04 hrs) 76. Verify Voltage, ampere hour (Ah), state of charge (SOC), depth of discharge (DOD), Efficiency, C-rating of battery from 5 different manufacturers. Compare and select suitable solar battery. (04 hrs) 77. Connect the charge controller (12V, 10A) with Solar battery (12V, 100Ah), Solar panel (75W) and DC load (12V such as LED light 3W & 5W, DC Fan & FM radio). (05 hrs)	Solar PV array; series and parallel calculation. Handling of PV modules. Module mounting; structures requirement. Photovoltaic cell and PV modules: types - mono crystalline, poly crystalline, amorphous silicon and thin film PV cells and their comparison. Recent thin film technologies (CdTe, GIGS, CIS etc.) Safe handling of panels. **Battery fundamentals;** Storage batteries: Various types of Batteries- Lead acid battery, nickel cadmium battery, lithium ion battery. Battery construction, working, charge/discharge and applications. Safe working with battery. Solar Rechargeable SMF Battery; energy, storage capacity specifications, voltage, ampere hour (Ah), state of charge (SOC), depth of discharge (DOD), Efficiency, C-rating, cycle life, self-discharge etc. Deep discharge and shallow cycle. Block diagram of a charge controller. Tools required for working with battery. Charge controllers, fuses, blocking diodes, bypass diode, LED indicators, low voltage disconnect, high voltage disconnect.

		78. Test the charge controller working with the above circuit and study the performance. (04 hrs) 79. Construct home lighting system using solar panel. (04 hrs) 80. Construct and test a solar powered mobile handset charger. (04 hrs) 81. Construct a dusk to dawn charge controller (12V, 10A) with Solar battery (12V, 100Ah), Solar panel (75W) and LED light (12V DC, 5W). (04 hrs) 82. Construct a home lighting system with manual control. (04 hrs)	Solar DC home lighting, Solar mobile Handset charger, Solar FM radio, Solar DC fan and other solar DC devices. Power packs for decentralized energy supply. Troubleshooting of batteries and charge controllers. (09 hrs)
Professional Skill 45 Hrs; Professional Knowledge 07 Hrs	Construct and demonstrate Solar DC appliances.	83. Construct a solar lantern using Solar PV panel (15W), Charge controller (6V, 5A), Output control circuit for variable illumination, Rechargeable battery (6V, 7Ah) and DC LED lamp (5W). (08hrs) 84. Construct a Solar Day lighting using manual charge controller (12V, 10A), Solar battery (12V, 100Ah), Solar panel (75 W) and 4X LED light (12V DC,5W). (08hrs) 85. Construct a Solar Garden light using dusk to dawn charge controller (12V, 10 A), Solar battery (12V, 100 Ah), Solar panel (75 W) and 4X LED light (12V DC, 5W). (07 Hrs) 86. Construct a Solar Street light using dusk to dawn charge controller (12V, 10 A), Solar battery (12V, 100 Ah), Solar panel (75 W) and 4X LED light (12V DC, 5W). (07 Hrs) 87. Construct a Solar Security system using a Manual charge controller rated (12V, 10 A), Solar battery (12V, 100 Ah), Solar panel (75 W) and Security camera & CCTV/Intruder alarm (12 V DC). (08 hrs) 88. Construct a Solar water pump using a DC pump (24 V), Solar Panel (250 W), Charge controller (24 V, 10 A). (07 hrs)	Solar DC domestic application: Making of solar lantern. Solar Day lighting. Solar Garden Lights. Safety in DC system. Quality standards List out the inventory list of equipments and tools for construction of a DC system. Solar DC industrial application: Solar street light. Solar home lighting system. Solar Security system. Solar DC water pump. Differentiate AC and DC solar pumps and their PV requirements for various HP capacity. (07 hrs)
Professional Skill 45 Hrs; Professional Knowledge 07 Hrs	Connect, test, under take maintenance and disposal of solar batteries.	89. Prepare connecting wires for grouping of solar batteries. (06hrs) 90. Connect two solar batteries (12V, 100Ah each) in series to a 24 V DC pump and Test the Voltage and current in the circuit. (06 hrs) 91. Connect two solar batteries (12V, 100 Aheach) in parallel to a parallel group of 12 Volts DC LED lights and Test the Voltage and current in the circuit. (06 hrs)	Battery bank: Series and parallel connections. Specific gravity. Use of hydrometer Safety aspects in handling batteries. Charging/ Discharging of batteries.

		92. Check the condition of electrolyte in a solar battery using hydrometer and add distilled water to the required level in the solar battery. (06 hrs) 93. Remove complete electrolyte from a lead acid battery and refill. (06 hrs) 94. Shift 12V 100Ah battery on a trolley to different location following safe handling practices. (05 hrs) 95. Plan for rack system of battery bank storage. (05 hrs) 96. Prepare a report on maintenance and disposal of solar batteries (05 hrs)	Maintenance of battery. Risk of batteries. Ventilation requirements. Requirement of connecting only similar batteries. Disposal procedure of batteries. Common defects in batteries. Procedure for capacity testing. (07 hrs)
Professional Skill 60 Hrs; Professional Knowledge 12 Hrs	Connect and test solar panel, Charge controller, Battery bank and Inverter.	97. Connect MC 4 connectors to a solar panel using crimping tool. (04 hrs) 98. Connect the PWM controller with solar panel & solar battery and note input /output current and battery voltage at different time intervals. (04 hrs) 99. Connect the MPPT controller with solar panel & solar battery and note input and output current and battery voltage, at different time intervals. (04 hrs) 100 Compare the results of the above. (03hrs) 101.Open PWM and MPPT Charge controllers and identify components wired to understand mechanism. (04 hrs) 102.Connect solar panels to an Array Junction box. (05 hrs) 103.Connect and test a 12V DC/230V AC normal inverter. (05 hrs) 104.Connect a Solar panel (10W), Solar charge controller (12V, 10A), Solar battery (12V, 100 Ah) and a normal inverter and convert to a solar inverter. (05 hrs) 105 Prepare a comparative chart by collecting data sheets of different solar PCU and normal inverters. (05 hrs) 106 Practice procedural switching 'ON' and Shutdown of solar PCU. (05 hrs) 107 Connect a 1 KW Solar PCU to 1 KW Solar panel installation using a suitable battery bank and test the performance. (04 hrs) 108 Check of front panel features of a Solar PCU. (04 hrs)	Solar panel terminal wires and MC-4 connectors. Choice of wires (DC cables) used in the solar PV Electrical system. Array junction box (AJB) or combiner box. Protection devices in AJB. PWM charge controller. MPPT charge controller. Block diagram of charge controller. Overview of Sequence of connection (step wise) in an off grid system. Inverter: working, front panel controls and back panel controls. Normal and solar inverter. Solar charge controller for a normal inverter. Selection of solar inverter or Power Conditioning Unit (PCU). Switching ON and shut down procedure of a solar inverter Types of Inverter:- Standalone, Grid Tied (MPPT/Central/String), Micro inverter. IEC Std followed for Inverter in solar projects. Block diagram of Solar Photo voltaic electrical system. Classification of inverters- Stand alone or off-grid inverter, Hybrid inverter, Grid-tie inverter. Wall mount or array mount inverter. Inverter room planning for mega projects. Integration of inverters in large PV projects. Overview of PV System Software. (21 hrs)

		109 Check of back panel features of a Solar PCU. (04 hrs) 110. Demonstrate Solar PV e-learning software. (04 hrs)	
Professional Skill 45 Hrs; Professional Knowledge 07 Hrs	Prepare Bill of materials for small, medium and mega solar PV projects.	111 Prepare bill of material for a 1 KW solar PV installation. (08 hrs) 112 Prepare bill of material for a 5 KW solar PV installation. (08 hrs) 113 Prepare a Bill of materials for a 10 KW solar PV installation. (07 hrs) 114 Prepare a Bill of materials for a 20 KW solar PV installation. (07 Hrs) 115 Prepare a Bill of materials for a 100 KW solar PV installation. (09hrs) 116 Estimate cost of a 1 KW solar PV installation and prepare a quotation. (09hrs)	Single Line Diagram (SLD) and identifying different component symbols in SLD. System sizing: Selection of components of the Solar Photovoltaic Electrical system. Load calculation and system sizing. Battery sizing. Solar panel sizing. Sizing small and medium solar PV projects and their SLDs. System types based on: Backup requirements, Grid availability, Budget and space. Various skill requirements during solar PV plant installation. Guidance for Solar Installation by MNRE (07 hrs)
Professional Skill 20 Hrs; Professional Knowledge 05 Hrs	Perform various tests and measurement pertaining to PV Modules and their installation as per IEC standards.	117 Carry out visual inspection of PV modules. (05 hrs) 118 Measure Insulation resistance and Wet Leakage Current of PV Modules. (03 hrs) 119 Perform Bypass Diode test -Pmax at STC and Pmax at low irradiance. (04 hrs) 120 Measure Ground Continuity, Impulse Voltage, Reverse current and Partial Discharge. (03 hrs) 121 Practice to undertake precautions against Module breakage. (03 hrs) 122 Demonstrate hot spot on modules through audio visual aids. (02 hrs)	Performance standards IEC 62125/ 61646 (Diagnostic, Electrical, Performance, Thermal, Irradiance, Environmental, Mechanical) Safety Standards IEC 61730-1,2 (Electrical Hazards, Mechanical Hazards, Thermal Hazards, Fire Hazards) Hot spot on modules and method to detect them at site. (05 hrs)
Professional Skill 145 Hrs; Professional Knowledge 28 Hrs	Assist in Installation and commissioning of Solar PV plant and Hybrid plant.	123 Create a rough layout of the rooms showing existing Grid meter line, MCB, nearest shaded & dry place for a solar PCU and place for panels. (03 hrs) 124 Prepare a layout of roof showing open areas and occupied areas and mark obstructions that can cause shadows. Take site photographs. (03 hrs) 125 Mark locations for components of solar PV electrical system on site. (03 hrs) 126 Perform shadow analysis in the rooftop of a 1 KW Solar PV plant. Use sun path diagram for the latitude and solar pathfinder. (04 hrs)	**Site survey:** Inspection of field, Selection of site, Shadow analysis. Types of roofs, Weather monitoring. Solar path finder and sun path diagram. Wind Load conditions on Solar PV Panels like Wind Speed, Height of Panel above roof and Relative Location of Panels on roof. Identifying challenges' in the placement of modules/PCU in the site. (Portrait/ landscape placement, number of tables etc.). Roof area, shadow free area, structure, type& age of the building, usable area, O&M challenges, and integration issues.

		127 Install a roof top Solar panel mounting structure for 1 KW installation that uses Solar panels 250 W x 4 Nos. (05 hrs) 128 Mount Solar panels 250 W x 4 Nos. on the Mounting structure. (04 hrs) 129 Wire Solar panels 250 W x 4 Nos. (04 Hrs) 130 Connect the array junction box to the above installation and draw wires up to PCU. (04 hrs) 131 Perform different angle of inclination of Solar panel mounting for various cities considering their latitude. (04 hrs) 132 Perform Cable laying in the field. (04hrs) 133 Perform finishing work on mounting structure. Perform concrete foundation making over mounting pole base. (03hrs) 134 Perform setting of seasonal angles on mounting structure. (03hrs)	Wire (cable) requirement/ estimation. Special tools and material handling equipment required during installation. Solar panel mounting structures. Solar plant foundation planning. Installation of solar panels. Solar panel facing direction. Changing the angle of inclination as per location and seasonal setting. MMS systems or using trackers. Solar plant, civil works: drilling, digging, finishing, Mixing concrete. (07 hrs)
		135 Wire a battery bank for 1 KW installation, using 4X 12V, 100 Ah Solar batteries. (04 Hrs) 136 Wire the above installation panels, battery etc. to a 1 KW Solar PCU. (04 hrs) 137 Group and distribute the loads as per economical planning. (04 hrs) 138 Wire the AC mains connection to the Solar PCU (Do not switch 'ON'). (04 hrs) 139 Prepare a Checklist for finding out errors during above installation. (04 hrs) 140 Check as per the checklist and prepare a clearance certificate before commissioning. (04 hrs) 141 Perform Procedural first switch ON, observe No load test results and record. (04 hrs) 142 Perform 'ON Load' test, progressively add load till full load and record observation. (05 hrs) 143 Perform Overload test and record observation. (05 hrs) 144 Prepare a First inspection report onthe solar plant installation. (05 hrs) 145 Prepare a list of Do's and Don'ts in the installation. (05 hrs) 146 Prepare a report on Customer orientation. (04 hrs) 147 Prepare a report on visible and audio annunciations, alarms or alerts in a solar PCU. (05 hrs)	Battery Bank wiring, load wiring and distribution panel. Switching loads, economical planning of load distribution. Inverter wiring, Interface with the existing electrical system. Commissioning skills: Preparation of check off list. Safety precautions before initial starting. Observation of parameters pre and post operation. Operational test before connecting to Load. Progressive load connecting and on load testing. Overload testing. First inspection report generation. Customer orientation. Documentation and record. Do's and Don'ts in the installation. Types of installation for solar array mounts based roof types: Manual Mount: Raft/rack mounts Pillar or Pole mount Building integrated mount Ballast roof mounts RCC rooftop mount Tracking mounts: Manual track Automatic track Single axis and dual axis Safety at heights. Condition monitoring and report generation. (12 hrs)

		148 Perform shutting down procedure of the above solar plant. (06hrs)	
		149 Prepare a ballast foundation for tiled roof. (04 hrs) 150 Prepare a rack mount for a tilted roof. (04 hrs) 151 Plan and prepare a report on building integrated solar mount. (04 hrs) 152 Prepare a foundation for a single Pillar mount. (04 hrs) 153 Visit a Mega project and prepare a report including strings, array, inverter room, output transformers, plant layout and SCADA room. (04 hrs) 154 Prepare a report on site suitable for windmill. (04 hrs) 155 Observe the presence of obstacles in a site suitable for windmill. (04 hrs) 156 Evaluate windiness of a place using an anemometer. (04 hrs) 157 Prepare a report on wind mill energy conversion system through sufficient audio visual sessions. (04 hrs) 158 Test with a blower and model windmill & record the observations. (04 hrs)	Maintenance of a solar plant. Alarms & security. Data logger and SCADA room. Introduction to wind power Components of wind turbine generator (WTG). Windmill; principle of operation and types. Elements of a wind mill. Minimum threshold, nominal speed during operation and out of service, high speeds of wind energy. Speed governor and control of transmission of energy. Electrical generator and Charge controller for windmill. Small (mini) hydro electricity generation and charge controller. Basics of other renewable energy resources for power generation, such as bio gas plant. Windmill suitable for integration with solar PV plant and its integration. (14hrs)
Professional Skill 20 Hrs; Professional Knowledge 05 Hrs	Perform Operation & Maintenance of PV system with best practices.	159 Demonstrate Standard Operating Procedures of PV system. (05 hrs) 160 Demonstrate Electrical Maintenance of Inverters/Cables/Junction Boxes, Fault Indications of Inverters/PCU. (05 hrs) 161 Demonstration of Solar Panel Maintenance: - Cleaning, DC Array Inspection, Precautions While Cleaning. (05 hrs) 162 Demonstration of Battery Maintenance- Checking of Electrolyte Level, Specific Gravity Using Hydrometer, Physical Damage, Terminal Voltage, Cleaning of Battery Terminals. (05 hrs) 163 Inspection of Mounting Structure of Solar Modules, Procedure of replacement of defective Fixtures. (05 hrs)	SOP (Standard Operation Procedures) of PV system. Types of Maintenance (Preventive/ Corrective/Condition Based). Electrical maintenance /Solar Panel maintenance/ Battery maintenance/ Charge Controller maintenance / Solar Panel maintenance. (05 hrs)
Professional Skill 50 Hrs; Professional Knowledge 14 Hrs	Perform manufacturing of solar panel, prepare and commission marketable solar products.	164 Verify the I-V curve of solar cells. (04hrs) 165 Perform the incoming inspection of Solar PV cells and categorise according to the quality. (04hrs) 166 Construct a cell string. (03hrs) 167 Assemble a solar panel using the above cell string. (04hrs)	Solar panel manufacturing: Skills for incoming inspection of PV cells. Making of cell string. Parts of solar panel. Assembly of panel parts. Framework and sealing of panel. Testing and certification. Quality standards. Manual and automatic

		168 Perform the framework and seal the Solar panel. (04hrs) 169 Determine the I-V curve of finished solar PV panel and prepare a model certificate. (03hrs) 170 Visit a solar panel manufacturing industry and prepare a report. (or through an audio visual session) (04hrs) 171 Prepare a report on automatic manufacturing of solar panels through audio visual sessions. (04hrs) 172 Assemble, install and commission a solar street light. (04hrs) 173 Assemble, install and commission a model of solar fertilizer sprayer. (04hrs) 174 Prepare a report on possible innovative solar products for marketing. (04hrs) 175 Assemble, install and commission a solar water pump. (04hrs) 176 Assemble, install and commission a solar traffic light. (04hrs)	manufacturing. Solar water treatment plant Solar air conditioning Solar refrigeration. Solar agricultural products – sowing, digging, fertilizer or pesticide spraying. Introduction to solar energy technologies for decentralized (thermal) energy supply; Solar cookers for domestic and community cooking. Solar Sprinklers for drip irrigation, Solar water pumping, Solar dryer, Solar air Heater. Solar Traffic Light, Solar distillation, Solar pond. National and international energy policies. National Solar Mission, Renewable Purchase Obligation. Implementation at state level. Loan and promotional schemes. Incentives, subsidies & concessions. Solar rooftop business models. Administrative processes. Details of various websites and mobile apps where policies can be accessed. (14hrs)

Visit various sections of the institutes and identification of danger, warning, caution & safety signs

Objectives: At the end of this lesson 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 danger, warning, caution and safety signs.**

PROCEDURE

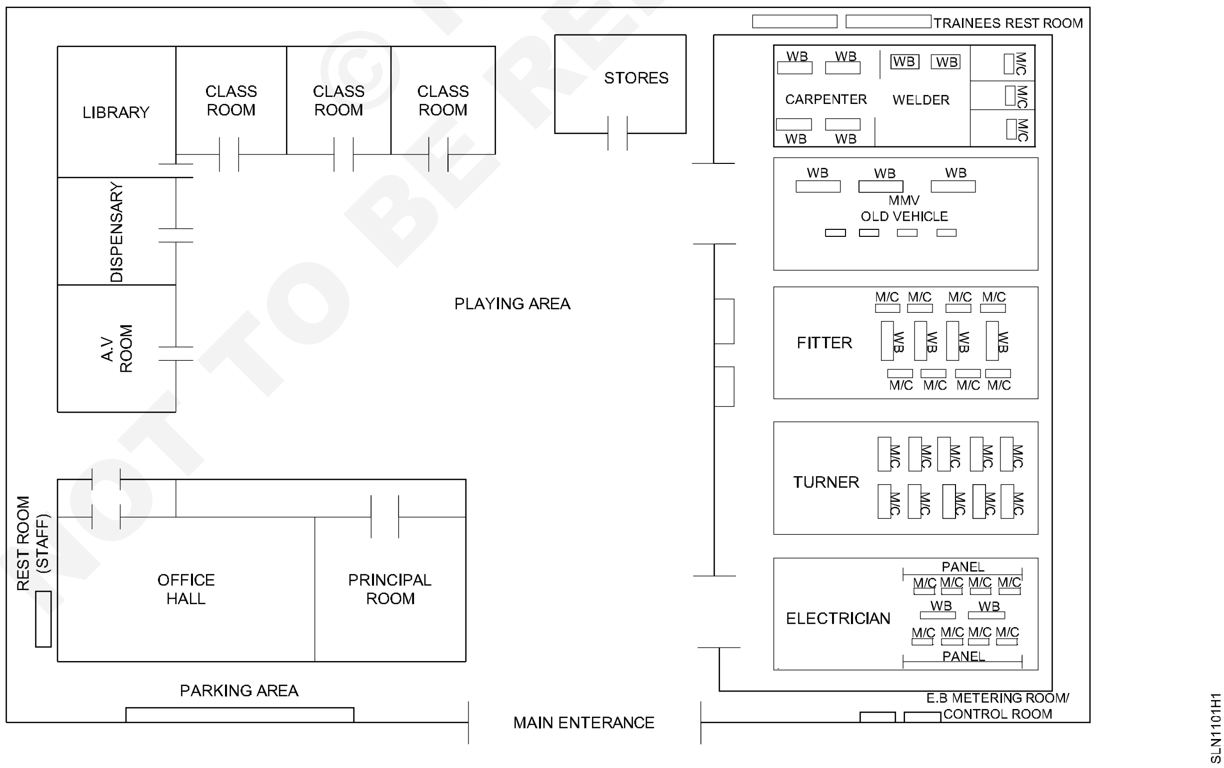
TASK 1: **Visit various sections of the ITI and draw the layout of your ITI**

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

1. Visit the various sections in your ITI/NSTI and identify thesections of the ITI/NSTI. List the trades and record it in yournote book.
2. Collect the information about the staff members ineach trade.
3. Identify the location of the ITI/NSTI with details about the railway and bus stations in the locality and note downthe list of bus route numbers which ply near the ITI/NSTI.
4. Collect the telephone numbers of the ITI/NSTI office, nearesthospitals, nearest police station and the nearest firestation and record.
5. Draw the layout of your ITI/NSTI showing various trades.

> **Note :A Sample layout of the ITI/NSTI (Fig 1) is givenfor your reference. Now draw the new layoutof your ITI/NSTI, 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).

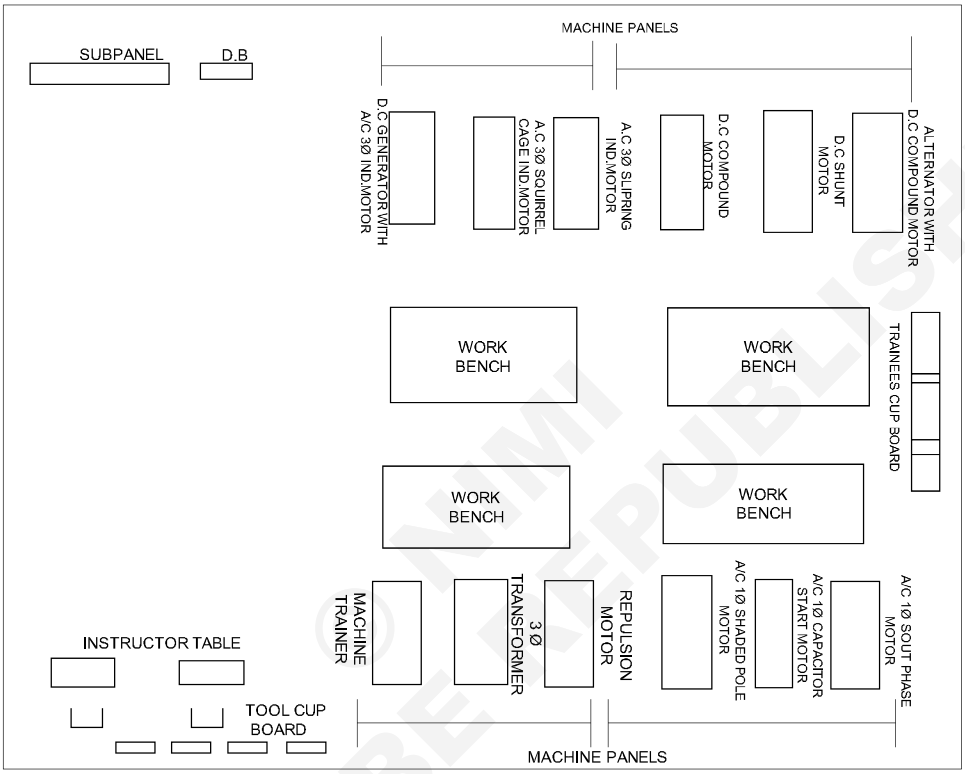
2 Take the length and the breadth measurements of machine foundations, work benches, panels, wiring cubicles, doors, windows, furniture, etc.

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 danger, warning, caution and safety signs**

1 Go around the institute and shop floor looking for sign boards

2 Collect information on the available sign boards and their meanings

3 Classify the signs in to General, Danger, Caution, Warning or safety signs

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

Objectives: At the end of this lesson 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.
• Fire extinguishers- CO_2	- 1 No.
• Scissors 100mm	- 1 No.
• Cell phone	- 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 rubbergloves or rubber mats.

2 Do not touch bare conductors.

3 Stand on a wooden stool or an insulated ladder whilerepairing live electrical circuits/appliances or replacingfused bulbs.

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

5 Always use safety belts while working on poles or highrisepoints.

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

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

8 Open the main switch and make the circuit dead.

9 Do not stretch your hands towards any moving part ofthe 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 electricallines.

12 Do not use water on electrical equipment.

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

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

15 Avoid spillage of electrolyte while working on Battery

16 Follow correct color coding of wires

17 Always use standard tools and equipment

18 Do not walk on the in stalled solar panels

19 Avoid touching hot metal frames of solar modules with bare hands.

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

1 Proceed with treatment as early as possible withoutpanic or becoming emotional.

2 Switch off the power or remove the plug or wrench thecable free.

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

Fig 1

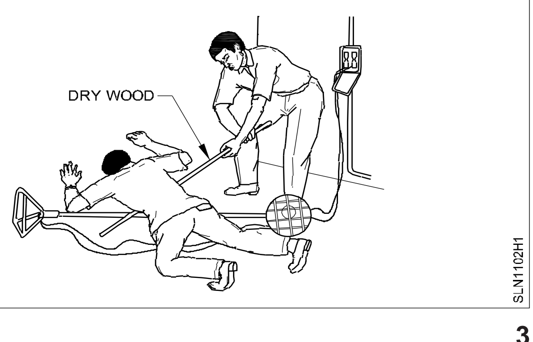
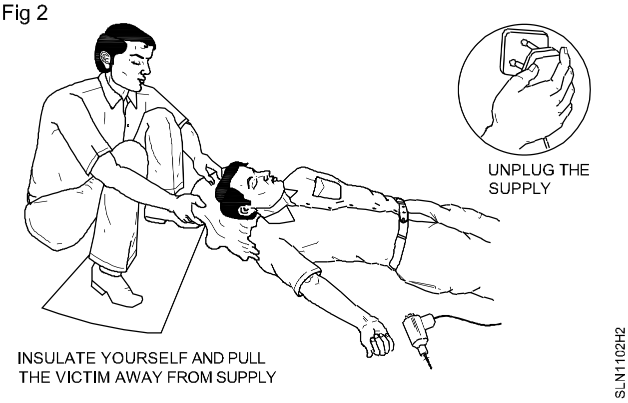


Fig 2



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

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 victin 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.

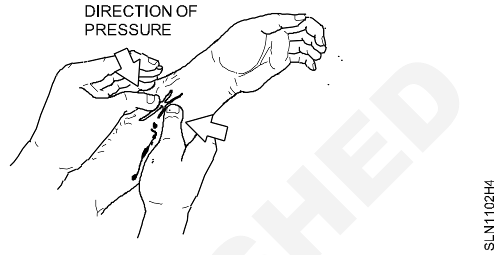
In case of severe bleeding

11 Lay the patient flat.

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

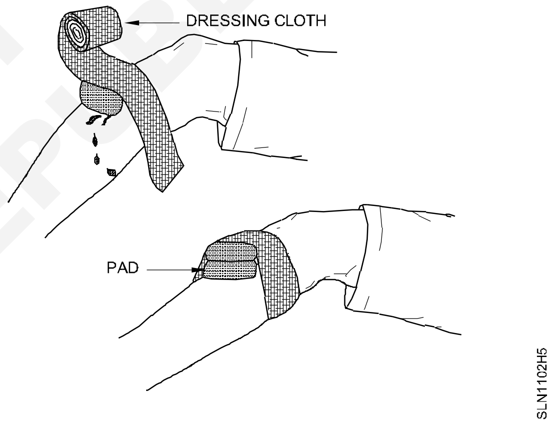
13 Apply pressure on the wound ,as long as necessary, to stop the bleeding. (Fig 4)

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 in unconscious

Practice safe methods of fire fighting in case of electrical fire

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

General procedure to be adopted during electrical fire

1 Raise an alarm. Follow the methods giving below to raise an alarm signals when the fire breaks 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 firefighting:

- 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 organized 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 co2 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 inidentification of the causes of the fire. The identified causes shall help in taking preventivemeasures to avoid similar occurrences in the future

Use of fire extinguishers

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

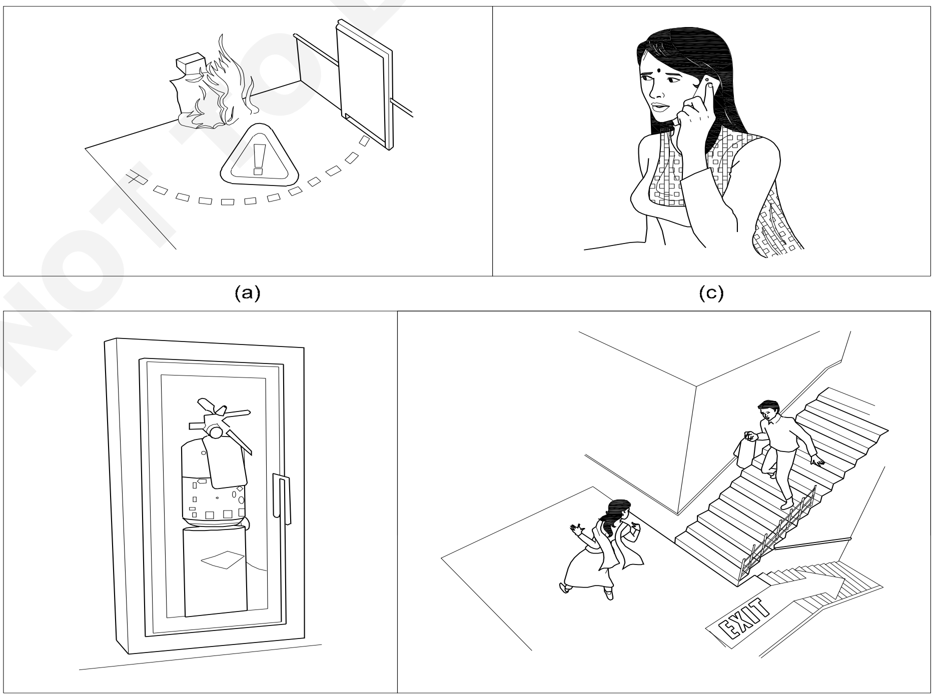
1 Alert people in the surrounding area by shouting fire, fire, fire when you see fire (Fig 1a & b).

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).

5 Switch “OFF” all electrical power supply.

Fig 1



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

Practice elementary first aid and artificial respiration

Objectives: At the end of this exercise you shall be able to
- **prepare the victim for elementary first aid and aritificial respiration**

Requirements

Tools/Equipment/Machines

- Number of Persons (Instructor can divide the trainees into suitable Number of groups) - 20 No.
- Control panel arrangement - 1 No.
- Motor - 1 No.
- Rubber mat - 1 No.
- Wooden stick - 1 No.
- 2 persons for demonstration purpose

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

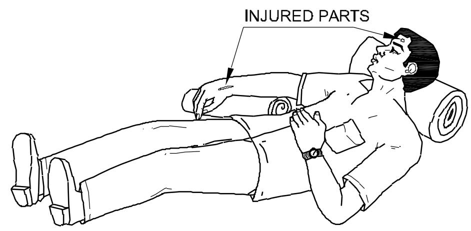
Fig 2

KEEP THE MOUTH OPEN

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

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

Fig 3



SAFETY ON THE LEVEL GROUND

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

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

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

Observe the condition of electric shock victim.If breathing has stopped, try to provide artifical 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 artifical respiration method.

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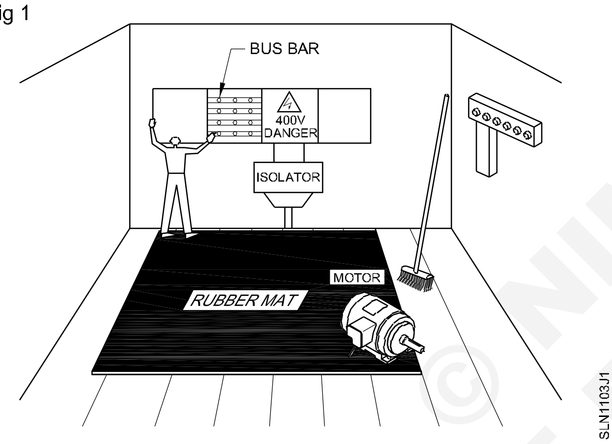
TASK 3: **Rescue a person (mock victim) from live supply (simulated).**

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)

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.

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TASK 4 : **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

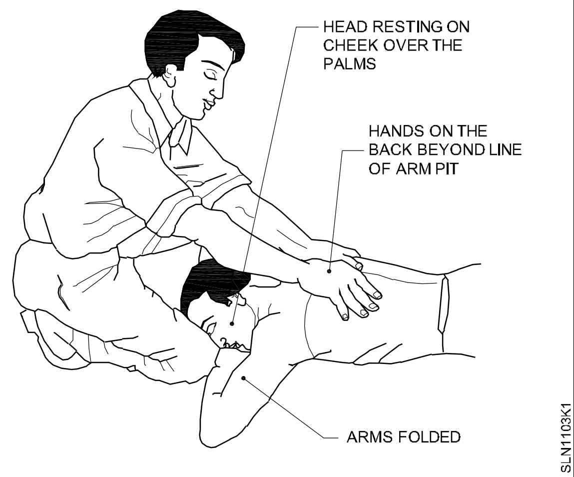
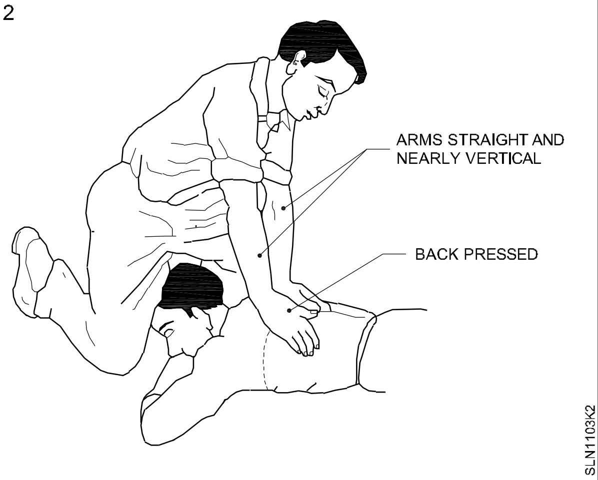


Fig 2

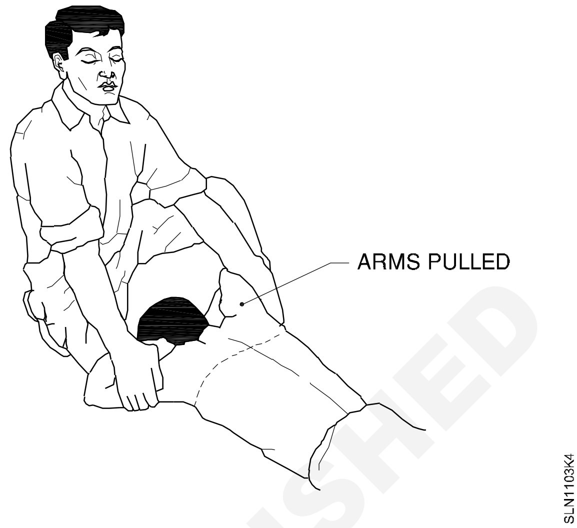


5 Synchronise the above movement of rocking back wards with your hands sliding downwards along the victim's arms, and grasp his upper arm just above the elbows as shown in Fig 3. Continue to rock backwards.

Fig 3

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.

Fig 4



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.

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TASK 5 : **Revive breathing in the victim by Schafer's method**

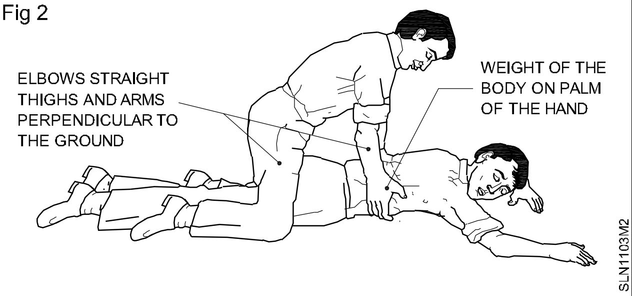
Note : Do not use this method when the victim has injuries on the chest and belly.

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.

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 2.

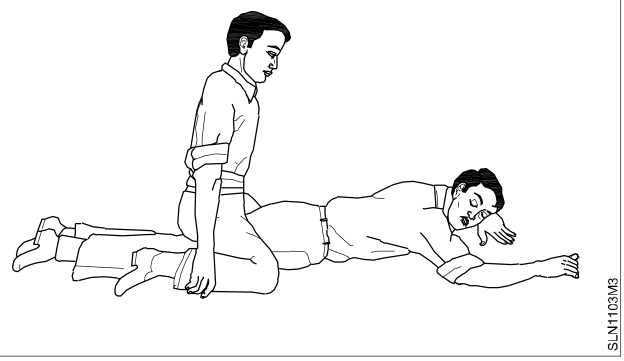
Fig 2



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 3.

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.

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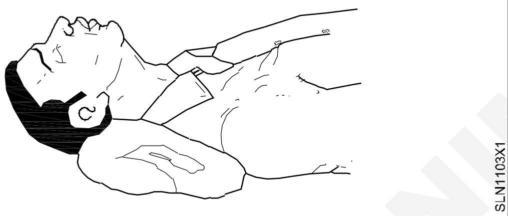
TASK 4: **Revive breathing in the victim by mouth-to-mouth method**

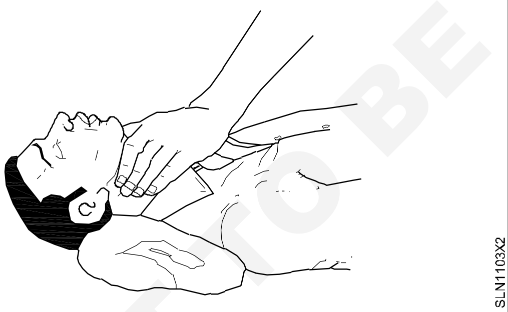
1 Lay the victim flat on his back and place a cloth roll under his shoulders to ensure that his head is thrown well back. (Fig 1)

Fig 1



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

Fig 2

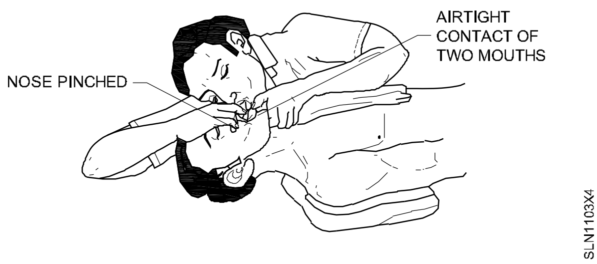


3 Grasp the victim's jaw as shown in Fig 3, and raise it upwards until the lower teeth are higher than the upper teeth you may also place your fingers on both sides of the jaw near the victim's ear lobes and pull upward. Maintain this jaw position throughout the duration to revive respiration to prevent 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 12 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 breathings 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.

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

Tools/Equipment/Machines

- Shovel - 1 No.
- Plastic/Metal bins - 4 No.
- Trolly with wheels - 3 No.
- 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

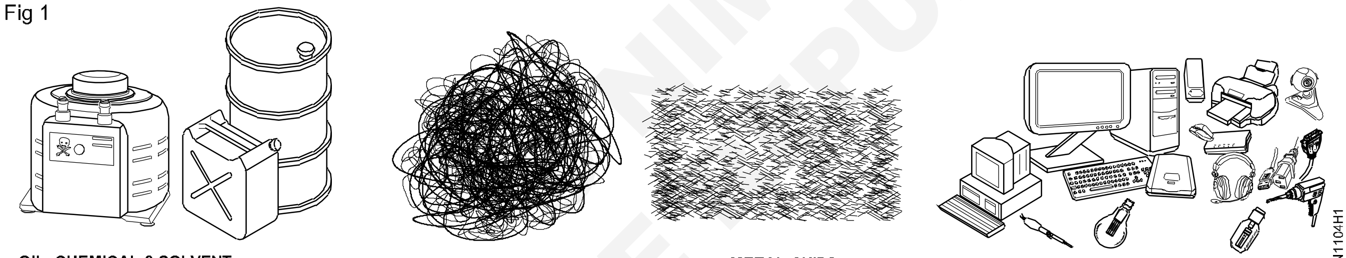


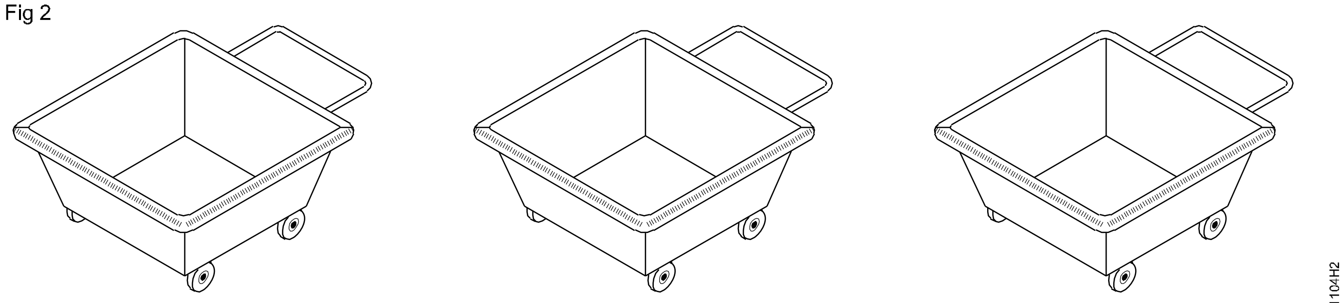
Table-1

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)

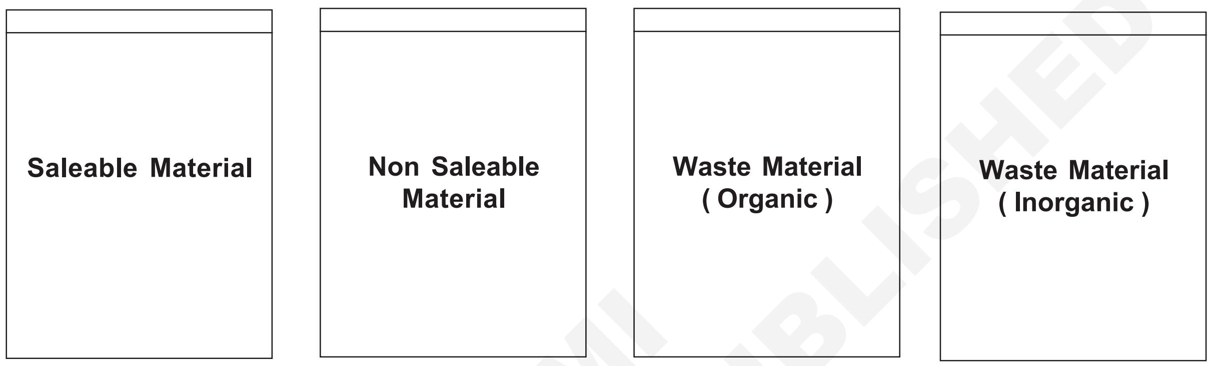
6 Put the cotton waste in the cotton trolly and similarly put the metal chips waste and others in the respective trolleys.

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



- - - - - - - - - - -

Skill Sequence

Separate the cotton waste and dispose it

Objectives: 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.

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.

- - - - - - - - - - -

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/Machines

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

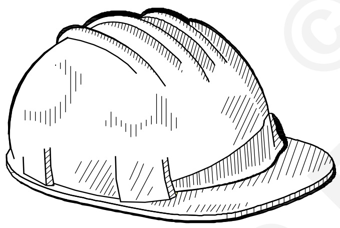
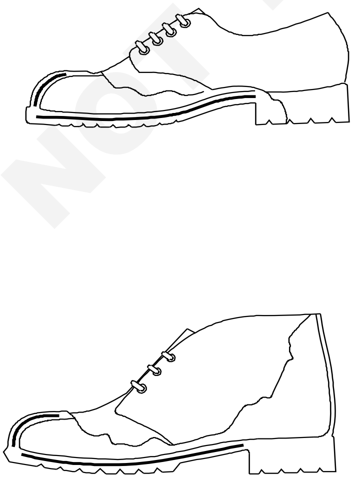
PROCEDURE

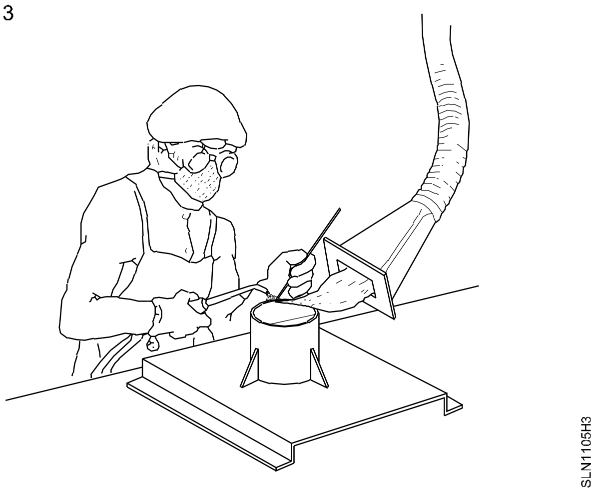
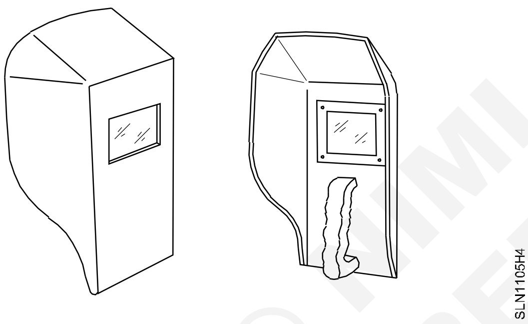
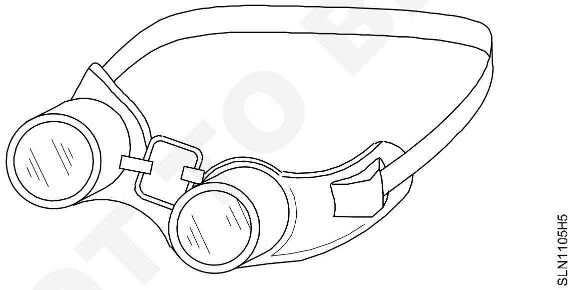
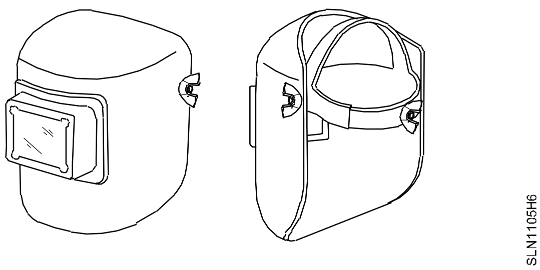
Instructor may arrange the available different types of PPEs in the table or provide the chart showing the PPEs. Instrcutor may also explain the types of PPEs and their uses, and the hazards for which each type is used.

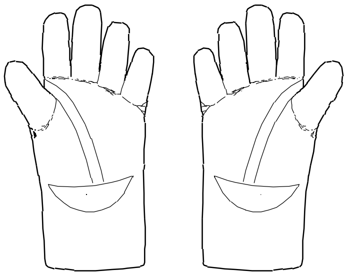
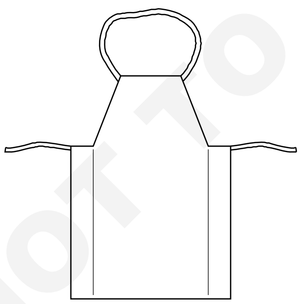
1 Identify the different types of PPEs and write their names with the help of the chart and write in Table 1.

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	Fig 1  SLN1105H1			
2	Fig 2  SLN1105H2			

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

Sl. No.	Sketches	Name of PPE	Type of Protection	Uses
7	Fig 7  SLN1105H7			
8	Fig 8  SLN1105H8			
9	Fig 9  SLN1105H9			

3 Get it checked by your instructor.

- - - - - - - - - - -

Power **Exercise 1.1.06**
Solar Technician (Electrical) - Safety and Basic workshop practices, hand tools

Familiarization with signs and symbols of electrical Accessories

Objectives: At the end of this exercise you shall be able to
- **identify of various symbols used in electrical and electronic circuit diagram**
- **read electrical and electronic wiring diagrams.**

Requirements

Tools/Equipment/Machines

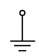
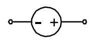
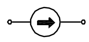
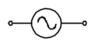
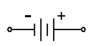
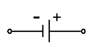
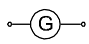
- Electrical Wiring symbols - 1 No.
- Power supply symbols - 1 No.
- Lamp and light bulb symbols - 1 No.
- Switch and relay symbols - 1 No.
- Solar power symbols - 1 No.

PROCEDURE

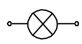
TASK 1 : **Get familiarize with the following symbols**

A **electrical symbol** is a pictogram used to represent various electrical and electronic devices or functions, such as wires, batteries, resistors, and transistors, in a schematic diagram of an **electrical** or **electronic** circuit.

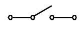
Electrical Wiring Symbols for Ground

S.No	Name	Meaning / Function	Symbol
1	Earth Ground	Protection against Electrical Shock	
2	Voltage Source	Constant Voltage Source	
3	Current Source	Constant Current Source	
4	AC Voltage Source	Source of AC Voltage	
5	Battery	Constant Voltage Source	
6	Cell	Constant Voltage Source	
7	Generator	Mechanical Voltage Source	

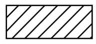
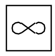
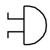
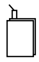
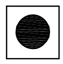
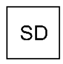
Power Supply Symbols

S.No	Name	Meaning / Function	Symbol
1	Lamp or Light Bulb	Generates Light with Flow of Current	

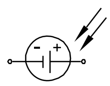
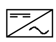
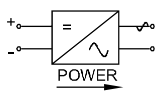
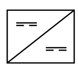
Lamp and light bulb symbols

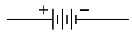
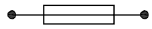
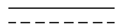
S.No	Name	Meaning / Function	Symbol
1	Switch	Disconnect Current when Open	

Other Important electrical wiring symbols

S.No	Name	Meaning / Function	Symbol
1	Electrical Panel	Install Electrical Panel	
2	Distribution Box	Install Distribution Box	
3	Thermostat	Install Thermostat	
4	Air Condition	Install Air Condition	
5	Fire Alarm	Install Fire Alarm	
6	Alarm	Install Alarm	
7	Doorbell	Install Doorbell	
8	Smoke Detector	Install Smoke Detector	

Solar power symbols

S.No	Names	SYMBOLS
1	Symbol of Solar cell	
2	Symbol of inverter	
3	Symbol of inverter	
4	Symbol of Charge controller	

5	Battery	
6	Fuse	
7	DC	
8	AC	
9	3 AC	

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**
- **mark parallel lines to the given dimension using Jenny caliper**
- **file and finish surfaces to an accuracy of 0.5mm**
- **fix the hacksaw blade in the correct position and saw the metal.**

Requirements

Tools/Instruments

- Single phase one HP 240V/50Hz capacitor start induction motor - 1 No.

Materials

- Lubricating oil - 100 ml
- Cotton waste - as reqd.
- Cotton c - 0.50 m
- Grease - as reqd.
- Emery sheet - 1 sheet.
- 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 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 146mm from surface 'c'.

11 Punch all the scribed lines.

12 File the sides 'd', 'e' and 'f' with a bastard file.

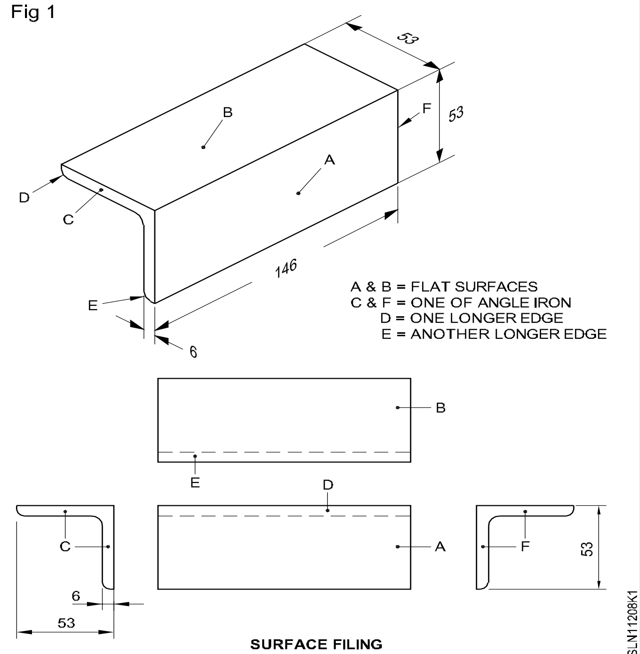
13 Finish the job with a second cut file. File within ± 0.5mm and check the right angles with reference to surfaces 'a' and 'b'.

14 Use an outside caliper for checking the finished sizes.

15 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.**

Fig 1



SURFACE FILING

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.**

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.

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.

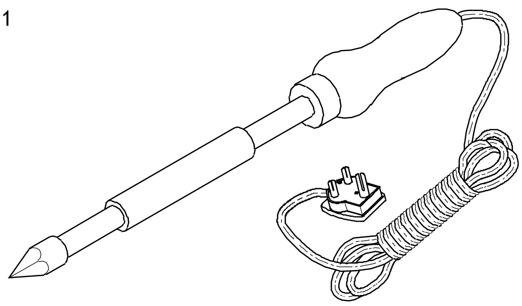
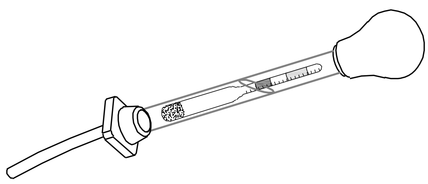
1 Identify the tools from the specification given.

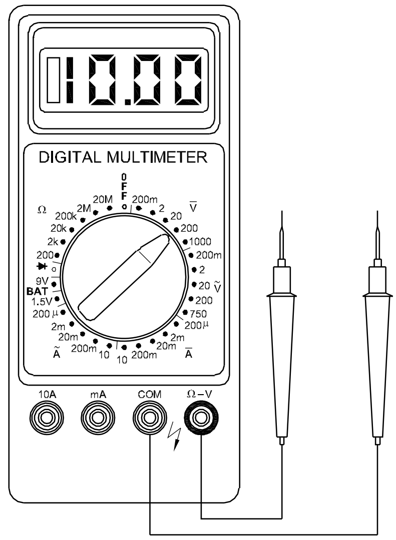
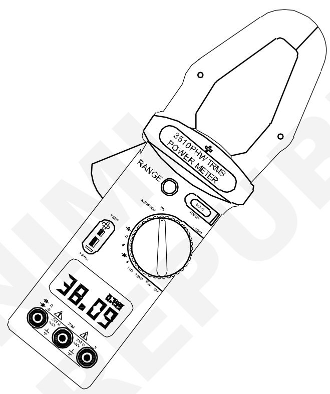
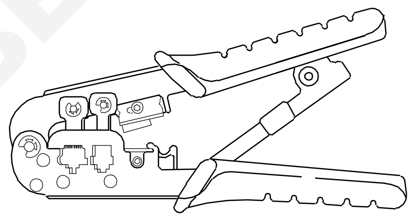
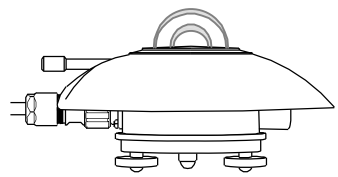
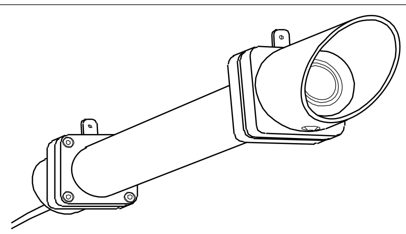
2 Draw a neat sketch against each item.

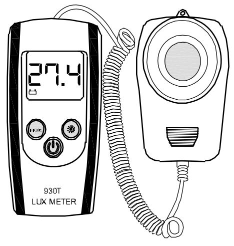
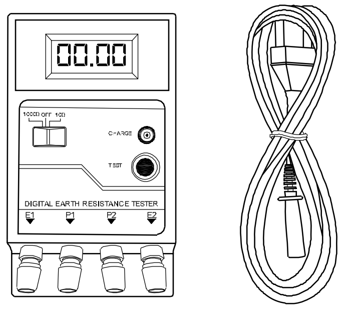
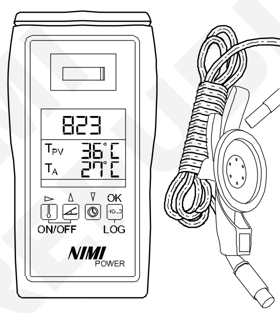
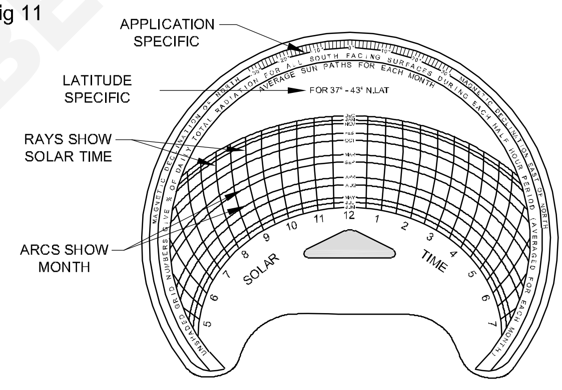
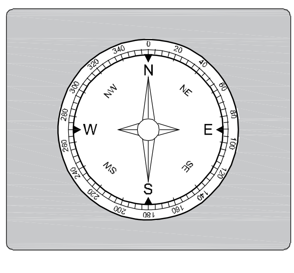
In case the specifications are different write the correct specification of the items given to you.

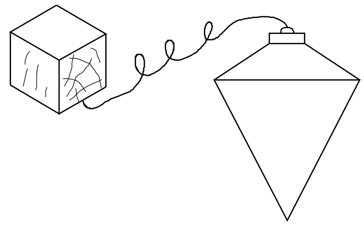
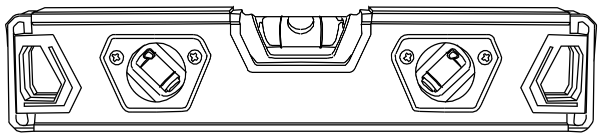
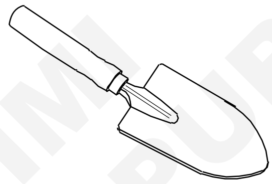
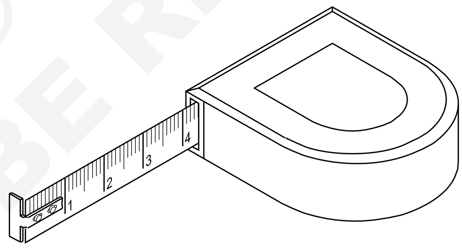
Table 1

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	Neon Test	
v	Wire Stripper	
vi	Drilling Machine	

Sl. No.	Name of tool	Diagrams
1	Soldering iron	Fig 1 
2	Hydrometer	Fig 2 

3	Multimeter	Fig 3  SL20N1207T13
4	Tong tester	Fig 4  SL20N1207T14
5	Crimping tools	Fig 5  SL20N1207T15
6	Pyranometer	Fig 6  SL20N1207T16
7	Pyreheliometer	Fig 7  SL20N1207T17

8	lux meter	Fig 8 
9	Earth tester	Fig 9 
10	IV curve tester	Fig 10 
11	Sun path finder	Fig 11 
12	Compass	Fig 12 

13	Plumb bob	Fig 13  SL20N1207T1D
14	Spirit level	Fig 14  SL20N1207T1E
15	Spade	Fig 15  SL20N1207T1F
16	Measuring tape	Fig 16  SL20N1207T1G

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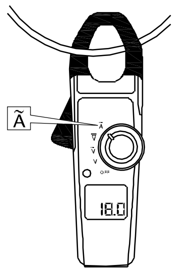
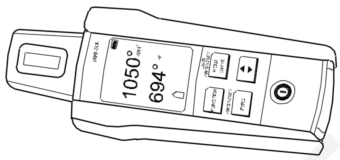
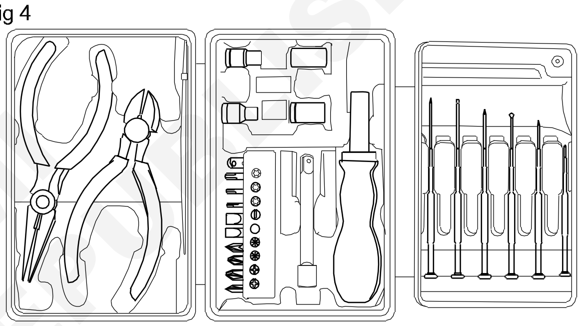
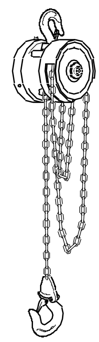
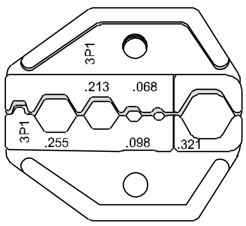
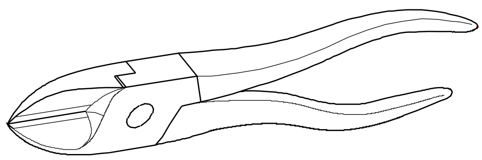
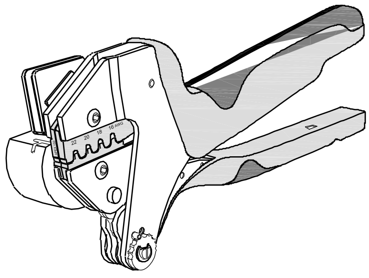
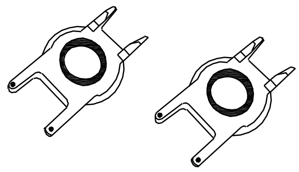
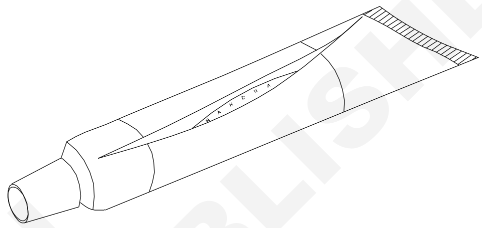
Sl. No.	Name of Accesories	Diagrams
1	Solar Survey 100 Irradiance Meter	Fig 1  SL20N1207T21

2	Solar Power Analyzer Clamp	Fig 2 
3	Solar Installation Tester	Fig 3 
4	Crimp Set	Fig 4 
5	1 Ton Chain Hoist Accessory	Fig 5 
6	Crimp Die Set	Fig 6 
7	14/12/10 AWG Wire Cutter	Fig 7 

8	MC4 Die Locator	Fig 8  ABC12345
9	Universal unlocking tool	Fig 9  SL20N1207T29
10	Structural Adhesive	Fig 10  SL20N1207T2A
11	Complete Solar tool kit	

Operations of allied trade tools

Objectives: At the end of this exercise you shall be able to
- **identify fitting, carpenter and sheetmetal tools**
- **write the names, specifications and operations of each tool.**

Instructor may display the fitter, carpenter and sheetmetal tools (allied trade) on the workbench in the section and demonstrate how to identify the tools, their operation with specifications. Then ask the trainees to record it in Table 1.

TASK 2 : **Identify fitter, carpenter and sheetmetal tools and mention their operation/uses**

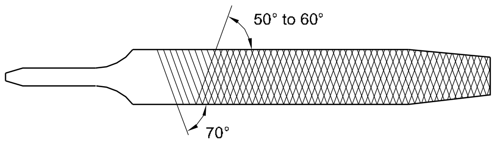
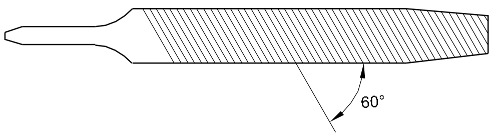
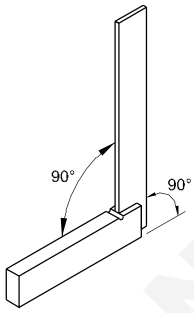
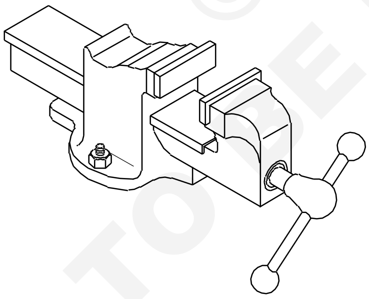
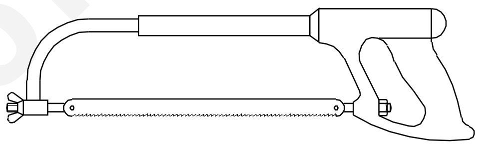
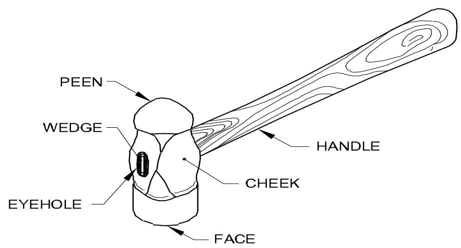
1 Identify fitter, carpenter and sheetmetal tools provided on the workbench and recognise them with their names.

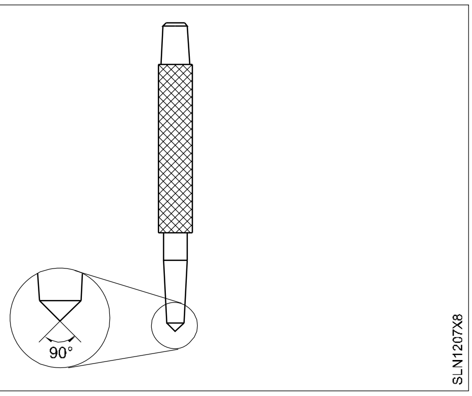
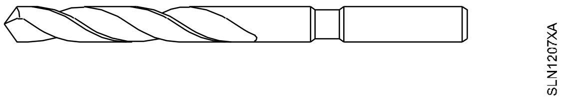
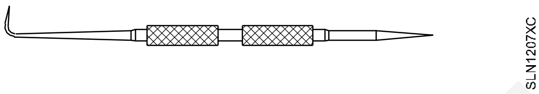
2 Write the name of the tool against the visual shown in Table 1 and mention the specifications.

3 Write the operations / uses of each trade tool.

Fitter, Carpenter, Sheet metal Worker - Fig 1 to 9

Table 1

Sl. No.	Visual of tool	Name of the tool with specifications	Operation/uses
1	Fig 1 		
2	Fig 2 		
3	Fig 3 		
4	Fig 4 		
5	Fig 5 		
6	Fig 6 		

7	Fig 7 		
8	Fig 8 		
9	Fig 9 		

Practice sawing, planing, drilling and assembling for making a wooden switchboard

Objectives: At the end of this exercise you shall be able to
- **make the lines and saw on the grains on wooden blocks (R)**
- **set the jack plane, flat surfaces on wooden blocks plane**
- **drill holes on boards and battens using hand drill, electric hand drilling machine and ratchet brace**
- **make countersink all the holes on wooden board.**

Requirements

Tools/Instruments

- Trainees' tool kit and shop floor tools

Equipment/Machines

- Electric hand drilling machine (6 mm) - 1 No.
- ISA 5555 Thickness - 8mm
- Bench vice 50 mm jaw - 1 No.
- Surface plate - 1 No.
- Angle plate - 1 No.

Materials

- Batten prepared in previous exercises - 1 No.
- Length -150mm
- 60 ISF 8 (Length - 350 mm.) - 1 No.

PROCEDURE

TASK 1: **Drill holes on the wooden batten**

1 Check the given material prepared.

2 Set the marking gauge for 15 mm.

3 Draw the centre line along the edge on both faces using the marking gauge.

4 Mark points at 151 mm from one end of the batten and 102 mm from the other end, using a steel rule and scriber or pencil.

5 Draw lines across the points using a Try square and scriber or pencil.

6 Extend the lines all round the batten with the Try square and scriber or pencil.

7 Cut the batten with a Tenon saw between the lines.

8 File the cut ends and finish to the lines marked.

Mark hole centres from any end as per drawing with a steel rule and pencil on the centre line on both battens.

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^{o} 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.**

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.

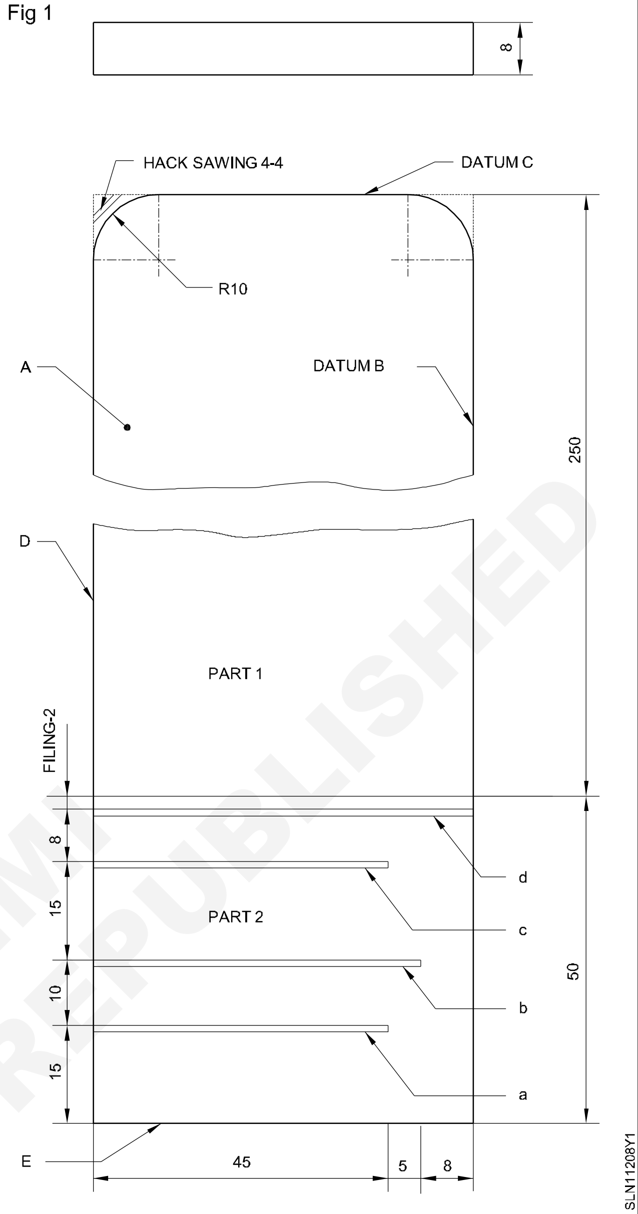
19 Saw the corners for removing the unwanted metal for filing the radius.

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



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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
- **file two adjacent sides to 90° and mark parallel lines for filing**
- **file and finish surfaces within ± 0.5mm**
- **mark by surface gauge for saw cut**
- **mark locations for drill hole centre using the surface gauge**
- **transfer measurements from steel rule to the divider**
- **scribe circles for holes by the divider**
- **make centre punch for centering drill bit**
- **make dot punch for saw line and circumference of the drill hole mark**
- **saw M.S. flat along a straight line**
- **chip flat surface using cold flat chisel**
- **drill through holes within ± 0.5 mm countersunk holes**
- **grind the cutting edge of the flat cold chisel.**

Requirements

Tools/Instruments

- Trainees' tool kit and shop floor tools

Equipment/Machines

- Bench vice - 1 No.
- Angle plate - 1 No.
- Pillar drilling machine - 1 No.
- Pedestal grinding machine - 1 No.
- Drilling accessories, chuck, sleeve, drift - 1 each
- Bench vice 50 mm jaw - 1 No.
- Drilling machine–pillar type - 1 No.
- Angle plate - 1 No.
- Surface plate - 1 No.
- Drilling accessories, chuck, sleeve and drift - as reqd.

Materials

- 58 ISF 10, length 300 mm - 2 Nos.
- Hacksaw blade 300 mm - 2 Nos.
- Finished part of Exercise 1.2.02 (filed full surface)

PROCEDURE

TASK 1 : **Check dimensions of the finished job**

1 Check the dimensions of the finished job 2 Evenly apply lump chalk on the job.

3 Mark all lines parallel to the finished datum edge C (Fig 1) for saw cut and centre of drill holes as per the drawing by placing the job on the levelling plate. (Refer skill sequence information - 1.2.16)

4 Scribe all the lines parallel to the finished datum edge B for saw cut and centre of drill holes as per the drawing by placing the job on the levelling plate.

5 Mark the intersection points of the centre lines of the drill holes with the dot punch.

6 Scribe the circle of the drill hole using the divider.

7 Punch mark the circle at four intersecting points with centre lines.

8 Fix the job in the machine vice of the drilling machine to drill holes marked in part A. (Fig 1)

9 Drill holes of diameter. 6 mm, 10 mm and 15 mm.

10 Drill without altering the setting of the job, change the drill bit to 18 mm and drill the hole.

> **No holes should be drilled in the portion of the job marked part D.**

11 Repeat the steps 1 to 10 in the second portion of the finished job in Exercise No 1.2.16

12 Make the saw cut at a b, 252 mm from datum C.

13 Chip off the L shape to the dimensions using a flat cold chisel and holding part A in the bench vice.

> **Use goggles to protect your eyes.**
>
> **Dip the tip of the chisel in oil at frequent intervals to keep the cutting edge cool.**

14 Repeat steps 12 and 13 on the second piece.

15 File and finish the edge G opposite to the datum edge C in both the pieces.

16 Clamp both the job pieces together and fix them in the drill machine vice. (Refer skill information-1-.2.17)

17 Drill 11.5 mm diameter. holes through both the pieces.

18 Drill a pilot hole for 18 mm diameter through both the pieces.

> **Do not disturb the setting in the drill machine.**

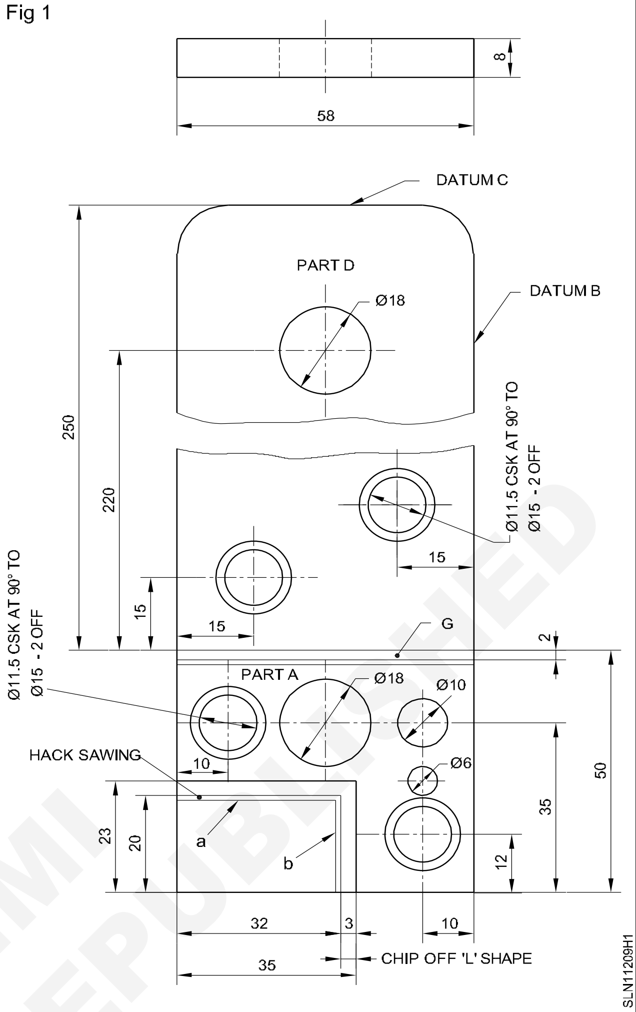
19 Drill 18 mm hole through the pilot hole already drilled.

20 Separate both the job pieces.

21 Countersink the 11.5 mm holes (4 OFF) as per the dimensions given in (Fig 1) in the two pieces of part A.

22 Countersink the 11.5 holes in part D of both the job pieces as per the drawing in Fig 1.

Fig 1



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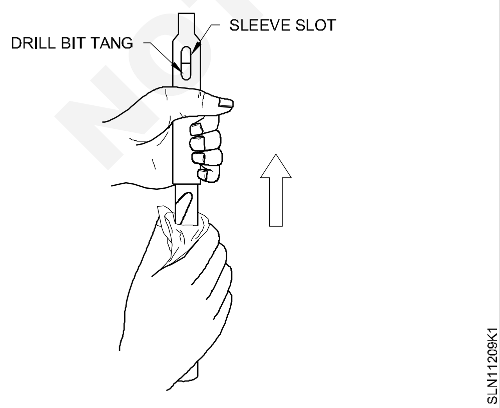
Inserting and removing taper shank drill bit

Objectives: At the end of this exercise you shall be able to
- **insert a drill bit (taper shank) in the spindle of the drilling machine**
- **remove the inserted drill bit from the spindle.**

Wipe the drill taper and the sleeve hole clean with a clear rag. Align the slot in the sleeve with the drill bit tang and insert it. (Fig 1)

Fig 1



Lower the main spindle far enough to see the wedge insertion hole. Throw the main spindle vertical handle to the right and stop the vertical movement of the main spindle .

Wipe the sleeve taper and the main spindle taper hole with a rag. Align the sleeve tang with the main spindle slot, and insert it. Start the main spindle, and make sure there is no wobble. Turn the inclined edge of the wedge down, and insert it into the main spindle slot.

Support the bit with your left hand to prevent it from falling. Lightly tap the top of the wedge with a hammer. (Fig 2)

Insert the wedge into the sleeve slot. Lightly tap the top of the wedge with a hammer. If you cannot support it with one hand, place a wooden block at the bottom with the sleeve, and then tap. (Fig 3)

Fig 2

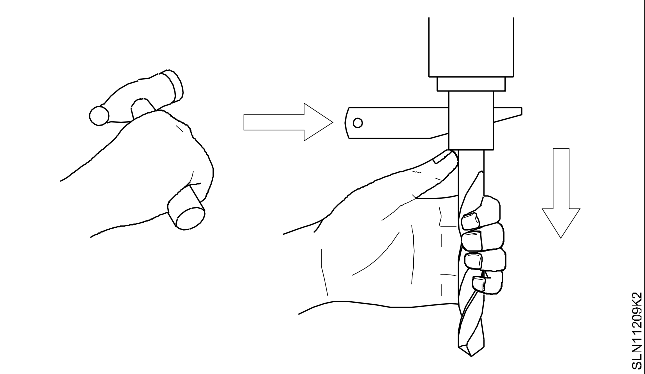
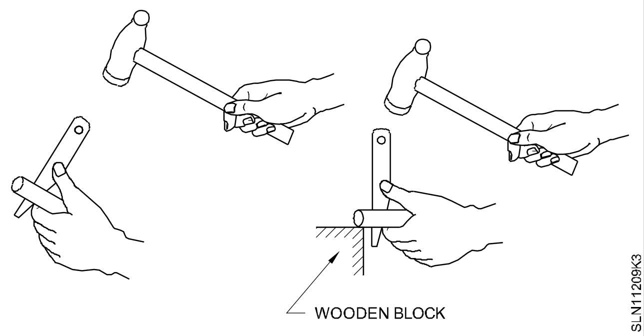


Fig 3



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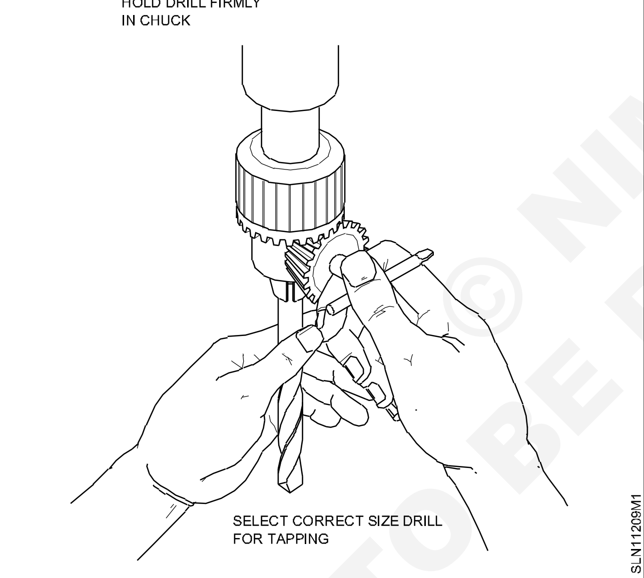
Drilling through holes

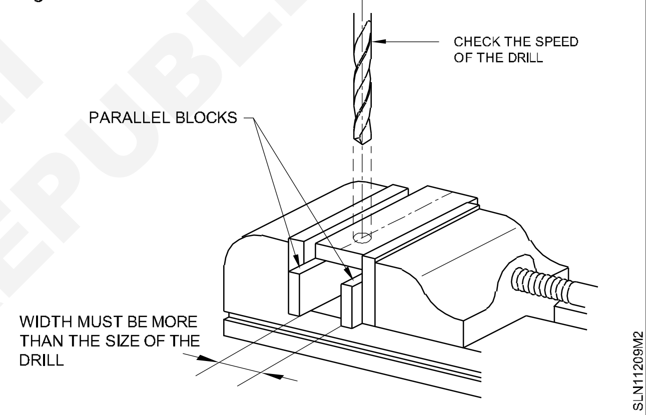
Objectives: This shall help you to
- **fix drill bit in the chuck**
- **drill a hole.**

Fig 1



Hold the straight shank drill firmly in the chuck. Adjust and check the speed of drill as per size. Hold the job deep in the vice jaws.

Fig 2



Support the job with suitable parallel blocks.

Remember that the drill must clear the parallel blocks when a hole is drilled.

Bring the drill point drawn for the correct centre punch position marked on the work. Use coolant at the time of drilling the hole. At the end of the drilling, apply less pressure on the drill.

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Internal threading of holes using hand taps

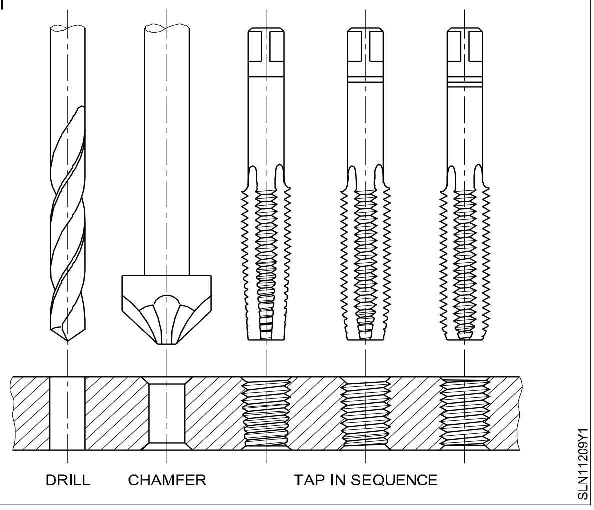
Objectives: This shall help you to
- **determine tap drill sizes for internal threading**
- **cut internal threads using hand taps.**

For cutting internal thread, it is necessary to determine the size of hole (tap drill size). This can be chosen from the table of tap drill sizes.

1 Drill the hole to the required tap drill size.

Remember give the chamfer required for aligning and starting the tap. (Fig 1)

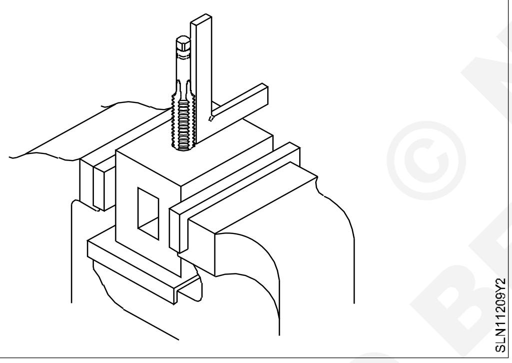
Fig 1



2 Hold the work firmly and horizontally in the vice.

The top surface should be slightly above the level of the jaws of the vice. This will help to use the Try square without any obstruction while aligning the tap. (Fig 2)

Fig 2

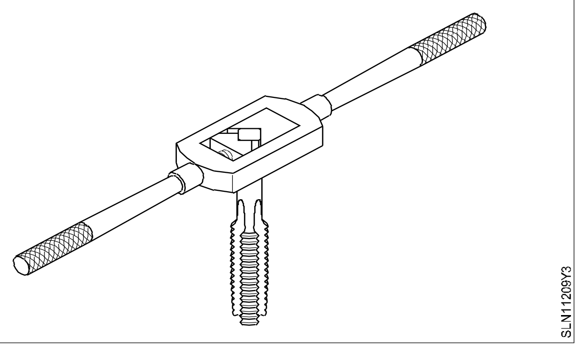


Use soft jaws while holding the finished surface on the vice.

3 Fix the first tap (taper tap) in the wrench.

Very small wrenches need more force to turn the tap. very large and too heavy tap wrenches will not give the required feel to turn the tap slowly as it cuts. (Fig 3)

Fig 3

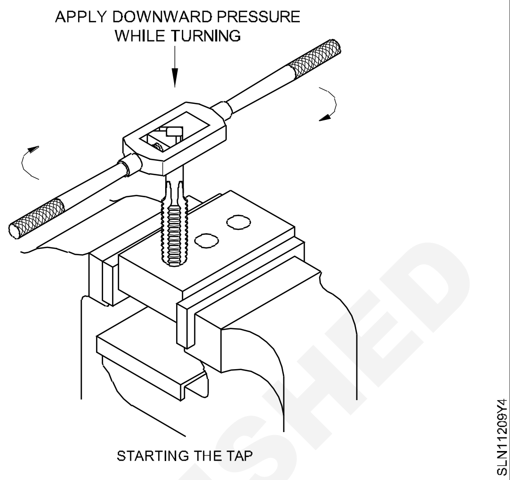


4 Position the tap vertically in the chamfered hole that and ensure the wrench is in the horizontal plane.

5 Exert steady downward pressure and turn the tap wrench slowly in the clockwise direction to start the thread.

6 Hold the tap wrench close to the centre. (Fig 4)

Fig 4



When you are sure of starting to thread, remove the tap wrench without disturbing the tap alignment.

7 Check that the tap is vertical, with the help of a small Try square. (Fig 5) Place the Try square in two positions, 90o to each other. (Fig 6)

8 Make corrections, if necessary.

This is done by exerting slightly more pressure on the opposite side of the tap inclination. (Fig 7)

Fig 5

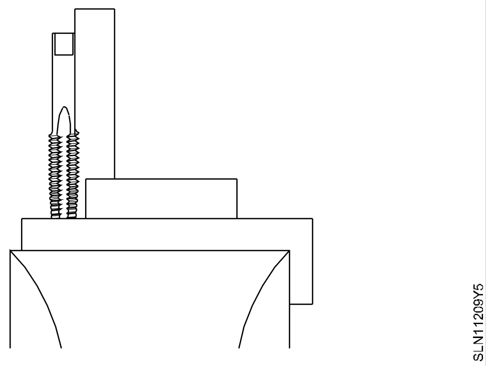


Fig 6

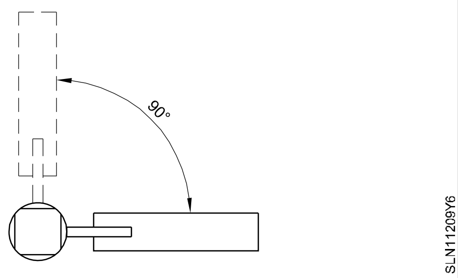
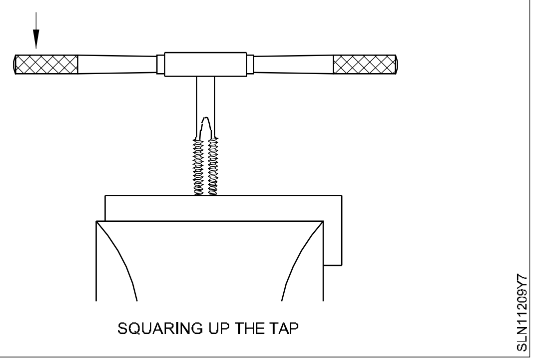


Fig 7



Apply side pressure after giving a turning motion to the tap.

9 Check the tap alignment again with a Try square.

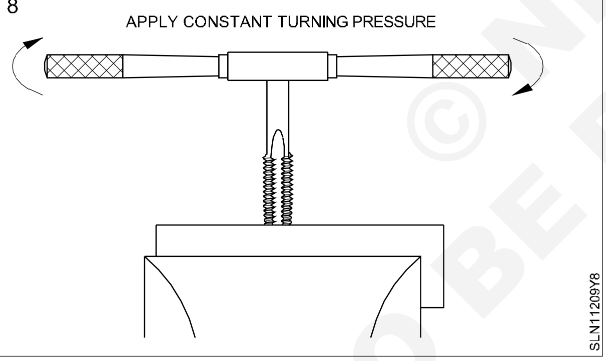
10 Fit the wrench and tighten without disturbing the tap alignment.

11 Make one or two turns and check the alignment.

The tap alignment should be achieved within the first few turns. This cannot be done afterwards as the threads may break.

12 After the tap is positioned vertically, turn the wrench lightly by holding the ends of the wrench handles without exerting any downward pressure. (Fig 8)

Fig 8

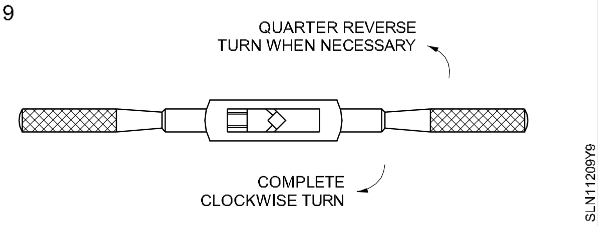


While turning the wrench the movement should be well balanced. Any extra pressure on one side will spoil the tap alignment, and can also cause the tap to break.

13 Continue cutting the thread.

14 Turn backwards frequently about quarter reverse turn to remove the chips. (Fig 9)

Fig 9



15 Stop and turn backwards when some obstruction to the movement is felt.

Use a cutting fluid while cutting the thread.

16 Cut the thread until the tap is fully inside the hole that is being threaded.

17 Finish and clean using the intermediate and plug tap.

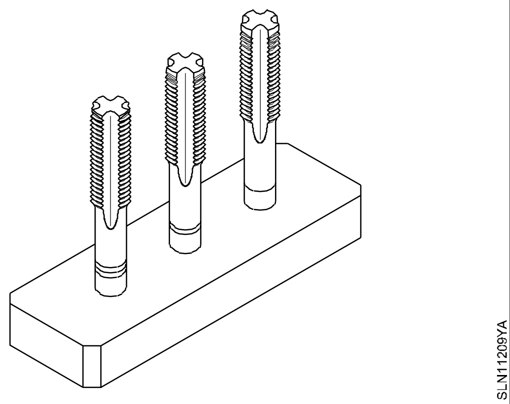
The intermediate and plug tap will not cut any thread if the taper tap has fully entered the hole.

18 Remove the chips from the work with a brush.

19 Check the threaded hole with a machining screw.

20 Clean the tap with a brush and place it back on the stand. (Fig 10)

Fig 10



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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

- Trainees' tool kit and shop floor tools

Equipment/Machines

- Hand drilling machine - 1 No.

Materials

- Sheet iron ISST (in mm) - 52 x 0.5 x 150
- Stack - as reqd.
- Hammer - as reqd.

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

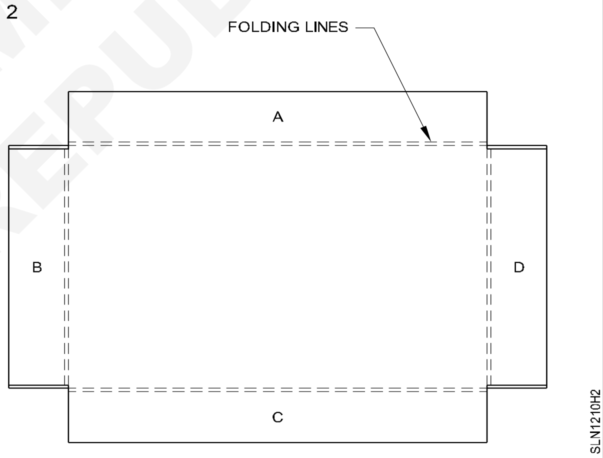
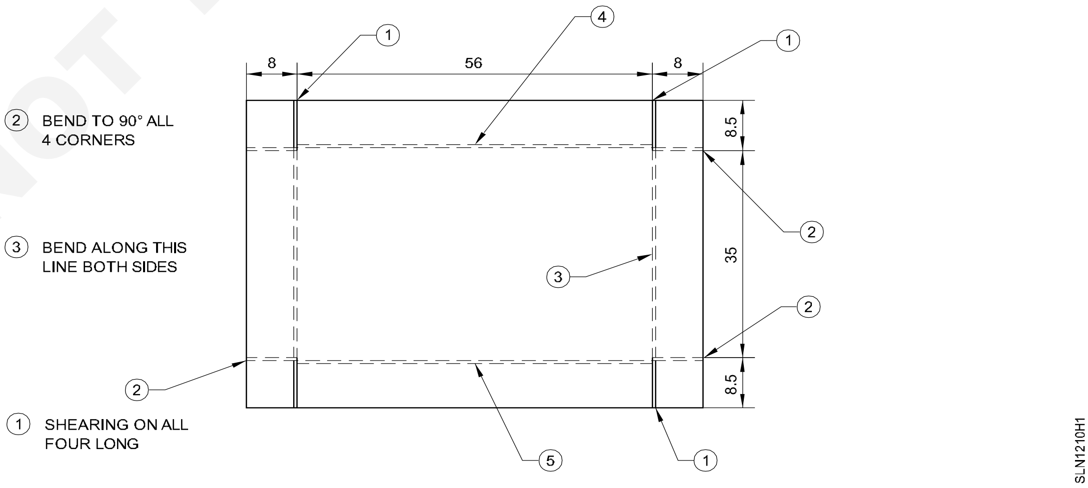


Fig 1



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

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

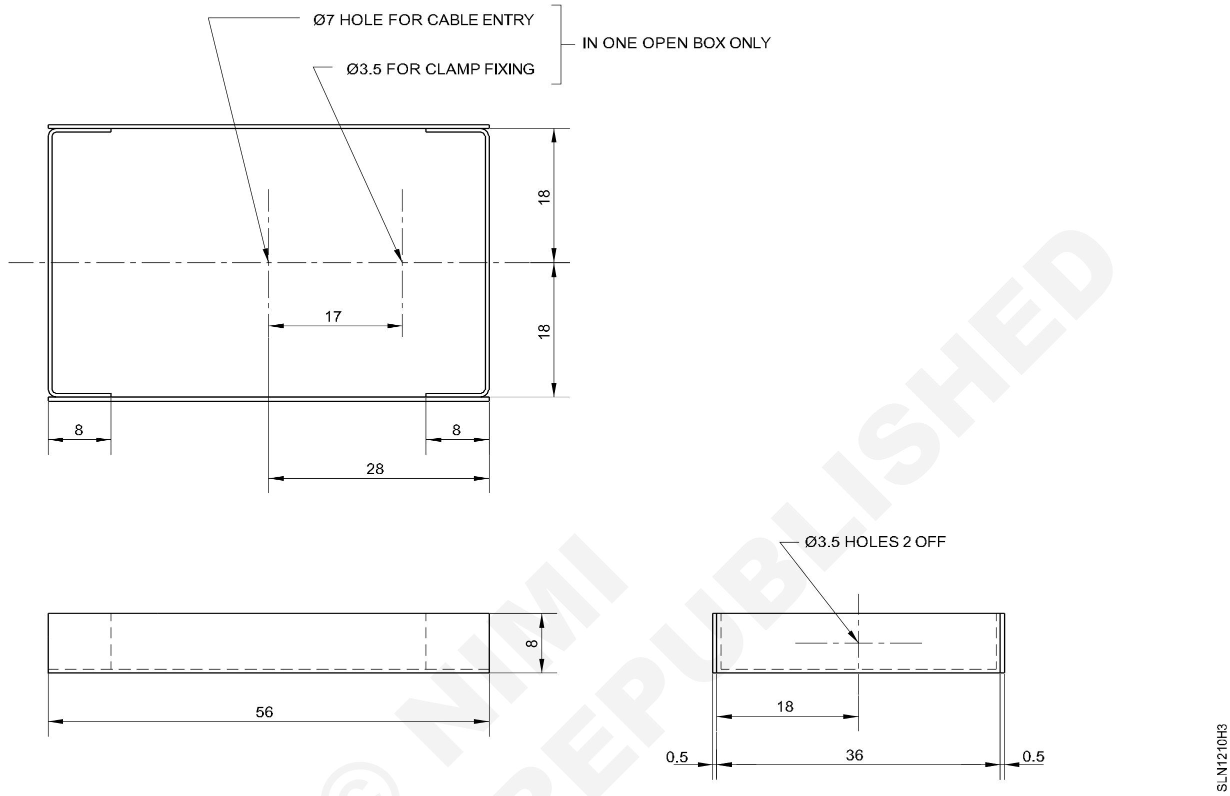
9 Make two marks on the holes of both the lines of at a distance equal to the radius to locate punches.

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

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

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

Fig 3



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

SI.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						

Fig 1

Solar cable

Fig 2

Battery cable

- - - - - - - - - - -

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.

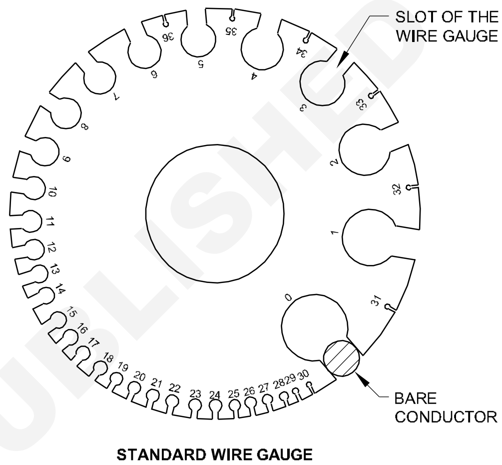
Do not straighten conductors by directly using hand tools on them.

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.

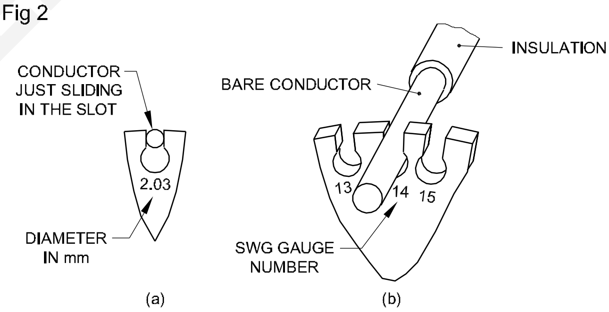
6 Record the measured size in Table 1.

Fig 1



SLN1312H1

Fig 2



SLN1312H2

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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.

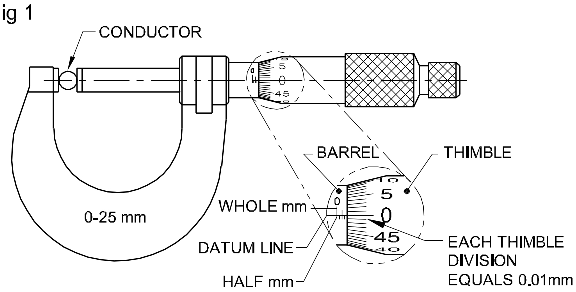
4 Place the cleaned, straight portion of the conductor between the jaws (anvil and spindle) of the micrometer. (Fig 1)

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

Use the ratchet drive to avoid overtightening.

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

Fig 1



SLN1312J1

8 Repeat the steps to find the measurement for the given cable

Make joints on single strand conductors

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

- Trainees' tool kit and shop floor tools

Materials

- Crimping eyelet, eye hole dia. 6 mm - 12 Nos.
- Crimping ferrule 4 mm,10 mm long - 6 Nos.
- Crimping spade lug 6A ,10A,16A - 6 Nos.
- Conducting paste - 1 tube
- Finished simple twist joint - 1 No.
- Sandpaper 'OO' grade - 9 Sq.cm
- Resin-cored solder - 25 gms

TASK 1: **Practice on twisting of single strand wires**

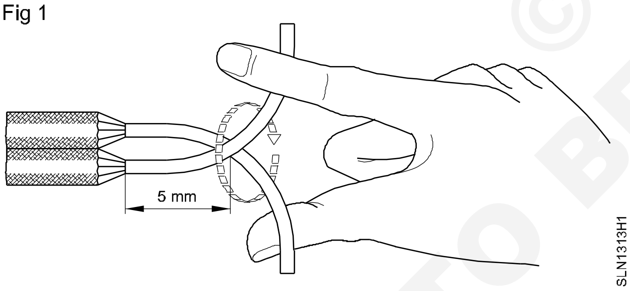
1 Take 300 mm of 1/1.5 mm^2 aluminium wire, or 1/1.2 mm P.V.C copper cable.

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)

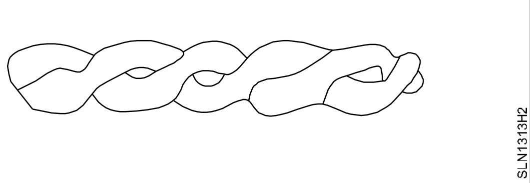
Fig 1



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

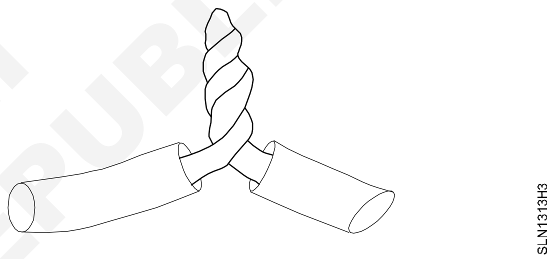
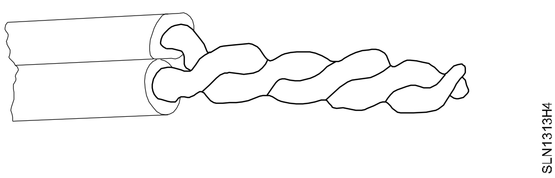


Fig 4

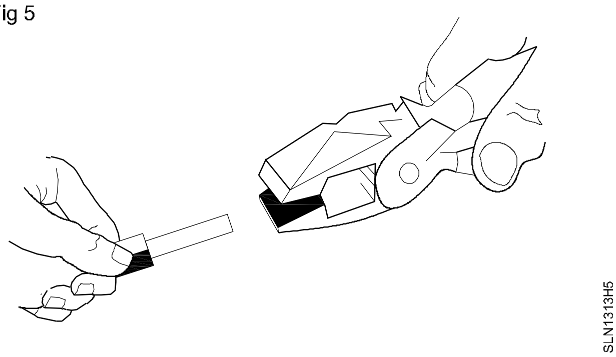


7 Get it checked by your instructor.

Joining of wires by twisting using plier.

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

Fig 5



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Practice in crimping and soldering of joints/lugs

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

- Trainees' tool kit and shop floor tools

Materials

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

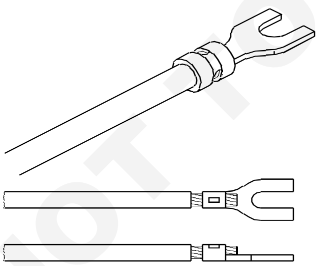
PROCEDURE

TASK 1 : **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).

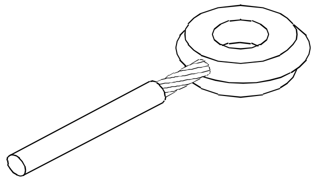
Fig 1



CRIMPED ON SPADE CONNECTOR

SLN1314H1

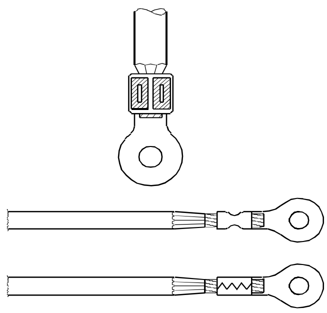
Fig 3



CRIMPED ON CLOSED LUG CONNECTOR

SLN1314H3

Fig 2

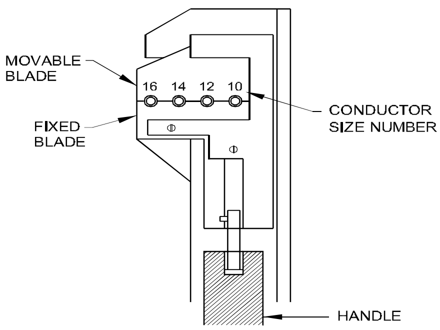


CRIMPED ON EYELET LUG USING PRESSURE PLIERS

SLN1314H2

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



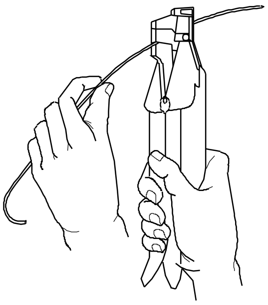
AUTO - WIRE STRIPPER

SLN1314H4

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.

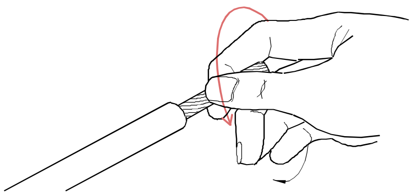
Fig 5



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

6 Select the crimping pliers that matches the terminal size.

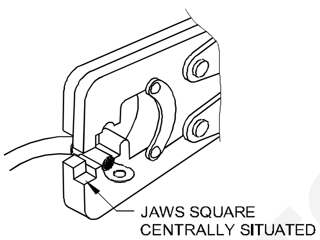
Fig 6



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

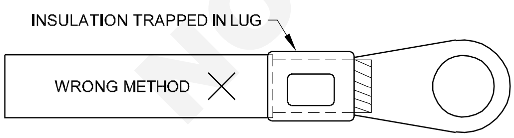
8 Insert the wire far enough in the compression connector. (Fig 7)

Fig 7



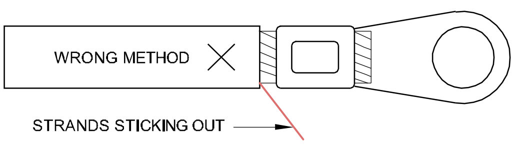
Do not clamp the insulation in the terminal. (Fig 8)

Fig 8



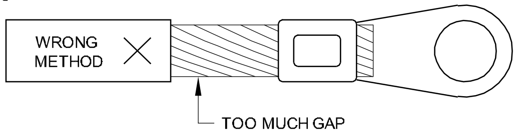
Strands must not stick out of the connector. (Fig 9)

Fig 9



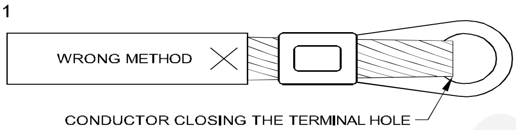
Do not strip too much insulation. (Fig 10)

Fig 10



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

Fig 11

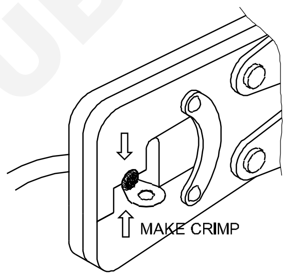


9 Apply light pressure to create a light impression on the compression connector.

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.

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.**

TASK 1: **Solder the copper joints**

(A finished soldered joint will look like Fig 1.)

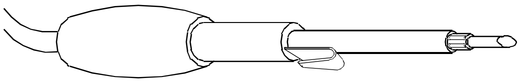
1 Select a 60W, 240V AC 50 Hz. soldering iron and check that the iron has no physical damage, the body is well insulated from the element and is of the correct voltage and power rating. (Fig 2)

Fig 1

SOLDERED JOINT

SLN1314X1

Fig 2



ELECTRIC SOLDERING IRON

SLN1314X2

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

SOLDERING BITS

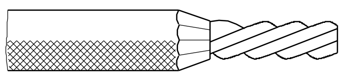
SLN1314X3

3 If found corroded, file the tip with a flat file, so that the surface is smooth and clean.

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 4



CABLE WITH REMOVED INSULATION

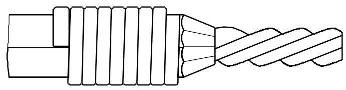
SLN1314Y3

4 Add about 2 mm to the marking, remove the insulation from the cable (Fig 4) and clean the strands.

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 5, and wet it with water.

Fig 5



WRAPPED WITH WET CLOTH

SLN1314Y4

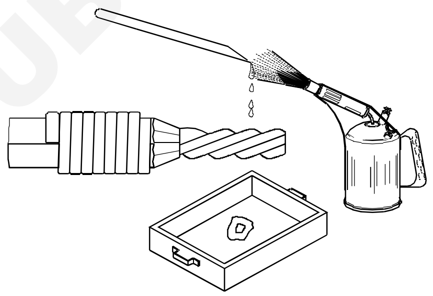
Use minimum water to wet the cloth/tape. Do not allow water to drip.

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 6.

Fig 6



TINNING CABLE END

SLN1314Y5

A thin coating of tin should be on the stranded cable end.

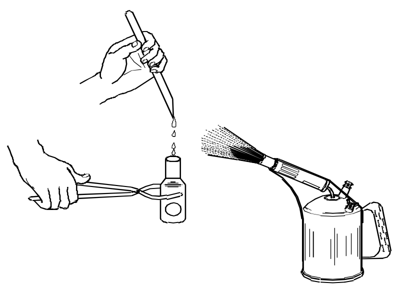
9 Apply a small quantity of flux inside the lug socket. Tin the lug by melting the solder stick to fill the socket and pour the molten solder in the tray.

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 7)

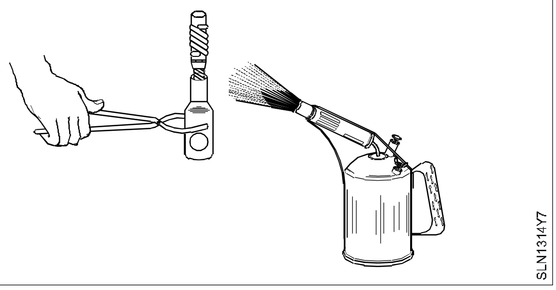
Fig 7



SLN1314Y6

12 Monitor the blowlamp flame on the socket, insert the cable in the socket and hold the cable vertically as shown in Fig 8.

Fig 8



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 8 and allow the solder to solidify.

Do not use water to cool the lug. This will crystallize the solder and make it weak.

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Power **Exercise 1.3.15**

Solar Technician (Electrical) - Characteristics of electrical and magnetic circuits

Verify Ohm's law in DC circuits

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.
- Graph sheet - 1 No.

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

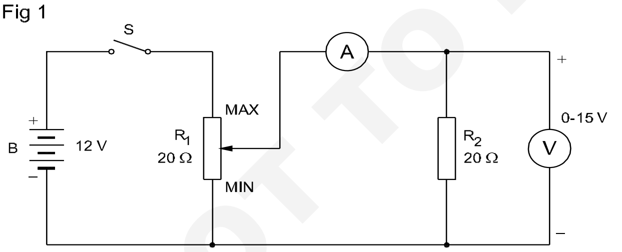


TABLE 1

No.	VOLTAGE (VOLTS)	CURRENT (AMPS)	RELATION BETWEEN I AND V

SLN1415H1

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.

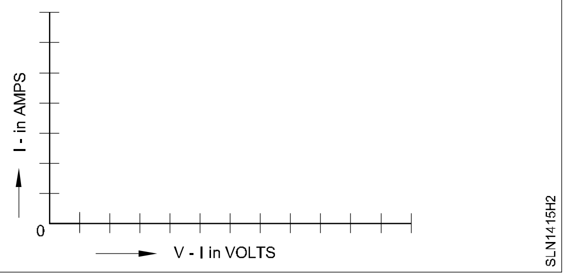
8 Measure the voltage and the corresponding current from the instruments.

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.**

10 Refer the recorded value and plot a graph. Write your conclusion considering the calculated R values.V in Y Axis; I in X axis as shown in Fig 2.

Fig 2



Conclusion

Write your findings and conclusion by interpreting the current and voltage

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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 3 with 0 -1A ammeter. Adjust V at 10 volts keep it constant.

Fig 3

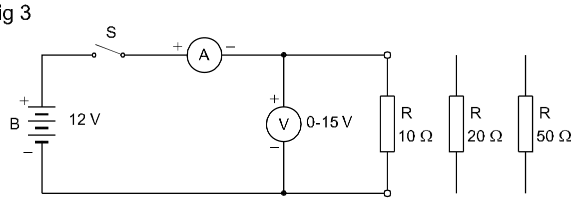


TABLE 2

No.	VOLTAGE (VOLTS)	RESISTANCE (OHMS)	CURRENT (AMPS)	RELATION- -BETWEEN I AND R

SLN1415H3

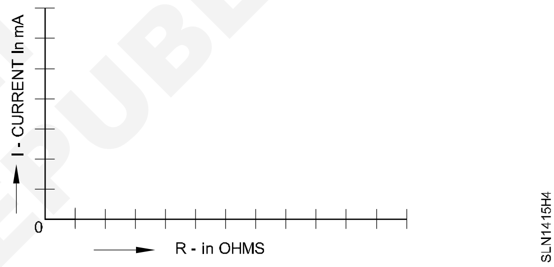
2 Close the switch ‘S’ and measure the current and voltage.

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 and plot the graph. Write your conclusion considering the calculated I values. R in Y Axis; V in X Axis as shown in Fig 4.

Fig 4



Write your findings and conclusion by interpreting the current and resistance.

Conclusion

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Measure current and voltage in DC 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

- 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.

Materials

- Resistors 1K - 4 Nos.
- Resistors 2.2K - 1 No.
- Resistors 3.3K - 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 (IT) and branch currents I_{S1} and I_{S2} 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.

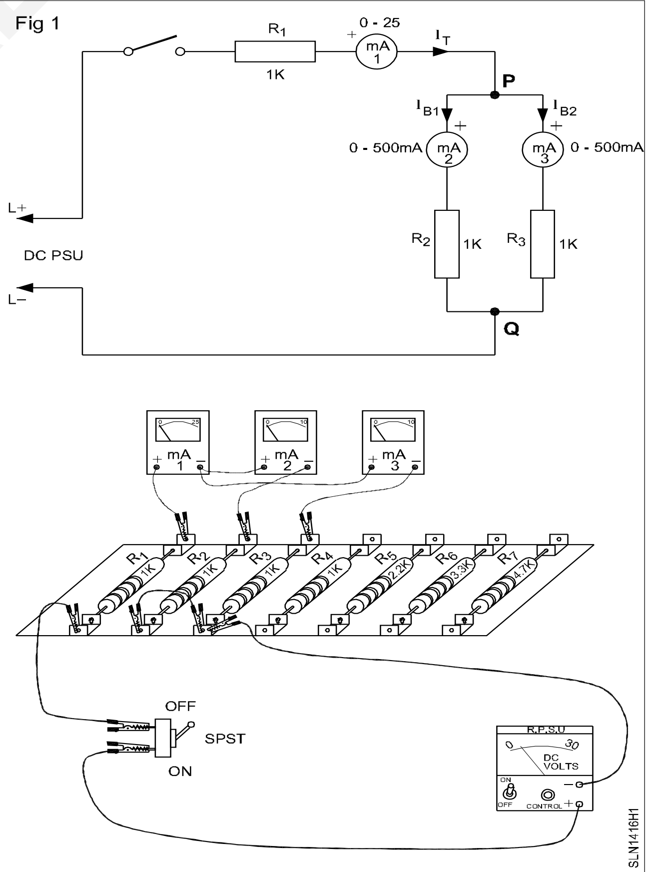
11 Repeat steps 4 and 6.

12 Switch OFF SPST and PSU.

13 Write Kirchhoff's current equations for the nodes P and Q.

14 Verify the equation substituting the measured current values.

Fig 1



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 current (IT) $I_T = I_{B1}+I_{B2}$	I_{B1}	I_{B2}	Total circuit current (IT) $I_T=I_{B1}+I_{B2}$	I_{B1}	I_{B2}
12V						
9V						

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TASK 2: **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 3.

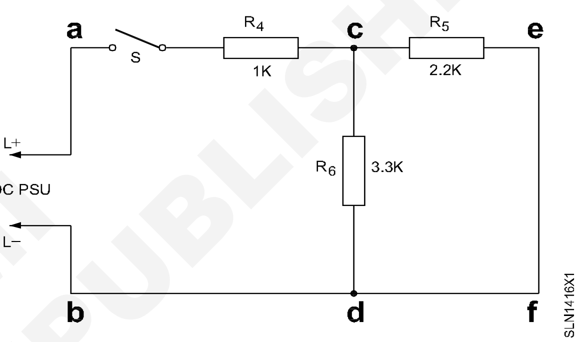
3 Mark the polarity of the voltage drops across resistors R_4, R_5 and R_6 in the copy of Fig 3.

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.

Fig 1



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.

Table 3

Set circuit voltage	Measured values of			Voltage measured across		
	R_4	R_5	R_6	V_{R4}	V_{R5}	V_{R6}

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Verify laws 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.
• Cutting plier 150 mm	- 1 No.
• Screw driver 150 mm	- 1 No.
• Voltmeter MI 0-300V	- 1 No.
• Ammeter MI 0 - 1A	- 1 No.
• AC source 240V/6A	-as reqd.

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

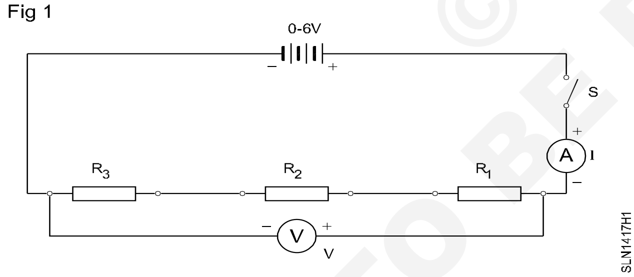
• Switch SPT 6A 250V	- 1 No.
• Resistor 10 ohm 1 W	- 2 Nos.
• Resistor 20, 30, 40 & 60 ohm 1 W	- 1 No. each
• Connecting cables	- as reqd.

PROCEDURE

TASK 1: **Verify the characteristics of series circuits**

1 Construct/ assemble the circuit as shown in Fig 1. ($R_1 = 10\ \Omega$, $R_2 = 20\ \Omega$, $R_3 = 10\ \Omega$)

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 and measure voltage (V_1) and current I_1 through R_1.

5 Switch OFF the supply. Reconnect the voltmeter and ammeter and measure the voltage (V_2) and current (I2) in R_2.

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 =	I1 =	I_2 =	I_3 =
Voltage	V =	V_1 =	V_2 =	V_3 =
Resistance	R = ______ =	R_1 = ______ =	R_2 = ______ =	R_3 = ______ =

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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 4 and measure the current I_s and V_s. Record the valuesin Table 2.

3 Get it checked by the instructor

Fig 4

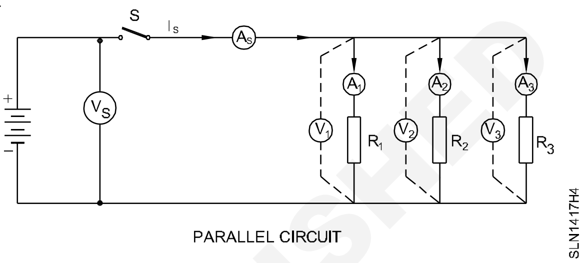


Table 2

Sl.No.	R_1	R_2	R_3	Calculated RT R_T =	I_s	V_s	R_T =

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 VS, 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 RT, from the above measured values.

8 Compare the measured and calculated values of total resistance RT.

Verification

Current Characteristics $I_S = I_1 + I_2 + I_3$

Voltage Characteristics $V_S = V_1 = V_2 = V_3$

Total Resistance $R_T = 1 / (1/R_1 + 1/R_2 + 1/R_3)$

Conclusion

____

____

9 Get the work checked by the instructor

Measure current and voltage and analyse the effects of shorts and opens in series circuits and parallel circuit

Objectives: At the end of this exercise you shall be able to
- **examine the effects of short and open circuited resistors in series circuits**
- **analyse the effects of short and open circuited resistor in series circuits.**

Requirements

Tools/ Instruments

- Screwdriver 150 mm - 1 No.
- MC Voltmeter 0-15V - 1 No.
- MC Ammeter 0 - 500mA - 1 No.
- Ammeter 0 - 500mA - 1 No.
- Multimeter - 1 No.
- Rheostat 0 - 300 ohm, 2A - 1 No.
- DC voltage source variable 0-15V, 1 amp or Battery lead acid 12V, 80AH - 1 No.

Materials

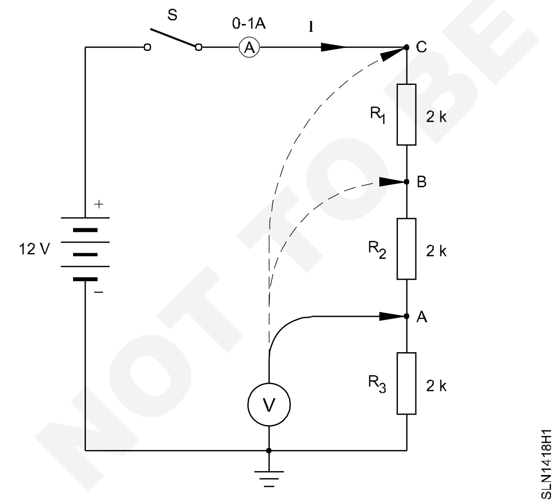
- Connecting leads - as reqd
- Switch 6A 250V - 2 Nos.
- Resistors, carbon composition 62KΩ - 1 Nos.
- 33 KΩ - 1 Nos. 1/4 W, ± 5%
- 22 KΩ - 1 Nos.
- 330 W - 1 No.
- 470 W - 1 No

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 VA, VB and VC and record them in Table 1.

Fig 1



Note : All voltages are with respect to ground.

2 Considering resistor R1 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 R1, 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

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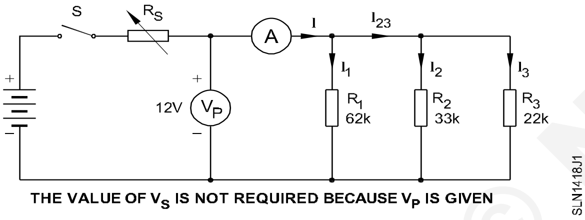
TASK 2: **Analyse the effect of short and open circuited resistors in parallel circuits**

1 Calculate the nominal values for the currents I, I1 and I_{23}, I_2 and I_3 for the circuit in Fig 1 and record them in Table 1.

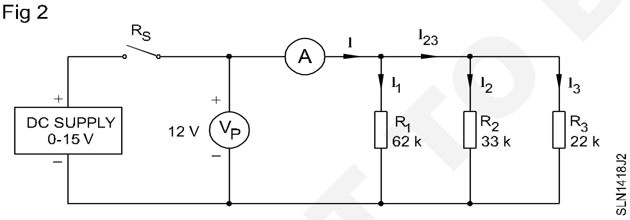
2 Construct the circuit (shown in Fig 1) and adjust RS, source voltage series resistor, to a value that produces 12 volts across the parallel set of resistors.

Fig 1



3 Set the current limit to 100mA, if the DC power supply with current limiting feature is used as Vs. Omit the series resistor Rs. (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 R1. 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 R1. 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.

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	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							

15 Get it checked and approved by the instructor.

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

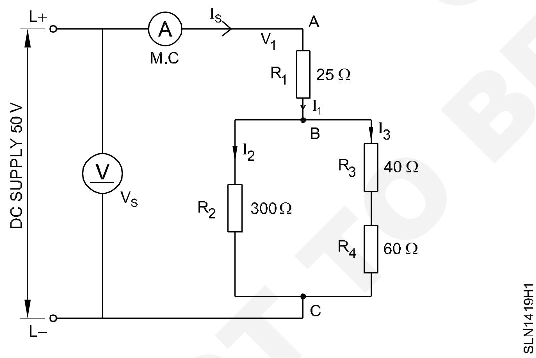
- Switch SPT 6A 250V - 1 No.
- Connecting cables - as reqd.

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 RT and total current IS for VS = 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 RT from Vs and Is and enter in

Table 2. Compare with the value obtained in step 2.

Verification

$IS = I_2 + I_3$; $V_T = V_{R1} + V_{R2}$. $R_T = R_1 + [R_2(R_3 + R_4)/R_2+R_3+R]$.

Table 1

V_s = 50v R_1 = 25Ω R_1 = 300 R_3 = 40Ω R_4 = 60Ω		V_{RI}	I_S	I_2	V_{R2}	I_3	V_{R3}	$R_3 + R_4$	$R_2 \| (R_3+R_4)$
	Calculated Values								
	Measured Values								

Table 2

Calculated Values	$R_T = R_1 + [R_2(R_3 + R_4)/R_2+R_3+R]$
Measured Values	R_1 =

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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
- Trainees' tool kit and shop floor tools

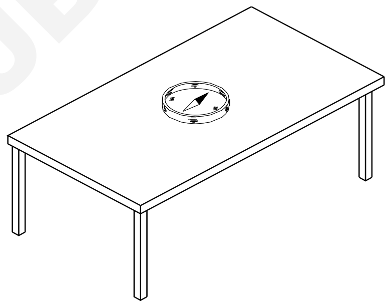
Materials
- Magnetic compass
- Bar magnet

Equipment/Machines
- Battery 12V, 80 or 100AH or variable voltage source DC 0-25V, 30A - 1 No.

PROCEDURE

TASK 1: **Identify the polarity of the magnetic compass**

Fig 1



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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.

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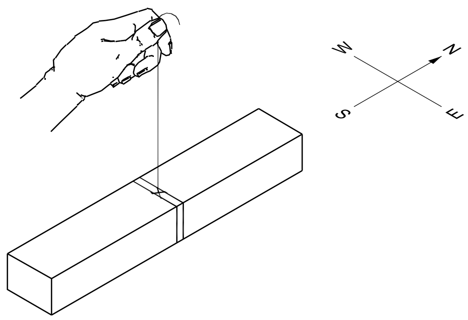
TASK 2: **Determine the polarity of a permanent bar magnet**

Fig 1



SLN1420J1

1 Suspend the magnet as shown in Fig 2 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 cofirm the polarity.
5 Check the identified polarity with a magnetic compass.

The compass needle must not be taken near the poles of the bar magnet.

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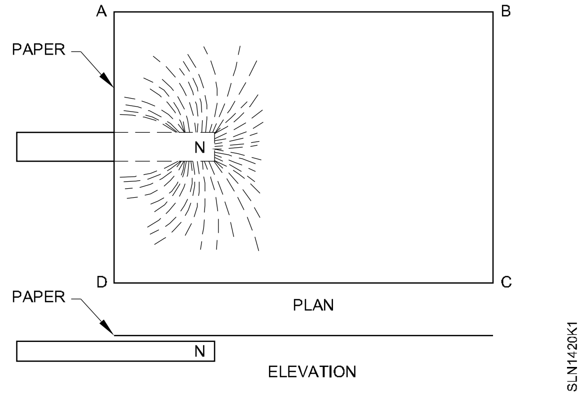
TASK 3: **Trace the magnetic path of the given magnetic bar**

1 Place the bar magnet's north pole underneath the paper as shown in Fig 3. Sprinkle some iron filings on the paper.

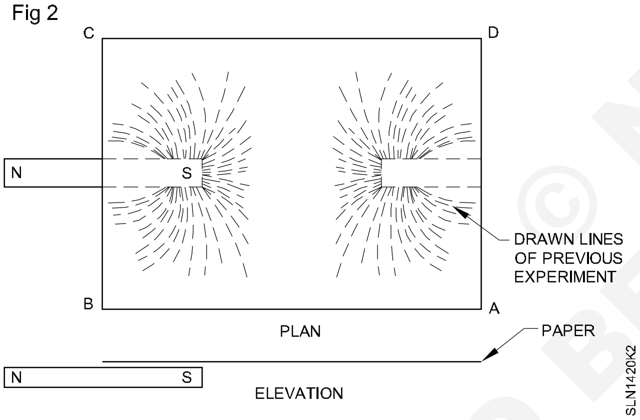
Fig 1



2 Tap the paper gently on all the corners. Observe the random filings getting oriented into a definite pattern.

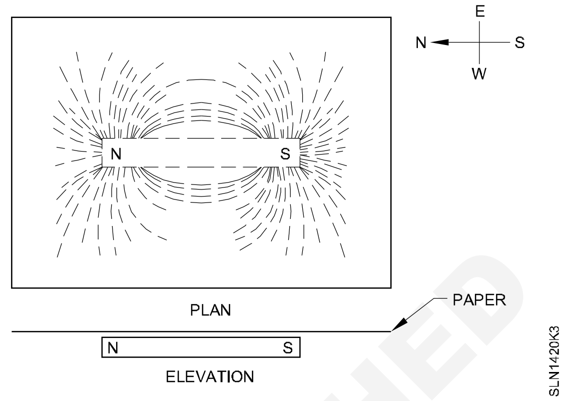
3 Gently draw lines along the orientation of the iron filings with a pencil. Repeat the expriment for the other pole as shown in Fig 4.

Fig 2



4 Place the bar magnet underneath a thin cardboard as shown in Fig 5. Sprinkle some iron filings. Gently tap the paper to orient the iron filings and trace the magnetic path with a pencil.

Fig 3

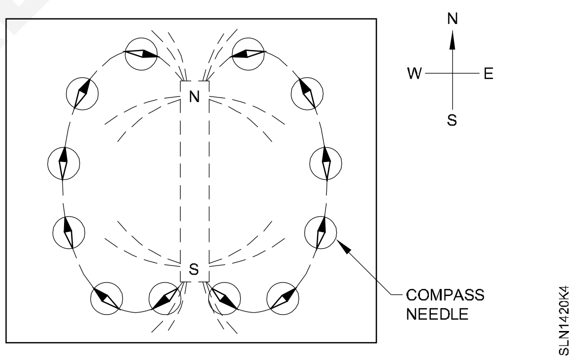


5 Place another thin card over the bar magnet as shown in Fig 6. Trace the magnetic lines using a compass needle by positioning the needle in the required areas..

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



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/Equipment

- Ohmmeter (multimeter - ohms range) - 1 No.
- MC Voltmeter (0 - 15V) - 1 No.
- MC Ammeter (100mA - 0 - 100mA) - 1 No.
- MI Voltmeter 0 to 300V - 1 No.
- MI Ammeter 0 to 500mA - 1 No.
- Rheostat, about 300 ohms 2A - 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

- DC source 12 V or 0-30V variable (R.P.S) - 1 No.
- 240V AC source.
- Auto transformer 0-270V/8A - 1 No.

Materials

- Capacitors - paper, mica, electrolytic, mylar, tantalum,variable air core and mica – assorted values and different voltage ratings - as reqd.
- Potentiometer 100 k ohm - 1 No.
- Single pole, double throw switch 16A 250V - 1 No.
- 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.
- 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 500W/0.5A - 1 No.
- Wire wound resistor 100W/1.5A - 1 No.
- Electrolytic capacitor 8mFd/400V - 1 No.
- Electrolytic 1mFd, 2mFd, 4mFd/400V - 1 each

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

3 From the capacitor provided by the instructor read the value of the capacitor and identify its type.

Fig 1

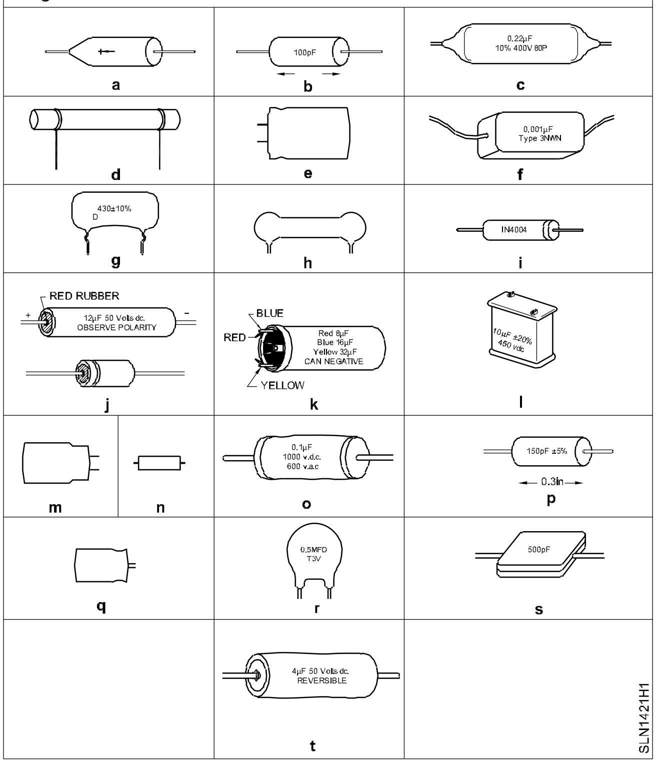


Table 1

Fig.No.	Name of component	Symbol	Type	Capacitance value	Voltage rating

_ _ _ _ _ _ _ _ _ _ _

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.

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.

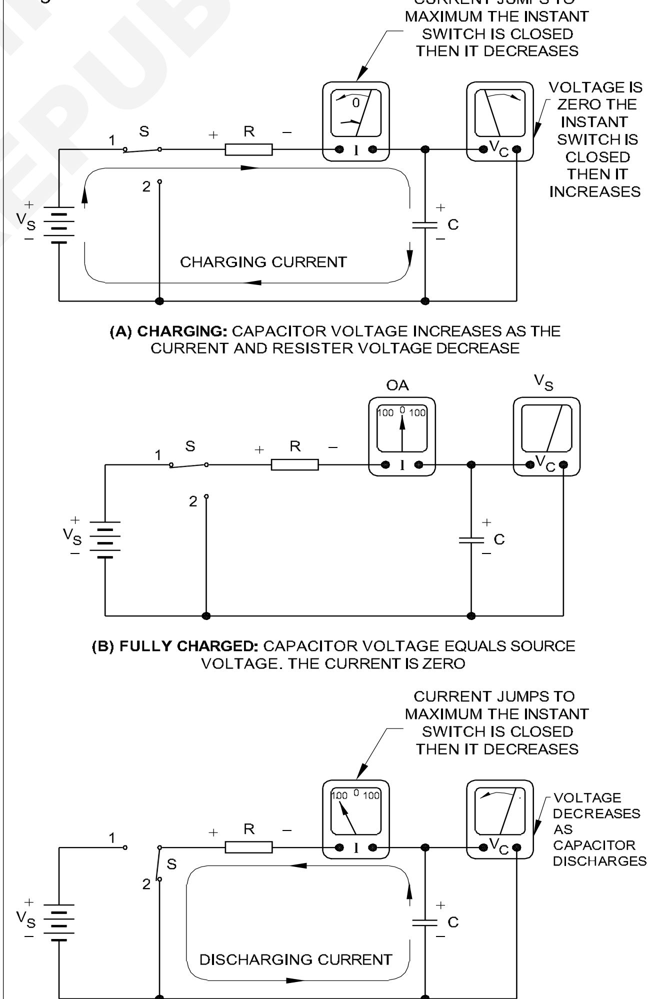
12 Repeat the test for different values of capacitance rated for different voltages.

> **The testing voltage should be close to the voltage rating of the capacitor.**

Table 3

Sl. No	Value of Capacitor μF	Value of Resistor KW	Time in Seconds	Voltage Volts
1	470	500		
2				
3				
4				
5	4370			
6				
7				
8				
9	470			
10				
11				
12				

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.

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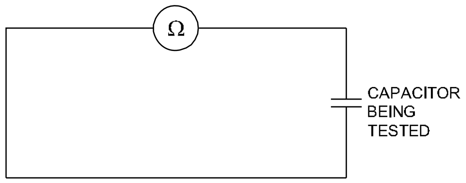
TASK 3 : **Testing of capacitor with ohmmeter**

1 Discharge the given capacitor.

2 Connect the ohmmeter to test the capacitor (Fig 3) 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.**

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

SLN1421K1

> **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 3 and record the findings in Table 4.

4 Discharge the capacitor.

5 Perform the test in different capacitors.

Table 4

S.NO	Value Capacitor	Meter Reading	Result
1			
2			
3			
4			
5			

For electrolytic capacitor only.

Identify various types of capacitors, charging/discharging and testing

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.**

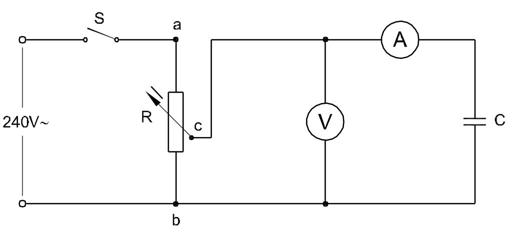
TASK 1: **Measure capacitive reactance (Xc)**

1 Form the circuit as shown in Fig 1 with a 2 - μF capacitor. (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).

Fig 1



SLN1421M1

3 Note the voltmeter and ammeter readings and record in Table 1.

4 Calculate the reactance $X_C = \frac{V}{I}$ and record the result in Table 1

Table 1

SI.NO	Value of Capacitor	Voltage	Current	X_c= V/I

5 Compare the calculated value using the formula

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.

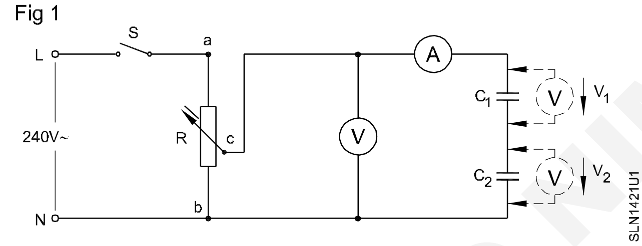
- - - - - - - - - - -

TASK 2 : **Connect capacitors in series**

1 Form the circuit with two capacitors in series as shown in Fig 2. (2 MFD, 2 MFD)

2 Determine the XC value for the series combination performing steps 2 to 5 of TASK 1. Fill XC values in Table 2 under the appropriate columns.

Fig 1



3 Calculate the total capacitance C total as

$$\frac{1}{C_{total}} = \frac{1}{C_1} + \frac{1}{C_2}$$

4 Calculate the Ctotal from the Xc. Check for its confirmity.

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

SI. 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 $XC = \frac{1}{2\Pi fc}$
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 XC of the parallel combination performing steps 2 to 5 of TASK 1. Fill up XC in Table 3.

3 Calculate the total capacitance Ctotal = C1 + C2. Record Ctotal in Table 3.

4 Calculate the Ctotal from XC. Check for its confirmity.

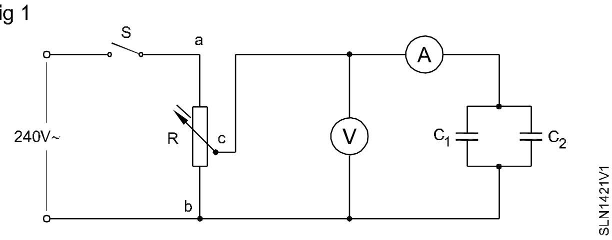
Result

In parallel combination of capacitance

i the total reactance ________________________

ii the total capacitance ______________________.

Fig 1



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 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	Capacitive reactance $XC = \frac{1}{2\Pi fc}$
1	2	2						
2	2	4						
3	4	8						

- - - - - - - - - - -

Test AC circuit with resistive load like lamp, heater, etc

Objectives: At the end of this lesson you shall be able to
- **Connect the lamp load, (Electric bulb of different wattages) to the AC mains single phase through a switch.**
- **Connect the ammeter in series**
- **Connect the voltmeter in parallel**
- **Switch ON and measure the current and voltage**
- **Find out power by calculation as well as using Wattmeter. Compare with rated power of the lamp.**
- **Record your observations**
- **Repeat the task with a Heating rod or electric oven or geyser.**

Requirements

Tools/Instruments
- MI voltmeter 0 - 300 V - 1 No.
- MI ammeter 0 - 1 A , 0 – 10 A - 1 No.
- Wattmeter 250 V, 5 amps - 1 No.
- Power factor meter (0.5 lag to 0.5 lead) 250 volts5 amps - 1 No.

Equipment/Machines
- Auto transformer 0-270V/8A - 1 No.

Materials
- Connecting cables - as reqd.
- I.C.D.P. switch - 16 amps, 250 volts - 1 No.
- Incandescent lamps 100W - 3 No.
- Electric Geyser 1KW - 1 No.
- Heating rod 500W - 1 No.

PROCEDURE

TASK 1 : **Test AC circuit with resistive load like lamp, heater, etc**

1 Assemble the circuit as per circuit diagram with the instruments and components collected.

Before forming the circuit, confirm that the Main switch is OFF.

2 Switch 'ON' the supply and adjust the Auto transformer until the voltmeter indicates 240 volts.

3 Measure the voltage across each Bulb and note it in the Table 1.

Table 1

	Supply	V_L	I_L	Measured power(W_L)	Power factor COSϕ	Calculated Power = V_L X I_L X Cos ϕ
Bulbs	240V					
Geyser	240V					
Heating rod	240V					

4 Measure the current and note the same in Table 1.

5 Measure the power WL& power factor Cosϕ and note the same in Table 1.

Switch off the circuit.

6 Calculate the power by using formulaPower = VL X IL X Cos ϕ and note in the Table

7 Compare the value of the measured power and calculated power.

8 Replace the Bulbs witha geyser and repeat the steps 2 to 7.

9 Replace the geyser with a heating rod and repeat the steps 2 to 7.

10 Get it checked by the instructor.

\- - - - - - - - - - -

Test AC circuit with inductive load like fan, pump, etc.

Objectives: At the end of this lesson you shall be able to
- **Connect the inductive load, (Table fan or ceiling fan) to the AC mains single phase through a switch.**
- **Connect the ammeter in series**
- **Connect the voltmeter in parallel**
- **Switch ON and measure the current and voltage**
- **Find out power by calculation as well as using Wattmeter. Compare with rated power of the lamp.**
- **Record your observations**
- **Repeat the task with a water pump.**

Requirements

Tools/Instruments
- MI voltmeter 0 - 300 V - 1 No.
- MI ammeter 0 - 2 A , 0 – 5 A - 1 No.
- Wattmeter 250 V, 5 amps - 1 No.
- Power factor meter (0.5 lag to 0.5 lead) 250 volts5 amps - 1 No.

Equipment/Machines
- Auto transformer 0-270V/8A - 1 No.

Materials
- Connecting cables - as reqd.
- I.C.D.P. switch - 16 amps, 250 volts - 1 No.
- Table fan 55W, 230V AC - 1 No
- Water pump ½ HP, 230V AC - 1 No.

PROCEDURE

TASK 1 **Test AC circuit with inductive load like Table fan and water pump**

1 Assemble the circuit as per circuit diagram with the instruments and components collected.

Before forming the circuit, confirm that the Main switch is OFF.

2 Switch 'ON' the supply and adjust the Auto transformer until the voltmeter indicates 240 volts.

3 Measure the voltage across the Table fan and note it in the Table 1.

	Supply	V_L	I_L	Measured power(W_L)	Power factor COSϕ	Calculated Power = V_L X I_L X Cos ϕ
Table fan	240V					
Water pump	240V					

4 Measure the current and note the same in Table 1.

5 Measure the power WL & power factor Cosϕ and note the same in Table 1.

Switch off the circuit.

6 Calculate the power by using formula Power = VL X IL X Cos ϕ and note in the Table

7 Compare the value of the measured power and calculated power.

8 Replace the Table fan with a water pump and repeat the steps 2 to 7.

9 Get it checked by the instructor.

- - - - - - - - - - -

Measure power, energy for lagging and leading power factors in single phase circuits.

Objectives: At the end of this lesson 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

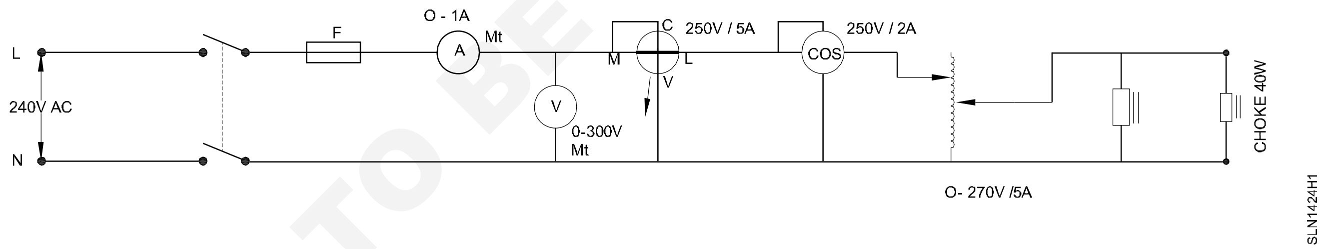
- Choke (T.L) 40W/250V - 2 Nos.
- Electrolytic capacitor, 2.5μFd/415V - 2 Nos.
- Connecting leads - as reqd.

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

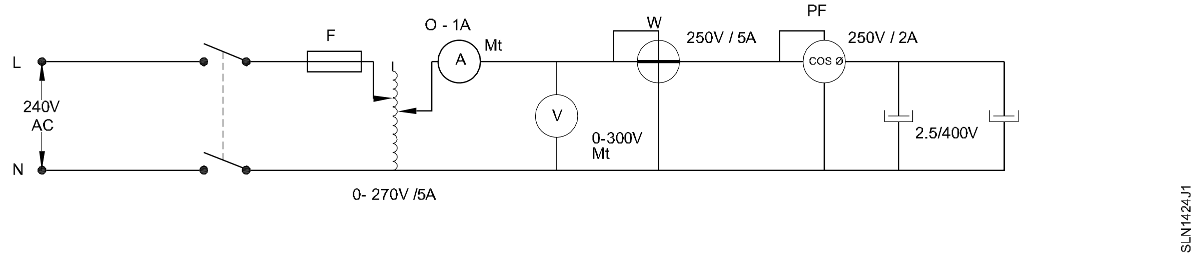
S.No	Volt (V)	Current (I)	W (w)	PF +/- Lag/Lead	No. of chokes
1					With one choke
2					With two choke

\- - - - - - - - - - -

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

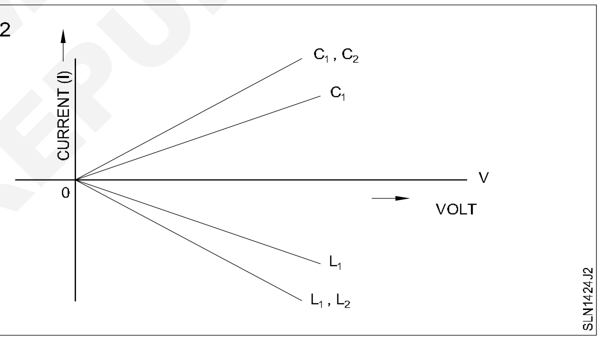
S.No	Volt (V)	Current (I)	W (w)	PF +/- Lag/Lead	Conditions
1					With one choke
2					With two choke

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 3.

7 Get your work approved by the instructor.

Fig 2



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Measure Current, voltage, power, energy and power factor in three phase circuits.

Objectives: At the end of this lesson 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 - 2 No.
- M.I Ammeter 0-5A/10A - 1 No.
- Power Factor meter 415V/20A - 1 No.
- 3 phase 4 wire energy meter 415V/20A - 1 No.
- Insulated combination pliers 200 mm - 1 No.
- Power factor improving capacitor bank 3 phase 415V, 1.5 KVAR - 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.
- 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 mm2 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

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.

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.

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.

7 Swtich 'OFF' the power supply.

8 Replace the 100 Watt lamp with 200W lamp load.

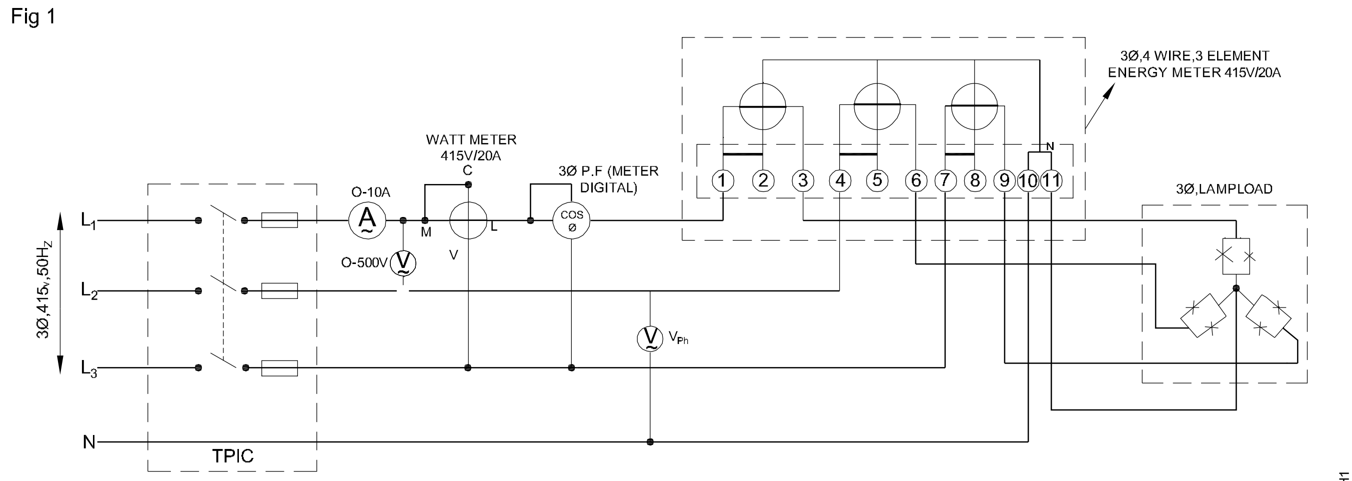
9 Repeat steps 3 to 6 and record the readings in Table 1.

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.

Fig 1



CIRCUIT DIAGRAM FOR MEASURING OF VOLTAGE, CURRENT,POWER,ENERGY AND P.F IN 3 PHASE CIRCUIT

Table 1

Load	Line Voltage V_L	Phase Voltage V_{PH}	Line Current I_L	Phase Current I_{PH}	Power (in watt)	Power factor	Initial reading in energy meter	Final reading after 10 min in energy meter F.R	Energy consump tion F.R - I.R kWh
Lamp road for 100W									
Lamp road for 200W									
3 Ind meter load									

Ascertain use of neutral by identifying wires of a 3-phase 4 wire system and find the phase sequence

Objectives: At the end of this lesson 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 Instruments

- 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.
- Connector screw driver 150 mm - 3 Nos.
- Three phase test board with netural link - 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

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

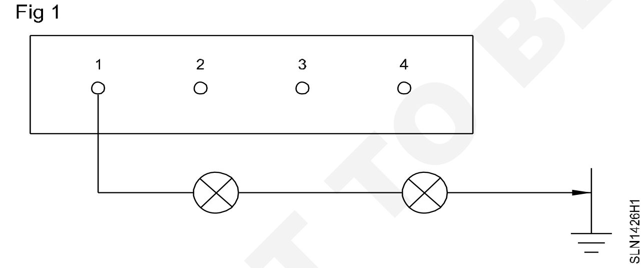


Table 1

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

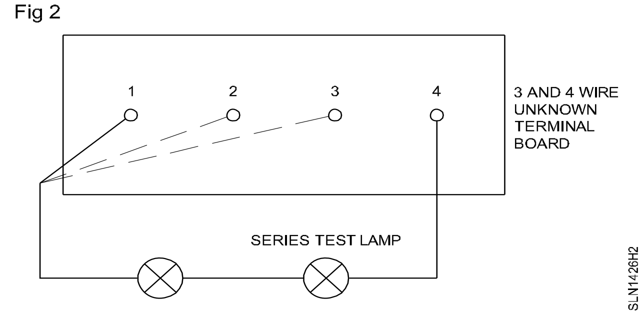


Table 2

Sl.No.	Terminals	Lamp condition	
		Glowing	Not glowing
1	4-1		
2	4-2		
3	4-3		

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

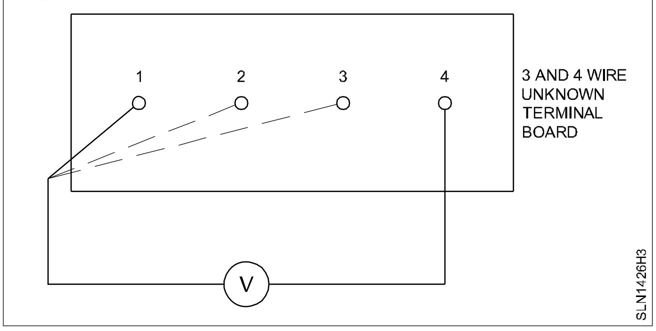


Table 3

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		

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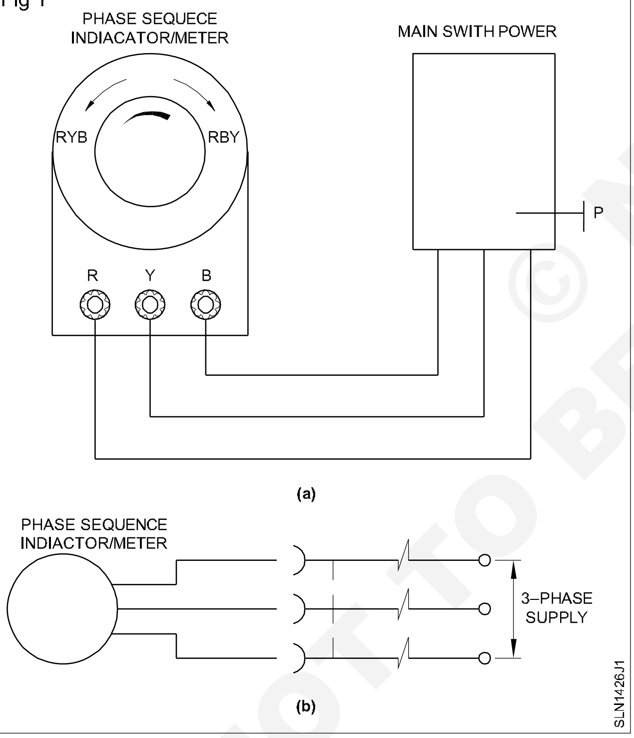
TASK 2: **Identify the phase sequence in 3-phase 4 wire system by using phase sequence meter**

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
RBY Sequence } Arrow marking to be indicated

Arrow in clockwise - ;

Arrow in anti-clockwise - L

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 the relationship between Line and Phase values for star and delta connections

Objectives: At the end of this lesson 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 and Instruments

- Screw driver 150 mm - 1 No.
- Combination plier 150 mm - 1 No.
- M.I Ammeter type (0-1 amp) - 2 No.
- M.I Voltmeter type (0-500V) - 3 No.
- ICTP switch 16A 500V - 1 No.
- M.I Voltmeter type (0-300V) - 1 No.

Materials

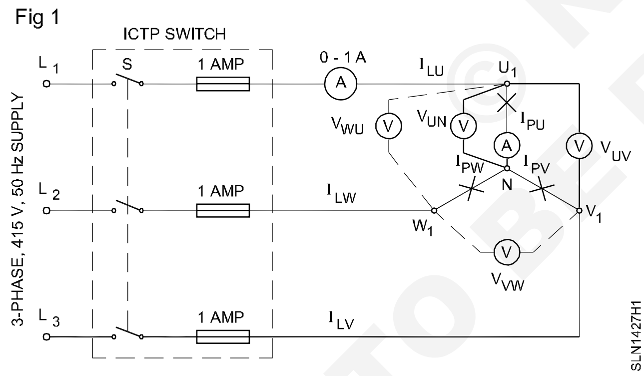
- Connecting leads - as reqd.
- Lamp BC - 40W 240V - 6 Nos.
- 100W 240V - 6 Nos.
- 200W 240V - 6 Nos.

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 VUV by placing the voltmeter leads between the two lines and enter the reading in Table 1.

5 Repeat for the other line voltages VVW, VWU.

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												

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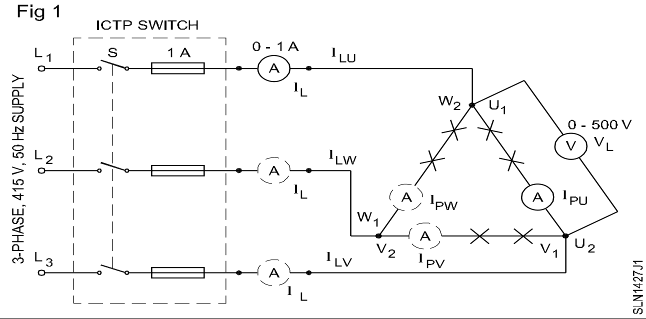
TASK 2 : **Verify the relationship between Line and Phase values in delta connection in three phase system**

1 Form the circuit as per the given circuit diagram. (Fig 2) 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 2.

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 3.

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 2 & 3

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												

Load	$\frac{V_{U_1V_1}}{V_{U_1U_2}}$	$\frac{V_{V_1W_1}}{V_{V_1V_2}}$	$\frac{V_{W_1U_1}}{V_{W_1W_2}}$			
40W						
100W						
200W						

Measure the power of 3-phase circuit for balanced and unbalanced loads

Objectives: At the end of this lesson 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 and 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.
- ICTP switch 16A,500V - 1No

Materials

- 200W, 250V lamps - 3 No.
- 100W, 250V lamps - 3 No.
- 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 confirmity with the calculated total power.

5 Repeat steps 1 to 4 for different load conditions.

Fig 1

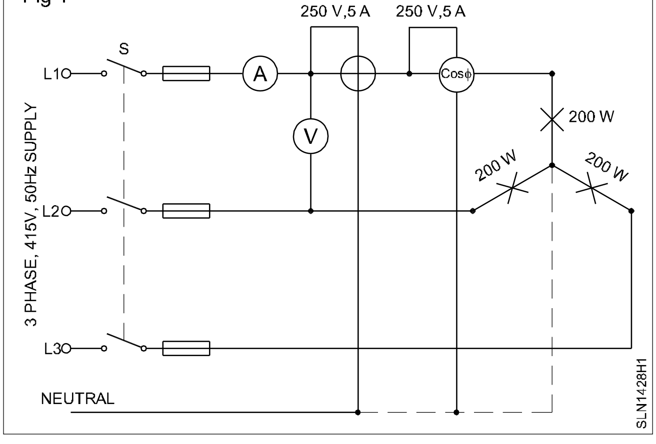


Table 1

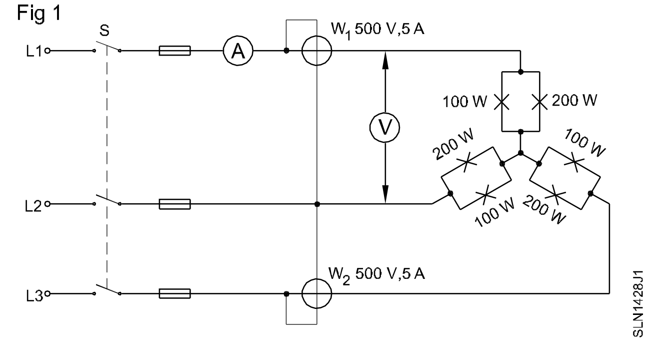
Type of Load	Wattmeter connected in the line			V_L	I_L	P.F	Calculated Total power $W=\sqrt{3}V_LI_L\cos\theta$	Total power = Total of three wattmeter readings $W_{L1}+W_{L2}+W_{L3}=W$
	W_{L1}	W_{L2}	W_{L3}					
1 2 3 4								

TASK 2: **Power measurement by two-wattmeter method in 3-phase load**

1 Form the circuit as per the given circuit diagram. (Fig 2)

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 W1 and W2 and record in Table 2. Add the readings W1 and W2 and record the total power; Go to step 6.

5 Switch on the supply and read the wattmeters W1 and W2. 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) L1 = 400 W bulb

L2 = 400 W bulb parallel 4 MFD capacitor

L3 = 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 $\text{Tan } \theta = \sqrt{3}\,\dfrac{W_1 - W_2}{W_1 + W_2}$
1				
2				
3				
4				
5				

Conclusion : ____

Identify various conduits and different electrical accessories.

Objectives: At the end of this exercise you shall be able to
- **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 4mm x150mm - 1 No.
- Insulated 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, two way - 1 No.
- S.P. switch 6A 250V mounting type single way, two-way - 1 No.
- Tube light starter holder 6A - 1 No.
- Combined tube and starter 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/ 16A wall socket, mounting type, flush type - 1 No.
- 2-pin 6A mounting type - 1 No.
- Ceiling rose 6A 250V 2 , 3 plate - 1 No.
- Fan regulator - 1 No.
- Kit-kat fuse 16A 250V - 1 No.
- Intermediate switch 6A 250V - 1 No.
- 3-pin 6A/16A 250 V plug - 1 No.
- Terminal plate 16A 250 V 3- way - 1 No.
- I.C.D.P. switch 16A 250V, 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 mounting type& flush 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

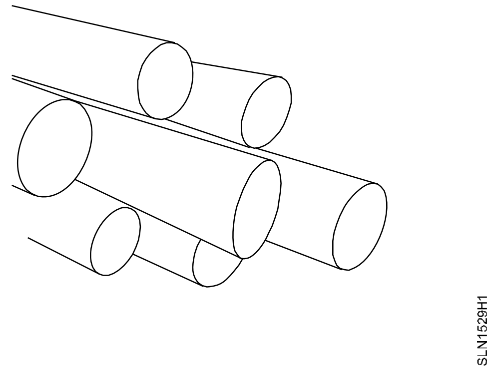
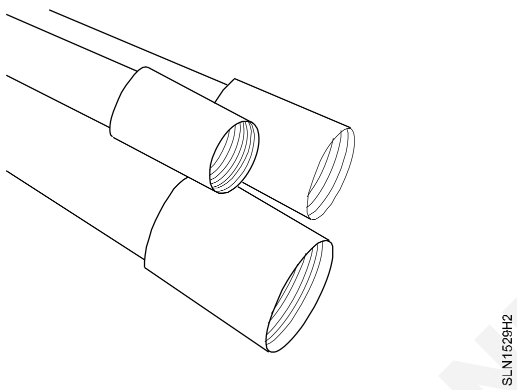
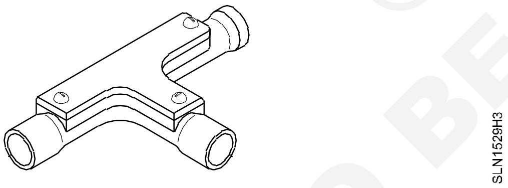
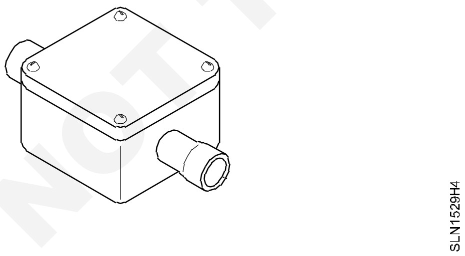
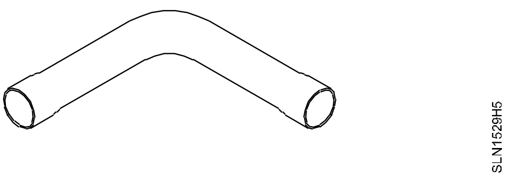
PROCEDURE

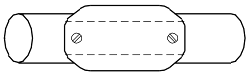
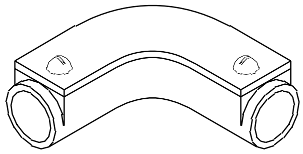
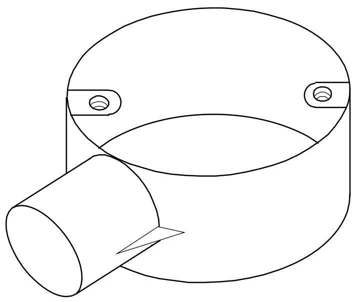
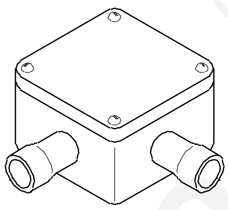
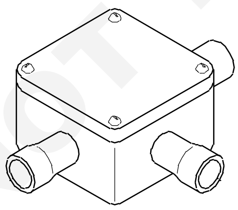
TASK 1 : **Identify various conduit and conduit accessories**

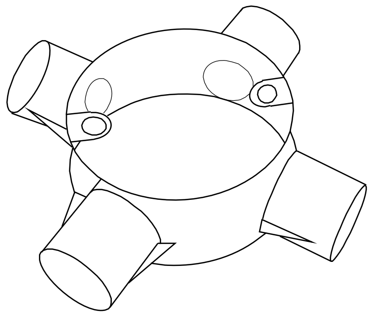
1 Identify each items and write the name in the table. (Fig 1 to Fig 11)

2 Write the specification and use of each conduit & conduit accessory in the column given.

Conduit Pipe & Conduit accessories

Sketch	Name	Specification	Use
Fig 1 			
Fig 2 			
Fig 3 			
Fig 4 			
Fig 5 			

Sketch	Name	Specification	Use
Fig 6  SLN1529H6			
Fig 7  SLN1529H7			
Fig 8  SLN1529H8			
Fig 9  SLN1529H9			
Fig 10  SLN1529HA			

Sketch	Name	Specification	Use
Fig 11  SLN1529HB			

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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 12 to 30)

Different manufacturers design the outline of accessories differently to suit various conditions. However, the electrical 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.

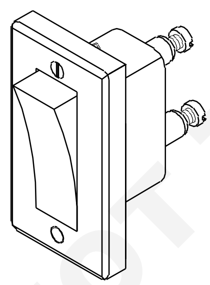
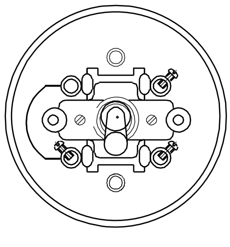
2 Write the specification of each accessory in the column given by the side of each (accessory) figure.

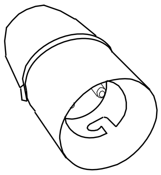
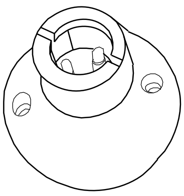
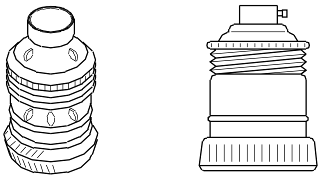
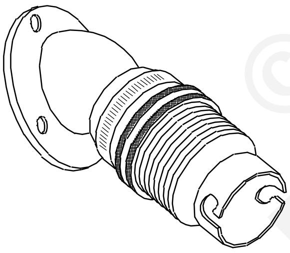
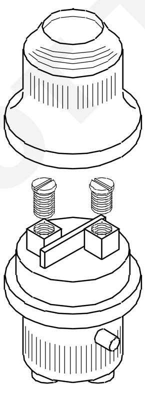
Most of the specifications can be collected from the markings on the accessory itself. Otherwise try to get them from an approved catalogue or approach the instructor for guidance.

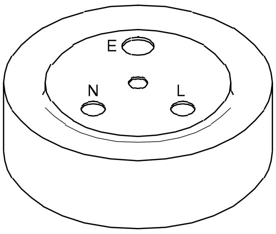
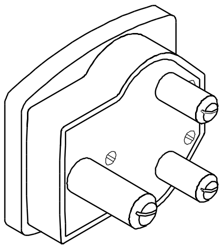
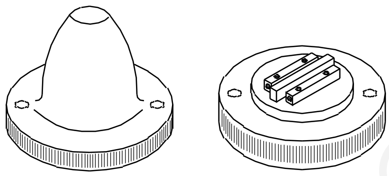
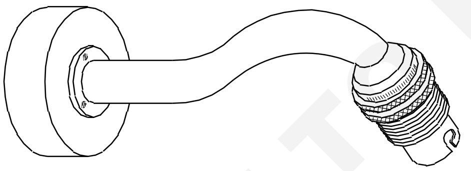
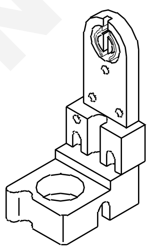
3 Identify the I.E symbols used for the accessory from the related theory or B.I.S.books and sketch the symbols in the columns/spaces provided.

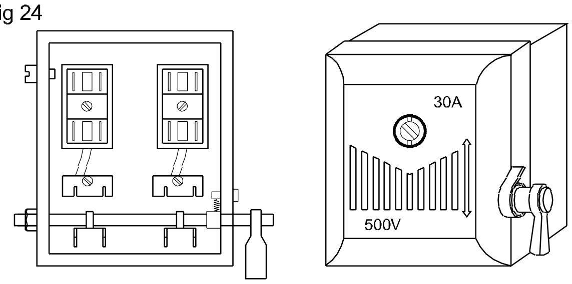
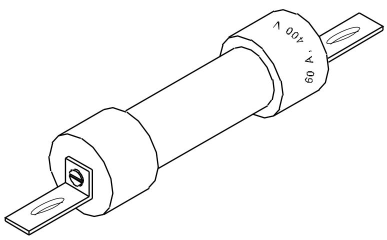
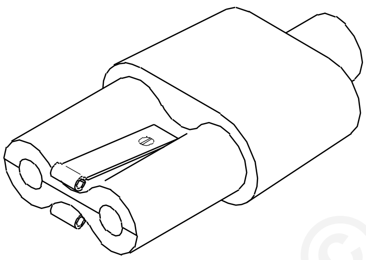
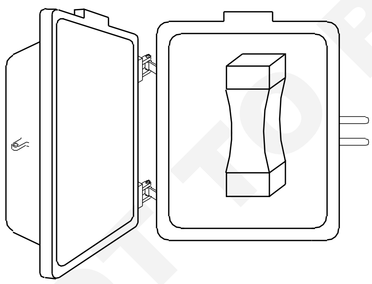
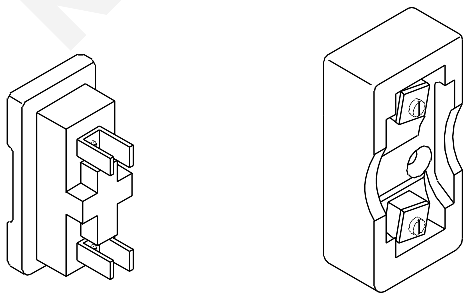
4 Show the completed sheets of specifications, identification and symbols to the instructor and get his approval.

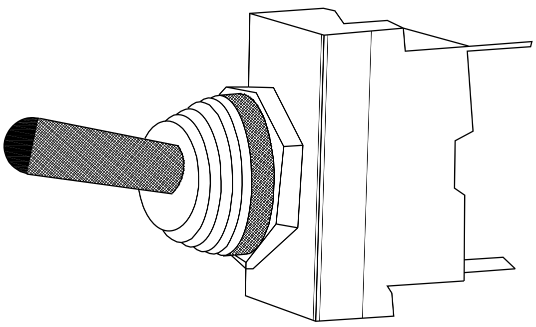
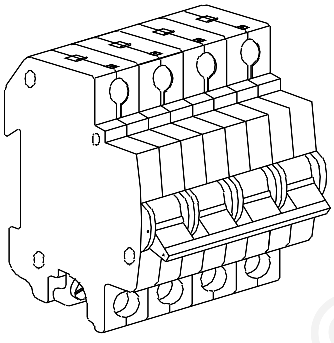
Table 2 - Electrical accessories

Sketch	Name	Specification	Use	IE Symbol
Fig 12  SLN1529HC				
Fig 13  SLN1529HD				

Sketch	Name	Specification	Use	IE Symbol
Fig 14 				
Fig 15 				
Fig 16 				
Fig 17 				
Fig 18 				

Sketch	Name	Specification	Use	IE Symbol
Fig 19 				
Fig 20 				
Fig 21 				
Fig 22 				
Fig 23 				

Sketch	Name	Specification	Use	IE Symbol
Fig 24  				
Fig 25  				
Fig 26  				
Fig 27  				
Fig 28  				

Sketch	Name	Specification	Use	IE Symbol
Fig 29  SLN1529HT				
Fig 30  SLN1529HU				

Practice cutting, threading of different sizes & laying Installations.

Objectives: At the end of this exercise you shall be able to
- **acquire skills such as Cutting, threading, fixing etc on various dimensions of metal conduit pipes**
- **acquire skills of making joints, fixing clamps, bonding and earthing on metal conduit pipes as per BIS guidelines**
- **terminate wiring and testing as per BIS guidelines.**

Requirements

Tools/Instruments

- Trainees' tool kit and shop floor tools

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.

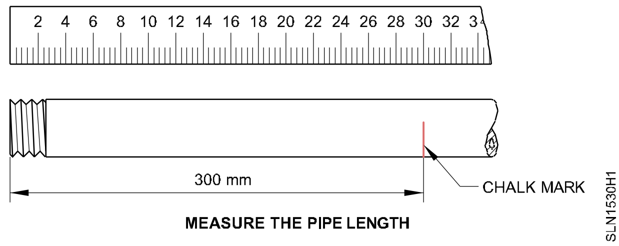
Cutting could be done either by pipe cutters or with hacksaws. In practice, cutting with a hacksaw is popular, and the method is explained below.

1 Measure 300mm from the threaded end of the 19 mm pipe and mark it with chalk as shown in Fig 1.

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

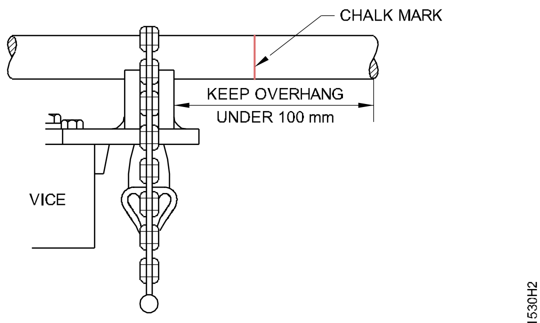
3 Keep the chalk mark of the pipe within 100 mm of the vice as shown in Fig 2.

Fig 1



MEASURE THE PIPE LENGTH

Fig 2

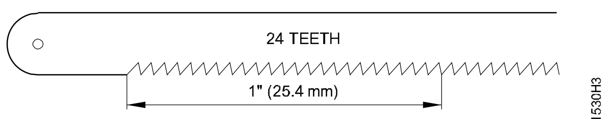


GRIP THE PIPE IN THE VICE FOR SAWING OPERATION

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

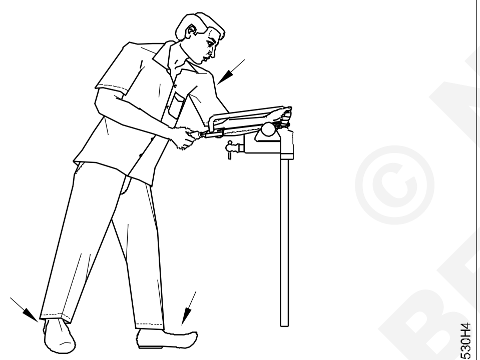
Ensure that the hacksaw blade is firmly tightened in the frame and that the teeth point in the forward direction.

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

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

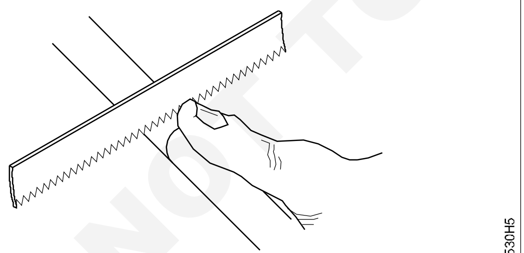
8 Prepare to cut by guiding the blade with the thumb of your left hand exactly on the cutting line against the saw blade as shown in Fig 5.

Fig 4



HACK SAWING - POSITION OF SAWING

Fig 5

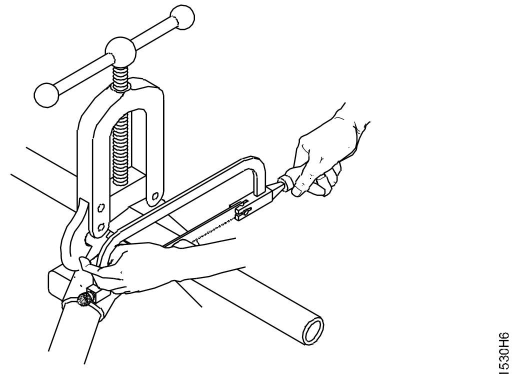


USE THUMB AS A GUIDE INITIALLY

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)

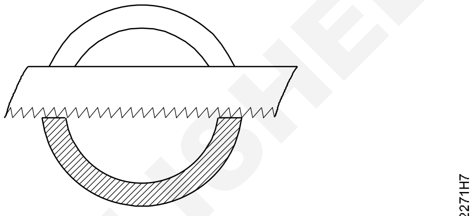
Fig 6



HOLDING SAW WHILE SAWING

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

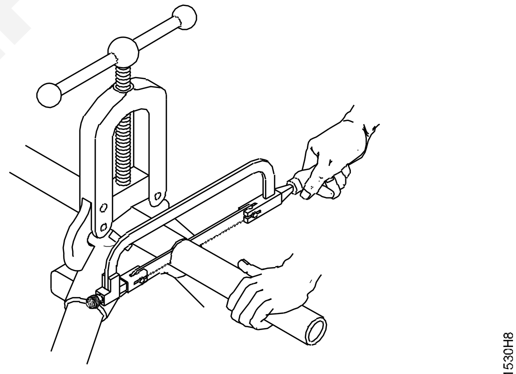
Fig 7



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

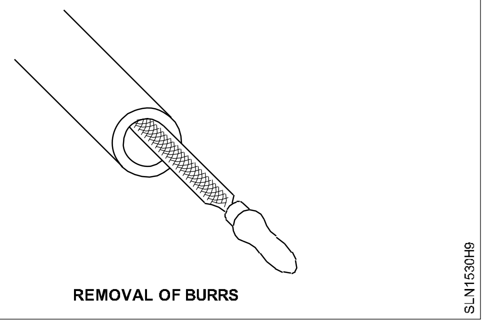
Support the free end of the conduit to prevent the blade of the hacksaw from being damaged.

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)

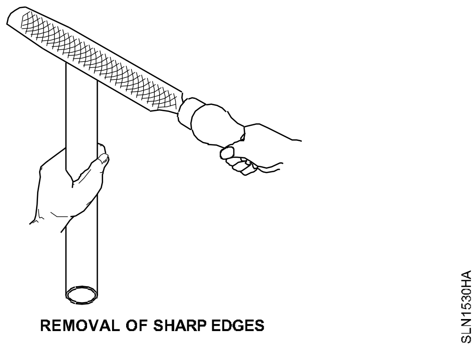
15 Again follow the steps 2 to 14 for cut the 300 mm long from the threaded end of 25 mm dia. 3 m long pipe.

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.

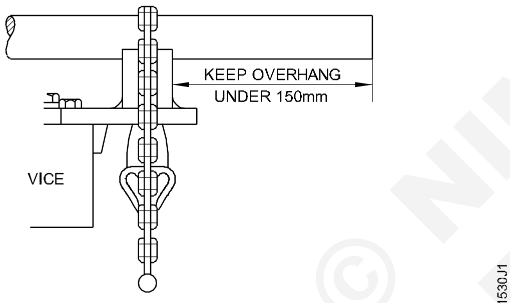
— — — — — — — —

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.

Fig 1



HOLD THE PIPE IN THE PIPE VICE FOR THREADING OPERATION

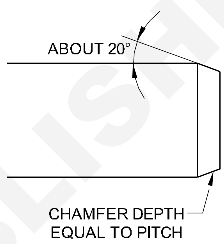
3 Close and tighten the vice as shown in Fig 11.

4 File the end of the tube flat and chamfer the outer edge to an angle of about 20° as shown in Fig 12.

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 13 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.

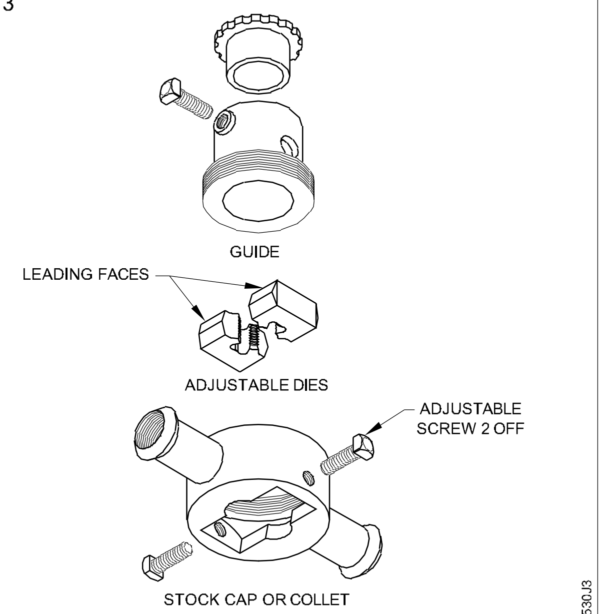
6 Insert each half of the die in the cap(stock) with the chamferred threads (leading faces) being adjacent to the guide.

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.

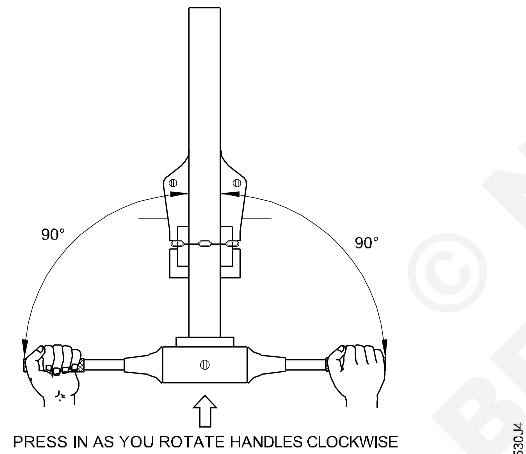
Fig 3



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 14.

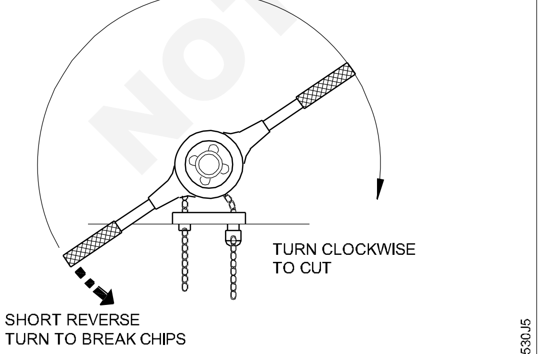
Fig 4



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 15.

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.

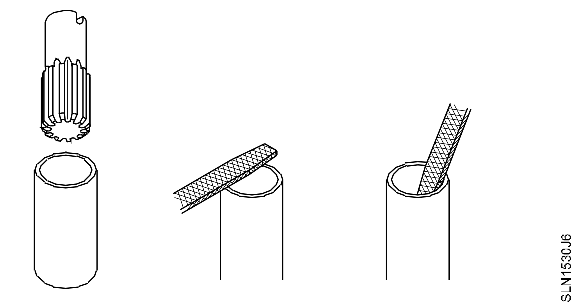
17 If the thread is not smooth (i.e.tight in the fittings) mount the stock and tighten the adjusting screws by half turn evenly and repeat working steps 10 to 16.

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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Prepare test boards/extension boards and mount accessories.

Objectives: At the end of this exercise you shall be able to
- **identify and use electrical 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

- Trainees' tool kit and shop floor tools

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 / 0.2mm - 5 metre

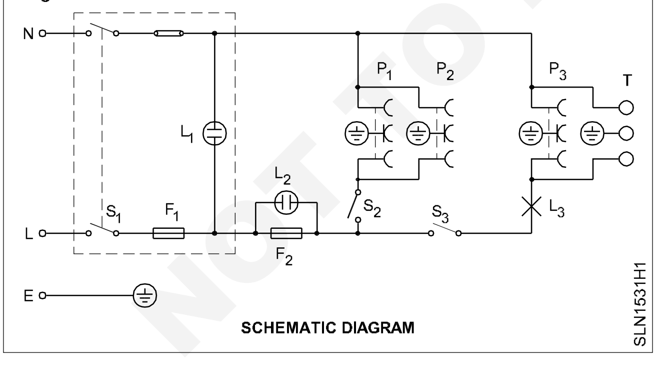
PROCEDURE

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

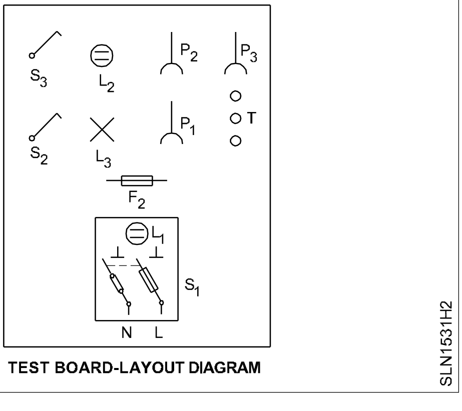
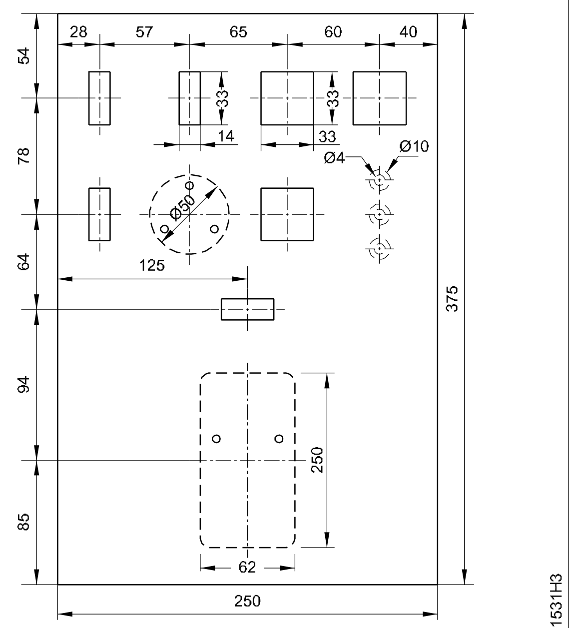


Fig 3



TEST BOARD FRONT PANEL DRAWING SHOWING THE PROFILE

9 Fix the electrical 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)

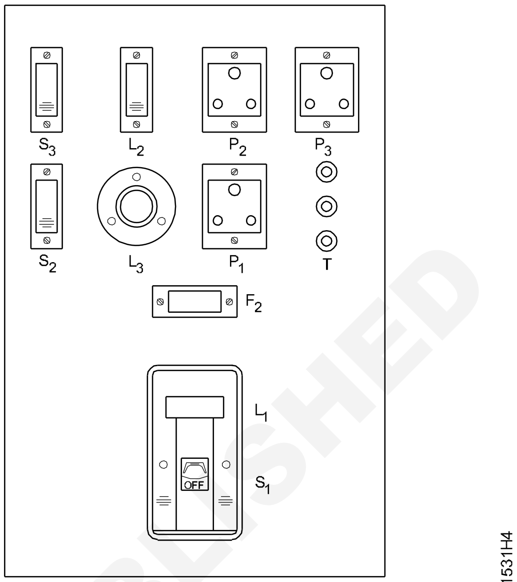
Use the B.I.S. recommended colour code for cable connections within the test board.

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.

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Draw layouts and practice PVC channels

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

- Trainees' tool kit and shop floor tools

Material required

- PVC casing and capping 25mm x 10 mm - 20mtrs
- 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 aluminimum 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 20mm -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 .

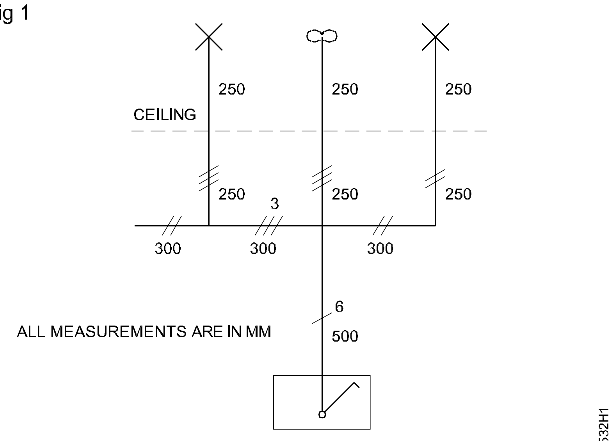
4 Check your material list with that of supplied list.

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



LAYOUT DIAGRAM

7 Drill holes in the PVC channel for fixing with a gap of 60cm 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)

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.

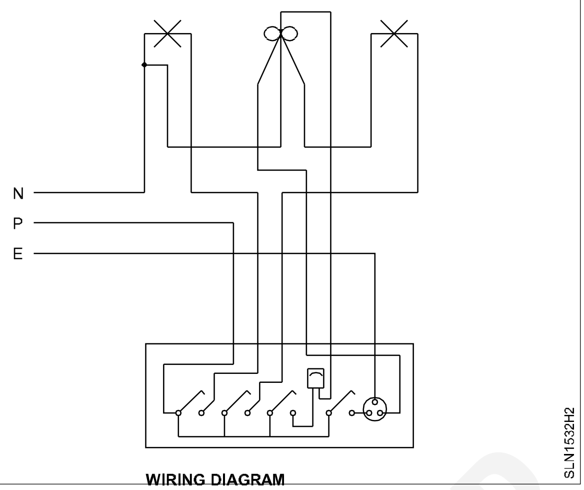
15 Terminate the cable in accessories and mount the switches, regulator & socket over the switch box.

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.

Fig 2



WIRING DIAGRAM

— — — — — — — —

Wire up PVC conduit wiring to control one lamp from two different places using two way switch.

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

- Trainees' tool kit and shop floor tools

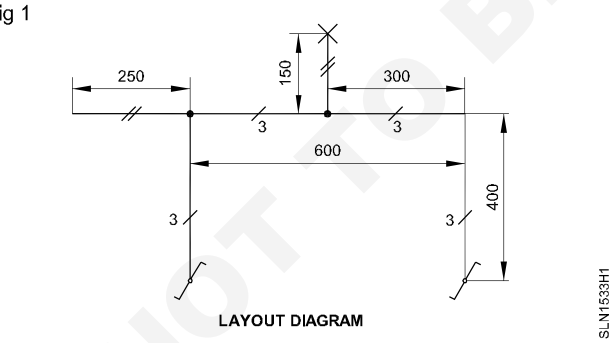
Materials

- 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



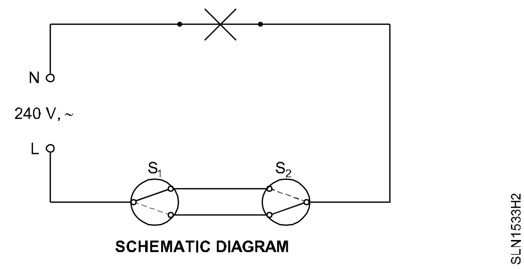
2 Collect materials as per the list.

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



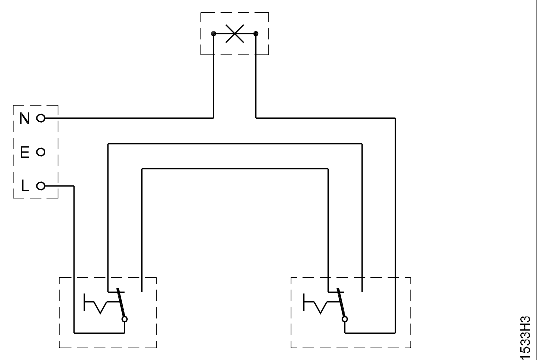
Get the approval of the instructor. If necessary, make alterations in the connections.

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	______________

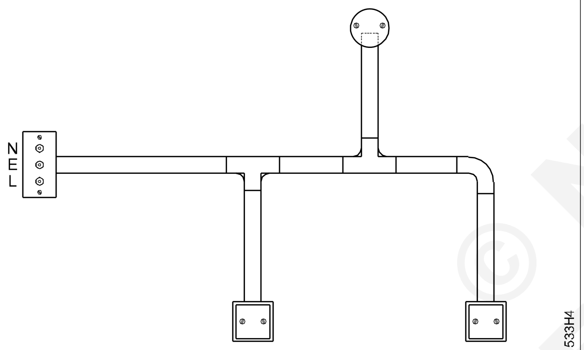
Fig 3



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.

— — — — — — — —

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

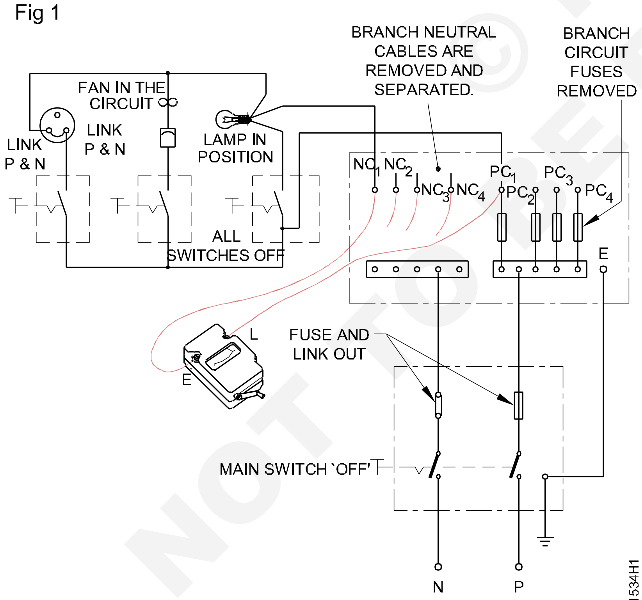
- Test lamp 100W, 240 V - 1 No.
- Crocodile clip 15A - 2 sets
- PVC flexible cable 1.5sq.mm, 660 V - 10m

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.

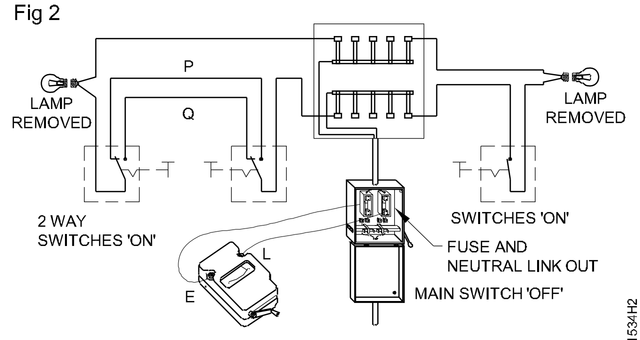
5 Check the circuits having 2 way switches, the concerned switches may be operated alternately to ensure the correct test result.

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.

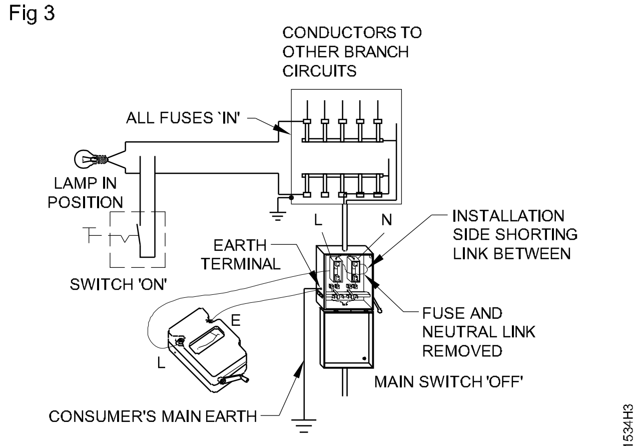
3 Connect the megger terminal ‘E’ to the live wire and L to the corresponding neutral wire, the megger will read zero or very low value of insulation resistance and confirms the short circuit.

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.

— — — — — — — —

Practice control panel wiring and mount control elements

Objectives: At the end of this exercise you shall be able to
- **identify the various components fitted in control panel**
- **practice past exercises on a control panel which is actual requirement**

PROCEDURE

TASK 1 : **Customized control panel or used ones for practice**

1 Get the blue print from instructor for assembling / mounting electrical accessories on the control panel

2 Identify the components and mount them in suitable places on the control panel

3 Use wherever required operations like drilling, tapping etc

4 Perform the internal wiring , marking with ferrules or labeling

5 Verify with instructor for the finished work is guided.

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Practice Earthing types and measure earth resistance

Objectives: At the end of this exercise you shall be able to
- **prepare the pipe for earthing**
- **dig the pit in the ground**
- **install the earth pipe and test it.**

Requirements

Tools/Instruments
- Trainees' tool kit and shop floor tools

Equipment/Machines
- Earth tester with connecting leads and spikes - 4 Nos. - 1 No.

Materials
- G.I. pipe 12.7mm dia. - 5 m
- G.I. bend 12.7mm dia. - 2 Nos.
- C.I.cover hinged to C.I. frame 300 mm square - 1 No.
- G.I. pipe 19mm dia. - 1 m
- G.I.pipe 38mm dia. having 12mm dia. holes - 2.5 m
- Reducer 38 x 19 mm - 1 No.
- Funnel with 19mm dia. sleeve & wire mesh - 1 No.
- G.I.nut for 19mm dia. sleeve & wire mesh - 1 No.
- G.I. check-nuts for 19mm dia. G.I.pipe - 4 Nos.
- G.I.washer 40mm with 19mm hole - 1 No.
- G.I. wire No.8 SWG - 10 m
- Copper lug 200 amps with 19 mm dia. hole - 1 No.
- Solder 60/40 -100 gms.
- Matchbox - 1 No.
- Soldering paste - 10 gms.
- Cement - 10 kgs.
- Blue metal chips 6mm size - 40 kgs.
- River sand - 80 kgs
- Salt (common) - 3 bags
- Coke or charcoal - 3 bags

PROCEDURE

1 Collect G.I.pipes and the accessories.

2 Make a slant cut of 30° in the 38mm dia. G.I.pipe to have sharp edge as shown in Fig 1.

3 Make threads in the other end of 38mm dia. G.I.pipe to a length of 25mm.

4 Make threads in both ends of 19mm dia. G.I.pipe to a length of 25mm on one side and 75mm on the other side.

5 Fabricate the 38mm and 19mm dia. G.I. pipes as shown in Fig 1.

6 Select an earth pit site atleast 1.5 metres away from the building foundation.

An earth electrode should not be installed in proximity to a metal fence to avoid the possibility of the fence becoming live. If the metal fence is unavoidable, it should be earthed.

7 Dig an earth pit of dimensions 1 m width x 1 m breadth x 3.75 m depth.

The depth given here is the minimum recommended. However, the depth may be increased till moist soil is reached.

8 Place the fabricated pipe in an upright position as shown in Fig 1 and position the pipe with the help of bamboo sticks.

9 Place the wooden box around the pipe and fill it to a height of about 15cm with charcoal, and fill the sorrounding outer space of the box with soil.

It is difficult to dig a pit 150mm square. A pit of dimension 1 metre square is therefore suggested to be dug. The area sufficient to be filled with salt and charcoal is about 150mm square. Hence fill the surrounding extra area with the soil which was taken out earlier.

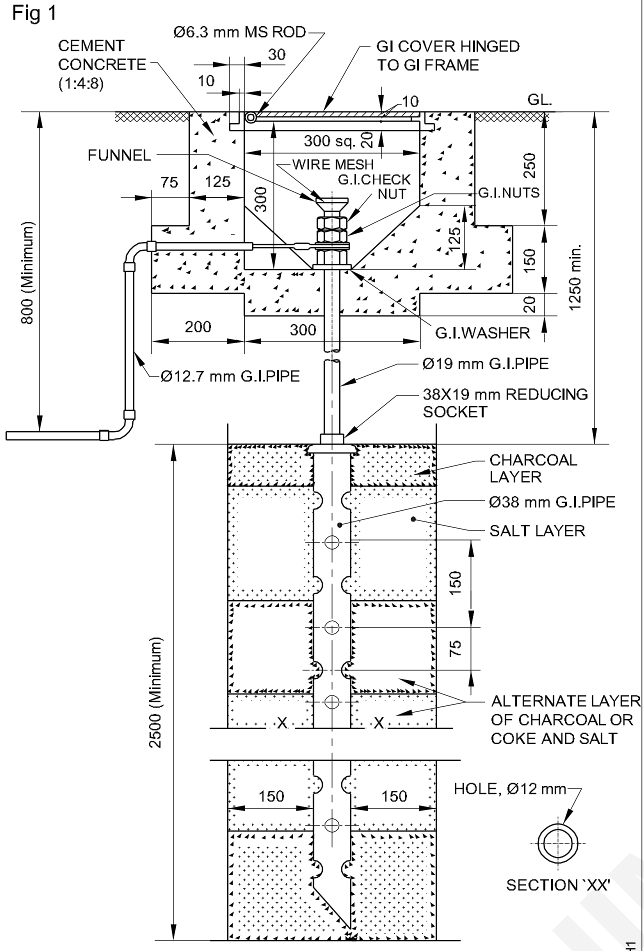
10 Lift and place the wooden box above the coke layer. Fill up with salt to a height of about 15cm and to an area of 150 x 150mm area around the pipe.

Fill up the surrounding area with soil.

11 Repeat the above steps 10 and 11 up to 2.5 metres as shown in Fig 1.

12 Place the G.I.pipe 12.7 mm dia. meter with G.I. bends in proper position for E.C.C. connection.

Fig 1



NOTE: DIMENSIONS ARE IN mm UNLESS OTHERWISE SPECIFIED.

PIPE EARTHING

13 Prepare the concrete mixture and build the structure as shown in Fig 1.

14 Fix the G.I. cover also.

Atleast allow one day for curing the concrete structure. Pour water every 2 hours. (A wetted gunny sack will hold the moisture for several hours.)

15 Insert the G.I.wire No.8 SWG through the 12.7mm dia. G.I.pipe.

The size of the earth wire depends upon the incoming supply cable size.

16 Use the ladle and the blowlamp and melt the solder.

17 Solder the lug in the G.I. wire.

18 Insert the lug in the 19mm dia. G.I.pipe and tighten it with the G.I.nut and check-nut.

19 Pour three or four buckets of water through the funnel.

Allow an hour for the water to be absorbed in the earth.

20 Test the earth electrode resistance with an earth Megger.

The earth continuity conductor (E.C.C.) should not be connected to the earth electrode while measuring the earth electrode resistance.)

21 Enter the value of the earth electrode resistance in Column 5 of Table 1. Fill up the other particulars also. The acceptable value of the earth electrode resistance has been given earlier. Check the value if it.

22 Check the value of the earth resistance is found higher than the acceptable value, make one more pipe earth electrode at a distance of 8 metres from the earlier one and connect both of them in parallel.

23 Measure the earth electrode value and enter it in Column 6 of Table 1.

The second reading with two electrodes will be approximately half the first reading which was taken with one electrode. The measured value should be within the recommended value.

Table - 1

S.no	Date	Climate	Earth Electrode Location	Earth Resistance in Ohms		Remarks
				Single	Double	
1	2	3	4	5	6	7

Prepare plate earthing and measure earth resistance by earth tester - megger

Objectives: At the end of this exercise you shall be able to
- **prepare the plate for earthing according to ISI standard**
- **prepare the earthing pit in ground according to required standard**
- **install the plate in earthing pit**
- **test the earthing and measure the earth resistance using earth tester / Megger.**

TASK 1: **Prepare the plate for earthing according to ISI standard**

1 Collect G.I plate and accessories for earthing

2 Mark thread on one side of 19mm dia GI pipes to a length of 25mm

3 Fabricate GI plate as shown in Fig 1 600mmx600mm square plate with a thickness of 6. 3mm

4 Fabricate 19mm dia G.I pipe as shown in Fig 2

Fig 1

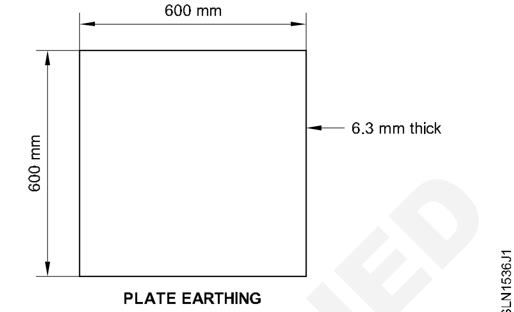


PLATE EARTHING

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TASK 2 : **Prepare the earthing pit in ground as per standard**

1 Select an earth pit site atleast 1.5meters away from the building foundation

An earth electrode should not be installed is proximity to a metal fence to avoid the possibility of the fence becoming live. If the metal fence is un avoidable it should be earthed

2 Dig an earth pit of dimensions 1m width x 1m breadth x2.5m depth

The depth given here is the minimum recommended. However the depth may be increased till moist soil is reached

3 Fabricate G.I pipe 12.7mm diameter with GI bonds in proper position and insert the G.I wire missing through GI pipe by soldering lug at external and fix GI plate with bolt and nut as shown in (Fig 2)

Fig 1

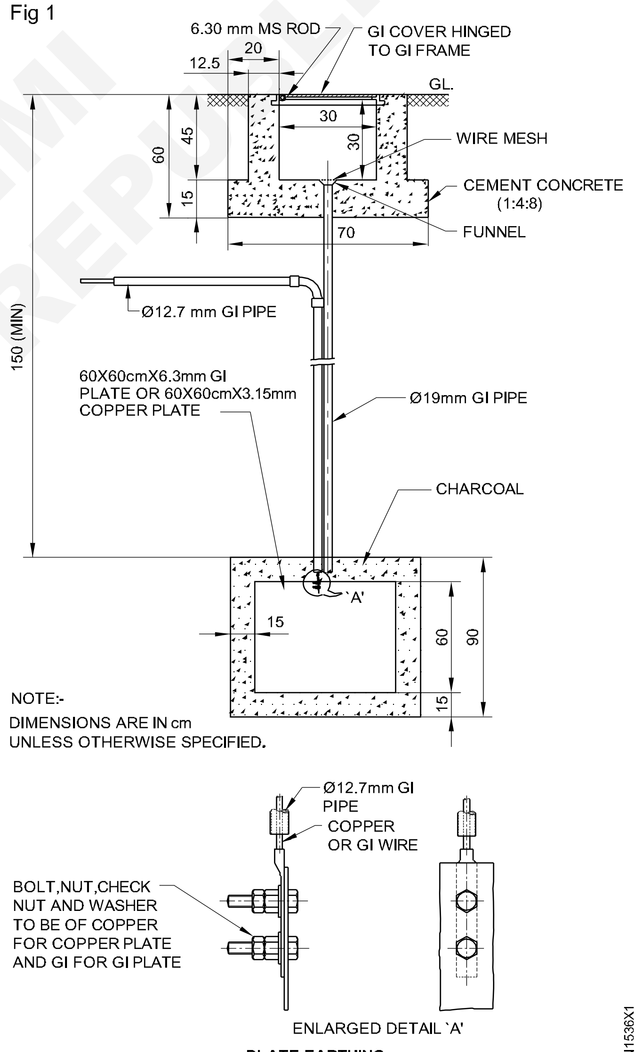

PLATE EARTHING

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TASK 3 : **Install the plate in earthing pit already prepared**

1 Place the fabricated 19mm GI plate in an upright position as shown in fig 2 and position the pipe with the helps bamboo sticks

2 Place the wooden box around the plate and fill it to a height of about 15cm with charcoal and fill the surrounding outer space of the box with soil.

It is difficult to dig a pit 150mm square .A pit of dimension 1 meter square is therefore suggested to be dig. The area sufficient to be filled with salt and charcoal is about 150mm square. Hence fill the surrounding area with the soil which was taken out earlier

3 Lift and place the wooden box above the coke layer and fill up with salt to a height of about 15cm and to an area of 150x 150mm area around the pipe.

Fill up the surrounding area with soil.

4 Prepare the concrete mixture and build the strcuture as shown in figure 2.

5 Fix the GI core with the plates

At least allow one day for curing the concrete structure. Pour water every 2 hours (A wetted gunny is a act will hold the moisture for several times.

6 Pour three or four buckets of water through the funnel to the earth pit

Allow an hour for the water to be obsorbed in the earth.

— — — — — — — —

TASK 4 : **Test the earthing and measure the earth resistance using earth tester**

1 Test the earth electrode resistance with an earth tester.

2 Record the earth electrode resistance.

If the earth resistance is found higher than the acceptable value, make one more plate earth electrode at a distance of 8 meters from the earth in one and connect both of them in parallel

3 Measure the resistance of earth electrode value and record

The second reading with two electrodes will be approximately half the first reading which was taken with one electrode. The measured value should be with in the recommended value. If not have an another earth electrode may be distance of 8 meters from the other electrodes.

— — — — — — — —

Practice Installation of lightning arrestor.

Objectives: At the end of this exercise you shall be able to
- **to understand assembly of lightning arrestor**
- **to practice erection of the lightning arrestor**

TASK 1 : **Visit actual substations or solar plants and learn or practice with the help of field executives the installation and maintenance of the lightning arrestor**

Note: Instructor and institute authorities should arrange necessary MoU or tie ups with suitable industry stake holders.

Identify and practice of various analog and digital measuring Instruments

Objectives: At the end of this exercise you shall be able to
- **find out the name of the instrument and sketch the circuit connection**

PROCEDURE

TASK 1: **Find out the name of the instrument and sketch the circuit connection in the following table**

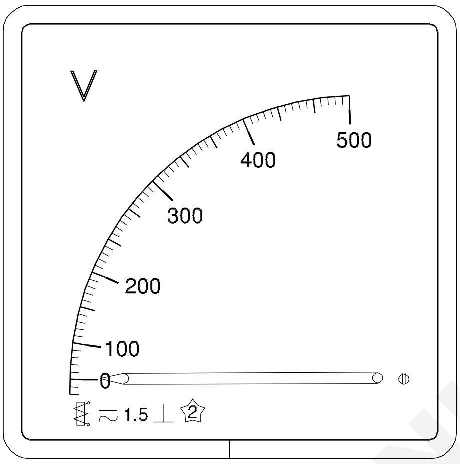
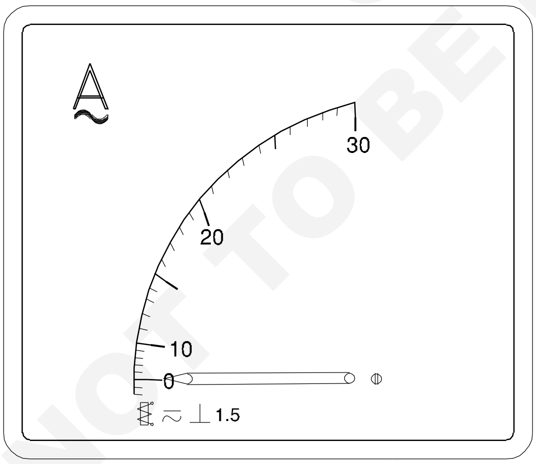
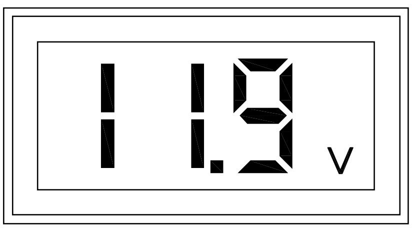
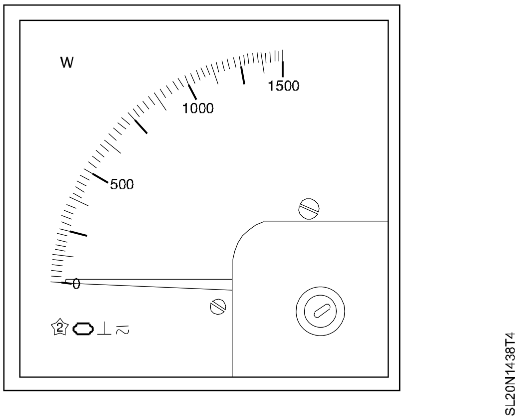
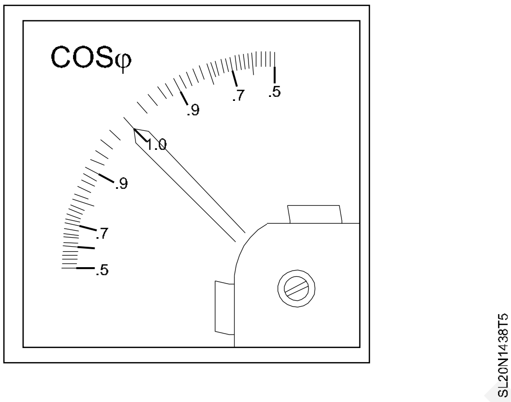
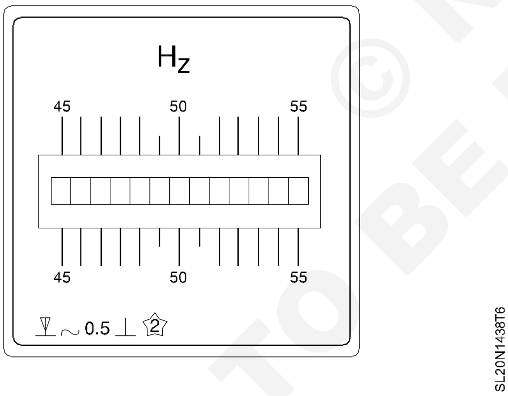
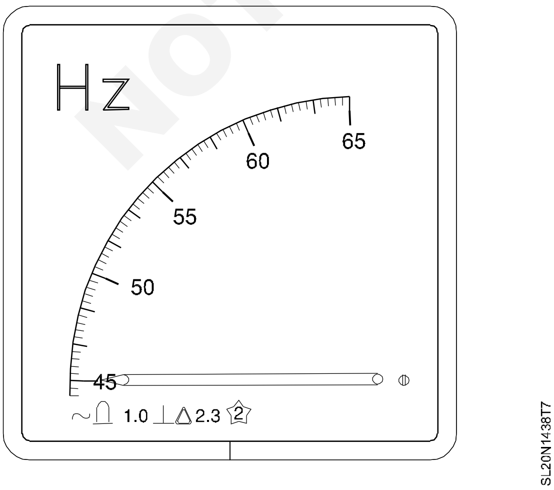
Given instrument	Name	Connection
Fig 1  SL20N1438T1		
Fig 2  SL20N1438T2		
Fig 3  SL20N1438T3		

Fig 4 		
Fig 5 		
Fig 6 		
Fig 7 		

Practice on measuring instruments in single and three phase circuits

Objectives: At the end of this exercise you shall be able to
- **connect various analog measuring instruments and measure electrical parameters**
- **connect various digital measuring instruments and measure electrical parameters.**

Requirements

Tools / Instruments

- MI voltmeter 0 - 500V (analog) - 1 No.
- Digital voltmeter 0 - 500V - 1 No.
- MI ammeter 0 - 30A (analog) - 1 No.
- Digital ammeter 0 - 30A - 1 No.
- Power factor meter 0.5 lag - 1 - 0.5 lead (Analog) - 1 No.
- Digital power factor meter - 1 No.
- Analog wattmeter 0-1500W - 1 No.
- Digital wattmeter 0-1500W - 1 No.
- Analog frequncy meter 45-55HZ - 1 No.
- Digital frequncy meter 45-55HZ - 1 No.

Equipment / Machines

- Squirrel cage Induction motor 3 phase, 440V, 5 HP - 1 No.

Materials

- Connecting leads - as reqd.
- TPIC switch 16A, 500V - 1 No.

PROCEDURE

TASK 2 : **Measure the value of current, voltage, power factor, power and frequency by connecting respecitve digital meters in the circuit**

1 Identify the digital type of voltmeter, ammeter, wattmeter, power factor meter and frequency meter from the given figure nos. 3 to 13.

2 Verify the range of digital voltmeter, ammeter, wattmeter, power factor meter and frequency meter.

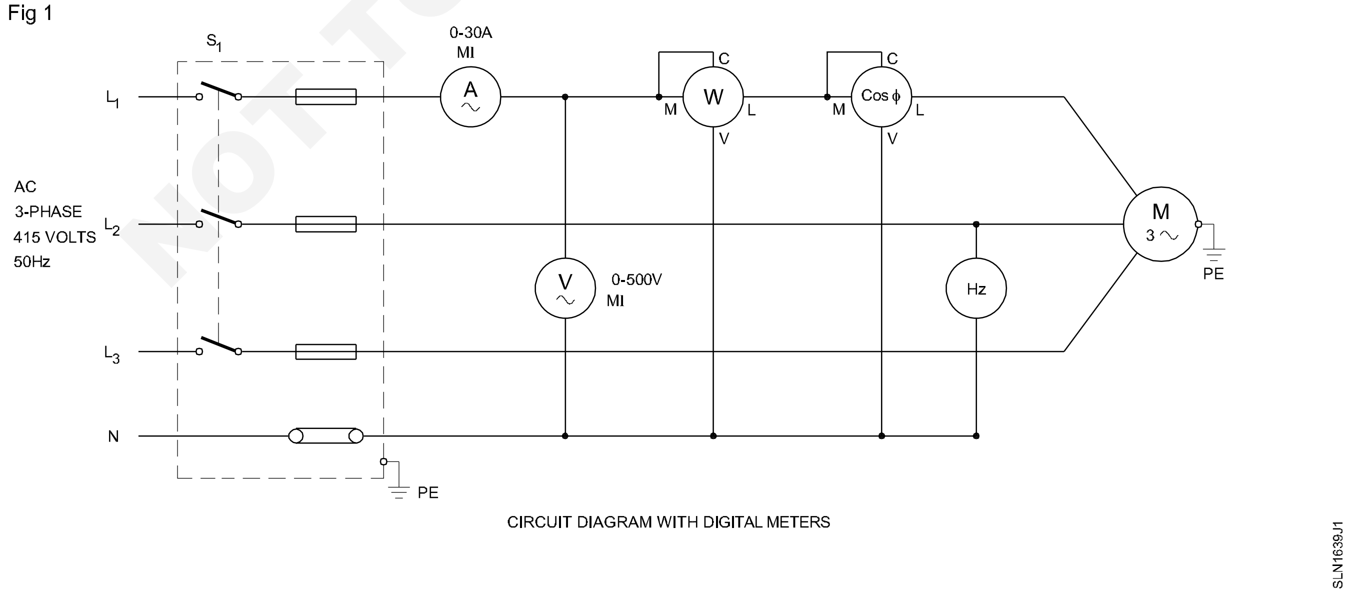
3 Connect the power supply with switch, fuse, digital meters and load as shown in Fig 2

4 Close the switch.

5 Measure the corresponding values from the instruments and record the values in Table - 2

6 Switch off the power supply and disconnect the connection.

Fig 1

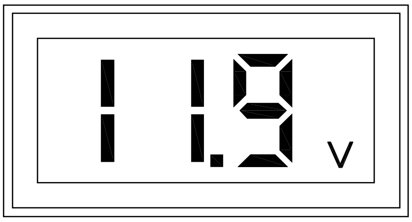


CIRCUIT DIAGRAM WITH DIGITAL METERS

Table 2

Sl. No.	Meter	Reading
1	Voltmeter	
2	Ammeter	
3	Watt meter	
4	Power factor meter	
5	Frequency meter	

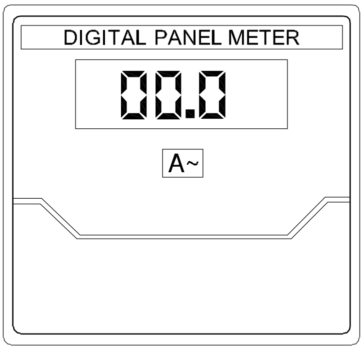
Fig 4



DIGITAL VOLT METER

ELN2592H4

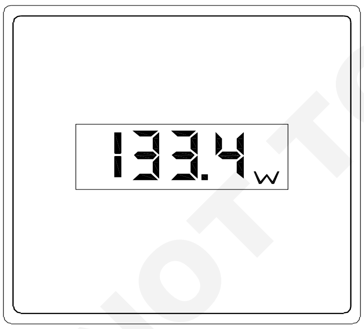
Fig 5



DIGITAL AMMETER

SLN1639J5

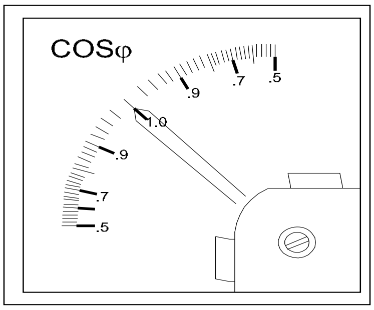
Fig 7



DIGITAL WATT METER

SLN1639J7

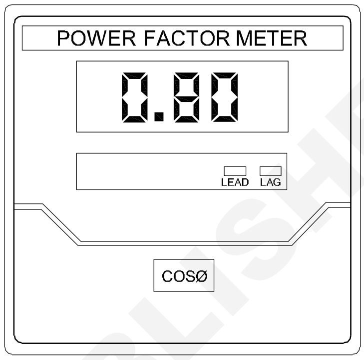
Fig 8



ANALOG POWER FACTOR METER

SLN1639J8

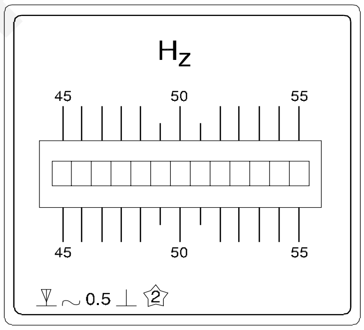
Fig 9



DIGITAL POWER FACTOR METER

SLN1639J9

Fig 10



FREQUENCY METER

SLN1639JA

Test single phase energy meter for its errors

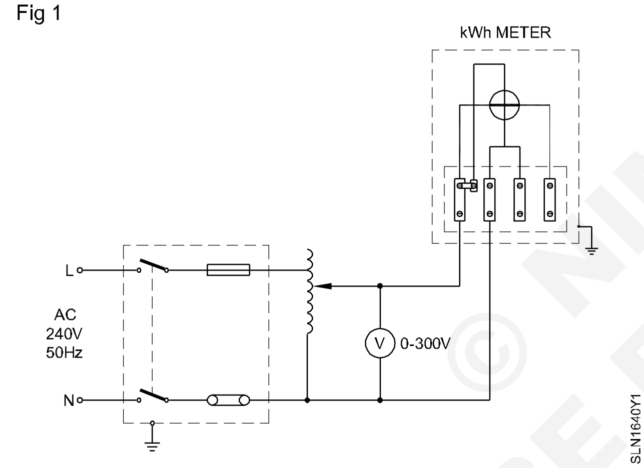
Objectives : At the end of this exercise you shall be able to
- **identify the creeping in energy meter**
- **test the energy meter for starting current error**
- **select suitable loading arrangements for determining errors in energy meters**
- **determine the percentage error in an energy meter.**

> **Adjustment of errors inside the energy meter is beyond the scope of this course as it requires costly equipment like rotating sub-standard meter etc. Hence the simplified method of finding errors only is included here.**

TASK 1 : **Check the energy meter at no load (to find the creeping error)**

1 Connect the energy meter through an auto-transformer as shown in Fig 1.

Fig 1



2 Vary the input voltage to the energy meter between 80% and 110% of the rated voltage of the energy meter.

> **For an energy meter rating of 240 Volts the input voltage is between 192 V to 264 V. Observe, if the meter disc is rotating or not. The load should not be connected or the load switch should be 'off' during the observation period.**

3 Write your observations correlating your findings from the above experiments with the recommendation given in IS 722.

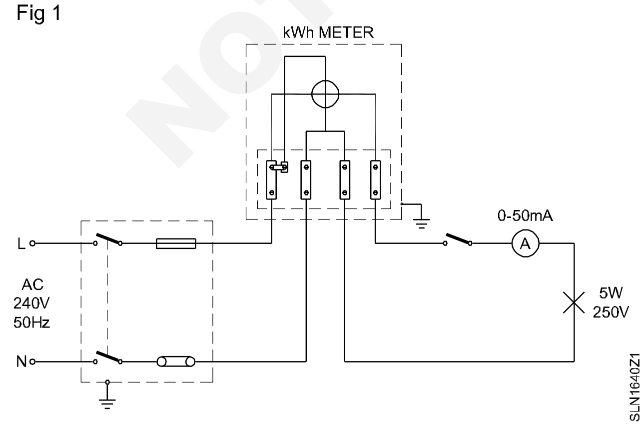
OBSERVATION

> **As per IS 722 (Part I) 1977 the meter shall not make a complete revolution at any voltage between 80% and 110% of the reference voltage.**

TASK 2: **Task for starting current error in energy meter**

1 Connect lamp load (5 W lamp) as shown in Fig 1.

Fig 1



2 Switch on the load and observe the meter rotation.

3 Write your observations, correlating your finding from the above experiment with the recommendation given in IS 722 (Part III).

OBSERVATION

____

____

____

____

____

> **As per IS 722 (Part II) 1977 the starting current shall be 0.5% of the rated basic current across = 1 for dial and pointer type register whereas for drum type register it will be 0.75%. For meters provided with reverse stop the values will be 1% and 1.5% respectively.**

Measure power consumption for different loads with various times of use and calculate watt-hour

Objectives : At the end of this exercise you shall be able to
- **connect voltmeter, ammeter, wattmeter, energy meter, frequency meter and power factor meter in single phase load**
- **connect voltmeter, ammeter, wattmeter, energy meter, frequency meter, power factor meter and phase sequence indicator in 3 phase balance load**
- **measure voltage, current, power, energy, frequency, power factor and record the values**
- **connect phase sequence meter to find the phase sequence.**

Requirement

Tools / Instruments

- Electric loads of different watts or visit a residential unit/workshop for connected loads of known wattage
- Timer
- Two number Incandesant Bulb of 40 W each
- Three number Incandesant bulb of 100 W each
- One Table fan of known wattage
- One fridge of known wattage
- One A/c of known wattage

TASK:

1 Connect all the loads in parallel

2 Connect wattmeter for each load

3 Using timer/clock/watch note down duration in hours for each load in connection and operated

4 Fill up the given table

5 Calculate energy in each case

6 Calculate total energy consumed

7 Give energy consumption in kWh

8 Calculate cost of energy based on your local electricity tariff

Sl no	Name of load	Wattage (Rated)	Time of use (Hour)	Energy (W x Hr)

Check the result with instructor

— — — — — — — —

Find out power ratings from product label and prepare a load calculation chart.

Objectives : At the end of this exercise you shall be able to
- **collect details of various connected loads in your institute/residence and their hours of operation.**
- **calculate possible energy consumption at the rate of eight hour duration per day and map it for one month**
- **calculate kW requirement of the complete building**
- **calculate energy cost for one month of 30 days.**

Requirement

Tools / Instruments

- Electric loads of different watts or visit a residential unit/workshop for connected loads of known wattage
- Timer
- Two number Incandesant Bulb of 40 W each
- Three number Incandesant bulb of 100 W each
- One Table fan of known wattage
- One fridge of known wattage
- One A/c of known wattage

TASK:

1 Connect all the loads in parallel

2 Using wattmeter for each load

3 Using timer/clock/watch note down duration in hours for each load in connection and operated

4 Fill up the given table

5 Calculate energy in each case

6 Calculate total energy consumed

7 Give energy consumption in kWh

8 Calculate cost of energy based on your local electricity tariff

Sl no	Name of load	Wattage (Rated)	Time of use (Hour)	Energy (W x Hr)

Total KW requirement of the complete building = ... KW

Possible energy consumed / 8 hours / day = ... Kwh

Possible energy consumed / month (30 days) = ... Kwh

Possible energy cost / month(30 days) = Kwh x tariff = ...

Check the result with instructor

— — — — — — — —

Verify terminals identify components and calculate transformation ratio of single phase transformers

Objectives: At the end of this exercise you shall be able to
- **read and interpret the details of the name-plate of single phase transformer**
- **identify H.T & L.T. winding**
- **determine transformation ratio (turns ratio) by the**
  - **voltmeter method**
  - **ammeter method.**

Requirements

Tools/Instruments

- VoltmeterM.I. 0 - 250/300V - 2 Nos.
- Ohmmeter (0 - 500 ohms) - 1 No.
- Ammeter M.I. type (0 - 10 Amp) - 1 No.
- Ameter M.I. 100 mA - 1 No.

Equipment/Machines

- Single phase transformer 115/230 volts, 1KVA - 1 No.
- Auto-transformer (IP-240V) OP 0-270V, 5A - 1 No.

Materials

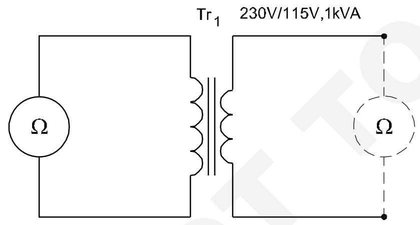
- Knife switch DPST 16A 250V - 1 No.
- Push-button 6A, 250V - 1 No.
- Connecting cables - as reqd.

PROCEDURE

TASK 1 : **Identification of terminals**

1 Find out the corresponding terminals of two windings (H.T. & L.T) with ohmmeter as shown in Fig 1, by checking the continuity.

Fig 1



CIRCUIT FOR IDENTIFICATION OF TERMINALS OF SINGLE PHASE TRANSFORMER

2 Determine HT and LT winding by measuring resistances with the ohmmeter.

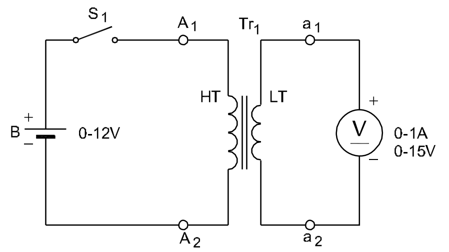
> **L.T. windings will have low resistance in the case of step down transformer.**

Record resistance of both pairs.

1st pair ___________ ohms. This is HT/LT winding.

2nd pair ___________ ohms This is HT/LT winding.

Fig 2



NOTE:
INSTEAD OF THE BATTERY DC STABILIZED POWER SUPPLY CAN BE USED

CIRCUIT FOR IDENTIFICATION OF POLARITY OF TRANSFORMER

3 Connect AC supply to HT through push-button swithch and connect the voltmeter to LT as shown in Fig 2.

4 Mark HT terminals as A_1 and A_2. Mark at LT terminals as a_1 and a_2.

5 Press the push-button switch. Observe the deflection of the pointer of the voltmeter. If the pointer deflects in the right direction, retain the markings made on terminals.

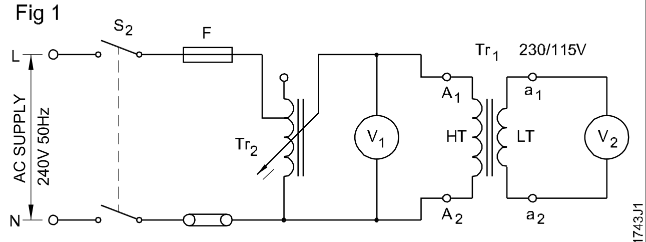
6 Change the voltmeter connections made to LT terminals and change the marking made on the LT terminals if the deflection is in the reverse direction. Now press the push-button switch once again and observe that the voltmeter deflects in right direction.

— — — — — — — —

TASK 2 : **Verification of transformation ratio (by voltmeter method)**

1 Connect the auto-transformer and the voltmeters to the transformer as shown in Fig 1. Check and set the auto-transformer at zero volt output position.

Fig 1



CIRCUIT FOR VERIFICATION OF TRANSFORMATION RATIO

2 Switch on ‘S_2’ and adjust the autotransformer to get the output voltage V_1 = 100 volts and read V_2 record the value in Table 1.

The output voltage of the auto-transformer should be adjusted to about 50% of the rating of the H.T. side.

3 Set the V_1 value for the values indicated in Table 1 and record the corresponding readings of V_2 in Table 1.

4 Calculate the transformation ratio from the measured V1 & V2 values.

Applying the formula -

$$\text{Transformation ratio} = \frac{V_2}{V_1}$$

Table 1

Sl. No.	V_1	V_2	Transformation ratio $K=V_2/V_1$
1	100 Volts		
2	125 Volts		
3	150 Volts		
4	200 Volts		
5	225 Volts		

5 Compare the calculated transformation ratio with the transformation

6 Transformation ratio calculated

from measurements =

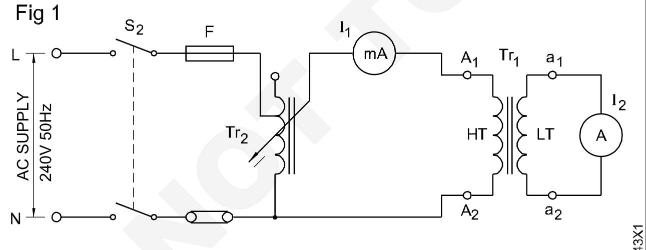
from markings =

— — — — — — — —

TASK 3 : **Verification of transformation ratio (by ammeter method)**

1 Connect the auto-ransformer output to the transformer H.T. winding through a milliammeter in the line as shown in Fig 1.

Fig 1



CIRCUIT FOR RATIO MEASURMENT USING AMMETER FOR HIGH RATED TRANSFORMER

The current in the H.T. winding should be kept low, but should be large enough to be measured accurately with a milliammeter.

2 Connect the L.T. winding to the ammeter. The ammeter should carry the rated current of L.T. side.

Use the current transformer and ammeter if the secondary rating is very high.

3 Increase the voltage to give the required current in H.T. winding.

4 Read the L.T. current. Record in Table 2.

5 Change the H.T. current to different values and record the corresponding L.T. current.

Table 2

Sl. No.	I_1	I_2	Transformation ratio $K=I_1/I_2$
1			
2			
3			
4			

6 Verify the transformation ratio with the markings on the name-plate and record your findings.

— — — — — — — —

Perform open circuit and short circuit test to determine the efficiency of single phase transformer

Objectives: At the end of this exercise you shall be able to
- **conduct open circuit test to determine iron or core loss**
- **conduct short circuit test to determine full load copper loss**
- **determine effiiciency of the transformer at different loads.**

Requirements

Tools/Instruments

- Wattmeter 250V, 5A - 1250W - 1 No.
- Frequency meter 45 to 55Hz. - 1 No.
- Power factor meter 0.5 lag -1-0.5 lead 250V rating - 1 No.
- Ammeter M.I.-0 to 5A, 0 to 10A each - 1 No.
- Voltmeter M.I.-0 to 300 V, 0 to 150 V - 1 No.

Equipment/Machines

- Auto-transformer input 240V Voutput 0 to 270V, 5A - 1 No.
- Induction motor with starter & loading
- arrangement 240V 50Hz 1 HP - 1 No.
- Single phase transformer 115/240V 1 kVA, 50 Hz air cooled - 1 No.
- Lamp bank 5 A, 250V - 1 No.

Materials

- Knife switch DPST 16A, 240V - 1 No.
- 40 watts-tube light fitting - 10 Nos.
- DPST switch 250V 16A - 2 Nos.
- SPT switch 6 A - 2 Nos.
- ICDP switch 16A 250V 50Hz - 4 Nos.
- Connecting cables - as reqd.

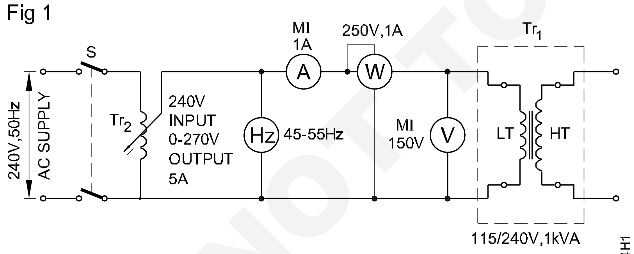
PROCEDURE

TASK 1 : **Conduct open circuit test to determine iron or core loss**

1 Identify the LT and HT windings of the given transformer.

2 Connect the Auto-transformer, frequency meter, ammeter, wattmeter. Voltmeter to the LT side of the transformer as shown in Fig 1.

Fig 1



OPEN CIRCUIT TEST FOR DETERMINATION OF IRON LOSS OF A SINGLE PHASE TRANSFORMER

Ensure that the auto-transformer is initially set at zero volt output position.

3 Close the switch 'S'.

Increase the voltage slowly up to (100%) of the rated value of the transformer L.T.

4 Check for the supply frequency is at rated value.

5 Observe the meters and record the readings in Table.

6 Repeat the above steps for 110% rated value of transformer voltage and record the readings in Table.

TABLE

Sl.No.	Rated	Voltage V	Current A	Total Iron loss W
1	100%			
2	110%			

From the above data the No Load Loss is equal to iron loss. Since the copper loss is negligible.

— — — — — — — —

TASK 2 : **Conduct shot circuit test to determine full load copper loss of a transformer**

Short circuit test

1 Connect the auto-transformer, ammeters, voltmeter and wattmeter in the HT side of the transformer as shown in Fig 1.

Ensure the auto-transformer is initially set at zero volt output position.

2 Close the switch ‘S’

The secondary is short circuited by the ammeter.

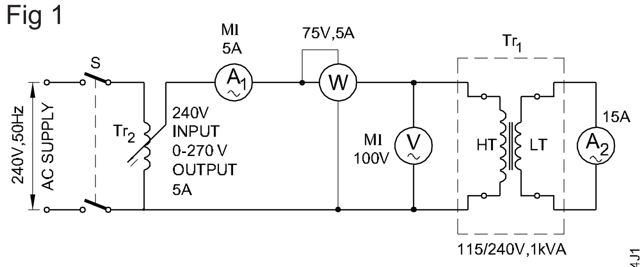
3 Increase the voltage gradually to obtain full load current in the secondary winding of the transformer.

4 Observe the wattmeter and record the readings.

W = Copper loss (full load).

3 The efficiency will be maximum when ________

Fig 1



SHORT CIRCUIT TEST FOR DETERMINATION OF COPPER LOSS OF A SINGLE PHASE TRANSFORMER

— — — — — — — —

Visit to transmission/distribution substation

Objectives: At the end of this exercise you shall be able to
- **visit and trace the transmission and distribution line of substation**
- **identify the equipments in sequential stages of distribution substation**
- **prepare the layout and draw the single line diagram of the transmission and distribution substation**
- **visit and trace the transmission and distribution line of major substation.**

Requirements

Tools/Instruments

- Drawing sheet - 1 No.
- Pencil HB. - 1 No.
- Eraser - 1 No.
- Scale - 1 No.

PROCEDURE

The instructor may take the trainees to the nearest transmission /distribution main substation, and explain the name of the equipments, their specification and function also instruct the trainees to follow the safety regulation while visiting the substation.

1 Visit the transmission and distribution main substation.

2 Identify the sequential stages of transmission/ distribution substations.

3 Trace and identify the various equipments like transformers, feeders, circuit breakers, Isolator, CT & PT etc, from the generator to the consumer points in sequence of transmission and distribution substation.

4 Note down the earthing system. The major substation provided with system earthing. Note the different values of earth resistance displayed in the earth pit. Note down which equipment/installation requires the least earth resistance value and irregular value. Identify the hollow conductors used for connection between feeders.

5 Note down their details in Table 1 (Name, Specification and functions)

Table 1

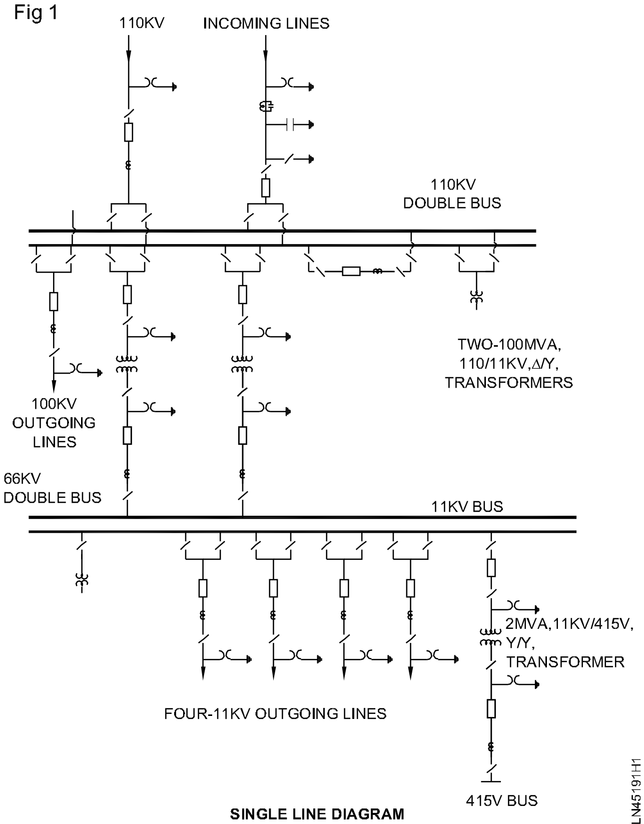
SI.NoN	ame of the equipments	Specification	Function
1			
2			
3			
4			
5			
6			
7			
8			

6 Locate the places of equipments and draw the single line diagram of transmission and distribution substation, which you have visited.

It may be like the diagrams (Fig 1, 2, 3 and 4) given for your guidance. Refer related theory of this exercise also.

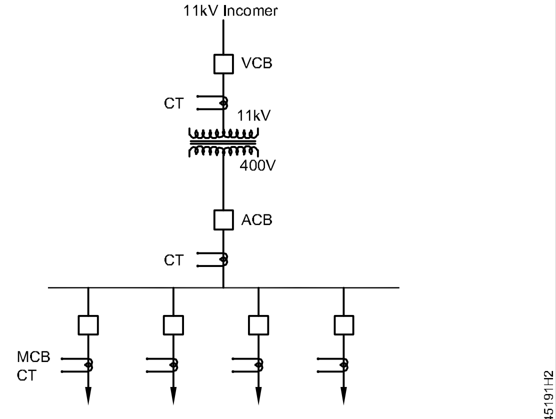
7 Get it checked with your instructor.

Fig 1



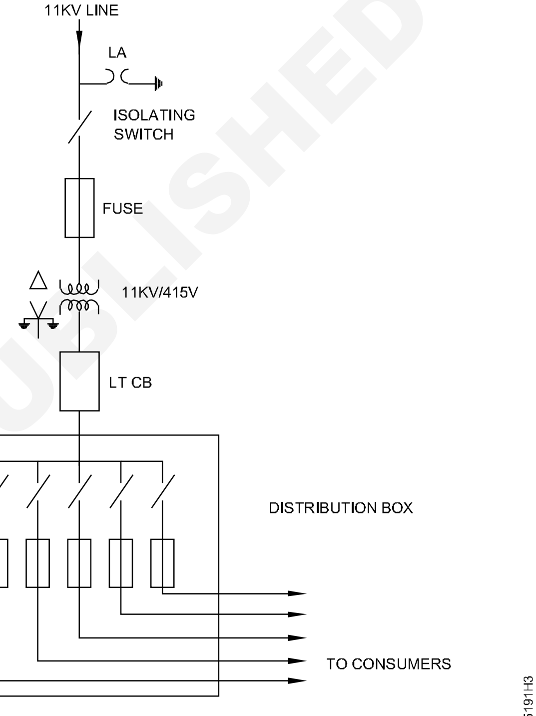
SINGLE LINE DIAGRAM

Fig 2



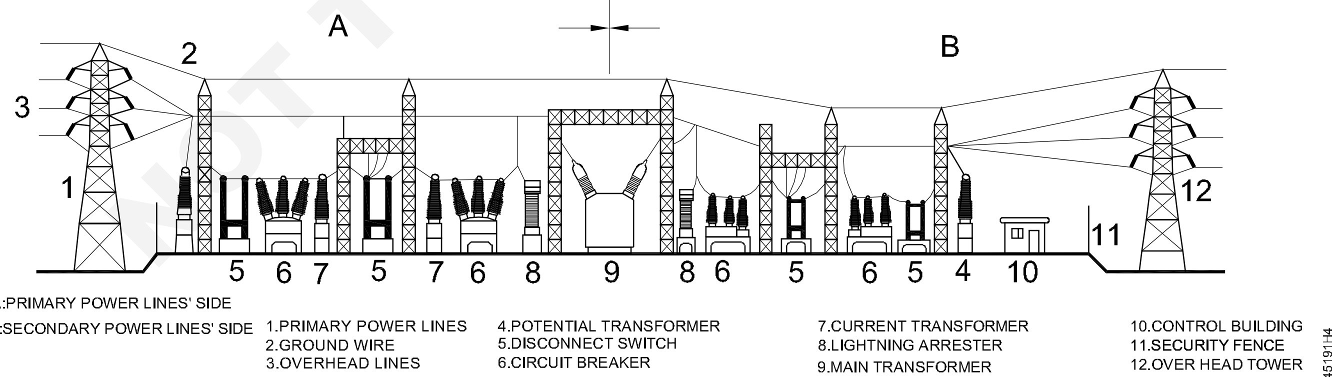
SINGLE LINE DIAGRAM OF 11000V/400 INDOOR SUBSTATION

Fig 3



POLE MOUNTED SUBSTATION

Fig 4



SUB STATION LAYOUT

Draw actual circuit diagram of substation visited and indicate various components

Objectives: At the end of this exercise you shall be able to
- **visit of substation and note down the various components**
- **draw the actual circuit diagram of substation with components.**

Requirements

Materials

• Drawing sheet	- 1 No.	• Eraser	- 1 No.
• Pencil HB.	- 1 No.	• Scale	- 1 No.

PROCEDURE

1 Visit the substation which is nearer to your institute with your instructor and note the various components installed as below.

- Incoming protection devices and their installations.
- Transformer specification - voltage rating capacity cooling method, earthing, HT and LT terminal connections.
- Installation of CTs and PTs and their connections.
- Installation of over voltage, under voltage, over current, earth fault relays and their protections - earthing - etc.
- Position of isolators, earth switches, feeders cable terminations and lights arrestors etc.
- Number of earth pits and their resistance values-periodical maintenance and testing procedure
- The load distribution method adopted in substation to customers.
- Methods followed in substation to meet maximum demand and monitoring.
- Substation maintenance chart and methods to carryout maintenance without effecting power shut down totally.
- Any other points noticed or learned in the substation.

2 Draw the circuit diagram of substation, which actually you visited and draw the layout diagram of substation with various components.

Refer the drawing illustrated in previous Exercise 4.5.191 (Fig 4) for your reference.

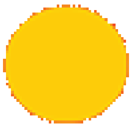
3 Get it checked with your instructor.

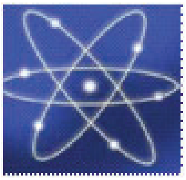
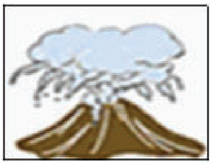
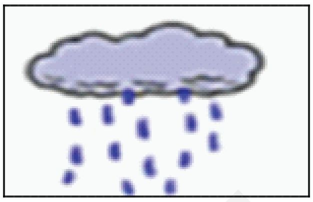
Solar Technician (Electrical) - Natural planetary movements and sunlight's path

Plot sun chart and locate the sun at your location for a given time of the day

Objectives: At the end of this exercise you shall be able to
- **Differentiate between non-renewable and renewable energy sources.**

TASK 1 : **Identify the Nonrenewable or Renewable Energy sources in the following table**

Name of Energy	Picture	Your Answer – Nonrenewable / Renewable Energy
Solar		
Coal		
Wood		
Fossil fuel: Crude oil (Petrol, Diesel)		
Wind		
Natural Gas		

Nuclear Energy		
Geothermal Energy		
Cow dung cake		
Hydro power		

- - - - - - - - - - -

TASK 2 : **Study the nature and analyze how does Solar energy influence the other renewable energy**

Renewable energy other than Solar energy	Explanation
Wind energy	
Hydro energy	
Bio mass	
Geo thermal energy	

- - - - - - - - - - -

TASK 3 : **Analyze the availability of sun light on your place based on observations made during the day, the month, the season and throughout the year.**

Time/Period	Observation
Daily	
Month(s)	
Seasons	
Yearly	

- - - - - - - - - - -

Find out relations between sunlight and earth motion by globe model

Objectives: At the end of this exercise you shall be able to
- **Describe the nature of solar radiation and variation in its reception on Earth due to different causes using Globe model and light source**
- **Demonstrate the Earth and Sun planets motion as well as its implications in maximizing Solar energy utility**
- **Get familiar with latitude and longitude for a given location.**

Requirements	
Tools/Instruments	
• A Candle or Electric bulb	• Rotating Globe model

TASK 1 : **Study the diagram given below which is a pictorial representation of Earth's path around the Sun and record your understanding**

Revolution of the Earth around the Sun (Fig 1)

Fig 1

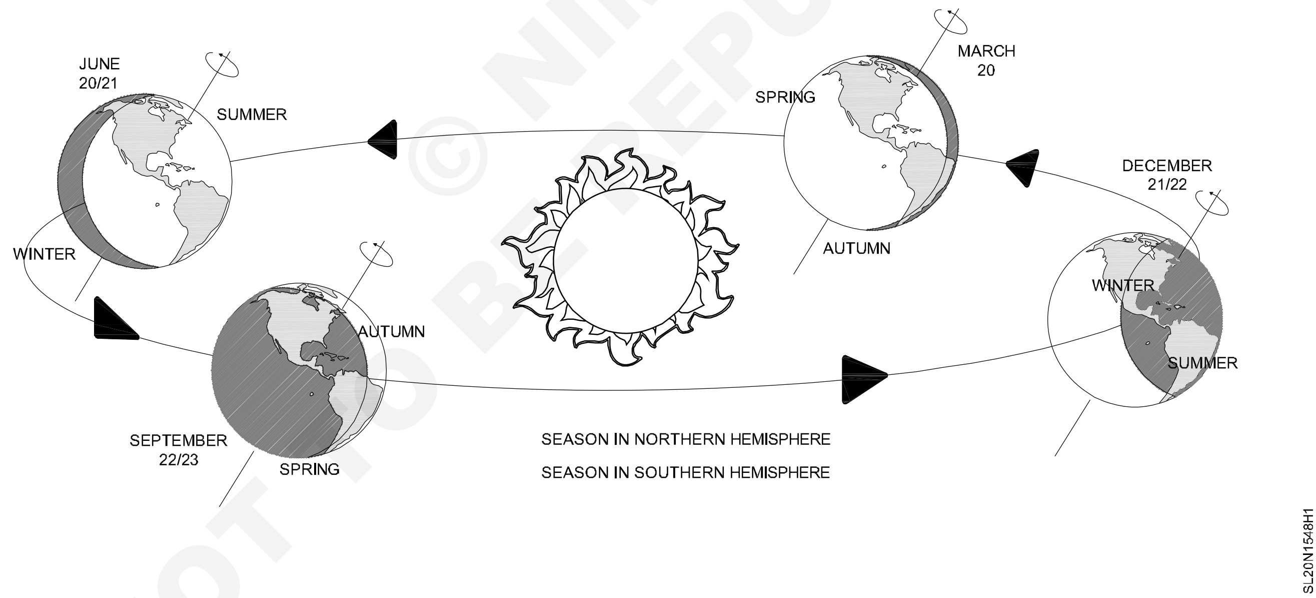
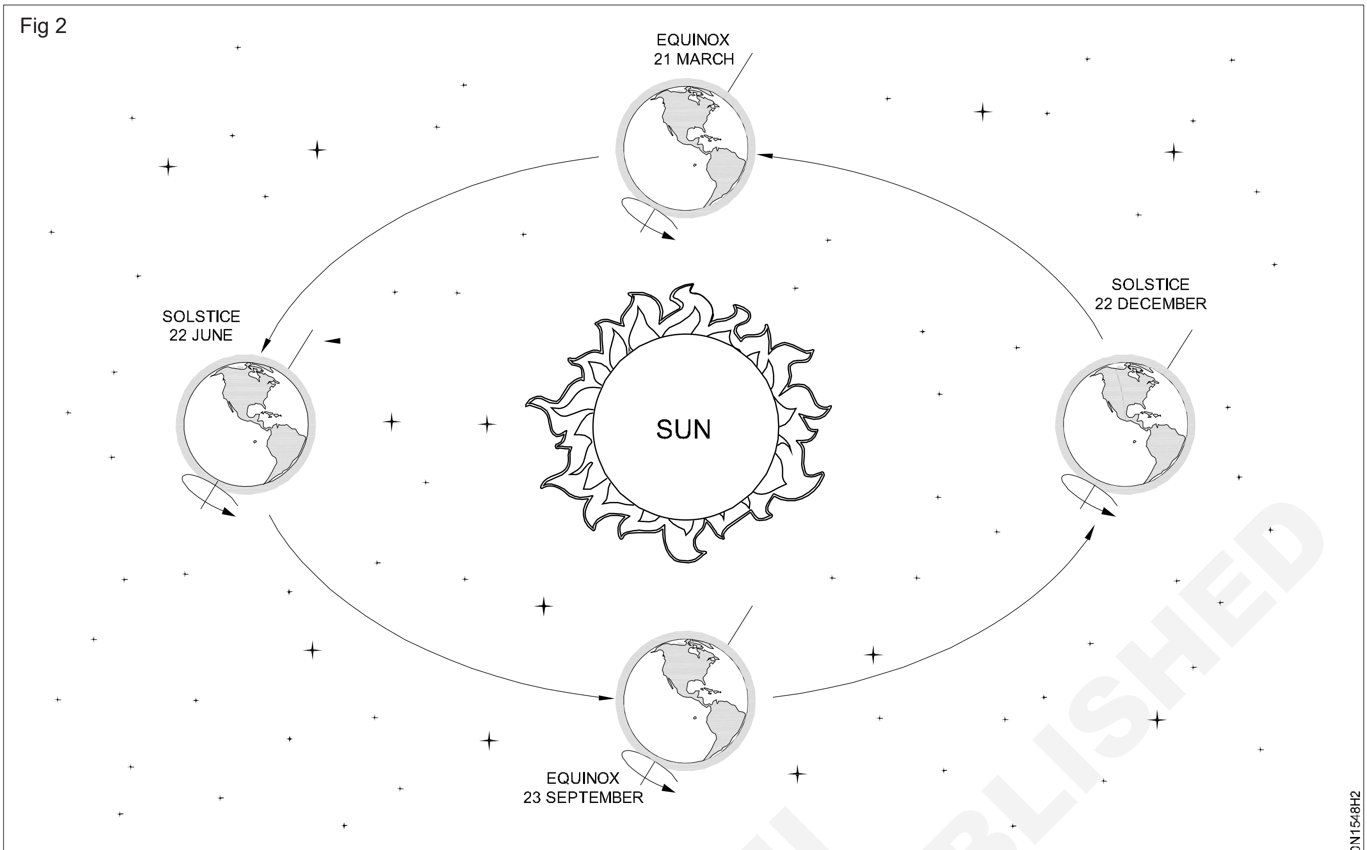


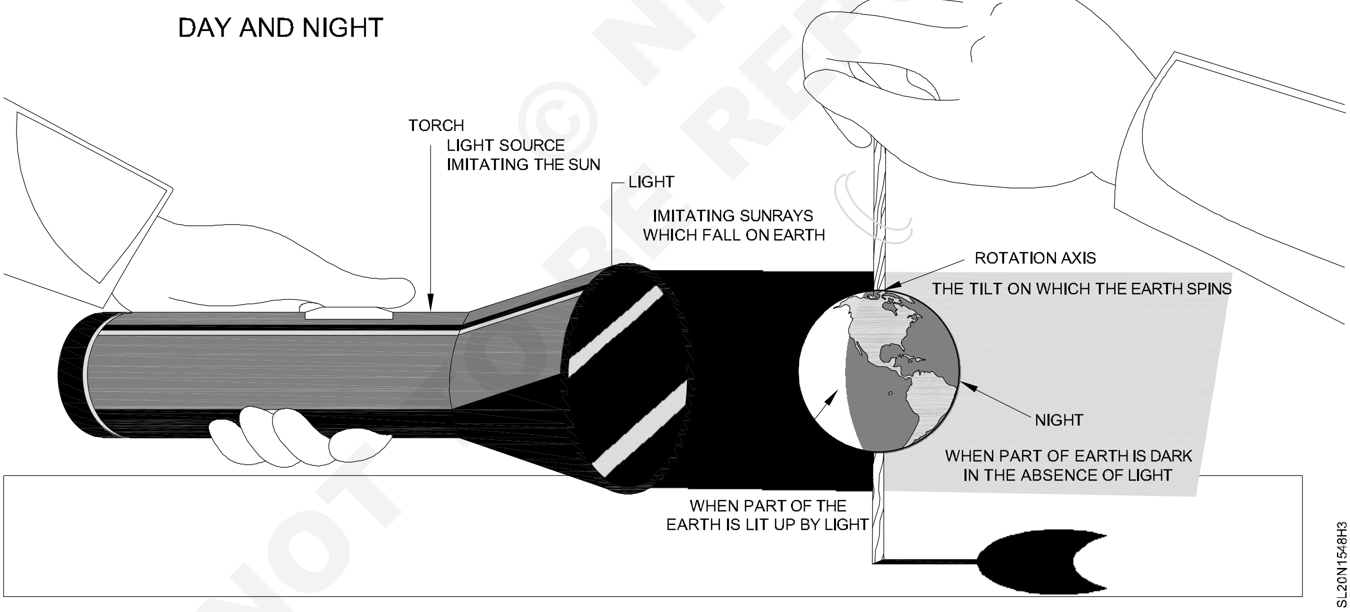
Fig 2



THE MOTION OF THE EARTH WITH RESPECT TO SUN OVER A YEAR

Fig 3

DAY AND NIGHT



Observations:

Solar Technician (Electrical) - Natural planetary movements and sunlight's path

Compare angle of sun rays in day time on different days

Objectives: At the end of this exercise you shall be able to
- **Describe about angle of inclination of Sun light rays on earth surface**
- **Get familiar about Azimuth and Zenith angles**

TASK 1 : **Study the diagram given below and explanation of angle of sunrays and give your understanding on daily observations**

Angle of sunrays on solar collector In order to estimate amount of solar radiation falling on an object (a solar collector) the angle of incidence of sunrays on collector should be known. In practice it is required that solar collectors are aligned perpendicular to the sunrays, from morning to evening, in order to collect the maximum solar radiation.

Fig 1

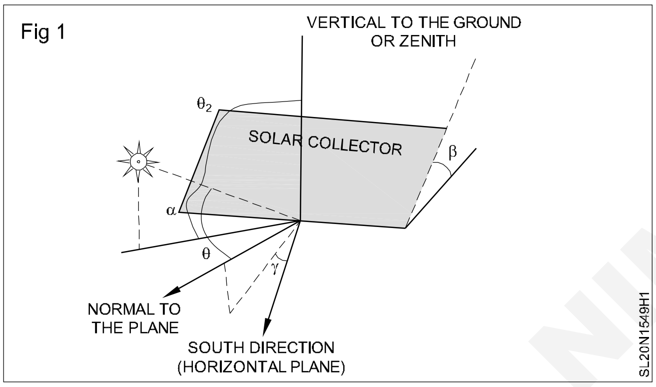
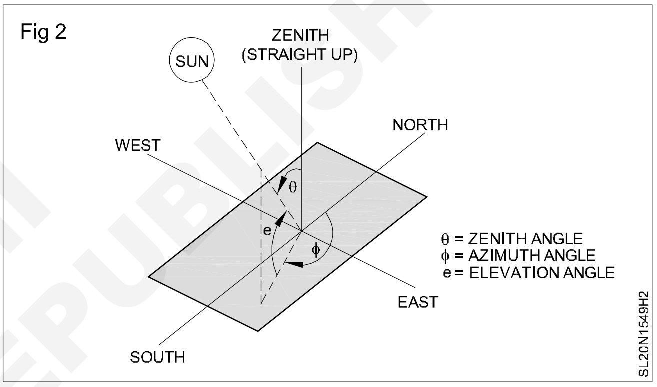


Fig 2



Understanding:

Locate magnetic poles (North and South) with the help of magnetic compass

Objectives: At the end of this exercise you shall be able to
- **Find out North and South poles**

Some details on magnetic poles:

- **Suspend a bar magnet and show it aligns roughly North and South. The pole which points North is the "North-seeking pole" of the magnet.**
- **You can use a compass to develop the idea of magnetic polarity. The compass points towards the Earth's North. The arrowhead end of the needle is a North-seeking pole. All magnets have a North-seeking pole and a South-seeking pole. Poles that are the same always repel each other. Poles that are different always attract each other. Show this with pairs of compass needles.**
- **Sometimes students get into a tangle about North-seeking and South-seeking poles when they learn that the Earth is a big magnet, and that the pole that is geographically to the North must be a South-seeking pole. So at this stage it is unhelpful to shorten 'North-seeking pole' and 'South-seeking pole' into plain North and South poles.**

TASK 1 : **Use magnetic compass and identify the North and South poles of the Earth. Verify the facts with the details given in the box.**

Observations:

List countries in Northern and southern hemisphere of globe

Objectives: At the end of this exercise you shall be able to
- **Find out countries in northern and southern hemisphere**

Requirements

Tools/Measurements/Equipments

- A Globe model or
- World Atlas

PROCEDURE

TASK 1 : **Find out the countries in the Northern hemisphere and record in the table below**

Names of the countries in the Northern hemisphere:

1.
2.
3.
4.
5.
6.
7.
8.
9.
10.

\- - - - - - - - - - -

TASK 2 : **Find out the countries in the Southern hemisphere and record in the table below**

Names of the countries in the Southern hemisphere:

1.
2.
3.
4.
5.
6.
7.
8.
9.
10.

Prepare a list of places around India, their latitude and longitude

Objectives: At the end of this exercise you shall be able to
- **Find out latitude and longitude of different cities in India**

Requirements

Tools/Measurements/Equipments

- A Globe model or
- World Atlas

PROCEDURE

TASK 1 : **Check on the India map or Globe model over India and select few city names from all regions. Find out their latitude and longitude. Append the findings in the table given below**

Name of the city	Latitude	Longitude

Measure intensity of solar radiation using Pyranometer and radiometers

Objectives: At the end of this exercise you shall be able to
- **Measure solar intensity**

Requirements

Tools/Measurements/Equipments

- Pyranometer and radiometer

A Pyranometer is a device that measures solar irradiance from a hemispherical field of view incident on a flat surface. The SI units of irradiance are watts per square metre (W/m^2).

Radiometer is a device used to measure the intensity of radiant energy. In order to measure radiation emitted from a specific spectrum or to incorporate the radiometer within a certain spectral response, an optical filter is normally used.

PROCEDURE

TASK 1 : **Take a Pyranometer and a radiometer. Measure the Solar intensity at different places inside the room, outside the room and in open sunlight. Record your observations. Compare results of both instruments**

Where do you measure?	Pyranometer reading	Radiometer reading

Notes:

Power **Exercise 1.5.54**

Solar Technician (Electrical) - Natural planetary movements and sunlight's path

Analyze shadow effect on incident solar radiation and find out contributors

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

- **Understand shadow effect in different places**

Requirements

Tools/Measurements/Equipments

- Pyranometer
- Opaque
- Transparent
- Semitransparent
- Reflecting plates

PROCEDURE

a) Take a Pyranometer. Measure the Solar intensity at different places inside the room, outside the room and in open sunlight. Record your observations.

b) Use opaque, transparent, semitransparent and reflecting plates to create shadow effects. Compare results of both instruments. Measure the Solar intensity and Record your observations. Discuss on the results.

No shadow effect		Shadow effects							
Inside room	Outside room	Using opaque		Using transparent plate		Using semitransparent plate		Using reflecting plate	
		Inside room	Outside room	Inside room	Outside room	Inside room	Outside room	Inside room	Outside room

Observations:

Plot curve of radiation measured with respect to time for a location

Objectives: At the end of this exercise you shall be able to
- **Plot a curve for Solar intensity versus time of a day**

Requirements

Tools/Measurements/Equipments

- Solar energy meter

PROCEDURE

- Study the path of the sun from sun rise to sun set in your location
- Measure the intensity using Solar energy meter by facing the sensor towards the sun
- Record the observations at equal interval of time say 30 minutes or one hour. Shorter the interval better the graph plot would be.
- Draw a graph with time intervals on X axis and Sun intensity in Y axis
- Result is the path of the sun versus its intensity in a day

Table 1

Assume:

Sun hours: 12 hours

Sun rise: 6.00 am

Sun set: 6.00 pm

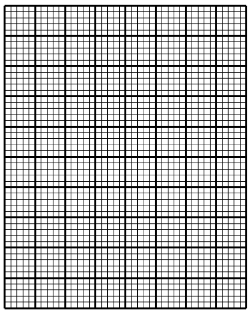
Note: all the above will vary from place to place over any location on the globe

Time (Hrs)	Solar intensity (W/m²)
6.00 am	
6.30 am	
7.00 am	
7.30 am	
8.00 am	
8.30 am	
9.00 am	
9.30 am	
10.00 am	
10.30 am	
11.00 am	
11.30 am	
12.00 noon	
12.30 pm	
1.00 pm	
1.30 pm	
2.00 pm	
2.30 pm	
3.00 pm	
3.30 pm	
4.00 pm	
4.30 pm	
5.00 pm	
5.30 pm	
6.00 pm	

Use the observations made and plot the curve in graph sheet.

Graph:

Fig 1

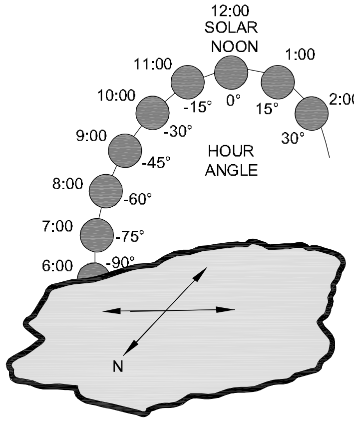


The ideal plot is given below. The actual may vary.

Sun hour Angle

The hour angle measures time before solar noon in terms of one degree for every four minutes, or fifteen per hour. Solar Hour Angle for a particular location on the earth is zero when the sun is straight overhead, negative before local noon and positive in the afternoon. In one 24 hour period, the Solar Hour Angle changes by 360 degrees (i.e. one revolution).

Fig 2



Observations:

TASK 3 : **Verify the following with your observation**

Solar Hour Angle (In Degrees)	True Solar Time	Time (O' Clock)
-90	6 hours before Solar Noon	6:00:00 Am
-75	5 hours before Solar Noon	7:00:00 Am
-60	4 hours before Solar Noon	8:00:00 Am
-45	3 hours before Solar Noon	9:00:00 Am
-30	2 hours before Solar Noon	10:00:00 Am
-15	1 hours before Solar Noon	11:00:00 Am
0	Sun overhead i.e. Solar Noon	12:00:00
15	1 hours after Solar Noon	1:00:00 Pm
30	2 hours after Solar Noon	2:00:00 Pm
45	3 hours after Solar Noon	3:00:00 Pm
60	4 hours after Solar Noon	4:00:00 Pm
75	5 hours after Solar Noon	5:00:00 Pm
90	6 hours after Solar Noon	6:00:00 Pm

Draw a solar map by collecting data of solar radiation in a location for one year

Objectives: At the end of this exercise you shall be able to
- **Draw a solar map over a year period for a location**

PROCEDURE

TASK 1 : **Browse the website and collect data of Solar irradiation for known location for one year period and plot a curve with months in X axis and intensity (W/m2) in Y axis**

Location:

Latitude:

Longitude:

Data:

Month	Solar irradiation (W/m²)
Jan	
Feb	
Mar	
Apr	
May	
Jun	
Jul	
Aug	
Sep	
Oct	
Nov	
Dec	

The amount of radiant energy emitted by the sun is called solar radiation, while solar irradiation refers to the amount of solar radiation received from the Sun per unit area which is expressed in (kW/ m²).

Bangalore is one of the ideal cities in India to go solar in. The moderate temperatures year-round, high wind speeds and availability of 280 days of good sunlight, combine to make Bangalore an excellent place for using solar power.

When sunlight hits the solar PV panels, the sun's energy is converted into electricity, which in turn powers homes, apartments, offices, schools, and more. Hence, solar panels harness the sun's light and not its heat. The amount of electricity generated depends on multiple factors:

1 Temperature

2 Wind speed

3 Daily sunlight hours

4 Intensity and angle of sunlight

5 Solar panel type

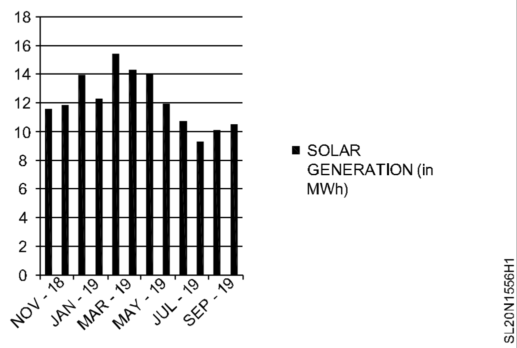
6 Inverter technology

7 Shading (by obstructions)

Typical Solar power generation in a solar PV plant in 12 months:

MONTH	SOLAR GENERATION (in MWh)
Nov-18	11.58
Dec-18	11.85
Jan-19	13.92
Feb-19	12.32
Mar-19	15.43
Apr-19	14.29
May-19	13.97
Jun-19	11.9
Jul-19	10.74
Aug-19	9.24
Sep-19	10.07
Oct-19	10.54
Total (12 months)	145.85

Fig 1



Compare the effects of direct radiation, diffused radiation and reflected radiation and prepare reports

Objectives: At the end of this exercise you shall be able to
- **Differentiate between Direct Sunlight, Diffused rays and reflected rays**

PROCEDURE

TASK 1 **: Differentiate between Direct Sunlight, Diffused rays and reflected rays**

Measure the Solar irradiation using Solar Energy meter in direct sunlight while there is clear sky and record the observations. In continuation measure at the same place with same instrument the radiation that comes out from filters such as Opaque, transparent, semitransparent and reflecting surface and record the observations.

Measurements should as quick as possible and with clear sky since results may vary with time, place and weather conditions. Prepare a comparative chart.

Direct Sunlight	Using opaque filter	Using transparent filter	Using semi transparent filter	Using reflecting surface

- - - - - - - - - - -

TASK 2 : **Using the observations made in task 1, classify the radiations in the given table**

Type of sunlight	Type of filter used or no filter
Direct	
Diffused	
Reflected	
Shadow	

- - - - - - - - - - -

Test a LED and a Photodiode to verify the photo emitting effect and light sensitivity

Objectives: At the end of this exercise you shall be able to
- **study the Photodiode and LED devices in circuits.**

PROCEDURE

TASK 1 : **Test a LED using a digital multimeter**

1 A digital Multimeter with diode testing

2 LED

3 Basic multi-meters measure just amps, volts, and ohms. To test LED lights, select a multi-meter with a diode setting.

4 Connect the red and black test leads to the outlets on the front of the multimeter. The red lead is the positive charge. The black lead is the negative and should be plugged into the input labelled “COM.”

5 Connect the black probe to the cathode and the red probe to the anode. Touch the black probe to the cathode end of the LED, which is usually the shorter prong. Next, touch the red probe to the anode, which should be the longer prong.

6 Be sure to connect the black probe before the red probe, as the reverse might not give you an accurate reading.

7 Turn the dial on the front of the multi-meter clockwise to move it away from the “off” position.

\- - - - - - - - - - -

TASK 2 : **Test a Photo Diode**

1 A digital Multi-meter with diode testing

2 Photo diode

3 Connect the photodiode to the multi-meter, similar to testing a normal diode or a LED, by referring to the diagram shown.

4 Take precautions in connecting the probes as well as the terminals of the photodiode.

Observations:

\- - - - - - - - - - -

TASK 3 : **Testing LED and photodiode in combination**

1 A digital Multi-meter or millivoltmeter

2 Photo diode

3 LED with a suitable current control resistor

4 6 V battery or DC power supply

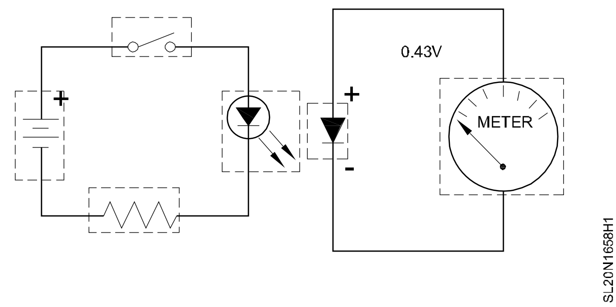
5 Control switch

6 The photodiode can be tested for actual operation by arranging the light from a LED to fall on its sensing side.

7 Connect the LED and photodiode in a circuit as shown below.

8 Switch ON the circuit and verify the deflection/reading on the meter

Fig 1



9 Switch OFF and verify the deflection/reading on the meter

10 Record your observations

Observations:

Test a Photo voltaic cell for different illumination levels and verify photovoltaic property

Objectives: At the end of this exercise you shall be able to
- **Test the photovoltaic (PV) cell**

PROCEDURE

TASK 1 : **Test a Photo voltaic cell**

1 A digital Multi-meter or millivoltmeter
2 A Photo voltaic cell, 3.5 W, 0.5 V, 7 A (for e.g. 4 Nos.)
3 5 ohm, 5 W resistor
4 Sunlight
5 Alternatively Light source with illumination control
6 Placesolar cells in direct sunlight
7 Usea multi-meter that measures both Voltage and Ampere

Fig 1

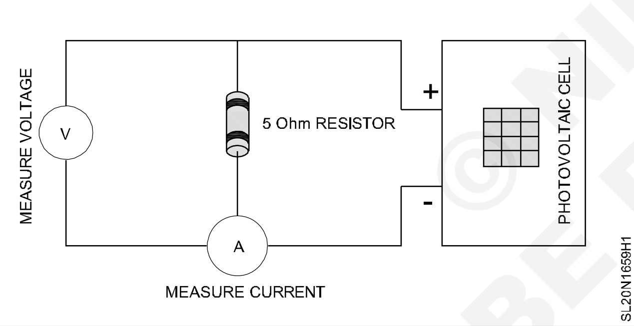
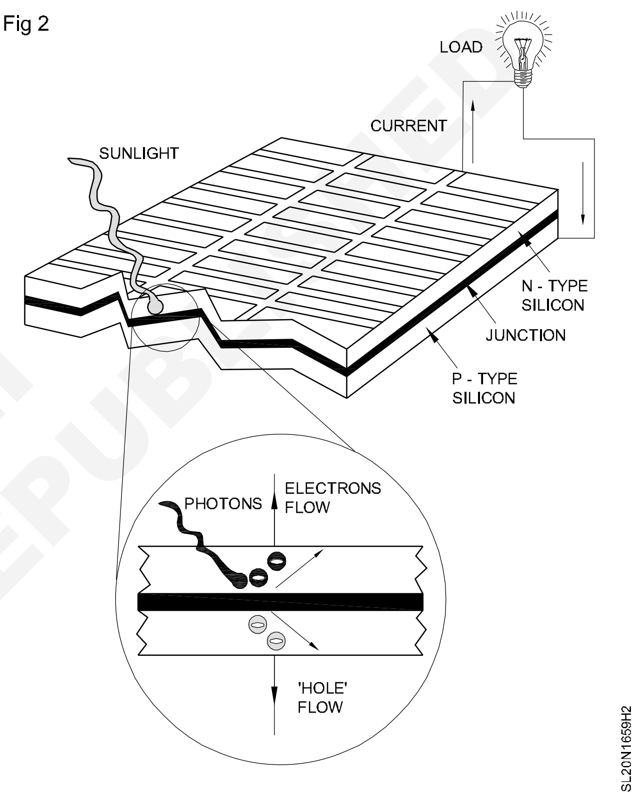


Fig 2



Observations:

S.NO		Voltage Measured	Current measured	Conditional the PV Cell
1	Photovoltaic cell - 1			
2	Photovoltaic cell - 2			
3	Photovoltaic cell - 3			
4	Photovoltaic cell - 4			

Plot I-V curve for photovoltaic cell based on the illumination at constant temperature

Objectives: At the end of this exercise you shall be able to
- **Demonstrate the IV characteristics of PV cell for variation in illumination**
- **Demonstrate the IV characteristics of PV cell for variation in load.**

Requirements

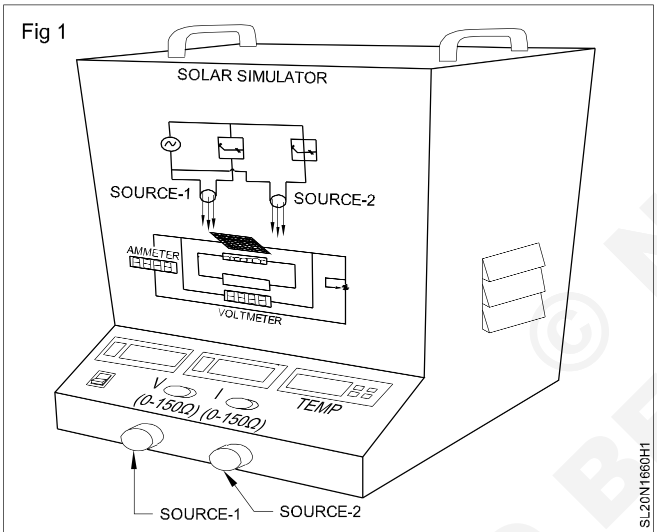
Tools/Measurements/Equipments

- Solar energy meter
- Solar Simulator equipments

PROCEDURE

TASK 1 : **Understand the lab equipment Solar simulator**

Fig 1



(All pictures and Circuit of Solar Simulator shown below are indicative. Actual design may vary.)

1 Study the lab equipment available in shop floor to learn the IV characteristics of PV cell.

2 Go through the manual supplied along with the equipment to know the different controls used in it and their usage

3 Learn the do's and don'ts

4 Get familiar with simulation with Solar light's properties

5 Remember: Technical circuit inside and its functioning not required for your study of PV cell.

6 Common features of this Solar Simulator should be

7 To simulate the sun, set of lamps are used as the source of light

8 To simulate the sun for its heat radiation an electrical hot plate is used

9 To simulate east-west movement of the sun the lamps are provided individual control

10 To simulate variation in solar irradiation the intensity of the lamps need to be controlled

11 To simulate variation in temperature the heat generated by hot plate needs to be controlled

12 The location of the solar PV cell is to be over the hot plate facing the lamps

13 A variable resistive load is required across the terminals of the solar PV cell to indicate actual load conditions

14 A set of digital (Preferably) voltmeter and ammeter are essential on front side

15 Control of intensity and heat should be independent.

- - - - - - - - - - -

TASK 2 : **Study of V/I, Characteristics of Solar Cell**

1 Solar Simulation lab

2 Connect the Solar Simulator equipment to mains power supply and switch ON

3 Set both the intensity control rotary switch of lamps at maximum position to get the full intensity (Steps variation or continuous variation depending on the model)

4 Measure the intensity using Solar energy meter and record the observed value (W/m2)

5 Set the variable resistor load provided at high to simulate no load condition

6 Measure and record the voltage and current of solar cell at no load condition on display

7 The voltage displayed on Voltmeter is open circuit voltage (Voc)

8 Vary the load progressively downwards, simultaneously measure the V, I readings and record

9 The minimum position of load indicates the short circuit across the PV cell and hence the current will be highest. It isthe short circuit current (Isc) of solar **PV cell.**

Observations

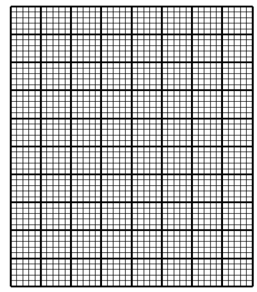
Intensity of lamps (Solar irradiation) = ……….. W/m2

Sl. No.	Voltmeter reading (V)	Ammeter reading (A)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

Graph

Plot the path of curve for recorded values of V and I to get the IV curve of the solar PV cell at fixed intensity.

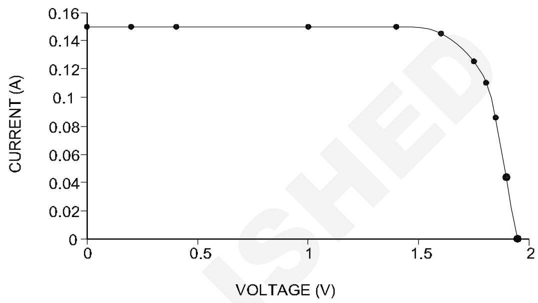
Fig 1



SLN1960H3

Indicative plot of graph

Fig 2

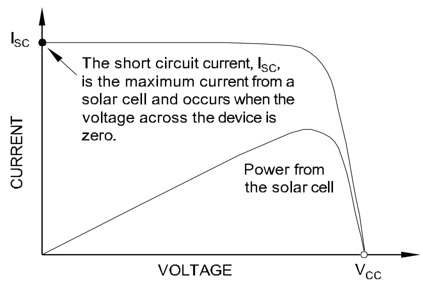


SLN1960H4

The VOC = 2 V indicates there are four numbers of PV cells are connected in series.

The ISC = 0.15 mA in this graph

Fig 3



SLN1960H5

TASK 3 : **Study of V/I, Characteristics of Solar Cell with variation of light intensity and varying load conditions**

Solar Simulator equipment

1 Connect the Solar Simulator equipment to mains power supply and switch ON

2 Set both the intensity control rotary switch of lamps at maximum position to get the full intensity (Steps variation or continuous variation depending on the model)

3 Measure the intensity using Solar energy meter and record the observed value (W/m2)

4 Set the variable resistor load provided at high to simulate no load condition

5 Measure and record the voltage and current of solar cell at no load condition on display

6 The voltage displayed on Voltmeter is open circuit voltage (Voc)

7 Vary the load progressively downwards, simultaneously measure the V, I readings and record the observations

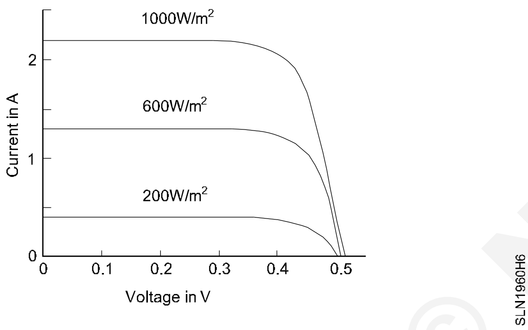
8 The minimum position of load indicates the short circuit across the PV cell and hence the current will be highest. It isthe short circuit current (Isc) of solar PV cell.

9 Repeat the above with reduced intensity at different levels

Observations

Sl No	Intensity = …...W/m2		Intensity = …...W/m2		Intensity = …...W/m2		Intensity = ……W/ m2	
	V	I	V	I	V	I	V	I

Fig 1

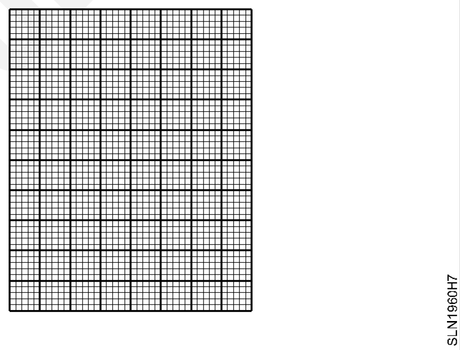


- Plot a graph for each set of observations to get the IV curves of the Solar PV Cell

- Indicative IV curves for a Solar PV cell

Note : On increasing intensity of light you will observe Voc and Isc increases.

Fig 2



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Plot I-V curve for photovoltaic cell based on temperature at constant illumination

Objectives: At the end of this exercise you shall be able to
- **demonstrate the IV characteristics of PV cell for variation in temperature on cell.**

Requirements

Tools/Measurements/Equipments

- Solar Simulator equipment
- Solar energy meter
- Thermometer

PROCEDURE

TASK 1 : **Study the IV curve for three different temperatures on solar PV cell with constant intensity**

1 Connect the Solar Simulator equipment to mains power supply and switch ON

2 Set both the intensity control rotary switch of lamps at maximum position to get the full intensity (Steps variation or continuous variation depending on the model)

3 Measure the intensity using Solar energy meter and record the observed value (W/m2)

4 Measure the room temperature

5 Record the observations

Observations:

6 Use the temperature controller and set a value little above room temperature

7 Set the potentiometer to maximum to get no load condition

8 Measure the voltage(Voc) and current of solar cell at no load condition on display

9 Vary the potentiometer towards minimum. Measure the voltageand current (Isc) of solar cell at full load condition on display

10 Record the observations

11 Repeat the steps above with temperature at still higher set vaue. Record the observations

12 Draw the graph for normal, higher and much higher temperature values and compare

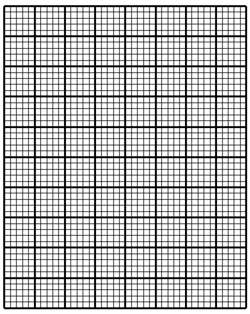
13 Record the observations

Observations : Intensity = …...W/m^2

Sl No	Temparature = …◦C		Temparature = …◦C		Temparature = …◦C	
	V	I	V	I	V	I

Graph

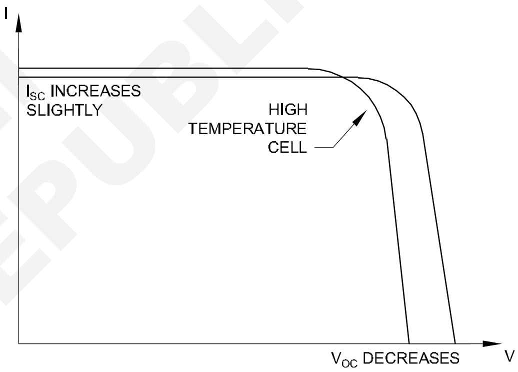
Fig 1



SLN1961H1

Note: With an increase in temperature Voc decreases and Isc increases slightly.

Fig 2



THE EFFECT OF TEMPERATURE ON THE IV CHARACTERISTICS OF A SOLAR CELL

SLN1961H2

Notes:

Test photovoltaic cell in sunlight at various angles of inclination and direction

Objectives: At the end of this exercise you shall be able to
- **perform working with PV cell/panel in sunlight at different angles and directions.**

Requirements

Tools/Measurements/Equipments

- Solar PV cell
- Voltmeter
- Ammeter
- 5 ohm resistor
- Magnetic compass
- Spirit Level
- Clinometer

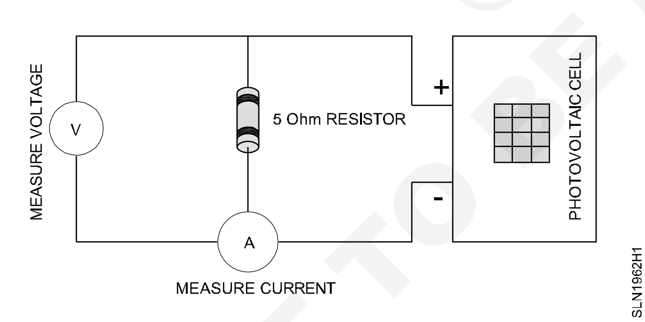
PROCEDURE

TASK 1 : **Study the Solar power generated in different directions**

Note:The light sensor of the Solar energy meter should face in the same direction as the Solar PV cell in each case of testing

- Connect the given components as shown in circuit

Fig 1



- Place the Solar PV cell in sunlight
- Locate the North pole using the Magnetic compass
- Keep theSolar PV cell facing the North pole
- Record the readings on Voltmeter and Ammeter and Solar irradiation intensity
- Rotate the facing of theSolar PV cell by 90◦ from North clockwise
- Record the readings on Voltmeter and Ammeter
- Continue to rotate the facing of theSolar PV cell by 90◦ from earlier position clockwise
- Record the readings on Voltmeter and Ammeter
- Continue to rotate the facing of theSolar PV cell by 90◦ from earlier position clockwise
- Record the readings on Voltmeter and Ammeter
- Compare the results

Position	Solar intensity	V (Volt)	A (Ampere)
N			
E			
S			
W			

- - - - - - - - - - -

TASK 2 : **Study the Solar power generated in different angle of inclinations**

Note:

The light sensor of the Solar energy meter should face in the same direction as the Solar PV cell in each case of testing

At any point of experiment mind that no shadow falls on the PV cell

1 Connect the given components as shown in circuit

2 Place the Solar PV cell in sunlight at flat surface; if mounted on adjustable plane allowing different inclinations more suitable otherwise manually done

3 Check the spirit level shows flat surface parallel to the ground. Measure the angle using clinometer and confirm it shows 0◦.

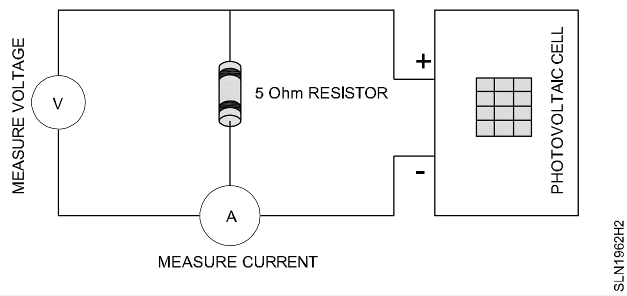
4 Keep theSolar PV cell facing the South.

5 Record the readings on Voltmeter and Ammeter and Solar irradiation intensity

6 Lift the facing of theSolar PV cell by steps of 5◦from 0◦. (Steps of 2 or 3 degrees of change in angles give better results)

7 Record the readings on Voltmeter and Ammeter

Fig 2



8 Continue to change the angle of facing of theSolar PV cell from earlier position towards south

9 Record the readings on Voltmeter and Ammeter

10 Repeat the above for some more angles

11 Compare the results

12 The angle that gives maximum Solar power is the Tilt angle for given location

Angle (◦)	Solar intensity	V (Volt)	A (Ampere)
0			
5			
10			
15			
20			
25			

- - - - - - - - - - -

Solar Technician (Electrical) - Characteristics of Photovoltaic cells, Modules, Batteries and Charge controllers and DC appliances of solar PV

Test different rated Photovoltaic modules (Panels) and plot I-V curve

Objectives: At the end of this exercise you shall be able to
- **test different rated solar panels.**

Requirements

Tools/Measurements/Equipments

- 5W,10W,40W poly crystalline module
- DC load bank
- DC Voltmeter comparable with specifications of module
- DC Ammeter comparable with specifications of module
- DC watt meter

PROCEDURE

TASK 1 : **Study performance characteristics of 5 W Solar PV module**

1 Place the 5 W Solar PV panel in sunlight

Cover the top side with black cloth or keep the panel upside down till experiment begins to avoid shock during preparation

2 Connect a switch in series with the positive terminal of the Solar PV panel

3 Connect the voltmeter across the other end of the switch and negative terminals of Solar PV panel

4 Take care of the polarities

5 Connect the ammeter in series from positive terminal after the switch

6 Connect the other end of the Ammeter to the positive terminal of the load

7 Connect the negative terminal of the Solar PV panel to the negative terminal of the load

8 Turn the Solar PV panel upright or remove the black cloth as the case may be

9 Measure the intensity using Solar energy meter and record the observed value (W/m2)

10 Set the load at high to simulate no load condition

11 Measure and record the voltage and current of solar cell at no load condition

12 The voltage measured now is open circuit voltage (Voc)

13 Vary the load progressively downwards, simultaneously measure the V, I readings and record the observations

14 The minimum position of load indicates the short circuit across the PV panel and hence the current will be highest. It is close to the short circuit current (Isc) of solar PV panel.

15 Record the observations in table 1 and plot the IV curve of the 5 W Solar PV panel

Note

Measurements should as quick as possible

Other members should record simultaneously

Sun light intensity and angle varies continuously.

Shadow conditions also may affect the observed table for 5w solar PV Module

Table - 1

Sl. No.	Voltmeter reading (V)	Ammeter reading (A)
1		
2		
3		
4		
5		
6		
7		

Sl. No.	Voltmeter reading (V)	Ammeter reading (A)
8		
9		
10		

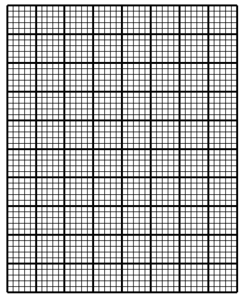
Observations

Intensity of lamps (Solar irradiation) = ………… W/m2

Graph

Plot the path of curve for recorded values of V and I to get the IV curve of the solar PV panel

Fig 1



VI CURVE FOR 5W SOLAR PV PANEL

SL20N1663H1

- - - - - - - - - - -

TASK 2 : **Study performance characteristics of 10 W Solar PV module**

1 Replace the 5w solar PV panel with 10w,40w solar PV panel, one by one.

2 Repeat the procedure to record the table - 2 & table - 3 respectively

3 Plot the I-V curve for 10w, 40w solar panel

Observations

Intensity of lamps (Solar irradiation) = ………… W/m^2

Graph

Plot the path of curve for recorded values of V and I to get the IV curve of the solar PV panels of 10w & 40w

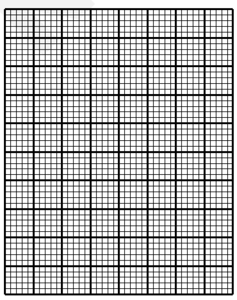
Table - 2

Sl. No.	Voltmeter reading (V)	Ammeter reading (A)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

Table - 3

Sl. No.	Voltmeter reading (V)	Ammeter reading (A)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

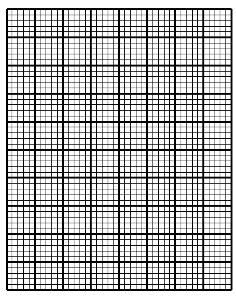
Fig 1



VI CURVE FOR 10W SOLAR PV PANEL

SL20N1663J1

Fig 2



VI CURVE FOR 40W SOLAR PV PANEL

SL20N1663J2

Record specification of different solar panels and compare specifications to select a panel

Objectives: At the end of this exercise you shall be able to
- **compare the specifications of different rated solar panels.**

Requirements

Tools/Measurements/Equipments

- 5W, 10W, 40W and 250W poly crystalline modules

PROCEDURE

TASK 1 : **Compare specifications of different solar panels**

1 Study the specification chart provided on each panel and fill up the table below

2 Compare and comment on their suitability for your use.

Specification	1	2	3	4
W_P: Peak Power	**5W**	**10W**	**40W**	**250W**
V_M: Maximum voltage at **W_P**				
I_M: Maximum current at **W_P**				
V_{OC}: open circuit voltage				
I_{SC}: Short circuit current				
V_{SYS}: Maximum system voltage				
S_{TC}: Standard Testing Condition				
No. of cells				

Observations:

- - - - - - - - - - -

Solar Technician (Electrical) - Characteristics of Photovoltaic cells, Modules, Batteries and Charge controllers and DC appliances of solar PV

Test different types of PV panels such as, mono crystalline, poly crystalline, amorphous silicon and thin film modules

Objectives: At the end of this exercise you shall be able to
- **study of types of Solar PV modules**
- **compare the specifications of different types of solar panels.**

Requirements

Tools/Measurements/Equipments

- 250W poly crystalline module
- 75 W mono crystalline module
- 75 W amorphous silicon module
- 250 W thin film module

TASK 1 : **Compare specifications of different types of solar panels**

1 Study the specification chart provided on each panel and fill up the table below

2 Compare and comment on their suitability for your use

Observations

Specification	Poly crystalline	Mono crystalline	Amorphous silicon	Thin film module
$\mathbf{W_P}$: Peak Power	**250W**	**75 W**	**75 W**	**250W**
$\mathbf{V_M}$: Maximum voltage at $\mathbf{W_P}$				
$\mathbf{I_M}$: Maximum current at $\mathbf{W_P}$				
$\mathbf{V_{OC}}$: open circuit voltage				
$\mathbf{I_{SC}}$: Short circuit current				
$\mathbf{V_{SYS}}$: Maximum system voltage				
$\mathbf{S_{TC}}$: Standard Testing Condition				
No. of cells				
Physical properties				

Notes:

TASK 2 : **Study performance characteristics of types of Solar panels**

1 Follow the procedures for 1.9.63. Task 1

2 To perform experiments for thegiven different types of solar panels one by one.

3 Record the observations and plot IV curves

4 Compare the results

Observations

Sl. No.	250W poly crystalline		75 W mono crystalline		75 W amorphous Si		250 W thin film	
	Voltmeter reading (V)	Ammeter reading (A)	Voltmeter reading (V)	Ammeter reading (A)	Voltmeter reading (V)	Ammeter reading (A)	Voltmeter reading (V)	Ammeter reading (A)
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								

- - - - - - - - - - -

Solar PV panels of ratings, 5 W, 10 W, 40 W and 250 W

Objectives: At the end of this exercise you shall be able to
- **get the relation between no. of cells and specifications of a solar panel.**

TASK 1 : **Explore the importance of number of cells and application requirements**

Observations:

Solar panel W	No of cells	V_M Max. voltage at W_P	Comments	Utility in application
5 W				
10 W				
40 W				
250 W				

\- - - - - - - - - - -

Connect suitably rated wires in the terminal box of a solar panel and connect end terminals using MC 4 connectors

Objectives: At the end of this exercise you shall be able to
- **connect wires or DC cables to MC4 connectors.**

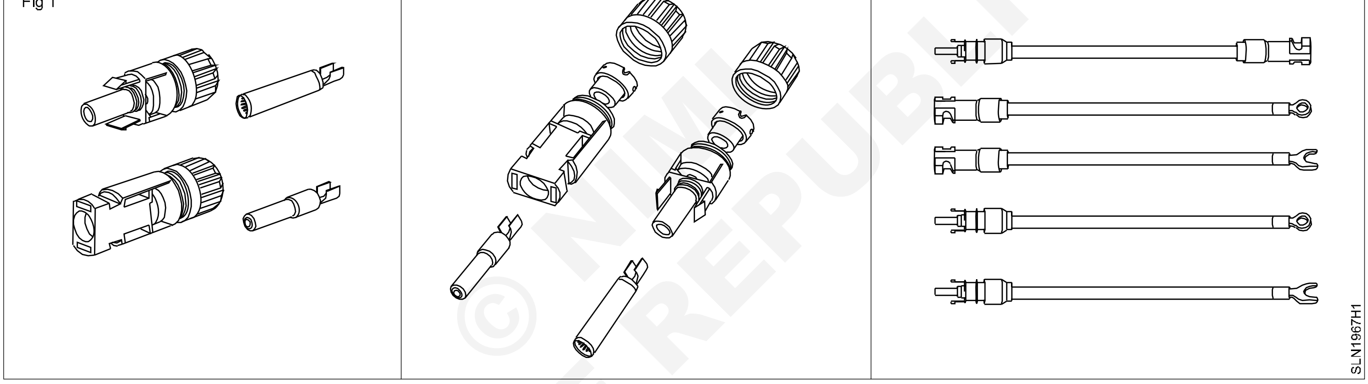
Requirements

Tools/Measurements/Equipments

- MC 4 connectors
- DC cables
- Wires
- Tools kit with crimping tool
- Soldering iron 25 W

TASK 1 : **Connecting MC 4 connectors**

Fig 1



Caution: DC volt more than 70 volts prove very dangerous. Once solar panels are exposed to sunlight they start generating DC volt.

1 Study the pictures to familiarize with assembly parts of MC4 connectors

2 Practice connecting the MC4 connectors on Red and Black DC cables suitably selected

3 Practice extension of Solar panel output wires as per requirement

4 Where panel terminal junction box do not have OEM output cables select suitable colour coded cables and on one end MC4 connectors. On another ends solder to the relevant terminals on the panel junction box

- - - - - - - - - - -

Connect Solar panels in series and perform V, I measurements

Objectives: At the end of this exercise you shall be able to
- **test series connected solar panels.**

Requirements

Tools/Measurements/Equipments

- 10 Wpoly crystalline module 4 nos
- DC load bank
- DC Voltmeter comparable with specifications of module
- DC Ammetercomparable with specifications of module
- DC watt meter
- MC connectors
- Connecting wires and DC cables

PROCEDURE

TASK 1 : **Test 4 nos of 10 W solar panels connected in series**

1 Follow the procedure of 1.9.67. Task 1 and prepare MC 4 connector and DC cables ready (Fig 1)

2 Connect the 4 X 10 W panels in series

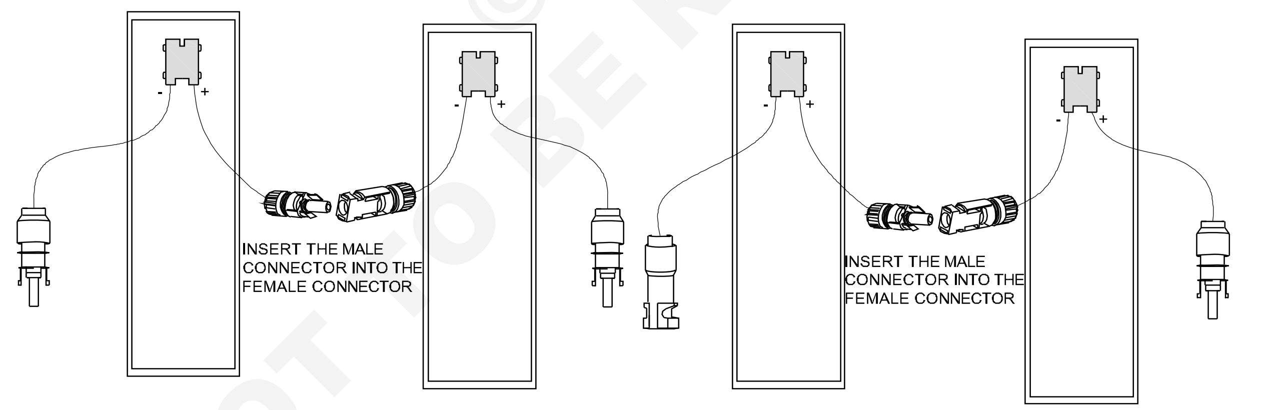
3 Connect suitable load, voltmeter, ammeter and wattmeter. (Fig 2)

4 Keep the panels in sunlight

5 Measure output voltage, current and watt

6 Record the observations

Fig 1



Observations

Watt/Solar PV module = ...Watts

Load condition	Voltmeter reading (V)	Ammeter reading (A)	Wattmeter reading (W)
No load			
Half load			
Full load			

TASK 2: **Test 4 X 40 W Solar panels in series**

1 Replace the 10w PV solar module with 40w PV solar module.

2 Repeat the steps from 2 to 5 of task 1

3 Record the observation in table 2

Observations

Watt/Solar PV module = ...Watts

Load condition	Voltmeter reading (V)	Ammeter reading (A)	Wattmeter reading (W)
No load			
Half load			
Full load			

\- - - - - - - - - - -

Connect Solar panels in parallel and perform V, I measurements

Objectives: At the end of this exercise you shall be able to
- **Test parallel connected solar panels.**

Requirements

Tools/Measurements/Equipments

- 10 Wpoly crystalline module 4 nos
- DC load bank
- DC Voltmeter comparable with specifications of module
- DC Ammetercomparable with specifications of module
- DC watt meter
- MC connectors
- Connecting wires and DC cables

PROCEDURE

TASK 1 : **Test 4 nos of 10 W solar panels connected in parallel**

1 Follow the procedure of 1.9.67 Task 1 and prepare MC 4 connector and DC cables ready.(Fig 1)

2 Additional double ended connectors with one end MC4 connector matched with positive or negative of panel terminals and other end free to do soldering, to facilitate parallel connection are required. (Fig 2)

3 Connect the 4 X 10 W panels in parallel

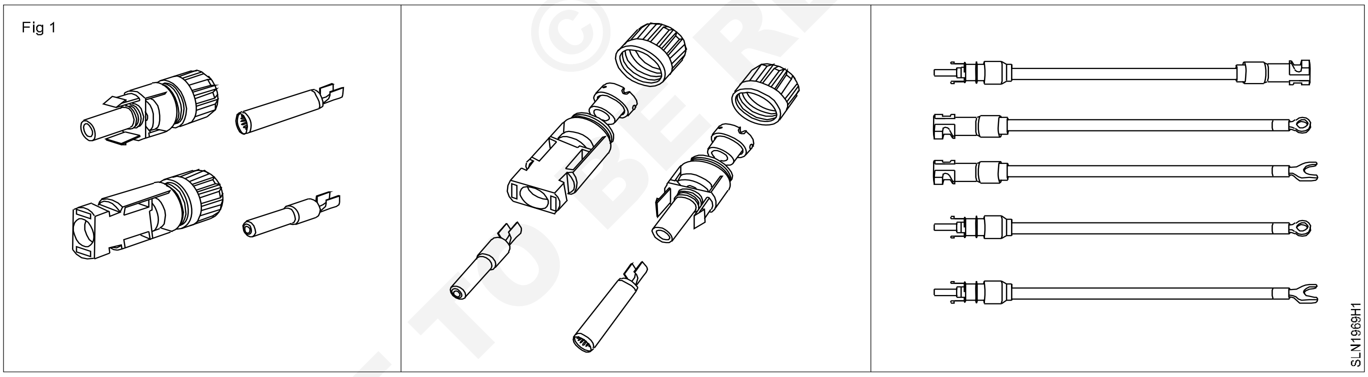
4 Connect suitable load, voltmeter, ammeter and wattmeter. (Fig 3)

5 Keep the panels in sunlight

6 Measure output voltage, current and watt

7 Record the observations in table 1

Fig 1



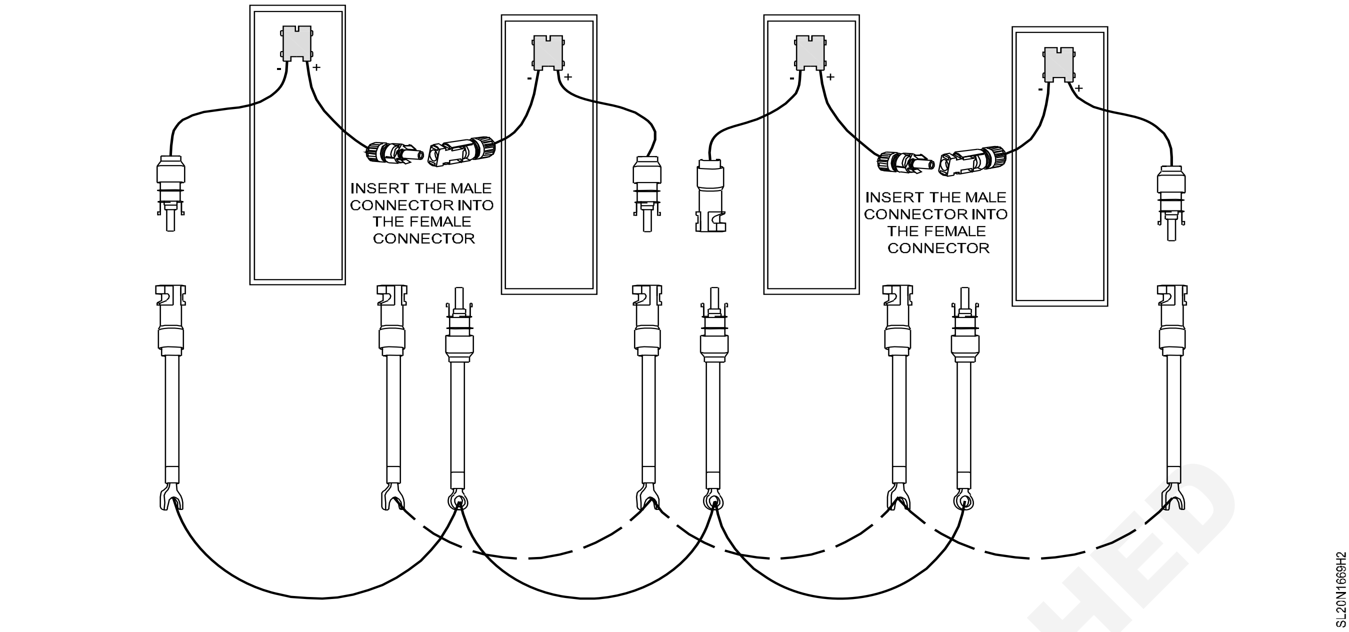
Observations

Table - 1

Watt/Solar PV module = ...Watts

Load condition	Voltmeter reading (V)	Ammeter reading (A)	Wattmeter reading (W)
No load			
Half load			
Full load			

Fig 2



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TASK 2 : **Test 4 X 40 W Solar panels in parallel**

1 Replace the 10w solar panel with 40w solar panel

2 Repeat the steps from 2 to 6 of task 1

3 Record the observations in table - 2

Table - 2

Watt/Solar PV module = ...Watts

Load condition	Voltmeter reading (V)	Ammeter reading (A)	Wattmeter reading (W)
No load			
Half load			
Full load			

Observations:

- - - - - - - - - - -

Shift the panels to rooftop or the place of installation using safe handling practices

Objectives: At the end of this exercise you shall be able to
- **learn to Shift safely the solar panel to other place or to rooftop.**

Requirements	
Tools/Measurements/Equipments	
• solar PV panel	- 250 w

PROCEDURE

TASK 1 : **Learn the method of handling the Solar panel**

1 Plan the steps involved in shifting a 250 W solar panel from ground stairs to roof top where it should be installed

2 Consider the weight of the panel and the number of people required etc

3 Perform the plan

- - - - - - - - - - -

Check the structural and area requirement for installation of 1 KW solar panel

Objectives: At the end of this exercise you shall be able to
- **identify the actual work spot and assess the feasibilities**
- **identify the places to position the different components and draw a plan**
- **foresee the difficulties that may arise after landing in the work place**
- **identifying the shadow causing areas that may vary the power output later on**
- **calculating the space requirement as per the work order**
- **identifying requirement of additional special tools or services specific to the work place.**

Requirements

Tools and Equipments

- 50-100 ft. measuring tape
- Solar Pathfinder
- Compass
- Maps
- Clinometers
- Spirit level
- Digital camera
- Or Android mobile with the apps for most of the above installed

PROCEDURE

TASK 1 : **Inspect the rooftop or field before starting installation**

1 Draw a rough layout of the rooms in entire building

2 Prepare a layout of the rooftop

3 Mark spots with existing generator/inverter

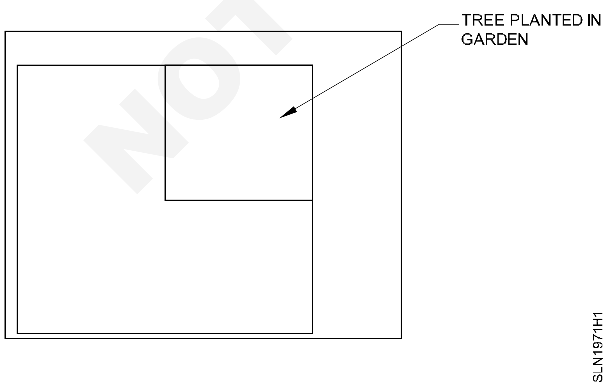
4 Mark nearest points for MCB or grid meter line

6 Note down any shaded places or possible for shade in future

7 Note down dry place for installing solar PCU

8 Locate North and South poles

Fig 1



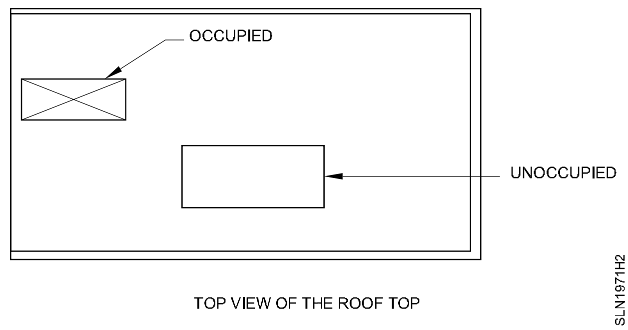
9 Draw a layout of the roof

10 Mark areas available for installation and occupied areas

11 Sketch all occupied and unoccupied areas available with dimensions

12 Mark true south direction

Fig 2



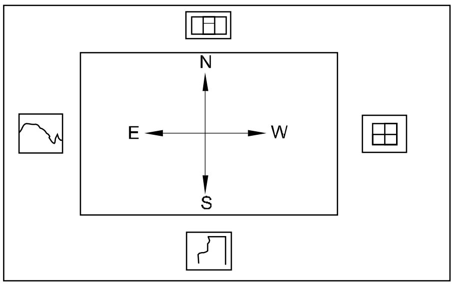
13 Mark obstructions that can cause shadows

14 click and mark photographs of the most suited spot on the roof for installing PV array

15 Take photographs in N/S/E/W directions

16 Note down obstacles to find out suitable spots

Fig 3



SLN1971H3

17 Take site photographs

18 Take photographs of the building, site and adjacent places to the site

19 Mark location of components

20 PCU and Battery

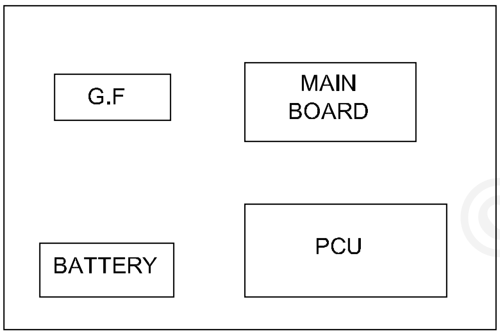
21 Shaded locations with ventilation

22 Preferable outside the building

23 No water spilling or rain water wetting

24 Theft safety

Fig 4



SLN1971H4

25 PV array

26 Type of roof

27 Selection of mount suitable for roof

28 Roof condition and strength; if required do structural analysis by experts

29 Slope or orientation of roof

30 Access restriction for work, approach and safety during installation as well as maintenance

31 Perform shadow analysis

32 Select 110 sqft or 10 sq meter area for a 1 KW installation and mark

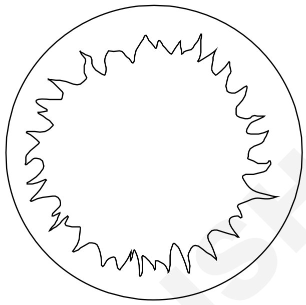
33 Draw a sketch

34 Do shadow analysis

35 Use Solar shading paper tool for the given location and use Sun path finder

36 Take photograph of resulted image

Fig 5



SUN PATH FINDER

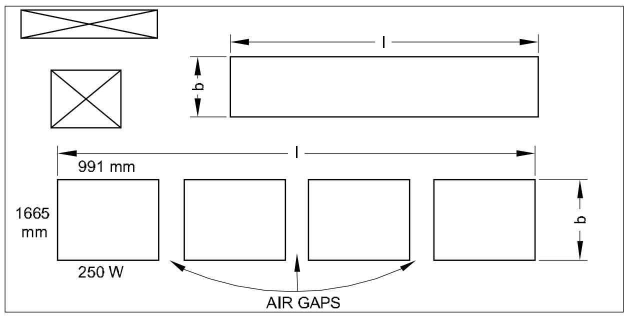
SLN1971H5

37 Assess area

38 Roughly 110 sqft or 10 sq meter area110 sqft or 10 sq meter area is required for a 1 KW installation. Accordingly assess the site and recommend for more capacity. This will benefit the business as well as customer.

39 Even otherwise you can keep a plan for future expansion

Fig 6



SLN1971H6

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Power — Exercise 1.6.72

Solar Technician (Electrical) - Characteristics of Photovoltaic cells, Modules, Batteries and Charge controllers and DC appliances of solar PV

Identify different solar panels as per specification

Objectives: At the end of this exercise you shall be able to
- **study blue print and select components.**

Requirement
Tools and Equipments • Blue print or plan • Bill of materials • Set of solar panels

PROCEDURE

TASK 1 : **Select the right solar panel as per blue print**

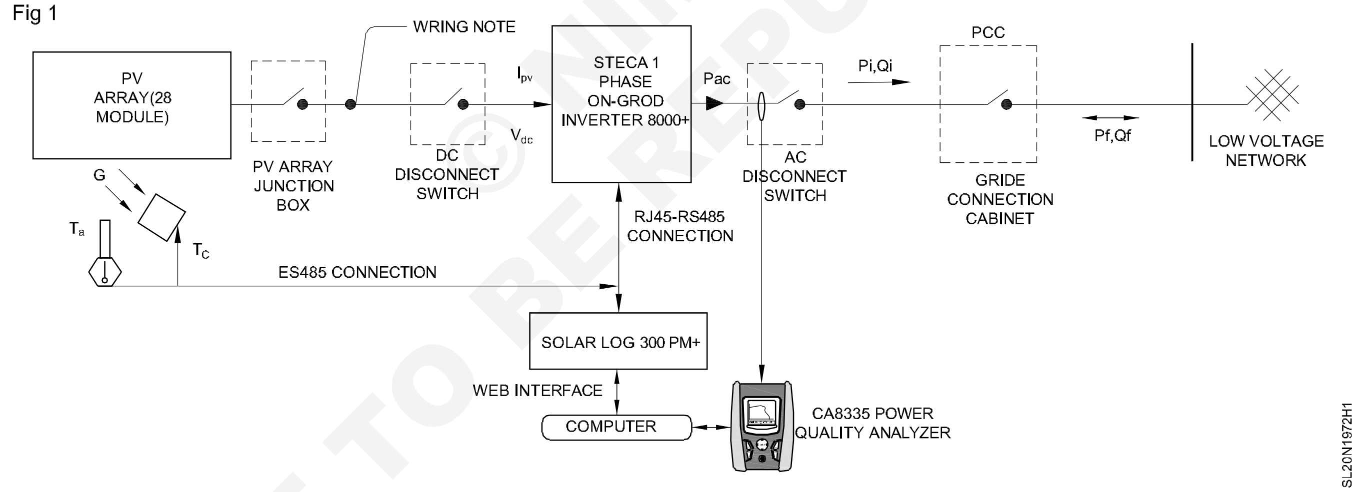
1 Study the blue print or plan chart given for installation work

2 Go through the specifications of the solar panel

3 Analyse the specification available on the backside of panels in store

4 Select the right panel matching the plan and bill of material

Fig 1



Technical Specifications

Solar PV Modules	300Wp (45V,8.36A)
PV Mounting Structure	Fixed type with landscape panel arrangement
Inverter	300W Grid Tied Inverter, SIngle Phase
Power Meter	Meco Imstruments PG08 - Can be used to measure Voltage, Current,Instantaneous Wattage. Watt hours, Power Factor, Co2 savings,Frequency and usage hours
Analog Meter	To measure DC specifies of solar PV Input
Loads	100W bulbs controllable with rheostat for testing, Universal load output point

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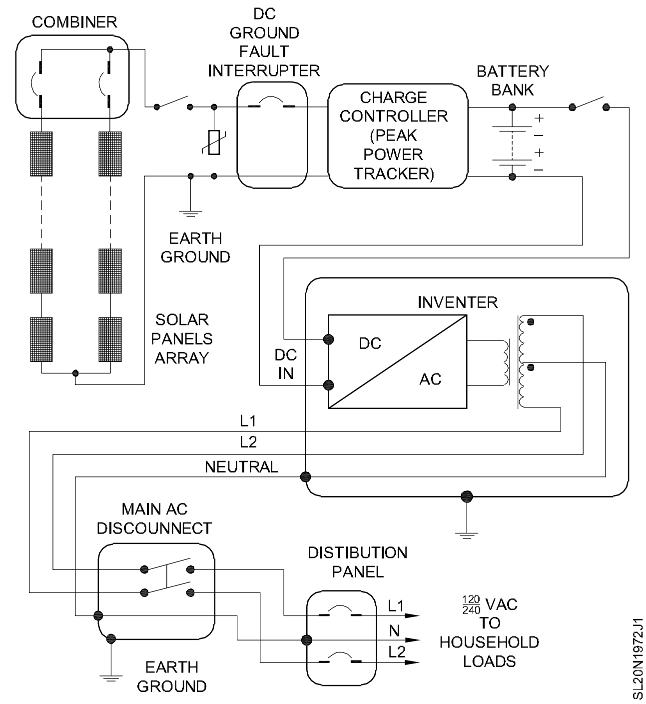
TASK 2 : **Repeat task 1 for following Schematic diagram and Technical inputs**

Fig 1



Technical Specifications

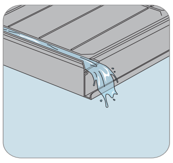
Solar PV Modules	250Wp (35V,7.14A) - 4 Nos
PV Mounting Structure	Adjustable type for Inclination angle
Array Junction Box	16A DC MCB - 4 Nos
Charge Controller	MPPT Type for 25-50V Input, 24V 40A Output
Inverter	1KVA Sine Wave type with UPS and Inverter mode
Solar Battery	SMF Type - 12V 100Ah,C10 type - 4 Nos
Loads	200W bulbs controllable with rheostat for testing Universal load output point

- - - - - - - - - - -

Compare different types of solar panels and prepare a report

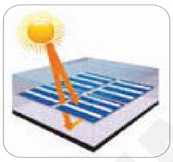
Objectives: At the end of this exercise you shall be able to
- **compare the product catalogues of solar panels and select a suitable one.**

Photovoltaic module
VBHN245SJ25
VBHN240SJ25



Water drainage frame
- Rain water is drained off the module surface.
- This avoids not only water accumulation, but also water stains after drying.
- Even in low-angle installations, water drainage corners keep the module clean.

Power from both sides
- HIT cells generate solar electricity simultaneously on the front and on the back side.
- This additional amount of light is combined with the light taken up by the front side of the module.



Vertically integrated factory
- Efficient production flow improves product quality as entire process from wafer to cell is done at the same location.
- No risk of damage of individual components during transportation between factories.

19.4%*
194 W/m²

*VBHN245SJ25

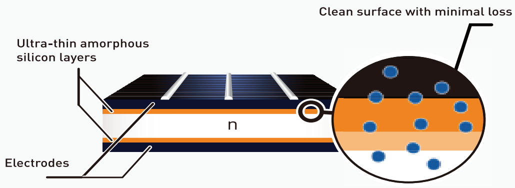
Cell technology
Our solar cell is made of a thin monocrystalline silicon wafer surrounded by ultra-thin amorphous silicon layers. This product offers the industry's leading performance and value, using state-of-the-art manufacturing techniques.

Quality
Panasonic is truly committed to quality since it began developing and manufacturing solar PV technology in 1975. Our long track record is supported by our claim-rate of less than 0.005% failure rate after more than 10 years experience in Europe (as of May 2017)

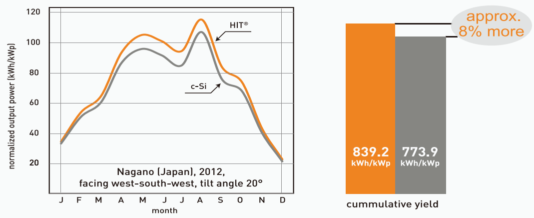
Special features
The solar modules are 100% emission free, have no moving parts and produce no noise. The dimensions of the HIT modules enable a space saving installation and the achievement of maximum output power possible on a given roof area.

High performance at high temperatures
With its very low temperature coefficient of only -0.258 %/°C, our solar cell can maintain a higher efficiency than a conventional crystalline silicon solar cell, even at high temperatures.

Solar cell structure



Yield comparison



Model	Cell efficiency	Module efficiency	Output/m²
VBHN245SJ25	22.0%	19.4%	194 W/m²
VBHN240SJ25	21.6%	19.0%	190 W/m²

Electrical and Mechanical Characteristics

VBHN245SJ25,VBHN240SJ25

Electrical data (at STC)

	VBHN245SJ25	VBHN240SJ25
Max. power (Pmax) [W]	245	240
Max. power voltage (Vmp) [V]	44.3	43.6
Max. power current (Imp) [A]	5.54	5.51
Open circuit voltage (Voc) [V]	53.0	52.4
Short circuit current (Isc) [A]	5.86	5.85
Max. over current rating [A]	15	
Production tolerance power [%]	+10/0*	
Max. system voltage [V]	1000	

Note: Standard Test Conditions: Air mass 1.5; Irradiance = 1000W/m²; cell temp. 25°C
*Each panel output is measured by Panasonic at the time of production.

Temperature characteristics

Temperature (NOCT) [°C]	44.0	
Temp. coefficient of Pmax [%/°C]	-0.258	
Temp. coefficient of Voc [V/°C]	-0.125	-0.123
Temp. coefficient of Isc [mA/°C]	3.22	3.22

At NOCT (Normal Operating Conditions)

Max. power (Pmax) [W]	187.3	183.9
Max. power voltage (Vmp) [V]	42.7	42.1
Max. power current (Imp) [A]	4.46	4.44
Open circuit voltage (Voc) [V]	50.2	49.6
Short circuit current (Isc) [A]	4.74	4.73

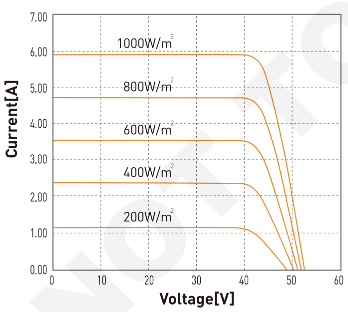
Note: Nominal Operating Cell Temp.: Air mass 1.5; Irradiance = 800W/m²;
Air temperature 20°C; wind speed 1 m/s

At low irradiance (20%)

Max. power (Pmax) [W]	46.8	45.9
Max. power voltage (Vmp) [V]	42.7	42.2
Max. power current (Imp) [A]	1.10	1.09
Open circuit voltage (Voc) [V]	49.6	49.0
Short circuit current (Isc) [A]	1.17	1.17

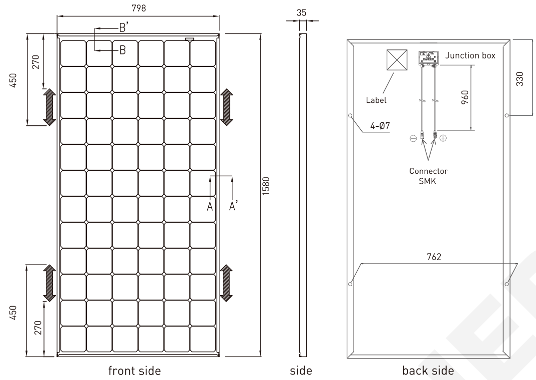
Note: Low irradiance: Air mass 1.5; Irradiance = 200W/m²; cell temp. = 25°C

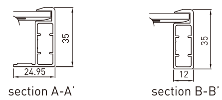
Dependence on irradiance



Reference data for model VBHN245SJ25

Dimensions and weight





weight:15 kg
weight/m²:11,9 kg/m²
unit:mm

Warranty

Power output: 25 years linear
[1st year 97%, from 2nd year -0.45%/year, in 25th year 86.2%]
[Measurement Tolerance ±3%]
Product workmanship: 10 years (based on warranty document)

Materials

Cell material:	5 inch HIT cells
Glass material:	AR coated tempered glass
Frame materials:	Black anodized aluminium
Connectors type:	SMK

Certificates

APPROVED PRODUCT
Certificate No. MCS PV0034
Photovoltaic System

IEC61215
IEC61730-1
IEC61730-2

RoHS COMPLIANT

IEC61701
salt mist corrosion
Severity 6

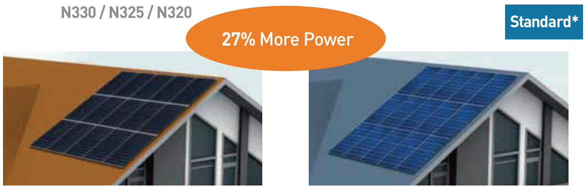
CE

Electrical Protection
Class II

Photovoltaic module
VBHN330SJ47/VBHN325SJ47/VBHN320SJ47

19.7% module efficiency

Enables reaching a higher output and lower specific installation and balance-of-system costs than with the same number of standard 60-cell modules.



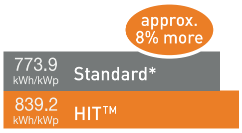
HIT™: 15pcs x 330W=4.95kW **VS** Standard* : 15pcs x 260W = 3.90kW

100% design

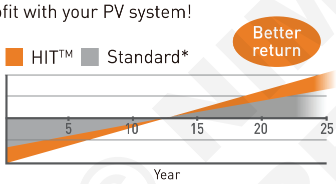
Proudly featuring original invention, the heterojunction solar cell.
With over 1 billion cells produced commercially over 20 years, 27 years after the breakthrough in the development and looking back to over 42 years of experience in solar, Panasonic really offers you a 25-year guarantee you can trust.

More energy, higher profit!

Helping you reach a higher final profit with your PV system!



Measured in Nagano (Japan) 2012



330W / 325W / 320W

High Efficiency + High Performance at High Temperatures = High Power Generation

QUALITY PROVEN 4 WAYS

1 Quality

- IEC and over 20 Panasonic internal tests
- Vertically integrated own manufacturing (wafer, cell and module)

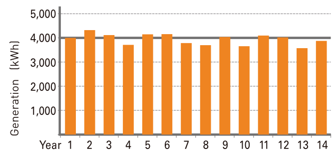
2 Record low claim rate

Less than 0.005% failure rate after more than 10 years experience in Europe (as of May 2017)

3 Less degradation on the field

14 years actual data prove a reliable and stable performance.

Installation: July, 2002
System size: 3.34kW
Location: Hyogo pre., Japan
Model: HIP-G751B1 [167W]
Direction: South



4 3rd Party verified

- Lifecycle testing (Long-Term-Sequential-Test) by TÜV Rheinland (tested on VBHN240SE10)
- PID-free (tested by Fraunhofer Institute)

Electrical and Mechanical Characteristics

VBHN330SJ47/VBHN325SJ47/VBHN320SJ47

Electrical data (at STC)

	VBHN330SJ47	VBHN325SJ47	VBHN320SJ47
Max. power (Pmax) [W]	330	325	320
Max. power voltage (Vmp) [V]	58.0	57.6	57.3
Max. power current (Imp) [A]	5.70	5.65	5.59
Open circuit voltage (Voc) [V]	69.7	69.6	69.4
Short circuit current (Isc) [A]	6.07	6.03	5.98
Max. over current rating [A]		15	
Power tolerance [%]		+10/-0 *	
Max. system voltage [V]		1000	
Solar Panel efficiency [%]	19.7	19.4	19.1

Note: Standard Test Conditions: Air mass 1.5; Irradiance = 1000W/m²; cell temp. 25°C
* Maximum power at delivery. For guarantee conditions, please check our guarantee document.

Temperature characteristics

Temperature (NOCT) [°C]	44.0	44.0	44.0
Temp. coefficient of Pmax [%/°C]	-0.258	-0.258	-0.258
Temp. coefficient of Voc [V/°C]	-0.164	-0.164	-0.163
Temp. coefficient of Isc [mA/°C]	3.34	3.32	3.29

At NOCT (Normal Operating Conditions)

Max. power (Pmax) [W]	253.5	249.3	245.2
Max. power voltage (Vmp) [V]	56.5	56.1	55.7
Max. power current (Imp) [A]	4.56	4.52	4.47
Open circuit voltage (Voc) [V]	66.0	65.9	65.7
Short circuit current (Isc) [A]	4.91	4.88	4.84

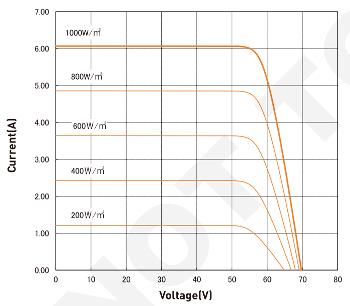
Note: Normal Operating Cell Temp.: Air mass 1.5; Irradiance = 800W/m²;
Air temperature 20°C; wind speed 1 m/s

At low irradiance (20%)

Max. power (Pmax) [W]	63.5	62.3	61.0
Max. power voltage (Vmp) [V]	57.0	56.4	55.9
Max. power current (Imp) [A]	1.12	1.11	1.10
Open circuit voltage (Voc) [V]	65.6	65.3	64.9
Short circuit current (Isc) [A]	1.22	1.21	1.20

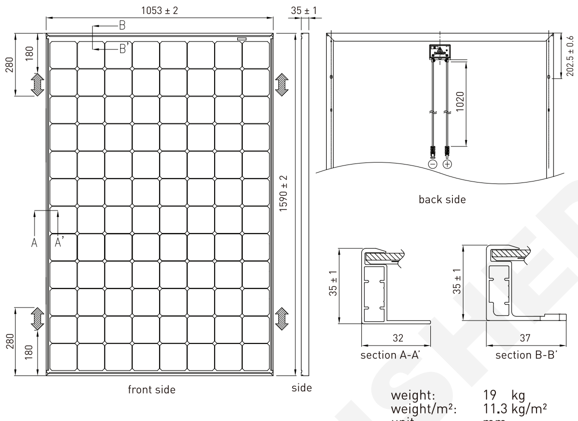
Note: Low irradiance: Air mass 1.5; Irradiance = 200W/m²; cell temp. = 25°C

Dependence on irradiance



Reference data for model
VBHN330SJ47
(Cell temperature: 25°C)

Dimensions and weight



weight: 19 kg
weight/m²: 11.3 kg/m²
unit: mm
Snow and Wind Load: 2400 Pa

Warranty

Power output: 25 years linear
[1st year 97%, from 2nd year -0.45%/year, in 25th year 86.2%]
[Measurement Tolerance ±3%]
Product workmanship: 10 years (based on warranty document)

Materials

Cell material: 5 inch photovoltaic cells
Glass material: AR coated tempered glass
Frame materials: Black anodized aluminium
Connectors type: SMK

Certificates

IEC61215
IEC61730-1
IEC61730-2

Electrical Protection Class II

IEC61701
salt mist corrosion
Severity 6

Please consult your local dealer for more information

⚠ CAUTION! Please read the installation manual carefully before using the products.

Used electrical and electronic products must not be mixed with general household waste. For proper treatment, recovery and recycling of old products, please take them to applicable collection points in accordance with your national legislation.

Power **Exercise 1.6.74**

Solar Technician (Electrical) - Characteristics of Photovoltaic cells, Modules, Batteries and Charge controllers and DC appliances of solar PV

Charge solar battery using battery charger by CC and CV methods

Objectives: At the end of this exercise you shall be able to
- **charge the solar battery using CC and CV methods and observe its characteristics.**

Requirements

Tools and Equipments

- Solarbattery rated 12V, 100 Ah
- Battery charger

PROCEDURE

TASK 1: **Charge a solar battery by CV method**

1 Connect positive and negative terminals of the Solar battery to the output terminals of the Battery charger

2 Switch ON the battery charger and keep the output switch OFF

3 Set the voltage to 12 V

4 Switch ON the output switch

5 Note down the voltage and current readings

6 Adjust the Voltage to 12 V if it has dropped down below 12 V

7 Keep watching the display for voltage drop and adjust to maintain 12 V for the charging cycle period

8 Refer the manual/ leaflet supplied with the battery for charging cycle

9 Confirm the Voltage on Battery building up

10 Charge may continue longer for 5 hrs/10 hrs/20hrs as guided in the manual

11 After the stipulated time disconnect the terminals and test the battery

12 If more charge required repeat the above steps and charge fully. Charge up to 85% is sufficient.

- - - - - - - - - - -

TASK 2 : **Charge a solar battery by CC method**

1 Connect positive and negative terminals of the Solar battery to the output terminals of the Battery charger

2 Switch ON the battery charger and keep the output switch OFF

3 Set the voltage to 12 V

4 Switch ON the output switch

5 Note down the voltage and current readings

6 Adjust the Voltage to 12 V if it has dropped down below 12 V.

7 Set the current for recommended C-rating normally 5A/10A

8 Keep watching the display for voltage drop and adjust to maintain C-rating for the charging cycle period

9 Refer the manual/ leaflet supplied with the battery for charging cycle, C-rating etc.

10 Confirm the Voltage on Battery building up

11 Charge may continue longer for 5 hrs/10 hrs/20hrs as guided in the manual

12 After the stipulated time the charging current won't rise above a minimum value. Then disconnect the terminals and test the battery

13 If more charge required repeat the above steps and charge fully. Charge up to 85% is sufficient.

- - - - - - - - - - -

Discharge Solar battery using DC load

Objectives: At the end of this exercise you shall be able to
- **observe during discharge of the solar battery its characteristics.**

Requirements

Tools and Equipments

- Solar battery rated 12V, 100 Ah (Fully charged)
- Variable DC load – wire wound resistance with watt rating equivalent or more that C rating of the battery
- Voltmeter
- Ammeter

PROCEDURE

TASK 1: **Test the discharge cycle of the Solar battery**

1 Connect the DC load to the fully charged Solarbattery rated 12V, 100 Ah through the ammeter in series.

2 Connect the Voltmeter across the terminals of the battery and switch ON

3 Note down the ammeter reading and adjust the load to maintain C –rating value

4 In equal time intervals adjust the load to maintain C –rating value

5 Stop discharging once the voltage drops below 25%

6 Disconnect and check hours of discharging matches the desired hours as rated

Notes:

- - - - - - - - - - -

Compare specifications of Solar batteries of different makes and select

Objectives: At the end of this exercise you shall be able to
- **compare the different brand batteries and select a one.**

Requirements

Tools and Equipments

- Manuals, product profiles and leaflets supplied with batteries from at least 5 different manufacturers

PROCEDURE

TASK 1 : **Select a right Solar battery**

1 Study the various features from the available reference profiles

2 Fill up the comparative chat

3 Analyse the product for better performance

4 Select the best one on competitive price

Observation

Particular	Brand 1	Brand 2	Brand 3	Brand 4	Brand 5
Voltage					
Ampere hour (Ah)					
State of charge (SOC)					
Depth of Dis-charge (DOD)					
Efficiency					
C-rating					

Recommendations:

Connect Solar PV DC power supply circuit

Objectives: At the end of this exercise you shall be able to
- **connect the components of a daylight solar PV system.**

Requirements

Tools and Equipments

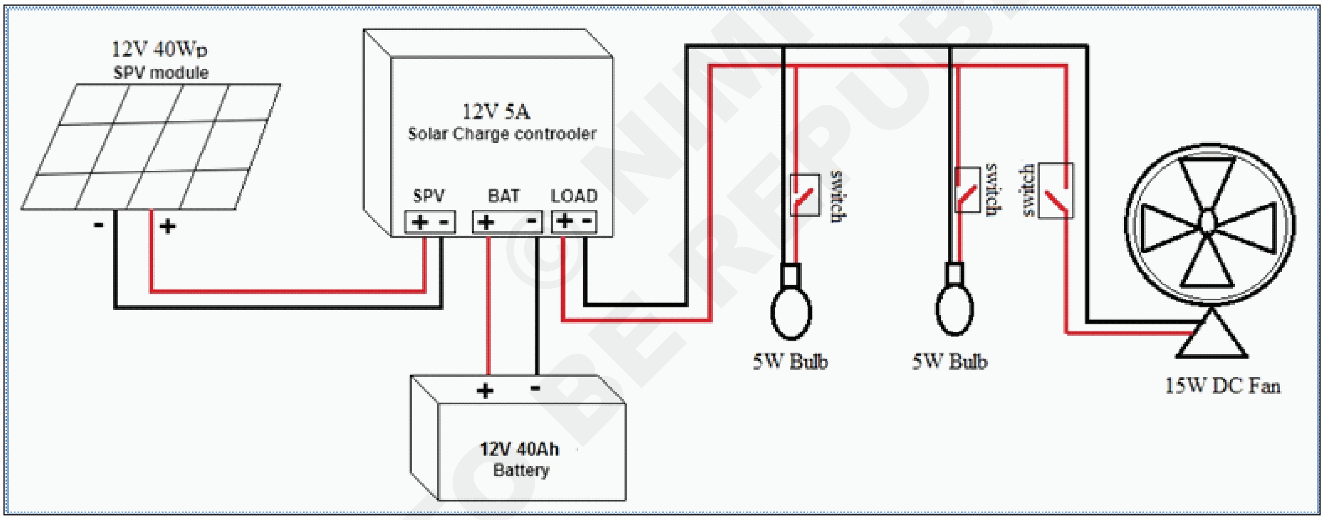
- Daylight Chargecontroller (12V, 10A)
- Solar battery (12V, 100Ah)
- Solar panel (75W)
- DC load (12V): LED light 3W / 5W, DC Fan & FM radio

PROCEDURE

TASK 1 : **Test a DC application of a Solar PV Panel**

Circuit diagram

Fig 1



1 Connect the components as per the diagram
2 Keep the Solar panel in Sunlight
3 Switch ON the daylight Charge controller
4 Check the indications in the charge controller for normal functioning
5 Switch ON the load one by one and verify their working
6 Record the observations

Observations:

Test the charge controller working with the above circuit and study the performance

Objectives: At the end of this exercise you shall be able to
- **verify the performance of charge controller in daylight solar PV system.**

Requirements

Tools and Equipments

- Daylight Chargecontroller (12V, 10A)
- Solar battery (12V, 100Ah)
- Solar panel (75W)
- DC load (12V): LED light 3W / 5W, DC Fan & FM radio

- Repeat the steps 1 to 6 of 1.9.77, task 1
- Now switch off the daylight charge controller and follow the steps of 5 & 6
- Record the observations

Observations:

- - - - - - - - - - -

Construct home lighting system using solar panel

Objectives: At the end of this exercise you shall be able to
- **connect a DC home lighting Solar PV system**
- **mount solar panel in rooftop for home lighting system.**

Requirements

Tools and Equipments

- Solar PV panel mounting structure
- DC cables, PVC conduit pipes, tools etc
- Daylight Chargecontroller (12V, 10A)
- Solar battery (12V, 100Ah)
- Solar panel (75W)
- DC load (12V): LED light 3W / 5W, DC Fan & FM radio
- Sockets, switches etc

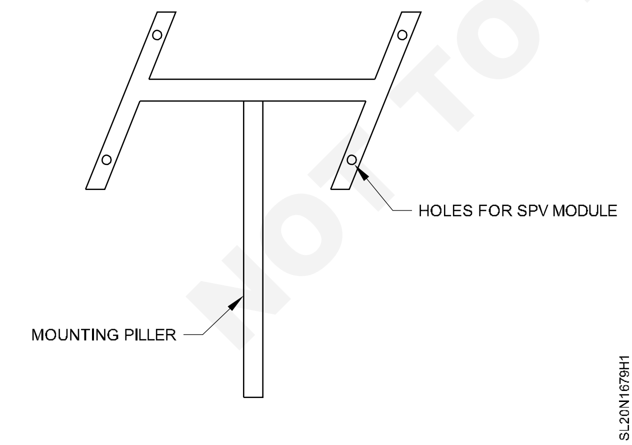
PROCEDURE

TASK 1 : **Fix the mounting structure for solar PV panel**

Small Solar home lighting systems are installed either in house, temple or farm houses etc. Since Small Solar home lighting system uses the sun light as the source of energy, the place of installation of SPV module must be

1 Free from shadows caused by the trees
2 Free from shadows caused by the buildings or any erected structures
3 Place must be appropriate for the fixing the mounting structure
4 Near to the Battery and charge controller

Fig 1



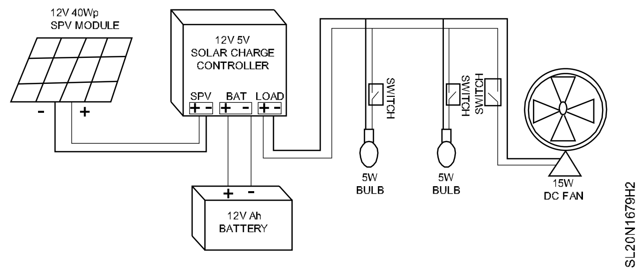
Mounting structures are:

- used to mount the panels in the particular direction and azimuth angles
- made up of steel with rust resistance paint.
- a metal frame with the pillar
- needs a proper wall, Pillar or Foundation with cement concrete
- the installation of the mounting structure shall be
- Perpendicular to the earth surface
- SPV surface inclined towards True south with proper inclination angle
- Once these conditions meet, the mounting structure is fixed with nails or cement concrete.
- Install the mounting structure in properly selected place on rooftop or field as guided
- Mount the Solar PV panel on the structure
- Connect DC cables to the panel
- Draw the cable through the conduit pipes and bring to the control box
- Fix the Charge controller, main control switch and output terminal box on the Control box.
- Connect the Charge controller, output switch and output terminal box
- Wire the required lighting layout and connect the DC loads
- Keep the output switch OFF
- Connect the Solar panel output to the input of Charge controller
- Check all wiring, polarities etc are correct
- Remove any errors in the above connections
- Switch ON the output switch

- Test the load one by one by the individual control switches
- Record the observations

Circuit diagram

Fig 2



Observations:

- - - - - - - - - - - -

Construct a Solar Mobile handset charger

Objectives: At the end of this exercise you shall be able to
- **connect solar mobile charger.**

Requirements

Tools and Equipments

- 0.5 Watt Solar Panel.
- 2xAA Rechargeable Batteries
- 2xAA Battery Holder
- Mini Slide Switch SPDT
- Mini Breadboard.
- DC to DC Booster Circuit: 0.9V to 5V Circuit.
- N914 Diode.
- Jumper Wires
- LEDs different colours
- Solid Core Wire

PROCEDURE

TASK 1 : **Test a solar powered mobile handset charger**

- Solder the components on to the bread board
- Connect in the output circuit positive terminal of DC to booster to the anode of the diode with the cathode pointing the output positive terminal
- Connect negative terminal – booster output to charger's output negative terminal
- Connect Mini Slide Switch SPDT in the output circuit and then to the 2xAA Battery Holder
- Connect output USB socket to the output of 2xAA Battery Holder
- Connect the 0.5 Watt Solar Panel to the input of booster considering the polarities
- Connect the LEDS in the input and output of the booster to indicate Solar ON and charger ON
- Connect third LED after SPDT switch to indicate output ON
- Place the 2xAA Rechargeable Batteries in the 2xAA Battery Holder
- Place the Solar panel in sunlight and verify solar ON and Charger ON
- Switch ON the SPDT switch and verify output ON
- Connect the USB cable to mobile and charger output
- Verify mobile getting charged
- Record the observations

Observations:

\- - - - - - - - - -

Construct solar DC power supply using Dusk to dawn charge controller

Objectives: At the end of this exercise you shall be able to
- **connect a dusk to dawn solar PV system.**

Requirements

Tools and Equipments
- Solar PV module,75W
- LED lamp 12V DC, 5W
- Dusk to Dawn charge controller 12V, 10A
- Solar battery, 12V, 100Ah

PROCEDURE

TASK 1 : **Test a dusk to dawn charge controller using other essential components**

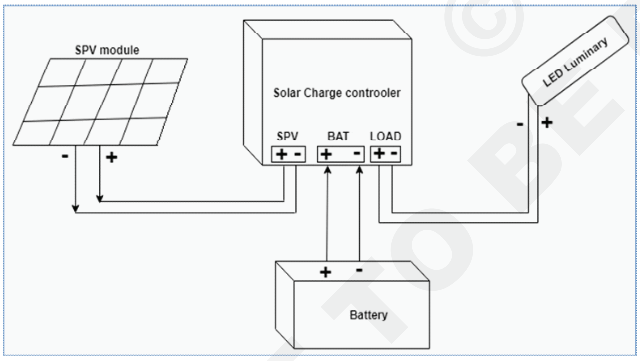
Note

The SPV Module receives solar energy and converts it into electrical energy.

Converted electrical energy is stored in the battery through solar charge controller

When the light intensity reduced to about 10 lx during sun set, charge controller will turn ON the LED Light

Fig 1



Battery provides the energy to luminary and discharges as time passes

When sun rises again next morning the charge controller will turn off the LED Light

During night if battery voltage reduces below its critical value the charge controller will turn off the LED light to protect battery from deep discharge.

1 Connect the Solar battery 12V/100Ah to the battery input terminals of the Dusk to Dawn charge controller 12V/10A

2 Connect LED lamp 12V DC/5W to the output terminals of the Dusk to Dawn charge controller

3 Connect the Solar PV module,75W to the solar input terminals of the Charge controller

4 Place the solar panel in sunlight

5 Check the indication in charge controller showing the battery charging going ON

6 After the charging is complete the indication shows intermittent

7 Observe at sunset when it becomes dark the LED automatically lights ON

8 Alternatively, during daylight if testing is required then the positive input terminal from Panel to charge controller can be disconnected to see the LED automatically lights ON.

Observations:

- - - - - - - - - - -

Construct a solar lantern.

Objectives: At the end of this exercise you shall be able to
- **assemble, test, install and maintain solar Lantern.**

Requirements

Tools and Equipments

- Solar PV panel (15W)
- Charge controller (6V, 5A)
- Output control circuit for variable illumination
- Rechargeable battery (6V, 7Ah)
- DC LED lamp (5W)
- Lantern assembly kit

PROCEDURE

TASK 1 : **Assemble, test, install and maintain solar Lantern**

1 Fix the LED bulb to the holder

2 Fix the LED bulb – holder assembly to the Top cover of the Lantern

3 Connect the wires one end to the Bulb holder and other end to the output of "Output control circuit for variable illumination'

4 The Rechargeable battery and Output control circuit to the corresponding terminal points on Charge controller

5 Fix the Rechargeable battery in the Bottom piece of the Lantern

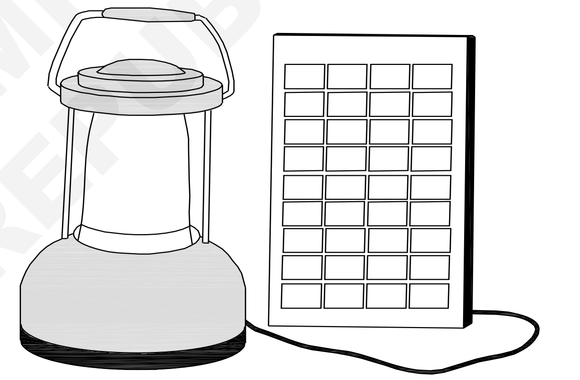
6 Fix the Charge controller and the output control circuit board

7 Complete the assembly

8 Place the solar panel in sunlight and test the kit

9 Record the observations

Fig 1



Observations:

- - - - - - - - - - -

Construct a day-lighting Solar PV system

Objectives: At the end of this exercise you shall be able to
- **install and test Manual Day lighting Solar System.**

Requirements

Tools and Equipments

- Manual charge controller (12V, 10A)
- Solar battery (12V, 100Ah)
- Solar panel (75 W)
- 4X LED light (12V DC, 5W)
- Sockets, switches, wires as necessary

PROCEDURE

1 Wire the load circuit using conduit pipes, Sockets, switches, wires etc in parallel connection. Take care of polarities

2 Keep the switches in OFF positions

3 Connect the LED bulbs

4 Verify the charge controller is in OFF position

5 Connect the load wires positive and negative to the corresponding output ports on charge controller

6 Connect the fully charged Solar battery (12V, 100Ah) to the battery input terminals of charge controller

7 Connect the Solar panel (75 W) to the solar input-terminals of charge controller

8 Place the solar panel in sunlight

9 Check charging 'LED' is ON

10 Switch ON the charge controller

11 Verify output LED is ON

12 Switch ON LED bulbs one by one and test the Day lighting circuit

Observations:

- - - - - - - - - - -

Construct solar garden light using Dusk to dawn charge controller

Objectives: At the end of this exercise you shall be able to
- **install and test Garden lights using solar power.**

Requirements

Tools and Equipments

- Dusk to dawn charge controller (12V, 10 A)
- Solar battery (12V, 100 Ah)
- Solar panel (75 W)
- 4X LED light (12V DC, 5W)
- Garden lamp assembly 4 sets
- Sockets, switches, wires as necessary

PROCEDURE

1 Wire the load circuit using conduit pipes, Sockets, switches, wires etc in parallel connection. Take care of polarities

2 Keep the switches in OFF positions

3 Connect the LED bulbs

4 Note that the Dusk to dawn charge controller LEDs are OFF.

5 Connect the fully charged Solar battery (12V, 100Ah) to the battery input terminals of Dusk to dawn charge controller

6 Connect the Solar panel (75 W) to the solar input terminals of Dusk to dawn charge controller

7 Place the solar panel in sunlight

8 Check charging 'LED' is ON

9 Connect the load wires positive and negative to the corresponding output ports on Dusk to dawn charge controller

- Verify the LED bulbs are not lighting
- Block the Solar Panel with Black Cloth. Alternately remove one wire of Solar input terminal on Dusk to dawn charge controller. Verify the charge controller gets switch ON after a time delay
- Verify output LED is ON
- Switch ON LED bulbs one by one and test the Garden lighting circuit
- Reconnect one wire of Solar input terminal removed earlier on Dusk to dawn charge controller (Or remove the Black cloth on the panel)
- Verify the LED bulbs going OFF after a time delay
- Assemble the LED bulbs in Garden light assembly
- Install Garden lights
- Record the learning

Observations:

- - - - - - - - - - -

Construct and install Solar Street light

Objectives: At the end of this exercise you shall be able to
- **construct foundation for pole of street light**
- **install and test solar streetlight.**

Requirements

Tools and Equipments

- Civil construction work related tools: crowbar, spade etc
- Marking pen and nail
- Thread
- Measuring tape
- Ruler
- Tool kit
- Safety gadgets
- Solar PV module
- LED lamps
- Light pole
- Control box (charge controller, battery)

Materials

- Gravels, sand, cement as per requirement
- Pole
- Marking
- Digging
- Bar bending
- Filling concrete mix
- Curing concrete

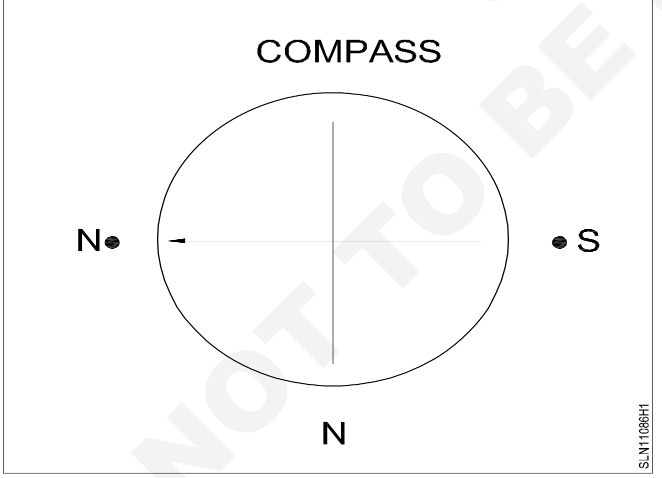
PROCEDURE

TASK 1 : **Marking of street light poles**

1 Use compass and mark true north and south poles

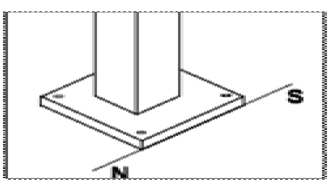
2 Draw line connecting north and south poles points

Fig 1



3 Place the pole mount aligned to the connecting lines

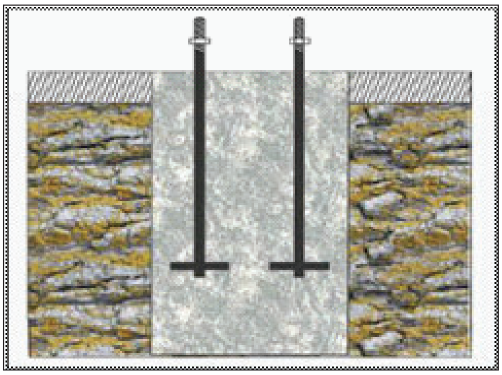
Fig 2



Making foundation on ground

- Mark the base
- Remove the pole mount
- Dig pit (Crater) as per drawing (Example: if Base is 1ft x 1 ft then the crater should be 1ft x 1 ft x 1.5ft as shown)
- Use the wooden stencil of base of the pillar mount
- Fix the bar bended TMT rods with thread on top end on to the stencil
- Keep the assembly in the carter with the stencil on ground level
- Fill in concrete mortar in the pit and allow to harden doing proper curing
- Remove the stencil & fasten the bolts; keep ready for next task

Fig 3



TASK 2 : **Assembly of Street light pole**

1 Assemble the Control box with charge controller and battery inside.

2 Do the wiring from battery to the controller, wires for the lamp and solar panel and bring outside the box

3 Insert the wires through the middle hole in the pole and draw it internally till top hole of the pole

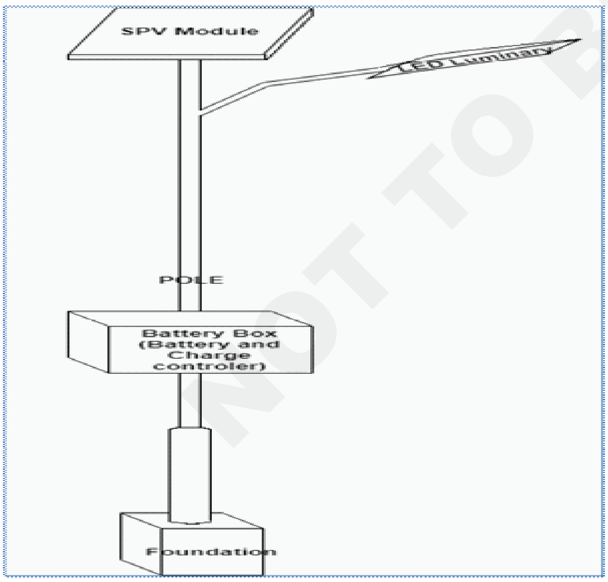
4 Assemble the lamp holder with LED light and fit to the Holding arm.

5 Complete the wiring to the LED lights

6 Fix the Solar panel on to the mounting frame and fit the assembly to the Pole top

7 Complete the assembly and check for dusk to dawn functioning of charge controller

Fig 1



8 Remove any error if so

9 Erect the pole and fit on to the mounting screw on the base made in Task 1

Parts of Typical Solar Street Light (Fig 1)

Luminary Integrated solar LED Street light

Electric connection of the solar street light system

10 Verify the solar panel orientation as shown in the figure above

11 Charging continues in the day time and stops once battery is fully charged

12 In the evening after sunset the LED lamp lights ON

13 Testing we can do by removing one of the panel wire from charge controller and then connecting back

Construct a solar PV powered security system

Objectives: At the end of this exercise you shall be able to
- **install and test Solar security system.**

Requirements

Tools and Equipments

- Manual charge controller rated (12V, 10 A)
- Solar battery (12V, 100 Ah)
- Solar panel (75 W) and Security camera & CCTV/Intruder alarm (12 V DC)

Notes:

- - - - - - - - - - -

Solar Technician (Electrical) - Characteristics of Photovoltaic cells, Modules, Batteries and Charge controllers and DC appliances of solar PV

Construct a Solar DC water pump

Objectives: At the end of this exercise you shall be able to
- **install and test solar DC water pump.**

Requirements

Tools and Equipments

- Manualcharge controller (24 V, 20A)
- Solar battery (2 X 12V, 100Ah)
- Solar panel (250 W)
- DC water pump (24V DC, 10A)
- Bucket of Water
- Inlet and outlet tubes
- Sockets, switches, wires as necessary

(Note: If DC 12 V water pump is available, use Charge controller 12 V 10 A, solar battery 12 V, 100 AHr and Solar panel 75 W)

PROCEDURE

- Wire the load circuit using conduit pipes, Sockets, switches, wires etc. Take care of polarities.
- Keep the switches in OFF positions
- Connect the DC water pump
- Connect water tubes to inlet and outlet mouths of water pump
- Immerse other end of inlet tube inside the bucket of water
- Keep the other end of outlet tube near top of bucket so that the water may fall inside bucket
- Verify the charge controller is in OFF position
- Connect the load wires positive and negative to the corresponding output ports on charge controller
- Connect the fully charged Solar battery bank (2 X 12V, 100Ah connected in series) to the battery input terminals of charge controller
- Connect the Solar panel (75 W) to the solar input terminals of charge controller
- Place the solar panel in sunlight
- Check charging 'LED' is ON
- Switch ON the charge controller
- Verify output LED is ON

Fig 1

- Switch ON the water pump and wait for water to get pumped and flow in the bucket
- If water is not pumped but still pump is ON switch OFF immediately and check for the problem if any. The inlet tube may not immersed in water, or inlet tube may have air block/bubbles inside or the solar panel may be in shade or not giving enough current. Do not 'Dry run' the pump because it may spoil the motor in it.
- Write down the observations

Observations:

- - - - - - - - - - -

Solar Technician (Electrical) - Connect, test, under take maintenance and disposal of solar batteries

Prepare connecting wires for grouping of solar batteries.

Objectives: At the end of this exercise you shall be able to
- **prepare DC cables for solar batteries.**

Requirements

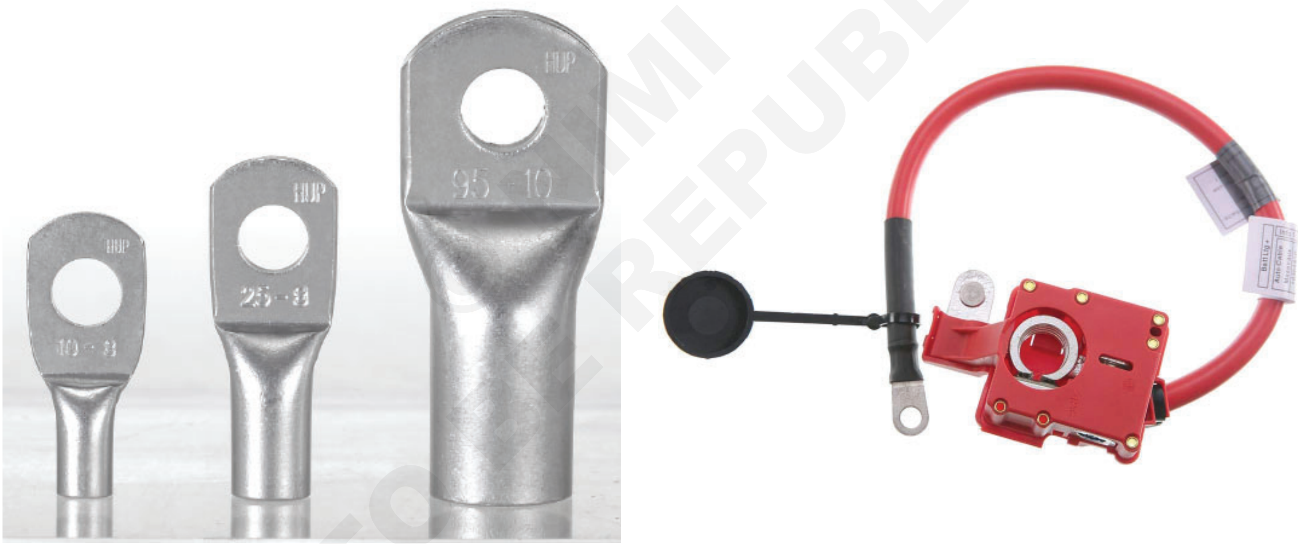
Tools and Equipments

- DC cables
- Connectors/lugs of same size as cables
- Knife
- Crimping tool
- Cutting pliers

PROCEDURE

Connectors used with battery cables

Fig 1



- Measure distance between terminals of two batteries
- Cut DC cables of required length
- Cut Sleeve in the ends using knife
- Insert the connectors or lugs
- Use proper crimping tool and crimp off the ends on connectors
- Cover the ends with black or red tapes or a dot of Paint to identify later polarities

Notes:

- - - - - - - - - - -

Connect two solar batteries (12V, 100Ah each) in series to a 24 V DC pump and Test the Voltage and current in the circuit

Objectives: At the end of this exercise you shall be able to
- **connect and test series connection of solar batteries.**

Requirements

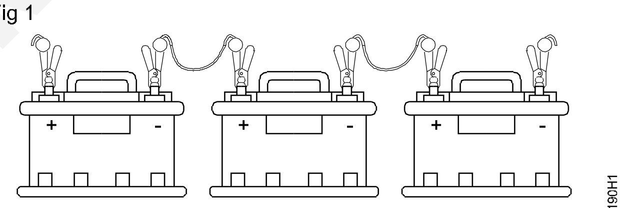
Tools and Equipments

- Solar batteries 12V, 100Ah – 2 No.
- 24 V DC pump
- Voltmeter
- Ammeter

PROCEDURE

- All batteries should be of same rating
- No mixing of different rated batteries is allowed
- In a combination all series path should have same number of batteries
- Prepare required lengths of DC cables of Red colour and Black colour with end connector and End colour marking
- Connect from negative terminal of one battery to the positive terminal of second battery using the prepared DC cables
- Connect a red colour DC cable to the positive terminal of second battery
- Connect a black colour DC cable to the negative terminal of second battery
- Test voltage between the two terminals
- Connect a 24 V DC pump to the terminals of series combination batteries through series connected switch in OFF position. Take care the polarities.
- Connect inlet and outlet tubes to the pump and insert the inlet pipe other end inside a bucket of water
- Keep a collecting bowl to the outlet tube
- Switch ON and test the running condition of pump
- Measure Voltage and current through the pump
- Record the observations

Fig 1



SERIES WINDING

Observations:

– – – – – – – – – – –

Solar Technician (Electrical) - Connect, test, under take maintenance and disposal of solar batteries

Connect and test solar batteries in parallel with DC loads

Objectives: At the end of this exercise you shall be able to
- **connect and test parallel connection of solar batteries.**

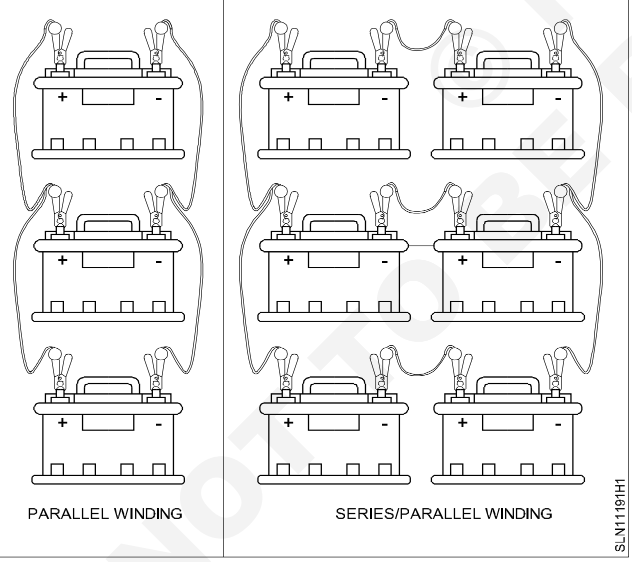
Requirements

Tools and Equipments

- Solar batteries 12V, 100Ah – 2 No.
- 24 V DC pump
- Voltmeter
- Ammeter

- All batteries should be of same rating
- No mixing of different rated batteries is allowed
- In a combination all series path should have same number of batteries
- Prepare required lengths of DC cables of Red colour and Black colour with end connector and End colour marking
- Connect from negative terminal of one battery to the negative terminal of second battery using the prepared DC cables

Fig 1



- Connect from positive terminal of one battery to the positive terminal of second battery using the prepared DC cables
- Connect a red colour DC cable to the positive terminal of second battery
- Connect a black colour DC cable to the negative terminal of second battery
- Test voltage between the two terminals
- Connect two no. of 12 V DC LED lights in series and connect the combination to the terminals of series combination batteries through series connected switch in OFF position. Take care the polarities
- Switch ON and test the lights
- Measure Voltage and current through the circuit
- Record the observations

Observations:

– – – – – – – – – – –

Solar Technician (Electrical) - Connect, test, under take maintenance and disposal of solar batteries

Check electrolyte in solar battery and add distilled water

Objectives: At the end of this exercise you shall be able to
- **check the condition of electrolyte in solar battery.**

Battery Hydrometer that is kept inside a glass tube fitted with a rubber bulb at the upper end.

PROCEDURE

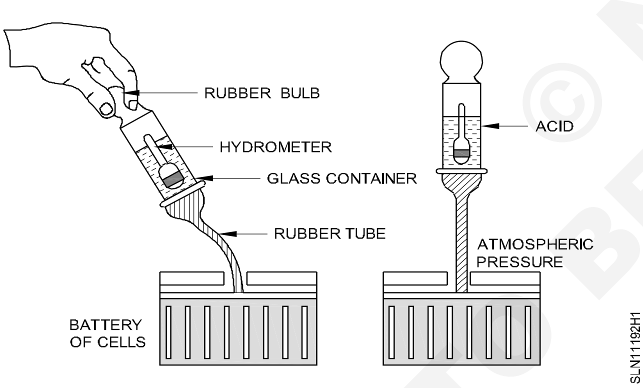
1 Submerge the lower end of the glass tube, which is connected with a narrow tube made of acid resistant material, in the acid in the accumulator.

2 Press the rubber bulb so that the air inside escapes from the narrow tube at the other end of the glass tube.

3 Observe that, as the pressure is removed there is a partial vacuum in the glass tube, the acid push up into the glass tube. Now the hydrometer floats in the acid.

4 Read the density of the acid on the floating hydrometer.

Fig 1



Observations:

The acid in a fully charged cell should have a relative density of 1.25 to 1.30.

A reading of less than 1.18 indicates that recharging is necessary.

5 Remove the Surface Charge if the battery has been charged within the last four hours.

Note

If the battery has been discharged within the last 15 minutes, wait for at least 15 minutes before testing it.

6 Squeeze the rubber bulb to release the electrolyte back into the battery's cell.

7 To increase the accuracy of the measurement, in the same cell, repeat this process several times so the float will reach the same temperature as the electrolyte.

8 At eye level and with the float steady, read the Specific Gravity at the point the surface of the electrolyte crosses the float markings.

9 Release the electrolyte back into the cell from which it was taken and record the reading.

Be sure to avoid spillage.

Thoroughly rinse the hydrometer with water after using it.

Hydrometer

- An instrument used for determining the density of a liquid.
- It usually consists of a glass float with a long thin stem which is graduated.
- The glass float is a large hollow bulb which increases the buoyancy so that the hydrometer floats.
- The narrow stem increases the sensitivity of the hydrometer.
- The bottom of the hydrometer is made heavier by loading it with lead shots so that it floats vertically.
- A hydrometer is used to measure the concentration of sulphuric acid (Specific Gravity) of battery electrolyte ("battery acid").
- We can easily and accurately determine a non-sealed battery's State-of-Charge.
- Sinks less in a denser liquid and more in a lighter liquid
- The lowest density is marked on the top of the stem of a hydrometer and the maximum density is marked at the bottom of the graduated stem.

Fig 2

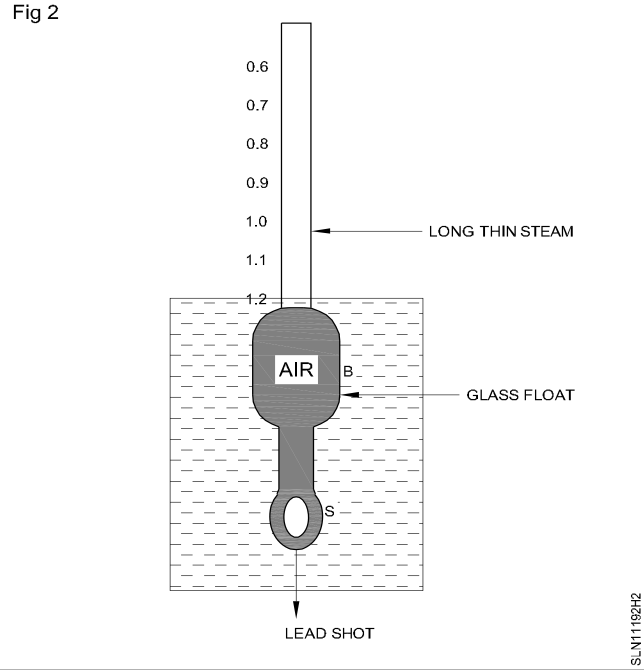
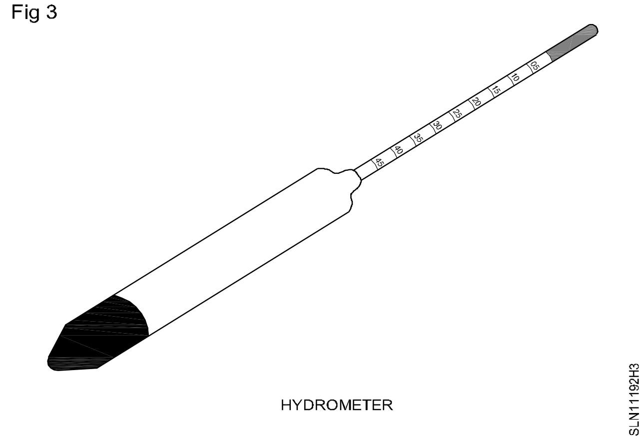

0.6
0.7
0.8
0.9
1.0
1.1
1.2
LONG THIN STEAM
AIR
B
GLASS FLOAT
S
LEAD SHOT
SLN11192H2

Fig 3


HYDROMETER
SLN11192H3

- - - - - - - - - - -

Remove complete electrolyte from a lead acid battery and refill

Objectives: At the end of this exercise you shall be able to
- **remove complete electrolyte from solar battery and refill.**

Requirements

Tools and Equipments

- Rubber siphon
- Glass beaker
- Funnel
- Diluted Sulphuric acid
- Lead acid battery 12 V 100 AHr

PROCEDURE

- Wear hand gloves
- Using rubber siphon drain out the electrolyte from the Battery kept at higher level to the glass beaker at the lower level
- After emptying check the anodes and cathodes for any cleaning requirement. Use light grade emery sheets and scrub the electrodes. Reinsert them back.
- Using funnel pour the diluted sulphuric acid inside the battery up to the electrodes get fully immersed
- Check the density and if found more add distilled water till get right specific gravity

Observations:

- - - - - - - - - - -

Shift 12V 100Ah battery on a trolley to different location following safe handling practices

Objectives: At the end of this exercise you shall be able to
- **handle and shift solar battery.**

Requirements

Tools and Equipments

- PPE kit
- Battery 12 V 100 AHr
- Trolley

PROCEDURE

- Wear hand gloves
- Do not carry the battery and run
- Do not try as single person even if you are strong enough
- Two persons minimum required for lifting one battery
- Using handle on the battery lift with uniform force either side and place slowly on the trolley base
- Take care about possible spillage of acid from battery
- Move the trolley slowly on the same level of floor
- While on slope care should be more
- While on different level of floors or steps lift and walk only acceptable

– – – – – – – – – – –

Solar Technician (Electrical) - Connect, test, under take maintenance and disposal of solar batteries

Plan for rack system of battery bank storage

Objectives: At the end of this exercise you shall be able to
- **plan for solar battery rack housing.**

PROCEDURE

- Bring out points why do you need rack system
- Based on the number of batteries, their weight, dimensions, possibility of lifting to heights either manually of material handling equipment make a design
- Ensure easy access for connecting cables while installation or during maintenance
- Sufficient ventilation should be there
- If the batteries are maintenance type provision for easily check electrolyte and changing it if required or adding distilled water
- Windows around to ensure windy circulation; providing ceiling fans more advisable
- Avoid using air conditioner in the battery room

Plans:

- - - - - - - - - - -

Prepare a report on maintenance and disposal of solar batteries

Objectives: At the end of this exercise you shall be able to
- **plan for maintenance of solar battery.**

POINTS TO REMEMBER:

Batteries require regular and careful maintenance. For a longer life batteries should:

1 Be cleaned for every 6 months

2 Have their electrolyte level checked

3 Be kept in a high state of charge

Cleaning (once a month)

Carry the battery outside when cleaning to avoid spilling of acid. Keep water nearby to rinse spills.

Checking and Topping up Electrolyte level (monthly)

1 Remove caps of each of the cells one at a time and check the level of electrolyte. Acid Level should be within two centimetres of the top battery. If you can look inside the battery, check the plates to see their condition

2 If the electrolyte level is down, add ionized distilled water till it is about two centimetres below the top of the battery.

Note:

1 Do not add rainwater collected in metal containers

2 Do not add acid, tap water or tonics to the battery

Task:

Keeping the points in mind plan for the maintenance of solar batteries

- - - - - - - - - - -

Connect MC 4 connectors to a solar panel using crimping tool

Objectives: At the end of this exercise you shall be able to
- **connect and test a normal inverter**
- **connect and test a solar inverter**
- **prepare DC cables for connecting solar panels.**

Requirements

Tools and Equipments

- MC 4 connectors
- DC cables
- Wires
- Tools kit with crimping tool
- Soldering iron 25 W

TASK 1 : **Connecting MC 4 connectors**

Caution: DC volt more than 70 volts prove very dangerous. Once solar panels are exposed to sunlight they start generating DC volt.

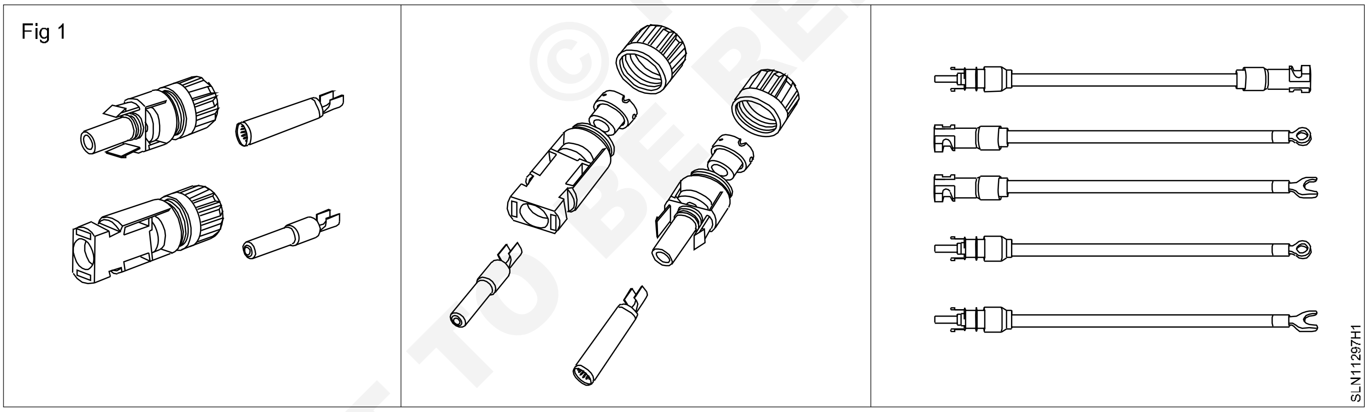
1 Study the pictures to familiarize with assembly parts of MC4 connectors

2 Practice connecting the MC4 connectors on Red and Black DC cables suitably selected

3 Practice extension of Solar panel output wires as per requirement

4 Where panel terminal junction box do not have OEM output cables select suitable colour coded cables and on one end MC4 connectors. On another ends solder to the relevant terminals on the panel junction box

Fig 1



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Connect the PWM controller with solar panel & solar battery and note input / output current and battery voltage at different time intervals

Objectives: At the end of this exercise you shall be able to
- **appraise about PWM charge controller.**

Requirements

Tools and Equipments

- Solarpanel 75 W
- Solarbattery 12 V 100 AHr
- PWM controller
- Voltmeter
- Ammeter

PROCEDURE

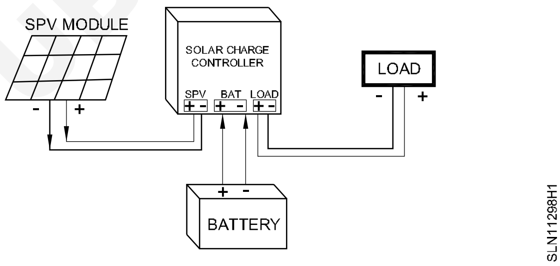
TASK 1:

1 Connect the components as per diagram

2 Place the solar panel in sunlight

3 Test input output voltages

Fig 1



Observations:

- - - - - - - - - - -

Connect the MPPT controller with solar panel & solar battery and note input and outputcurrent and battery voltage, at different time intervals

Objectives: At the end of this exercise you shall be able to
- **appraise about MPPT charge controller.**

Requirements

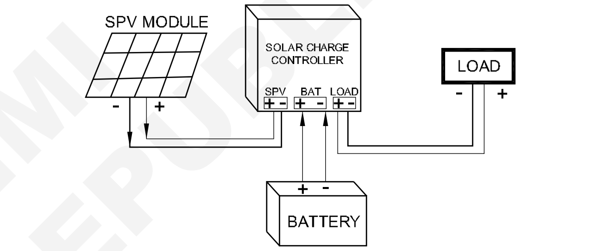
Tools and Equipments

- Solarpanel 75 W
- Solarbattery 12 V 100 AHr
- MPPT controller
- Voltmeter
- Ammeter

PROCEDURE

- Connect the components as per diagram
- Place the solar panel in sunlight
- Test input output voltages

Fig 1



Observations:

Compare the results of the above

Objectives: At the end of this exercise you shall be able to
- **compare the behaviour of PWM and MPPT charge controllers.**

Requirements

Tools and Equipments

- 12V 5A PWM Solar Charge controller -1 Nos
- 12/24V 10A PWM Solar Charge controller -1 Nos
- 12V 10A MPPT Charge controller -1 Nos

Observations:

1 Take the charge controller and look for lable on it (Usually at the back side)

2 Compare and write your comments in the table

Particular	PWM	MPPT
1		
2		
3		
4		
5		

\- - - - - - - - - - -

Open PWM and MPPT Charge controllers and identify components wired to understand mechanism

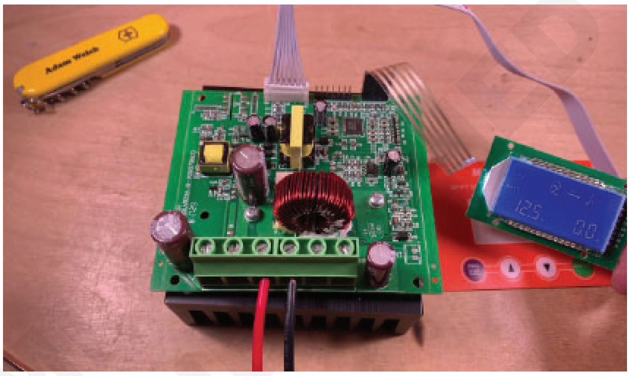
Objectives: At the end of this exercise you shall be able to
- **appraise the assembly of components inside a PWM and MPPT charge controllers.**

Compare the PCB, components, circuit etc and write your observations

Fig 1

PWM charge controller

Fig 2



MPPT charge controller

Observations:

- - - - - - - - - - -

Connect solar panels to an Array Junction box.

Objectives: At the end of this exercise you shall be able to
- **connect solar panels to array junction box.**

Requirements

Tools and Equipments

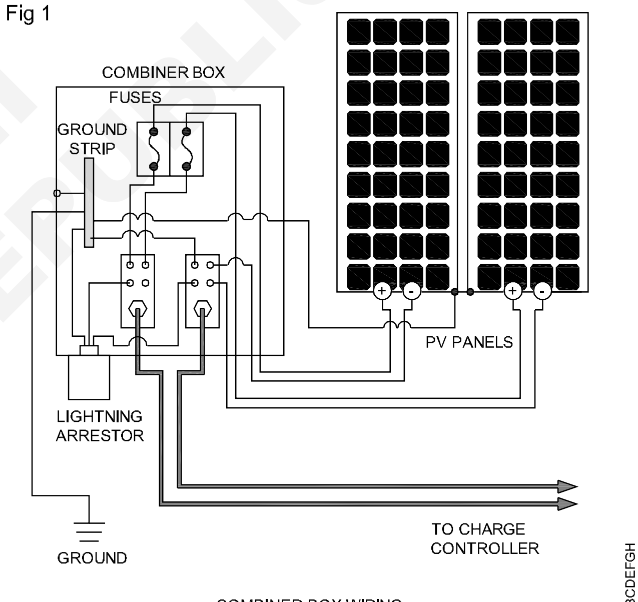
- Array junction box (AJB)/ Combiner box
- Solar panels
- Wires, Cables, tools
- Multi meter
- Open PCB assembled with components meant for PWM and MPPT charge controllers

PROCEDURE

- Open the AJB and understand the inside features
- Verify the circuit diagram below and compare
- Draw wires from Solar Panels and connect to input connector in AJB
- Wire the input connector for series connection
- Connect fuse, DC MCB and surge protectors
- Connect the output circuit
- Test the output voltage and current using multi meter
- Remove the above connections and repeat for parallel connection
- Record the observations
- Try connecting inside AJB for series or parallel connection for solar panels

Combiner box /AJB wiring (Fig 1)

Fig 1



COMBINER BOX WIRING

- - - - - - - - - - -

Connect and test a 12V DC/230V AC normal inverter

Objectives: At the end of this exercise you shall be able to
- **connect and test a normal inverter.**

Requirements

Tools and Equipments

- 12V DC/230V AC normal inverter
- Load
- 12V 100 AHr battery
- Clamp meter

PROCEDURE

- Study the inverter for input and output connections
- Connect the load bank to the output socket
- Connect the Solar battery 12V, 100 AHr to the battery input connectors
- Connect the mains cord to the AC mains socket
- Switch ON the mains and the inverter
- Check the normal functioning of the inverter
- Add load and measure load current
- Add load little more than maximum (overload) and verify that overload alert and trip occurs
- Remove overload and reset inverter
- In normal load conditions, retain on state of inverter and switch off the AC mains.
- Verify the functioning of inverter on battery mode
- Measure current drawn from battery using clamp meter
- Verify the backup time on battery mode to function for at least 80%
- Switch ON AC mains and verify the inverter resumes function on mains
- Disconnect the load
- Switch off the inverter
- Switch off the AC mains
- Record the observations

Observations:

- An inverter is a device that converts battery power (DC) into alternating current (AC) of a higher voltage. (Fig 1)
- A solar inverter's purpose is to convert the direct current (DC) electricity that is generated from a photovoltaic panel into an alternating current (AC) that can be used by in-home appliances and the community electricity grid. (Fig 2)

Fig 1

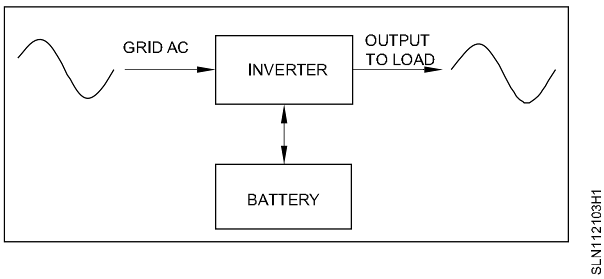
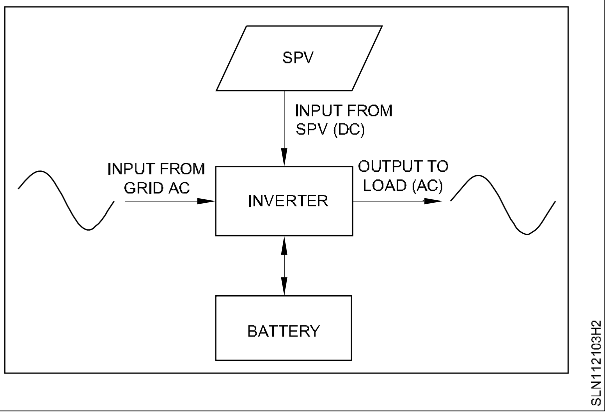


Fig 2


SPV
INPUT FROM
SPV (DC)
INPUT FROM
GRID AC
INVERTER
OUTPUT TO
LOAD (AC)
BATTERY
SLN112103H2

\- - - - - - - - - - -

Connect a Solar panel (10W), Solar charge controller (12V, 10A), Solar battery (12V, 100 Ah) and a normal inverter and convert to a solar inverter

Objectives: At the end of this exercise you shall be able to
- **connect a normal inverter to function as a solar inverter by adding a solar panel and charge controller.**

Requirements

Tools and Equipments

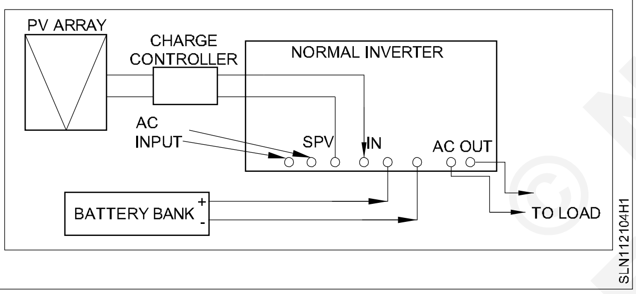
- 12V DC/230V AC normal inverter
- Solar panels 75 W x 2
- Charge controller
- Load bank
- 12V 100 AHr battery
- Clamp meter

PROCEDURE

- Study the inverter wiring diagram and connect the components of the solar inverter

Normal to Solar Inverter wiring (Fig 1)

Fig 1



Wiring Sequence

- Wire the charge controller
- Connect charge controller to battery
- Connect battery to inverter
- Connect panel to charge controller
- Connect loads

In all the above steps wire or connect means only physical connection. But not energizing.

- Keep all MCB in OFF position and fuses removed for safety.
- Follow the testing sequence of the inverter in 1.12.103 and test the solar inverter in a similar way for normal load, full load and overload conditions
- Record the observations

Observations:

- - - - - - - - - - -

Prepare data sheets of different solar PCU and normal inverters

Objective: At the end of this exercise you shall be able to
- **appraise the importance of technical specifications of solar PCU and normal inverters.**

Requirements

Tools and Instruments/equipment

- 1 kW normal inverter assembled with rechargeable battery, AC mains and ac load
- 1 kW solar inverter assembled with Solar battery bank, solar panel, AC mains, AC load

Note:
Product profile of a PCU.
Knowledge of specifications.
Product profiles of various PCUs.
Knowledge of purchase procedures/market study.

PROCEDURE

TASK 1: **Compare a normal inverter and a solar inverter**

1 Visit the institute premise or otherwise where a normal inverter and a solar inverter are already connected and in use.

2 Observe the user handling the inverters and record the observations.

3 Compare the two systems and list out difference in components.

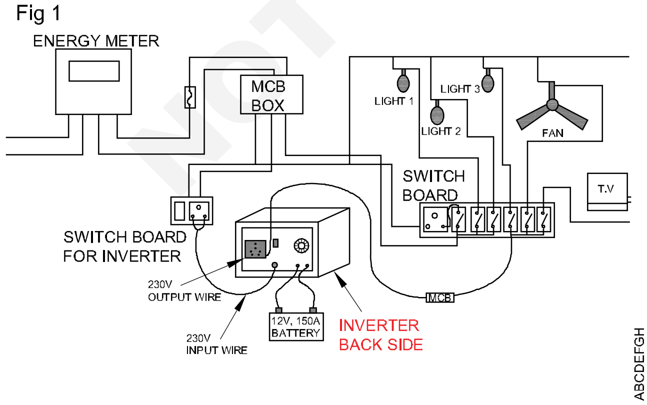
4 Compare the two systems and draw block diagrams indicating different stages.

5 List out essentials in solar PV electrical system when compared with normal inverter.

6 Record your observations and make a report.

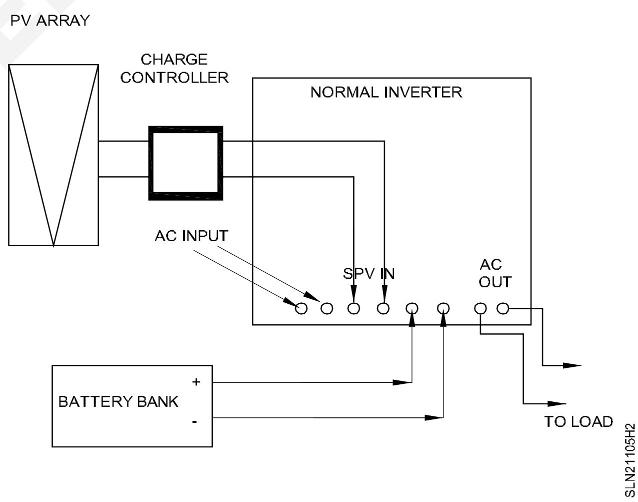
Normal inverter for Home (Fig 1)

Fig 1



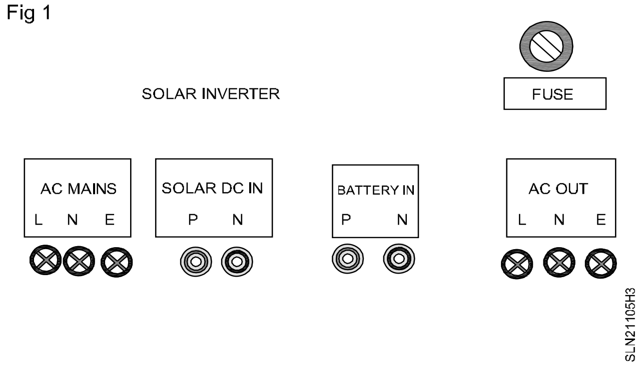
Normal Inverter converted to Solar inverter (Fig 2)

Fig 2



Back panel of a Solar inverter (Fig 3)

Fig 1



TASK 2: **Study the specification of a Power Conditioning unit (Fig 4)**

1 Collect from market product profile sheet having various performance specifications of a Power Conditioning Unit (PCU) of any popular make.

2 You can browse the internet for the product details and collect sheets.

3 Tabulate most useful parameters and their values as provided by the manufacturer in the product profiles.

4 Appraise how the data scrutinised will be useful in choosing the PCU for use in your application.

Sample Specification sheet/Product profile (Fig 4)

Fig 4

ENERTECH

LIFT INVERTER SYSTEMS

5.0 KVA TO 50 KVA (3PH-3PH)

SL	PARAMETERS	TECHNICAL SPECIFICATIONS
1	Model	5.0 KVA TO 50 KVA Lift Inverter Systems
2.	Technology	IGBT / Mosfet
3.	Input Voltage	415V AC (+/- 15%)
4.	Input Frequency	50 Hz (+/- 5%)
5.	Output Frequency	50 Hz (+/- 0.5%)
6.	Output Voltage	415V AC (+/- 3%)
7.	Load power Factor	0.8 to 1 lagging
8.	Inverter Efficiency	> 85% to 92% depending upon DC voltage
9.	Output Wave form	Sine
10.	Harmonic Distortion	Less than 3% with linear load
11.	Overload	<105% continuous 105% to 400% for 30 Sec. >400% Inverter Trips
12.	Battery Voltage	72 V DC to 360 V DC
13.	Indications	Mains ON, Inverter ON, Battery Low, Overload, Battery Bar graph, Load Bar Graph
14.	Audible Alarm	Mains Fail @15 sec Battery Low pre-alarm at 80% of discharge
15.	Protections	Input single phasing / Phasing Reversal, Battery over / under voltage, output Over/ Under voltage, Output Overload, Output short circuit
16.	Meter provided	Output voltage /Microprocessor based Digital LCD metering for multiple parameters
17.	Changeover	Electro-mechanical / Static Switch
18.	Backup time	10 min to 10 Hours
19.	Operating Temperature	0 deg C to 50 deg C
20.	Humidity	Max 95%, Non-condensing
21.	Acoustic Noise	Less than 45 dB at 1 Meter

Optional at Extra Cost

Note:-Specifications are subject to change without prior notice.

Obervation

Table 1

Parameter	Specified value
Output Voltage (V)	
Phases (single/Three)	
Power (VA/KVA)	
Solar DC input range (Vmin, Vmax)	
Battery input (V)	
Solar battery bank (V, AHr)	
Charge controller type: MPPT/PCM	
Back up time (minimum hours)	

— — — — — — — —

TASK 3: **Select suitable PCU for a given application**

1 Collect data sheets of different solar PCU and normal inverters from market and websites.

2 Group them according to their size (capacity).

3 Select important specifications and record.

4 Prepare a comparative chart.

5 Choose a more suitable one.

6 Recommend one with specifying merits.

Observations

Sample Comparative chart

1 Additional columns for Model, Output Voltage (V), Phases (single/Three), Back up time (minimum hours) etc can be added.

2 Minimum three makes required for good comparison.

3 Too many makes and specifications also can be ambiguous.

4 Experience will make better comparisons. Hence practice with various combinations and utilities.

Name of company	Solar DC input range (Vmin, Vmax)	Battery input (V)	Solar battery bank (V, AHr)	Charge controller	Power (VA/KVA)

Practice procedural switching 'ON' and shutdown of solar PCU

Objectives: At the end of this exercise you shall be able to
- **perform switching ON of the solar PCU**
- **perform proper shutdown of solar PCU.**

Requirements

Tools and Instruments/equipment

- A solar PCU or inverter in connected condition
- Operation manual of the given PCU/Inverter

PROCEDURE

TASK 1: **Switch ON inverter as per instructions**

1 Go to the inverter room.

2 Collect the operation manual of the connected PCU/ inverter from the operator.

3 Go through the manual, study and write in your observation the method of switching ON (Though all are inverters the similarity in procedural switching ON will be there in comparative models, but, look for minor variations possible which you can identify in the manuals).

4 Ask the daily operator to shut down the system and keep it ready for practice.

5 Practice the step by step procedure of switching ON of the PCU/inverter.

6 Record your observations.

Normal sequence of operation: (Suggestive)

1 Turn on the Solar Array DC Main Switch located next to the inverter.

2 Turn on Solar Array AC Main Switch located in the switchboard and/or next to the inverter.

3 Turn on the main DC battery isolator.

4 Confirm inverter is ON and functions normally.

5 Connect the load step by step.

Observation

Sl.No	List the observation

— — — — — — — —

TASK 2: **Shut down a Solar PCU**

1 Go to the inverter room.

2 Collect the operation manual of the connected PCU/ inverter from the operator.

3 Go through the manual, study and write in your observation the method of switching OFF (Shut down) (Though all are inverters the similarity in procedural switching OFF will be there in comparative models, but, look for minor variations possible which you can identify in the manuals).

4 Ask the daily operator to switch ON the system and keep it ready for practice.

5 Practice the step by step procedure of switching OFF of the PCU/inverter.

6 Record your observations.

Normal sequence of operation: (Suggestive)

1 Turn off the main DC battery isolator.

2 Turn off the Solar Array AC Main Switch located in the switchboard or next to the inverter.

3 In case you have 2 AC Switches, both have to be shutdown.

4 Turn off the Solar Array DC Main Switch located next to the inverter.

5 Please also check the shutdown procedure on the main switchboard.

Observations

Sl.No	List the observation

Test the performance of 1 kW solar PCU to 1 kW solar panel installation

Objectives: At the end of this exercise you shall be able to
- **connect 1 kw solar PV off grid plant (preinstalled)**
- **test 1 kW SPV off grid plant.**

Requirements

Tools and Instruments/equipment

- Block diagram
- Ready to use individual blocks
  - 4 x 250 W solar panels mounted, wired and assembled through combiner box suitable for charge controller
  - Charge controller 24 V, 40 A (say) suitable for inverter
  - 1 kW solar inverter with suitable solar DC input and Battery bank input terminals
  - Battery bank: 4 x 12 V 100 AHr connected suitable for given inverter
  - DC disconnects
  - AC disconnects
  - Tools and accessories
- Wiring diagram
- Wired blocks and interconnected as in task 2 below

PROCEDURE

TASK 1: **Study the block diagram of Off grid Solar PV electrical system**

1 Deeply go through the block diagram given below.

2 Observe the energy flow paths and type of energy.

3 Analyse level of energy at each point and describe the safety precautions to be taken while in that block.

4 Observe the DC and AC disconnects and appraise their importance.

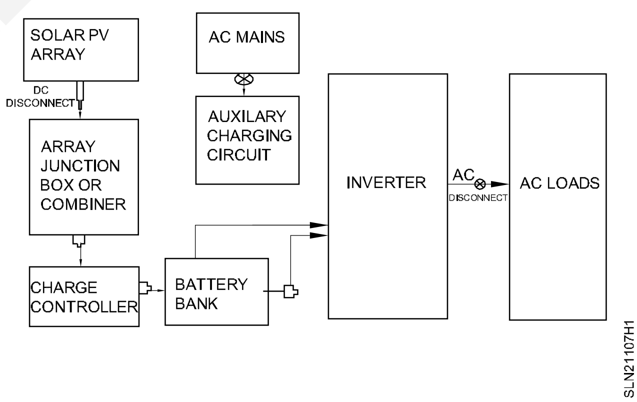
5 Assuming the entire connection is ready for use, describe a sequence of switching ON the Off grid Solar PV electrical system.

6 Write down the steps required for interconnecting blocks if individual blocks are already assembled, wired and kept ready.

7 Record your answers in observations column in sequence.

Block diagram of an Off grid Solar PV electrical system (Fig 1)

Fig 1



Observations

• **Energy flow paths**

• **Block wise safety precautions**
• **Sequence of switching ON**
• **Interconnecting blocks**

— — — — — — — —

TASK 2: **Interconnect different blocks of an Off grid Solar PV electrical system**

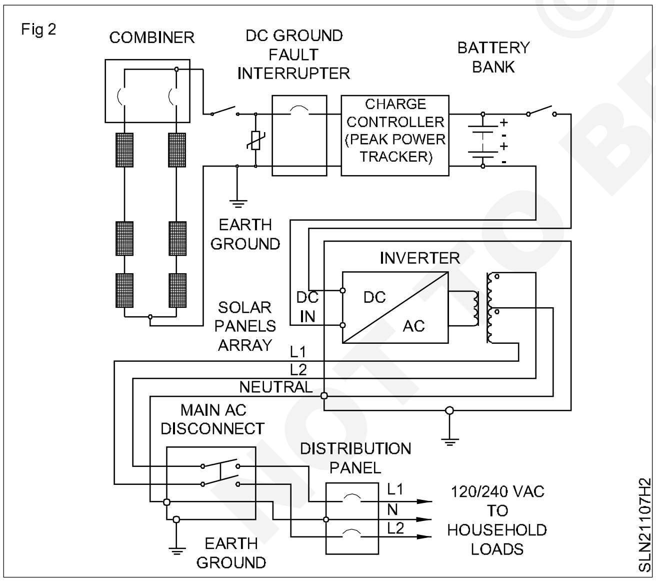
1 Follow the wiring diagram.

2 Keep all the MCBs and disconnects in OFF position.

3 Sequentially connect the different blocks.

4 Verify the connections made.

Wiring Diagram (Fig 2)



Suggested sequence of wiring

1 Wire the Charge controller.

2 Connect battery bank to charge controller or inverter as the case may be, through DC disconnect.

3 Connect solar array output from combiner box through dc disconnect to charge controller.

4 Connect charge controller output through dc disconnect to the input of the inverter.

5 Connect the AC mains to the inverter.

6 Connect the AC loads to the inverter output.

Observations

Sl.No	List the observation

— — — — — — — —

TASK 3: **Test the performance of the 1 kW SPV off grid system**

1 Follow a sequence and switch ON the above connected system.

Suggested sequence:

1 Switch ON DC disconnect between combiner box and charge controller.

2 Measure and record the Solar array output reaching the input of charge controller.

3 Switch ON the DC disconnect between Battery bank and charge controller or inverter as the case may be.

4 Measure the input to the charge controller or inverter as the case may be from battery bank and record the observations.

5 Switch ON the AC mains disconnect to the input of Inverter.

6 Measure input AC to the inverter.

7 Switch on the inverter and observe normal functioning.

8 Measure the output AC and record the observation.

9 Connect the AC loads and measure load current and watts.

10 Record all observations.

Observations

Sl.No	List the observation

— — — — — — — —

Check of front panel features of a solar PCU

Objective: At the end of this exercise you shall be able to
- **use the front panel controls of PCU.**

Requirements

Tools and Instruments/equipment

- Solar PCU in your lab or nearby installation or industry

PROCEDURE

TASK 1: **Identify and use the useful features on front panel of PCU**

1 Study the front panel of the PCU.

2 Observe the hard and soft keys available on the front panel for the user to control.

3 Record the observations and discuss the utilities of these controls.

4 Observe the LED annunciations on the front panel. What do they communicate?

5 Record your answers.

6 Observe the Digital Panel Meter and record the readings rolling over there.

7 If manual selection of different readings using switch is given on front panel use it and observe the behaviour on DPM.

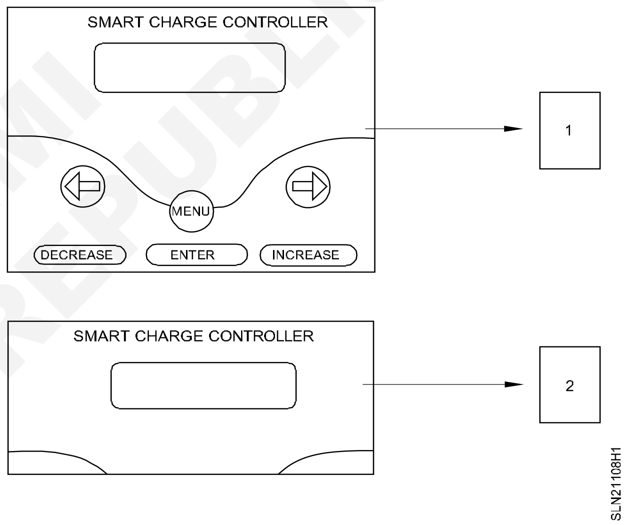
8 Record your observations.

Observations

Sl.No	List the observation

Sample front panel of PCU (Fig 1)

Fig 1



Possible interpretation of the display/LED indicators on Front panel

LCD Indication

1 This display is provided for SOLAR PCU charge controller and it displays following items :
- Battery Voltage
- Charging Current of Battery
- Total power(in terms of wattage) supplied from PV to Battery

2 This display is provided to show indication related to Inverter mentioned as below :
- MAINS ON
- CHARGER ON
- SOLAR PCU ON
- BATTERY LOW
- OVER LOAD

— — — — — — — —

Check of back panel features of a solar PCU

Objective: At the end of this exercise you shall be able to
- **perform connections on back panel of PCU.**

Requirements

Tools and Instruments/equipment

- Solar PCU in your lab or nearby installation or industry

PROCEDURE

TASK 1: **Identify and use the useful features on the back panel of PCU**

1 Study the back panel of the PCU.

2 Observe the switches/MCB available on the back panel for the user to control.

3 Record the observations and discuss the utilities of these switches.

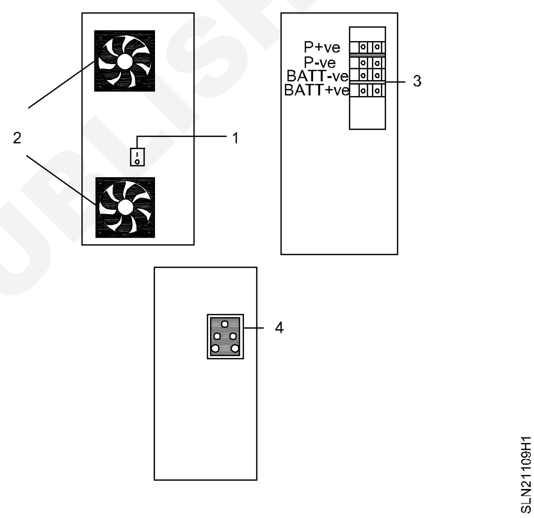
4 Observe the Fuse carrier on the back panel and note down rating indicated.

5 Record your answers.

6 Observe the connecting ports for different inputs and output. Do not touch any part since there may be live points which may give electric shock.

7 Record your observations

Fig 1



Observations

Back panel of a PCU (Fig 1)

SI.No	List the observation

Possible Back panel provisions:

1 ON/OFF SWITCH.-

This is provided to switch on or Off the PCU.

2 FANS :-

This are provided for ventilation to PCU.

3 BATTERY AND PV CONNECTIONS :-

This are provided to connect battery and solar panel to SOLAR PCU according to given polarities.

4 INVERTER OUTPUT

This is provided to connect load to SOLAR PCU.

According to given polarities.

— — — — — — — —

Demonstrate solar PV e-learning software

Objective: At the end of this exercise you shall be able to
- **appraise the benefits of solar design softwares.**

Requirements

Tools and Instruments/equipment

- A software like PVsyst or otherwise
- Simulation tools are available on web for purchase or freeware
- Some are RETScreen, System Advisor Model (SAM), Hybrid Optimization Model for Electric Renewables (HOMER), Transient System Simulation Tool (TRNSYS), Integrated Simulation Environment (INSEL) or similar Solar Design Tools

PROCEDURE

TASK 1: **Learn on line using downloadable software for Solar PV system guide**

1 Install the software in PC.

2 Follow the instructions.

3 Practice a design.

Suggested links:

www.retscreen.net, www.homerenergy.com, www.trnsys.com, www.insel.eu (freeware), www.pvsyst.com.

Observations

Sl.No	List the observation

— — — — — — — —

Prepare bill of material for a 1 kW solar PV installation

Objectives: At the end of this exercise you shall be able to
- **select components for 1 kW SPV after sizing**
- **draw SLD for 1 kW SPV system.**

Requirements

Tools and Instruments/equipment

- Inputs regarding sizing of PV plants (from Trade Theory book as well as websites)
- Inputs from market about component specifications
- Input from market about cost of components

Note:

Knowledge of matching the specifications of components.

Knowledge of SLD.

Inputs from market about component specifications.

Input from market about cost of components.

Knowledge of matching the specifications of components.

PROCEDURE

TASK 1: **Discuss different probabilities of combinations of making 1 KW solar PV installation**

1 Study related theory and also from web about the technical details.

2 Discuss among trainees and instructors, the technical feasibilities.

3 Prepare at least three variants which deliver 1000 W AC power output.

4 Consider cost variation also.

5 Record your observations.

6 Prepare SLDs for each case.

Observations

Sl.No	Bill of Materials	Quantity

— — — — — — — —

TASK 2: **Prepare a bill of materials for the given SLD**

1 Study the SLD.

2 Review the sample component profiles.

3 Collect similar specifications from market.

4 Discuss and prepare a bill of materials for purchase.

Bill of materials

Sl.No	Bill of Materials	Quantity

— — — — — — — —

TASK 3: **Prepare bill of materials for 1 kW SPV off grid plant**

1 Similar to task 2 above consider serial connection of solar panels.

2 Draw a SLD for 1 kW SPV off grid plant with serial connection of solar panels.

3 Consider changes required in ratings of other components.

4 Prepare bill of materials.

5 **Bill of materials:**

Sl.No	Bill of Materials	Quantity

Prepare bill of material for a 5 kW solar PV installation

Objectives: At the end of this exercise you shall be able to
- **select components for 5 kW SPV after sizing**
- **draw SLD for 5 kW SPV system.**

Requirements

Tools and Instruments/equipment

- Product profile of solar panels, inverters, solar batteries etc.

Note: Knowledge of PV sizing.

PROCEDURE

TASK 1: **Prepare bill of materials for a 5 KW solar PV installation**

1 Calculate using PV sizing theory the approximate voltage, current requirements of PV array and inverter.

2 Select from obtained technical specifications of various models of inverters and panels suitable ones for your sized PV plant.

3 Match the different components.

4 Draw a SLD.

5 Prepare bill of materials.

Suggestions

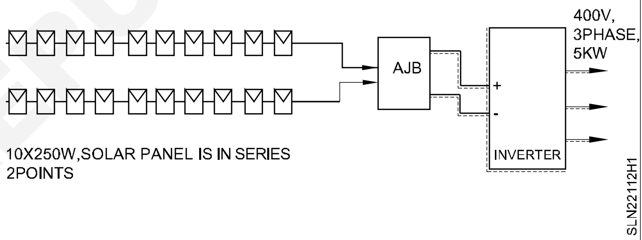
1 Select from available 200 W or 250 W solar panels.

2 Select a single phase 5 kW inverter.

3 Plan for a On grid SPV plant.

Sample SLD: Sample SLD for 5 kW SPV plant (Fig 1)

Fig 1



Bill of Materials

Sl.No	Bill of Materials	Quantity

— — — — — — — —

Prepare a bill of materials for a 10 kW solar PV installation

Objectives: At the end of this exercise you shall be able to
- **select components for 10 kW SPV after sizing**
- **draw SLD for 10 kW SPV system.**

Requirements

Tools and Instruments/equipment

- Product profile of solar panels, inverters, solar batteries etc.

Note: Knowledge of PV sizing.

PROCEDURE

TASK 1: **Prepare bill of materials for a 10 kW solar PV installation**

1 Calculate using PV sizing theory the approximate voltage, current requirements of PV array and inverter.

2 Select from obtained technical specifications of various models of inverters and panels suitable ones for your sized PV plant.

3 Match the different components.

4 Draw a SLD.

5 Prepare bill of materials.

Suggestions

1 Select from available 200 W or 250 W solar panels.

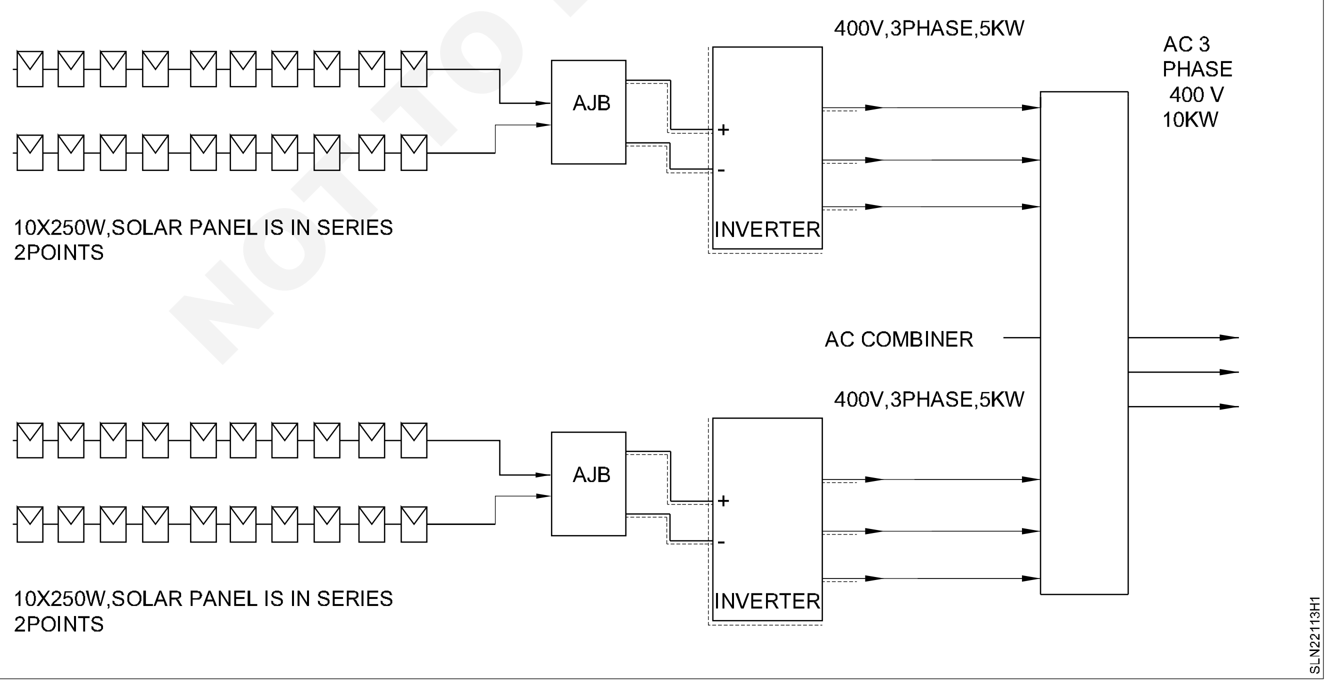
2 Select two numbers of single phase 5 kW inverter along with AC combiner or a single three phase 10 kW inverter.

3 You can size for two variants.

4 Plan for a On grid SPV plant.

Sample SLD: Sample SLD for 10 kW SPV plant (Fig 1)

Fig 1



Bill of Materials

Sl.No	Bill of Materials	Quantity

— — — — — — — —

Prepare a bill of materials for a 20 kW solar PV installation

Objectives: At the end of this exercise you shall be able to
- **select components for 20 kW SPV after sizing**
- **draw SLD for 20 kW SPV system.**

Requirements
Tools and Instruments/equipment
• Product profile of solar panels, inverters, solar batteries etc.

Note: Knowledge of PV sizing.

PROCEDURE

TASK 1: **Prepare bill of materials for a 20 KW solar PV installation**

1 Calculate using PV sizing theory the approximate voltage, current requirements of PV array and inverter.

2 Select from obtained technical specifications of various models of inverters and panels suitable ones for your sized PV plant.

3 Match the different components.

4 Draw a SLD.

5 Prepare bill of materials.

Suggestions

1 Select from available 200 W or 250 W solar panels.

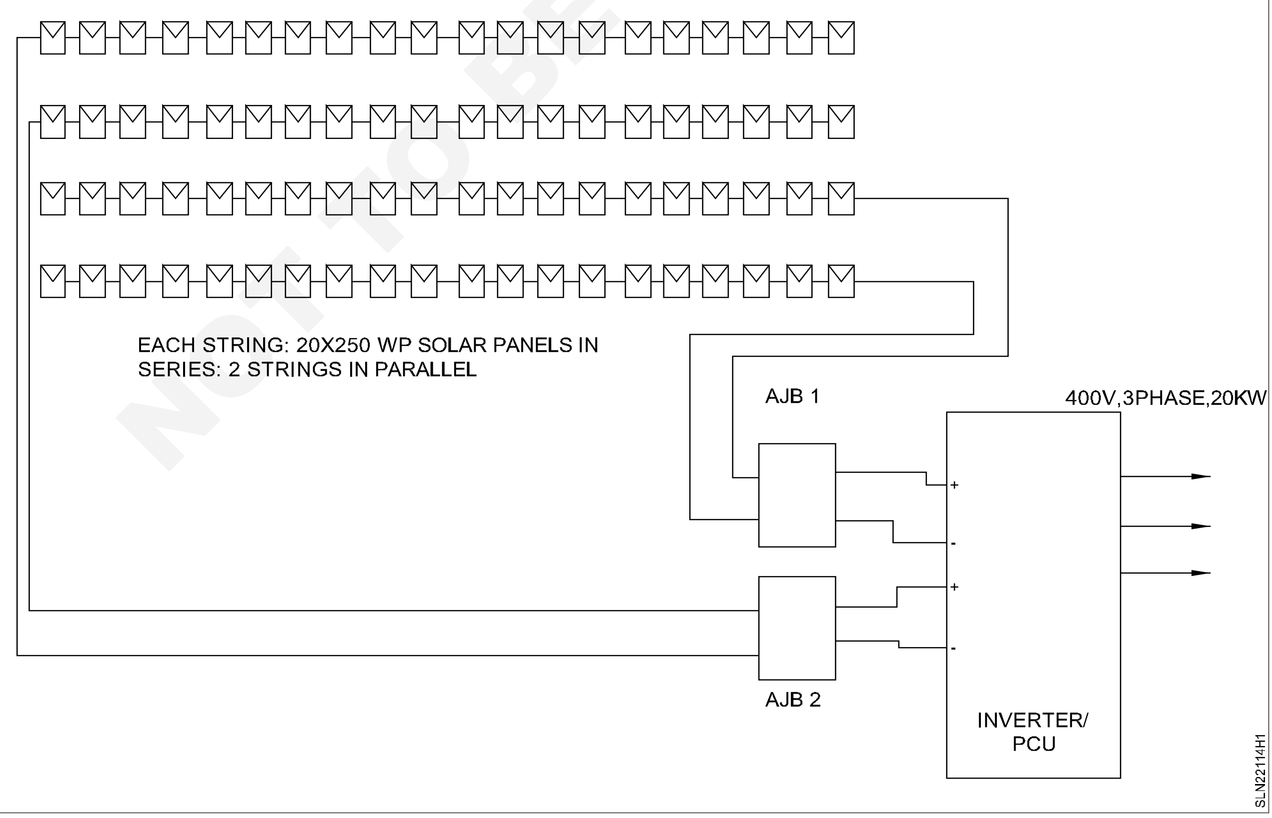
2 Select a three phase 20 kW inverter and use both solar DC inputs if available.

3 You can size for two variants.

4 Plan for a On grid SPV plant.

Sample SLD: SLD for 20kW (Fig 1)

Fig 1



Bill of Materials

Sl.No	Bill of Materials	Quantity

Prepare a bill of materials for a 100 kW solar PV installation

Objectives: At the end of this exercise you shall be able to
- **select components for 100 kW SPV after sizing**
- **draw SLD for 100 kW SPV system.**

Requirements

Tools and Instruments/equipment

- Product profile of solar panels, inverters, solar batteries and other major components

PROCEDURE

TASK 1: **Prepare bill of materials for a 100 KW solar PV installation**

1 Calculate using PV sizing theory the approximate voltage, current requirements of PV array and inverter.

2 Collect details of other major components

3 Select from obtained technical specifications of various models of inverters and panels suitable ones for your sized PV plant.

4 Match the different components.

5 Draw a SLD.

6 Prepare bill of materials.

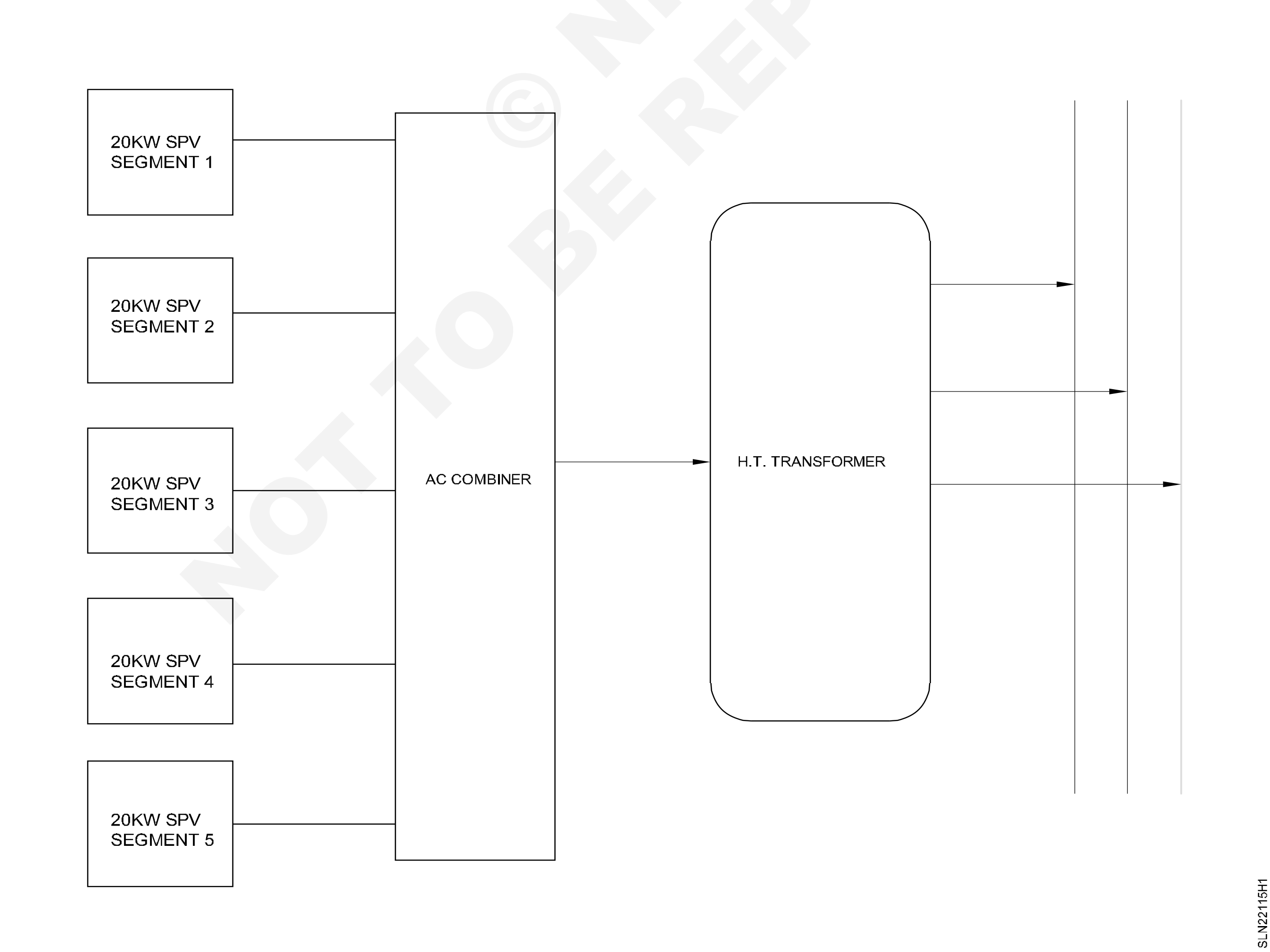
Suggestions

1 Select from available 200 W or 250 W solar panels.

2 Select five numbers of three phase 20 kW inverters.

Sample SLD: SLD for 100 kW SPV plant (Fig 1)

Fig 1



Bill of Materials

Sl.No	Bill of Materials	Quantity

— — — — — — — —

— — — — — — — —

Estimate cost of a 1 kW solar PV installation and prepare a quotation

Objective: At the end of this exercise you shall be able to
- **select components prices in market for 1 kW SPV after sizing and prepare an estimate - approximate cost of the project.**

Requirements

Tools and Instruments/equipment

- Bill of materials including Electrical, electronic equipment and materials, mechanical fittings and accessories, civil equipment and materials etc and their cost
- Cost of Tools and consumables including rentals of installation equipment and logistics
- Cost of mounting structures
- Market trend on labour cost

Note: Knowledge profit and loss calculations.

PROCEDURE

TASK 1: **Prepare a complete financial projection for a 1 kW SPV off grid plant**

1 Analyze all the possibilities of financial commitments.

2 Prepare separate heads of expenditure for own and outsourced avenues.

3 Prepare complete project report.

4 Submit to experts and get evaluated the project.

5 Record all through activities in observation.

Observation

Sl.No	Estimation	Remarks

— — — — — — — —

Carry out visual inspection of PV modules

Objective: At the end of this exercise you shall be able to
- **perform visual inspection PV modules before installation and in installed plant.**

Note:
- **Knowledge of possible failures.**
- **Information on different manufacturers.**
- **Knowledge of scheduling the activities.**

PROCEDURE

TASK 1: **Prepare a visual inspection checklist for the evaluation of mounted photovoltaic (PV) modules**

1 Collect data describing the field performance of PV modules.

2 Collect details of PV panels having visual defects such as Damage, Material problem, Delamination, Decolouration, Degree of damage or decolouration, Coverage of defect ¡V partial or complete, Dust, soils, snails on cells, etc.3 Divide into various sections.

Observations

Sl.No	List the observation

TASK 2: **Define inspection checklists and prepare forms for field inspections**

1 Analyse the collected data.

2 Divide into various sections.

3 Document each section by the appearance or properties of a part of the module.

4 Facilitate the user by easy questionnaire and answerable check boxes.

5 Evaluate the checklist at different sites at different periods of time.

6 Appraise the results and record.

7 Prepare Checklists for various check points for easy filling up in field.

Measure insulation resistance and wet leakage current of PV modules

Objective: At the end of this exercise you shall be able to
- **appraise about the insulation resistance and leakage current of a solar PV panel.**

Requirements

Tools and Instruments/equipment

- Grid connected PV systems composed of multi crystalline silicon panels of 1 MW size
- Systems with 1) negative ground and 2) floating ground for comparisons
- Megohm meter
- Set of PV modules
- Water tank

PROCEDURE

TASK 1: **Measure insulation resistance in PV modules**

1 Connect the Megohm meter between the negative terminal of the string and the grounded support structure as shown in the figure below.

2 Connect the positive probe to the negative pole of photovoltaic string.

3 Connect the negative probe to the support structure, or ground cable.

4 Set the Megohm meter at 1,000 V dc.

5 Operate the Megohm meter for 2 minutes without the light.

6 Measure the insulation resistance value and record.

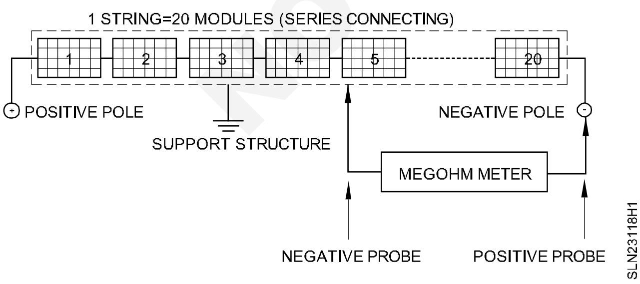
7 Measure and Record the insulation resistance of each PV string.

8 Repeat the test under hot and humid climatic conditions to compare the results.

9 Record the observations.

Measuring insulation resistance to analyze leakage current on PV string (Fig 1)

Fig 1



Note: The leakage current test result is normally presented in the insulation resistance form for the easier testing and monitoring.

Possible results

The leakage current test of the PV string sampled of negative grounded and floating grounded PV systems – typical results. (Fig 2)

Observation:

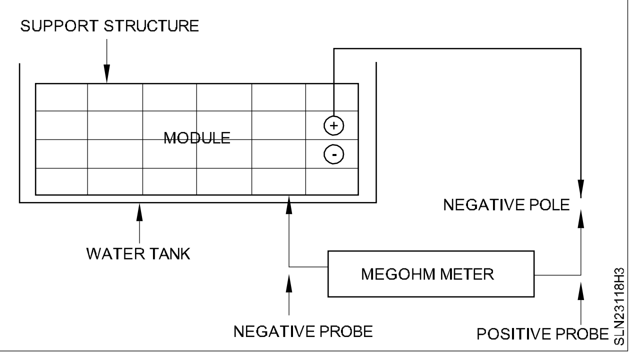
Sl.No	List the observation

— — — — — — — —

TASK 2: **Measure wet leakage current of a PV module**

Measuring of insulation resistance to analyze wet leakage current on PV module. (Fig 2)

Fig 2



1 Put the PV module inside the water tank.

2 Connect the positive probe of the Megohm meter to the negative pole of the module.

3 Connect the negative probe of the Megohm meter to the support structure.

4 Operate the Megohm meter for 2 minutes without the light.

5 Measure the insulation resistance to estimate wet leakage current.

6 Record the observation.

7 Sample of 20 modules for about 1100 modules in a mega plant are to checked.

8 Repeat the steps for all 20 samples and record the observations.

— — — — — — — —

Perform bypass diode test - P_{max} at STC and P_{max} at low irradiance

Objective: At the end of this exercise you shall be able to
- **perform testing of solar panel for status of bypass diode.**

Requirements

Tools and Instruments/equipment

- Solar panel (wattage)
- Technical specification of the solar panel at STC (Label on back side or actual QC certificate of solar panel)
- Chamber of light source and temperature as per STC
- Multimeter

PROCEDURE

TASK 1: **Test the bypass diode at STC of a solar panel by measuring P_{max}**

1 Set the conditions as per STC (Normally 1000 W/m^2, 25°C, AM1: or 1.5).

2 Connect the solar panel for performing test for I-V curve plotting.

3 Measure simultaneously all parameters (P_{max}, V_{oc}, I_{sc}, V_m, I_m).

4 Perform 'Batch measurements' of open-circuit voltage, short-circuit current, and bypass route resistance for panels in array.

5 Discover open faults.

6 Discover short-circuit faults.

7 Find out the difference between the measured value and the reference value.

8 Record the observation.

9 Compare your findings with the results.

Observation

STC (Normally 1000 W/m^2, 25°C, AM1: or 1.5)

Tested parameter	Specified value	Measured value
P_{max}		
V_{oc}		
I_{sc}		
V_m		
I_m		

No. of cells per panel:

No. of bypass diodes:

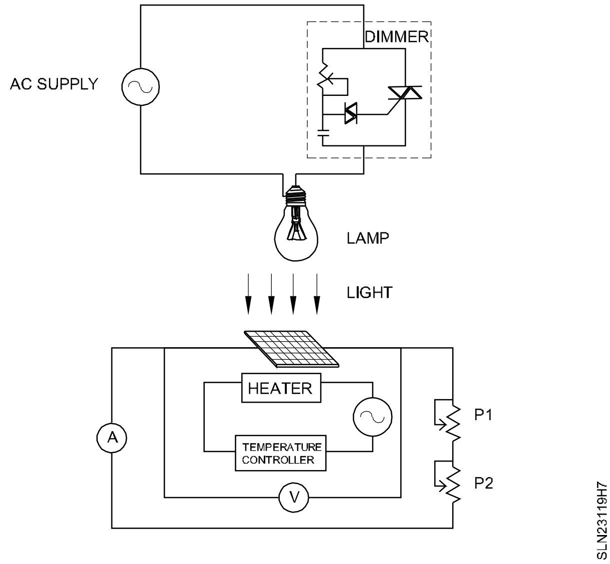
Conditions of Bypass diodes:

Reasons for difference in specified and measured values:

Conclusions:

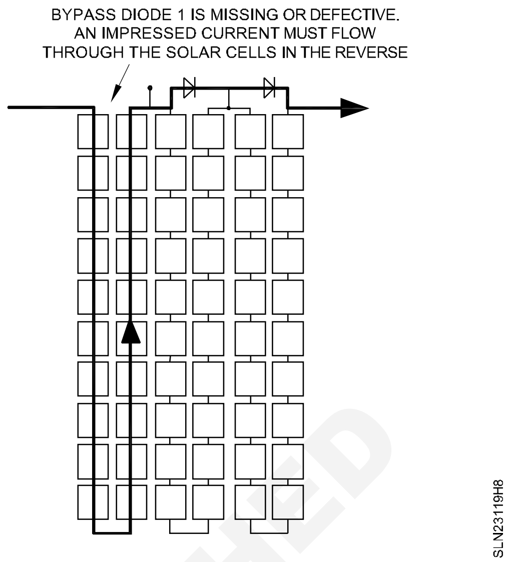
Standard set up required for setting STC for conducting I-V & P-V curves tests. (Fig 1)

Fig 1



Effect of open bypass diode on solar panel. (Fig 2)

Fig 2



— — — — — — — —

TASK 2: **Test the bypass diode at low irradiance on a solar panel by measuring P_{max}**

Repeat task 1 above with low irradiance and measure the same values. Record your observations and inference from the testing.

Observations

Irradiance: 200 W/m²

Tested parameter	Measured value
P_{max}	
V_{oc}	
I_{sc}	
V_m	
I_m	

No. of cells per panel:

No. of bypass diodes:

Conditions of Bypass diodes:

Reasons for difference in specified and measured values:

Conclusions:

Note: Commercially in the field batch testing of bypass diodes can be done by using bypass diode tester and defective ones can be screened out. Since open diodes can result in hot spots thermography methods using drone cameras are also in use to expedite the testing for mega projects.

— — — — — — — —

Measure ground continuity, impulse voltage, reverse current and partial discharge

Objective: At the end of this exercise you shall be able to
- **check the quality of the encapsulation of the solar PV panel.**

Requirements

Tools and Instruments/equipment

- Solar PV string with proper ground Digital Multimeter
- Megohm meter
- Suitable device for safe disconnection and short-circuiting
- A solar panel with known specifications
- Impulse voltage generator
- Copper sheet
- Minimum three strings in parallel
- Voltmeter, ammeters comparable with specifications of panel and string voltage
- Blocking diodes and fuses
- Calibrated charge measuring device or radio interference meter

PROCEDURE

TASK 1: **Check the PV system for ground faults by measuring the voltage (Check Ground continuity)**

Destruction of the measuring device due to overvoltage: Only use measuring devices with a DC input voltage range of 600 V or higher.

1 Disconnect the inverter from any voltage sources (see the inverter installation manual). (Danger to life due to high voltages).

2 Select a string.

3 Measure the voltage between the positive terminal and the ground potential (PE).

4 Measure the voltage between the negative terminal and the ground potential (PE).

5 Measure the voltage between the positive and negative terminals.

6 Check each string in the PV system for ground faults.

_ _ _ _ _ _ _ _

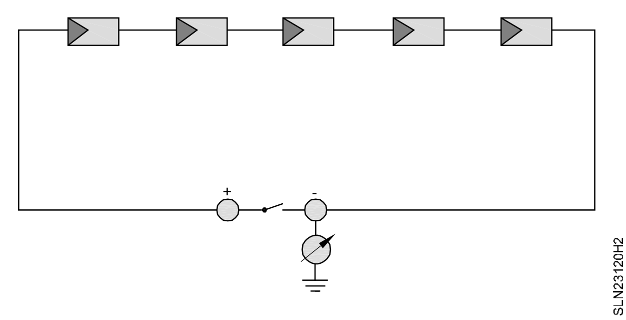
TASK 2: **Measure the insulation resistance**

1 If the voltage measurement does not provide sufficient evidence of a ground fault, the insulation resistance measurement can provide more exact results.

2 The insulation resistance can only be measured with a suitable device for safe disconnection and short-circuiting of the PV array. If no suitable device is available, the insulation measurement must not be carried out.

Schematic diagram for measuring Insulation resistance (Fig 1)

Fig 1



1 Calculating the insulation resistance.

- The expected total resistance of the PV system or of an individual string can be calculated.
- The exact insulation resistance of a PV module can be obtained from the module manufacturer or the datasheet.
- For the resistance of a PV module an average value can be assumed:
  - for thin-film PV modules approximately 40 MOhm per PV module.
  - for polycrystalline and mono-crystalline PV modules approximately 50 MOhm per PV module.

2 Calculate the expected insulation resistance per string.

3 Danger to life due to high voltages: Disconnect the inverter from any voltage sources (see the inverter installation manual).

4 Install the short circuit device.

5 Connect the measuring device, Megohm meter, for insulation resistance.

6 Short-circuit the first string.

7 Set the test voltage. The test voltage should be as close as possible to the maximum system voltage of the PV modules but must not exceed it (see datasheet of the PV modules).

7 Measure the insulation resistance.

8 Eliminate the short circuit.

9 Measure the remaining strings in the same manner.

10 If the insulation resistance of a string deviates considerably from the theoretically calculated value, there is a ground fault present in that string.

11 Reconnect to the inverter only those strings from which the ground fault has been eliminated.

12 Reconnect all other strings to the inverter after rectification.

13Re-commission the inverter (see inverter installation manual).

14 If the inverter still displays an insulation error, contact the Service personnel. The PV modules might not be suitable for the inverter in the present quantity.

15 Record your observations for both the tasks.

Observations

Sl.No	List the observation

— — — — — — — —

TASK 3: **Perform impulse voltage test on a solar PV panel**

1 Connect the positive and negative terminals of the solar panel and extend the connection outward.

2 Wrap the solar panel, completely covered with one or two layers of 0.001-in. or 0.0015-in. thick copper foil so the total buildup is 0.002 in. to 0.003 in. This foil is not available in widths large enough to cover the module, so the pieces are joined together using conductive glue. The standard gives us some guidance on the glue characteristics, specifying “conductivity <1Ω, measuring area: 625 mm^2. (Actually these standards are according to quality assurance norms specified by IEC standards. For testing in institute let us try with aluminium foil for which cost may be less. Suggested as alternative only for test in institute and understand the procedure. Quality standards does not specify this)

3 After the module is successfully wrapped, connect the negative lead of the impulse voltage tester to the foil

4 Connect the positive lead of the impulse voltage tester to the shorted output terminals of the module.

5 The impulse voltage is based on the maximum voltage of the module. For systems with a maximum voltage from 100 V to 150 V, Class A modules will see a 2,500-V peak impulse while Class B modules will see 1,500-V peak.

6 Set the impulse tester to deliver a 1.2-µs x 50-µs pulse and apply impulses.

7 Repeat the test three times

8 Then conduct three more times with the polarity reversed.

9 Disconnect and unwrap the module.

10 Perform visual inspection on the module tested

11 If there is no tracking or breakdown and the module survives the visual inspection, the test is considered passed.

12 Record your observation.

TASK 4: **Measure reverse current in a string**

1 Connect the solar panels in three strings with equal number of panels per string.

2 Connect Ammeters in series with each string.

3 Connect One ammeter in the output of the combiner box (consider rating of ammeter is greater than 3 times of Im of solar panel.

4 Connect Voltmeter in the output of the combiner box.

5 Measure the readings when luminance is around 1000 W/m^2.

6 Record the observations.

7 Select any string and create short circuit on output terminals of one or more modules.

8 Simultaneously and quickly measure currents and their direction.

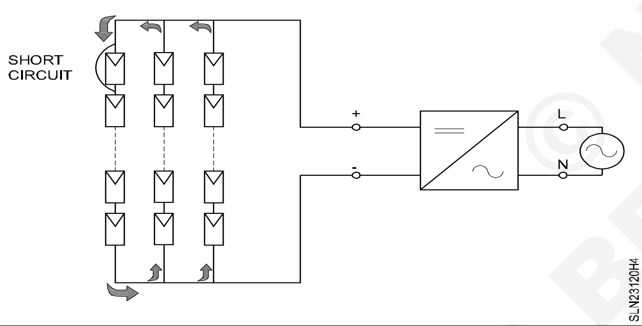
9 Immediately remove the shorts to avoid the damage to cells.

10 You have observed the reverse current from other strings flowing into string which has lost modules due to short.

11 Record your observations.

Flow of reverse current (Fig 2)

Fig 2



Observations

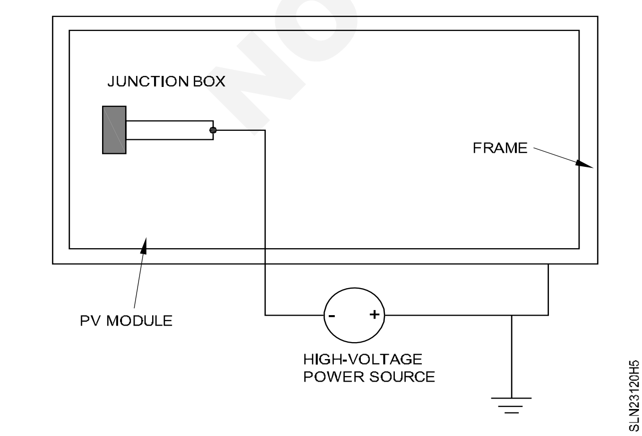
Sl.No	List the observation

Note: To prevent the reverse current into any string, we use blocking diodes or fuses in series with the each string in a group of strings connected in parallel. This can be tested in above task.

TASK 5: **Measure the partial discharge**

Schematic diagram for PD test (Fig 3)

Fig 3



1 Apply starting from a value below the maximum system voltage, up to the point at which partial discharge takes place (inception voltage), the test voltage shall be further increased by 10 %.

2 Lower the voltage to the point at which the partial discharge extinction voltage is reached.

3 The extinction voltage shall be considered to be reached once the charge intensity has dropped to a value of 1 pC. This voltage shall be measured with accuracy better than 5 %.

4 The partial discharge extinction voltage may be influenced by environmental conditions. These influences are taken into account by a basic safety factor F1 of 1,2.

5 The hysteresis factor is reduced to 1. The additional safety factor for reinforced insulation F3 = 1,25 is

required for safety class A. The initial value of the test voltage is therefore 1,5 VOC (system voltage given by the module manufacturer).

Note: The solid insulation has passed the test if the mean value minus the standard deviation of the partial discharge extinction voltage is greater than 1.5 times the given maximum system voltage.

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Practice to undertake precautions against module breakage

Objective: At the end of this exercise you shall be able to
- **handle the solar PV modules safely in installation sites.**

Requirements

Tools and Instruments/equipment

- O & M manual for Solar PV installation
- Material handling equipment
- PPE kits

Serious hazards that solar technicians face:

- Lifting and arranging unwieldy solar panels.
- The potential for falls off many-storied rooftops.
- Panels that heat up as soon as they're uncovered.
- Risks of traditional roofing.
- Carpentry and electrical trades related injury-prone occupations.

The Occupational Safety and Health Administration (OSHA) requires employers to implement safety training and protection for their employees. Many solar installation companies have taken OSHA's requirements a step farther by creating manuals of their own that detail the specific measures they require to manage solar energy safely. Safety issues are common for solar installations, but proactively putting preventive measures in place can help mitigate on-the-job injuries.

PROCEDURE

TASK 1: **Practice the precautionary measures for safe working with solar modules**

1 Read thoroughly the guidelines for best practice in Solar PV installation.

2 Discuss with team and prepare instructions for yourselves to follow in the site.

3 Practice the prepared list of activities.

Suggestions:

1 Every Worksite Presents Different Risks. No two worksites are the same. Before a solar installation begins, it's essential for the installer to visit the site, identify the safety risks and develop specific plans for addressing them.

2 Plans shall include:

- Equipment to be used for safe lifting and handling of solar panels.
- Type and size of ladders and scaffolding if needed.

  Fall protection for rooftop work.
- Personal protective equipment for each installer.

3 All equipment needed for the job should be inspected and verified to be in good working order before being brought to the worksite.

4 Lifting and Handling Solar Panels

5 Ladder Safety

- Solar construction often involves working on roofs and from ladders. Choosing the right ladder and using it properly are essential.

Demonstrate hot spot on modules through audio visual aids

Objectives: At the end of this exercise you shall be able to
- **trouble shoot a solar plant reported to generate much lesser than installed capacity, by taking thermal image of the array**
- **interpret the findings from thermal image with defects of the solar panel and take remedial actions.**

Requirements

Tools and Instruments/equipment

- Thermal camera
- Visit to a larger solar PV plant
- Laptop or desktop

PROCEDURE

TASK 1: **Verify the performance of thermal camera for the features discussed here**

1 Study thoroughly about the digital thermal imager/ camera for its utility, handling and methods of fault finding in field.

2 Carry the thermal camera in early morning or in the evening.

3 Visit the solar PV plant.

4 Capture pictures of the solar panels in operation.

5 Transfer images to the computer tag them.

6 Analyse the defective modules and tabulate probable reasons.

7 Suggest remedies for the defective panels.

8 Record your observations and prepare a report.

Possible damages:

Nature of defect noticed by image (shape and the location of their thermal patterns)	Indications (Identification of defects)
An entire module warmer than others	it is open circuited
On the scale of a module, a patchwork pattern	the whole module is short-circuited
One cell clearly warmer than the others	a shadowing effect or a defective or delaminated cell
A warmer part of a cell indicates	the presence of cracks
A pointed heating	a partly shadowed area due to a bird dropping (e.g.)

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Create layout for avaliable space in a site prior to installation

Objective: At the end of this exercise you shall be able to
- **plan a layout for available space in a site prior to installation.**

Requirements

Tools and Instruments/equipment

- 50-100 ft. measuring tape
- Digital camera
- Record/log book or diary

Note:

Knowledge of Electrical equipment, meter etc and domestic & industrial wiring.

Prior experience of installation of SPV systems or assisting thereof.

PROCEDURE

TASK 1: **Inspect the site**

1 Identify the actual work spot and assess the feasibilities of installation.

2 Identify the places to position the different components.

3 Identify accessibility to rooftop for men and material to reach as well as safe working.

4 Foresee and analyse the difficulties that may arise after landing in the work place.

8 Identify the shadow causing areas that may vary the power output later on.

9 Capture photographs.

10 Record your observations.

— — — — — — — —

TASK 2: **Locate existing components**

1 Identify already installed equipment such as electric meter, control boards, flow of wiring, division of wiring groups in the entire building etc.

2 Identify normal loads and high power loads.

3 Capture photographs.

4 Draw a rough plan based on above points collected showing existing electric meter, wiring path, main and auxiliary control boxes including MCBs (existing and proposed), additional wiring requirements etc.

5 Record your observations.

Rough sketch - example (Fig 1)

Photograph of Existing MCB layout (Fig 2)

Consider

Perform Load Assessment such that Solar array and batteries are sized according to need, Critical loads are backed up and the customer's gets maximum value for money.

Fig 1

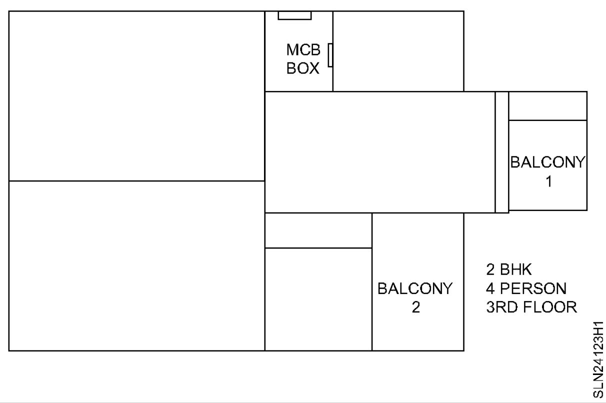
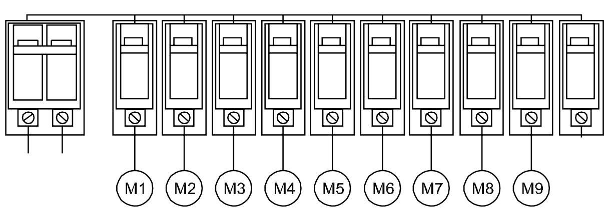


Fig 2



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TASK 3: **Recommend places for different components and submit site inspection report of proposed SPV installation**

1 Calculate the space requirement as per the work order.

2 Identify requirement of additional special tools, PPE, material handling equipment or services specific to the work place.

3 Draw a sketch for seating proposed PCU/inverter in safe, shadowed, dry, and adequately ventilated space.

4 Schedule pre requisite activities to be performed to carry out the installation work including clearing old items dumped area on roof with prior discussion with site owner, either through hiring or outsourcing.

5 Estimate additional cost probability specific to this site and inform owner of site as well as company so that the budget can be reset.

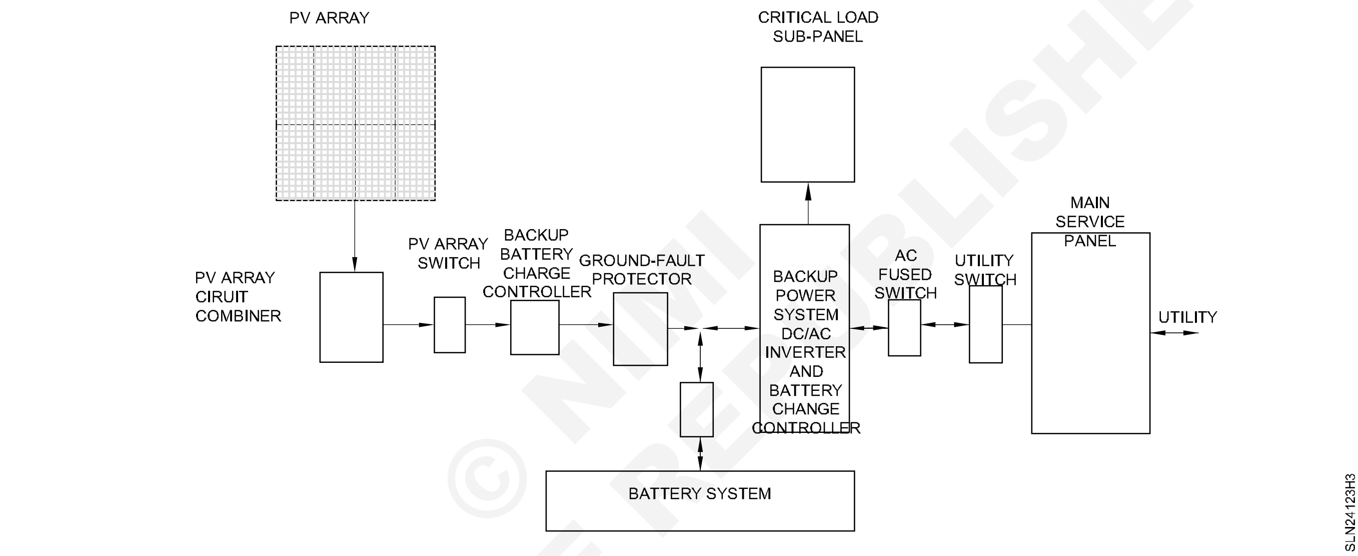
6 Submit and store the records including photographs properly in the company.

Consider

Perform Site Assessment so that Components are placed in proper locations where they function without hindrance, Shadows do not fall on the arrays maximizing output and The area remains safe for humans and equipment.

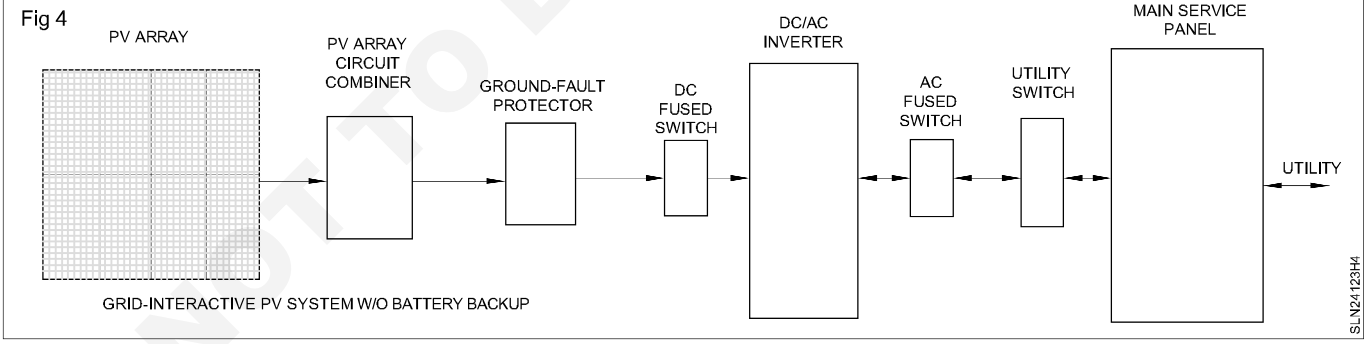
Components of SPV system proposed, layout and flow of energy directions (Fig 3)

Fig 3



Components of Grid interactive SPV system without battery backup. (Fig 4)

Fig 4



Observation

Sl.No	List the observation

Prepare a layout of the site showing shadow free areas for installation

Objective: At the end of this exercise you shall be able to
- **mark locations on the site showing shadow free areas for installation.**

Requirements

Tools and Instruments/equipment

- 50-100 ft. measuring tape
- Digital camera
- Record/log book or diary

Note:

Knowledge of Electrical equipment, meter etc and domestic & industrial wiring.

Prior experience of installation of SPV systems or assisting thereof.

PROCEDURE

TASK 1: **Inspect the site for shadow free area and sketch a place on rooftop for mounting structures**

1 Select an open space on rooftop or on field.

2 Identify shadow free areas for installation.

3 Identify possible locations for array, battery and inverter.

4 Identify cable routing options.

5 Assess suitability of roof condition.

6 Identify risks for human safety.

7 Prepare site map and dimensioning plan.

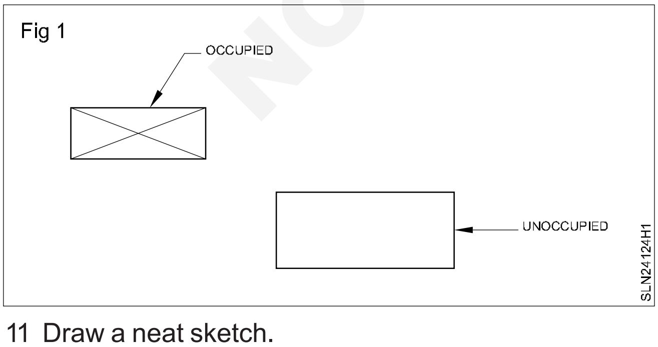
8 Mark nearby tall trees, buildings or water tank etc which may cause shadowing keeping in mind sun path at different times and seasons at that site.

9 Mark by open boxes (rectangle or square) for possibilities of SPV installation.

10 Mark by crossed boxes where shadow possibility is there.

Mark occupied and unoccupied areas on site. (Fig 1)

Fig 1



11 Draw a neat sketch.

12 Calculate area marked for installation and compared with desired installation capacity.

13 Recommend allowed size – same as prosed, greater or lesser than proposed as the case may be.

14 Essentially mark site layout with dimensions on paper.

15 Walk through the open terrace and draw the layout.

16 Mark the dimensions and directions – N, E, S and W.

17 Mark the visible obstructions and measure/estimate their dimensions.

18 Find possibilities of moving the obstructions or otherwise.

19 Capture minimum four photographs of the roof from different angles.

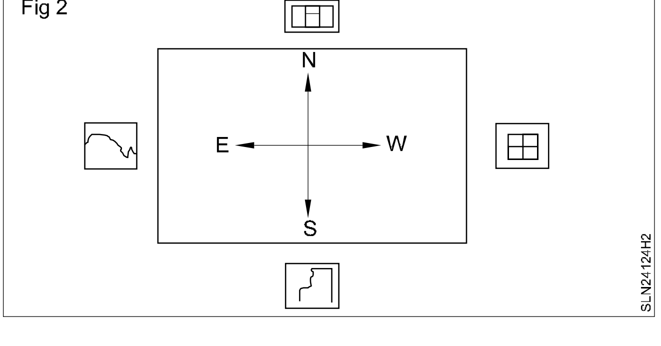
20 Capture a photo of recommended place on the site to install SPV mount.

21 Capture photograph of obstacles on N, S, E and W directions.

22 Record your observations and recommendations.

Capture photographs of neighbourhood on four directions. (Fig 2)

Fig 2



Prepare layout for components of solar PV electrical system on site

Objective: At the end of this exercise you shall be able to
- **sketch a layout for fixing various components of SPV system on site.**

Requirements

Tools and Instruments/equipment

- 50-100 ft. measuring tape
- Digital camera
- Record/log book or diary
- Product manuals for PCU / inverter, battery etc along with their dimensions

Note:

Outcomes of previous tasks.

Prior experience of installation of SPV systems or assisting thereof.

PROCEDURE

TASK 1: **Sketch a layout for fixing various components of SPV system on site**

1 Plan exactly for locating the various components.

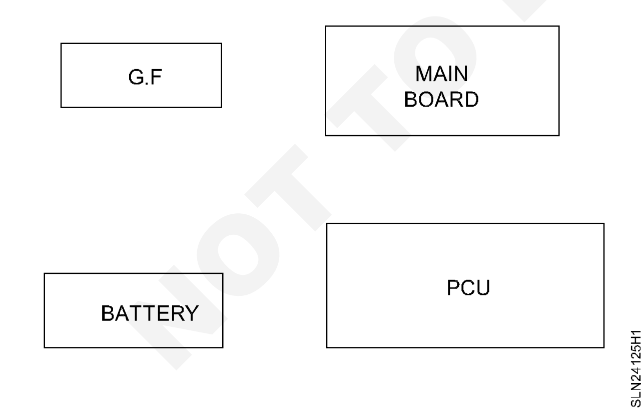
2 Consider component dimensions and installation requirements suggested by manufacturers.

3 Sketch out a drawing to show locations of all components in the site.

4 Hint about moving/bringing the components to required places including tools requirements.

Location of components (Fig 1)

Fig 1



Note: Roughly 110 sqft or 10 sq meter area110 sqft or 10 sq meter area is required for a 1 KW installation. Accordingly assess the site and recommend for more capacity. This will benefit the business as well as customer.

Remember

1 Inverter should be located in a room or shelter protected from sun and rain.

2 Batteries should be kept in a room or shelter in a rack and the room should be ventilated.

3 If such space does not exist, you should suggest the customer to the possibility of constructing shelters for equipment.

4 For cable routing, do keep in mind that the inverters should be kept as close as possible to the DC combiner box as DC side wire loss increases drastically with the length of the wire.

5 Draw a rough sketch of how the cables will be routed and estimate the length of the wiring that may be required up to the switchboard.

— — — — — — — —

Perform shadow analysis in the rooftop of a 1 kW Solar PV plant

Objective: At the end of this exercise you shall be able to
- **analyse the shadow free area on site using solar path finder.**

Requirements

Tools and Instruments/equipment

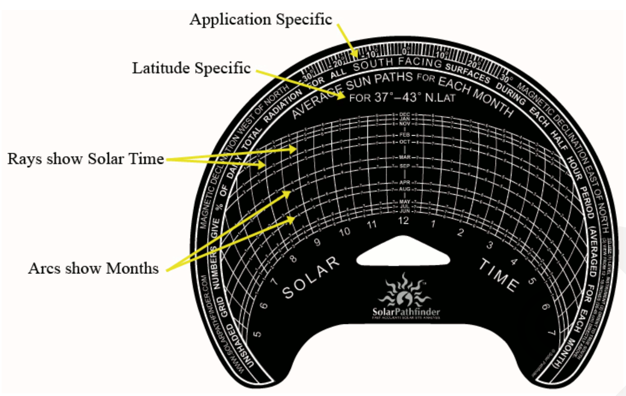
- Solar path finder

PROCEDURE

TASK 1: **Analyse the shadow free area on site using solar path finder**

Diagram of a Solar Path Finder. (Fig 1)

Fig 1

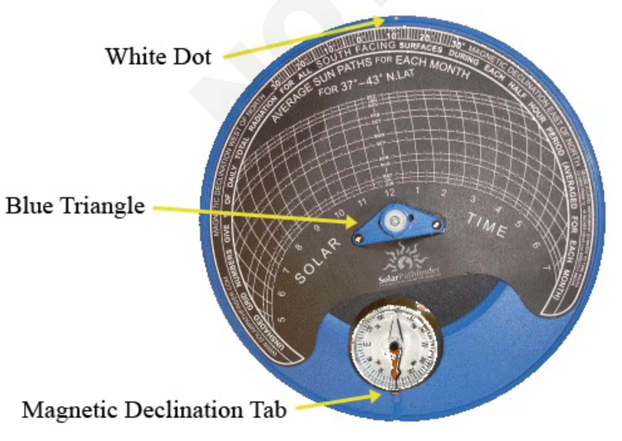


1 Solar path finder is the tool for shading analysis.

- Time window for shading during a day.
- Shading from surrounding objects.
- Shading from vegetation.

Solar Path Finder (Fig 2)

Fig 2



2 The solar path sheet shown in fig 2 is specific to the latitude. It can be obtained from websites such as http://solardat.uoregon.edu/SunChartProgram.html.

3 Each curved line represents the sun path of a specific month of the year. Note that in the summer months, the path is wider.

4 Place on a spot; observe that the fish eye lens on the pathfinder projects a shadow on the solar path sheet.

5 Observe the area below the marked black line.

6 It shows the shading times for that day.

7 Use this to select the location with least shading.

8 Shading during early morning and late evening does not affect as much as any shading during 10A.M – 4 P.M.

9 Shading situations present a challenge for preparation of PV system implementation plans. It has an effect on system yield.

10 Shading analysis tells us how much hours of sunlight, a selected location will receive in a given month of the year.

Note: Simulation programs are also available. They generally simulate shading effects using horizon photographs of shade generating objects based on 3D simulation. Other tools for doing shading analysis similar to Solar Pathfinder are SunEye and paper tools.

Software simulation tools like PVSOL and PVsyst are useful for doing shadow analysis and annual energy generation projections. Results from solar pathfinder and other instruments are used as an input in the above solar simulation software for energy generation projections.

Install a roof top solar panel mounting structure for 1 kW

Objective: At the end of this exercise you shall be able to
- **install 1 kW solar panel mounting structure.**

Requirements

Tools and Instruments/equipment

• Pillar mounts Qty	- 2 Nos
• Connecting frames Qty	- 2 Nos
• Swinging rod Qty	- 2 Nos
• Angle adjusting rod Qty	- 2 Nos
• Panel fitting arms Qty	- 8 Nos
• Tool kit	

- Mounting screws, bolts and nuts, washers, anchor bolts
- Tools, drilling machine
- Magnetic compass
- Marking pen and nail
- Thread
- Measuring tape
- Ruler

PROCEDURE

TASK 1: **Marking base of pillar mount on roof top**

1 Follow carefully the steps for making foundation on rooftop.

2 Wear necessary PPE kits.

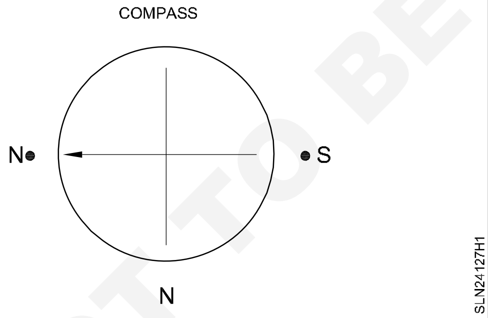
3 Collect all elements of Pillar mount on the roof top.

4 Collect all tools on the rooftop.

5 Use compass and mark true north and south poles.

Marking magnetic poles (Fig 1)

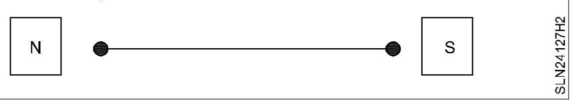
Fig 1



6 Draw line connecting north and south poles points.

Connecting N - S marked points (Fig 2)

Fig 2



7 Place the pillar mount aligned to the connecting lines.

8 Mark the holes of base on ceiling.

9 Draw a parallel line in the direction of N - S, at a distance as per the drawing.

10 Place the second pillar.

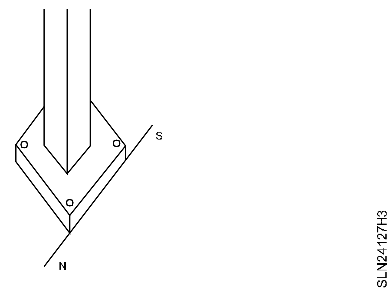
11 Mark the holes of second base on ceiling.

12 Remove the pillar mounts.

13 Verify the dimensions and parallelism before going to Task 2.

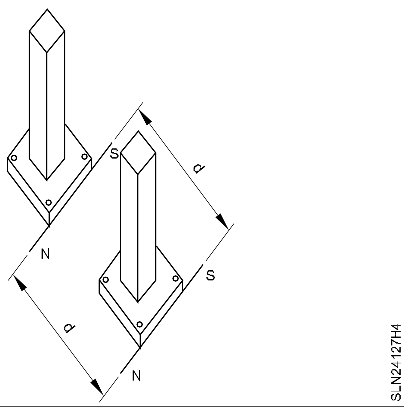
Marking Pillar base (Fig 3)

Fig 3



Marking second pillar parallel to first (Fig 4)

Fig 4



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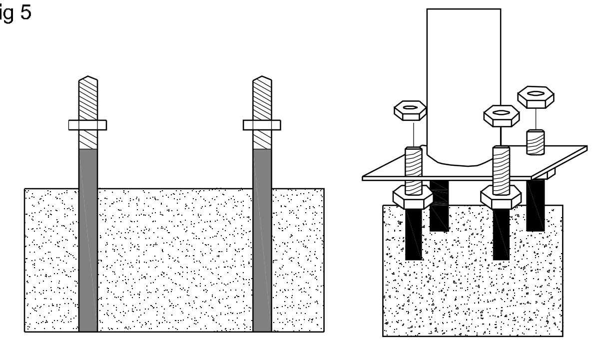
TASK 2: **Drilling on rooftop for pillar mount base**

1 Drill holes on the markings for both pillar bases.

2 Hammer the anchor bolts on the holes.

Fixing anchor bolts on RCC roof (Fig 5)

Fig 5



TASK 3: **Fixing the pillars on rooftop**

1 Keep the pillar mount aligned to the anchor bolts and fix nuts.

2 Mark parallel to the first pillar mount and repeat the above steps for second pillar.

3 Fix the second parallel pillar and fasten the nuts.

4 Check the parallelism between pillars.

TASK 4: **Assemble remaining components on the pillar mounts on rooftop**

Finished pillar mount (Fig 6)

1 Assemble swinging rods to the top of pillars.

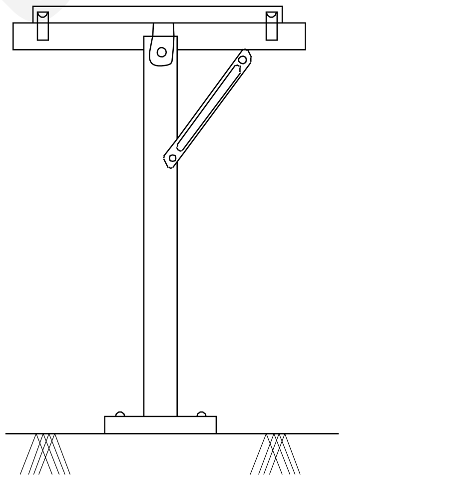
2 Assemble angle adjustment link rod between Pillar and swinging rod.

3 Assemble connecting frames between swing rods over the pillars.

4 Leave the frames assembled to incline towards south.

5 Do not tighten all the bolts.

Fig 6



Setup solar panels 250 W x 4 nos on the mounting structure

Objective: At the end of this exercise you shall be able to
- **mount solar panels on mounting structure.**

Requirements

Tools and Instruments/equipment

- Modem - 1 No
- Pillar mounts Qty - 2 Nos
- Connecting frames Qty - 2 Nos
- Swinging rod Qty - 2 Nos
- Angle adjusting rod Qty - 2 Nos
- Panel fitting arms Qty - 8 Nos
- Solar panels 4 x 250 W
- Mounting screws, bolts and nuts, washers, anchor bolts
- Tools, drilling machine
- Magnetic compass
- Marking pen and nail
- Thread
- Measuring tape
- Ruler

PROCEDURE

TASK 1: **Mount solar panels on the mounting structure**

1 Wear the PPE necessary.

2 Use the finished structure for pillar mount on rooftop.

3 Assemble the panels over the frames with the panels facing south at desired angles.(4x250Wp)

4 Check all fittings for correctness.

5 Check the wind gap between solar panels.

6 Secure tightness on base to roof and pillar to frame, bolt and nuts.

7 Secure tightness on the panels to frame fitting points.

Setup wire solar panels 250 W x 4 nos on the mounting structure

Objectives: At the end of this exercise you shall be able to
- **identify the connectors**
- **perform assembly of connectors**
- **crimple the terminals end**
- **perform wiring the mounted solar panels**
- **interconnect the panels**
- **perform wiring and extension till inverter input**
- **lay conduit pipe**
- **lay underground cable**
- **connect end terminals to inverter.**

Requirements

Tools and Instruments/equipment

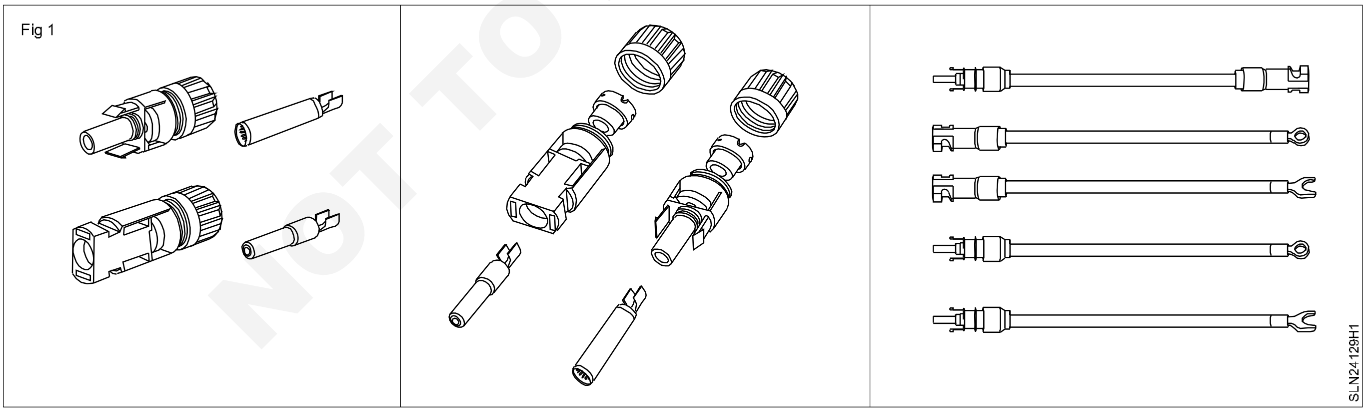
- MC4 connectors - as reqd.
- Crimping tools - as reqd.
- Wire stripper - as reqd.
- Solar DC cables - as reqd.
- Digital Multimeter - as reqd.

Caution:

- **Keep all the circuit breakers & switches in OFF position.**
- **keep all fuses removed &stored separately till commissioning starts.**
- **DC volt more than 70 volts prove very dangerous.**
- **Once solar panels are exposed to sunlight they start generating DC volt.**
- **Construction work continues for long period based on capacity of the plant.**

MC4 connectors and DC cables for extension of Solar panel output wires. (Fig 1)

Fig 1



PROCEDURE

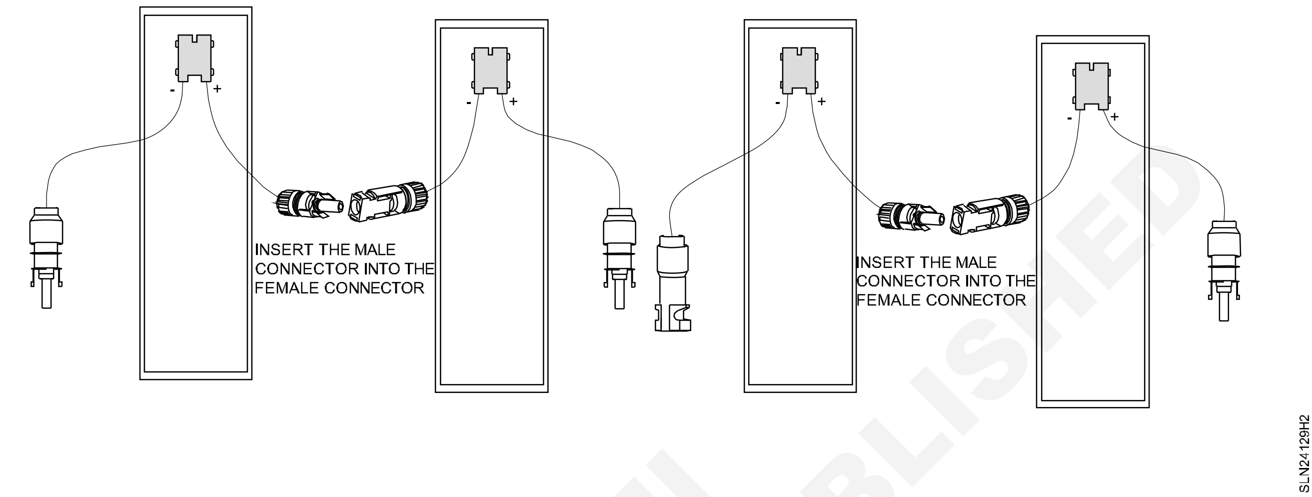
TASK 1: **Carry out wiring on mounted solar panels for series wiring by using MC4**

1 Interconnect solar PV panels using the MC4 connectors as shown in Fig 2.

2 Positive terminal of first panel and negative terminal of the last panel are the outout terminals of series combination of these 4 x 250W solar panels.

Serial wiring (Fig 2)

Fig 2



TASK 2: **Carry out wiring on mounted solar panels for parallel wiring by using MC4**

1 Refer the Fig 3.

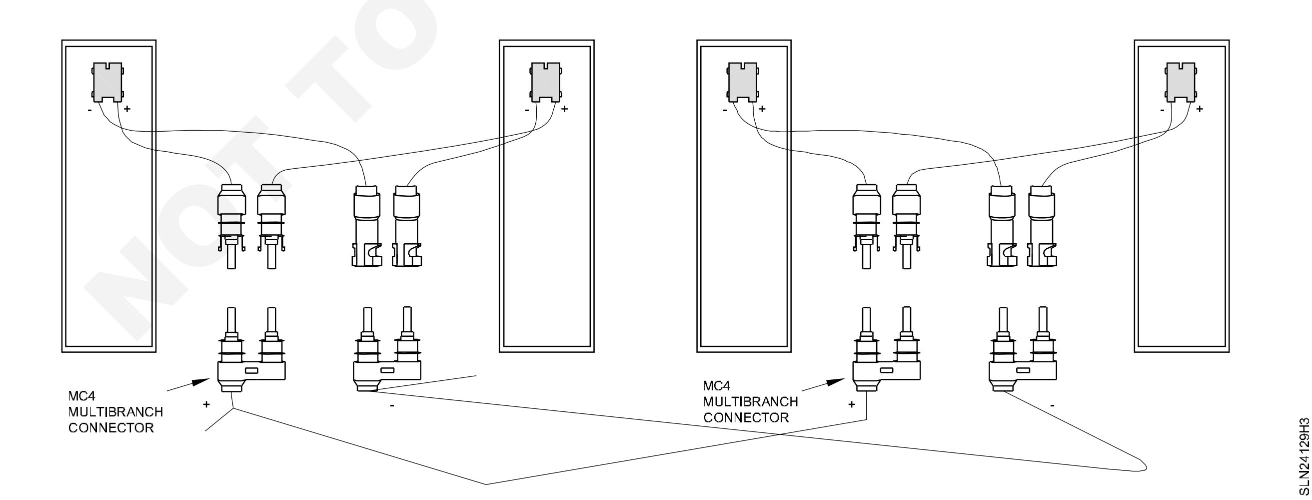
2 Use MC4multi branch connectors and connect adjacent solar panels.

3 Use connecting solar cables with terminals ended with suitable male/female MC4 connectors and connect sets of panels.

Parallel wiring (Fig 3)

Note: the above tasks are possible to perform with AJB or combiner box for better safety.

Fig 3



Power **Exercise 1.12.129**

Solar Technician (Electrical) - Installation Solar PV Plant and Hybrid Plant

Connect the array junction box to the above installation and draw wires up to PCU

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

- **perform AJB wiring and PCU wiring.**

Requirements

Tools and Instruments/equipment

- Pillar mount with solar panels 4 X 250W solar panels mounted on it
- Array junction box or combiner box
- Pre-installed with surge protector, DC MCB, connectors, link and fuses
- Wires and tool

PROCEDURE

TASK 1: **Wire the Array Junction Box for series wiring**

1 Fix the AJB in the centre of the Mounting structure or in the end as per convenience in the site to draw the output wire to PCU.

2 Extend positive wires from solar panels to DC (positive) input connectors of AJB.

3 Extend negative wires from solar panels to DC (negative) input connectors of AJB.

4 Link inside the DC input connectors (positive and negative) of AJB provides parallel connection.

5 Remove the link.

6 Provide loops of wires on to the connector for serial wiring.

AJB wiring (Fig 1)

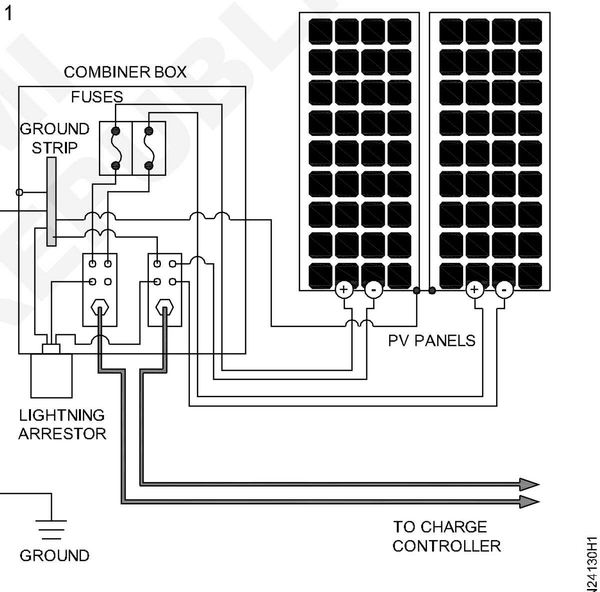
6 Internally the connectors outputs are taken to Surge Protecting Device (SPD), DC MCB and DC fuses (Factory built).

7 Take out Combined DC output from AJB and extend till solar DC IN of PCU.

8 Earth wire (Green) is connected to chassis or box cover.

Parts of AJB

Fig 1



COMBINER BOX WIRING

TASK 2: **Wire the Array Junction Box for parallel wiring**

1 Fix the AJB in the centre of the Mounting structure or in the end as per convenience in the site to draw the output wire to PCU.

2 Extend positive wires from solar panels to DC (positive) input connectors of AJB.

3 Extend negative wires from solar panels to DC (negative) input connectors of AJB.

4 Link inside the DC input connectors(positive and negative) of AJB provides parallel connection.

5 Check for link available in position; if not provide link there. Check for parallel connection and confirm.

6 Internally the connectors outputs are taken to Surge Protecting Device (SPD), DC MCB and DC fuses (Factory built).

7 Take out Combined DC output from AJB and extend till solar DC IN of PCU.

8 Earth wire (Green) is connected to chassis or box cover.

After completion of AJB wiring record your experience in Observation column

Observations

Sl.No	List the observation

— — — — — — — —

Carry out setting of inclination of Solar panel mounting for various cities

Objective: At the end of this exercise you shall be able to
- **carry out setting and varying angle of inclination of solar panel according to tilt angle desired.**

Requirements

Tools and Instruments/equipment

- Pillar mount on rooftop assembled with 4 x 250 W solar panels and wired
- Maps / android mobile
- Clinometers (Android mobile app is available)
- Spirit level (Android mobile app is available)
- Calculation of Tilt angle

The solar panel is mounted on a Tilt angle towards south or north (Facing) based on location on Earth. The usage of above tools explained next.

Solar panel facing direction

Facing of the panel is towards

- South for locations in Northern Hemisphere (Above equator).
- North for locations in southern hemisphere (Below equator).
- Flat on equator.

Tilt angle is

- 0° at equator.
- θ° towards south or north depending on the location of site.
- θ depends on latitude of a place on the Earth.

PROCEDURE

TASK 1: **Set the Tilt angle for a given location**

1 Find tilt angle (as follows).

2 Using mobile with GPS or location ON you can get local latitude.

3 In Google browser search latitude of .... (Name of a place); then you will get latitude of other locations.

4 In solar tilt app by feeding latitude angle you will get four seasons tilt angles.

Hint:

Optimum Tilt of Solar Panels*

1 If your latitude is below 25°, use the latitude times 0.87.

2 If your latitude is between 25° and 50°, use the latitude, times 0.76, plus 3.1 degrees.

*Only results were shown here collected from reliable sources. Derivations are not given here.

3 Simple tool to find the angle of inclination:

Procedure for Set/Adjust the Tilt angles

1 Loosen the bolt and nuts on connecting lever on either side.

Sl.No.	Latitude	Angle of Inclination
1	0 - 15°	15°
2	15° - 25°	Same as latitude
3	25° - 30°	Latitude + 5°
4	30° - 35°	Latitude + 10°
5	35° - 40°	Latitude + 15°
6	Above 40°	Latitude + 20°

2 Vary the entire tilt of entire solar array.

3 Simultaneously measure the desired angle using the clinometers*.

4 After setting desired angles fasten the nuts on connecting levers.

*Clinometer and spirit level apps are available in android mobiles and can be installed & used.

*The task can be repeated for different locations or different angles meant for different choice of locations.

Observation

Sl.No	List the observation

Perform cable laying in the field

Objective: At the end of this exercise you shall be able to
- **perform laying cable in the field.**

PROCEDURE

TASK 1: **Cable laying or conduit pipe wiring**

1 If from rooftop the wires coming out from AJB are to be extended down the floors conduit pipe wiring is preferred.

2 Lay the Conduit pipe on the wall for the required distance.

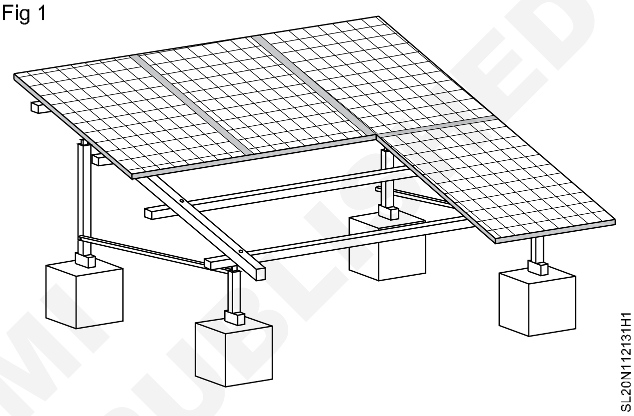
3 Draw the wires through conduit pipe using spring for entire length.

4 Connect the end of wires to the SPV input of solar inverter.

- DC disconnects are to be installed as per drawing.
- Practice cable laying by visiting on- going Mega project by having MoU with Solar PV Integrators (In-plant training).

Cable laid from Solar PV array field to Central inverter room. (Fig 1)

Fig 1



— — — — — — — —

Carry out civil work on the mounting structure, perform concrete foundation pole base

Objective: At the end of this exercise you shall be able to
- **carry out civil works on the mounting structure.**

Requirements

Tools and Instruments/equipment

- Civil construction work related tools: spade, container etc
- Marking pen
- Measuring tape
- Ruler
- Materials: Gravels, sand, cement as per requirement
- Bricks

PROCEDURE

TASK 1: **Finish base of pillar mount**

This activity can be outsourced. However for mini projects in case of start-up groups this can be done by the same team for economic reasons.

1 Mix proportionately the gravel, sand and cement to prepare concrete base.

2 Mark the around the base of each pillar required space.

3 Cover the marked space with bricks to make box like structure around the base of pillar.

4 Pour the concrete mix sufficiently and sauté with spoon to remove any air hole inside.

5 Neatly finish the top.

6 Leave it dry for few hours.

7 Verify the concrete hardened.

8 Remove the bricks.

9 Plaster the surface.

10 Next day cure it with water to set the concrete.

Concrete support around base of pillar mount. (Fig 1)

Observations

Sl.No	List the observation

— — — — — — — —

Perform setting of seasonal angles on mounting structure

Objective: At the end of this exercise you shall be able to
- **carry out setting of seasonal angles on solar panel.**

Requirements

Tools and Instruments/equipment

- Pillar mount on rooftop assembled with 4 x 250 W solar panels and wired
- Maps / android mobile
- Clinometers (Android mobile app is available)
- Spirit level (Android mobile app is available)
- Solar tilt app
- Calculation of Tilt angle

PROCEDURE

TASK 1: **Set the seasonal angles on the pillar mount**

1 Find tilt angle (as follows).

2 Using mobile with GPS or location ON you can get local latitude.

3 In Google browser search latitude of .... (Name of a place); then you will get latitude of other locations.

4 In solar tilt app by feeding latitude angle you will get four seasons tilt angles.

5 Loosen the bolt and nuts on connecting lever on either side.

6 Vary the entire tilt of entire solar array.

7 Simultaneously measure the desired angle using the clinometers*.

8 After setting desired angles fasten the nuts on connecting levers.

*Clinometer and spirit level apps are available in android mobiles and can be installed & used.

— — — — — — — —

Wire a battery bank for 1 kW battery bank installation

Objective: At the end of this exercise you shall be able to
- **perform wiring battery bank.**

Requirements

Tools and Instruments/equipment

- 4 x 12 V, 100 AHr Solar Batteries
- Connecting DC cables –red and black
- Connecting lugs
- Insulators or insulating tape

PROCEDURE

TASK 1: **Perform grouping batteries in series - parallel**

1 Arrange the batteries in the rack.

2 Plan according to the requirement for positioning the terminals conveniently.

3 Connect the lugs at the ends of the dc cables – choose proper colour of cables wires.

4 Safely wearing gloves remove the nuts on the terminals.

5 Connect proper wire as per diagram and place the nuts.

6 Verify the connections are correct.

7 Take care no short circuit to happen or the final two wires to come int contact.

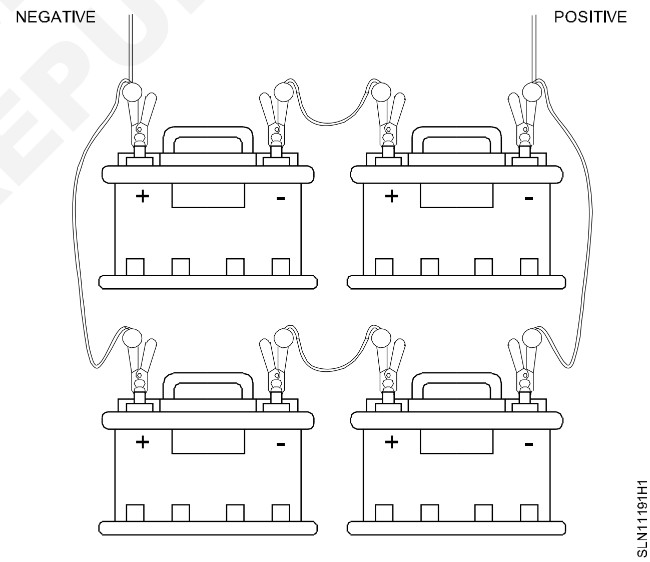
8 Using spanners tighten the nuts firmly. Any loose contact can give spark and shock.

9 Apply gel on the terminals.

10 Record your observations.

Series – parallel combination of 4 x 12 V, 100 AHr solar batteries. (Fig 1)

Fig 1



— — — — — — — —

Carry out wiring the above installation panels, battery etc. to a 1 kW solar PCU

Objective: At the end of this exercise you shall be able to
- **perform wiring of components interconnection in SPV plant.**

Requirements

Tools and Instruments/equipment

- Finished solar panel mount
- Finished AJB wiring
- Finished battery bank
- PCU

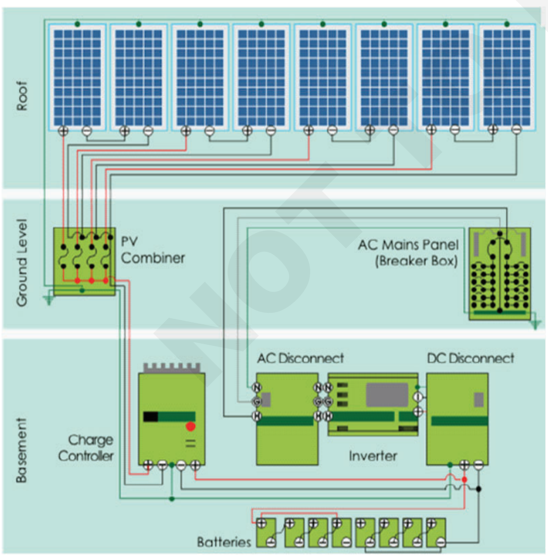
PROCEDURE

TASK 1: **Finish the electrical wiring of 1 kW SPV off grid plant**

Caution:
- **Keep all the circuit breakers & switches in OFF position.**
- **keep all fuses removed &stored separately till commissioning starts.**
- **DC volt more than 70 volts prove very dangerous.**
- **Once solar panels are exposed to sunlight they start generating DC volt.**
- **Construction work continues for long period based on capacity of the plant.**

Sample off grid SPV system wiring diagram. (Fig 1)

Fig 1



1 Wire the Charge controller (If separately available).
2 Connect battery bank to charge controller or inverter as the case may be, through DC disconnect.
3 Connect solar array output from combiner box through dc disconnect to charge controller.
4 Connect charge controller output through dc disconnect to the input of the PCU/inverter.
5 If charge controller is internal to the PCU/inverter the connect the battery terminals to corresponding input to the PCU/inverter.
6 Do not switch ON any disconnect or MCB.
7 Verify all wiring are correctly done.
8 Record your observations and work done.

Observations

Sl.No	List the observation

— — — — — — — —

Carry out woring a battery to a 1kW solar PCU distribute the loads as per economic planning

Objective: At the end of this exercise you shall be able to
- **divide the loads into groups to facilitate connect/disconnect based on requirement.**

Note:
- **Knowledge of domestic and industrial wiring.**
- **Knowledge of low, medium and high power AC loads.**
- **Distribution panels.**
- **MCBs, fuses.**
- **Sub-meter (optional).**

PROCEDURE

TASK 1: **Plan distribution of AC loacs**

1 Analyse the AC loads in the site.

2 Explore possibility of additional loads in near future.

3 Calculate daily average consumption in watt-hours.

4 Compare with the installation capacity of the Solar PV on-grid or off-grid electrical system.

5 Accordingly discuss and divide the loads into two or more groups.

6 Consider grouping similar loads.

7 Consider high power loads together.

8 Consider essential and not so essential category.

9 Consider emergency line.

10 Provide individual disconnects and fuse.

11 Mark on the MCBs with numbers/letters and include chart explaining the loads connected in each.

12 Demonstrate including or excluding loads as per power conditions and convenience.

Observations/ work done

Sl.No	List the observation

— — — — — — — —

Practice to the AC mains connection to the solar PCU

Objective: At the end of this exercise you shall be able to
- **perform wiring in AC circuit.**

Requirements

Tools and Instruments/equipment

- Connected Solar PV system.

PROCEDURE

TASK 1: **Connect AC and finish connections**

> **Caution:**
> - **Keep all the circuit breakers & switches in OFF position.**
> - **Keep all fuses removed &stored separately till commissioning starts.**
> - **DC volt more than 70 volts prove very dangerous.**
> - **Once solar panels are exposed to sunlight they start generating DC volt.**
> - **Construction work continues for long period based on capacity of the plant.**

1 Verify Finished AC loads wiring with MCBs and keep them OFF.

2 Connect the AC mains to the inverter.

3 Connect the AC loads to the inverter output.

System is ready for commissioning but do not switch ON. Follow next task.

— — — — — — — —

Carry out wiring to prepare a checklist for finding out errors during installation

Objective: At the end of this exercise you shall be able to
- **get ready for first switch ON.**

Requirements

Tools and Instruments/equipment
- Installed SPV system.

PROCEDURE

TASK 1: **Evaluate the installation free of errors**

1 Look out for possibilities of errors might have got included during the above phases.

2 Group the findings and arrange them block wise.

3 Prepare a chart of important points like questionnaire to be answered by the person inspecting the site.

4 Include check boxes with tick marks can be indicated to show ‘Yes’ or ‘No’.

5 Include in the bottom company’s name and address, inspector’s name and signature, Team in-charge name and signature, Box for recommendation, remarks etc.

6 Record the finalised check list in the observation column.

Observations

Sl.No	Checklist parameter	Remarks

Model check list

Solar Electric (PV) system installation checklist

Following the completion of each item on the checklist below, check the box to the left of the item and insert the date and initials of the person completing the item whether that is the installing contractor or owner-installer.

Remember to follow the proper safety procedures while performing the system installation. The appropriate safety equipment for each section of the checklist is listed above each section of the checklist.

Before starting any PV system testing:

PPE: hard hat and eye protection

1 Check that non-current carrying metal parts are grounded properly. (array frames, racks, metal boxes, etc. are connected to the grounding system).

2 Ensure that all labels and safety signs specified in the plans are in place.

3 Verify that all disconnect switches (from the main AC disconnect all the way through to the combiner fuse switches) are in the open position and tag each box with a warning sign to signify that work on the PV system is in progress.

PV Array Circuit Wiring

PPE: hard hat and eye protection

1 Check home run wires (from PV modules to combiner box) at DC string combiner box to ensure there is no voltage on them.

2 Recheck that fuses are removed and all switches are open.

Prepare a checklist and clearance certificate for commissioning

Objective: At the end of this exercise you shall be able to
- **issue a clearance certificate for first switch ON.**

> **Note: Verified check list signed by the inspector (Technician).**

PROCEDURE

TASK 1: **Grant permission to first switch ON**

1 Complete information about the installation.

2 Verify important points as an in - charge of team.

3 Consider risk blocks.

4 Have a verbal check up with the technician signed.

5 Rectify any loose connection or short comings reported.

6 On satisfactory completion sign the document and release it for 'First Switch On'.

Observations

Sl.No	Checklist parameter	Remarks

— — — — — — — —

Perform and record load test results and record

Objective: At the end of this exercise you shall be able to
- **carry out first switch ON and no load test.**

Requirements

Tools and Instruments/equipment

- Clearance certificate of Team in charge
- Operational manual of the plant
- SLD
- Testing equipment
- Clamp meter
- PPE kit
- Documents for recording the observations

PROCEDURE

TASK 1: **Conduct the 'No load test' after ' Switch ON'**

Observation of parameters pre operation and Operational test before connecting to Load:

1 Switch on disconnect of charge controller (if available external to PCU) to battery.

2 Switch on the disconnect of battery to inverter.

3 Switch on disconnect of solar PV panel to charge controller

4 Switch on the inverter.

5 Observe correct working condition of above before connecting load.

6 Test and measure voltage and current on.

- Battery voltage
- Charge controller
- Solar panel
- Inverter output

7 Record the observations.

Observations

Sl.No	List the observation

— — — — — — — —

Perform 'ON load' test and record observation

Objective: At the end of this exercise you shall be able to
- **carry out ON-load test.**

Requirements
Tools and Instruments/equipment • Documents and test equipment

PROCEDURE

TASK 1: **Conduct ON load and overload test**

1 After assuring the above step is free of any defect connect the load step by step.

2 Check for,

- Normal load operation - Progressive load connecting and on load testing.
- Visual and audio alarms.

3 Record all the above in printed forms. This is an important document for the customer as well as for solar company to claim against any warranty and guaranty - First inspection report generation.

4 Customer orientation.

Observations

Sl.No	List the observation

— — — — — — — —

Perform overload test and record observation

Objective: At the end of this exercise you shall be able to
- **carry out over load test.**

Requirements
Tools and Instruments/equipment
• Documents and test equipment

PROCEDURE

TASK 1: **Conduct overload test and explain to the customer**

1 After assuring the above step is free of any defect connect the load step by step.

2 Check for,
- Over load indication (Connect little excess load and observe) - Overload testing.
- Short circuit indication (Use ELCB).
- Visual and audio alarms.
- Tripping of circuit and breakers.
- Protection circuits operation.

3 Record all the above in printed forms. This is an important document for the customer as well as for solar company to claim against any warranty and guaranty - First inspection report generation.

4 Customer orientation.

Observations

Sl.No	List the observation

Prepare a first inspection report on the solar plant installation

Objective: At the end of this exercise you shall be able to
- **organize first inspection report.**

Note: Commissioned SPV installation and Document.

PROCEDURE

TASK 1: **Generate a First Inspection report of a SPV plant while handing over the plat**

1 Perform the first switch ON activity after the satisfactory visual inspection of installation.

2 Verify AC mains input Voltage and current, solar array Voltage and current, battery charging Voltage and current, Inverter output AC Voltage and current in the prescribed form brought from company.

3 Perform the above step with no load, step by step increase in load, full load and little overload condition.

4 Record all the actual observations in front of customer to show him the proper functioning of the Solar PV plant what he ordered.

5 Record any abnormality noticed and rectify it, if possible.

6 Inform maintenance team otherwise.

7 Take the acceptance from customer by getting his/her signature in the test report.

Prepared Report

Sl.No	Inspection report	Remarks

— — — — — — — —

Prepare a list of do's and don'ts in the installation

Objective: At the end of this exercise you shall be able to
- **formulate do's and don'ts.**

Note:

O & M manual from reputed Solar PV integrator.

Knowledge of the complete SPV plant commissioned.

PROCEDURE

TASK 1: **Organize a list of safe handling of the SPV plant**

1 Prepare a procedure for cleaning the PV modules including period of maintenance.

The normal operation of the PV system is automatic and does not require any intervention by the customer. However, he should know about the basic procedures to clean the PV modules for good performance of the system.

2 Give information on possible significant variation in the system performance under varying conditions such as rain, fog and sunshine.

3 Give information on electric shock possible areas.

4 Include managing batteries and maintenance of batteries.

5 Educate about saving energy.

6 Give methods of load management.

7 Explain method of cleaning the area around inverter frequently.

8 Include method of changing fuse.

9 Explain what are possible by the customer.

10 Clearly explain what conditions need the customer to call the maintenance team.

— — — — — — — —

Prepare a report on customer orientation

Objective: At the end of this exercise you shall be able to
- **perform customer orientation.**

Note:

O & M manual from reputed Solar PV integrator.

Knowledge of the complete SPV plant commissioned.

PROCEDURE

TASK 1: **Explain System Maintenance to the Customer**

1 Explain the customer preserving the maintenance manual and how to use it.

2 Explain the Do's and Don'ts by the customer.

3 Explain how many backup hours the system is designed for if there is full sun shine.

4 Explain how many cloudy days will fully discharge the batteries under expected load.

5 Explain how fog can affect the backup hours.

6 Explain that month to month output from the system will vary based on seasons and weather.

7 Explain the estimated yearly savings in electricity the customer can expect.

8 Provide numbers to call if there is a problem.

9 Provide numbers to call if there is an emergency such as electric shock or fire.

10 Explain the cost of receiving service.

11 Explain what costs are covered by warranties and which ones are not.

12 Hand over documentation and explain the importance of each document to the customer including.

Work done

Sl.No	

— — — — — — — —

Prepare a report on visible and audio annunciations, alarms or alerts in a solar PCU

Objective: At the end of this exercise you shall be able to
- **demonstrate alarms and alerts on PCU.**

Requirements

Tools and Instruments/equipment

- Outcome of previous tests 2.4.142 and 2.4.143
- Documents and test equipment
- Commissioned SPV plant
- O & M manual of the PCU

PROCEDURE

TASK 1: **Conduct again ON load and overload test**

1 After assuring the above step is free of any defect connect the load step by step.

2 Check for,

- Normal load operation - Progressive load connecting and on load testing.
- Over load indication (Connect little excess load and observe) - Overload testing.
- Short circuit indication (Use ELCB).
- Visual and audio alarms.
- Tripping of circuit and breakers.
- Protection circuits operation.

3 Record all the above in printed forms. This is an important document for the customer as well as for solar company to claim against any warranty and guaranty - First inspection report generation.

4 Customer orientation.

— — — — — — — —

TASK 2: **Demonstrate visible and audio annunciations, alarms or alerts in a solar PCU**

1 Switch ON and perform normal functioning of the SPV plant.

2 Verify the visual alerts described in the Operating and Maintenance manual of the PCU and confirm they are active.

3 Attend the audio alerts and verify what they communicate with reference to the O & M manual.

4 Record your observations.

Observations

Sl.No	List the observation

— — — — — — — —

Perform shutting down procedure of the above solar plant

Objective: At the end of this exercise you shall be able to
- **demonstrate shutting down of a PCU.**

Requirements

Tools and Instruments/equipment

- Commissioned SPV plant

PROCEDURE

TASK 1: **Demonstrate Start-up and Shutdown Procedures**

Once commissioned, a PV system does not need to be shut down and started up under regular operation. The customer needs to shut down and start up the system under specific circumstances as described below:

1 There is any malfunction that can be observed in the inverters or batteries such as unusual noise, overheating, fumes etc.

2 The customer finds voltage fluctuations in your electricity supply and is not sure of the reasons.

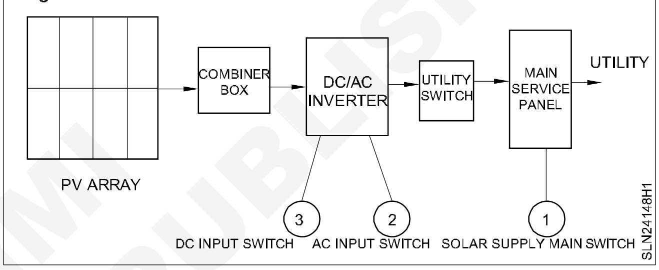
3 There is a safety event related to the PV system or to the general electrical wiring in the facility.

4 The customer is instructed to switch off the system by the service provider.

5 A customer will need to understand the system with a simple block diagram and locate the specific switches that need to be turned off or on. The diagram below shows the shutdown sequence in a simple block diagram understandable to the customer.

Shut down precedure (Fig 1)

Fig 1



Shut down in the following sequence:

1 Switch off the solar supply main switch in the main service panel.

2 Switch off the AC input or AC isolator switch on the solar inverter.

3 Switch off the DC input switch, which connects to the solar array.

The start-up procedure will operate in reverse. It is extremely important to follow the above mentioned shutdown sequence because the probability of arcing is more at DC breaker than at AC breakers. So the AC breakers are switched off first to isolate load and reduce the generated current. This is safer and also leads to increased life of the protection devices used in the circuit.

Practice different foundation procedures for ballast foundation

Objective: At the end of this exercise you shall be able to
- **construct a ballast foundation.**

Requirements

Tools and Instruments/equipment

- Readymade ballasts with best specifications
- Material handling equipment
- Civil construction utensils
- Civil materials
- Plan of solar array with clear dimensions
- Measuring tape
- Spirit level
- Plumb Bob

PROCEDURE

TASK 1: **Make ballast foundation**

1 With ballast-mounted systems, the flat roof mounts are anchored without penetrating the roof.

2 Place Concrete blocks, slabs or plinths on the flat roof without any further fixing.

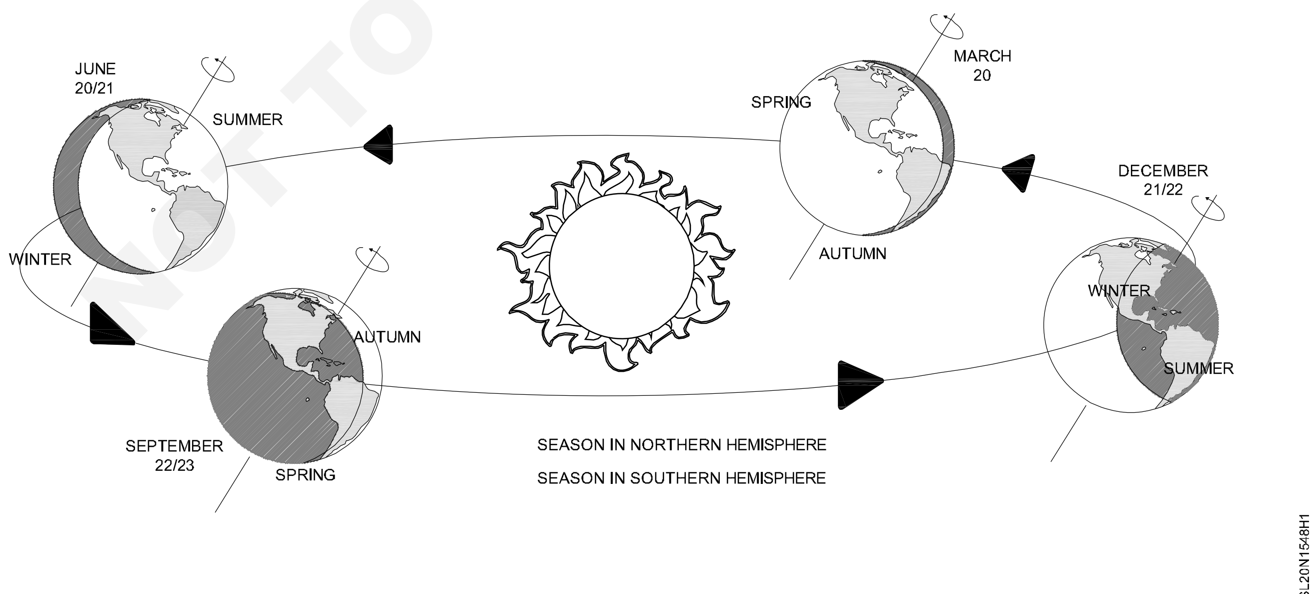
3 Secure the support frames to these with screw anchors.

4 Use standard building materials such as curbs, paving slabs or specially made foundation slabs for the concrete elements.

5 Lay mat beneath to protect the roof skin from sharp edges.

6 Alternatively, insert the concrete weights in channels on the support frame.

Fig 1



Practice foundation procedures of a rack mount for a tilted roof

Objective: At the end of this exercise you shall be able to
- **assemble a rack mount.**

Requirements

Tools and Instruments/equipment

- Set of rack mount fittings (Panel Rack: Panel racking in general, consists of rails/ rafters, roof mounts, fasteners like mid clamp, end clamp)
- Accessories
- Drilling machine
- PPE required
- Material handling equipment

PROCEDURE

TASK 1: **Assemble a rack mount**

1 Refer design and user manual for installation, since, Installation of mounting structure is site and product specific.

2 Locate structural roof members and install structural attachments.

3 Secure the rails/array base to the roof using footings, standoffs and other types of mounts.

4 Hold the modules in place on the rails / array base.

5 Tighten the fasteners.

Panel Racking - Rails/rafters, fasteners (clamps). (Fig 1)

The modules are fitted above the existing roof covering using a metal substructure.

The metal structure to support the modules consists of three main components:

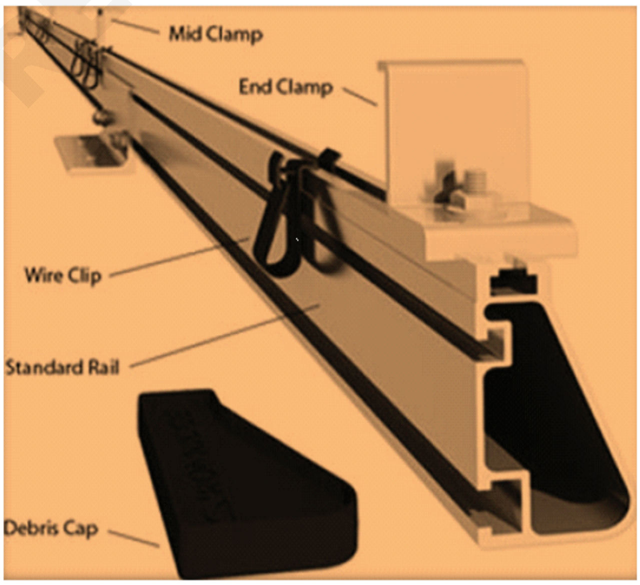
1 Roof mounts

2 Mounting rails

3 Module fixings

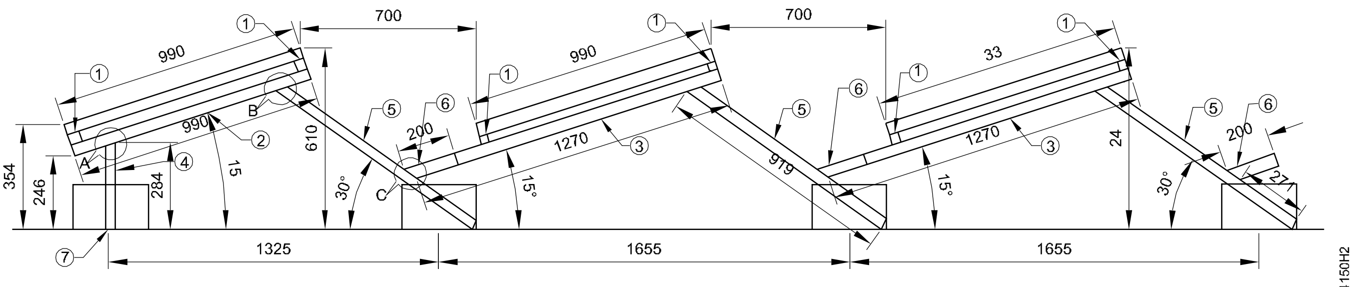
Using the roof mounts, a rail system is anchored to the roof structure beneath the roof covering or is fixed directly to the roof cover itself (but only if the roof covering is structurally strong enough). The modules are fixed to the rails with system-specific fixing elements. Most preferred material for rails is aluminium & SS fasteners. Aluminium makes the structure light while SS fasteners are strong and durable.

Fig 1



Module support structure (Fig 2)

Fig 2



Observation

Sl.No	List the observation

— — — — — — — —

Practice to prepare report on building integrated solar mount

Objective: At the end of this exercise you shall be able to
- **design a building integrated solar mount.**

> **Note:**
> **Knowledge of building integrated solar mounts.**
> **Visit to be arranged by the institute.**

PROCEDURE

TASK 1: **Design a building integrated solar mount**

1 Visit a modern green building with integrated solar fixtures.

2 Study the features.

3 Collect information.

4 Record your observations.

5 Design a miniature model of Building integrated solar mount.

Observations

Sl.No	List the observation

— — — — — — — —

Prepare a foundation for a single pillar mount

Objective: At the end of this exercise you shall be able to
- **making a foundation for a single pillar mount.**

Requirements

Tools and Instruments/equipment

- Civil construction work related tools: crowbar, spade etc
- Marking pen and nail
- Thread
- Measuring tape
- Ruler
- Tool kit
- Safety gadgets

Materials

- Gravels, sand, cement as per requirement
- Pole

Civil works in work area

- Skills required in making foundation on ground
  a Marking
  b Digging
  c Bar bending
  d Filling concrete mix
  e Curing concrete

PROCEDURE

TASK 1: **Prepare civil foundation for the pillar mount**

1 Use compass and mark true north and south poles.

2 Draw line connecting north and south poles points.

3 Place the pillar mount aligned to the connecting lines.

4 Mark the base.

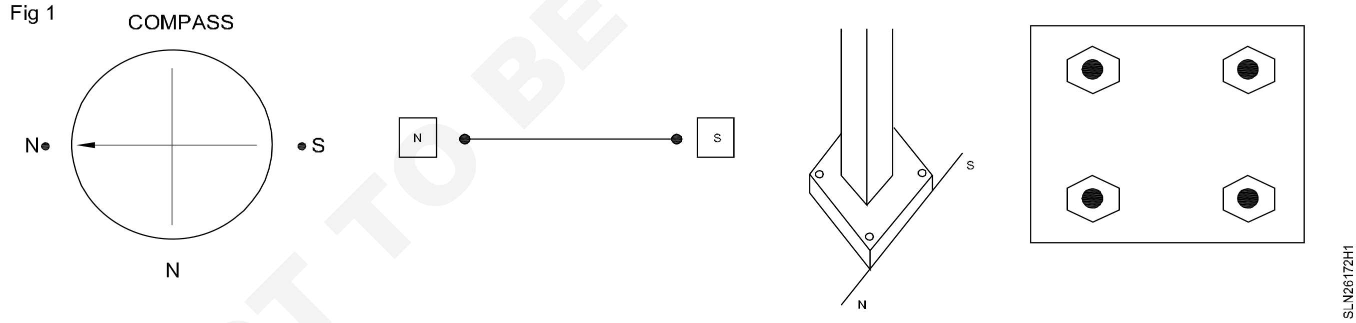
5 Remove the pillar mount.

6 Dig pit (Crater) as per drawing (Example: if Base is 1ft x 1 ft then the crater should be 1ft x 1 ft x 1.5ft as shown).

7 Use the wooden stencil of base of the pillar mount.

Marking for foundation on ground (Fig 1)

Fig 1



8 Fix the bar bended TMT rods with thread on top end on to the stencil.

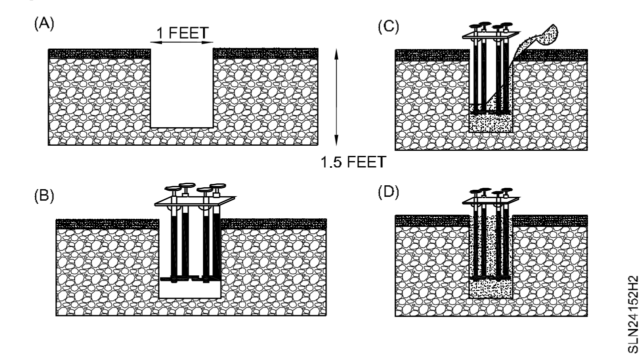
9 Keep the assembly in the carter with the stencil on ground level.

10 Fill in concrete mortar in the pit and allow to harden doing proper curing.

11 Remove the stencil & fasten the bolts; keep ready for next task.

Making Foundation (Fig 2)

Fig 2



— — — — — — — —

Prepare a report for mega solar project strings, array, inverter room, output transformers, plant layout and SCADA room

Objective: At the end of this exercise you shall be able to
- **appraise locations of all components in a mega solar plant.**

> **Note:**
>
> **MoU of Institute with Mega projects of SPV plant for in plant training.**

PROCEDURE

TASK 1: **Prepare a complete project report**

1 Visit the mega plant.

2 Prepare detailed project report on design, procurement, installation, commissioning and maintenance of the mega plant.

Observation

SI.No	Site Inspection report	Remarks

— — — — — — — —

Prepare a report on site suitable for windmill

Objective: At the end of this exercise you shall be able to
- **assess a site for wind mill.**

Note:

MoU of Institute with wind power plant for in plant training / site visit.

PROCEDURE

TASK 1: **Prepare a complete project report on wind power plant**

1 Visit the wind power plant.

2 Observe the site suitableness for the wind plant.

3 Get expert consent on deciding a place suitable for wind plant.

4 Prepare a report using the findings.

Observation

Sl.No	Site Inspection report	Remarks

— — — — — — — —

Observe the presence of obstacles in a site suitable for windmill

Objective: At the end of this exercise you shall be able to
- **evaluate hurdles for functioning of wind mill in a site.**

Requirements

Tools and Instruments/equipment

- Visit places of windy areas
- Anemometer
- Record sheets

PROCEDURE

TASK 1: **Find out obstacles for wind flow**

1 Explore windy areas.

2 Visit raised places like tall buildings, towers, apartments.

3 Observe wind flow at different sections of visited area.

4 Find out places nearby the above where wind speed reduces.

5 Analyse the reasons behind speed loss.

6 List out the obstacles thereof.

Observation

Sl.No	Site Inspection report	Remarks

— — — — — — — —

Check windiness of a place using an anemometer

Objective: At the end of this exercise you shall be able to
- **examine the flow of wind in site.**

Requirements

Tools and Instruments/equipment

- Site visit
- Anemometer
- Record sheets

PROCEDURE

TASK 1: **Prepare a report on windiness**

1 Visit windy areas.

2 Measure wind speed at different points.

3 Prepare a report on the types of wind.

4 Observe through records the windiness of regions in India and summarize.

Work done

Sl.No	Anemometer reading	Remarks

— — — — — — — —

Prepare a report on wind mill energy conversion through audio visual sessions

Objective: At the end of this exercise you shall be able to
- **appraise a wind power plant.**

Requirements

Tools and Instruments/equipment

- Website browsing on Wind energy
- AV sessions

PROCEDURE

TASK 1: **Discuss on wind energy conversion system**

1 Browse the net and collect information on wind energy conversion system.

2 View AV sessions.

3 Explain how electricity is generated through wind energy.

4 Visit the wind power plant.

5 Prepare detailed project report on design, procurement, installation, commissioning and maintenance of the wind power plant.

Observation

Sl.No	Report	Remarks

— — — — — — — —

Perform practice on lab model of wind power plant

Objective: At the end of this exercise you shall be able to
- **perform practice on lab model of wind power plant.**

Requirements

Tools and Instruments/equipment

- A blower
- Model windmill

PROCEDURE

TASK 1: **Perform practice on lab model of wind power plant**

1 Collect the inferences from previous tasks about wind mill.

2 Face the model windmill in front of the blower.

3 Switch ON the blower and find the effect on the wind mill.

4 Vary the speed of wind.

5 Change the direction and plane of the wind mill with respect to the blower.

6 Observe in each case the behaviour and output from the wind mill.

7 Record your observations.

Observations

Sl.No	List the observation

— — — — — — — —

Demonstrate standard operating procedures of PV system

Objectives: At the end of this exercise you shall be able to
- **follow SOP of solar photovoltaic electrical system**
- **demonstrate various safety measures to be taken in the field/site**
- **monitor activities and foresee problems**
- **solve issues onsite**
- **execute remedial actions at once**
- **adapt the standard operating procedures on SPV installation site.**

Note:
- **Work spot where installation is going on.**
- **Finished and operating PV plants.**
- **Plants under AMC.**
- **Plants not under AMC.**
- **Any other PV site selected by the instructor (Define nature of site….).**

PROCEDURE

TASK 1: **Collect information on probable activities by Solar Technician which may result in injury or accident to one or more persons in the team**

1 Divide the technicians into groups of four or five each.

2 Select work places different for each team.

3 Visit the spot on different days and time.

4 Collect details of occurrences all over which may lead to injuries, failures, health issue or accidents or any other kind (Specify).

5 Classify the events based on men, machine and material.

6 Evaluate the happenings based on:
- Risk
- Waste
- Fire and emergency
- Electrical
- Work at height and fall
- Tools and equipment
- Traffic (Men/material)
- Personal protection
- Fellow workers/onsite people protection
- Work permit
- Lifting or handling
- Health
- Safety

7 Highlight chances of failures to men or material or anything else (specify).

8 Suggest precautionary measures.

9 Suggest actions for remedies in case of failure.

10 Suggest educative aids to improve safety.

11 Prepare a SOP in general.

— — — — — — — —

TASK 2: **Preparation of safe work area: Arrange materials and tools for safe working**

1 Study the list of materials, tools and equipment.

2 Compare with site requirement and add/delete any item required/not required.

3 Recall the usage of the tools and equipment.

4 Learn and practice about unknown or forgotten means.

5 Educate the team members about everything in the list.

6 Demonstrate once usage of PPE kits and explain what happens when not used.

7 Prepare short guidelines after these exercises for safe working in the site as a reminder.

— — — — — — — —

TASK 3: **Assist to implement safety policies and procedures: Practice implementing**

1 Define hygiene.

2 Define first aid.

3 Practice Safety policies.

- Report abnormalities with reference to the safety policies to your Supervisor/team leader.
- Display the basic identity of hazardous products.
- Affix Material Safety Data Sheets at work place if not provided even after reminding.
- Implement for Housekeeping policy of tools and equipment, components and protective equipment.
- Adapt strictly safe working at heights policy: A worker must wear a safety belt of safety harness with a lanyard tied off to a fixed support whenever the worker may fall 3 meters or more.
- Display a statement of the purpose of the policy.
- Display an expression of the organisation's commitment to controlling the hazard or issue at its source.
- Display an outline of how the hazard or issue will be controlled, including resources to be provided and a timeframe for action.
- The roles and accountabilities of relevant stakeholders, particularly managers and supervisors.
- Affix a description of how the safety policy will be implemented.

Safety Policy Format (Fig 2)

4 Practice Safety procedures.

- Help to demonstrate and display a written statement of health and safety policy.
- Assist to implement the overall work flow, from materials coming into the workplace, to the final product going out;
- Inspect workplace safety.
- Display the step by step activity procedure where there are workplace hazards, and risks to health and safety.
- Identify workplace hazards and issues. - hazard identification, risk assessment and risk control.

Safety Procedure (Fig 3)

- Collect information about the hazardous activity or issue.
- Prepare the policy or procedure.
- Implement the policy or procedure.

5 Report hazards

- Help to investigate incidents and issues, with corrective actions.
- Support reactive and response activities such as: first aid and medical emergencies.

6 Report illness, injury.

7 Report incidents and dangerous occurrences.

- Help to establish the First Aid procedure.

Demonstrate electrical maintenance of inverters

Objectives: At the end of this exercise you shall be able to
- **maintain inverter/PCU**
- **maintain cable**
- **maintain junction box**
- **maintain fault indicators of PCU.**

Requirements

Tools and Instruments/equipment

- Service manual of PCU/inverter
- Digital multimeter
- SLD

PROCEDURE

TASK 1: **Review the safety precautions to avoid injury and to prevent damage to the SOLAR PCU or inverter**

1 To avoid potential hazard use the SOLAR PCU or inverter only as specified.

2 Service shall be done ONLY by qualified / authorized personnel!.

3 To Avoid Fire or Personal Injury, never use Automobiles Batteries with your SOLAR PCU. They are not suitable for these applications.

4 Always check the water level in batteries (For flooded batteries only).This will keep your batteries in good condition and also enhance its life.

5 Verify whether 'Do's are followed, such as:

- Provide proper ventilation!.
- Install the power SOLAR PCU in a location that is well ventilated so that the heat it generates can be dissipated easily.
- Do check the water level of your battery for every 3 months as this is very much essential to keep the battery in good condition.
- Keep your batteries rust-free, good lubricating oil or petrol can be beneficial to lubricate your battery terminals at least once every month.
- Check that your SOLAR PCU is earthed properly.
- Always mount the SOLAR PCU in a cool and dry location.
- While wiring your Power SOLAR PCU use Standard and insulated Wires, poor.
- Wiring may lead to Short Circuit that may even lead to fire.

6 Verify that 'Don't 's are strictly not done.

- Do not operate without covers!.
- Do not operate SOLAR PCU with covers removed.
- Avoid exposed circuitry!.
- Do not touch exposed connections and components when powered.
- Do not operate with suspected failures! If you suspect that the SOLAR PCU is damaged, have it inspected by qualified personnel.
- Do not operate in an explosive atmosphere!.
- Do not touch the SOLAR PCU terminals while the power is applied to the SOLAR PCU even if the SOLAR PCU stops.

— — — — — — — —

TASK 2: **Troubleshoot PCU/inverter as allowed by user or technician visiting user**

1 Check only in any case of unsatisfactory operation.

2 If symptom is "Battery is not charging even if mains available" check if LCD display shows "MAINS : OFF" or Batteries are fully charged / Check if input MCB is OFF.

3 If the symptom is - LCD Displays "OVERLOAD" then Check load and wiring; Reset the SOLAR PCU by switching; OFF the unit first and then by switching ON the unit again.

4 Similarly follow the user/service manual and perform remaining checks.

5 Call factory service personnel wherever it is mentioned to do so; do not overdo there.

— — — — — — — —

TASK 3: **Check the indicators**

1 Follow the service manual.

2 Verify the indicators on front panel of PCU.

3 LCD Indication display is provided for SOLAR PCU charge controller and it displays following items:

- Battery Voltage.
- Charging Current of Battery.
- Total power(in terms of wattage) supplied from PV to Battery.

4 LED indicators are provided to show indication related to Inverter mentioned as below:

- Main ONMAINS ON
- Charge ON
- SOLAR PCU ON
- Batteryt low
- Over load

5 If the LED are lighting it corresponds to the good status as mentioned in the manual.

6 If the LED is not lighting the corresponding function may or may not be correct.

7 If system doesn't give any other mal function but LED indication not there it may require change of LED. Refer manual for method changing and verify spares provided. If not mentioned call service personnel. Do not leave the faulty LED not changed. Because the purpose of intimating the fault is not served.

8 If LED doesn't light and corresponding function not available then PCU needs servicing.

— — — — — — — —

TASK 4: **Maintain cable and junction boxes**

1 Visually inspect the site even while normal function.

2 Look for damages due to regular activities in the site due to preventive maintenance activities.

3 Check for damages due animals or insects.

4 Regularly clean the junction boxes.

5 Look for MCB trip, fuse blown and blackening of SPDs etc.

6 Report faults immediately and take suitable remedies.

Sample log sheet for inspection during periodic maintenance

Balance of systems log sheet

	Date	**Date**	**Date**
Name			
Battery voltage			
Regular			
Item clean			
Insects removed			
Cables connections OK			
Functioning OK			
Inverter			
Item clean			
Insects removed			
Cables connections OK			
Functioning OK			
Battery Charger			
Item clean			
Insects removed			
Cables connections OK			
Functioning OK			

Demonstrate of solar panel maintenance

Objective: At the end of this exercise you shall be able to
- **perform maintenance of solar PV panels.**

Requirements

Tools and Instruments/equipment

- Container
- Clean water
- Wiper
- Cleaning fluid

PROCEDURE

TASK 1: **Clean the solar PV array (manual)**

1 Do not sit, stand or walk on solar panel.

2 Even keeping palm on panel for resting for few moments also can damage internally the PV cell.

3 Ensure water used is free from dirt and physical contaminants. (De-ionized water is preferable).

4 Water with mineral content more than 200 ppm should NOT be used.

5 Cleaning agent must be mild, non-caustic and non-abrasive detergent may be used.

6 For normal cleaning where dirt is not visible only water or thinly diluted cleaning agent can be used.

7 Add more cleaning agent where dirt or dust level is more.

8 Pour the mix on the surface exposed to sun and gently brush with wiper to clean.

9 Do not brush or clean on the reverse side of the modules to avoid damage to the lead wires or the junction box.

10 For removing stubborn marks of bird droppings, insects, dirt etc. make use of a soft sponge, fiber cloth or non-abrasive brush.

11 Do not sit, stand or step on the modules for cleaning.

12 Do not use a metal brush to clean solar panel surface.

— — — — — — — —

Demonstrate of battery maintenance

Objective: At the end of this exercise you shall be able to
- **maintain battery bank.**

Requirements

Tools and Instruments/equipment
- Preventive maintenance schedule
- Log book
- PPE

PROCEDURE

TASK 1: **Perform Preventive maintenance of Battery bank**

1 Verify the following common practice on batteries:
- Check the tops of the batteries for clean and dry.
- Check for caps in place and secure.
- Check all wired connections are secure.
- Confirm that there are no shelves, hooks, or hangers above the batteries.
- Check the electrolyte level of every cell in every non-sealed battery. It should always be above the top of the plates, but below the tops of the battery cases.
- Verify the ventilation systems are functional.
- Label each battery with a number for the battery and numbers for each cell.

Sample Battery log sheet

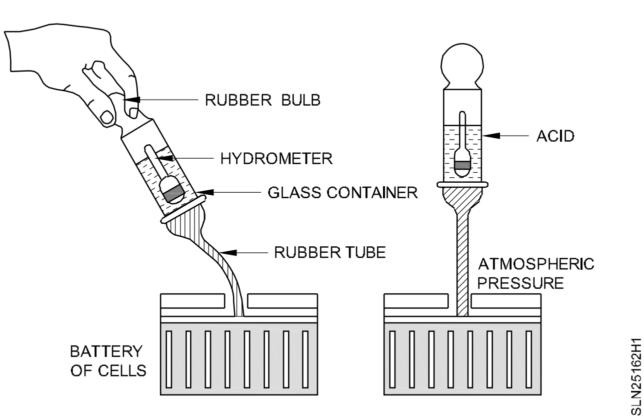
Battery bank log sheet

	Date	Date	Date
Name			
Battery voltage			
Ambient temperature			
Cell 1			
S G			
Electrolyte temperature			
Corrected SoC			
Cell volts			
Water used in litres			
....			
Cell x			
S G			
Electrolyte temperature			
Corrected SoC			
Cell volts			
Water used in litres			
Interconnections OK?			
Battery cases OK?			
Comments			

TASK 2: **Check for specific gravity of electrolyte in a battery**

Testing specific gravity (Fig 1)

Fig 1



1 If the battery has been charged within the last four hours, remove the Surface Charge. If the battery has been discharged within the last 15 minutes, wait for at least 15 minutes before testing it.

2 While holding a clean hydrometer vertically and wearing glasses, squeeze the rubber bulb, insert the nozzle into the electrolyte in the cell, and release the bulb. The electrolyte will be sucked up into the barrel or container allowing the float to ride freely. Start with the cell that is closest to the Positive terminal.

3 Squeeze the rubber bulb to release the electrolyte back into the battery's cell.

5 At eye level and with the float steady, read the Specific Gravity at the point the surface of the electrolyte crosses the float markings. The Specific Gravity reading should be between 1.100 and 1.300.

6 Release the electrolyte back into the cell from which it was taken and record the reading. Be sure to avoid spillage.

8 Thoroughly rinse the hydrometer with water after using it.

Specific gravity to corresponding battery state of charge

Electrolyte Temperature (°C)	**Specific Gravity Reading and State of Charge**				
	SG Reading at 100% SOC	**SG Reading at 75% SOC**	**SG Reading at 50% SOC**	**SG Reading at 25% SOC**	**SOC SG Reading at 0% SOC**
48.9	1.249	1.209	1.174	1.139	1.104
43.3	1.253	1.213	1.178	1.143	1.106
37.8	1.257	1.217	1.182	1.147	1.112
32.2	1.261	1.221	1.186	1.151	1.116
26.7	1.265	1.225	1.190	1.155	1.120
21.1	1.269	1.229	1.194	1.159	1.124
15.6	1.273	1.233	1.198	1.163	1.128
10.0	1.277	1.237	1.202	1.167	1.132
4.4	1.281	1.241	1.206	1.171	1.136
-1.1	1.285	1.245	1.210	1.175	1.140
-6.7	1.289	1.249	1.214	1.179	1.144
-12.2	1.293	1.253	1.218	1.183	1.148
-17.8	1.297	1.257	1.222	1.187	1.152

— — — — — — — —

TASK 3: **Perform monthly battery maintenance**

1 Check electrolyte level flooded lead acid batteries.

2 It should always be above the top of the plates, but below the tops of the battery cases.

3 Level monitors are also available in some batteries.

4 Top up if required.

5 Wipe electrolyte residue from the top of the battery top up of electrolyte. (Fig 2)

6 Inspect all terminals for corrosion.

7 Check for loosened cable connections.

8 Clean the corroded terminals.

9 Tighten the loose connections.

10 After cleaning, add anti-oxidant/petroleum jelly to exposed wire and terminals.

Cleaning of terminals (Fig 3)

11 Operate the system loads from the batteries for five minutes.

12 Turn off the loads.

13 Disconnect the batteries from the rest of the system.

14 Measure the voltage across the terminals of every battery using digital multimeter.

15 Verify in the table to check the open circuit voltages and corresponding states of charge for deep cycle lead acid batteries during this load test.

Overall maintenance check sheet

Inspect of mounting structure of solar modules

Objectives: At the end of this exercise you shall be able to
- **collect evidences for failure of mount possibilities in existing SPV plant**
- **repair the defective fixtures on module mounting structure.**

Requirements

Tools and Instruments/equipment

- Visit to existing SPV plant
- Solar array log sheet
- Layout of Solar PV array in a SPV plant
- Details of fixtures / MMS installed including dimensions and material
- Method of installation guidelines
- Spare parts
- PPE
- Material handling equipment

PROCEDURE

TASK 1: **Perform inspection of solar array mounting in existing SPV plant**

1 Follow the guidelines as per suggested log sheet.

2 Check for Cleaned modules.

3 Check for array structure.

4 Check for array cabling mechanical.

5 Check for array cabling electrical.

6 Check for array voltage.

7 Check for array current.

Activity done

Sl.No	

Sample solar module mount log sheet for maintenance

Solar array log sheet							
Date	Name	Cleaned modules	Array structure OK	Array cabling mechanical	Array cabling electrical	Array output voltage	Array output current
		☐	☐	☐	☐		
		☐	☐	☐	☐		
		☐	☐	☐	☐		
		☐	☐	☐	☐		
		☐	☐	☐	☐		
		☐	☐	☐	☐		
		☐	☐	☐	☐		
		☐	☐	☐	☐		
		☐	☐	☐	☐		

— — — — — — — —

TASK 2: **Structure of Solar Modules, Procedure of replacement of defective Fixtures**

1 Inspect the Solar PV array for mechanical faults.

2 Check the condition of the array mounting frame for defects such as bolts rusting, bent in connecting frames, loss of Galvanizing done, break or crack in frame, wind bearings, weakened foundation etc.

3 Report even any minor crack as it may lead to major accident damaging the entire structure. Even it may be thrown off in strong winds leading to great loss.

4 Check array mounting bolts to ensure that the frame and modules are firmly secured.

5 Prepare a chart for each defect with suitable suggested remedial action.

6 Tighten loose bolts.

7 Correct minor errors suitably.

8 For major defect like replacement a member of frame derive an action plan since the maintenance activity should not lead damage of structure.

9 Make a replacement member frame as per design originally made found from drawings and choosing right materials and processes.

10 Use proper material handling equipment and support structure for carrying out the remedy.

11 Record your activities done.

Activities done

S.No	List the observation

— — — — — — — —

Exercise : 1.13.164 - 169: These are in plant training in Solar panel manufacturing industry. Facilities for these exercises are not included in the T E list since it is industry setup. Institutes should make necessary MoU with Industries.

Visit a solar panel manufacturing industry and prepare a report (or through an audio visual session) (includes 2.6.164 - 2.6.169)

Objective: At the end of this exercise you shall be able to
- **make a solar panel.**

Note:
- **Visit to solar panel manufacturing industry.**
- **Obtain in-plant training through MoU from institute with the industry.**
- **Audio-video sessions of making solar panels.**
- **Materials required for making of solar panels.**

PROCEDURE

TASK 1: **Learn the skills of making solar panel**

1 Through the methods given above learn the skills required in making of solar panel.
2 Verify the I-V curve of solar cells on purchase.
3 Perform the incoming inspection of Solar PV cells and categorise according to the quality.
4 Construct a cell string and group as per the design of the panel.
5 Assemble a solar panel using the above cell string.
6 Perform the framework and seal the Solar panel.
7 Determine the I-V curve of finished solar PV panel and prepare a model certificate.
8 Pack the solar panel made and get ready for dispatch.

Activities done

Sl.No	List the observation

Prepare a report on automatic manufacturing of solar panels

Objective: At the end of this exercise you shall be able to
- **make a solar panel.**

Note:
- **Visit to solar panel manufacturing industry.**
- **Obtain in-plant training through MoU from institute with the industry.**
- **Audio-video sessions of making solar panels.**

PROCEDURE

TASK 1: **Learn the skills of making solar panel in automatic manufacturing**

1 Learn the processes in automatic manufacturing of solar panels.

2 Prepare a project report.

Observations

Sl.No	List the observation

— — — — — — — —

Install and commission a solar street light

Objective: At the end of this exercise you shall be able to
- **install and commission a street light.**

Requirements

Tools / Instruments

- Civil construction work related tools: crowbar, spade etc
- Marking pen and nail
- Thread
- Measuring tape
- Ruler
- Tool kit
- Safety gadgets
- Solar PV module
- LED lamps
- Light pole
- Control box (dusk to dawn charge controller battery)
- Select suitable ratings matching each other and as available in the market

Equipment / Machines:

- Gravels, sand, cement as per requirement
- Pole

Civil works in work area:

- Skills required in making foundation on ground.
  a Marking
  b Digging
  c Bar bending
  d Filling concrete mix
  e Curing concrete

PROCEDURE

TASK 1: **Prepare civil foundation for the Solar Street light**

1 Use compass and mark true north and south poles.

2 Draw line connecting north and south poles points.

3 Place the pole mount aligned to the connecting lines.

4 Mark the base.

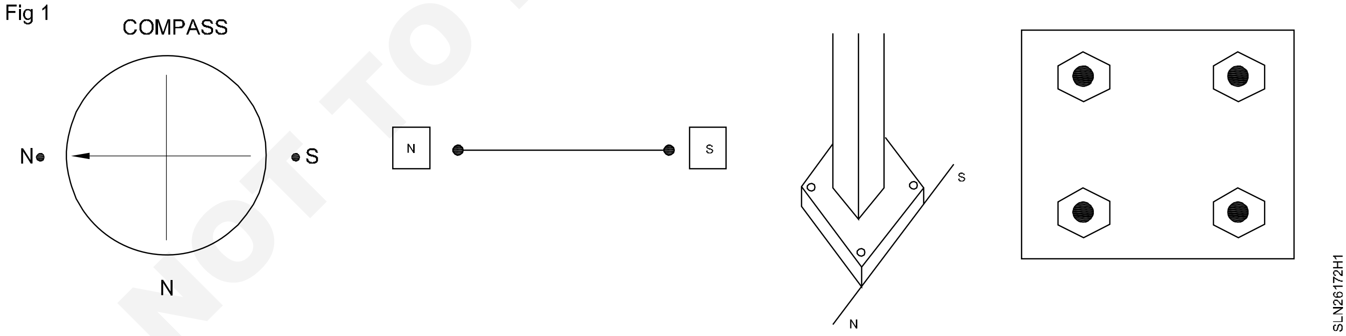
5 Remove the pole mount.

6 Dig pit (Crater) as per drawing (Example: if Base is 1ft x 1 ft then the crater should be 1ft x 1 ft x 1.5ft as shown).

7 Use the wooden stencil of base of the pillar mount.

Marking for foundation on ground. (Fig 1)

Fig 1



8 Fix the bar bended TMT rods with thread on top end on to the stencil.

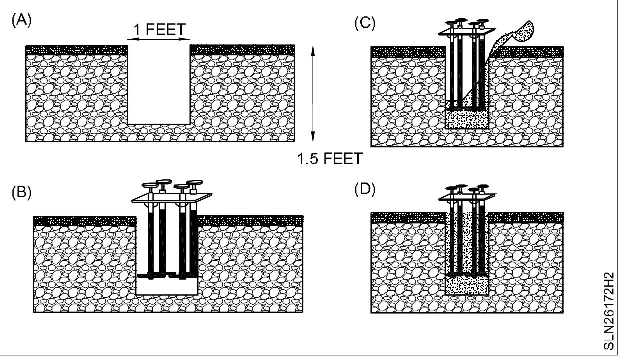
9 Keep the assembly in the carter with the stencil on ground level.

10 Fill in concrete mortar in the pit and allow to harden doing proper curing.

11 Remove the stencil & fasten the bolts; keep ready for next task.

Making Foundation. (Fig 2)

Fig 2



TASK 2: **Assembly of Street light pole**

1 Assemble the Control box with charge controller and battery inside.

2 Do the wiring from battery to the controller, wires for the lamp and solar panel and bring outside the box.

3 Insert the wires through the middle hole in the pole and draw it internally till top hole of the pole.

4 Assemble the lamp holder with LED light and fit to the Holding arm.

5 Complete the wiring to the LED lights.

6 Fix the Solar panel on to the mounting frame and fit the assembly to the Pole top.

7 Complete the assembly and check for dusk to dawn functioning of charge controller.

8 Remove any error if so.

9 Erect the pole and fit on to the mounting screw on the base made in Task 1.

10 Verify the solar panel orientation as shown in the Fig 3.

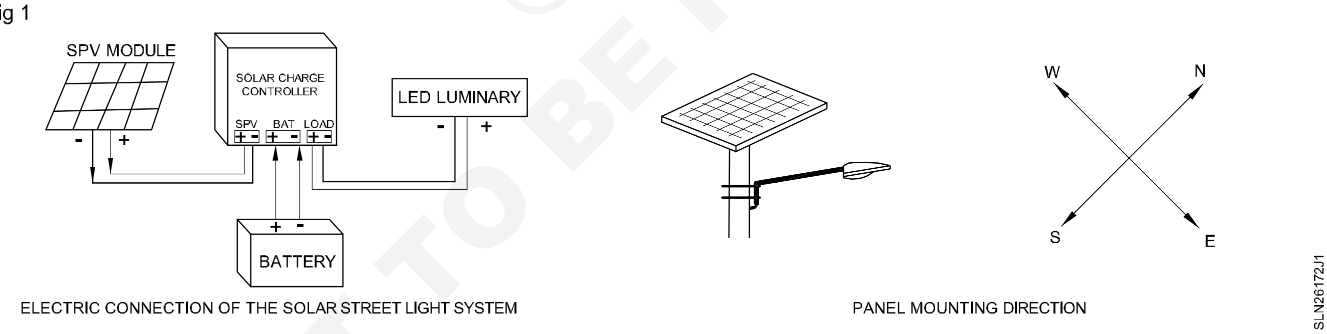
11 Charging continues in the day time and stops once battery is fully charged.

12 In the evening after sunset the LED lamp lights ON.

13 Testing we can do by removing one of the panel wire from charge controller and then connecting back.

Instructions for streetlight. (Fig 3)

Fig 1



Install and commission a model of solar fertilizer sprayer

Objective: At the end of this exercise you shall be able to
- **construct and test a solar fertilizer sprayer.**

Requirements

Tools / Instruments

- Rechargeable Battery (6 Volt, Lithium battery) operated miniature motorized (DC) water sprayer (Pump and hose with nozzle end)
- Container for liquid (Fertilizer or pesticide)
- Solar panel 10 W
- Charge controller 6 V/5A
- Shoulder back holding brackets or jackets

PROCEDURE

TASK 1: **Make a solar fertilizer sprayer**

1 Wire the charge controller.

2 Connect the battery terminals to ports on charge controller.

3 Connect the DC Motor-pump to the output of charge controller.

4 Connect the Solar panel 10 W through switch to the input of Charge controller.

5 Keep the switch in OFF position.

6 Construct the sprayer using the solar panel on exposed back side and jacket or holding bracket on the other side. Battery positioned behind panel.

7 Pour liquid (diluted fertilizer or pesticide as the case may be) in the container.

8 Hold the combined set on shoulder back.

9 Switch On the circuit.

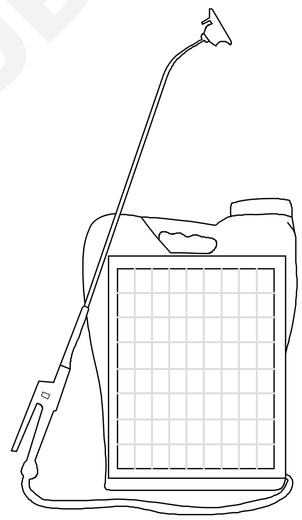
10 Press the nozzle and test pump starting.

11 Demonstrate spraying.

Refer the picture below

Solar Fertilizer/Pesticide sprayer (Fig 1)

Fig 1



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Prepare a report on possible innovative solar products for marketing

Objective: At the end of this exercise you shall be able to
- **make marketable solar electric products.**

Note: Innovative business ideas.

PROCEDURE

TASK 1: **Make marketable solar electric products.**

Refer theory part of Solar Technician Vol I of II for pictures of valuable application solar DC products. Select few and apply your mind. Make in small level. Appraise the achievements.

Hints:

1 Assemble, install and commission a solar water pump.

2 Assemble, install and commission a solar traffic light.

Project work / Industrial visit:

1 Solar –wind Hybrid plant (500 W + 500 W).

2 Report on skills required in the Solar PV installation.

3 Report on existing National and state level energy policy.

4 Report for setting up a small business in the solar industry.

5 Report on recent development s in Renewable Energy Industry.

6 Report on employment opportunities in Renewable Energy Industry globally.

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Install and commission a solar water pump

Objective: At the end of this exercise you shall be able to
- **construct and test solar water pump.**

Requirements

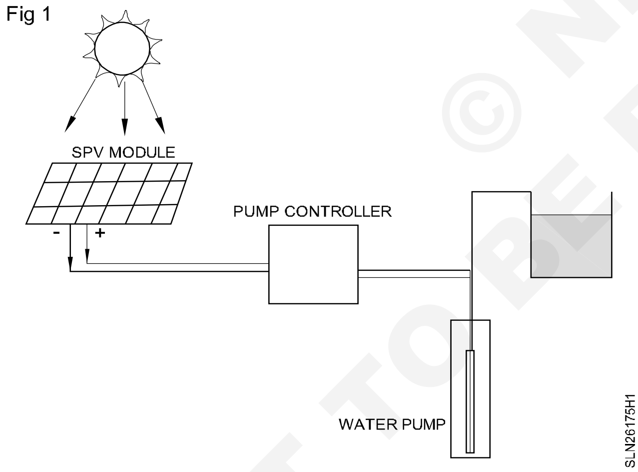
Tools / Instruments

- D.C. Motor Pump Set with Brushes or Brush Less D.C.(B.L.D.C.) to pump 50 liters of water per watt peak of PV array, from a Total Dynamic Head of 20 metres (Suction head, if applicable, up to a maximum of 7 metres) and with the shut off head being at least 25 metres. (AC motor pump and suitable pump controller also another choice)
- Suitable pump controller
- Solar PV panels, as recommended for the pump purchased from market
- Connecting cables and control switches
- Tools (Electrical, civil and plumbing requirements)

Note: As the project is costlier, it is recommended that the institute shall make MoU with local solar PV contractors for involving the Solar technician trainees into on job training while the contractors are in field work as per their work orders.

Block Diagram (Fig 1)

Fig 1



Make a solar fertilizer sprayer

1 Select and prepare the location:

The Solar Pump system uses the sun light as the sourceof energy. So the place of installation of the solar pumpsystem shall be;

- Free from shadows caused by the trees for Solar array.
- Free from shadows caused by the buildings or anyerected structures for array.
- Free from natural water channels.
- Plane area.
- Near to the Bore well or the Pump.

If the place does not satisfy the above requirements, thenit is necessary to prepare the suitable place.

2 Civil work

Civil work includes the preparation of proper foundation for mounting structure. the number of SPV modules aremore and all must be mounted on the same structure.So, the foundation must be strong enough to hold theweight of the SPV module and withstand wind. The civilwork includes;

- Prepare the Pit for mounting structure andelectrical ground point.
- Prepare the cement concrete.
- Erect the Structure.

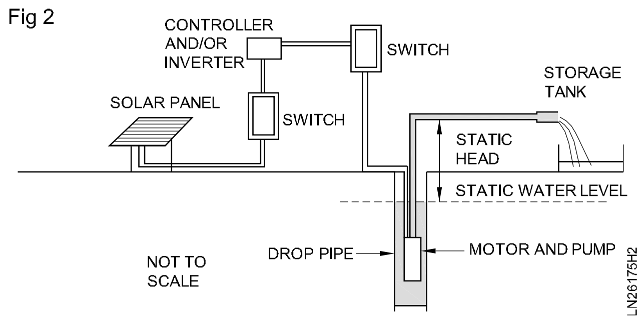
(Refer earlier exercises on Solar PV foundation, mounting of panels, panel wiring etc).

3 Electrical connection

The electrical connection is the process of connectingall the devices electrically together. The typical electricalcircuit diagram of Solar pump system is as shown in Fig 2.

Circuit diagram of solar pump system (Fig 2)

Fig 2



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Install and commission a solar traffic light

Objective: At the end of this exercise you shall be able to
- **construct and test solar traffic lights.**

Requirements

Tools / Instruments

- Manual charge controller rated (12V, 10 A)
- Solar battery (12V, 100 Ah)
- Solar panel (75 W)
- Traffic lights (12 V DC)
- Sequence control electronic circuit for traffic lights (Consult Electronic Mechanic tarde) (Check DC supply requirements to match with Charge controller output)

PROCEDURE

TASK 1: **Construct a Solar traffic light**

1 Wire the charge controller.

2 Connect the battery terminals to ports on charge controller.

3 Connect the Sequence control electronic circuit for traffic lights to the output of charge controller.

4 Connect the traffic lights to output of Sequence control electronic circuit.

5 Connect the Solar panel 75 W through switch to the input of Charge controller.

6 Keep the switch in OFF position.

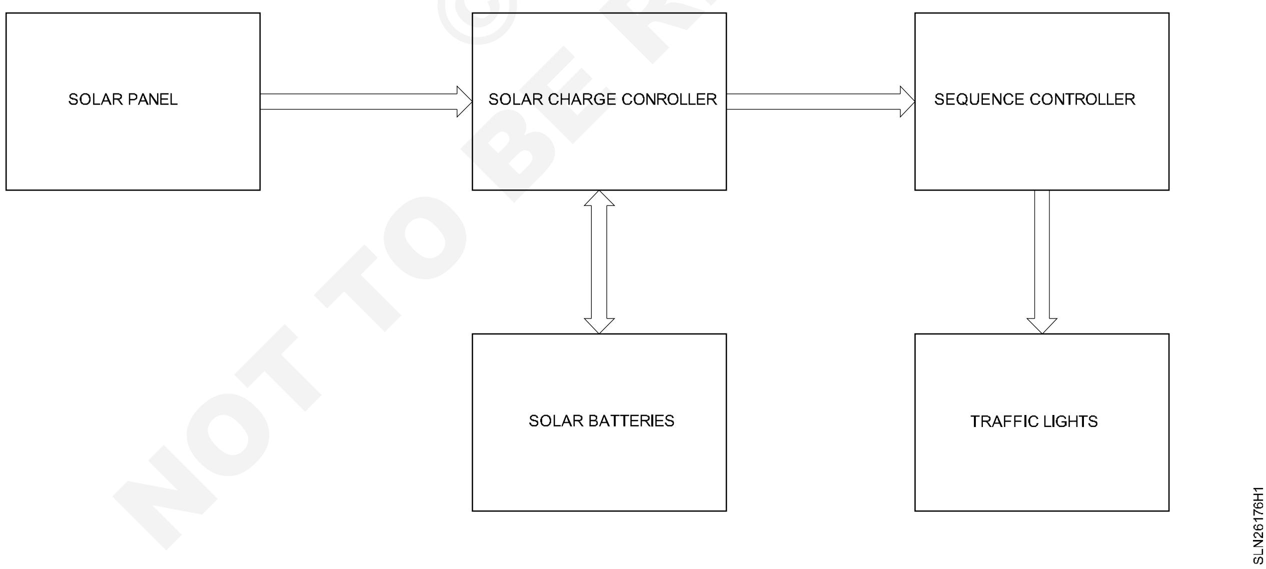
7 Test the connections.

8 Switch On the circuit.

9 Demonstrate traffic light control for different timings.

Block Diagram (Fig 1)

Fig 1



Project work / Industrial visit:

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