

SOLAR TECHNICIAN (ELECTRICAL)

NSQF LEVEL - 4

Volume II of II

TRADE PRACTICAL

Sector: Environmental Science



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 : Environmental Science

Duration : One Year

**Trade : Solar Technician (Electrical) - (Volume II of II) - Trade Practical -
NSQF level - 4**

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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) - (Volume II of II) - Trade Practical - NSQF Level - 4 in Environmental Science Sector under annual Pattern**. The NSQF Level - 4 Trade Practical will help the trainees to get an international equivalency standard where their skill proficiency and competency will be duly recognized across the globe and this will also increase the scope of recognition of prior learning. NSQF Level - 4 trainees will also get the opportunities to promote life long learning and skill development. I have no doubt that with NSQF Level - 4 the trainers and trainees of ITIs, and all stakeholders will derive maximum benefits from these IMPs and that NIMI's effort will go a long way in improving the quality of Vocational training in the country.

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

Jai Hind

Director General/ Addl. Secretary
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 **Environmental Science** Sector for ITIs.

MEDIA DEVELOPMENT COMMITTEE MEMBERS

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Shri. S. Gopalakrishnan	-	Assistant Manager, NIMI, Chennai - 32

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 - 4 syllabus are covered.

The manual is divided into Six modules.

Module 1	- Connect and Test Solar Panel	75 Hrs
Module 2	- Bill of Materials for Solar PV Projects	50 Hrs
Module 3	- Tests and Measurement of PV Modules and Installation	25 Hrs
Module 4	- Installation Solar PV Plant and Hybrid Plant	175 Hrs
Module 5	- Operation & Maintenance of PV System	25 Hrs
Module 6	- Manufacturing of Solar Panel	50 Hrs
Total		<u>400 Hrs</u>

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)** (Volume II of II) Trade Practical NSQF Level- 4 in Environmental Science. The contents are sequenced according to the practical exercise contained in NSQF LEVEL - 4 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 perceptual 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.

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LEARNING / ASSESSABLE OUTCOME

On completion of this book you shall be able to

Sl.No.	Learning /Outcome	Refer Ex:No
1	Select various components of Solar PV electrical system 2.1.109	2.1.105, 2.1.108,
2	Connect and test solar panel, Charge controller, Battery bank and Inverter	2.1.107, 2.4.128, 2.4.129, 2.4.133, 2.4.134, 2.4.136
3	Prepare Bill of materials for small, medium and mega solar PV projects	2.2.111 - 2.2.116
4	Perform various tests and measurement pertaining to PV Modules	2.3.117 - 2.3.122
5	Perform Installation and commissioning of Solar PV plant	2.4.123 - 2.4.146
6	Perform installation and commissioning of Hybrid plant	2.4.147 - 2.4.149
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8	Perform tests on the installation as per IEC standards	2.5.164 & 2.5.165
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SYLLABUS (Vol II of II)

Duration	Reference Learning Outcome	Professional Skill (Trade Practical) (With indicative hour)	Professional Knowledge (Trade Theory)
Professional Skill 75 Hrs; Professional Knowledge 21 Hrs	Connect and test solar panel, Charge controller, Battery bank and Inverter.	105 Prepare a comparative chart by collecting data sheets of different solar PCU and normal inverters. (06hrs) 106 Practice procedural switching 'ON' and Shutdown of solar PCU. (06hrs) 107 Connect a 1 KW Solar PCU to 1 KW Solar panel installation using a suitable battery bank and test the performance. (06hrs) 108 Check of front panel features of a Solar PCU. (06hrs) 109 Check of back panel features of a Solar PCU. (06hrs) 110. Demonstrate Solar PV e-learning software. (05 hrs)	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)
Professional Skill 50 Hrs; Professional Knowledge 14 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. (08hrs) 112 Prepare bill of material for a 5 KW solar PV installation. (08hrs) 113 Prepare a Bill of materials for a 10 KW solar PV installation. (08hrs) 114 Prepare a Bill of materials for a 20 KW solar PV installation. (08Hrs) 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 (14 hrs)

Professional Skill 25 Hrs; Professional Knowledge 07 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. (04hrs) 119 Perform Bypass Diode test - Pmax at STC and Pmax at low irradiance. (05 hrs) 120 Measure Ground Continuity, Impulse Voltage, Reverse current and Partial Discharge. (04hrs) 121 Practice to undertake precautions against Module breakage. (04 hrs) 122 Demonstrate hot spot on modules through audio visual aids. (03 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. (07 hrs)
Professional Skill 175 Hrs; Professional Knowledge 49 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. (03hrs) 124 Prepare a layout of roof showing open areas and occupied areas and mark obstructions that can cause shadows. Take site photographs. (03hrs) 125 Mark locations for components of solar PV electrical system on site. (03hrs) 126 Perform shadow analysis in the rooftop of a 1 KW Solar PV plant. Use sun path diagram for the latitude and solar pathfinder. (05hrs) 127 Install a roof top Solar panel mounting structure for 1 KW installation that uses Solar panels 250 W x 4 Nos. (06hrs) 128 Mount Solar panels 250 W x 4 Nos. on the Mounting structure. (06hrs) 129 Wire Solar panels 250 W x 4 Nos. (4Hrs) 130 Connect the array junction box to the above installation and draw wires up to PCU. (04hrs) 131 Perform different angle of inclination of Solar panel mounting for various cities considering their latitude. (06hrs)	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. 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.

		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)	Solar plant, civil works: drilling, digging, finishing, Mixing concrete. (14 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. (05hrs) 138 Wire the AC mains connection to the Solar PCU (Do not switch 'ON'). (05 hrs) 139 Prepare a Checklist for finding out errors during above installation. (05 hrs) 140 Check as per the checklist and prepare a clearance certificate before commissioning. (05 hrs) 141 Perform Procedural first switch ON, observe No load test results and record. (05hrs) 142 Perform 'ON Load' test, progressively add load till full load and record observation. (06hrs) 143 Perform Overload test and record observation. (06hrs) 144 Prepare a First inspection report on the solar plant installation. (06hrs) 145 Prepare a list of Do's and Don'ts in the installation. (06hrs) 146 Prepare a report on Customer orientation. (06hrs) 147 Prepare a report on visible and audio annunciations, alarms or alerts in a solar PCU. (06hrs) 148 Perform shutting down procedure of the above solar plant. (06hrs)	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. (21 hrs)

		149 Prepare a ballast foundation for tiled roof. (05 hrs) 150 Prepare a rack mount for a tilted roof. (05 hrs) 151 Plan and prepare a report on building integrated solar mount. (05hrs) 152 Prepare a foundation for a single Pillar mount. (05hrs) 153 Visit a Mega project and prepare a report including strings, array, inverter room, output transformers, plant layout and SCADA room. (05hrs) 154 Prepare a report on site suitable for windmill. (05hrs) 155 Observe the presence of obstacles in a site suitable for windmill. (05hrs) 156 Evaluate windiness of a place using an anemometer. (05hrs) 157 Prepare a report on wind mill energy conversion system through sufficient audio visual sessions. (05hrs) 158 Test with a blower and model windmill & record the observations. (05hrs)	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 25 Hrs; Professional Knowledge 07 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. (07 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) 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)	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 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)
Project work / Industrial visit: • Solar applications viz. Solar traffic light, solar water pump etc. • Hybrid plant • Report on skills required in the Solar PV installation. • Report on existing National and state level energy policy. • Report for setting up a small business in the solar industry.			

Solar Technician (Electrical) - Connect and Test Solar Panel

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.

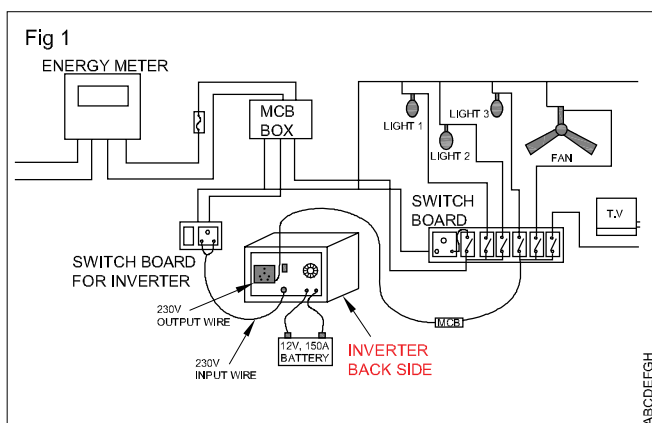
Knowledge of purchase procedures/market study.

PROCEDURE

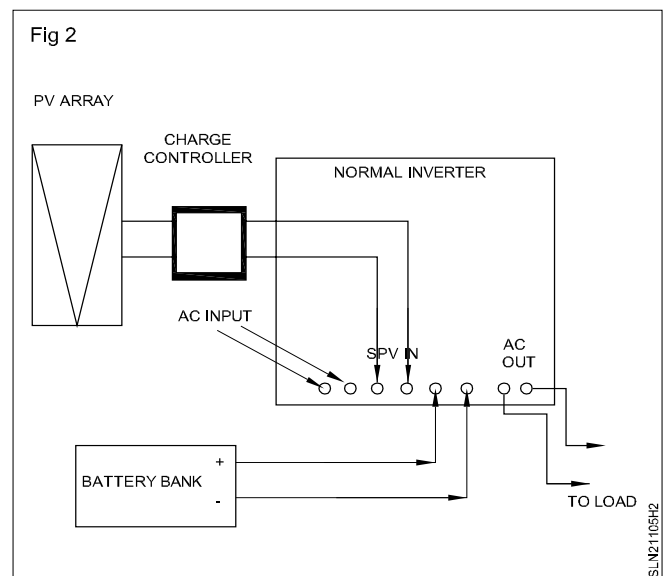
TASK 1: Compare a normal inverter and a solar inverter

- 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.

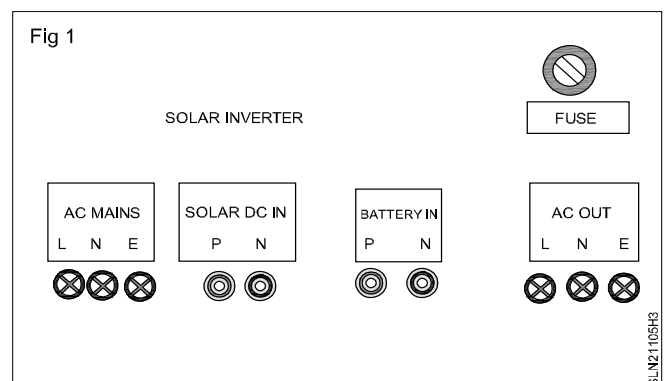
Normal inverter for Home (Fig 1)



Normal Inverter converted to Solar inverter (Fig 2)



Back panel of a Solar inverter (Fig 3)



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

		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 <i>Note:- Specifications are subject to change without prior notice.</i>		

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 (Fig 5)

- 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.

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.

Observations

Name of company	Solar DC input range (Vmin, Vmax)	Battery input (V)	Solar battery bank (V, AHr)	Charge controller	Power (VA/KVA)

Sample Specification (additional) (Fig 5)

Fig 5

Solar PCU

REQUEST CALLBACK



Make:

Approx. Rs / KWGet Latest Price

Product Details:

Usage/Application	Home, Office, Industrial
Model Name/Number	AAAAAA12345
Brand	XXX
Capacity	1-10 KVA
Phase	Single, Three
Output Frequency	50 Hz
Degree Of Protection	IP 65
Power Factor	0.9
Display	LCD
Operating Current	50 Amp

Solar PCU is an integrated system consisting of a solar charge controller, inverter and a Grid charger. It provides the facility to charge the battery bank either through Solar or Grid/DG Set. The PCU continuously monitors the state of Battery Voltage, Solar Power output and the loads.

Features:

- Lcd Display with advance Program.
- MPPT based charge controller with 50 Amp.
- IGBT Based Option for Home & Motorised Load .
- DSP Based Pure Sinewave Solar PCU.
- Optimum Power Genration from Solar Panels.

Recommendation:

Solar Technician (Electrical) - Connect and Test Solar Panel**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.

- 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

Normal sequence of operation: (Suggestive)

- 1 Turn on the Solar Array DC Main Switch located next to the inverter.

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.

- 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

Normal sequence of operation: (Suggestive)

- 1 Turn off the main DC battery isolator.

Typical comparison of different models

Models	Output Volt Amp / Watt Capacity	DC Voltage VDC	Mal.PV open Circuit Array Voltage	No Battery
S0312	300VA / 240W	12V	22VDC	1
S0612	600VA / 480W	12V	22VDC	1
S0812	800VA / 640W	12V	22VDC	1
S01024	1000VA / 800W	24V	44VDC	2
S01524 S01536 S01548	1500VA / 1200W	24V / 36V / 48V	44 / 66 / 88 VDC	2 / 3 / 4
S02036 S02048 S02072	2000VA / 1600W	36V / 48V / 72V	66 / 88 / 132 VDC	3 / 4 / 6
S02548 S02572	2500VA / 2000W	48V / 72V	88 / 132 VDC	4 / 6
S03048 S03072 S03096	3000VA / 2400W	48V / 72V / 9 V	88 / 132 / 176 VDC	4 / 6 / 8
S03548 S03572 S03596	3500VA / 2800W	48V / 72V / 96V	88 / 132 / 176 VDC	4 / 6 / 8
S04072 S04096	4000VA / 3200W	72V / 96V	132 / 176 VDC	6 / 8
S05036 S05048 S05096 S05120 S05144 S05192	5000VA / 4000W	36V / 48V / 96V / 120V / 144V / 192V	66 / 88 / 176 / 220 / 264 / 352 VDC	3 / 4 / 8 / 10 / 12 / 16
S06144 S06192	6000VA / 4800W	144V / 192V	264 / 352 VDC	12 / 16
S07.5144 S07.5192	7500VA / 6000W	144V / 192V	264 / 352 VDC	12 / 16
S010096 S010120 S010192	10000VA / 8000W	96V / 120V / 192V	176 / 220 / 352 VDC	8 / 10 / 16
S015096 S010120 S010192	15000VA / 12000W	96V / 120V / 192V	176 / 220 / 352 VDC	8 / 10 / 16
S020096 S020120 S020192	20000VA / 16000W	96V / 120V / 192V	176 / 220 / 352 VDC	8 / 10 / 16

Solar Technician (Electrical) - Connect and Test Solar Panel

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

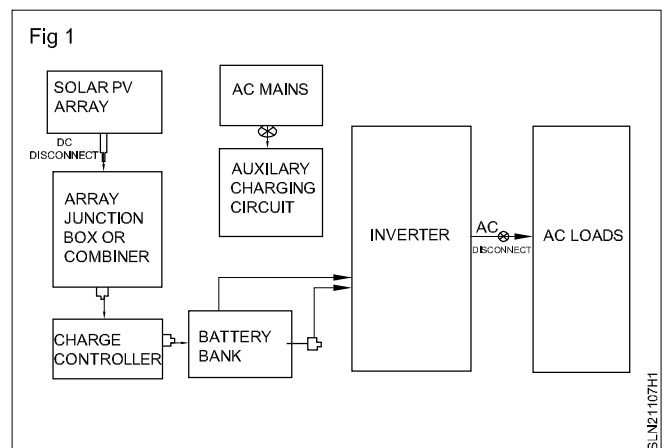
- Block diagram
- Ready to use individual blocks
 - 4 x 250 W solar panels mounted, wired and assembled through combiner box suitable for charge controller
 - Charge controller 24 V, 40 A (say) suitable for inverter
 - 1 kW solar inverter with suitable solar DC input and Battery bank input terminals
- 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)



Observations

- Energy flow paths

TASK 3: Test the performance of the 1 kW SPV off grid system

- 1 Follow a sequence and switch ON the above connected system.
 - 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.
- 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.

Observations

Sl.No	List the observation

— — — — —

Solar Technician (Electrical) - Connect and Test Solar Panel

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

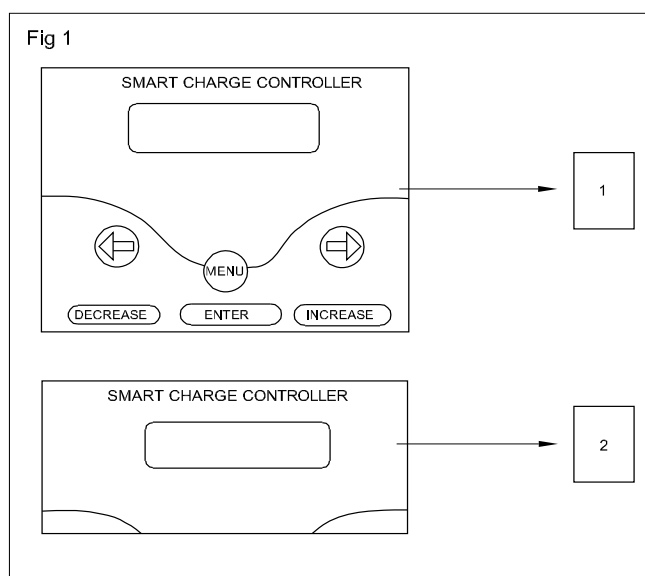
Identify and use the useful features on front panel of PCU

- 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)



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

Solar Technician (Electrical) - Connect and Test Solar Panel

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

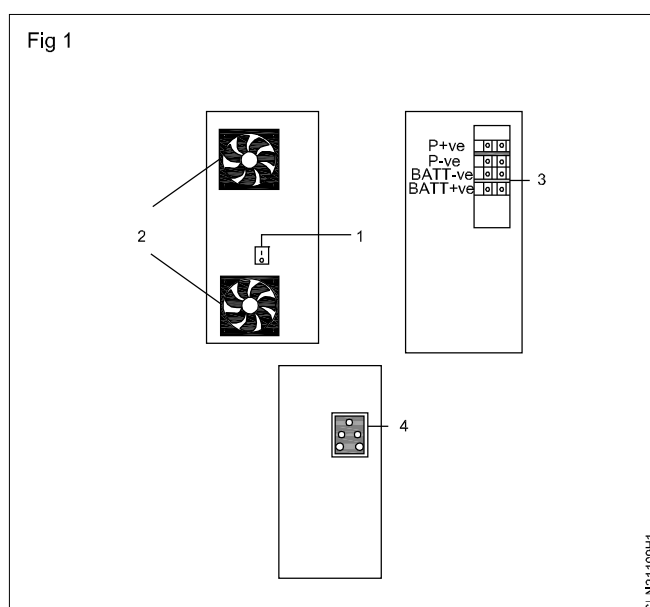
Identify and use the useful features on the back panel of PCU

- 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

Observations

Sl.No	List the observation

Back panel of a PCU (Fig 1)



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.

Solar Technician (Electrical) - Connect and Test Solar Panel**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**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

Solar Technician (Electrical) - Bill of Materials for Solar PV Projects**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

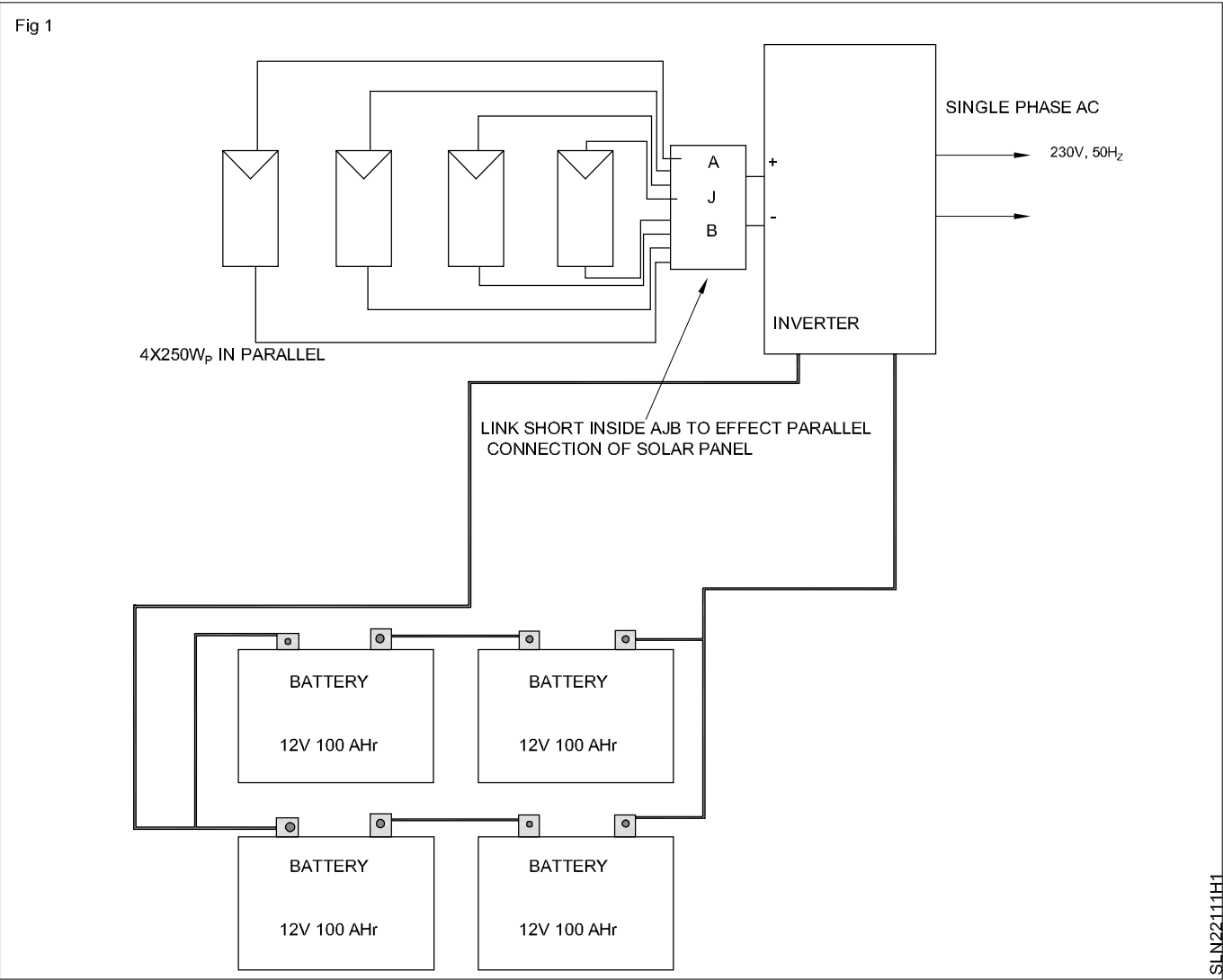
Sl.No	Bill of Materials	Quantity

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.

SLD

SLD for 1 kW using parallel combination of solar panels (Fig 1)



Bill of materials

Sl.No	Bill of Materials	Quantity

TASK 3: Prepare bill of materials for 1 kW SPV off grid plant

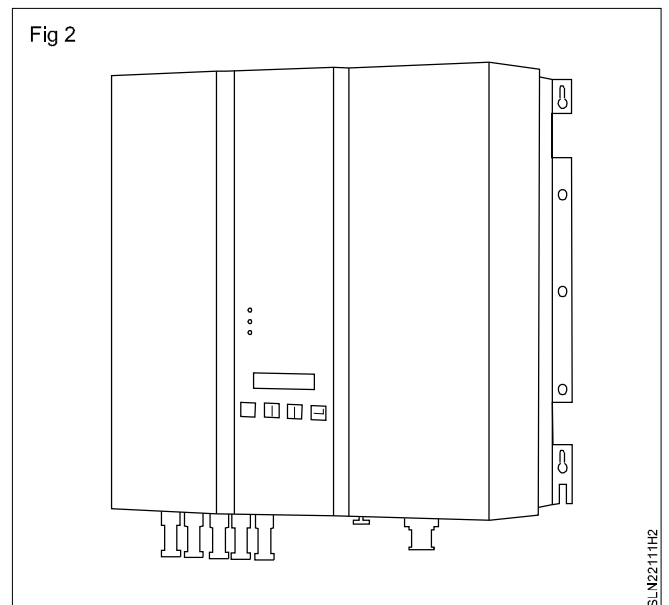
- 1 Similar to task 2 above consider serial connection of solar panels.
- 2 Draw a SLD for 1 kW SPV off grid plant with serial connection of solar panels.
- 3 Consider changes required in ratings of other components.
- 4 Prepare bill of materials.
- 5 **Bill of materials:**

Sl.No	Bill of Materials	Quantity

Sample product profiles:

- 1 For academic interest only; not recommended commercially.
- 2 Similar products from different manufacturers are available in market.

Transformer-based string inverter (Fig 2)



Technician data SOLIVIA 2.5 TR

INPUT (DC)	SOVILIA 2.5 AP G3 TR
Max. recommended PV power	3100 W _p
Nominal power	2750 W
Voltage range	125 ... 540 V
Full power MPP range	150 ... 450 V
Nominal current	9.8 A
Max. current	18 A

OUTPUT (AC)

Nominal power	3000 W
Voltage range	210 ... 264 V
Nominal current	13A
Nominal frequency	50 Hz
Frequency range	48 ... 52 Hz
Power factor	> 0.99 @ nominal power
Total harmonic distortion (THD)	< 3 % @ nominal power

GENERAL SPECIFICATION

Model name	SOLIVIA 2.5 AP G3 TR
Part number Delta	EOE45010272
Max. efficiency	96%
Efficiency EU	94.8%
Operating temperature	-25 ... + 70 °C
Full power without derating	-25 ... + 55 °C
Storage temperature	-25 ... + 80 °C
Humidity	0...98%
Max. operating altitude	2000 m (above sea level)

MECHANICAL DESIGN

Size (L x W x D)	410 x 410 x 180 mm
Weight	21.5 kg
Cooling	Convection
AC connector	Wieland RST25i3S
DC connector	4 pairs of Multi-Contact MC4
Communication interfaces	2 x RJ45 / RS485
Display	3 LEDs, 2-line LCD

Standards/ directives	SOLIVIA 2.5 AP G3 TR
Protection degree	IP65
Safety class	I
Configurable trip parameters	Yes
Insulation monitoring	Yes
Overload behavior	Current limitation: power limitation
Anti-islanding protection/ Grid regulation	AS 4777.2: AS 4777.3: IEC 60255.5
EMC	AS 4777.1: AS 4777.2: AS 4777.3; EN 61000-6-2: IEC / EN 61000-6-3
Safety	AS/NZS 60950; AS/NZS 3100: AS 4777.2: AS 4777.3

Technician data SOLIVIA 3.0 TR

INPUT (DC)	SOVILIA 3.0 AP G3 TR
Max. recommended PV power	3650 W _p
Nominal power	3300 W
Voltage range	125 ... 540 V
Full power MPP range	150 ... 450 V
Nominal current	11.8 A
Max. current	22 A

OUTPUT (AC)

Nominal power	3000 W
Voltage range	210 ... 264 V
Nominal current	13 A
Nominal frequency	50 Hz
Frequency range	48 ... 52 Hz
Power factor	> 0.99 @ nominal power
Total harmonic distortion (THD)	< 3 % @ nominal power

GENERAL SPECIFICATION

Model name	SOLIVIA 3.0 AP G3 TR
Part number Delta	EOE46010259
Max. efficiency	96%
Efficiency EU	94.8%
Operating temperature	-25 ... + 70 °C
Full power without derating	-25 ... + 55 °C
Storage temperature	-25 ... + 80 °C
Humidity	0...98%
Max. operating altitude	2000 m (above sea level)

MECHANICAL DESIGN

Size (L x W x D)	410 x 410 x 180 mm
Weight	21.5 kg
Cooling	Convection
AC connector	Wieland RST25i3S
DC connector	4 pairs of Multi-Contact MC4
Communication interfaces	2 x RJ45 / RS485
Display	3 LEDs, 2-line LCD

Standards/ directives	SOLIVIA 3.0 AP G3 TR
Protection degree	IP65
Safety class	I
Configurable trip parameters	Yes
Insulation monitoring	Yes
Overload behavior	Current limitation: power limitation
Anti-islanding protection/ Grid regulation	AS 4777.2: AS 4777.3: IEC 60255.5
EMC	AS 4777.1: AS 4777.2: AS 4777.3; EN 61000-6-2: IEC / EN 61000-6-3
Safety	AS/NZS 60950; AS/NZS 3100: AS 4777.2: AS 4777.3

Technician data SOLIVIA 3.3 TR

INPUT (DC)	SOVILIA 3.3 AP G3 TR
Max. recommended PV power	4000 W _p
Nominal power	3630 W
Voltage range	125 ... 540 V
Full power MPP range	150 ... 450 V
Nominal current	13 A
Max. current	24 A

OUTPUT (AC)

Nominal power	3300 W
Voltage range	210 ... 264 V
Nominal current	14.4 A
Nominal frequency	50 Hz
Frequency range	48 ... 52 Hz
Power factor	> 0.99 @ nominal power
Total harmonic distortion (THD)	< 3 % @ nominal power

GENERAL SPECIFICATION

Model name	SOLIVIA 3.3 AP G3 TR
Part number Delta	EOE46010260
Max. efficiency	96%
Efficiency EU	94.8%
Operating temperature	-25 ... + 70 °C
Full power without derating	-25 ... + 55 °C
Storage temperature	-25 ... + 80 °C
Humidity	0...98%
Max. operating altitude	2000 m (above sea level)

MECHANICAL DESIGN

Size (L x W x D)	410 x 410 x 180 mm
Weight	21.5 kg
Cooling	Convection
AC connector	Wieland RST25i3S
DC connector	4 pairs of Multi-Contact MC4
Communication interfaces	2 x RJ45 / RS485
Display	3 LEDs, 2-line LCD

Standards/ directives	SOLIVIA 3.3 AP G3 TR
Protection degree	IP65
Safety class	I
Configurable trip parameters	Yes
Insulation monitoring	Yes
Overload behavior	Current limitation: power limitation
Anti-islanding protection/ Grid regulation	AS 4777.2: AS 4777.3: IEC 60255.5
EMC	AS 4777.1: AS 4777.2: AS 4777.3; EN 61000-6-2: IEC / EN 61000-6-3
Safety	AS/NZS 60950; AS/NZS 3100: AS 4777.2: AS 4777.3

Technician data SOLIVIA 5.0 TR

INPUT (DC)	SOVILIA 3.3 AP G3 TR
Max. recommended PV power	6000 W _p
Nominal power	5500 W
Voltage range	125 ... 540 V
Full power MPP range	150 ... 450 V
Nominal current	17.2 A
Max. current	32 A

OUTPUT (AC)

Nominal power	5000 W (power limit option: 4600 W)
Voltage range	210 ... 264 V
Nominal current	22 A
Nominal frequency	50 Hz
Frequency range	48 ... 52 Hz
Power factor	> 0.99 @ nominal power
Total harmonic distortion (THD)	< 4 % @ nominal power

GENERAL SPECIFICATION

Model name	SOLIVIA 5.0 AP G3 TR
Part number Delta	EOE46010301
Max. efficiency	95.6%
Efficiency EU	94.6%
Operating temperature	-25 ... + 60 °C
Storage temperature	-25 ... + 80 °C
Humidity	0...98%
Max. operating altitude	2000 m (above sea level)

MECHANICAL DESIGN

Size (L x W x D)	510 x 410 x 180 mm
Weight	32 kg
Cooling	Convection
AC connector	Wieland RST25i3S
DC connector	4 pairs of Multi-Contact MC4
Communication interfaces	2 x RJ45 / RS485
Display	3 LEDs, 2-line LCD

Standards/ directives	SOLIVIA 5.0 AP G3 TR
Protection degree	IP65
Safety class	I
Configurable trip parameters	Yes
Insulation monitoring	Yes
Overload behavior	Current limitation: power limitation
Anti-islanding protection/ Grid regulation	AS 4777.2: AS 4777.3: IEC 60255.5
EMC	AS 4777.1: AS 4777.2: AS 4777.3; EN 61000-6-2: IEC / EN 61000-6-3
Safety	AS/NZS 60950.1; AS/NZS 3100: AS 4777.2: AS 4777.3

Three phase inverter without transformer (Fig 3)

Fig 3



Technician data SOLIVIA 15 TL

INPUT (DC)	SOVILIA 15 EU G4 TL
Max. recommended PV power	19 kW
Nominal power	15.3 kW
Voltage range	250 ... 1000 V
Full power MPP range	350 ... 800 V
Max. current	48 A (24 A per MPP)
Max. number of MPP trackers	32 A

OUTPUT (AC)

Nominal apparent power	15 kVA ¹⁾
Voltage range	3 x 230 / 400V (± 20%) + N + PE (3 phases, 5 wires) ²⁾
Nominal current	22 A (per phase)
Nominal frequency	50 / 60 Hz
Frequency range	50 / 60 Hz ± 5 Hz ²⁾
Power factor adjustable	0.8 cap ... 0.8 ind
Total harmonic distortion (THD)	< 3 % @ nominal apparent power

GENERAL SPECIFICATION

Model name	SOLIVIA 15 EU G4 TL
Part number Delta	EOE48010362
Max. efficiency	98%
Efficiency EU	> 97.8%
Operating temperature	-20 ... + 60 °C
Full power without derating	-20 ... + 40 °C
Storage temperature	-20 ... + 70 °C
Humidity	0 ... 90%
Max. operating altitude	2000 m (above sea level)

MECHANICAL DESIGN

Size (L x W x D)	952 x 625 x 275 mm
Weight	67.2 kg
Cooling	Fan
AC connector	Amphenol C16/3
DC connector	4 pairs of Multi-Contact MC4
Communication interfaces	2 x RJ45 / RS485
DC disconnect	Integrated
Display	Black/white graphical LCD

Standards/ directives	SOLIVIA 15 EU G4 TL
Protection degree	IP65 / IP55 ³⁾
Safety class	I
Configurable trip parameters	Yes
Insulation monitoring	Yes
Overshoot behavior	Current limitation: power limitation
Anti-islanding protection / Grid regulation	DIN VDE 0126-1-1; RD 661/ 2007; RD 1699/2011; CEIO-21; TERNAA70; UTE C15-712-1; Synergrid C10/11 (June 2012); EN 50438; G59/2; VDE-AR-N 4105: BDEW; AS 4777
EMC	EN61000-6-2; EN61000-6-3; EN61000-3-11; EN61000-3-12; C-Tick
Safety	IEC62109-1 / -2; AS/NZS 3100

- 1 Cos Phi = 1 (VA= W)
- 2 AC voltage and frequency range will be programmed according to the individual country requirements.
- 3 IP65 for electronics / IP55 for cooling area.

Technician data SOLIVIA 20 TL

INPUT (DC)	SOVILIA 20 EU G4 TL
Max. recommended PV power	25 kW _p
Nominal power	20.4 kW
Voltage range	250 ... 1000 V
Full power MPP range	350 ... 800 V
Max. current	60 A (30 A per MPP)
Max. number of MPP trackers	2

OUTPUT (AC)

Nominal apparent power	20 kVA ¹⁾
Voltage range	3 x 230 / 400V (± 20%) + N + PE (3 phases, 5 wires) ²⁾
Nominal current	29 A (per phase)
Nominal frequency	50 / 60 Hz
Frequency range	50 / 60 Hz ± 5 Hz ²⁾
Power factor adjustable	0.8 cap ... 0.8 ind
Total harmonic distortion (THD)	< 3 % @ nominal apparent power

GENERAL SPECIFICATION

Model name	SOLIVIA 20 EU G4 TL
Part number Delta	EOE48010364
Max. efficiency	98%
Efficiency EU	> 97.8%
Operating temperature	-20 ... + 60 °C
Full power without derating	-20 ... + 40 °C
Storage temperature	-20 ... + 70 °C
Humidity	0 ... 90%
Max. operating altitude	2000 m (above sea level)

MECHANICAL DESIGN

Size (L x W x D)	952 x 625 x 275 mm
Weight	67.2 kg
Cooling	Fan
AC connector	Amphenol C16/3
DC connector	4 pairs of Multi-Contact MC4
Communication interfaces	2 x RJ45 / RS485
DC disconnect	Integrated
Display	Black/white graphical LCD

Standards/ directives	SOLIVIA 15 EU G4 TL
Protection degree	IP65 / IP55 ³⁾
Safety class	I
Configurable trip parameters	Yes
Insulation monitoring	Yes
Oveload behavior	Current limitation: power limitation
Anti-islanding protection / Grid regulation	DIN VDE 0126-1-1; RD 661/2007; RD 1699/2011; CEI0-21; TERNAA70; UTE C15-712-1; Synergrid C10/11 (June 2012); EN 50438; G59/2; VDE-AR-N 4105: BDEW; AS 4777
EMC	EN61000-6-2; EN61000-6-3; EN61000-3-11; EN61000-3-12; C-Tick
Safety	IEC62109-1 / -2; AS/NZS 3100

- 1 Cos Phi = 1 (VA= W)
- 2 AC voltage and frequency range will be programmed according to the individual country requirements.
- 3 IP65 for electronics / IP55 for cooling area.

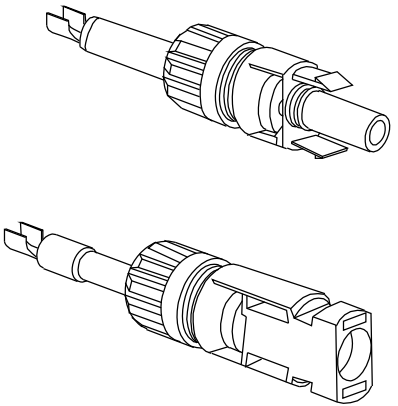
Technical specification of connection cable

Connection cables - Harting

Part Number Delta	Connection Cable	
3081129500	Connection cable from Delta solar inverter to WEBlogger from Meteocontrol: - Assembled outdoor cable with Haring RJ45 PushPull and RJ12 plugs. IP65. length of 5 meters. - Only suitable for SOLIVIA TR string inverters.	
3081186300	Connection cable from inverter to inverter. - Harting RushPull system cable RJ45. 8-core for IP85/67 applications. length of 1.5 meters. - Only suitable for SOLIVIA TR string inverters.	
3081186500	Connection cable from inverter to inverter. - Harting PushPull system cable RJ45. 8-core for IP85/67 applications. length of 3.0 meters. - Only suitable for SOLIVIA TR string inverters	
3081186600	Connection cable from inverter to inverter: - Harting RushPull system cable RJ45. 8-core for IP85/67 applications. length of 5.0 meters. - Only suitable for SOLIVIA TR string inverters.	
3081186200	Connection cable from inverter to inverter: - Harting RushPull system cable RJ45. 8-core for IP85/67 applications. length of 10.0 meters. - Only suitable for SOLIVIA TR string inverters.	
3081186400	Connection cable from inverter to inverter: - Harting push-pull system cable RJ45. 8-core for IP85/67 applications. length of 20.0 meters. - Only suitable for SOLIVIA TR string inverters.	

Technical specification of MC4 connectors

PV plug connectors - Multi-Contact MC4

Part Number Delta	Plug Connectors	
	Female cable coupler as individual part (including insulating part) Type: PV-KBT4/2,5I-UR; Ø range of cable gland: 3 - 6 mm; Conductor cross section: 1.5 - 2.5 mm ² .	
	Male cable coupler as individual part (including insulating part) Type: PV-KST4/2,5I-UR; Ø range of cable gland: 3 - 6 mm; Conductor cross section: 1.5 - 2.5 mm ² .	
	Female cable coupler as individual part (including insulating part) Type: PV-KBT4/2,5II-UR; Ø range of cable gland: 5.5 - 9 mm; Conductor cross section: 1.5 - 2.5 mm ² .	
	Male cable coupler as individual part (including insulating part) Type: PV-KST4/2,5II-UR; Ø range of cable gland: 5.5 - 9 mm; Conductor cross section: 1.5 - 2.5 mm ² .	
	Female cable coupler as individual part (including insulating part) Type: PV-KBT4/6I-UR; Ø range of cable gland: 3 - 6 mm; Conductor cross section: 4 - 6 mm ² .	

Part Number Delta	Plug Connectors	
	Male cable coupler as individual part (including insulating part) Type: PV-KST4/6I-UR; Ø range of cable gland: 3 - 6 mm; Conductor cross section: 4 - 6 mm ² .	
	Female cable coupler as individual part (including insulating part) Type: PV-KBT4/6II-UR; Ø range of cable gland: 5.5 - 9 mm; Conductor cross section: 4 - 6 mm ² .	
	Male cable coupler as individual part (including insulating part) Type: PV-KST4/6II-UR; Ø range of cable gland: 5.5 - 9 mm; Conductor cross section: 4 - 6 mm ² .	

Technical specification of AC connectors and terminating plug

AC Connectors

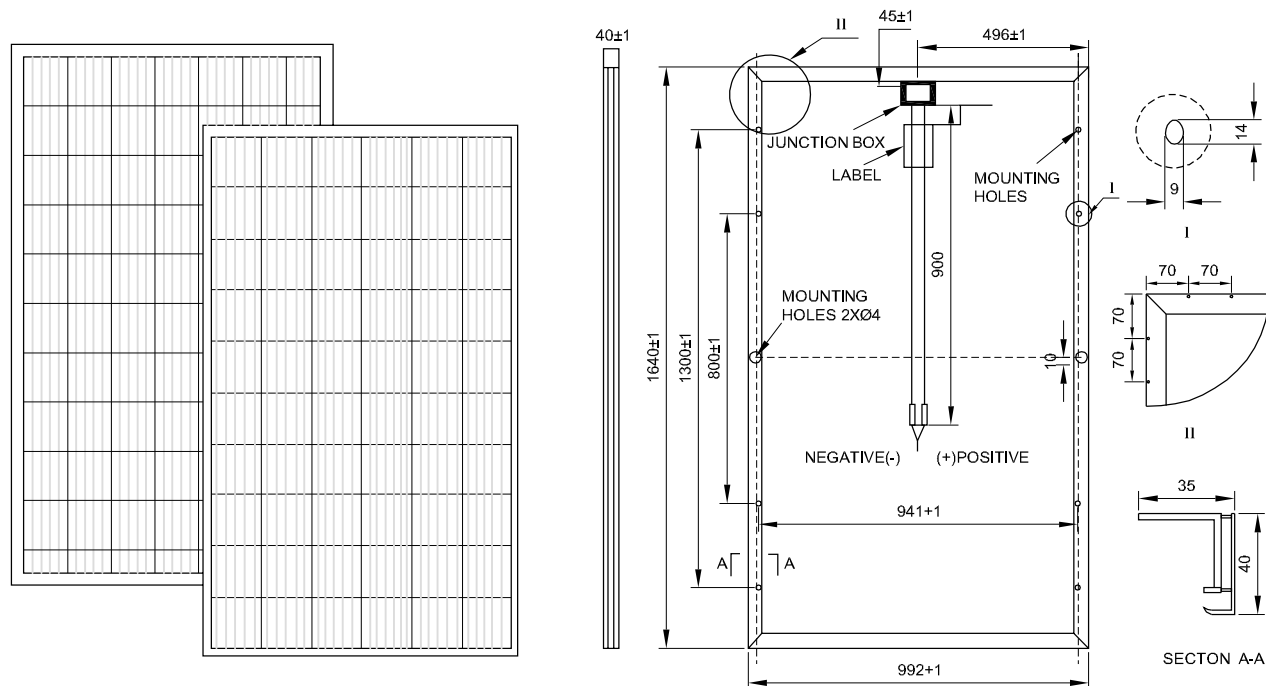
Part Number Delta	AC Connectors
307229555N	- AC connector Wieland RST25i3S. - Suitable for SOLIVIA TR string inverters.
3072390220	- AC connector Amphenol C16/3. - Suitable for SOLIVIA 15 EU TL and SOLIVIA 20 EU TL string inverters.

Terminating plug

Part Number Delta	AC Connectors
3072438991	- RJ 45 terminating plug G3RT / Harting IP67.

Dimensions of a solar panel 250 W (Fig 13)

Fig 13



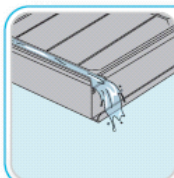
SLN2211HD

Fig 14

Panasonic

Photovoltaic module HIT™

VBHN245SJ25
VBHN240SJ25
VBHN235SJ25

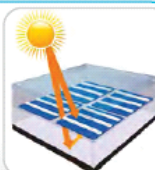


Water drainage frame

- 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.



19.4%*
194 W/m²



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.

*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. The development of the solar cell was supported in part by the New Energy and Industrial Technology Development Organization (NEDO).

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 only 0.0036% in our European factory in Dorog, Hungary (as of September 2013).

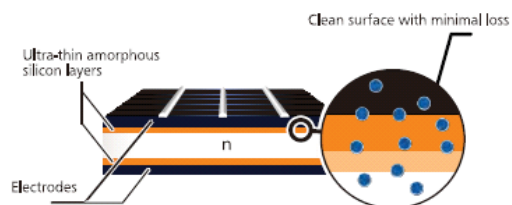
Special features

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.

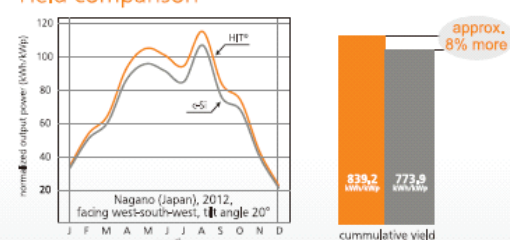
High performance at high temperatures

With its very low temperature coefficient of only -0.29%/°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



HIT™
Photovoltaic Module

*HIT™ is a trademark of Panasonic Group.

Model	Cell efficiency	Module efficiency	Output/m ²
VBHN245SJ25	22.0%	19.4%	194 W/m ²
VBHN240SJ25	21.6%	19.0%	190 W/m ²
VBHN235SJ25	21.1%	18.6%	186 W/m ²

Panasonic Corporation

Fig 15



Electrical and Mechanical Characteristics

VBHN245SJ25, VBHN240SJ25, VBHN235SJ25

Electrical data (at STC)

	VBHN245SJ25	VBHN240SJ25	VBHN235SJ25
Max. power (Pmax) [W]	245	240	235
Max. power voltage (Vmp) [V]	44,3	43,6	43,0
Max. power current (Imp) [A]	5,54	5,51	5,48
Open circuit voltage (Voc) [V]	53,0	52,4	51,8
Short circuit current (Isc) [A]	5,86	5,85	5,84
Max. over current rating [A]	15		
Production tolerance power [%]	+10/-5*		
Max. system voltage [V]	1000		

Note: Standard Test Conditions: Air mass 1,5; Irradiance = 1000W/m²; cell temp. 25°C

Temperature characteristics

Temperature (NOCT) [°C]	44,0		
Temp. coefficient of Pmax [%/°C]	-0,29		
Temp. coefficient of Voc [V/°C]	-0,133	-0,131	-0,130
Temp. coefficient of Isc [mA/°C]	1,76	1,76	1,75

At NOCT (Normal Operating Conditions)

Max. power (Pmax) [W]	187,4	183,2	178,4
Max. power voltage (Vmp) [V]	42,5	41,7	41,0
Max. power current (Imp) [A]	4,41	4,39	4,35
Open circuit voltage (Voc) [V]	50,3	49,7	48,9
Short circuit current (Isc) [A]	4,71	4,71	4,70

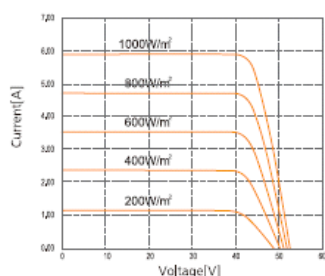
Note: Nominal Operating Cell Temp.; Air mass 1,5; Irradiance = 800W/m²; Air temperature 20°C; wind speed 1 m/s

At low irradiance (20%)

Max. power (Pmax) [W]	47,0	45,9	45,0
Max. power voltage (Vmp) [V]	43,2	42,2	41,6
Max. power current (Imp) [A]	1,09	1,09	1,08
Open circuit voltage (Voc) [V]	49,6	49,0	48,4
Short circuit current (Isc) [A]	1,17	1,17	1,17

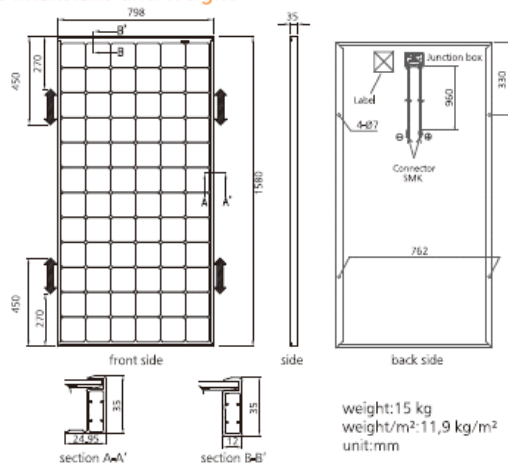
Note: Low irradiance: Air mass 1,5; Irradiance = 200W/m²; cell temp. = 25°C

Dependence on irradiance



Reference data for model VBHN245SJ25

Dimensions and weight



Guarantee

Power output: 10 years (90% of Pmin), 25 years (80% of Pmin)
Product workmanship: 10 years (based on guarantee document)

Materials

Cell material: 5 inch HIT cells
Glass material: AR coated tempered glass
Frame materials: Black anodized aluminium
Connectors type: SMK

Certificates



Member of



Fig 16

ELECTRICAL PERFORMANCE

All specified Parameters are at STC 25°C Ambient, 1000W/m² irradiance and AM 1.5

Type		PR-270M6-60	PR-275M6-60	PR-280M6-60	PR-285M6-60	PR-290M6-60	PR-295M6-60	PR-300M6-60
Power Output	P _{max} (W)	270	275	280	285	290	295	300
Power Output Tolerance	P _{max} (%)	0~+3	0~+3	0~+3	0~+3	0~+3	0~+3	0~+3
Max-Power Voltage	V _{mp} (V)	31.43	31.65	31.89	32.06	32.19	32.35	32.50
Max-Power Current	I _{mp} (A)	8.59	8.69	8.78	8.89	9.01	9.12	9.23
Open-Circuit Voltage	V _{oc} (V)	38.15	38.33	38.51	38.67	38.83	39.01	39.18
Short-Circuit Current	I _{sc} (A)	9.31	9.42	9.54	9.66	9.78	9.84	9.96
Cell Efficiency	(%)	19.6	19.9	20.3	20.7	21.0	21.4	21.8
Module Efficiency	(%)	16.6	16.9	17.2	17.5	17.8	18.1	18.4

THERMAL CHARACTERISTICS

Nominal Operating Cell Temperature	NOCT(°C)	45±2
Temperature Coefficients of P _{max}	(%/°C)	-0.438
Temperature Coefficients of V _{oc}	(%/°C)	-0.297
Temperature Coefficients of I _{sc}	(%/°C)	0.037

OPERATING CONDITIONS

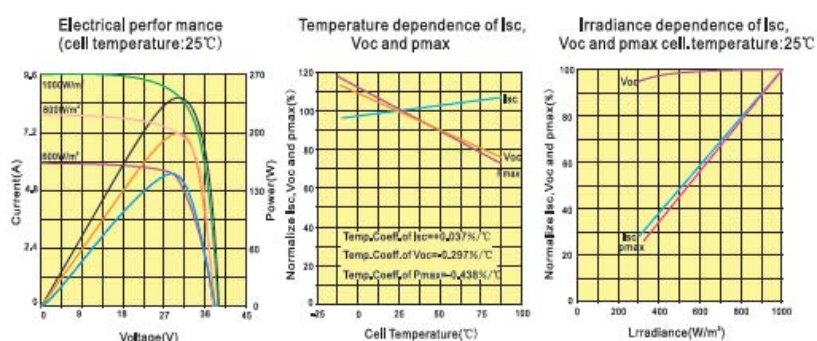
Maximum System Voltage	(VDC)	1000V(IEC)
Maximum Series Fuse	(A)	15
Operating Temperature	(°C)	-40~+85
Maximum Load(snow/wind)		5400pa/2400pa

MECHANICAL CHARACTERISTICS

Solar cells(type/dimension)	Mono-Crystalline Silicon/156mm*156mm
Cells number	60pcs(6*10)
Front cover(material/thickness)	Low iron tempered glass/3.2mm
Backsheet(color)	White
Frame(material/color)	Anodized aluminum alloy/Silver
Junction box(protection degree)	≥IP65
Cables/Plug Connector	Diameter 4mm ² , Length 900mm/MC4 or MC4 compatible
Module Dimension	1640×992×40mm
Module Weight	19kg

PACKING DETAILS

Container	20'GP	40'HQ
Pieces per pallet	52	56
Pallets per container	6	14
Pieces per container	312	784



Solar Technician (Electrical) - Bill of Materials for Solar PV Projects

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

Prepare bill of materials for a 5 KW solar PV installation

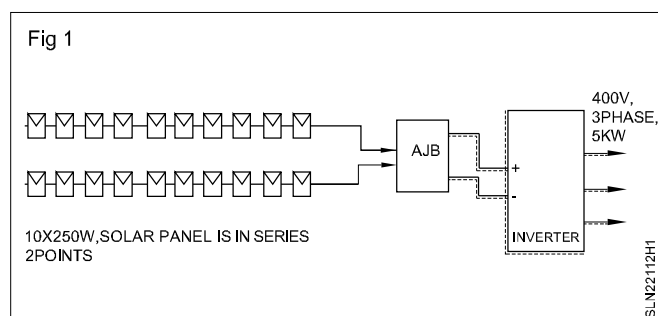
- 1 Calculate using PV sizing theory the approximate voltage, current requirements of PV array and inverter.
- 2 Select from obtained technical specifications of various models of inverters and panels suitable ones for your sized PV plant.
- 3 Match the different components.
- 4 Draw a SLD.
- 5 Prepare 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)



Bill of Materials

Sl.No	Bill of Materials	Quantity

Solar Technician (Electrical) - Bill of Materials for Solar PV Projects

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

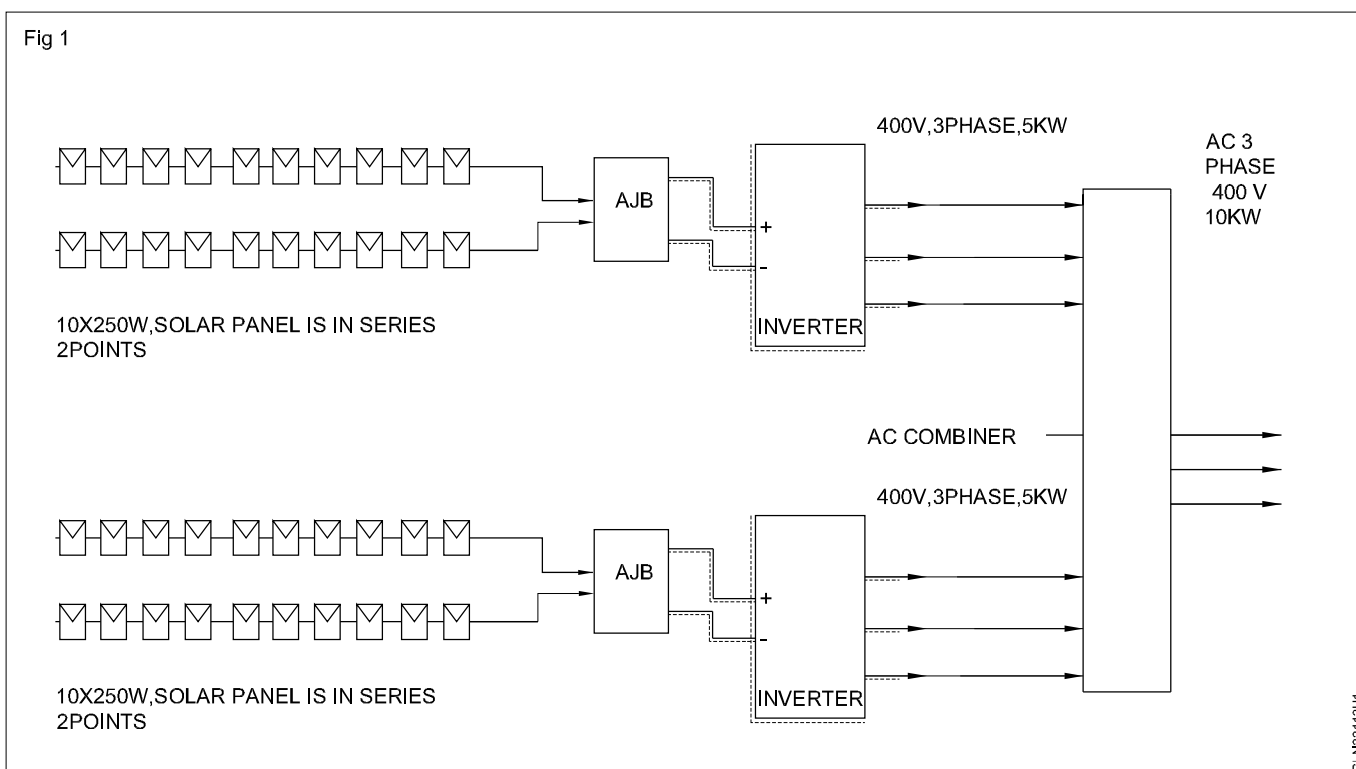
Prepare bill of materials for a 10 kW solar PV installation

- 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)



Bill of Materials

[illegible]

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

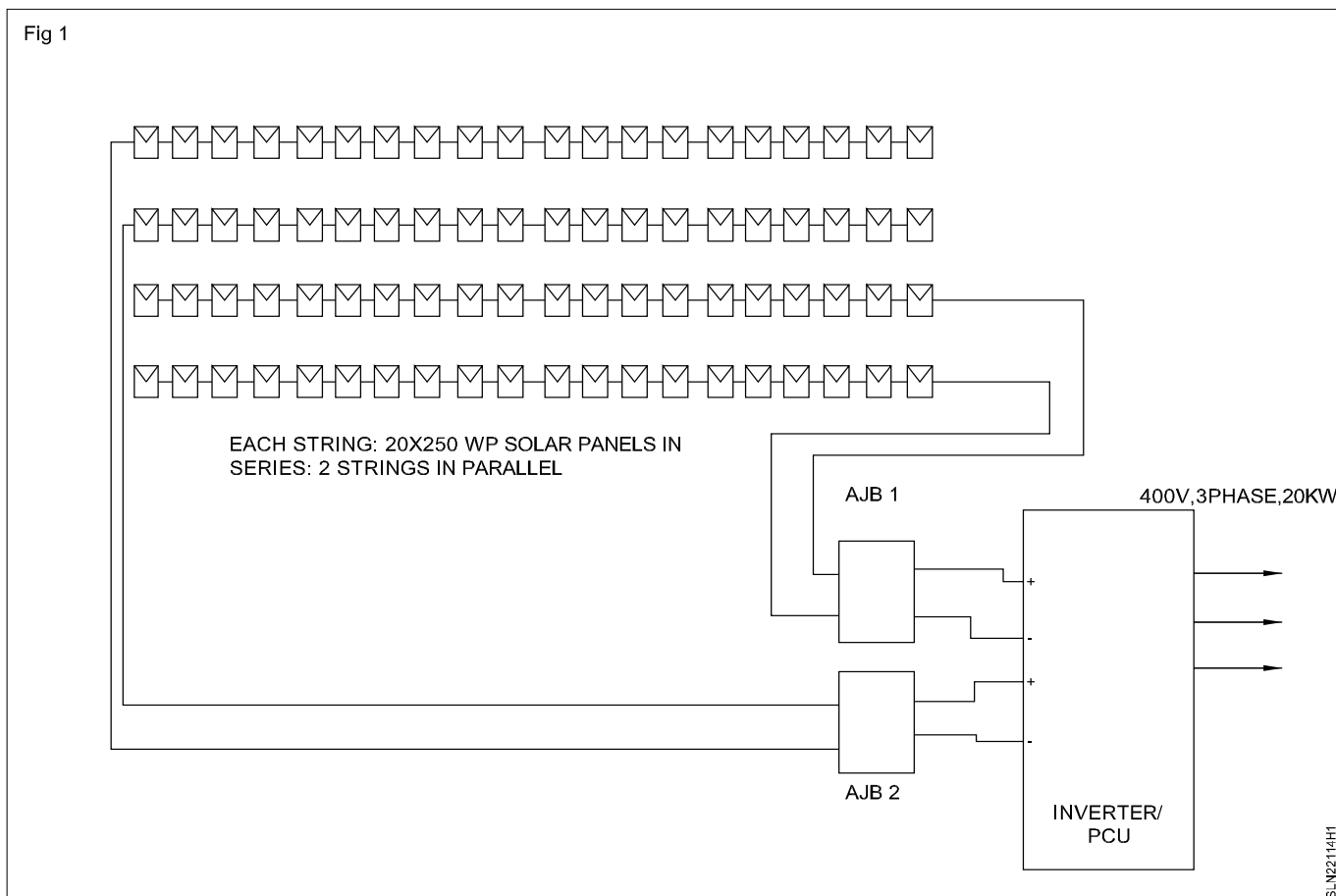
Prepare bill of materials for a 20 KW solar PV installation

- 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)



Bill of Materials

[illegible]

Solar Technician (Electrical) - Bill of Materials for Solar PV Projects

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

Prepare bill of materials for a 100 kW solar PV installation

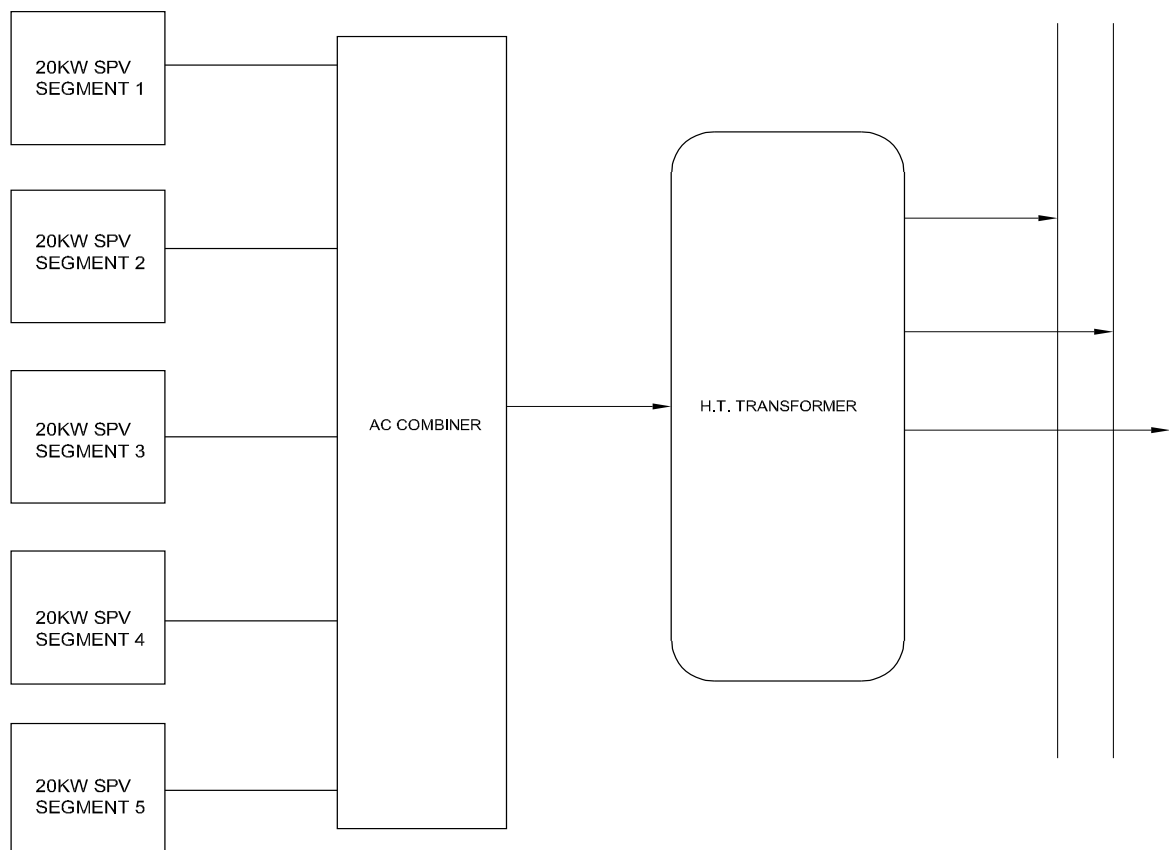
- 1 Calculate using PV sizing theory the approximate voltage, current requirements of PV array and inverter.
- 2 Collect details of other major components
- 3 Select from obtained technical specifications of various models of inverters and panels suitable ones for your sized PV plant.
- 4 Match the different 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

[illegible]

Solar Technician (Electrical) - Bill of Materials for Solar PV Projects**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**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

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.

Frameless Edge Seal (Fig 1)

Fig 1



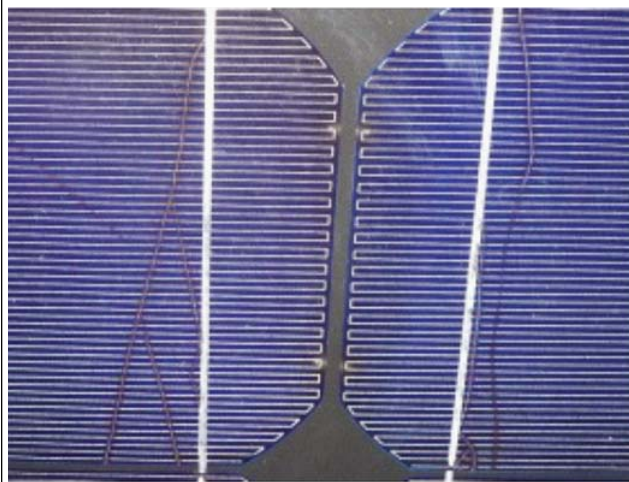
Absorber delamination (Fig 2)

Fig 2



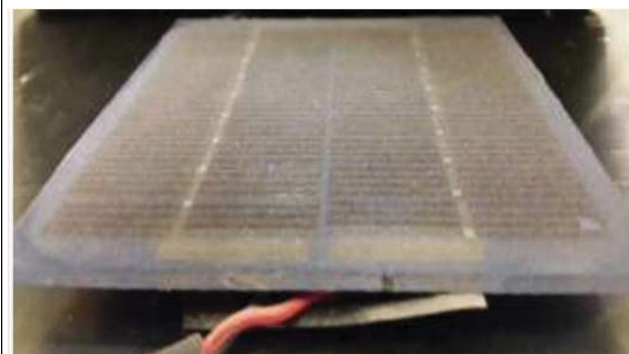
Cracks in PV cells (Fig 3)

Fig 3



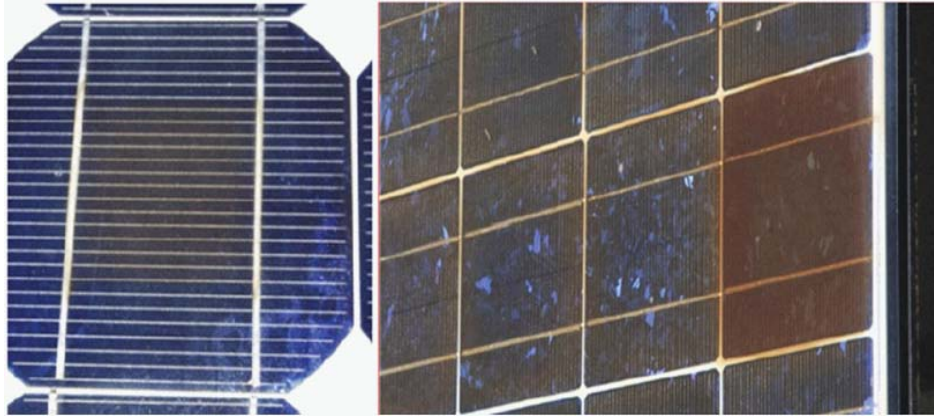
Soiled PV Cell (Fig 4)

Fig 4



Discolorations (Fig 5)

Fig 5



PV de-laminations (Fig 6)

Fig 6



Snail trials in a PV cell (Fig 7)

Fig 7



Material problem (Fig 8)

Fig 8



Observations

[illegible]

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.

Note:

Inspection over 60 modules from nearly 20 manufacturers can give.

- 1 Best results for comparison and preparing guidelines.
- 2 Reduce ambiguity and variation in survey responses.

Note:

Suggested check points

- 1 Field site
- 2 System configuration
- 3 Module identification
- 4 Individual module components
- 5 Starting from the back and ending at the front of the module.
- 6 Locations of electronic records such as I-V curves, infrared images etc.

Important: The check list should be prepared such that a full visual evaluation can be completed in approximately 8 minutes by a pair of experienced inspectors/technicians, though this can be reduced significantly for data sets consisting of a large number of similar modules or by the use of the abbreviated inspection list. periods of time.

Example check point - Damage

Damage: ☐ no damage ☐ small, localized ☐ extensive
Damage Type (mark all that apply):
☐ Crazeing of other non-crack damage
☐ Shattered (tempered) shattered (non-tempered) ☐ Cracked (a.) ☐ Chipped (b.)
(a.) Cracks (#): 1 ☐ 2 ☐ 3 ☐ 4 - 10 ☐ >10
Crack(s) start from: ☐ module corner ☐ module edge ☐ cell ☐ junction box
(b.) Chips (#): 1 ☐ 2 ☐ 3 ☐ 4 - 10 ☐ >10
Chipping location: ☐ modue corner ☐ module edge

Example check point - Appearance

Appearance: ☐ like new ☐ discoloration (a.) ☐ visibly degraded
(a.) Fraction affected by discoloration:
☐ <5% ☐ 5 - 25% ☐ 50% ☐ 75% - 100% (consistent overall)
Material problems:
☐ squeezed/pinched out ☐ shows signs of moisture penetration
Delamination: ☐ local only ☐ widespread
Fraction Delamination: ☐ <5% ☐ 5 - 25% ☐ 50% ☐ 75% - 100% (consistent overall)

Example check point - Discoloration (Fig 11)

Discoloration: ☐ none/like new ☐ light discoloration ☐ dark discoloration

Number of cells with any discoloration: _____
of these, average % discoloration area:

☐ <5% ☐ 5 - 25% ☐ 50% ☐ 75% ☐ 100% (consistent overall)

Discoloration location(s) (mark all that apply):

☐ module center ☐ module edges ☐ cell centers ☐ cell edges

☐ over gridlines ☐ over busbars ☐ over tabbing ☐ between cells

☐ individual cell(s) dark that others ☐ partial cell discoloration

Junction box area: ☐ same as elsewhere ☐ more affected ☐ less affected

Discoloration of PV module (Fig 12)



A: No discoloration

B: Discoloration over Center Of Cells

C: Discoloration over whole

Example check point - Delamination

Note:

- 1 A preliminary analysis illustrates the types of data that become available through visual inspection.
- 2 If visually observable defects can be correlated or conclusively linked with the measured electrical performance degradation rates, visual inspection may provide a relatively low impact method for assessing which PV installations may be more likely to see accelerated degradation based on the frequency and types of defects that develop.

Damage: ☐ no damage ☐ small, localized ☐ extensive

Damage Type (mark all that apply): ☐ burn marks(s) ☐ cracking

☐ possible moisture ☐ foreign particale embedded

Delamination: ☐ no delamination ☐ small, localized ☐ extensive

Location: ☐ from edges ☐ uniform ☐ corner(s) ☐ near junction box ☐ near busbar

☐ along scribe lines

Delamination Type: ☐ absorb delamination ☐ AR coating delamination ☐ other

Most frequently observed issues at 2 different sites – outcome of visual.

Site 1		Site 2	
Observation	% of Modules	Observation	% of Modules
Glass (front): Lightly soiled	55%	Glass (front): Small, localized damage	50%
Glass (front): Bird droppings	24%	Wires: Pliable but degraded	43%
Connectors: Pliable but degraded	22%	Glass (front):Lightly soiled	43%
Encapsulant: Major discoloration	20%	Junction box: Seal will leak	36%
Backsheet: Small, localized damage	20%	Thin film module: Distance between frame and cells < 10 mm	36%

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.

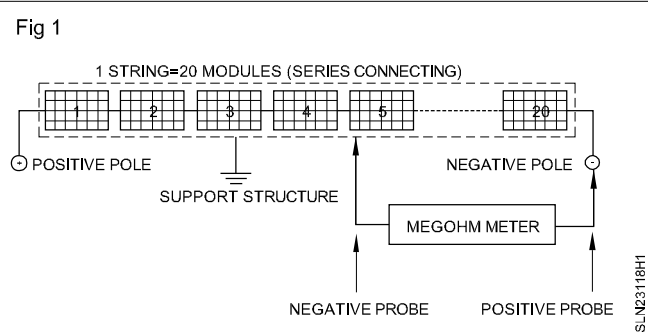
Requirements
Tools and Instruments/equipment • Grid connected PV systems composed of multi crystalline silicon panels of 1 MW size • Systems with 1) negative ground and 2) floating ground for comparisons • Megohm meter • Set of PV modules • Water tank

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.

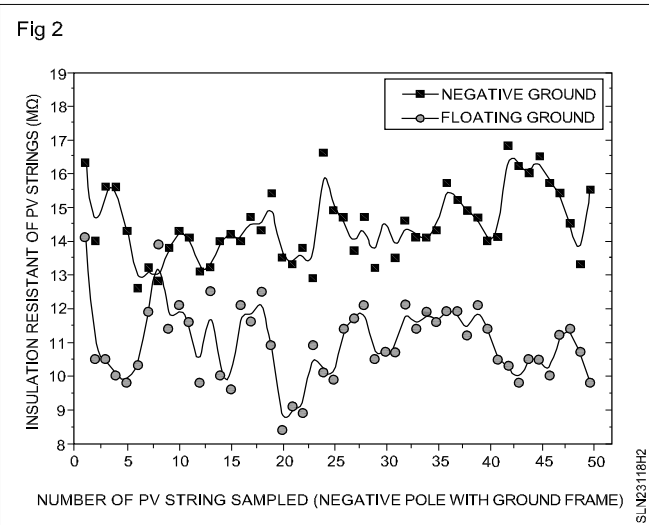
Measuring insulation resistance to analyze leakage current on PV string (Fig 1)



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)

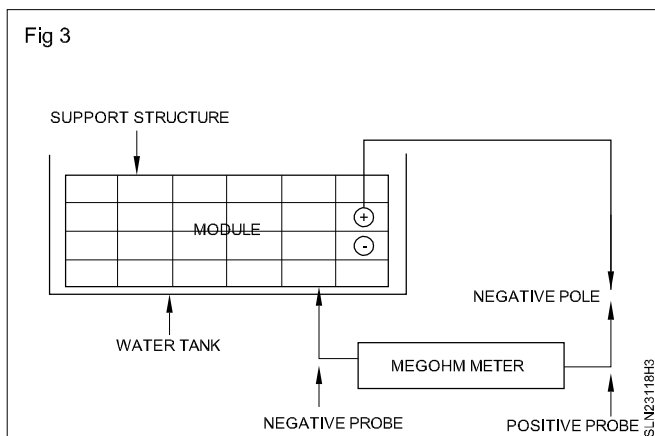


Observstion:

Sl.No	List the observation

TASK 2: Measure wet leakage current of a PV module

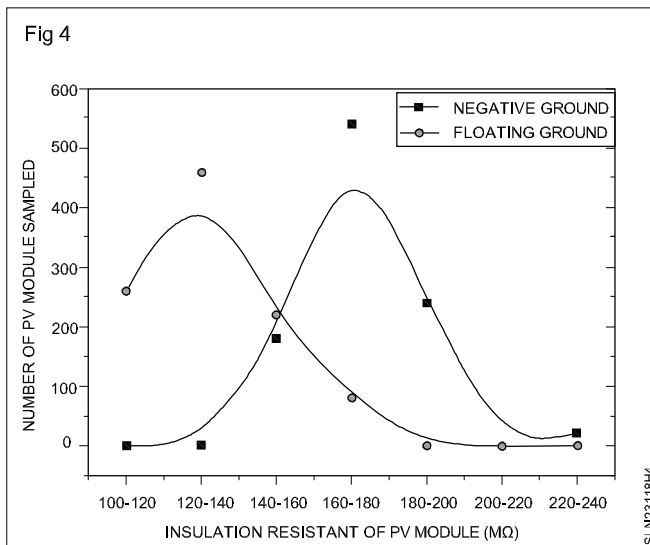
Measuring of insulation resistance to analyze wet leakage current on PV module. (Fig 3)



- 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 be checked.
- 8 Repeat the steps for all 20 samples and record the observations.

Possible results

The wet leakage current test of the PV module sampled from different grounded system PV systems. (Fig 4)



Note: The wet leakage current test result can be presented in the form of insulation resistance when the PV module is submerged in the water tank. In a typical test, 20 PV modules were sampled by representing every insulation resistance range of 1,100 modules for both types of grounded PV systems. The average insulation resistance value and average leakage current of PV string/module operation in 2 Years are given below:

Typical results of Insulation resistance and wet leakage current.

Leakage current test in string level		
System	Average Insulation resistance (MΩ)	Average leakage current (μA)
Negative ground	14.5	68.9
Floating ground	11.0	90.9
Wet Leakage current test in module level		
System	Average Insulation resistance (MΩ.m²)	Average leakage current (μA)
Negative ground	174	5.75
Floating ground	133	7.51

Solar Technician (Electrical) - Tests and Measurement of PV Modules and Installation**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/m², 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/m², 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:

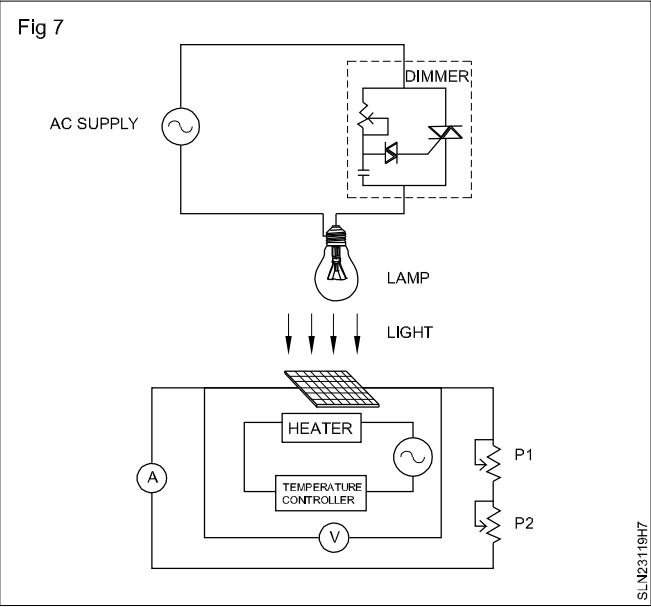
No. of bypass diodes:

Conditions of Bypass diodes:

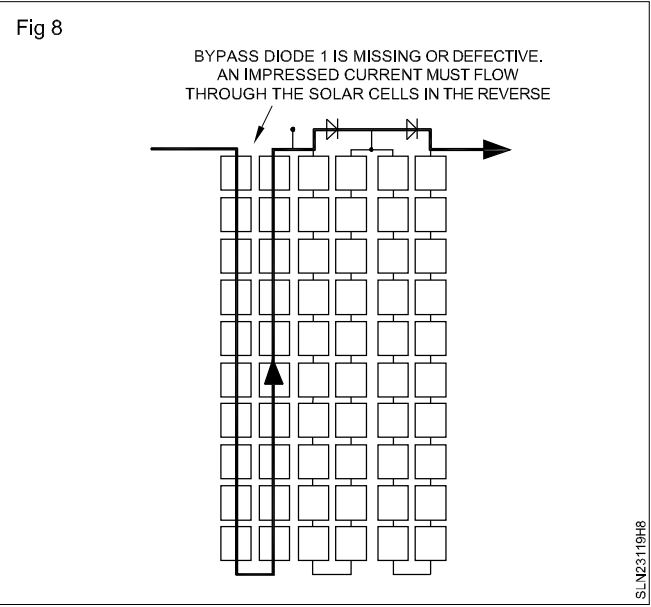
Reasons for difference in specified and measured values:

Conclusions:

Standard set up required for setting STC for conducting I-V & P-V curves tests. (Fig 7)



Effect of open bypass diode on solar panel. (Fig 8)



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.

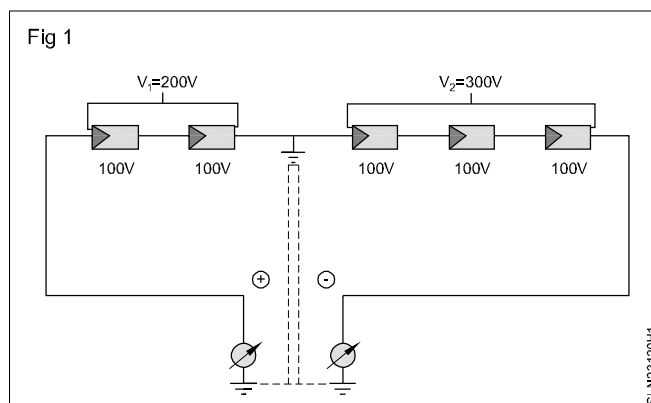
- 1 Disconnect the inverter from any voltage sources (see the inverter installation manual). (Danger to life due to high voltages).
- 2 Select a string.
- 3 Measure the voltage between the positive terminal and the ground potential (PE).
- 4 Measure the voltage between the negative terminal and the ground potential (PE).
- 5 Measure the voltage between the positive and negative terminals.
- 6 Check each string in the PV system for ground faults.

Confirm is there a ground fault:

- 1 If the following results are present at the same time, there is a ground fault in the PV system:
 - 2 All measured voltages are stable.
 - 3 The sum of the two voltages to ground potential is approximately equal to the voltage between the positive and negative terminals.
 - If a ground fault is present, determine the location of the ground fault via the ratio of the two measured voltages and eliminate the ground fault. The example shows a ground fault between the second and third PV module (Fig 1)

- If a definite ground fault cannot be measured and the message is still displayed in inverter, measure the insulation resistance (Task 2).
- Reconnect the strings without ground faults to the inverter and re-commission the inverter (see inverter installation manual).

Schematic diagram for finding ground fault/continuity (Fig1)



If the inverter displays the event numbers such as 3501, 3601 or 3701, there could be a ground fault. The electrical insulation from the PV system to ground is defective or insufficient.

Danger to life due to electric shock when touching live system components in case of a ground fault:

- 1 If a ground fault occurs, parts of the system may still be live. Touching live parts and cables results in death or lethal injuries due to electric shock.

TASK 3: Perform impulse voltage test on a solar PV panel

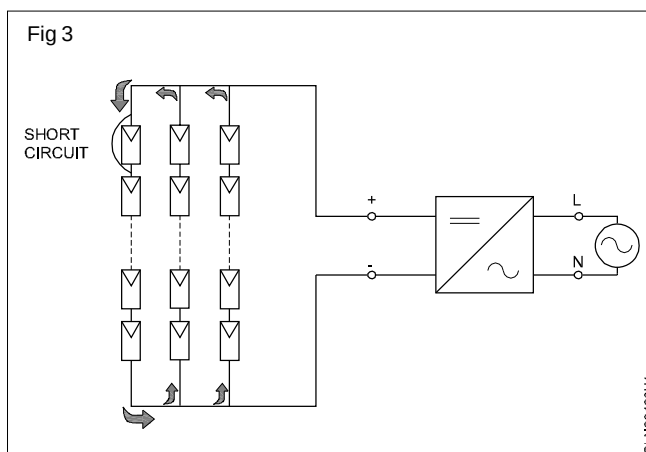
- 1 Connect the positive and negative terminals of the solar panel and extend the connection outward.
- 2 Wrap the solar panel, completely covered with one or two layers of 0.001-in. or 0.0015-in. thick copper foil so the total buildup is 0.002 in. to 0.003 in. This foil is not available in widths large 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 $<1\Omega$, measuring area: 625 mm². (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- μ s x 50- μ s 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.

Note: Impulse Voltage Test Equipment should be carefully selected, since the impulse voltage test is a very specialized test. At first glance, the test specification seems pretty generic. The purpose of the test is to verify that the module will be able to “withstand over-voltages of atmospheric origin”. The test also is performed to ensure that the module can withstand any line-conducted surges.

Note: Reverse current into the faulty string = total current of the remaining strings.

Flow of reverse current (Fig 3)



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/m².
- 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.

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.

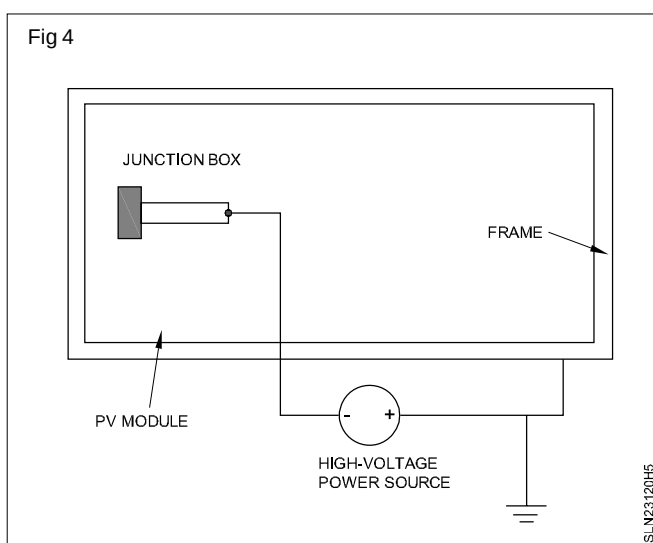
TASK 5: Measure the partial discharge

Note:

- **Polymeric materials intend for use as a superstrate or substrate, without appropriate IEC insulation pre-qualification must comply with the partial discharge test. This test should apply to any polymeric material serving as a superstrate or substrate.**
- **Preconditioning:** It is advisable to perform the partial discharge-test before inserting the reverse side foil into the PV modules.

- 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).

Schematic diagram for PD test (Fig 4)



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.

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

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
 - Solar panels are heavy and awkward to lift and carry. Loading and unloading panels from trucks and onto roofs can cause strains, sprains, muscle pulls and back injuries as well as cumulative trauma that stresses the spine. The panels can also heat up quickly when exposed to sunlight, causing burns if not handled safely.

Solar Technicians handling Solar panel on roof top. (Fig 1)



Safety measures for solar workers:

- Lift each solar panel with at least two people while applying safe lifting techniques.
- Transport solar panels onto and around the work site using mobile carts or forklifts.
- Never climb ladders while carrying solar panels. To get solar panels onto rooftops, use properly inspected cranes, hoists or ladder-based winch systems.
- Once unpackaged, cover panels with an opaque sheet to prevent heat buildup.
- Always wear gloves when handling panels.

5 Ladder Safety

- Solar construction often involves working on roofs and from ladders. Choosing the right ladder and using it properly are essential.

Safety measures for solar workers:

- Select the ladder that best suits the need for access – whether a stepladder, straight ladder or extension ladder. Straight or extension ladders should extend a minimum of three feet above the rung that the worker will stand upon.
- Select the right ladder material. Aluminum and metal ladders are the most commonly used today and may have their place on the job, but they're a serious hazard near power lines or electrical work. Use a fiberglass ladder with non-conductive side rails near power sources.
- Place the ladder on dry, level ground removed from walkways and doorways, and at least 10 feet from power lines and secure it to the ground or rooftop.

6 Trips and Falls

- Trips and falls are a common hazard of all construction jobs, including solar. They can happen anywhere on the jobsite, especially off roofs or ladders. Rooftop solar installations are especially hazardous because the work space diminishes as more panels are installed, increasing the risk of falls.

Safety measures for solar workers:

- Keep all work areas dry and clear of obstructions.
- For fall distances of six feet or more, take one of three protective measures: install guardrails around ledges, sunroofs or skylights; use safety nets; or provide each employee with a body harness that is anchored to the rooftop to arrest a potential fall.
- Cover holes on rooftops, including skylights, and on ground-level work surfaces.

7 Solar Electrical Safety

- Solar electric (photovoltaic or PV) systems include several components that conduct electricity: the PV solar array, an inverter that converts the panel's direct current to alternating current, and other essential system parts. When any of these components are "live" with electricity generated by the sun's energy, they can cause injuries associated with electric shock and arc-flash. Even low-light conditions can create sufficient voltage to cause injury.
- It's also important to recognize that with PV systems, electricity comes from two sources: the utility company and the solar array that is absorbing the sun's light. Even when a building's main breaker is shut off, the PV system will continue to produce power. This makes isolating the power source more difficult, and requires extra caution on the part of the solar worker.

Safety measures for solar workers:

- Cover the solar array with an opaque sheet to "turn off" the sun's light.
- Treat the wiring coming from a solar PV array with the same caution as a utility power line. Use a meter or circuit test device to ensure that all circuits are de-energized before working on them.
- Lock out the power on systems that can be locked out. Tag all circuits you're working on at points where that equipment or circuit can be energized.
- Never disconnect PV module connectors or other associated PV wiring when it is under load.

8 Personal Protective Equipment

- Personal Protective Equipment is an essential part of every solar installation. It's the employer's job to assess the workplace for hazards and provide the PPE deemed necessary for the employee's safety. Hard hats, gloves and steel-toed shoes with rubber soles are among the commonly required PPE for solar projects.
- Employees are in turn responsible for using PPE in accordance with their employer's instructions, maintaining it in a safe and reliable condition and requesting replacements when necessary.
- Risk is part of running any business, but when it comes to an employee's safety and health, risk should be avoided at all cost. Proactive safety planning and its successful implementation on the job can help ensure that accidents don't happen.

Practice using PPE before actual usage on site.

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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

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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Solar Technician (Electrical) - Installation Solar PV Plant and Hybrid Plant

Create layout for available 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

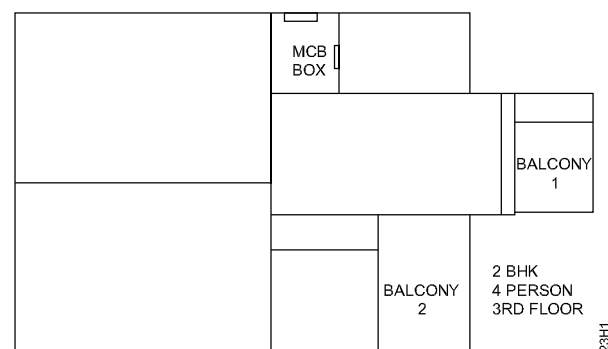
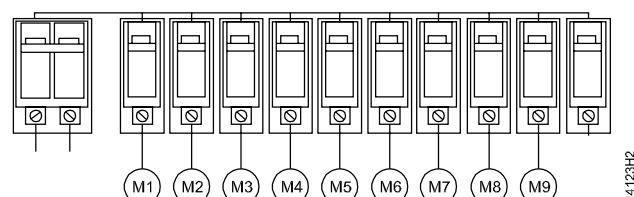


Fig 2



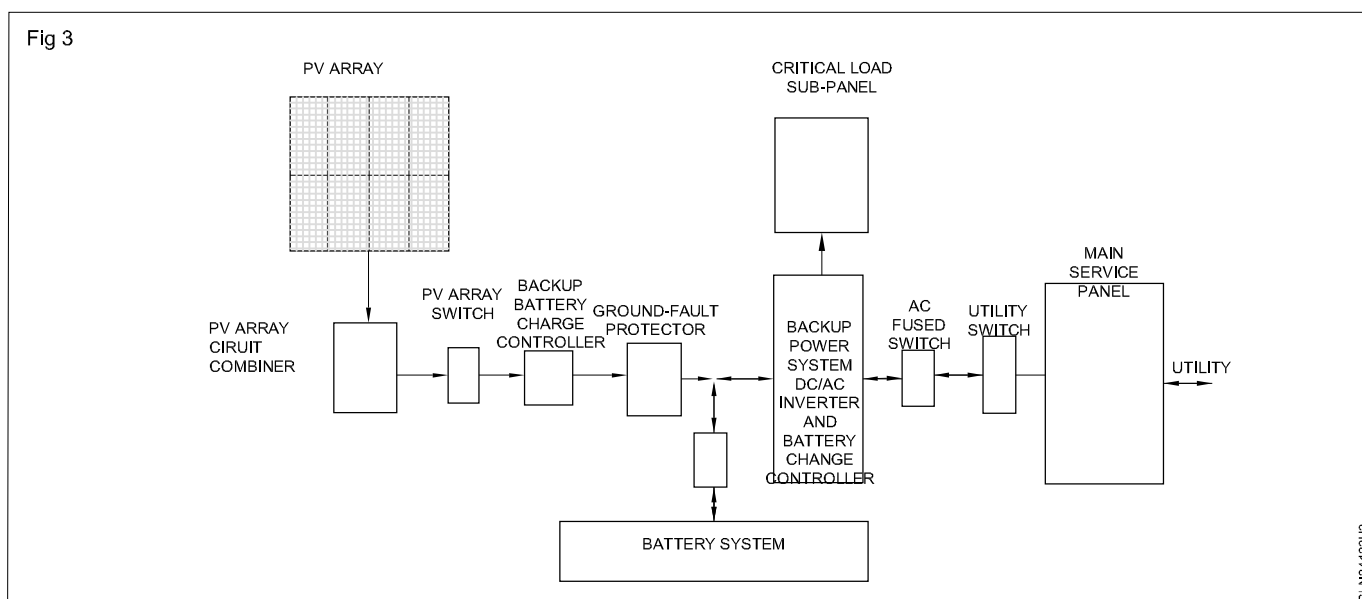
TASK 3: Recommend places for different components and submit site inspection report of proposed SPV installation

- 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.

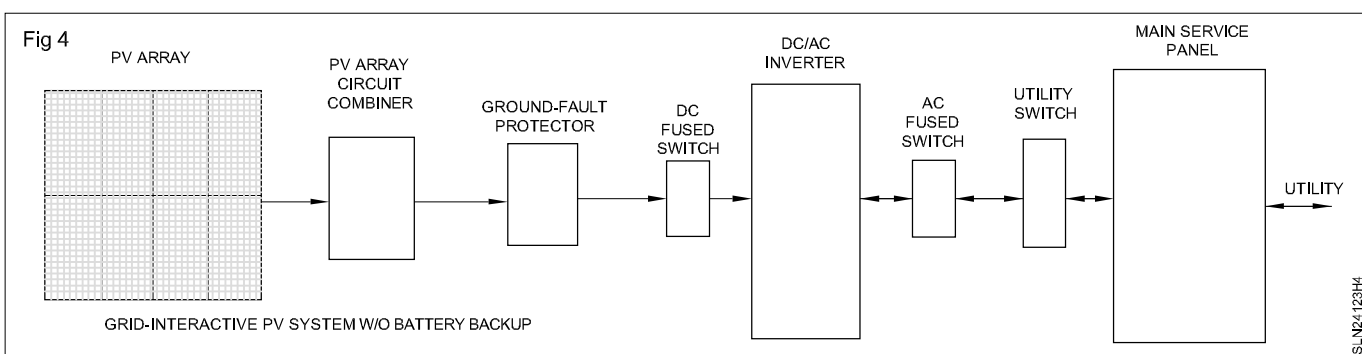
Consider

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)



Components of Grid interactive SPV system without battery backup. (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.

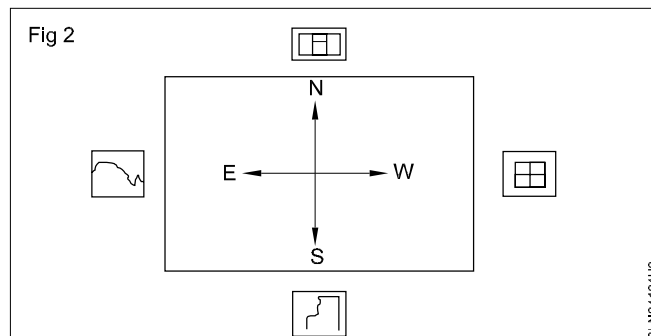
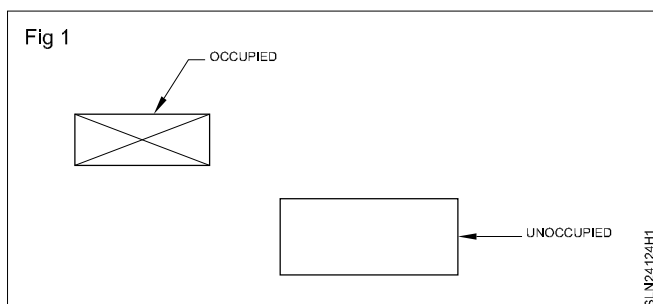
Prior experience of installation of SPV systems or assisting thereof.

PROCEDURE

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.
- 11 Draw a neat sketch.
- 12 Calculate area marked for installation and compared with desired installation capacity.
- 13 Recommend allowed size – same as proposed, 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.

Mark occupied and unoccupied areas on site. (Fig 1)



Solar Technician (Electrical) - Installation Solar PV Plant and Hybrid Plant

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.

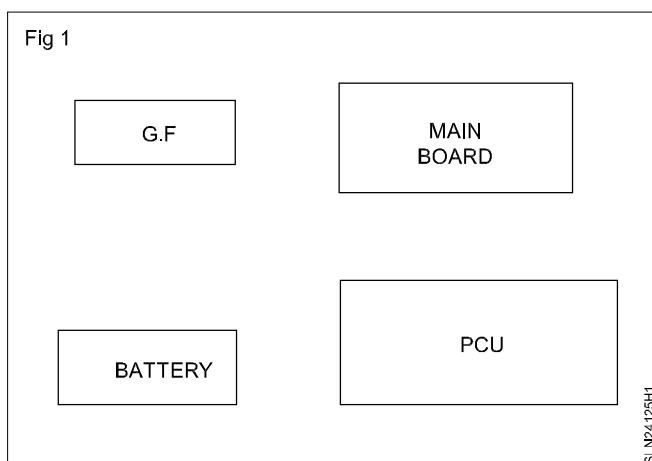
Prior experience of installation of SPV systems or assisting thereof.

PROCEDURE

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)



Note: Roughly 110 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

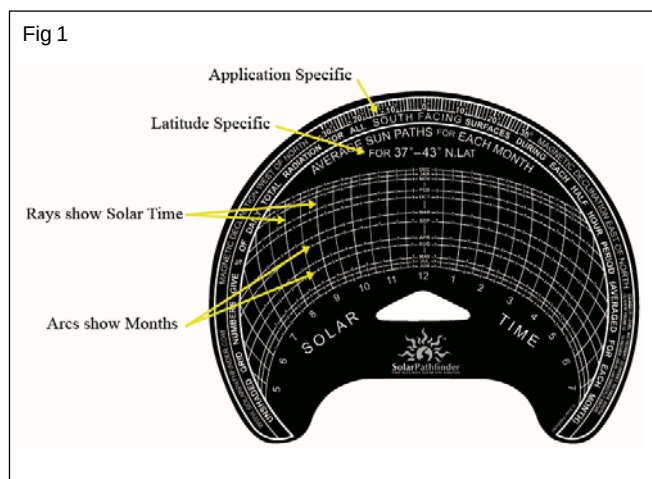
Tools and Instruments/equipment

- Solar path finder

PROCEDURE

Analyse the shadow free area on site using solar path finder

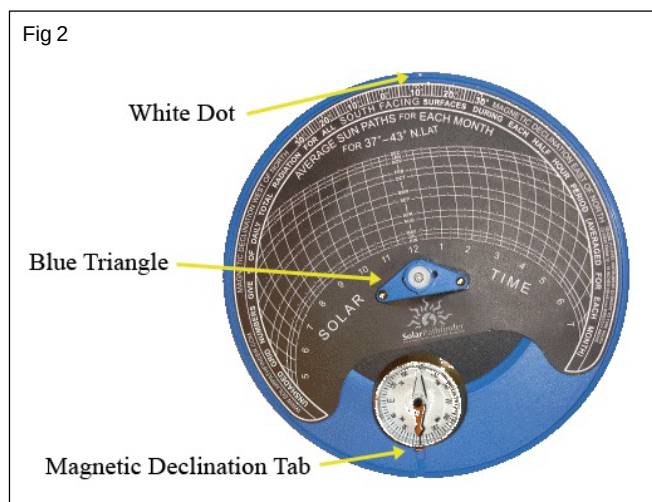
Diagram of a Solar Path Finder. (Fig 1)



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)

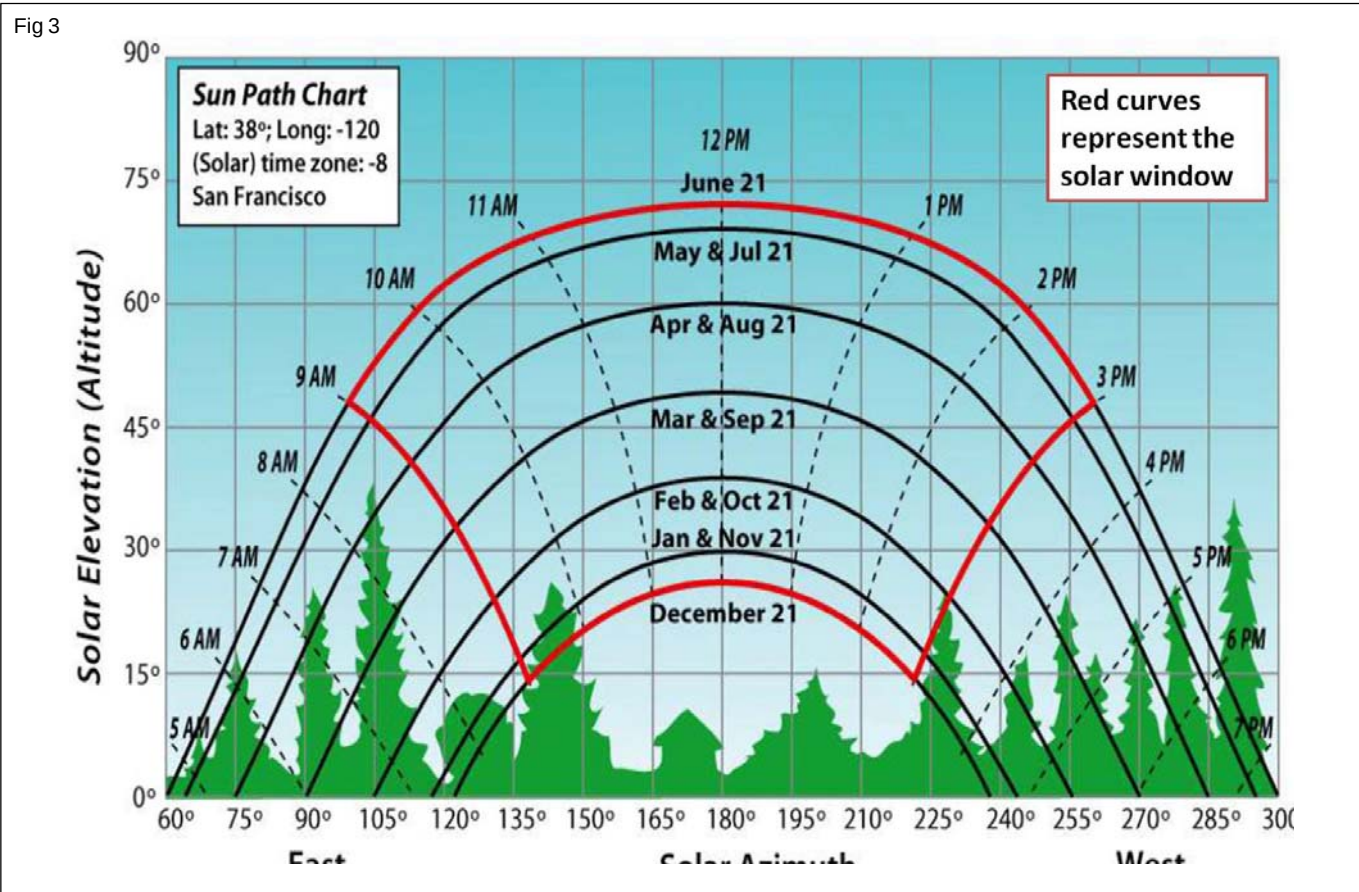


- The solar path sheet shown in fig 2 is specific to the latitude. It can be obtained from websites such as <http://solardat.uoregon.edu/SunChartProgram.html>.
- Each curved line represents the sun path of a specific month of the year. Note that in the summer months, the path is wider.
- Place on a spot; observe that the fish eye lens on the pathfinder projects a shadow on the solar path sheet.
- Observe the area below the marked black line.
- It shows the shading times for that day.
- Use this to select the location with least shading.
- Shading during early morning and late evening does not affect as much as any shading during 10A.M – 4 P.M.
- Shading situations present a challenge for preparation of PV system implementation plans. It has an effect on system yield.
- 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.

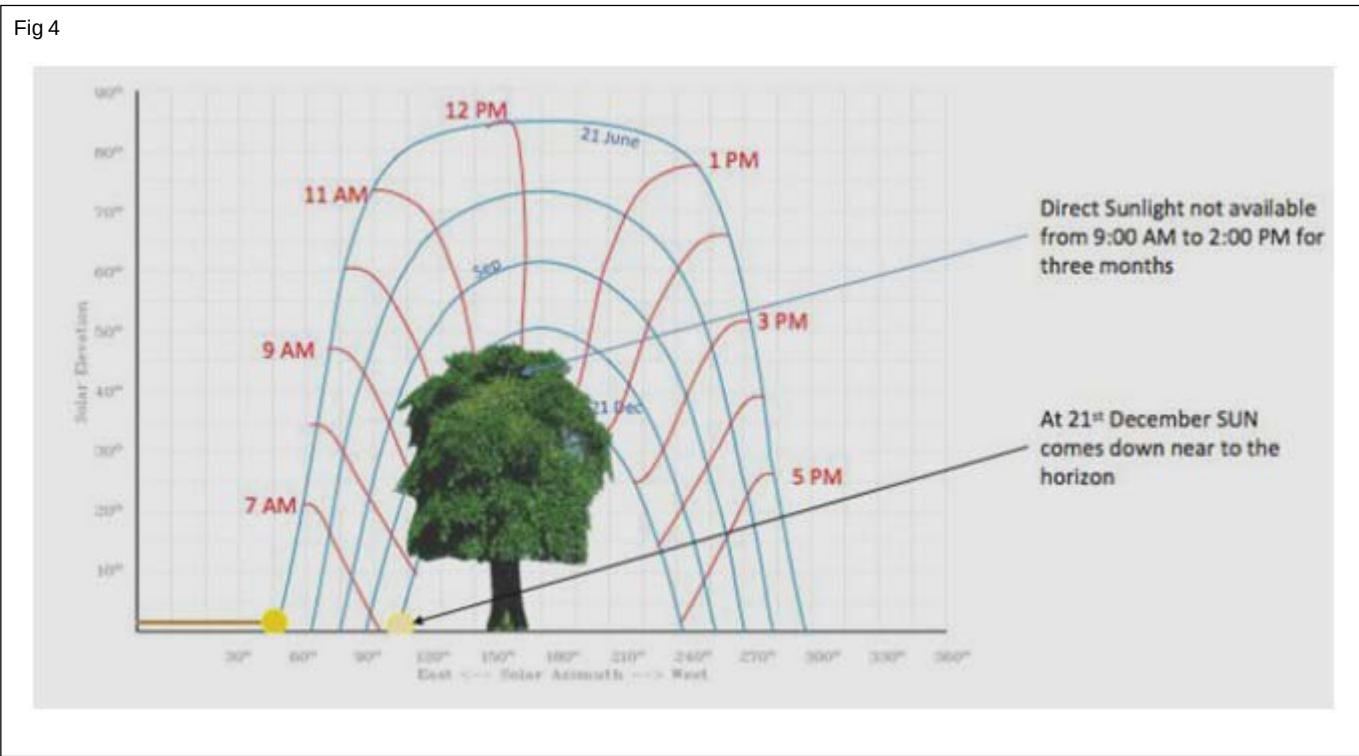
Software simulation tools like PVSOL and PVsyst are useful for doing shadow analysis and annual energy generation projections. Results from solar pathfinder and other instruments are used as an input in the above solar simulation software for energy generation projections.

Sunlight availability mapped on a sun path diagram during the entire day. (Fig 3)



Observations

Shading analysis carried out using sun path diagram.
(Fig 4)



Install a roof top solar panel mounting structure for 1 kW installation

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

- install 1 kW solar panel mounting structure.

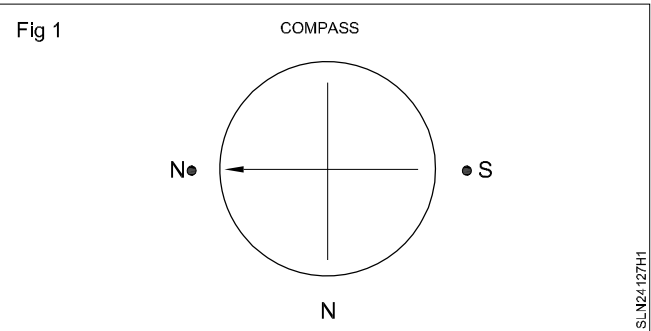
Requirements		
Tools and Instruments/equipment		
• Pillar mounts Qty • Connecting frames Qty • Swinging rod Qty • Angle adjusting rod Qty • Panel fitting arms Qty • Tool kit	- 2 Nos - 2 Nos - 2 Nos - 2 Nos - 8 Nos	• Mounting screws, bolts and nuts, washers, anchor bolts • Tools, drilling machine • Magnetic compass • Marking pen and nail • Thread • Measuring tape • Ruler

PROCEDURE

TASK 1: Marking base of pillar mount on roof top

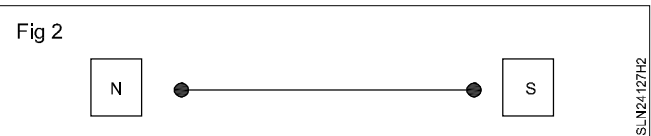
- 1 Follow carefully the steps for making foundation on rooftop.
- 2 Wear necessary PPE kits.
- 3 Collect all elements of Pillar mount on the roof top.
- 4 Collect all tools on the rooftop.
- 5 Use compass and mark true north and south poles.

Marking magnetic poles (Fig 1)



- 6 Draw line connecting north and south poles points.

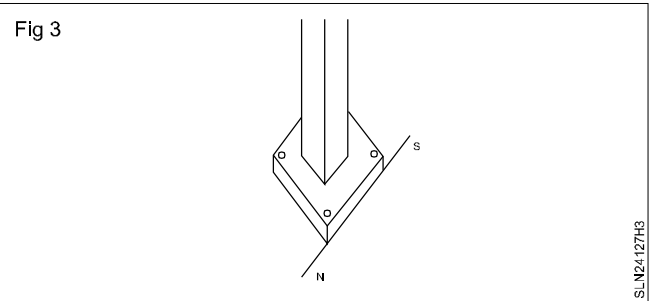
Connecting N - S marked points (Fig 2)



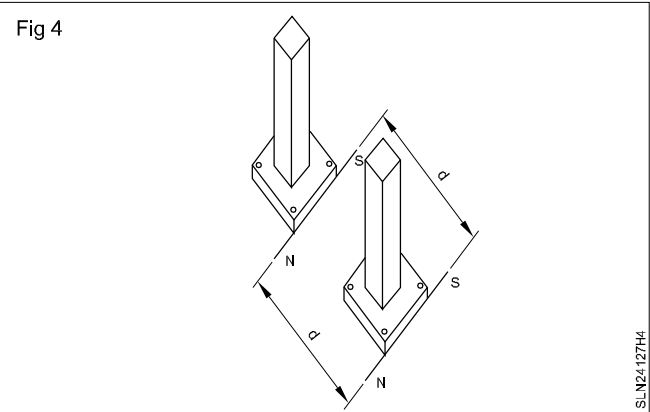
- 7 Place the pillar mount aligned to the connecting lines.
- 8 Mark the holes of base on ceiling.
- 9 Draw a parallel line in the direction of N - S, at a distance as per the drawing.

- 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)



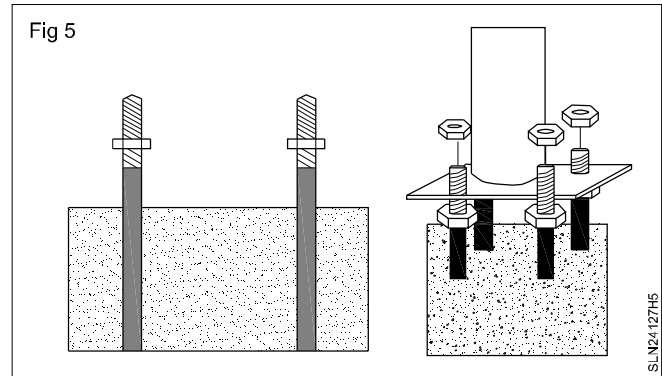
Marking second pillar parallel to first (Fig 4)



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)



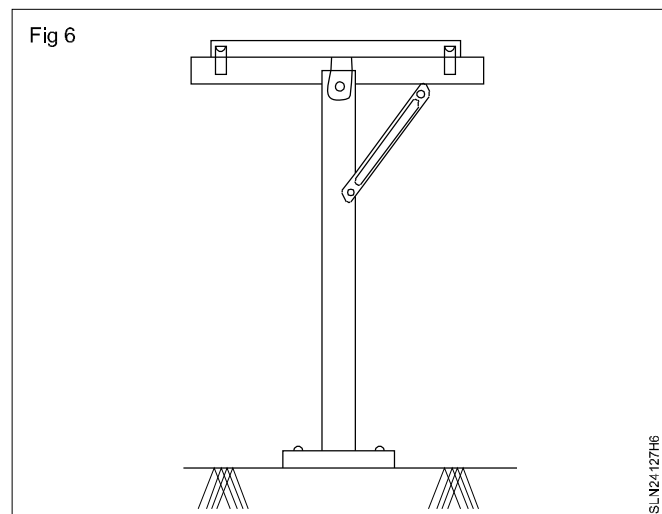
TASK 3: Fixing the pillars on rooftop

- 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.



Solar Technician (Electrical) - Installation Solar PV Plant and Hybrid Plant**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	• Mounting screws, bolts and nuts, washers, anchor bolts
• Pillar mounts Qty	- 2 Nos	• Tools, drilling machine
• Connecting frames Qty	- 2 Nos	• Magnetic compass
• Swinging rod Qty	- 2 Nos	• Marking pen and nail
• Angle adjusting rod Qty	- 2 Nos	• Thread
• Panel fitting arms Qty	- 8 Nos	• Measuring tape
• Solar panels 4 x 250 W		• Ruler

PROCEDURE**Mount solar panels on the mounting structure**

- 1 Wear the PPE necessary.
- 2 Use the finished structure for pillar mount on rooftop of 2.4.127.
- 3 Assemble the panels over the frames with the panels facing south at desired angles.
- 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.

Installation of Solar panels

Here we have mechanical fitting nature of works such as lifting, shifting, storing, mounting, setting gaps between panels and adjusting angle of tilt.

While mounting of Solar PV panels, the solar technicians have to:

- 1 Mount the connecting arms over the pillar mounts.
- 2 Fit the angle adjusting rod between the arms and pillar mount.
- 3 Mount the solar PV panels on the arms.
- 4 Set the angle of inclination (Tilt angle) for the solar array towards south for given location.
- 5 Adjust the angle for different locations.
- 6 Set manually the Tilt angle for different seasons.

Steps involved in mounting Solar PV panels over Pillar structure are:

- 1 Assemble the complete structure of pillar mount (rooftop/Ground mount).
- 2 Mount the solar panels (example 4 X 250WP panels for 1 kW plant).
- 3 Face the solar panels towards south.
- 4 Adjust the inclination towards proper facing.

Procedure for mounting connecting arms over Pillar mounts:

- 1 Mount the swinging arm on the pillar mount by keeping the hole for angle adjustment rod/lever towards south.
- 2 Mount the angle adjustment rod/lever connecting the pillar and swinging arm.
- 3 Repeat the steps for second or more pillar mounts.
- 4 Mount the long connecting arm over the swinging arms.
- 5 Adjust the levers and fit evenly.

Procedure for mounting the Solar PV panels:

- 1 Place the panels on the connecting arms matching the holes if available.
- 2 If not mark the holes over the arms; repeat for remaining panels and mark leaving air gap of minimum 10 mm between the panels.
- 3 In marked case drill holes on the arms.
- 4 Place the panels and fit with bolt and nuts.

Solar Technician Mounting Solar panel. (Fig 1)

Fig 1



Solar panels 4 x 250 W mounted on mounting structures. (Fig 2)

Fig 2



Solar technicians handling panel for next set of mounting. (Fig 3)

Fig 3



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
- crimp 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

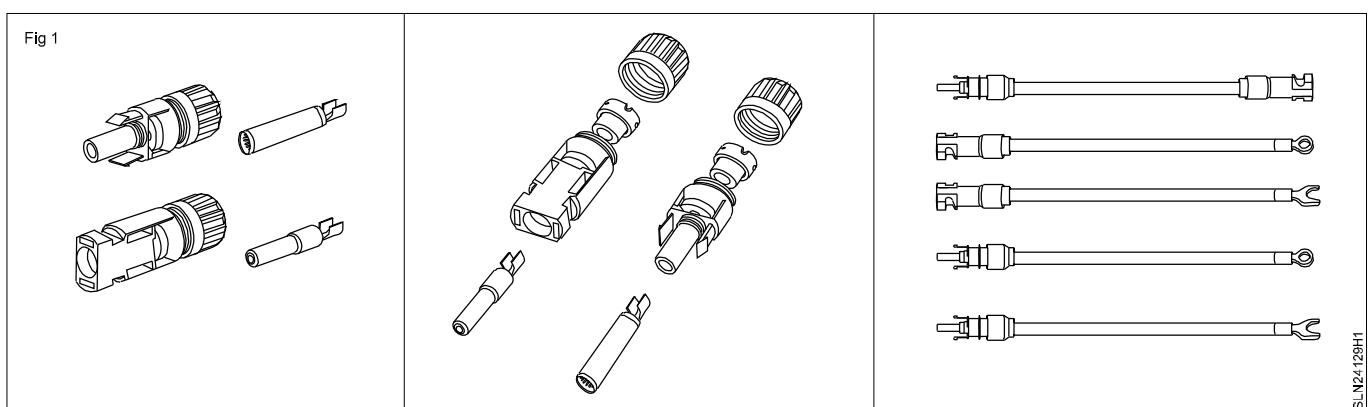
Tools and Instruments/equipment

- | | |
|----------------------|------------|
| • 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)

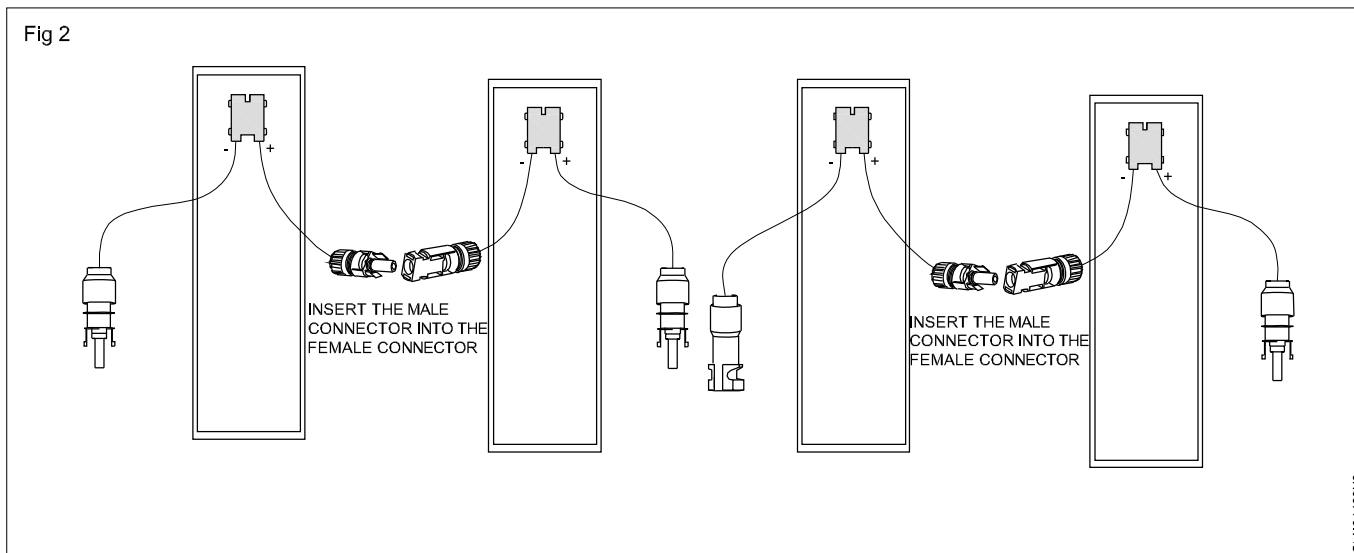


PROCEDURE

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 output terminals of series combination of these 4 x 250W solar panels.

Serial wiring (Fig 2)

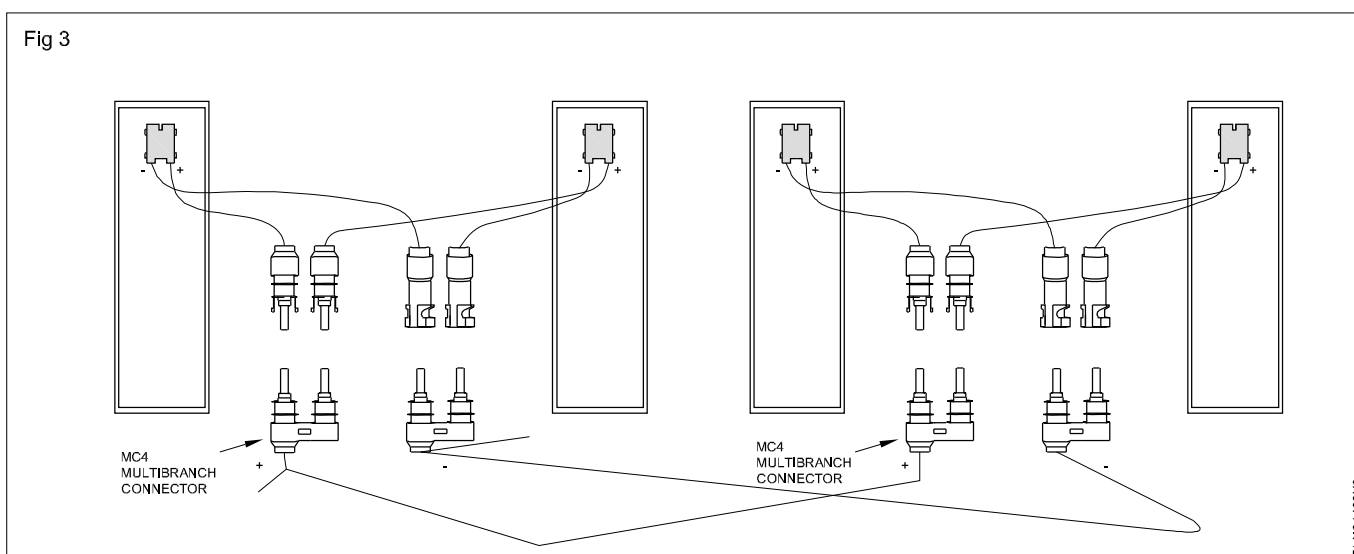


TASK 2: Carry out wiring on mounted solar panels for parallel wiring by using MC4

- 1 Refer the Fig 3.
- 2 Use MC4 multi 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.



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

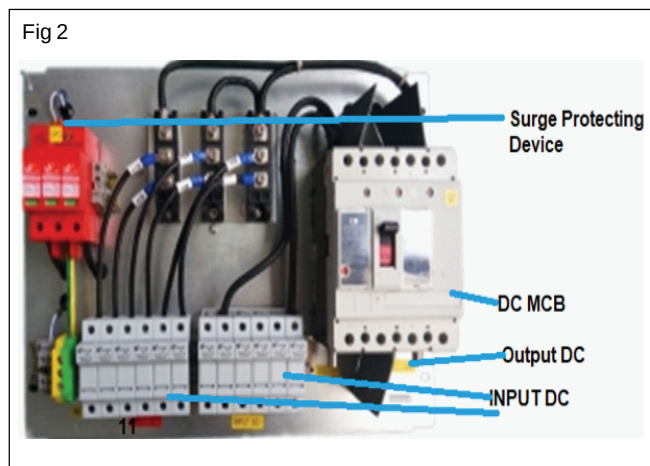
- Pillar mount with solar panels 4 X 250W solar panels mounted on it
- Array junction box or combiner box
- Pre-installed with surge protector, DC MCB, connectors, link and fuses
- Wires and tool

PROCEDURE

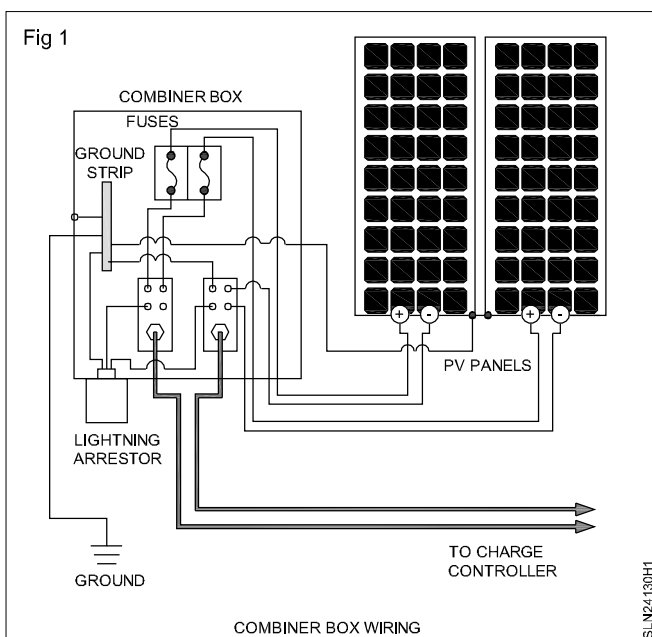
TASK 1: Wire the Array Junction Box for series wiring

- 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.
- Extend positive wires from solar panels to DC (positive) input connectors of AJB.
- Extend negative wires from solar panels to DC (negative) input connectors of AJB.
- Link inside the DC input connectors (positive and negative) of AJB provides parallel connection.
- Remove the link.
- Provide loops of wires on to the connector for serial wiring.
- Internally the connectors outputs are taken to Surge Protecting Device (SPD), DC MCB and DC fuses (Factory built).
- Take out Combined DC output from AJB and extend till solar DC IN of PCU.
- Earth wire (Green) is connected to chassis or box cover.

Parts of AJB (Fig 2)



AJB wiring (Fig 1)



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. | 5 | Check for link available in position; if not provide link there. Check for parallel connection and confirm. |
| 2 | Extend positive wires from solar panels to DC (positive) input connectors of AJB. | 6 | Internally the connectors outputs are taken to Surge Protecting Device (SPD), DC MCB and DC fuses (Factory built). |
| 3 | Extend negative wires from solar panels to DC (negative) input connectors of AJB. | 7 | Take out Combined DC output from AJB and extend till solar DC IN of PCU. |
| 4 | Link inside the DC input connectors(positive and negative) of AJB provides parallel connection. | 8 | Earth wire (Green) is connected to chassis or box cover. |
| | | After completion of AJB wiring record your experience in Observation column | |

Observations

[illegible]

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.

Solar Technicians measuring angle of inclination (Fig 1)

Fig 1



PROCEDURE

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:

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°

Procedure for Set/Adjust the Tilt angles

- 1 Loosen the bolt and nuts on connecting lever on either side.
- 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.

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

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)

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**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.

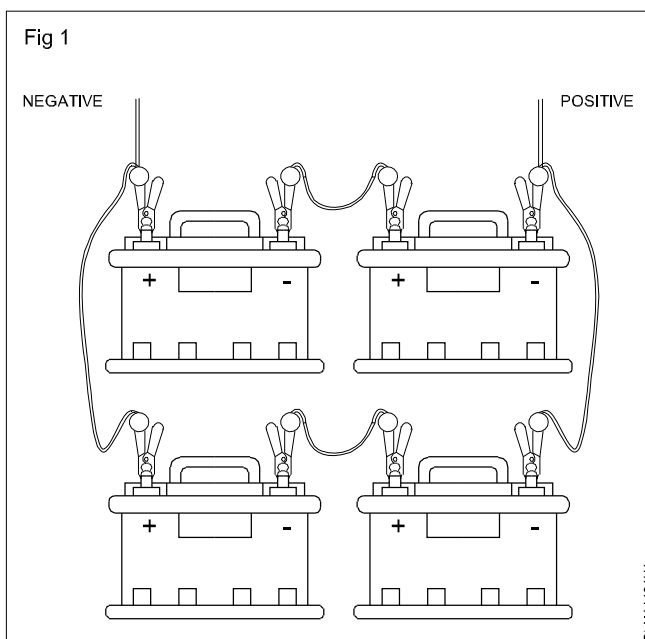
Requirements**Tools and Instruments/equipment**

- 4 x 12 V, 100 AHr Solar Batteries
- Connecting DC cables –red and black
- Connecting lugs
- Insulators or insulating tape

PROCEDURE**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)



Solar Technician (Electrical) - Installation Solar PV Plant and Hybrid Plant**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**

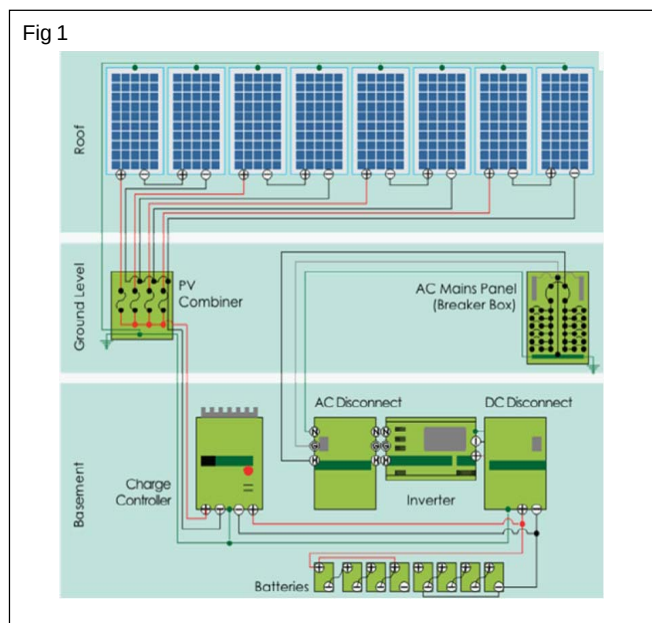
- Finished solar panel mount
- Finished battery bank
- Finished AJB wiring
- PCU

PROCEDURE**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.

- 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.

Sample off grid SPV system wiring diagram. (Fig 1)

**Observations**

Sl.No	List the observation

Solar Technician (Electrical) - Installation Solar PV Plant and Hybrid Plant**Carry out working 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**Plan distribution of AC loads**

- 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**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.

— — — — —

Solar Technician (Electrical) - Installation Solar PV Plant and Hybrid Plant**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**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—General**PPE: hard hat, gloves, and eye protection**

- 1 Verify that all combiner fuses are removed and that no voltage is present at the output of the combiner box.
- 2 Visually inspect any plug and receptacle connectors between the modules and panels to ensure they are fully engaged.
- 3 Check that strain reliefs/cable clamps are properly

installed on all cables and cords by pulling on cables to verify.

- 4 Check to make sure all panels are attached properly to their mounting brackets and nothing catches the eye as being abnormal or misaligned.
- 5 Visually inspect the array for cracked modules.
- 6 Check to see that all wiring is neat and well supported.

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.
- 3 Connect the home run wires to the DC string combiner box terminals in the proper order and make sure labeling is clearly visible.

Repetitive Source Circuit String Wiring

PPE: hard hat, gloves, and eye protection

The following procedure must be followed for each source circuit string in a systematic approach—i.e. east to west or north to south. Ideal testing conditions are midday on cloudless days March through October.

- 4 Check open-circuit voltage of each of the panels in the string being wired to verify that it provides the manufacturer's specified voltage in full sun. (Panels under the same sunlight conditions should have similar voltages--beware of a 20 Volt or more shift under the same sunlight conditions.)
- 5 Verify that the both the positive and negative string connectors are identified properly with permanent wire marking.
- 6 Repeat this sequence for all source circuit strings.

Continuation of PV Array Circuit Wiring

PPE: hard hat, gloves, and eye protection

- 7 Recheck that DC Disconnect switch is open and tag is still intact.
- 8 VERIFY POLARITY OF EACH SOURCE CIRCUIT STRING in the DC String Combiner Box (place common lead on the negative grounding block and the positive on each string connection-- pay particular attention to make sure there is NEVER a negative measurement). Verify open-circuit voltage is within proper range according to manufacturer's installation manual and number each string and note string position on as-built drawing. (Voltages should match closely if sunlight is consistent.)

Warning: If polarity of one source circuit string is reversed. This can start a fire in the fuse block resulting in the destruction of the combiner box and possibly adjacent equipment. Reverse polarity on an inverter can also cause damage that is not covered under the equipment warranty.

- 9 Retighten all terminals in the DC String Combiner Box.

Wiring Tests—Remainder of System:

PPE: hard hat, gloves, and eye protection

- 10 Verify that the only place where the AC neutral is grounded is at the main service panel.
- 11 Check the AC line voltage at main AC disconnect is within proper limits (115-125 Volts AC for 120 Volts and 230-250 for 240 Volts).
- 12 If installation contains additional AC disconnect switches repeat the step 11 voltage check on each switch working from the main service entrance to the inverter AC disconnect switch closing each switch after the test is made except for the final switch before the inverter (it is possible that the system only has a single AC switch).

— — — — —

Solar Technician (Electrical) - Installation Solar PV Plant and Hybrid Plant**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**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

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

— — — — —

Solar Technician (Electrical) - Installation Solar PV Plant and Hybrid Plant**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**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

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.
 - Tripping of circuit and breakers.
 - Protection circuits operation.
- 2 Check for,
 - Over load indication (Connect little excess load and observe) - Overload testing.
 - Short circuit indication (Use ELCB).
 - 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

[illegible]

Inverter Startup Tests PPE: hard hat, gloves, and eye protection

- 1 Be sure that the inverter is off before proceeding with this section.
- 2 Test the continuity of all DC fuses to be installed in the DC string combiner box, install all string fuses, and close fused switches in combiner box.
- 3 Check open circuit voltage at DC disconnect switch to ensure it is within proper limits according to the manufacturer's installation manual.
- 4 If installation contains additional DC disconnect switches repeat the step 4 voltage check on each switch working from the PV array to the inverter DC disconnect switch closing each switch after the test is made except for the final switch before the inverter (it is possible that the system only has a single DC switch).
- 5 At this point consult the inverter manual and follow proper startup procedure (all power to the inverter should be off at this time).
- 6 Confirm that the inverter is operating and record the DC operating voltage in the following space _____.
- 7 Confirm that the operating voltage is within proper limits according to the manufacturer's installation manual.
- 8 After recording the operating voltage at the inverter close any open boxes related to the inverter system.
- 9 Confirm that the inverter is producing the expected power output on the supplied meter.
- 10 Provide the homeowner with the initial startup test report.

System Acceptance Test PPE: hard hat and eye protection

Ideal testing conditions are midday on cloudless days March through October. However, this test procedure accounts for less than ideal conditions and allows acceptance tests to be conducted on sunny winter days.

- 1 Check to make sure that the PV array is in full sun with no shading whatsoever. If it is impossible to find a time during the day when the whole array is in full sun, only that portion that is in full sun will be able to be accepted.
- 2 If the system is not operating, turn the system on and allow it to run for 15 minutes before taking any performance measurements.
- 3 Obtain solar irradiance measurement by one of two methods and record irradiance on this line: W/m^2 . To obtain percentage of peak sun, divide irradiance by $1000 W/m^2$ and record the value on this line. (example: $692 W/m^2 \div 1000 W/m^2 = 0.692$ or 69.2%).

Method 1: Take measurement from calibrated solar meter or pyranometer.

Method 2: Place a single, properly operating PV module, of the same model found in the array, in full sun in the exact same orientation as the array being tested. After 15 minutes of full exposure, test the short circuit current with a digital multimeter and place that reading on this line: Amps. Divide this number into the short circuit current (I_{sc}) value printed on the back of the PV module and multiply this number by $1000 W/m^2$ and record the value on the line above. (example: $I_{sc}\text{-measured} = 3.6 \text{ Amps}$; $I_{sc}\text{-printed on module} = 5.2 \text{ Amps}$; $Irradiance = 3.6 \text{ Amps} / 5.2 \text{ Amps} \times 1000 W/m^2 = 692 W/m^2$).

4 Sum the total of the module ratings and place that total on this line Watts STC. Multiply this number by 0.7 to obtain expected peak AC output and record on this line Watts AC-estimated.

5 Record AC Watt output from the inverter or system meter and record on this line Watts AC-measured.

6 Divide Watts AC-measured by percent peak irradiance and record on this line Watts AC-corrected. This "AC-corrected" value is the rated output of PV system. This number must be within 90% or higher of Watts AC-estimated recorded in step 4. If it is less than 90%, the PV system is either shaded, dirty, false wired, fuses are blown, or the modules or inverter are not operating properly.

Example

A PV system is made up of 20, 100 Watt STC PV modules operating at an estimated irradiance of $692 W/m^2$ using method 2 shown above. The power output is measured to be 1000 Watts AC-measured at the time of the test.

Is this system operating properly or not?

Solution:

Sum of module ratings = $100 \text{ Watts STC per module} \times 20 \text{ modules}$
= 2,000 Watts STC.

Estimated AC power output = $2,000 \text{ Watts STC} \times 0.7$
= 1,400 Watts AC-estimated.

Measured AC output = 1,000 Watts AC-measured.

Corrected AC output = $1,020 \text{ Watts AC-corrected} \div 0.692$
= 1,474 Watts AC-corrected.

Comparison of corrected and estimated outputs: $1,474 \text{ Watts AC-corrected} \div 1,400 \text{ Watts}$

AC-estimated = $1.05 \div 0.9$ (acceptable performance).

Solar Technician (Electrical) - Installation Solar PV Plant and Hybrid Plant**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**Generate a First Inspection report of a SPV plant while handing over the plat**

- | | |
|---|--|
| <ol style="list-style-type: none"> 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. | <ol style="list-style-type: none"> 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

— — — — —

Solar Technician (Electrical) - Installation Solar PV Plant and Hybrid Plant**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**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

Explain System Maintenance to the Customer

- [illegible]

Work done

[illegible]

Solar Technician (Electrical) - Installation Solar PV Plant and Hybrid Plant**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.
 - Visual and audio alarms.
 - Tripping of circuit and breakers.
- 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).
- 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

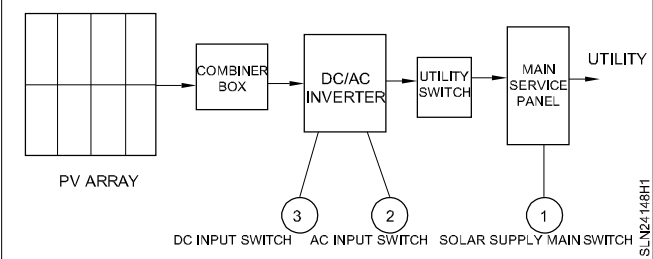
Demonstrate Start-up and Shutdown Procedures

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

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.

Ballast - concrete blocks - ready for foundation. (Fig 1)

Fig 1



Footings for Module Mount structures

The solar array of a PV system can be mounted on rooftops, generally with a few inches gap and parallel to the surface of the roof. If the rooftop is horizontal, the array is mounted with each panel aligned at an angle. If the panels are planned to be mounted before the construction of the roof, the roof can be designed accordingly by installing support brackets for the panels before the materials for the roof are installed. The installation of the solar panels can be undertaken by the crew responsible for installing the roof. If the roof is already constructed, it is relatively easy to retrofit panels directly on top of existing roofing structures.

The most preferred method is to construct a pedestal like footing to avoid any roof penetration. Type of footing required is entirely depends on the type of roof. In India generally two type of roof structure are common: Flat roof and Slope roof.

Installing PV panels onto roofs introduces hazards that can affect the structural integrity of the roof. Not only does the roof support the dead load of the PV system itself, but also external forces introduce structural loading. Outside installations expose the PV system and roof assembly to hazardous elements such as wind, hail, snow, debris, and extreme temperatures. The mounting structure should be such that the external environment factors do not reduce the life of the structure to less than 25 years.

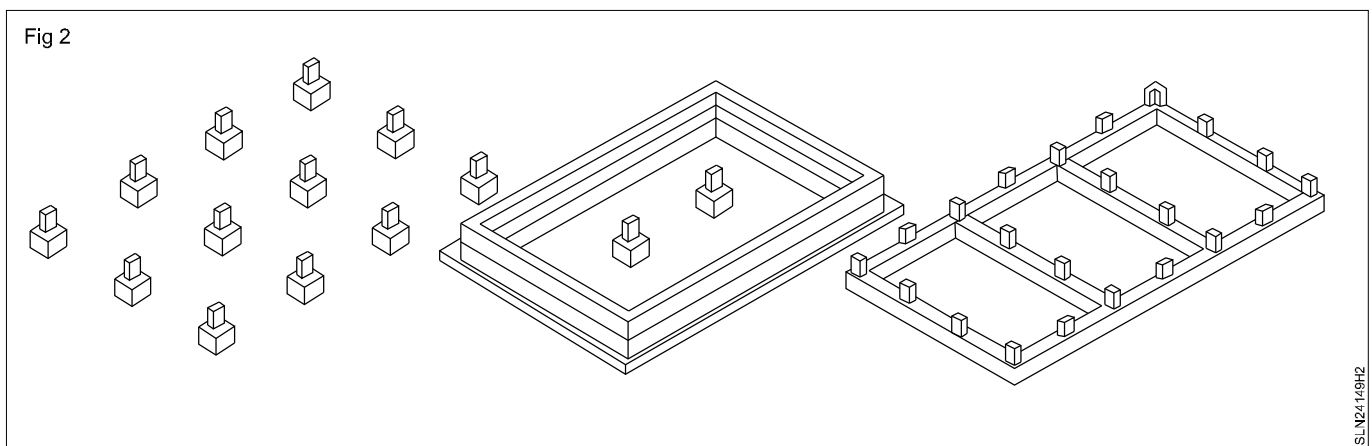
Types of Footing can be Spot footing, Continuous spread footing or Grade beam footing.

- 1 Spot footing is used to support a single point of contact, such as under a pier or post. Typically, spot footing is of 2' by 2' square pad, 10" to 12" thick, and made with reinforced concrete rated to 3,000 to 5,000 pounds per square inch (psi) in compression.
- 2 Continuous spread footing is commonly used to provide a stable base around the perimeter of a structure or between the front leg and the back leg of the structure. The footing thickness provides the strength needed to support the weight. The wider width of the footing base creates a large area to transfer this weight. The dimensions of a continuous spread footing vary

according to the load placed on the footing, soil conditions, and the wind sustainability analysis. Typically, spread footings are frequently 16"•to 24" wide, 6"•to 16"•• thick, and made with reinforced concrete rated to 2,000 to 5,000 psi in compression.

- 3 Grade beam footing is a continuous reinforced-concrete member used to support loads with minimal bending. Typically, a continuous grade beam is frequently constructed by digging a trench at least 8"• wide to the depth or creating the same height of footing above the roof, needed to span the distance between supports. Grade beam footings differ from continuous spread footings in how they distribute loads. The depth of a grade beam footing is designed to distribute loads to bearing points.

Footings (Fig 2)



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

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.

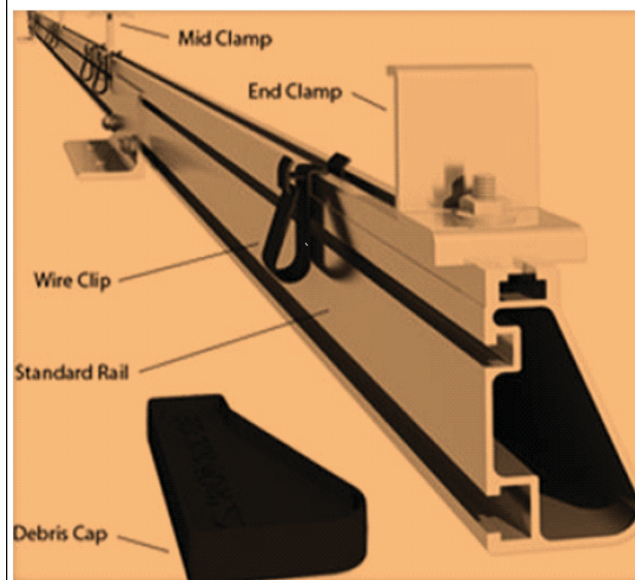
The metal structure to support the modules consists of three main components:

- 1 Roof mounts
- 2 Mounting rails
- 3 Module fixings

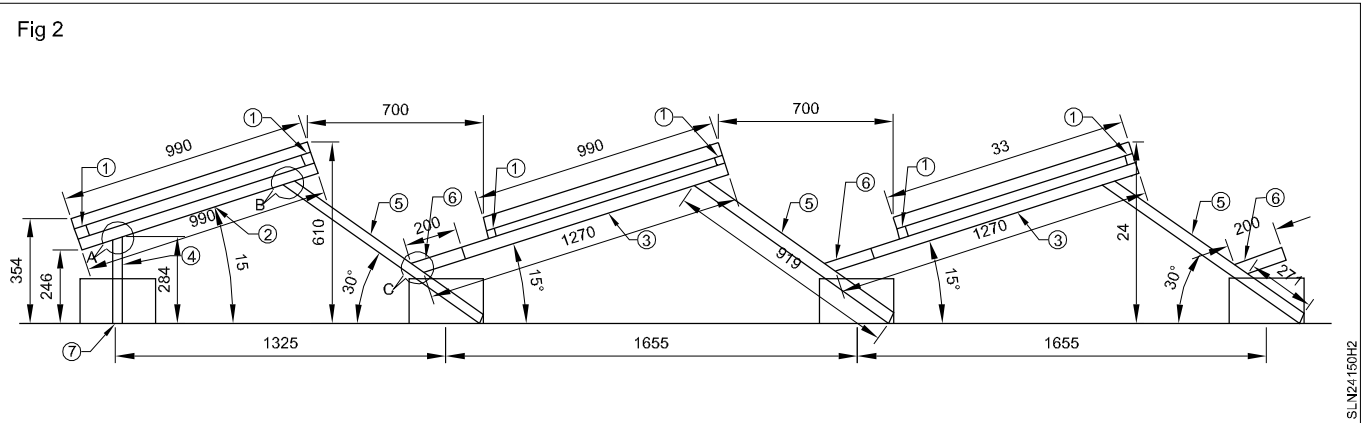
Using the roof mounts, a rail system is anchored to the roof structure beneath the roof covering or is fixed directly to the roof cover itself (but only if the roof covering is structurally strong enough). The modules are fixed to the

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)



- 1 Purlin
- 2 Rafter-1 (based on length)
- 3 Rafter-2 (based on length)
- 4 Front Leg
- 5 Back Angle
- 6 Angle
- 7 Base Plate & Jointing Plate
- 8 Bolts

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**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

Prepare civil foundation for the pillar mount

- 1 Use compass and mark true north and south poles.

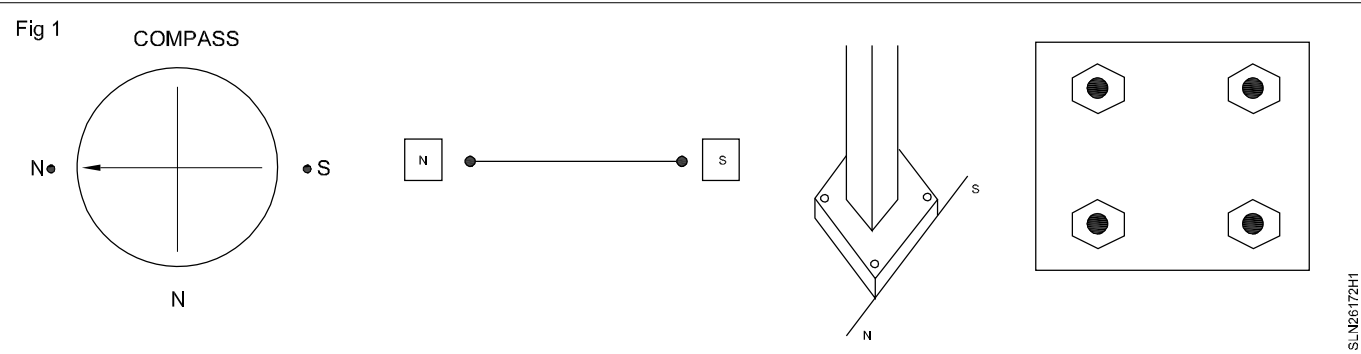
2 Draw line connecting north and south poles points.

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)



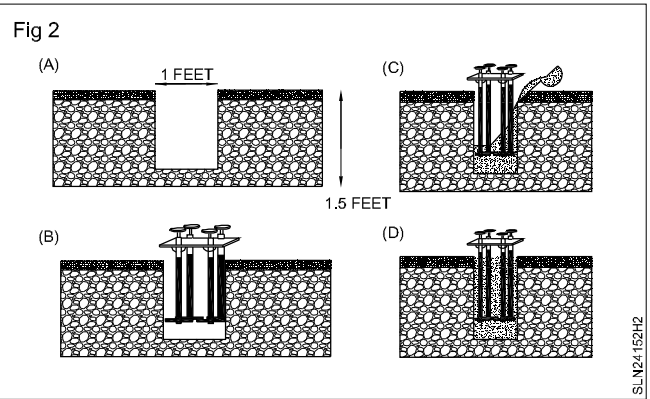
- 8 Fix the bar bended TMT rods with thread on top end on to the stencil.

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)



Solar Technician (Electrical) - Installation Solar PV Plant and Hybrid Plant

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

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

Sl.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

Prepare a complete project report on wind power plant

- 1 Visit the wind power plant.
- 2 Observe the site suitability 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

— — — — —

Solar Technician (Electrical) - Installation Solar PV Plant and Hybrid Plant**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**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

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

— — — — —

Solar Technician (Electrical) - Installation Solar PV Plant and Hybrid Plant**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**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

- 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

— — — — —

Solar Technician (Electrical) - Operation & Maintenance of PV System**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. | • Tools and equipment |
| 2 Select work places different for each team. | • Traffic (Men/material) |
| 3 Visit the spot on different days and time. | • Personal protection |
| 4 Collect details of occurrences all over which may lead to injuries, failures, health issue or accidents or any other kind (Specify). | • Fellow workers/onsite people protection |
| 5 Classify the events based on men, machine and material. | • Work permit |
| 6 Evaluate the happenings based on: | • Lifting or handling |
| • Risk | • Health |
| • Waste | • Safety |
| • Fire and emergency | 7 Highlight chances of failures to men or material or anything else (specify). |
| • Electrical | 8 Suggest precautionary measures. |
| • Work at height and fall | 9 Suggest actions for remedies in case of failure. |
| | 10 Suggest educative aids to improve safety. |
| | 11 Prepare a SOP in general. |

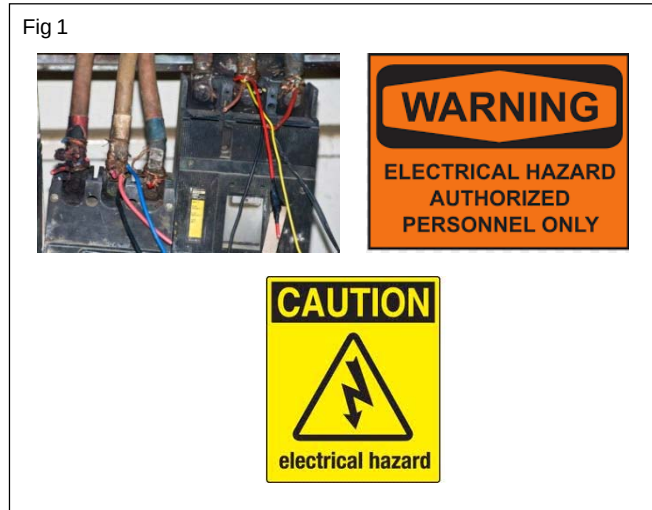
TASK 2: Preparation of safe work area: Arrange materials and tools for safe working

- | | |
|--|--|
| 1 Study the list of materials, tools and equipment. | 5 Educate the team members about everything in the list. |
| 2 Compare with site requirement and add/delete any item required/not required. | 6 Demonstrate once usage of PPE kits and explain what happens when not used. |
| 3 Recall the usage of the tools and equipment. | 7 Prepare short guidelines after these exercises for safe working in the site as a reminder. |
| 4 Learn and practice about unknown or forgotten means. | |

TASK 3: Safety precautions: Adapt safety measures in work area

- 1 Report unsafe practices, conditions of equipment and tools to your Supervisor/team leader.
- 2 Report Supervisor/team leader right away if safety hazards cannot be removed or resolved immediately.

Safety precaution (Fig 1)



- 3 Remind co-Technicians always when you see them working unsafely or not wearing proper safety equipment.
- 4 Use proper tools for the job and use them correctly.
- 5 Do not select wrong tool for a given work.
- 6 Wear proper personal protective equipment as per directions of the Supervisor/team leader.
- 7 Display Material Safety Data Sheets at work area.
- 8 Take precautions to prevent the outbreak of fire at the project.
- 9 Be familiar with the location of suitable fire protection equipment.
- 10 Know and make all others know the hazard symbols.
- 11 Know the location of the nearest fire extinguisher and know how to use it even if you don't find any chance of fire (Remember once used you can't use it again).

TASK 4: 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.
- 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.

Safety Policy Format (Fig 2)

Fig 2

(Company Name)

Safety Policy

I. OBJECTIVE

The Safety Policy of Company Name is designed to comply with the Standards of the Occupational Safety and Health Administration, and to endeavor to maintain a safe and injury/illness free workplace. A copy of the OSHA Safety and Health Standards 1926 and 1910 are available for all employees= use and reference. These Standards shall be available in the home office at all times and will be sent to the jobsite on request.

Compliance with the following Safety Policy and all items contained therein is mandatory for all employees of the company. The authorization and responsibility for enforcement has been given primarily to the Responsible Person. The Other Responsible Person(s) share in this responsibility as well.

II. POLICY

It is company policy that accident prevention be a prime concern of all employees. This includes the safety and well being of our employees, subcontractors, and customers, as well as the prevention of wasteful, inefficient operations, and damage to property and equipment.

III. APPLICABILITY

This Safety Policy applies to all employees of Company Name, regardless of position within the company. The Safety Rules contained herein apply to all subcontractors and anyone who is on a company project site.

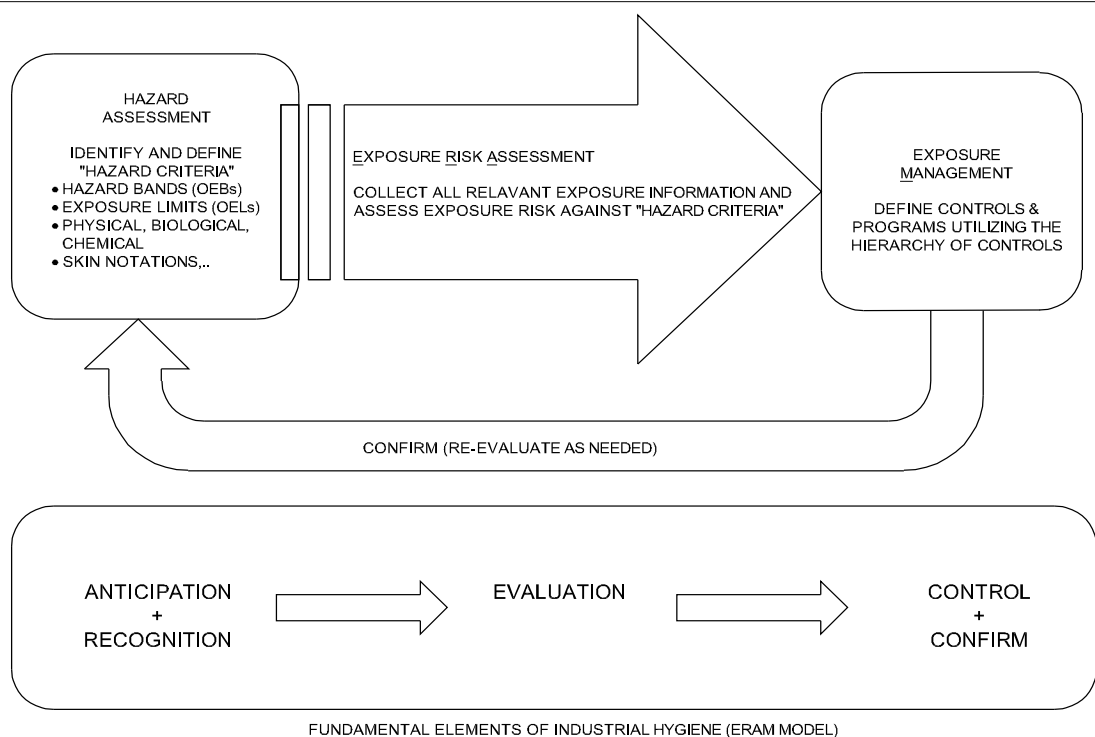
Every employee is expected to comply with the Safety Policy, as well as OSHA Health and Safety Standards.

IV. IMPLEMENTATION

This Safety Policy supports six fundamental means of maximum employee involvement:

- A. Management commitment to safety.
- B. Weekly tool box safety meetings at all jobsites.
- C. Effective job safety training for all categories of employees.
- D. Job hazard analysis provided to all employees.

Fig 3



SLN25159H3

TASK 5: Assist to make arrangement for recovery from accidents using first aid materials: Practice first –aid and arrange for recovery from accident

- 1 Affix Electric shock posters at all workplace and electrical power source.
 - 2 Provide first aid information.
 - 3 First aid procedures and instructions displayed near first aid box location.
 - 4 Support to assess the risk of workplace injury and illness.
 - 5 Report all accidents, no matter how slight, immediately to a Supervisor.
 - 6 Maintain First Aid Kit that it should be frequently inspected to ensure that they are full, in usable condition and that the contents have not expired.
 - 7 Assist in stabilizing an injured or ill person until professional medical help arrives.
 - 8 Demonstrate like drama the first aid activities in group.
- First Aid after fall due to shock. (Fig 4)
- 9 In case of Electrical shock, switch off all sources of power.

Fig 4



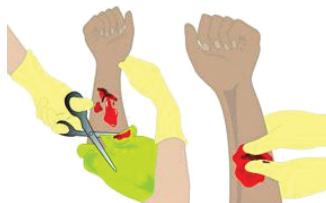
- 10 In case of danger due to electric shock, call for help and emergency help by using mobile phone.
 - 11 Check appropriate first aid equipment is available in the workplace.
 - 12 Ensuring first aid equipment in the workplace is appropriate for the identified hazards and associated risks.
 - 13 Assess the scene and the victims.
 - 14 Respond to life-threatening emergencies (establishing responsiveness, shock, controlling bleeding with direct pressure, asphyxiation, poisoning and medical emergencies).
 - 15 Respond to non-life threatening emergencies (wounds, burns, temperature extremes, eye injuries, musculoskeletal injuries, mouth/teeth injuries and bites/stings).
 - 16 In case of burns- Cool burns for a minimum of 10 minutes under cold water.
- Chart for First Aid for external bleeding.

First Aid for External Bleeding

- 1 Put your safety first and ensure that you are not in danger.
- 2 If available, wear protective examination gloves.
- 3 If you don't have glove, you should avoid direct contact with casualty's blood and use an improvised barrier.
- 4 Create a barrier between yourself and the potential source of infection. This can be done by using gloves, or anything that may be available. eg. plastic bags.



- 1 Reassure the casualty.
- 2 Assess the wound and source of the loss of blood.
- 3 If necessary remove clothing from the casualty to confirm the source of blood loss.
- 4 Check for foreign objects in the wound. eg. glass. If present it must stay in place and not be removed (see Dressing section).



- 1 Do not waste precious seconds by attempting to open and apply dressings at this stage.
- 2 With your gloved hand apply external direct pressure to the wound.
- 3 If a foreign object is present, you will have to apply pressure around the object.
- 4 If appropriate, allow the casualty to apply external direct pressure with their free hands.
- 5 If you have not done so already, ensure your casualty is sitting lying down.



First Aid for External Bleeding

- 1 Whenever possible, the injured body part should be raised, if there are no embedded objects.
- 2 Ideally, elevation particularly with regard to limbs should be above the heart.
- 3 If dealing with legs, the casualty should lie down with both legs elevated.
- 4 The elevated limb may require support.



- 1 Select a suitable sterile dressing from your first aid box.
- 2 If the dressing is applied to a limb, check the circulation to the hand or foot to ensure the dressing has not been tied too tightly.
- 3 Apply a dressing directly to the wound and bandage it firmly in place.
- 4 Whilst keeping the injury elevated watch for any signs of blood seeping through the dressing.
- 5 If blood seeps through the dressing apply a 2nd dressing on top of the first dressing.
- 6 If there is a foreign object in the wound leave it in place. Call 999 for major bleeds.

NB - Do not use a tourniquet to prevent blood loss.



- 1 Intact skin is a good barrier infection, however the first aider should make sure all cuts or open areas are covered.
- 2 If you have accidentally come into contact with blood wash the area with soap and water, seek medical advice.
- 3 If blood has splashed in your eyes or in an open wound/ needlestick injury/ punctured skin rinse thoroughly with water or eyewash, seek medical advice.
- 4 Should you have any concerns discuss these with your Doctor or Occupational Health Department.



TASK 6: Make arrangements of personal safety equipment at work area: Establish PPE availability

- 1 Identify and keep ready all safety equipment at work area as per list.
- 2 Issue personal protective equipment to workers engaged at work place.
- 3 Affix the flow chart of safety equipment and procedure to wear the same.
- 4 Insist to wear safety equipment as per instruction charts.

Practice: List and identify PPE

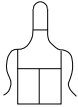
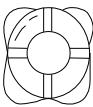
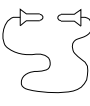
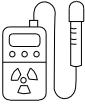
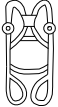
Sl. No.	PPE figure and symbol	Identify and Label the PPE available in the Lab	Uses
			
			
			
			

Sl. No.	PPE figure and symbol	Identify and Label the PPE available in the Lab	Uses
			
			
			
			
			
			
			

5 Explain the Safety Instruction and Poster.

Poster	Explanation
	
	
	
	

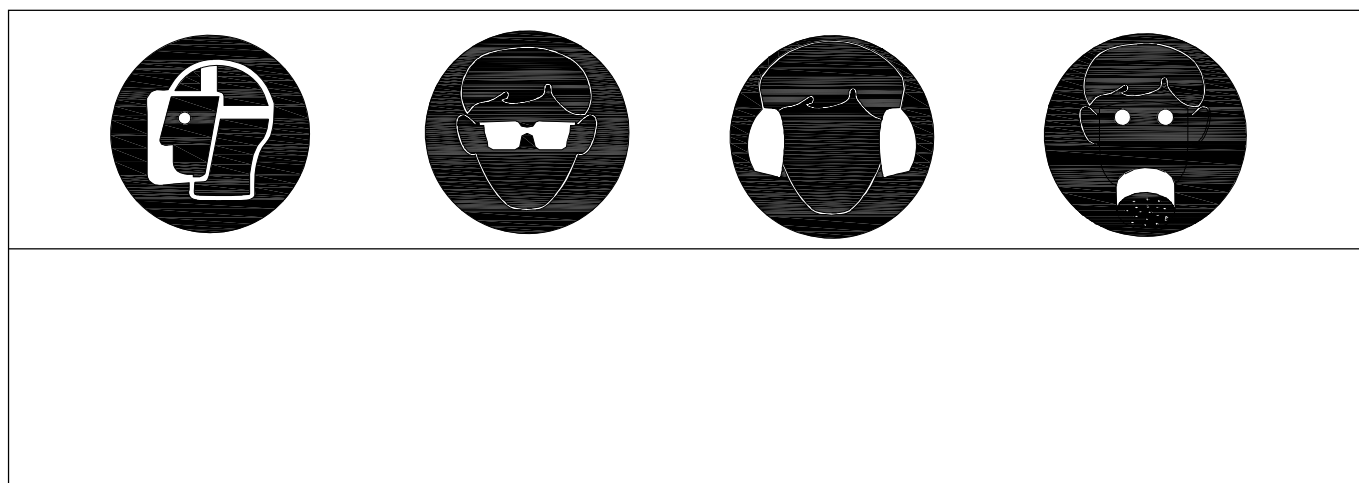
6 Name the following PPE Symbols.

 PROTECTIIONAL MASK	 FIRST-AID KIT	 SCRUBS	 HAND PROTECTION	 PROTECTIVE HEADPHONES
 DISPOSABLE RESPIRATOR	 RESPIRATOR	 APRON	 SURVIVAL RING BUOY	 FIRE BOOTS
 ESCAPE HOOD	 TRAFFIC SAFETY	 ELECTRICAL GLOVES	 SAFETY VEST	 GAS MASK
 BUMP CAP	 REFLECTIVE VEST	 FACE SHIELD	 EAR PLUGS	 RADIATION DETECTOR
 FALL PROTECTION	 NUISANCE MASK	 FIRE EXTINGUISHER	 RUBBER BOOTS	 EYE PROTECTION

- 7 Identify the following sign boards bearing ISO symbols for “Wear Face Shield,” “Wear Eye Protection,” “Wear Ear Protection,” and “Wear Respiratory Protection” (The

ISO 3864-3 Design principles for graphical symbols for use in safety signs using the standardized universal head)

8 Sign Boards.



Activities done

Sl.No	

— — — — —

TASK 7: Identify and visual inspect the wear and tear of safety equipment: Check the condition of safety equipment

- 1 Identify the defects in protective safety equipments as per check list.
- 2 Examine visually all personal protective equipments (PPE) before issuing to workers.
- 3 If any defective or bad condition of PPE, immediately bring the notice to the site supervisor.
- 4 Separate the defective and replace the safety equipments with good or new one.

Check list:

Sl.No.	PPE Requirement	Yes	No	Remarks
1	Are supervisors enforcing the use of required PPE?			
2	Is PPE inspected regularly and properly maintained?			
3	Is worn and damaged PPE removed from service and replaced?			
4	When the following type of PPE is necessary, is the employer providing and paying for the PPE as stated by the OSHA standard 1910.132?			

Inspecting safety harness (Fig 6)

Fig 6



TASK 8: Interpret the expiry dates of personal protection equipment (PPE): Check usable condition of PPE

- 1 Identify the manufacture details of protective safety equipments as per label on it.
- 2 Examine visually expiry date of all personal protective equipments (PPE).
- 3 Not to issue expired PPE to workers on site and immediately bring to notice of the site supervisor.
- 4 Separate the expired and obsolete safety equipments from good equipments.

PPE Inspection Database Format

Sl. No.	Type of PPE	Facilities where it is used	Manufacture Details	Model Number	Expiry date	Date of last inspection	Date of Next inspection
1	Helmet						
2	Respirator						
3	Gloves						
4	Boots						
5	Safety clothes						
6	Spectacles/ goggles, shields, visors.						
7	Ear muffs and plugs						
8							
9							
10							

TASK 9: Identify and report of electrical hazards at workplace

- | | |
|--|--|
| 1 Clean work area and identify hazards. | 5 Identify earth/ground hazard before using power tools. |
| 2 Assist in preparation of hazard report. | 6 In case of Electrical shock, switch off power. |
| 3 Affix Electric shock posters at every electrical power source. | 7 In case of danger due to electric shock, call for help and emergency help by using mobile phone. |
| 4 Support to assess the risk of workplace injury and illness. | 8 Assist appropriate first aid for electrical shock. |

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TASK 10: Identify, Inspect and prepare report of personal safety hazards: Evaluate safety hazards

- | | |
|--|---|
| 1 Clean work area and identify risk sources. | 5 Assist in Survey job sites for hazards before work begins and create a work plan. |
| 2 Assist to solar project team in preparation of risk assessment report. | 6 Make sure all tools and equipment are available to complete installation safely and properly. |
| 3 Support to assess the risk of workplace injury and illness. | 7 Assist to wear all necessary personal protective equipment (PPE), which can include sturdy work boots, gloves and safety glasses. |
| 4 Affix risk minimize procedure / instructions chart at work place. | |

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TASK 11: Remove / Clear the tools, materials, dispose and fall protection equipments from work area at height after completion of the project.

- | | |
|--|---|
| 1 Verify all the tools, materials, protection equipments used in project area. | 4 Dispose the scrap materials as per the instruction from the supervisor. |
| 2 Remove tools, test equipments, protection equipments as per list. | 5 Dismantle and Remove safety/fall protection arrangement as per the procedure. |
| 3 Remove the scrap materials and Clean work area. | |

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Solar Technician (Electrical) - Operation & Maintenance of PV System

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 personnell.
- 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.
- 6 Check that your SOLAR PCU is earthed properly.
- 7 Always mount the SOLAR PCU in a cool and dry location.
- 8 While wiring your Power SOLAR PCU use Standard and insulated Wires, poor.
- 9 Wiring may lead to Short Circuit that may even lead to fire.
- 10 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
- Battery 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.

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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			

	Date	Date	Date
Control Board			
Item clean			
Insects removed			
Cables connections OK			
All switches/circuit breakers operate correctly OK?			
Cables/conduits mechanically OK?			
Electrical connections OK?			
Comments			

Sample log sheet for maintenance of inverters and other electricals

Inverter log sheet						
Date	Name	Cleaned inverter	No insects	Cable connections	Inverter operating correctly	Comments
		☐	☐	☐	☐	
		☐	☐	☐	☐	
		☐	☐	☐	☐	
		☐	☐	☐	☐	
		☐	☐	☐	☐	
		☐	☐	☐	☐	
		☐	☐	☐	☐	
		☐	☐	☐	☐	
		☐	☐	☐	☐	
		☐	☐	☐	☐	
		☐	☐	☐	☐	

Bos log sheet						
Date	Name	Cable connections PK	All switches and CB's operating	Cable connections OK	Meter operating correctly	Comments
		☐	☐	☐	☐	
		☐	☐	☐	☐	
		☐	☐	☐	☐	
		☐	☐	☐	☐	
		☐	☐	☐	☐	
		☐	☐	☐	☐	
		☐	☐	☐	☐	
		☐	☐	☐	☐	
		☐	☐	☐	☐	
		☐	☐	☐	☐	

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**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.

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Solar Technician (Electrical) - Operation & Maintenance of PV System

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.

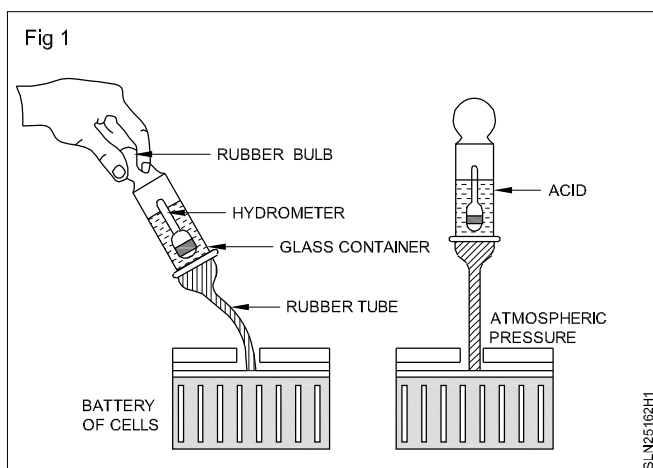
Sample Battery log sheet

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)



- 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.
- 4 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. If you are measuring a large battery, stratification can occur when the more concentrated electrolyte settles to the bottom. If you notice a difference in the readings between the top and bottom of the cell, average the two readings.
- 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.
- 7 Repeat the process for each individual cell. The Specific Gravity reading should not have a difference of more than 30 "points" (.030) between the lowest and highest reading or 10 "points" (.010) below the battery manufacturer's recommended temperature value with the battery fully charged. If so, try and equalize the battery by following the battery manufacturer's procedures or the procedure. If equalizing does not help, replace the battery. You can determine the battery's State-of-Charge by taking the average of the temperature compensated cell readings.
- 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)

Fig 2

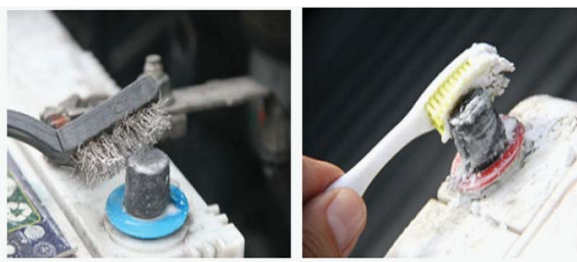


- 6 Inspect all terminals for corrosion.
- 7 Check for loosened cable connections.
- 8 Clean the corroded terminals.
- 9 Tighten the loose connections.

- 10 After cleaning, add anti-oxidant/petroleum jelly to exposed wire and terminals.

Cleaning of terminals (Fig 3)

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.

Open Circuit Voltage		State of Charge	
2 Volt Battery	6 Volt Battery		
2.12 or more	6.36 or more	12.72 or more	100%
2.10 to 2.12	6.30 to 6.36	12.60 to 12.72	75 - 100%
2.08 to 2.10	6.24 to 6.30	12.48 to 12.60	50 - 75%
2.03 to 2.08	6.90 to 6.24	12.12 to 12.48	25 - 50 %
1.95 to 2.03	5.85 to 6.90	11.70 to 12.12	0 - 25%
1.95 or less	5.85 or less	11.70 or less	0%

Overall maintenance check sheet

Safety first

DATE

- 1 Do not climb above 2 metres to maintain PV modules or wind turbines without safety rails or harness.
- 2 Do not touch any component with a voltage 120V DC. 50V AC or greater.
- 3 Wear personal protective clothing when maintaining batteries.
- 4 Do not maintain batteries while there's an acrid smell in the vicinity.
- 5 No smoking, sparks or naked flames in battery enclosure.
- 6 Ensure clean water is readily accessible while maintaining batteries.
- 7 Ensure all tools are Insulated while maintaining batteries.

PV Modules	Balance of System	Battery	Genset
☐ Cleaned	☐ Battery voltage	☐ Battery voltage	☐ Run hours
☐ Check structure	☐ Switches/CBs	☐ Interconnections	☐ Oil change
☐ Cabling mechanical	☐ Connections	☐ Ambient temp	☐ Fuel filter
☐ Cabling electrical	☐ Regulator	☐ Log completed for each cell	☐ Oil filter
☐ Output voltage	☐ Inverter	☐ SG	☐ Log completed
☐ Output current	☐ Charger	☐ Temperature	
☐ Log completed	☐ Control board		
	☐ Cleaned	☐ SoC	Wind Generator
	☐ Bugs removed	☐ Voltage	☐ Guys
	☐ Cables	☐ Water	
	☐ Working OK	☐ Case OK	Pico-hydro
	☐ Log completed		☐ Intake cleaned

— — — — —

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

Sl.No	List the observation

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Exercise : 2.6.164 to 2.6.169: 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.

- make a solar panel.

- **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.**

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.

[illegible]

Stages of Solar panel manufacturing

		
Incoming inspection of cells	Grouped cells	Cell string
		
Cell strings assembly	EVA sheet spread	Checking
		
Taping and framing	Frame sealing	Fixing Junction box
		
Testing	Certificate	Packing

- **make a solar panel.**

- **Visit to solar panel manufacturing industry.**
- **Obtain in-plant training through MoU from institute with the industry.**
- **Audio-video sessions of making solar panels.**

Learn the skills of making solar panel in automatic manufacturing

- ## Observations

[illegible]

Solar Technician (Electrical) - Manufacturing of Solar Panel

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:

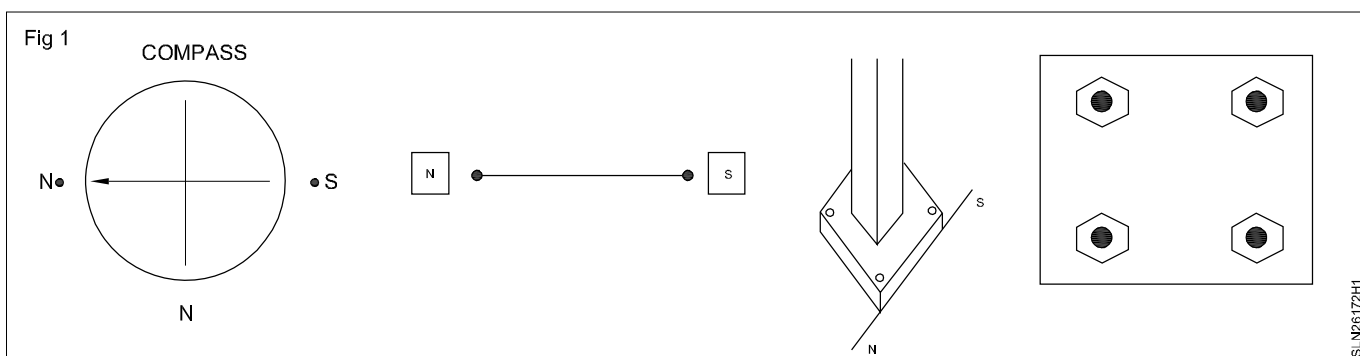
- Skills required in making foundation on ground.
 - a Marking
 - b Digging
 - c Bar bending
 - d Filling concrete mix
 - e Curing concrete

PROCEDURE

TASK 1: Prepare civil foundation for the Solar Street light

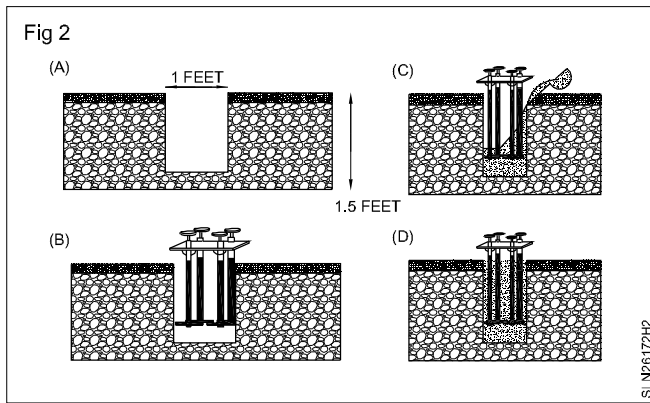
- 1 Use compass and mark true north and south poles.
- 2 Draw line connecting north and south poles points.
- 3 Place the pole mount aligned to the connecting lines.
- 4 Mark the base.
- 5 Remove the pole mount.
- 6 Dig pit (Crater) as per drawing (Example: if Base is 1ft x 1 ft then the crater should 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)



- 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.

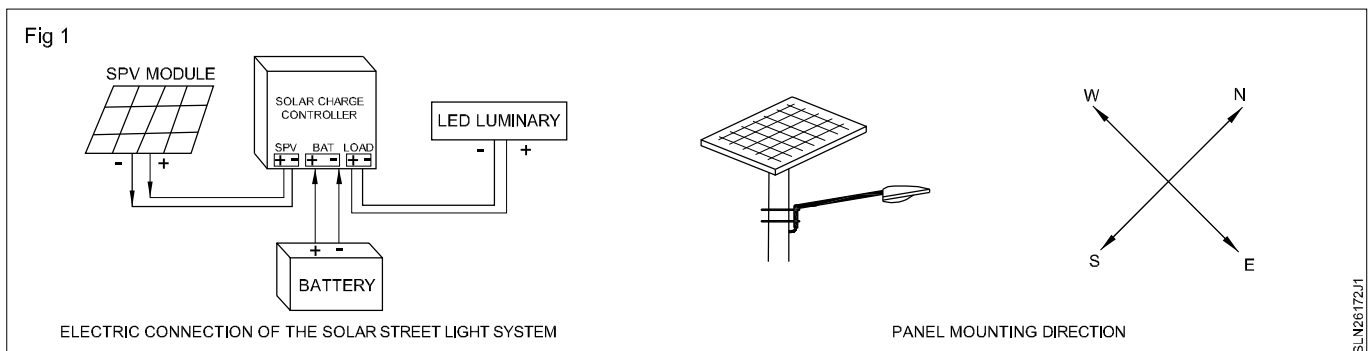
Making Foundation. (Fig 2)



TASK 2: Assembly of Street light pole

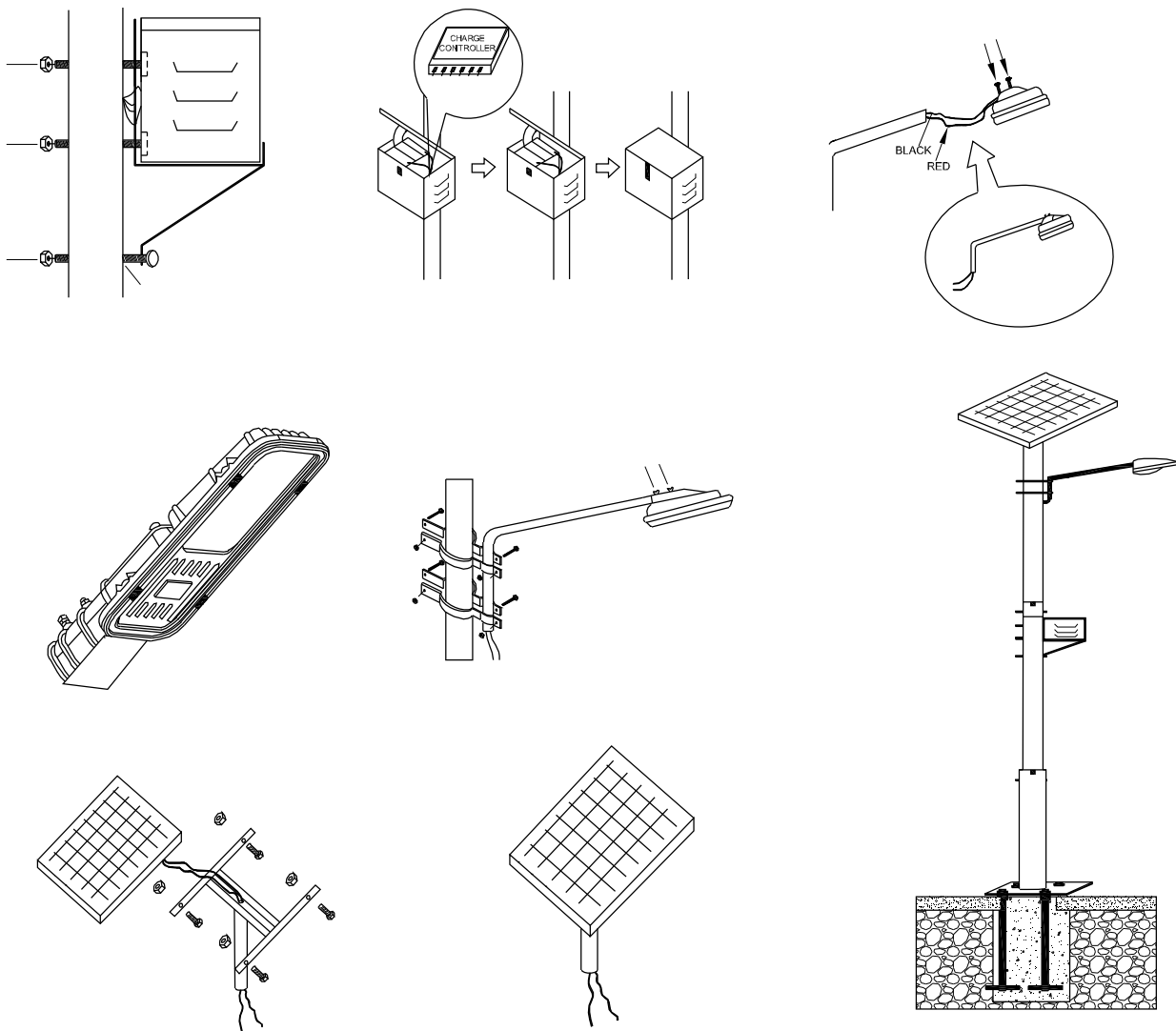
- 1 Assemble the Control box with charge controller and battery inside.
- 2 Do the wiring from battery to the controller, wires for the lamp and solar panel and bring outside the box.
- 3 Insert the wires through the middle hole in the pole and draw it internally till top hole of the pole.
- 4 Assemble 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)



Erecting integrated solar LED Street light. (Fig 4)

Fig 4



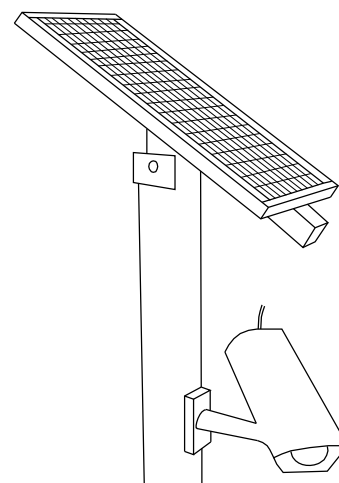
SL_N26172H4

Practice similar exercises : Only load varies; Take care of the load ratings match with that of charge controller, solar panel etc.

Example: 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).

Solar Security System (Fig 5)

Fig 5



SL_N26172H5

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

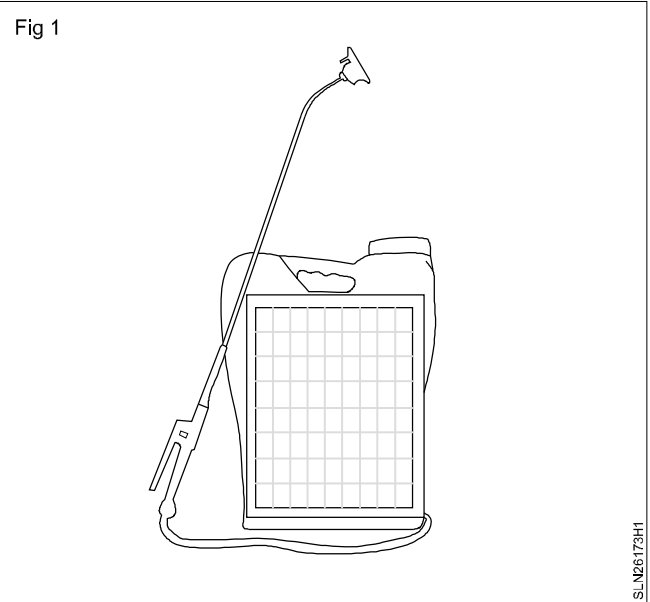
PROCEDURE

Make a solar fertilizer sprayer

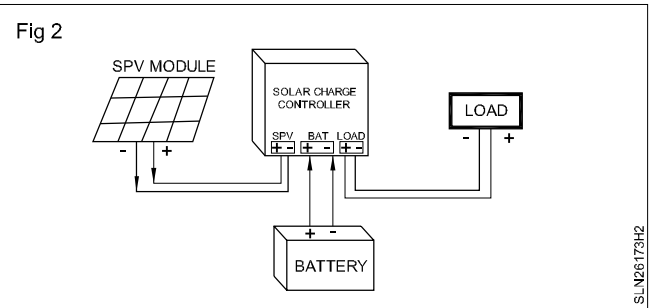
- Wire the charge controller.
- Connect the battery terminals to ports on charge controller.
- Connect the DC Motor-pump to the output of charge controller.
- Connect the Solar panel 10 W through switch to the input of Charge controller.
- Keep the switch in OFF position.
- Construct the sprayer using the solar panel on exposed back side and jacket or holding bracket on the other side. Battery positioned behind panel.
- Pour liquid (diluted fertilizer or pesticide as the case may be) in the container.
- Hold the combined set on shoulder back.
- Switch On the circuit.
- Press the nozzle and test pump starting.
- Demonstrate spraying.

Refer the picture below

Solar Fertilizer/Pesticide sprayer (Fig 1)



Circuit diagram for a solar DC product (Fig 2)



Solar Technician (Electrical) - Manufacturing of Solar Panel

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

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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Solar Technician (Electrical) - Manufacturing of Solar Panel

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.

- Plane area.
- Near to the Bore well or the Pump.

If the place does not satisfy the above requirements, then it 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 are more and all must be mounted on the same structure. So, the foundation must be strong enough to hold the weight of the SPV module and withstand wind. The civil work includes;

- Prepare the Pit for mounting structure and electrical ground point.
- Prepare the cement concrete.
- Erect the Structure.

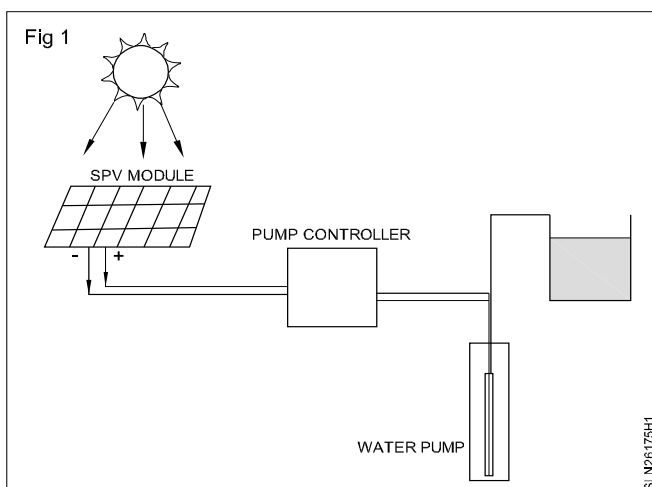
(Refer earlier exercises on Solar PV foundation, mounting of panels, panel wiring etc).

3 Electrical connection

The electrical connection is the process of connecting all the devices electrically together. The typical electrical circuit diagram of Solar pump system is as shown in Fig 2.

Circuit diagram of solar pump system (Fig 2)

Block Diagram (Fig 1)

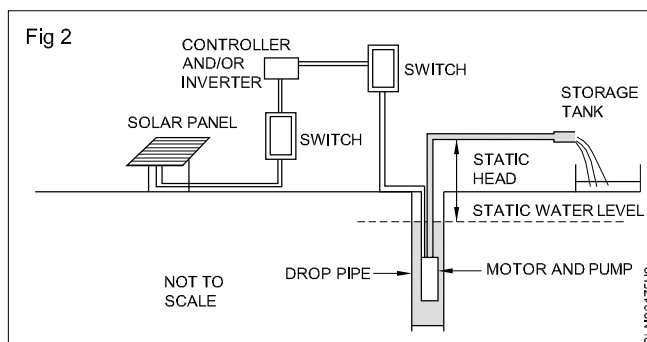


Make a solar fertilizer sprayer

1 Select and prepare the location:

The Solar Pump system uses the sun light as the source of energy. So the place of installation of the solar pump system shall be;

- Free from shadows caused by the trees for Solar array.
- Free from shadows caused by the buildings or any erected structures for array.
- Free from natural water channels.



Solar Technician (Electrical) - Manufacturing of Solar Panel

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

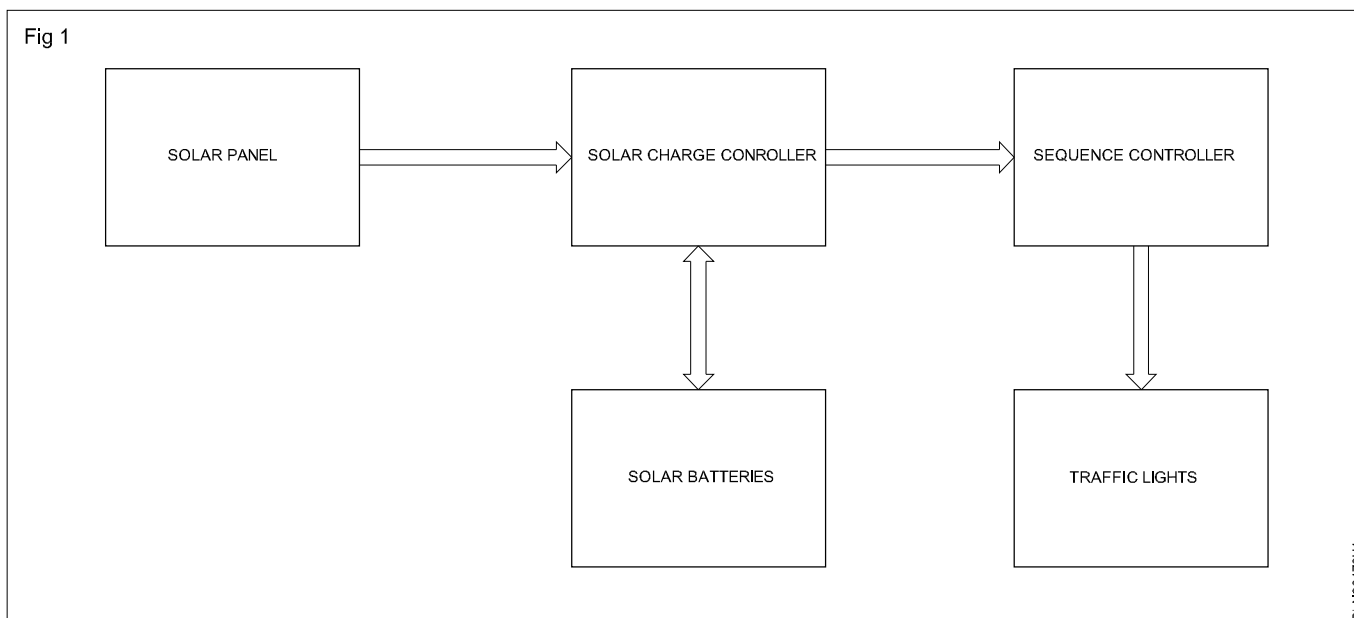
- Manual charge controller rated (12V, 10 A)
- Solar battery (12V, 100 Ah)
- Solar panel (75 W)
- Traffic lights (12 V DC)
- Sequence control electronic circuit for traffic lights (Consult Electronic Mechanic tarde) (Check DC supply requirements to match with Charge controller output)

PROCEDURE

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)



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 developments in Renewable Energy Industry.
- 6 Report on employment opportunities in Renewable Energy Industry globally.