VI Semester B.Tech. - E.E.E. (Scheme-2020)

Hybrid Power Systems Lab (HPSP)

G. Pulla Reddy Engineering College (Autonomous): Kurnool
Department of Electrical & Electronics Engineering
Accredited by NBA of AICTE & NAAC of UGC
Affiliated to Jawaharlal Nehru Technological University Anantapur, Ananthapuramu

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Study of Pyranometer

Expt. No: **Date:**

Aim: To measure solar irradiance, ambient and PV module temperature, array orientation and tilt angles of PV module/cells.

Apparatus:

Irradiance meter (Pyranometer)
Soar PV module/cell

Pyranometer Diagram and Description:

Fig 1: Fluke Solar Irradiance meter

The Fluke IRR1-SOL Irradiance Meter is as shown in Fig. 1. It has been designed from the ground up to simplify the installation, commissioning, and trouble-shooting of photovoltaic arrays, measuring irradiance, temperature, inclination and direction of the solar array in a single handheld tool.

The overview of IRR1-SOL irradiance meter is as shown in Fig. 2. It shows the functioning of various buttons and operational procedure of the meter.

Study of Pyranometer

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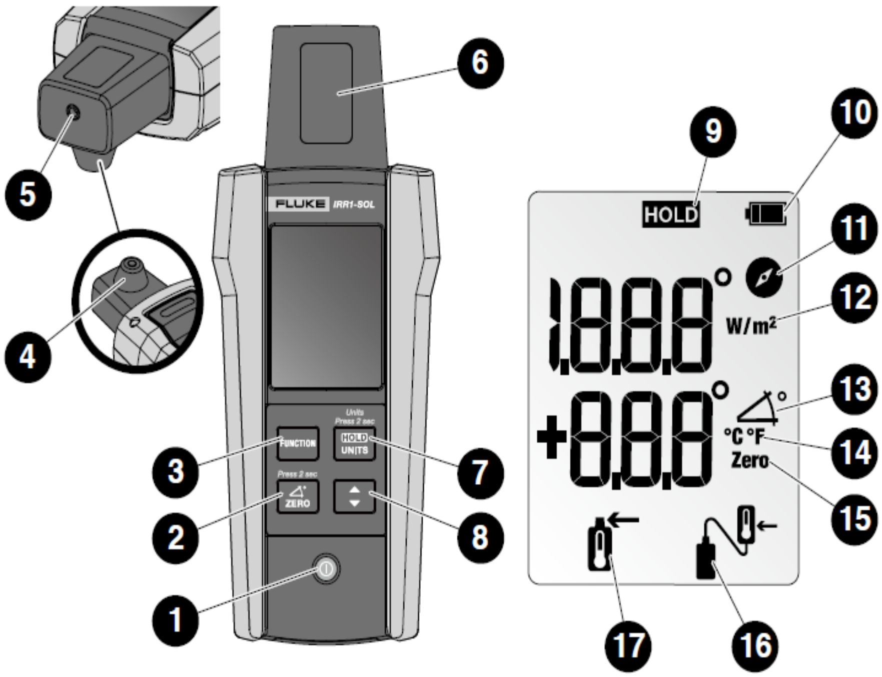


Fig 2: Overview of irradiance meter

1. On/Off button
2. Angle Reset Button (Use function to measure angle difference between solar panel and surface)
3. Function key for Irradiance, Temperature, Compass and Angle measurements
4. Integrated Temperature Sensor for panel's surface measurement
5. External Temperature Probe Socket.
6. Photovoltaic Irradiance sensor.
7. Hold Button to hold measurement on the display (Push button for 2 seconds to enable temperature units change mode)
8. Temperature units switch button (Celsius / Fahrenheit)
9. Hold indicator
10. Battery level indicator
11. Compass function indicator
12. Irradiance units and function indicator
13. Angle function indicator
14. Temperature unit indicator (Celsius / Fahrenheit)
15. Angle reset indicator

Study of Pyranometer

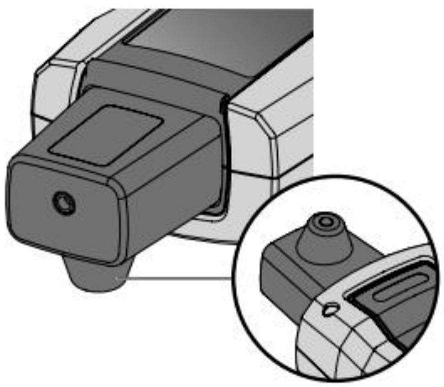
Expt. No: **Date:**

16. External temperature probe indicator
17. Integrated temperature sensor indicator

Procedure:

Measuring Temperature and Irradiance:

It measures the irradiance and temperature by simply placing the meter directly onto the PV panel. The internal, embedded conductive sensor in the back of the meter as shown in Fig. 3 will automatically take the temperature reading.



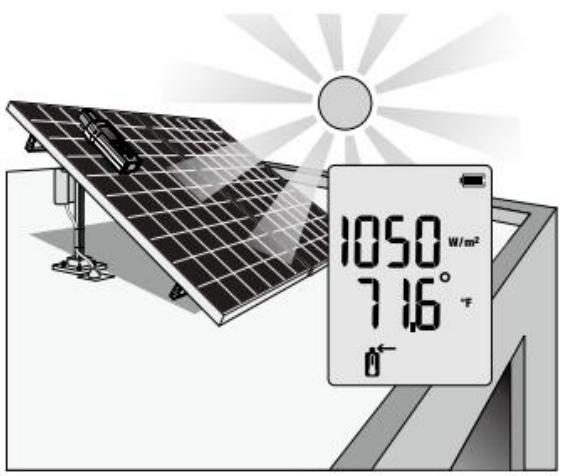


Fig 3: Measurement of Temperature and Irradiance

Study of Pyranometer	
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Temperature can also be taken through the external temperature probe. In this procedure, the temperature probe will be attached to the top of the Meter. The screen automatically shows the icon once connected. The icon indicates that the temperature is now being read by the external probe. Place the Meter on or beside the PV panel and connect the suction cup to the underside of the PV panel as shown in Fig. 4.

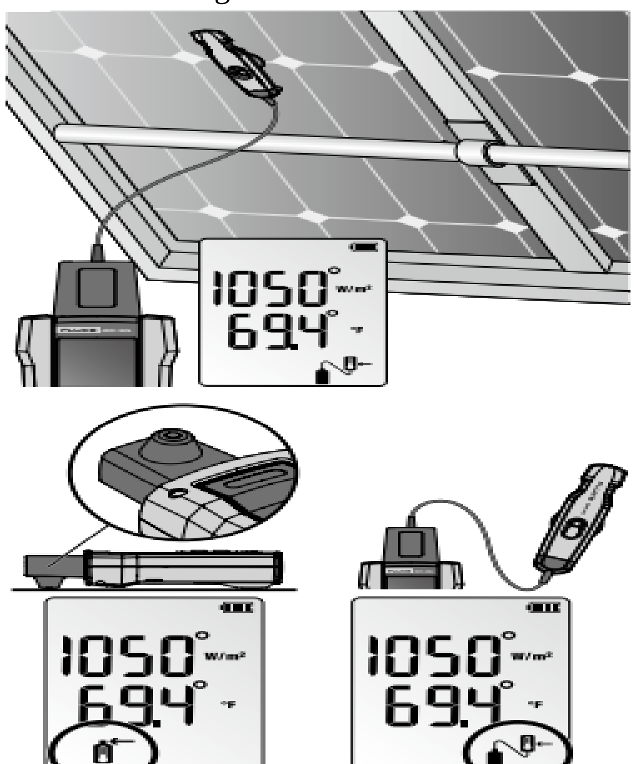

Fig. 4: Measurement of temperature through external probe

Measuring Inclination and Cardinal Direction:

Place the meter directly onto the PV panel to get accurate tilt as shown in Fig. 5. For surfaces of rooftops with inclinations different than 0°, push the ZERO button for 2 seconds to reset the angle and measure the true inclination of a solar panel. The compass measurement will require a two-step process for accurate cardinal direction.

Step 1:

Perform irradiance, temperature and inclination measurements with meter placed on and aligned with the PV panel. The compass function will show "--------" when the tilt angle is above 20^o. At a tilt angle of $<20^o$ any compass reading shown will be inaccurate due to the influence by surrounding metal objects.

Study of Pyranometer

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Step 2:

Perform the compass measurement away from the PV panel by holding the meter or placing meter on a horizontal surface (0 to 20^{o} tilt) pointing the tip of the meter in the direction that the PV panel faces. Keep away from any metal objects.

Note:

The compass will reference magnetic north. The compass reading will be unreliable if the meter is placed on or near objects containing metal (including solar panels, metal roofs, concrete surfaces with rebar, etc).

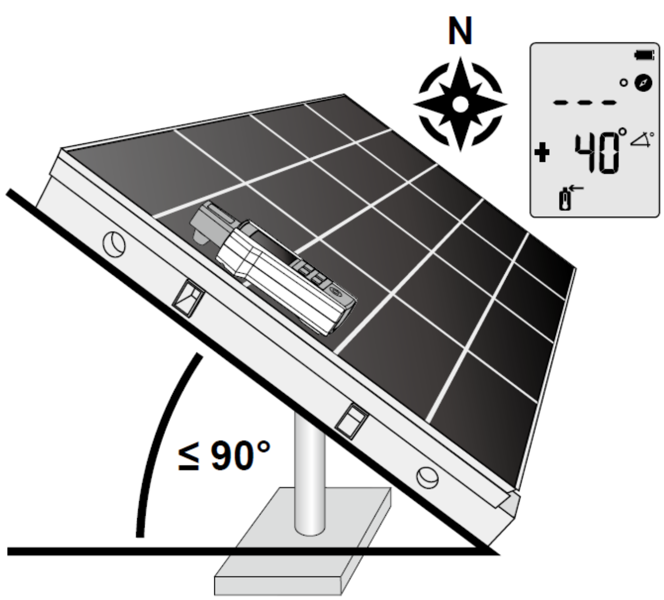

Fig 5 (a): Measurement of Inclination and Cardinal direction.

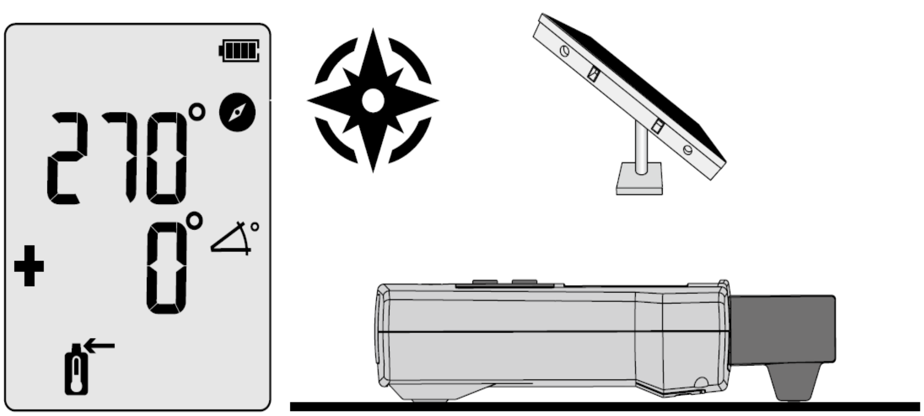

Fig 5 (b): Tilt angle measurement of solar PV cell/module

Study of Pyranometer

Expt. No: **Date:**

Observations:

Result:

Post Test Questions (Viva):

1. Define irradiation. Name the devices used to measure irradiation.
2. What is the difference between irradiance and irradiation?
3. Why irradiance is different from one location to another?

Study of Pyranometer

Expt. No: **Date:**

Simulation of V-I and P-V characteristics of PV cell, Series and Parallel connection of PV cells

Expt. No : **Date:**

Aim:

To simulate the V-I and P-V characteristics of PV cell, Series and Parallel connection of PV cells using MATLAB-Simulink.

Apparatus:

Personal Computer
MATLAB software

Circuit Diagram:

a) Solar PV cell:

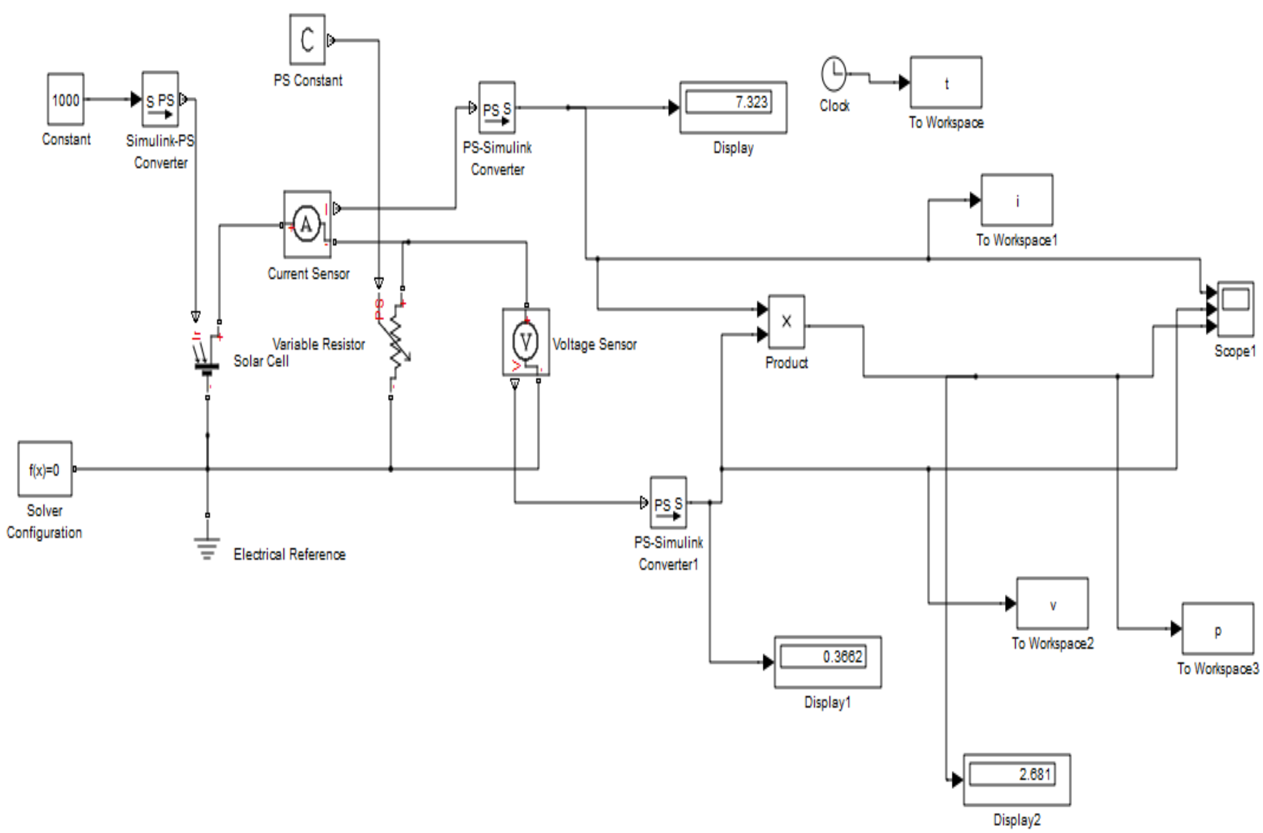

Fig.1: Schematic Diagram of Solar PV Cell

Simulation of V-I and P-V characteristics of PV cell, Series and Parallel connection of PV cells

Expt. No : **Date:**

b) Three Cells Connected in Series:

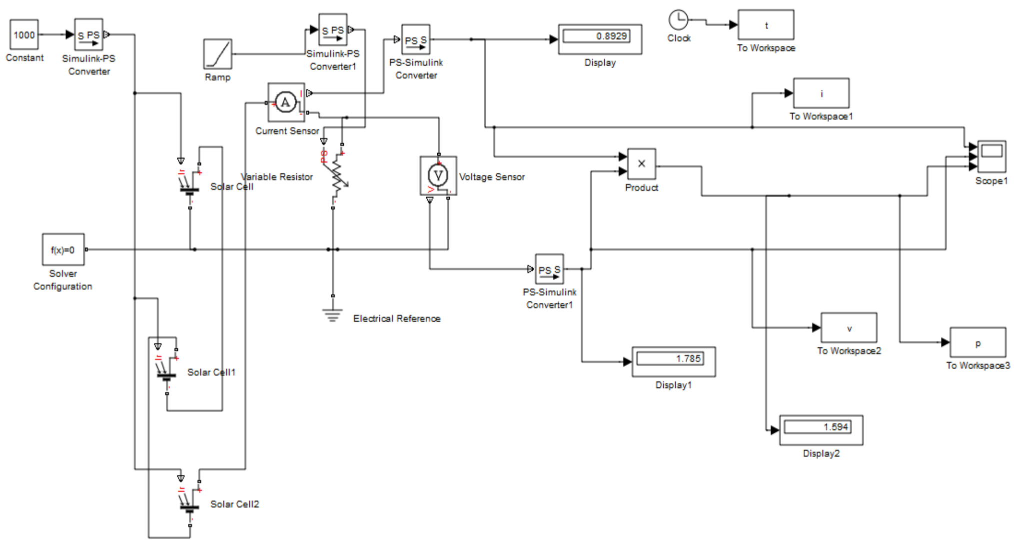

Fig.2: Schematic Diagram of Three Solar PV Cell Connected in Series

c) Three Cells Connected in Parallel:

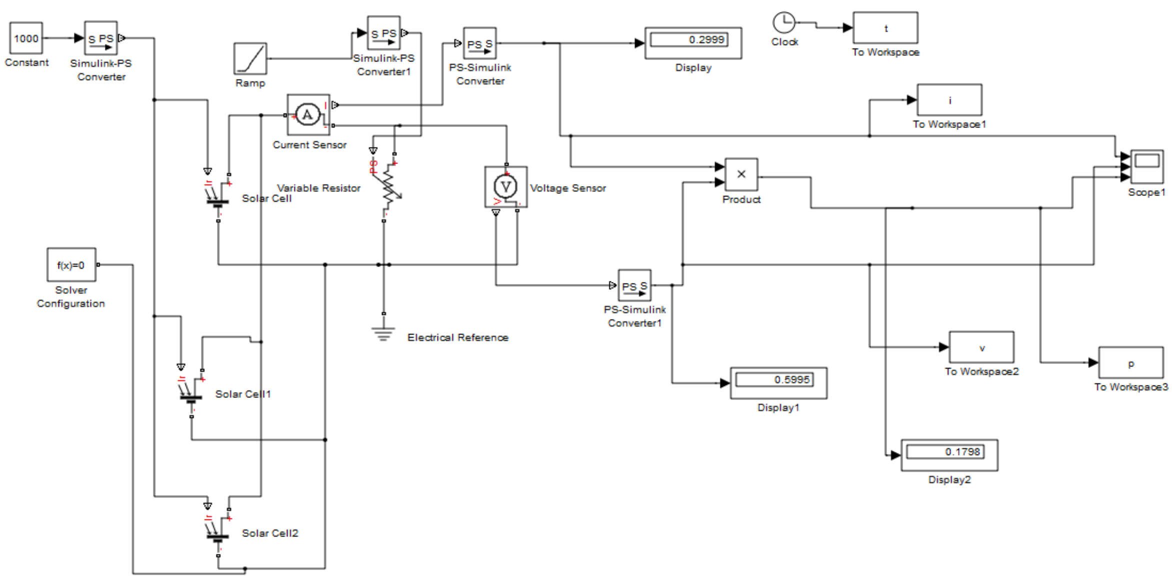

Fig.3: Schematic Diagram of Three Solar PV Cell Connected in Parallel

Simulation of V-I and P-V characteristics of PV cell, Series and Parallel connection of PV cells

Expt. No : **Date:**

Theory: A solar PV model can be expressed by the equivalent circuit shown in below Fig. 4.

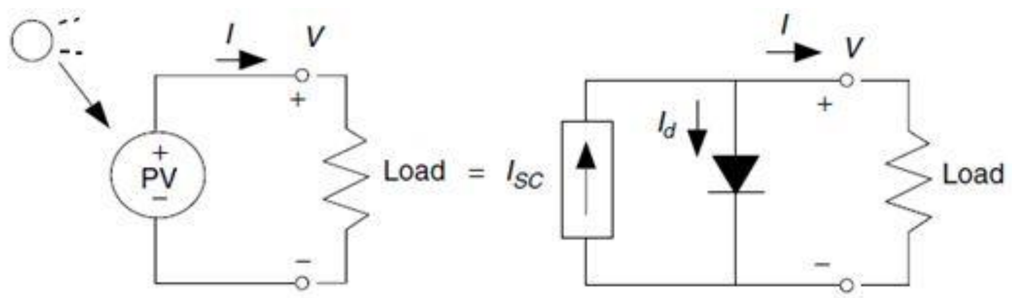

Fig 4: Equivalent Circuit of a PV model

Open-circuit voltage of a solar cell:

The open-circuit voltage V_{OC} is the maximum voltage available from a solar cell. As the cell temperature increases, V_{OC} decreases. V_{OC} is measured using a volt meter connected across the solar cell when no load is connected, shown in Fig 5.

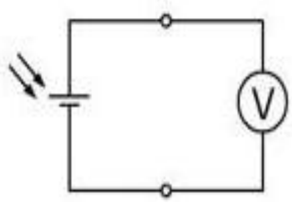

Fig 5: Measuring open-circuit voltage

Short-circuit current of a PV cell:

The short-circuit current I_{SC} is the maximum current a solar cell can supply. I_{SC} is directly proportional to the irradiance. If irradiance increases, I_{SC} will increase. If irradiance decreases, ISC will decrease. For example, if irradiance is cut in half, I_{SC} will drop by half. The current is measured using an ammeter connected directly across the solar cell, shown in Fig 6.

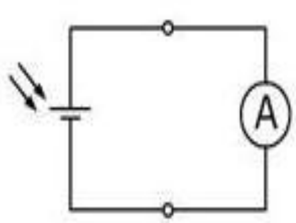

Fig 6: Measuring short-circuit current

Simulation of V-I and P-V characteristics of PV cell, Series and Parallel connection of PV cells

Expt. No : **Date:**

Procedure:

1. Click on the MATLAB icon.
2. Open new model file.
3. Open the new library browser.
4. Select the required blocks from library.
5. Choose the configuration parameters appropriately and run the simulation model.
6. Observe the characteristics curves in scope.
7. Copy the model file and plot the output characteristics.

Expected Output Characteristics:

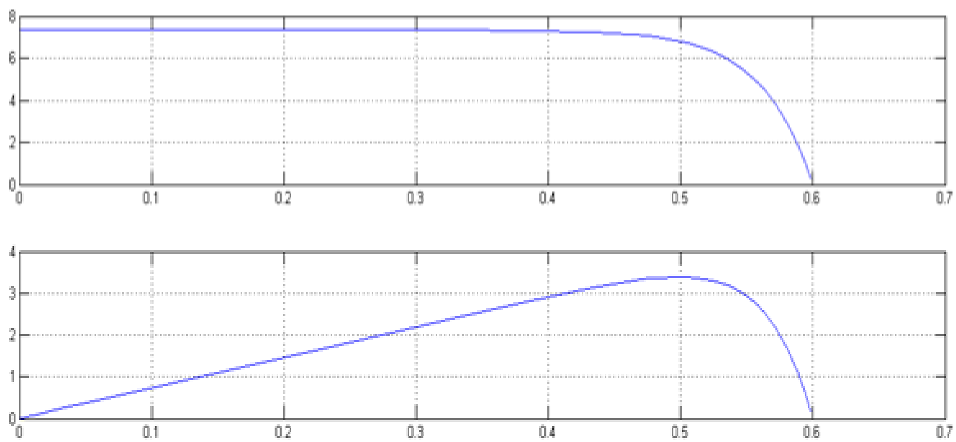

Fig 7: V-I and P-V characteristics of a Solar PV cell

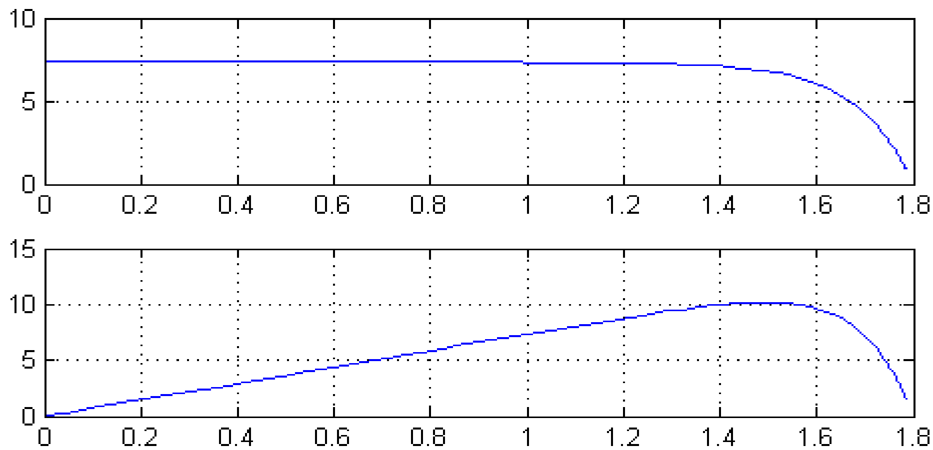

Fig 8: V-I and P-V characteristics of a Three Solar PV cells in Series

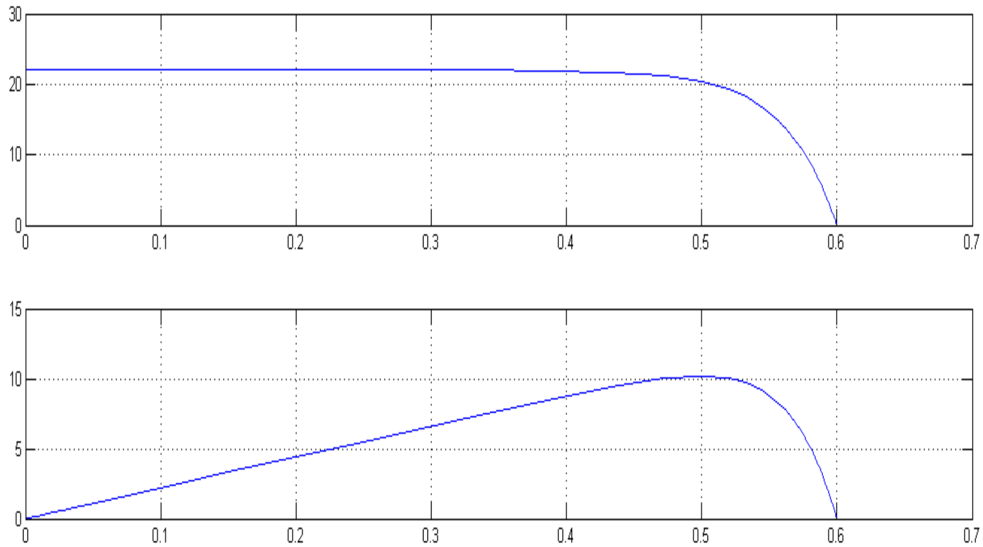

Fig 9: V-I and P-V characteristics of a Three Solar PV cells in Parallel

Result:

Post Test Questions (Viva):

1. Justify the statement "**Solar energy is one of the main sources for all other sources of renewable energy"**
2. Why shadow free area is required for solar PV system?
3. Derive the equation for Ipv (Solar PV current) for single diode model.

Simulation of V-I and P-V characteristics of PV cell, Series and Parallel connection of PV cells

Expt. No : **Date:**

Simulation of V-I and P-V characteristics of PV cell, Series and Parallel connection of PV cells

Expt. No : **Date:**

Practical Verification of V-I and P-V characteristics of PV cell, Series and Parallel connection of PV cells

Expt. No: **Date:**

Aim:

To conduct an experiment and draw the V-I and P-V characteristics of PV cell, Series and Parallel connection of PV cells.

Apparatus:

PV panels, 200w incandescent lamps or Halogen lamps, Ammeter, Voltmeter, Rheostat (Resistor)

Circuit Diagram:

Solar PV cell: The solar cell, resistor and meters are connected as shown in Fig. 1.

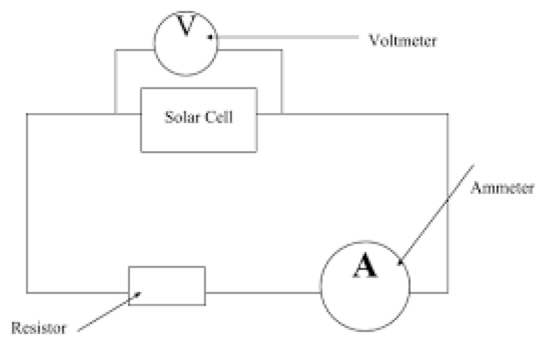

Fig 1: Solar cell voltage current measurement

Series Connection of Solar PV Cells:

The series connection of three solar PV cells along with the resistor (rheostat) and necessary meters is as shown in Fig. 2.

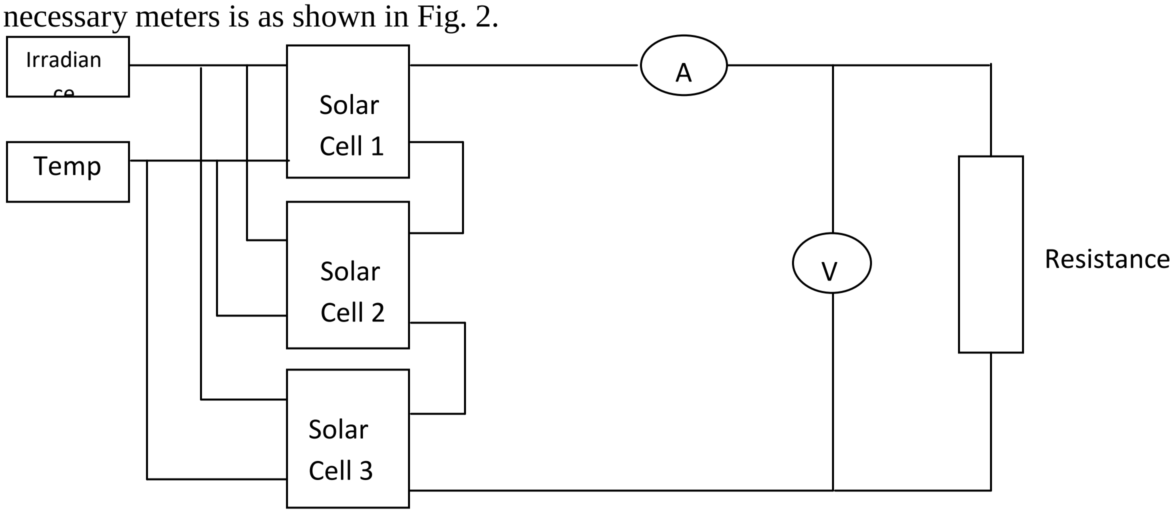

Fig 2: Voltage and current measurement of three solar cells connected in series

Practical Verification of V-I and P-V characteristics of PV cell, Series and Parallel connection of PV cells

Expt. No: **Date:**

Three cells are connected in Parallel:

The parallel connection of three solar PV cells along with the resistor (rheostat) and necessary meters is as shown in Fig. 3.

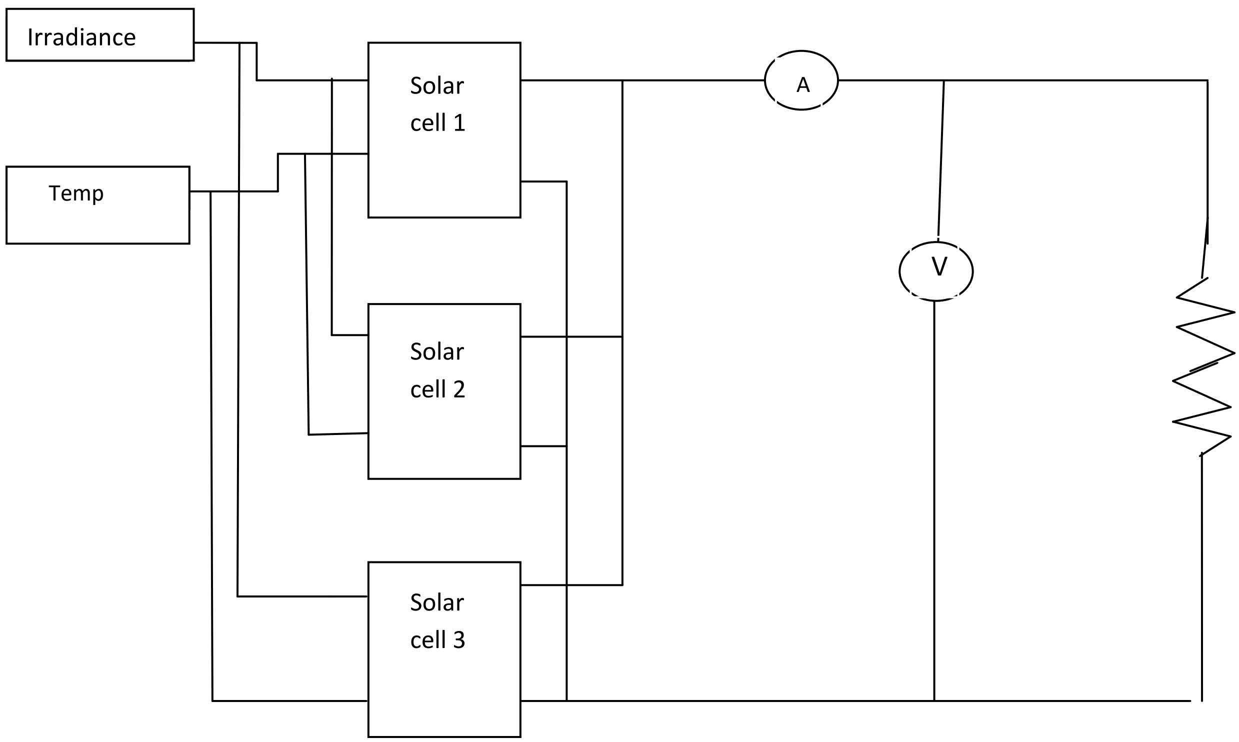

Fig 3: Voltage and current measurement of three solar cell connected in parallel

Theory:

The solar cell is a semi conductor device, which converts the solar energy into electrical energy. It is also called a photovoltaic cell. A solar panel consists of numbers of solar cells connected in series or parallel. The number of solar cell connected in a series generates the desired output voltage and connected in parallel generates the desired output current. The conversion of sunlight (solar energy) into electric energy takes place only when the light is falling on the cells of the solar panel. Most solar cells are built from silicon, and the presence of impurities influences their performance. Solar cell efficiencies vary from 6% for amorphous silicon-based solar cells to 42.8% with multiple-junction research lab cells. The major advantages of using PV cells are: short lead time for designing and installing a new system, output power matching with peak load demands, static structure, no moving parts, longer life, no noise, high power capability per unit of weight, inexhaustible and pollution free, highly mobile and portable because of its light weight. In most practical applications, the solar panels are used to charge the lead acid or Nickel-Cadmium batteries. In the sunlight, the solar panel charges

Practical Verification of V-I and P-V characteristics of PV cell, Series and Parallel connection of PV cells

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the battery and also supplies the power to the load directly. When there is no sunlight, the charged battery supplies the required power to the load.

Procedure:

1. The connections are made as per the circuit diagrams Fig.1 – Fig. 3 for a single solar cell, series connection and parallel connection of solar cells respectively.
2. By varying the resistance values, the readings of ammeter and voltmeter are noted.
3. Plot a graph between output voltage vs. output current by taking voltage along X-axis and current along Y-axis.
4. Plot a graph between output voltage vs. output power by taking voltage along X-axis and power along Y-axis.

Observations:

For a Single Solar PV Cell:

Potentiometer (Ω)	Output Voltage (V)	Output Current (A)	Output Power (W)

For a Series Connection of Three Solar PV Cells:

Potentiometer (Ω)	Output Voltage (V)	Output Current (A)	Output Power (W)

For a Parallel Connection of Three Solar PV Cells:

Potentiometer (Ω)	Output Voltage (V)	Output Current (A)	Output Power (W)

Practical Verification of V-I and P-V characteristics of PV cell, Series and Parallel connection of PV cells

Expt. No: **Date:**

Output Characteristics:

Solar PV cell:

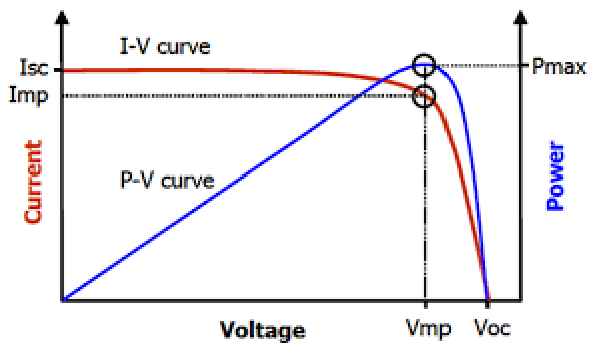

Fig 4: V-I and P-V characteristics of a Solar PV cell

Characteristics for a Series Connection of Three Solar PV Cells:

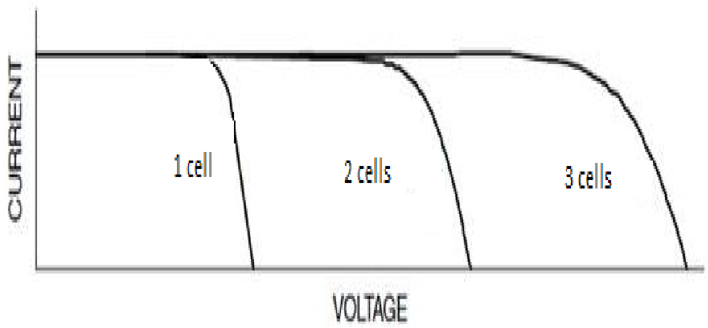

Fig 5: I-V and P-V characteristics for a series connection of three solar PV cells

Characteristics for a Parallel Connection of Three Solar PV Cells:

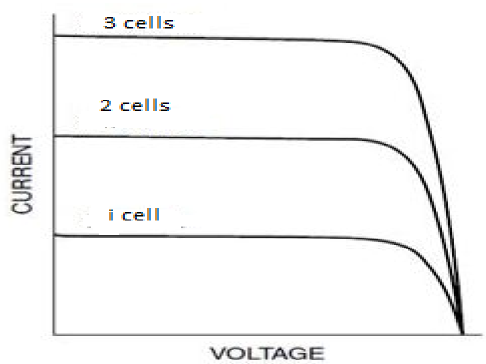

Fig 6: I-V and P-V characteristics for a parallel connection of three solar PV cells

Practical Verification of V-I and P-V characteristics of PV cell, Series and Parallel connection of PV cells

Expt. No: **Date:**

Result:

Graph:

Practical Verification of V-I and P-V characteristics of PV cell, Series and Parallel connection of PV cells

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Practical Verification of V-I and P-V characteristics of PV cell, Series and Parallel connection of PV cells

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Practical Verification of V-I and P-V characteristics of PV cell, Series and Parallel connection of PV cells

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Practical Verification of V-I and P-V characteristics of PV cell, Series and Parallel connection of PV cells

Expt. No: **Date:**

Post Test Questions (Viva):

1. What happens to voltage and current if pv cells are connected in series as well as in parallel?
2. What do you mean by STC?
3. Why PV modules are installed/facing towards south direction only?

Practical Verification of V-I and P-V characteristics of PV cell, Series and Parallel connection of PV cells

Expt. No: **Date:**

Simulation of V-I and P-V characteristics of PV module, Series and Parallel connection of PV modules

Expt. No: **Date:**

Aim:

To simulate the V-I and P-V characteristics of PV module, Series and Parallel connection of PV modules using MATLAB-Simulink.

Apparatus:

Personal Computer
MATLAB software

Circuit Diagrams:

Solar PV Module:

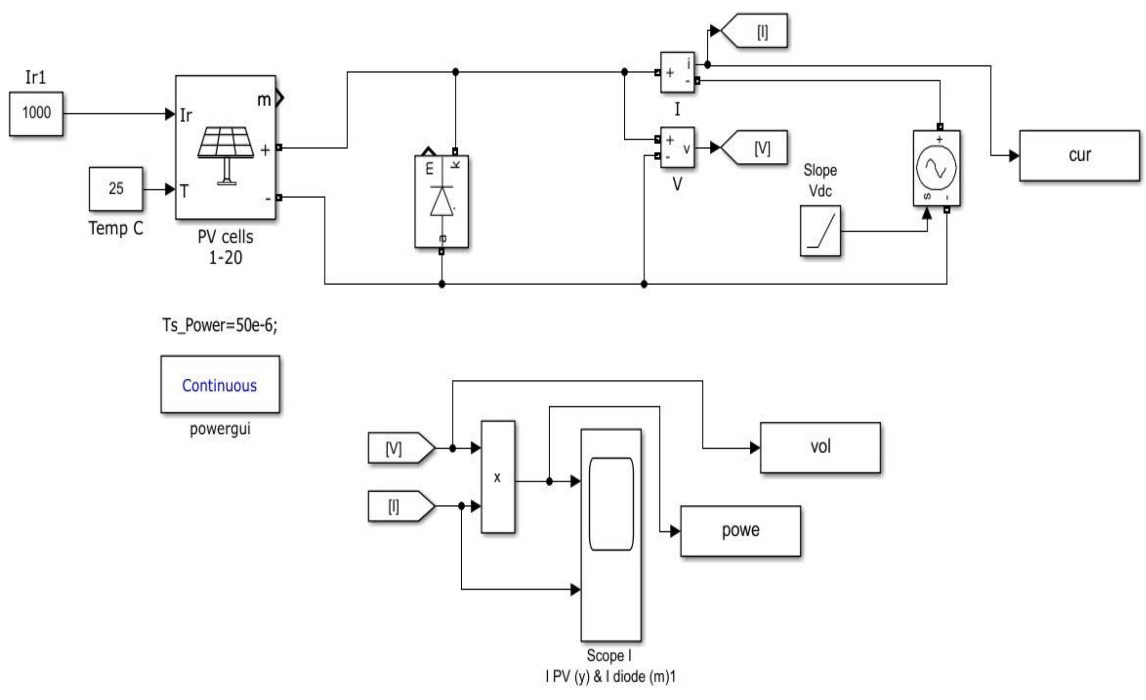

Fig 1: Simulink diagram of a Solar PV module

Simulation of V-I and P-V characteristics of PV module, Series and Parallel connection of PV modules

Expt. No: **Date:**

Three Modules Connected in Series:

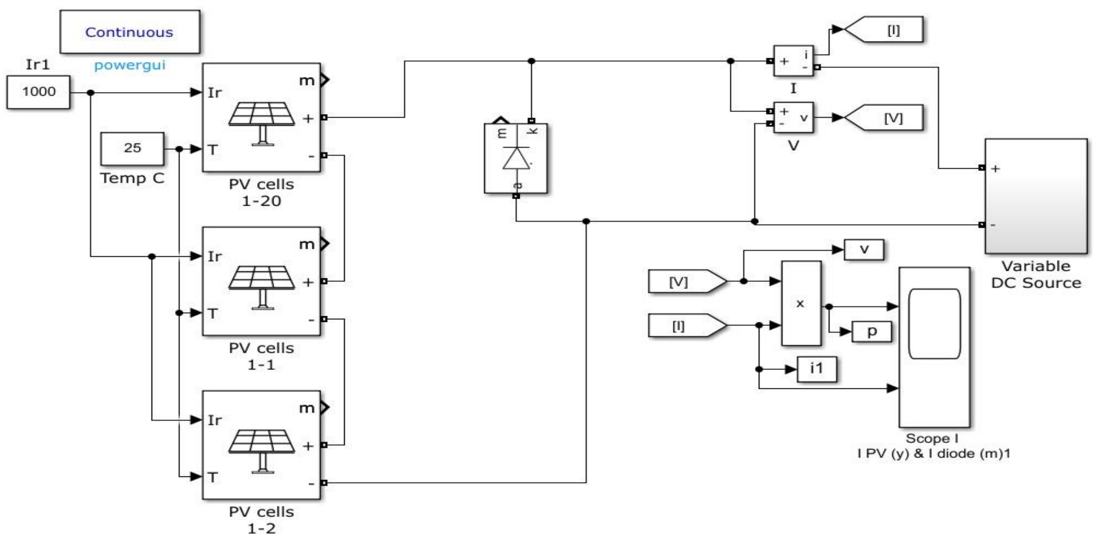

Fig 2: Simulink diagram of a three Solar PV module connected in series

Three Module Connected in Parallel:

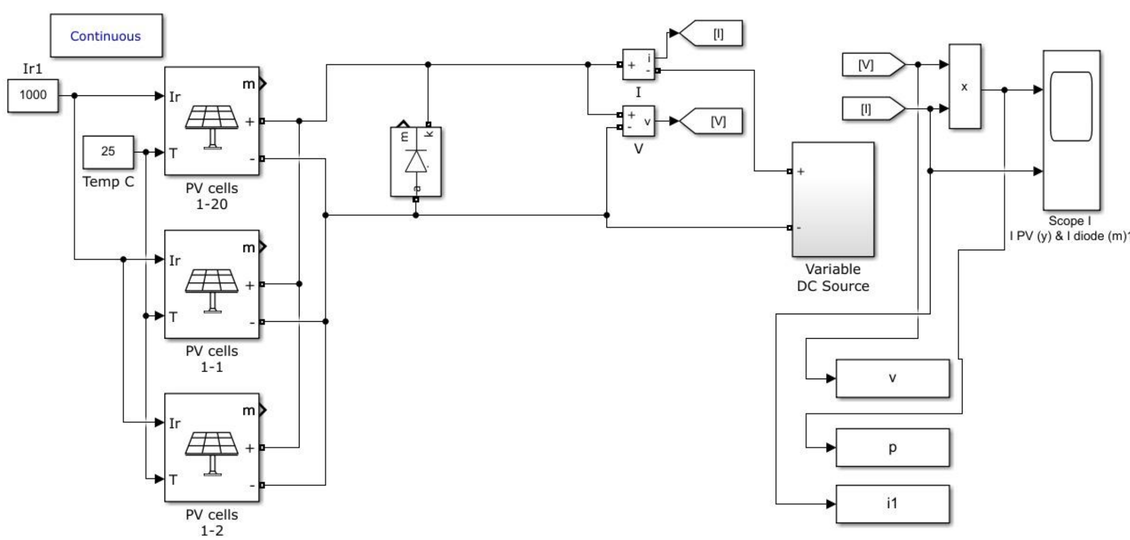

Fig 3: Simulink diagram of a three Solar PV module connected in parallel

Theory:

Simulation of V-I and P-V characteristics of PV module, Series and Parallel connection of PV modules

Expt. No: **Date:**

A solar PV model can be expressed by the equivalent circuit shown in below figure 1.

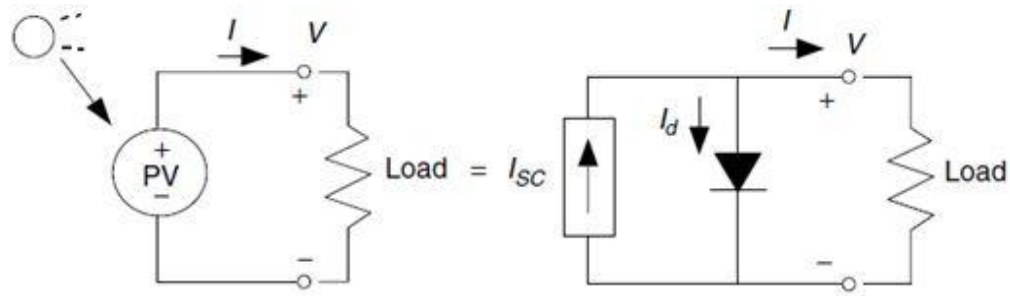

Fig 4: Equivalent circuit of a PV model.

Open-circuit voltage of a solar cell:

The open-circuit voltage V_{OC} is the maximum voltage available from a solar cell. As the cell temperature increases, V_{OC} decreases. V_{OC} is measured using a volt meter connected across the solar cell when no load is connected, shown in Figure 2.

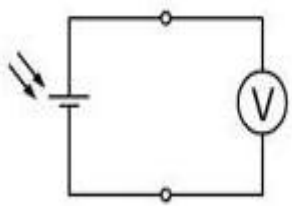

Fig 5: Measuring open-circuit voltage.

Short-circuit current of a PV cell:

The short-circuit current I_{SC} is the maximum current a solar cell can supply. I_{SC} is directly proportional to the irradiance. If irradiance increases, I_{SC} will increase. If irradiance decreases, ISC will decrease. For example, if irradiance is cut in half, I_{SC} will drop by half. The current is measured using an ammeter connected directly across the solar cell, shown in Figure 3.

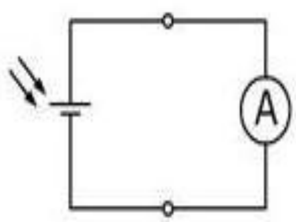

Fig 6: Measuring short-circuit current.

Simulation of V-I and P-V characteristics of PV module, Series and Parallel connection of PV modules

Expt. No: **Date:**

Output Characteristics:

Solar PV module:

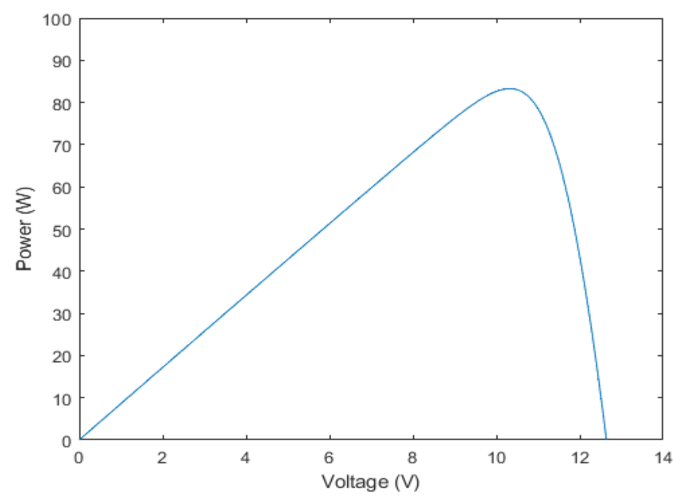

Fig 7: V-I and P-V characteristics of a Solar PV module.

Characteristics for three modules connected in Series:

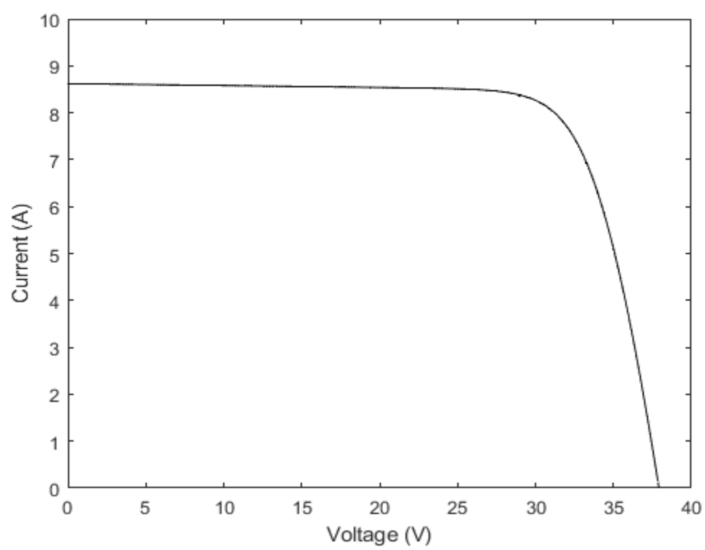

Fig 8: V-I characteristics of a Solar PV modules connected in series.

Simulation of V-I and P-V characteristics of PV module, Series and Parallel connection of PV modules

Expt. No: **Date:**

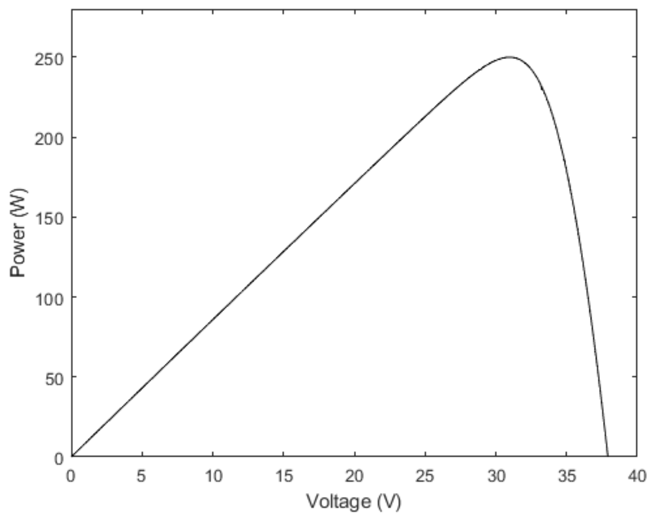

Fig 9: P-V characteristics of a Solar PV modules connected in series.

<u>Characteristics for three modules are connected in Parallel:</u>

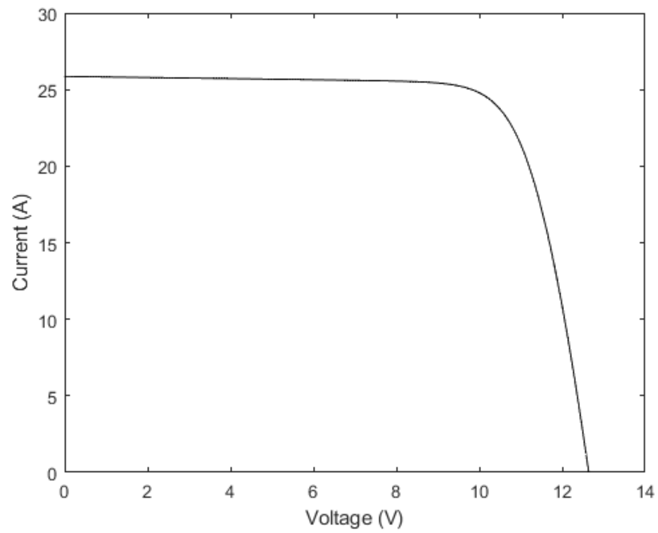

Fig 10: V-I characteristics of a Solar PV module connected in parallel

Simulation of V-I and P-V characteristics of PV module, Series and Parallel connection of PV modules

Expt. No: **Date:**

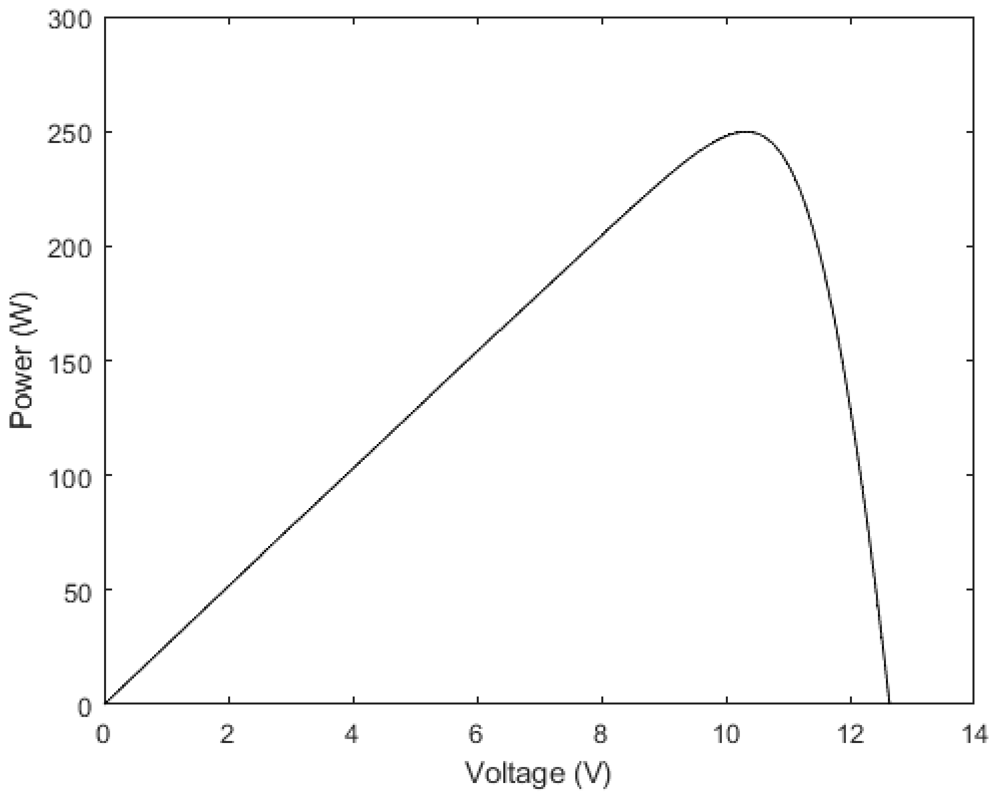

Fig 11: P-V characteristics of a Solar PV module connected in parallel

PROCEDURE:

1. Place the solar module and the light/source opposite to each cell.
2. Connect the circuit as shown in figures (Fig.1, Fig. 2 and Fig.3).
3. Select the voltmeter and ammeter to required range.
4. Expose the light on Solar module (Switch ON the lamp).
5. Set the distance between solar module and source/lamp in such a way that current meter shows deflections.
6. Note down the observation of voltage and current and tablet them.
7. Vary the load resistance and note down the current and voltage readings.
8. Plot a graph between output voltage vs. output current by taking voltage along X-axis and current along Y-axis.
9. Plot a graph between output voltage vs. output power by taking voltage along X-axis and power along Y-axis.

Simulation of V-I and P-V characteristics of PV module, Series and Parallel connection of PV modules

Expt. No: **Date:**

Result:

Post Test Questions (Viva):

1. What is the effect of change in irradiation and temperature on output of a PV module?
2. Draw the VI characteristics of a PV module at different temperatures with constant irradiation.
3. Draw the VI characteristics of a PV module at different irradiations with constant temperature.

Simulation of V-I and P-V characteristics of PV module, Series and Parallel connection of PV modules

Expt. No: **Date:**

Practical Verification of V-I and P-V Characteristics of PV module, Series and Parallel connection of PV modules

Expt.No: **Date:**

Aim:

To conduct an experiment and draw the V-I and P-V characteristics of PV module, Series and Parallel connection of PV module.

Apparatus:

PV modules, Ammeter, Voltmeter, Resistors (Rheostats)

Circuit Diagram:

Solar PV module:

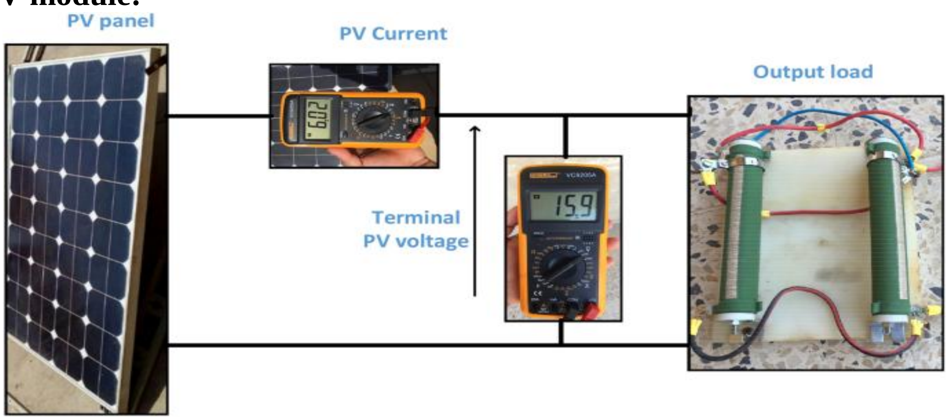

Fig 1: Solar PV module voltage and current measurement

Three PV modules connected in Series:

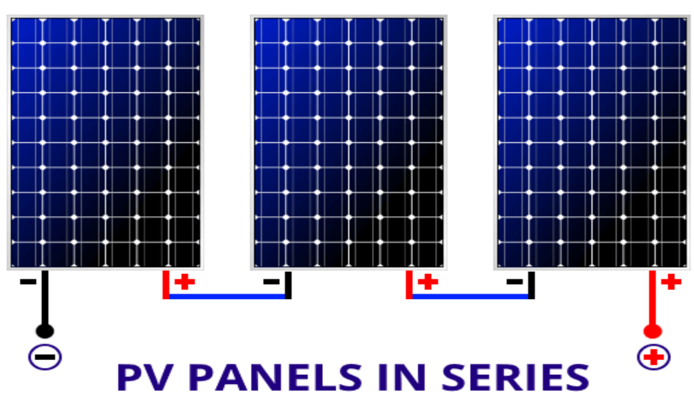

Fig 2: Voltage and current measurement of three solar PV modules connected in series

Three PV Modules Connected in Parallel:

Practical Verification of V-I and P-V Characteristics of PV module, Series and Parallel connection of PV modules

Expt.No: **Date:**

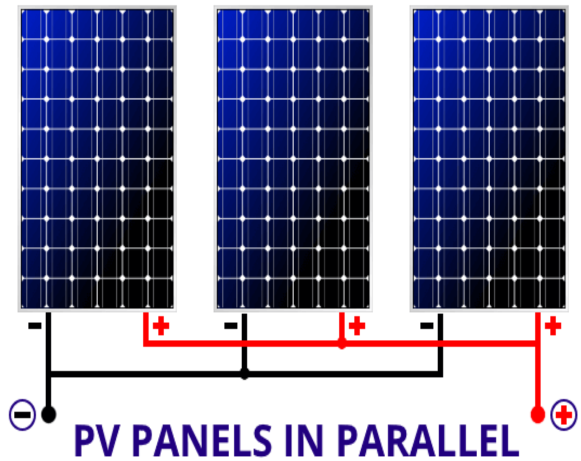

Fig 3: Voltage and current measurement of three PV modules connected in parallel

Theory:

A single solar cell cannot provide required useful output. So to increase output power level of a PV system, it is required to connect number of such PV solar cells. A solar module is normally series connected sufficient number of solar cells to provide required standard output voltage and power. One solar module can be rated from 3 watts to 300 watts. The solar modules or PV modules are commercially available basic building block of a solar electric power generation system.

Actually a single solar PV cell generates very tiny amount that is around 0.1 watt to 2 watts. But it is not practical to use such low power unit as building block of a system. So required number of such cells are combined together to form a practical commercially available solar unit which is known as solar module or PV module.

In a solar module the solar cells are connected in same fashion as the battery cell units in a battery bank system. That means positive terminals of one cell connected to negative terminal voltage of solar module is simple sum of the voltage of individual cells connected in series in the module.

The output from a solar module depends upon some conditions such as ambient temperature and intensity of incidence light. Hence the rating of a solar module must be specified under such conditions. It is standardized practice to express rating of PV or solar module at 25^{o}C temperature and 1000 w/m^2 light radiation. The solar modules are rated with their output open circuit voltage (Voc), short circuit current (Isc) and peak power (Wp). That means these three parameters (Voc, Isc and Wp) can be delivered by a

Practical Verification of V-I and P-V Characteristics of PV module, Series and Parallel connection of PV modules

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solar module safely at 25^{o}C and 1000 w/m^2 solar radiations. These conditions i.e. 25^{o}C temperature and 1000 w/m^2 solar radiations are collectively called Standard Test Conditions.

Procedure:

1. Place the solar module and the light/source opposite to each module.
2. Connect the circuit as shown in figures (Fig.1, Fig. 2 and Fig.3).
3. Select the voltmeter and ammeter to required range.
4. Expose the light on Solar Cell (Switch ON the lamp).
5. Set the distance between solar module and source/lamp in such a way that current meter shows deflections.
6. Note down the observation of voltage and current and tablet them.
7. Vary the load resistance and note down the current and voltage readings.
8. Plot a graph between output voltage vs. output current by taking voltage along X-axis and current along Y-axis.
9. Plot a graph between output voltage vs. output power by taking voltage along X-axis and power along Y-axis.
10.

Observations:
Solar PV cell:

Potentiometer (Ω)	Output Voltage (V)	Output Current (A)

Three cells are connected in Series:

Potentiometer (Ω)	Output Voltage (V)	Output Current (A)

Three cells are connected in Parallel:

Practical Verification of V-I and P-V Characteristics of PV module, Series and Parallel connection of PV modules

Expt.No: **Date:**

Potentiometer (Ω)	Output Voltage (V)	Output Current (A)

Output Characteristics:

Solar PV module:

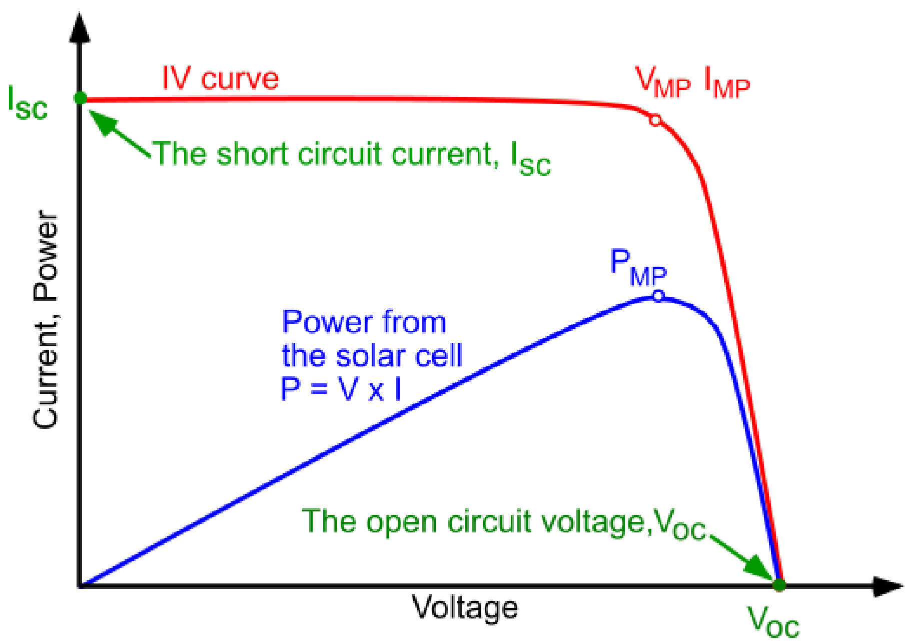
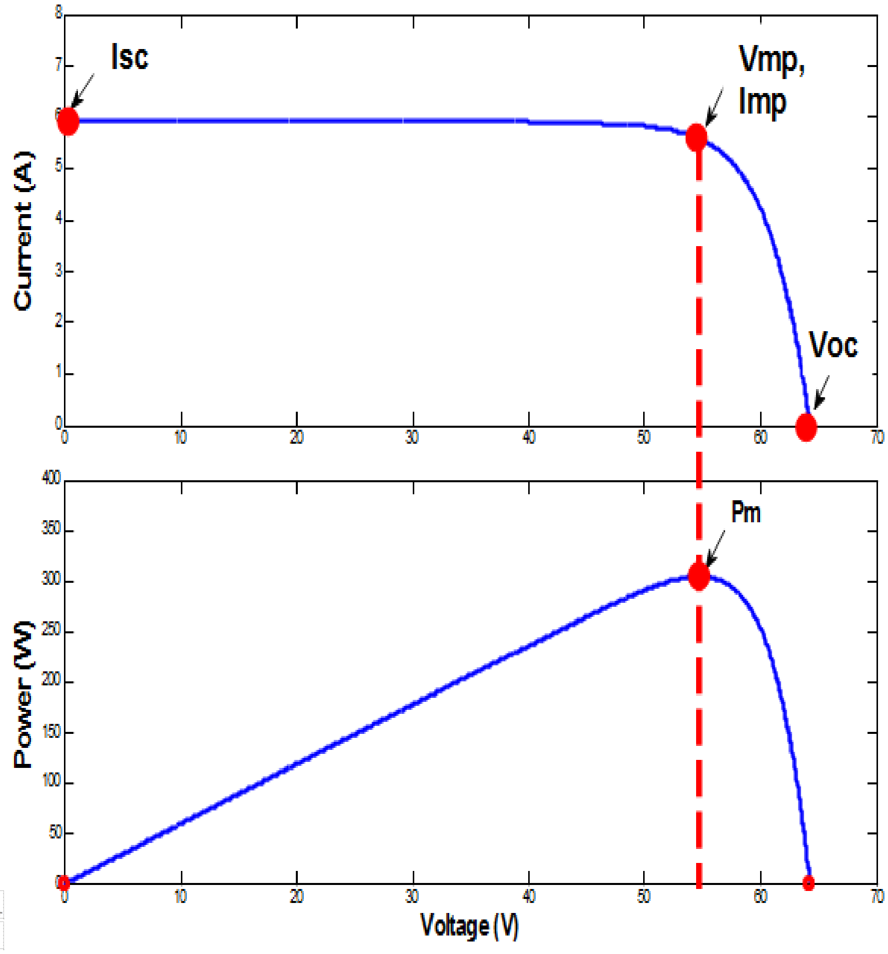


Fig 4: V-I and P-V characteristics of a Solar PV module.

Characteristics for three modules are connected in Series:

Practical Verification of V-I and P-V Characteristics of PV module, Series and Parallel connection of PV modules

Expt.No: **Date:**



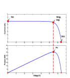


Fig 5: I-V and P-V characteristics when three modules are connected in Series

Characteristics for three modules are connected in Parallel:

Practical Verification of V-I and P-V Characteristics of PV module, Series and Parallel connection of PV modules

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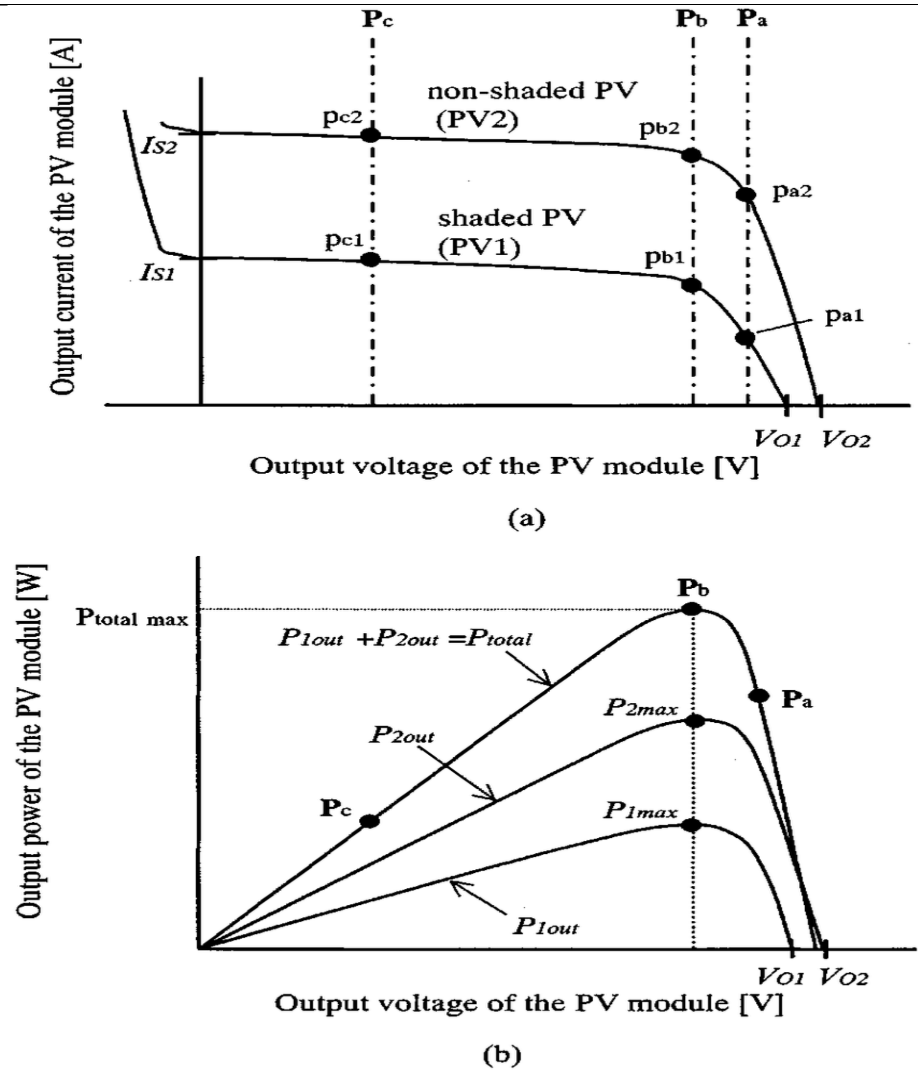

Fig 6: I-V and P-V characteristics when three modules are connected in parallel.

Result:

Practical Verification of V-I and P-V Characteristics of PV module, Series and Parallel connection of PV modules

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Graph:

Practical Verification of V-I and P-V Characteristics of PV module, Series and Parallel connection of PV modules

Expt.No: **Date:**

Practical Verification of V-I and P-V Characteristics of PV module, Series and Parallel connection of PV modules

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Practical Verification of V-I and P-V Characteristics of PV module, Series and Parallel connection of PV modules

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Post Test Questions (Viva):

1. Define the following
   String ii) Array iii) Angle of inclination iv) Solar constant

2. Model a PV systems for a load of 23Amperes, 300 Volts with a PV module rating of 30 Watts, 7.8 Amps, 26 Volts

3. Design a PV module for your domestic load with different load.

Practical Verification of V-I and P-V Characteristics of PV module, Series and Parallel connection of PV modules

Expt.No: **Date:**

Practical Verification of V-I and P-V Characteristics of PV module, Series and Parallel connection of PV modules

Expt.No: **Date:**

Simulation of MPPT Technique on PV Array

Expt. No: **Date:**

Aim:

To simulate maximum power point tracking (MPPT) technique (Perturb and Observe method only) on PV array.

Apparatus:

Personal Computer
MATLAB software

Circuit Diagram:

The product of the voltage and current is the power delivered by the PV panel. The maximum power point (MPP) is at the knee of the I-V curve where the product of voltage and current reaches the maximum. The I-V characteristics of PV panels will vary with irradiance and temperature. Hence, the maximum power point will vary accordingly. The general MPPT control block diagram is as shown in Fig.1. The input of the DC-DC converter is connected to a solar panel and output is connected to a load.

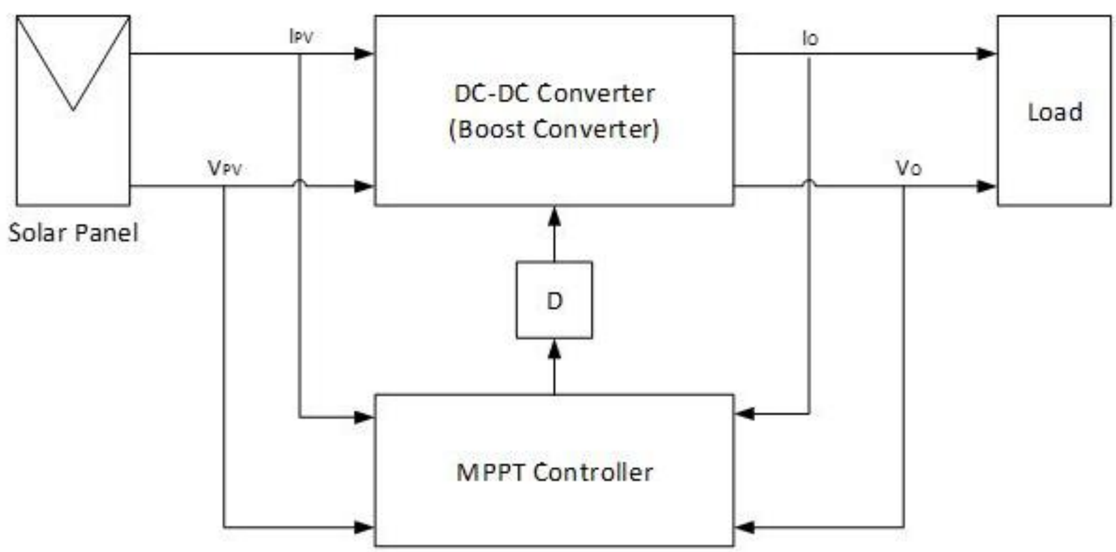

Fig 1: MPPT control block diagram of a solar panel

The MPPT controller takes feedback from PV panel voltage V_{PV}, PV panel current I_{PV}, output voltage V_O and current I_O from DC-DC converter, then uses Perturb and Observe (P&O) control algorithms to calculate duty cycle for the DC-DC converter. The Simulink block diagram for MPPT control with P&O method is as shown in Fig. 2.

Simulation of MPPT Technique on PV Array

Expt. No: **Date:**

Theory:

From the I-V and P-V curves for a PV panel, the important parameters such as open-circuit voltage V_{oc}, and the short-circuit current I_{sc} can be identified as shown in Fig. 2. The product of the voltage and current is the power delivered by the PV module. The output power is zero at the two ends of the I-V curve because either voltage or current is zero at those points. The maximum power point (MPP) is at the knee of the I-V curve where the product of voltage and current reaches the maximum. In Fig 2, it shows the voltage at maximum power point (MPP) is V_R, and the current at MPP is I_R.

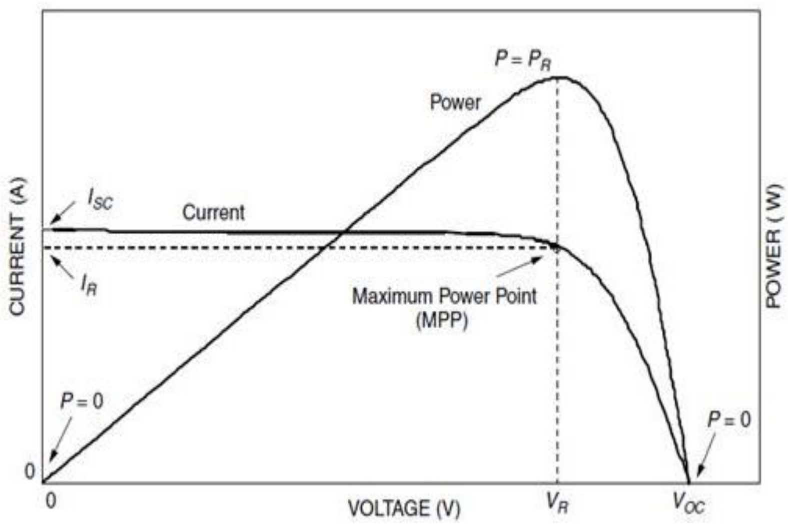

Fig 2: I-V curve and P-V curve for a PV module

The most commonly used MPPT control algorithm is Perturb and Observe (P&O) method. This method measures the PV panel's output voltage and current, and then perturbs the operating point to determine the change direction. From the P-V curve in Fig 2, when operating on the left of the MPP, incrementing the voltage increases the power, and decrementing the voltage decreases the power. On the other hand, when operating on the right of the MPP, incrementing the voltage decrease the power, and decrementing the voltage increases the power. Therefore, if there is an increase in power, the subsequent perturbation should be in the same direction to reach the MPP. If there is a decrease in power, the perturbation should reverse direction to reach the MPPT. Fig 3 shows the flowchart for P&O control algorithm. Table 1 shows how to determine the direction of next perturbation.

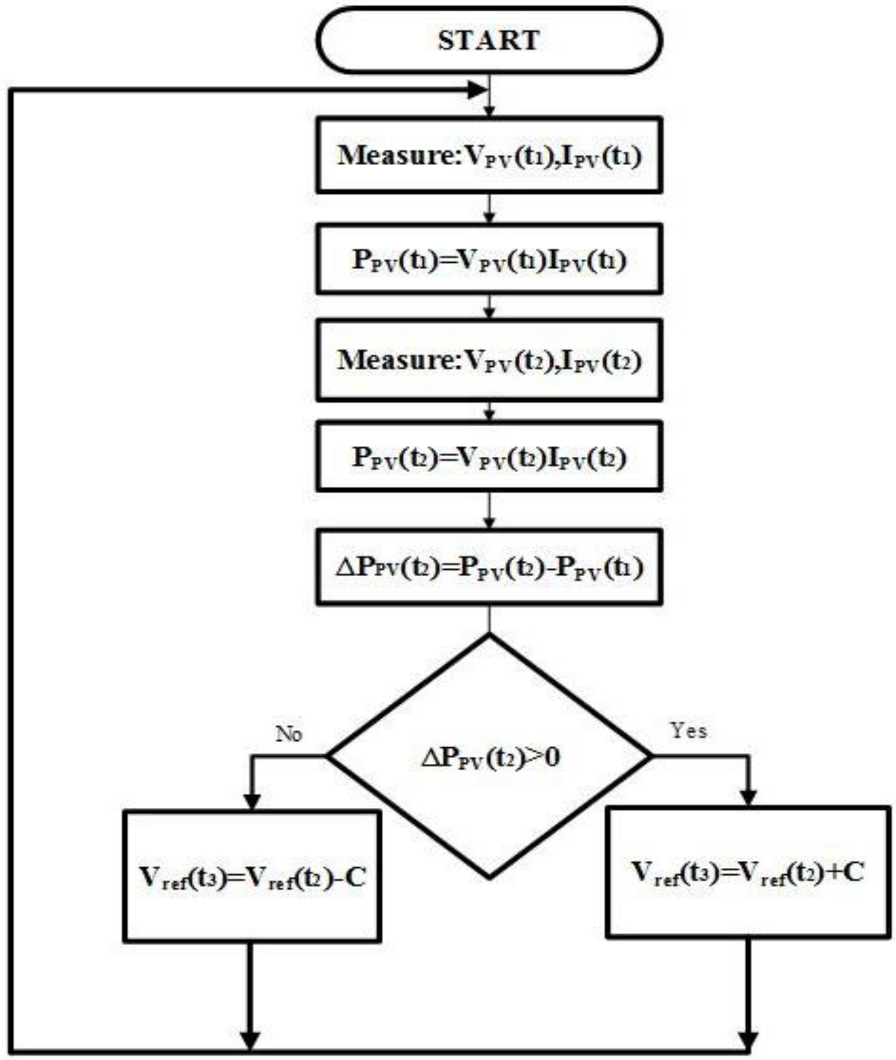

Fig 3: Perturb and observe control algorithm

Table 1. Directions of perturbation for P&O algorithm

Perturbation	Change in Power	Next Perturbation
Positive	Positive	Positive
Positive	Negative	Negative
Negative	Positive	Negative
Negative	Negative	Positive

Simulation of MPPT Technique on PV Array

Expt. No: **Date:**

Procedure

(A) Maximum Power Point Tracking (Block Diagram)

1. Connect the blocks for MPPT control.

(B) Maximum Power Point Tracking (Flowcharts)

1. Complete the flowchart for Perturb & Observe (P&O) control algorithm for MPPT.
2. Complete the flowchart for Incremental Conductance control algorithm for MPPT.

(C) Maximum Power Point Tracking (Control)

1. Give the value of 1000 W/m^2 to irradiation, and value of 25 ℃ to temperature.
2. Start the MPPT control. Observe the solar panel's output voltage, current and power.
3. Plot the IV curve and identify the maximum power point on the IV and PV curve.
4. Compare the voltage, current and power from the MPPT control with the values of maximum power point on IV and PV curve.
5. Repeat the MPPT control for irradiation from 800 to 1200 W/m^2 with an interval of 100 W/m^2
6. Verify the MPPT control is able to reach the maximum power point when irradiation changes.

Result:

Post Test Questions (Viva):

1. What do you mean by MPPT? List the types of MPPTs.
2. What is the necessity of MPPT concept?
3. What parameters gets affected with shadowing on PV module?

Simulation of MPPT Technique on PV Array

Expt. No: **Date:**

Simulation of MPPT Technique on PV Array

Expt. No: **Date:**

Simulation of Solar PV System

Expt. No: **Date:**

Aim:

To simulate the solar PV system using HOMER Pro software.

Apparatus:

Personal Computer
HOMER Pro software

Theory:

HOMER stands for Hybrid Optimization Model for Electric Renewables. Midwest Research Institute has the copyrights of this software. It was developed by National Renewable Energy Laboratory (NREL) of United States. It is used to help the designing of various power plant configurations. It has different built in components in it such as PV panels, Wind turbines, Utility loads of various kinds, Generators, Converters and Battery Backup etc. It is used to simulate various schematics of power plants and then those schematics are simulated to find most optimized power plant configuration with respect to operating cost, net present cost (NPC), gases emission and economic comparison etc. The demand of electricity is increasing throughout the world. Needed to design some innovative new renewables energy systems which can decrease the dependence on conventional energy resources. Non-conventional sources of energy (solar) can play a very important role in fulfilling the energy demand of the world. Solar power generation using PV is very simple in construction, compact and can be installed domestically for power generation. Solar resource data shows amount of solar radiations that strikes with the earth surface in a typical year. In HOMER Pro this is the input parameter for Solar GHI Resource. That data is fed to the HOMER Pro

Procedure:

1. First select the location by adding name in search option by giving the location coordinates as shown in the Fig 1. Based on the location (latitude and longitude) the resources will be available.
2. The loads are selected (the load may be residential, commercial and industrial used as an average daily load (kWh/day)) and the peak month is assumed to April month. The load in the study which is commercial as shown in Fig 2.
3. Select the PV in kW rating as per load requirement. Add the capital cost and replacement cost. The block diagram of solar PV system is as shown in Fig.3.
4. After adding the PV, suitable suggestions can be observed as shown in Fig.4. Solar GHI resource, It may be exported/downloaded with internet as given by location, or manually added which is shown in below Fig 4.

Simulation of Solar PV System	
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5. Add a converter as shown in Fig.5 to the model as the load is AC type and PV will generate DC. If the load is less than power generation, the excess power will be stored in batteries or any other energy storage elements as shown in Fig.6.
6. After adding all loads, resources and components the complete PV system model represents as shown in Fig 7.
7. To run the model, click on "calculate". Then the model will be simulated and gives the optimal results.

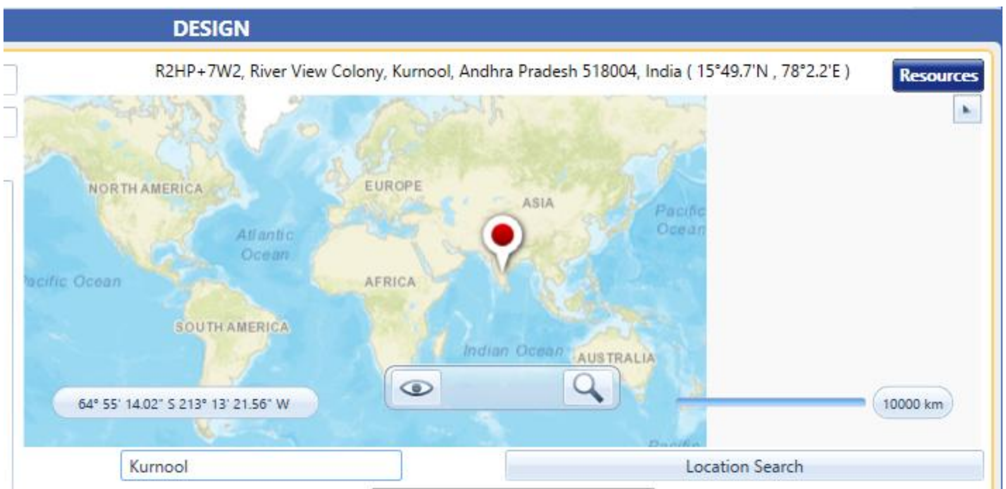

Fig 1: Diagram of search of location.

Fig 2: Selection of load(s) profile.

Simulation of Solar PV System

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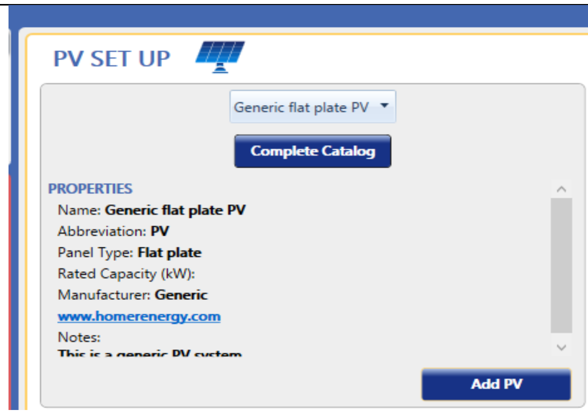


Fig 3: Selection of Solar PV

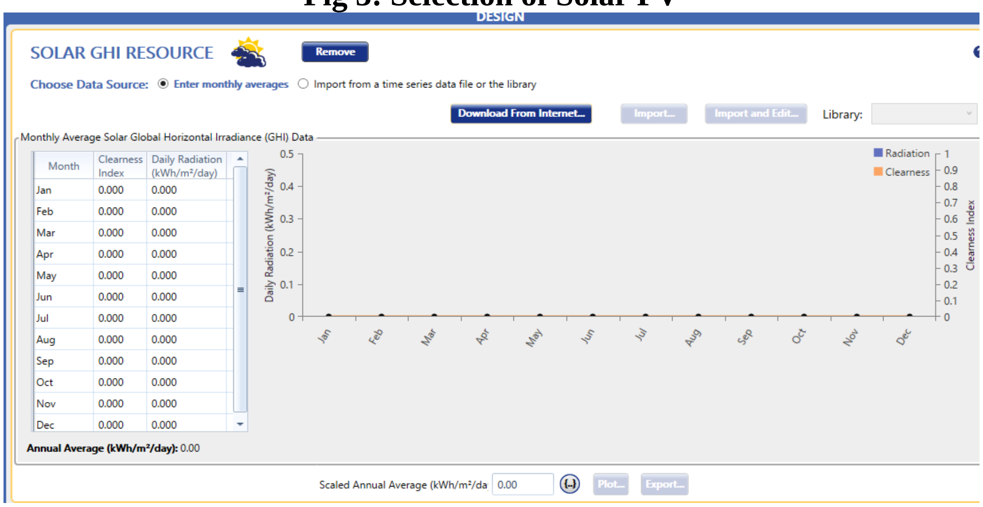


Fig 4: Exporting or downloading of resource

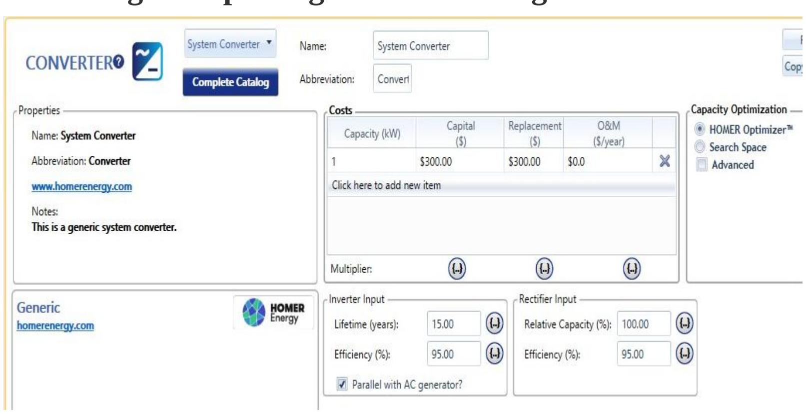


Fig 5: Adding of converter to the model

Simulation of Solar PV System	
Expt. No:	**Date:**

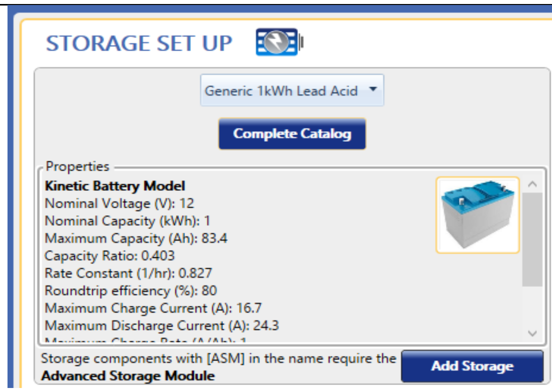


Fig 6: Adding of storage device.

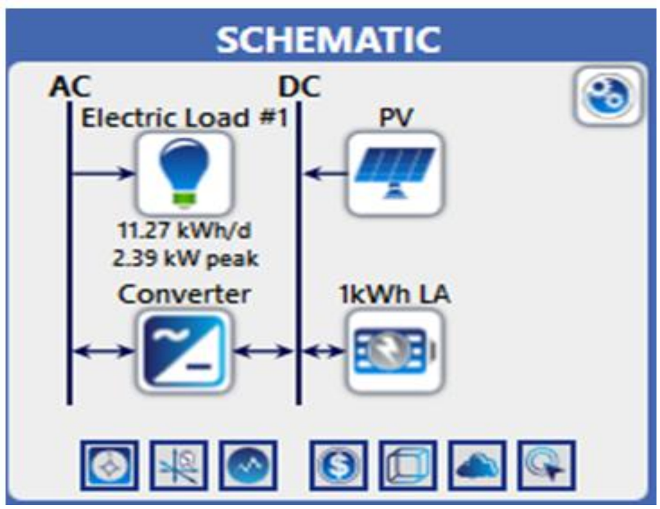


Fig 7: Schematic diagram/model of solar PV system using HOMER Pro software

Result:

Post Test questions (Viva):

1. What is the necessity of converter in Homer software?
2. List the types of resources available in Homer software.
3. What is Homer and what is its purpose in Renewable energy systems?

Simulation of Solar PV System

Expt. No: **Date:**

Simulation of Solar PV System

Expt. No: **Date:**

Simulation of Wind Turbine System	
Expt. No:	**Date:**

Aim:

To simulate the Wind turbine system using HOMER Pro software.

Apparatus:

Personal Computer
HOMER Pro software

Theory:

The HOMER Pro® microgrid software by HOMER Energy is the global standard for optimizing microgrid design in all sectors, from village power and island utilities to grid-connected campuses and military bases. Homer Pro, or HOMER (Hybrid Optimization of Multiple Electric Renewables), simplifies the task of evaluating designs for both off-grid and grid-connected power systems. The large number of technology options, variation in costs, and availability of energy resources make these decisions difficult. HOMER's optimization and sensitivity analysis algorithms make it easier to evaluate the many possible system configurations.

Wind power system can play a very important role in fulfilling the energy demand of the world. The wind turbine shows a complete wind power plant with an AC output. In schematic wind turbine symbol G3 shows a complete wind power plant. Wind turbines costs approximately 70% of the entire project. In HOMER Pro this is the input parameter for wind resource. That data is fed to the HOMER Pro software.

Procedure:

1. First select the location by adding name in search option by giving the location coordinates as shown in the Fig 1. Based on the location (latitude and longitude) the resources will be available.
2. The loads are selected (the load may be residential, commercial and industrial used as an average daily load (kWh/day)) and the peak month is assumed to April month. The load in the study which is commercial as shown in Fig 2.
3. Select the wind turbine generator in kW rating as per load requirement. Add the capital cost and replacement cost. The block diagram of wind turbine system is as shown in Fig.3.
4. After adding the wind turbine generator, suitable suggestions can be observed as shown in Fig.4. Adding of wind resource, It may be exported/downloaded with internet as given by location, or manually added which is shown in below Fig 4.
5. Next add number of wind turbines and its ratings to model as shown in Fig 5.

Simulation of Wind Turbine System

Expt. No: **Date:**

6. Add a converter as shown in Fig.6 to the model as the load is AC type and wind power will also generate AC. Excessive generation will be storied in batteries or any other energy storage elements as shown in Fig.7.
7. After adding all loads, resources and components the complete Wind turbine system model represents as shown in Fig 8.
8. To run the model, click on "calculate". Then the model will be simulated and gives the optimal results.

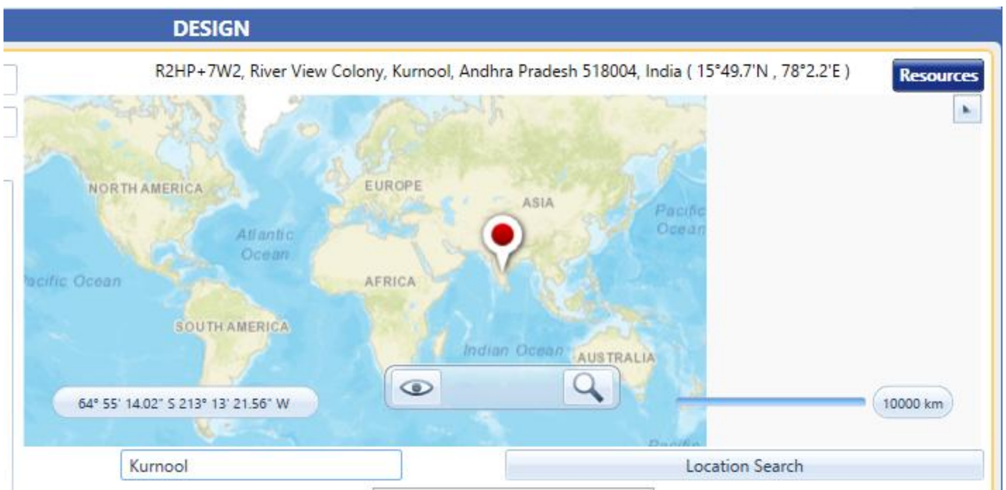


Fig 1: Diagram of search of location.

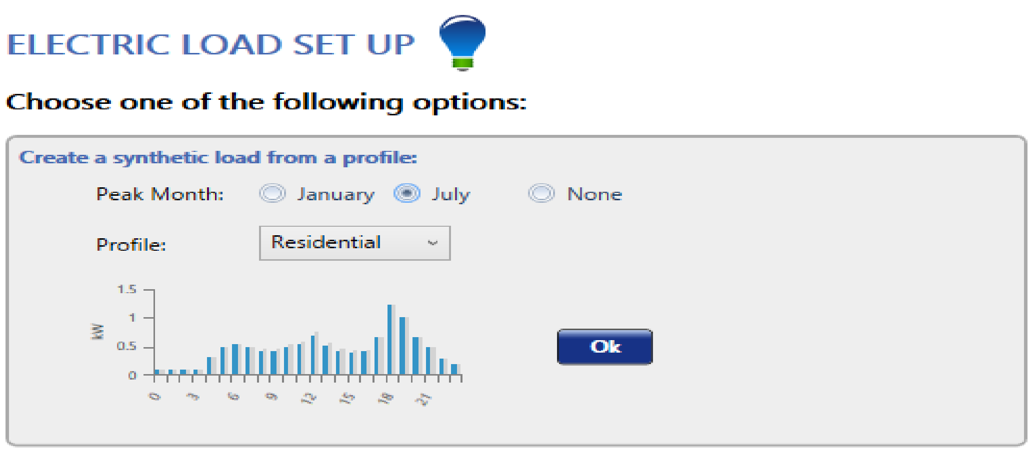


Fig 2: a) Systematic load selection.

Simulation of Wind Turbine System

Expt. No: **Date:**

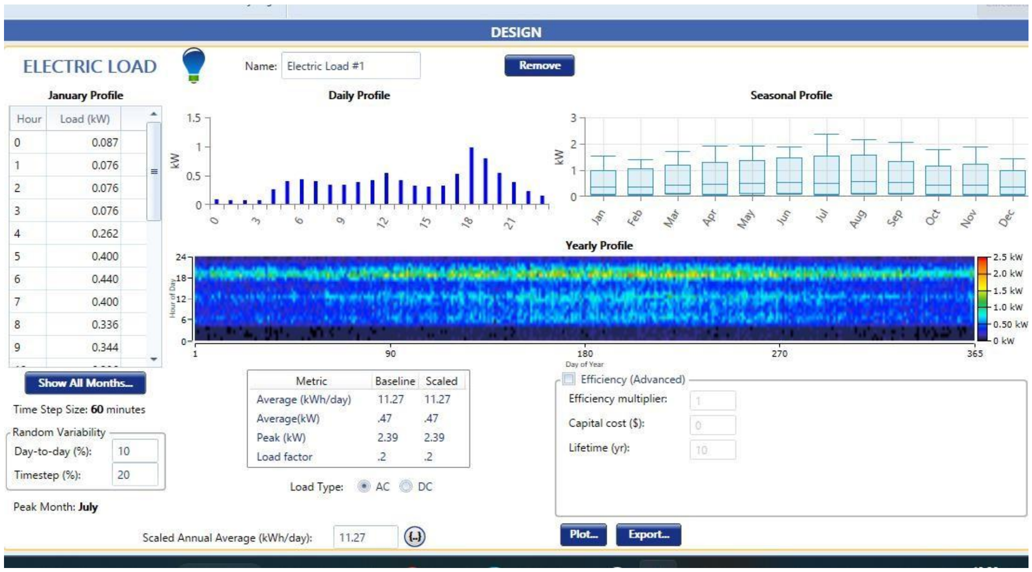


Fig 2: b) Selection of load(s) profile.

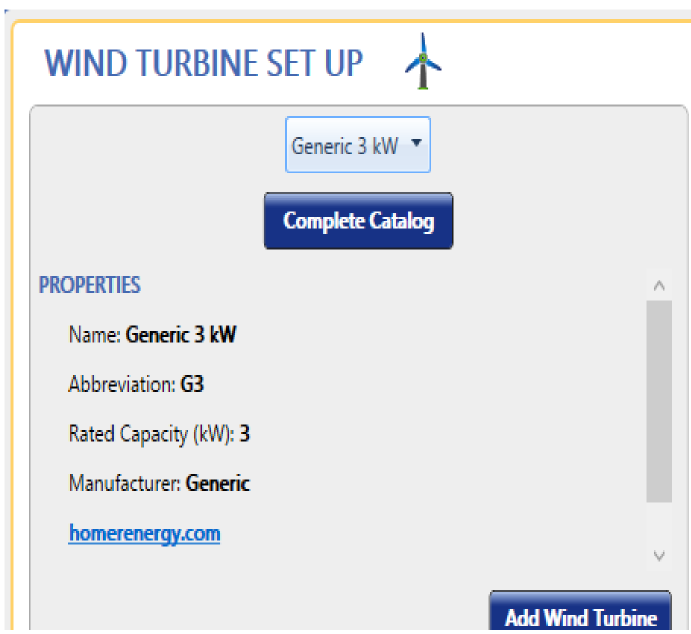


Fig 3: Selection of Wind turbine generator (WTG).

Simulation of Wind Turbine System

Expt. No: **Date:**

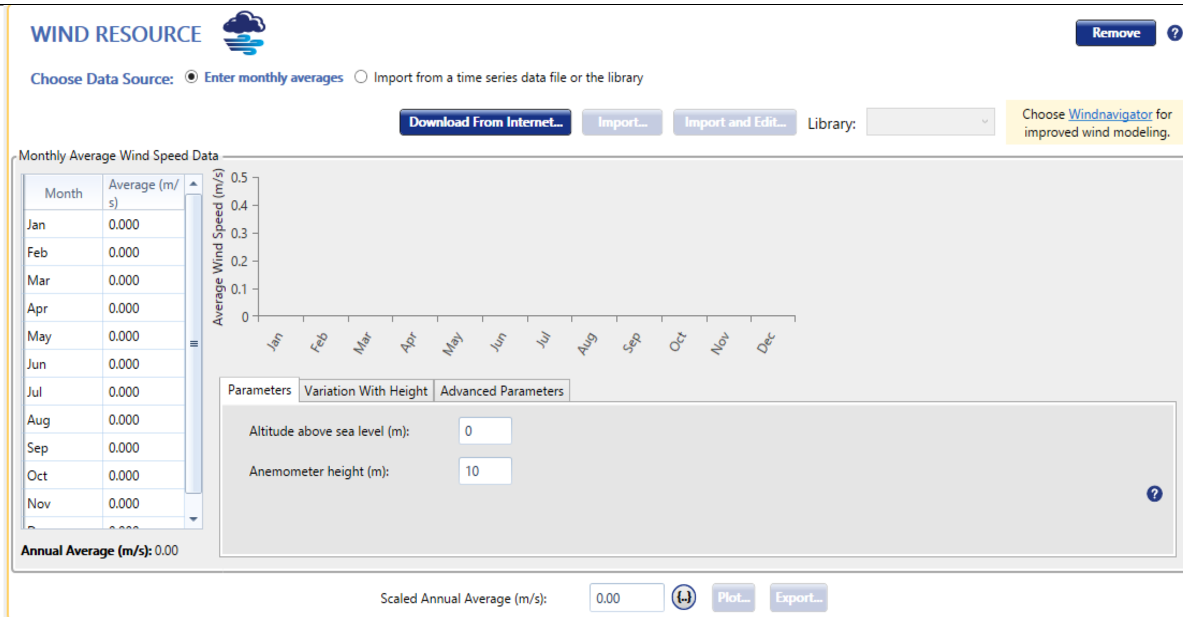


Fig 4: Exporting or downloading of Wind resource.

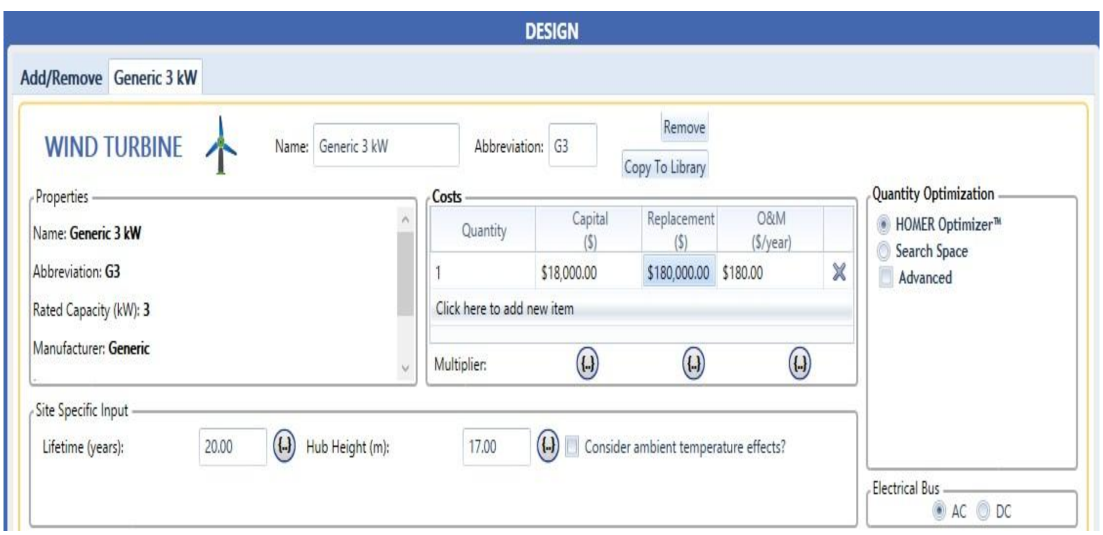


Fig 5: Adding/ rating of wind turbine

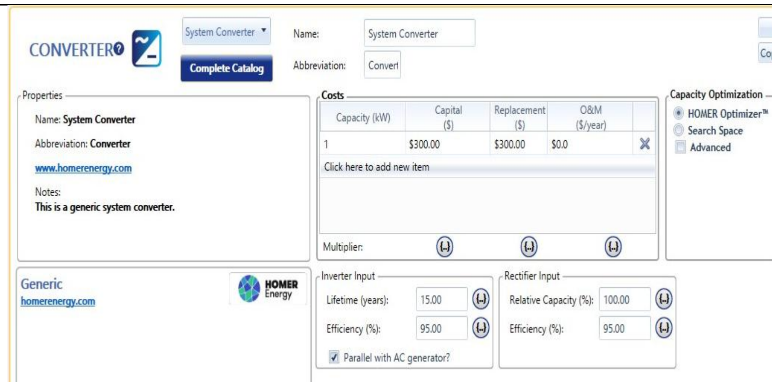


Fig 6: Adding of converter to the model.

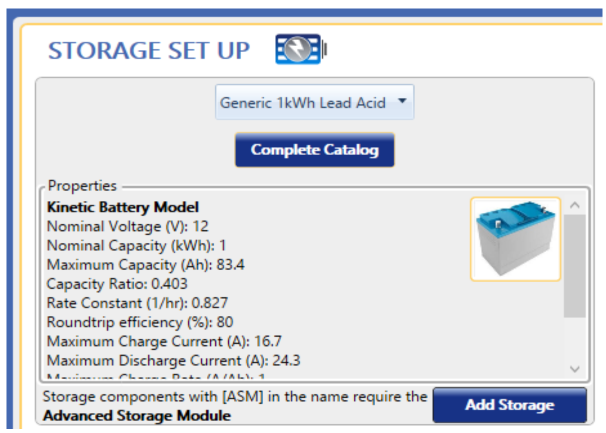


Fig 7: Adding of storage device.

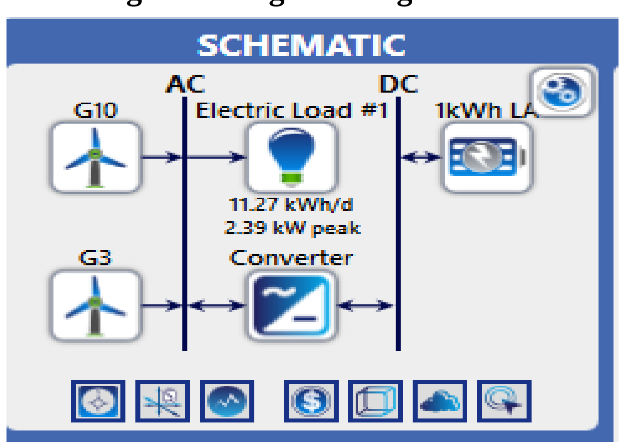


Fig 8: Schematic diagram/model of Wind turbine system using HOMER Pro software

Simulation of Wind Turbine System

Expt. No: **Date:**

Result:

Post Test Questions (Viva);

1. Why Homer suggest the selection or adding of storage device during simulation?
2. Which device is necessary when DC type of load is added to the model?
3. Write a short note on report generation in Homer.

Simulation of Wind Turbine System

Expt. No: **Date:**

Simulation of Solar PV and Wind Turbine combination System

Expt. No: **Date:**

Aim:

To simulate the wind turbine system using HOMER Pro software

Apparatus:

Personal Computer
HOMER Pro software

Theory:

The HOMER Pro® microgrid software by HOMER Energy is the global standard for optimizing microgrid design in all sectors, from village power and island utilities to grid-connected campuses and military bases. Homer Pro, or HOMER (Hybrid Optimization of Multiple Electric Renewables), simplifies the task of evaluating designs for both off-grid and grid-connected power systems. The large number of technology options, variation in costs, and availability of energy resources make these decisions difficult. HOMER's optimization and sensitivity analysis algorithms make it easier to evaluate the many possible system configurations.

Wind power system can play a very important role in fulfilling the energy demand of the world. The wind turbine shows a complete wind power plant with an AC output. In schematic wind turbine symbol G3 shows a complete wind power plant. Wind turbines costs approximately 70% of the entire project. In HOMER Pro this is the input parameter for Solar GHI Resource. That data is fed to the HOMER Pro software.

Procedure:

1. First select the location by adding name in search option by giving the location coordinates as shown in the Fig 1. Based on the location (latitude and longitude) the resources will be available for both solar and wind.
2. The loads are selected (the load may be residential, commercial and industrial used as an average daily load (kWh/day)) and the peak month is assumed to April month. The load in the study which is commercial as shown in Fig 2.
3. Select the PV in kW rating as per load requirement. Add the capital cost and replacement cost. The block diagram of solar PV system is as shown in Fig.3.
4. After adding the PV, suitable suggestions can be observed as shown in Fig.4. Solar GHI resource, It may be exported/downloaded with internet as given by location, or manually added which is shown in below Fig 4.

Simulation of Solar PV and Wind Turbine combination System

Expt. No: **Date:**

5. Select the wind turbine generator in kW rating as per load requirement. Add the capital cost and replacement cost. The block diagram of wind turbine system is as shown in Fig 5.
6. After adding the wind turbine generator, suitable suggestions can be observed as a adding of resource (wind resource). It may be exported/downloaded with internet as given by location, or manually added which is shown in below Fig 6.
7. Next add number of wind turbines and its ratings to model as shown in Fig 7.
8. Add a converter as shown in Fig 8 to the model as the load is AC type and PV will generate DC. If the load is less than power generation (or if the load is less than generation it will be converted to DC), the excess power will be stored in batteries or any other energy storage elements as shown in Fig.9.
9. After adding all loads, resources and components the complete PV system model represents as shown in Fig 10.

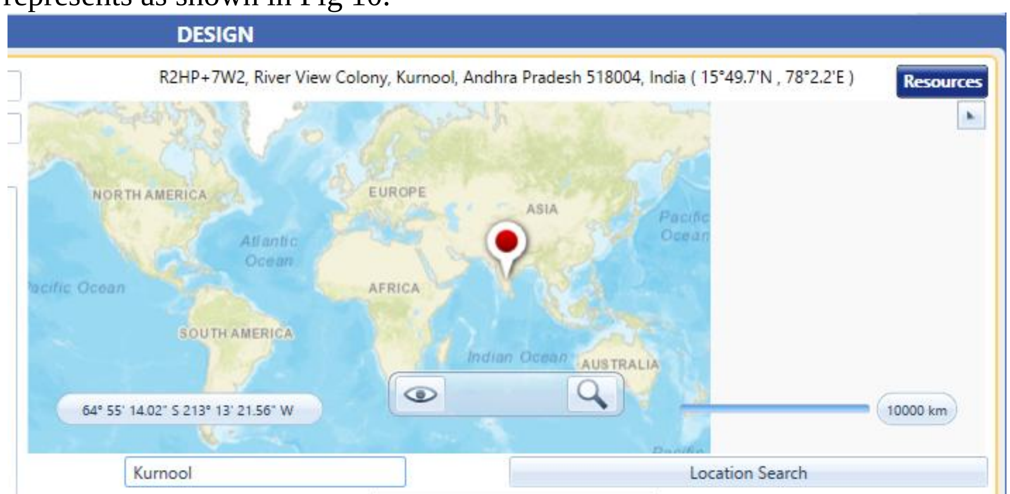
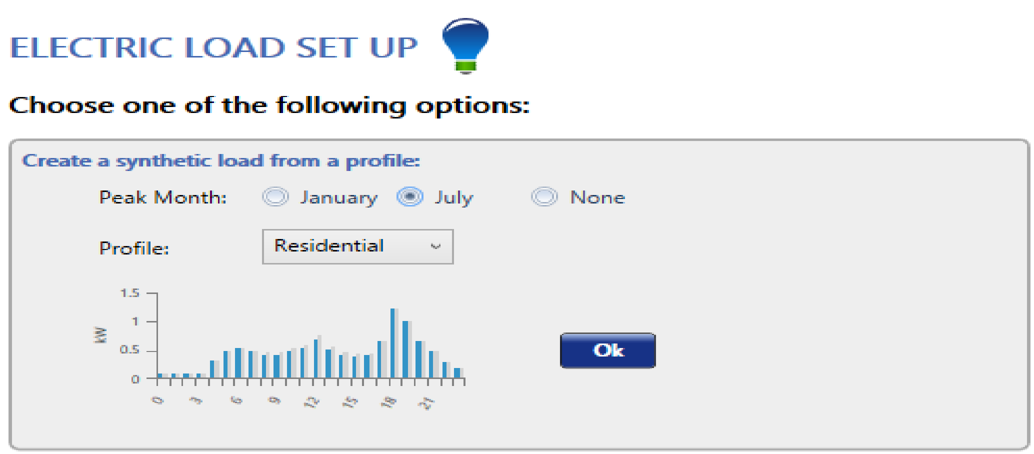


Fig 1: Fig 1: Diagram of search of location.



Simulation of Solar PV and Wind Turbine combination System

Expt. No: **Date:**

Fig 2: a) Systematic load selection.

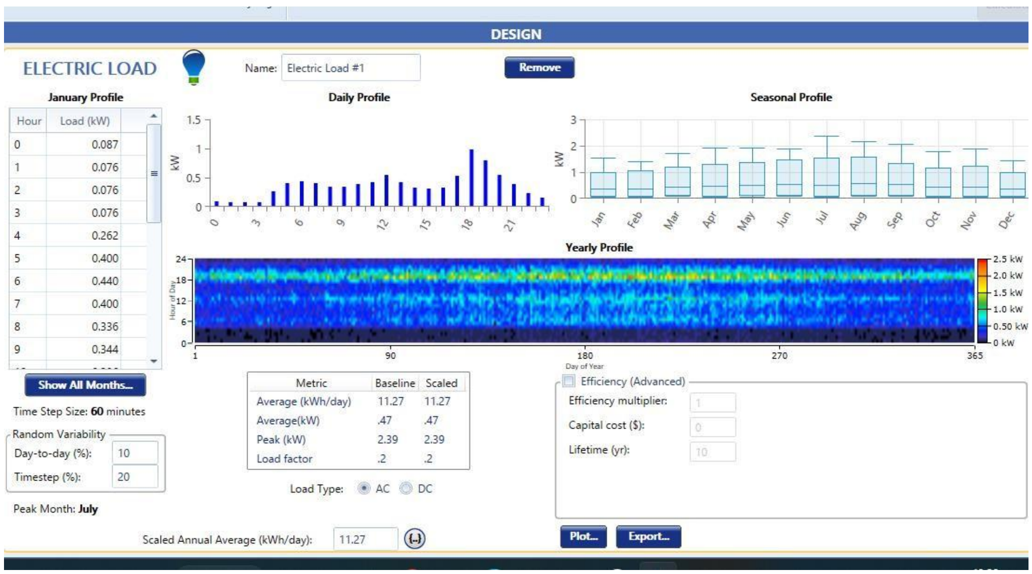


Fig 2: b) Selection of load(s) profile.

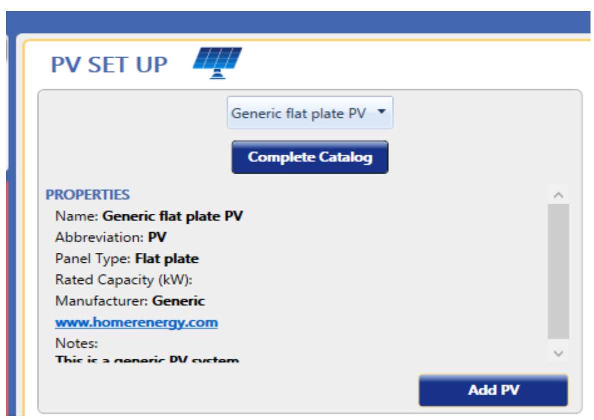


Fig 3: Selection of Solar PV

Simulation of Solar PV and Wind Turbine combination System

Expt. No: **Date:**

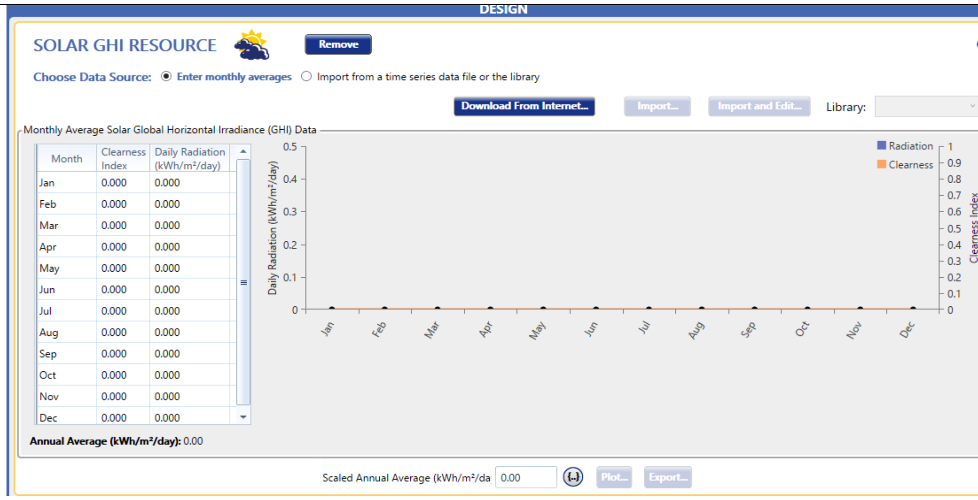


Fig 4: Exporting or downloading of resource

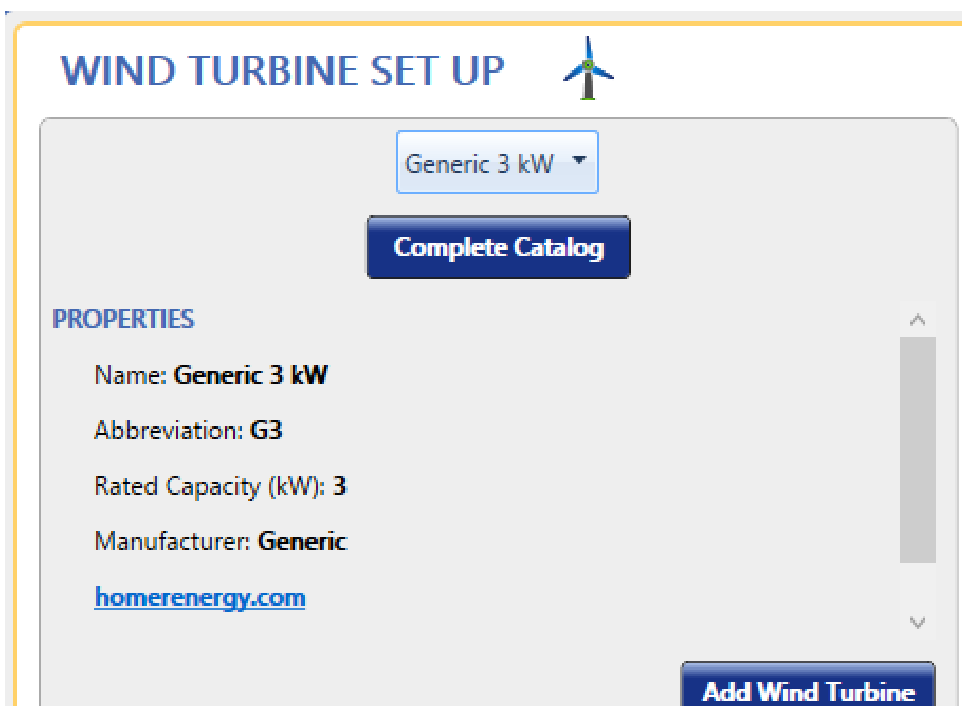


Fig 5: Selection of Wind turbine generator (WTG).

Simulation of Solar PV and Wind Turbine combination System

Expt. No: **Date:**

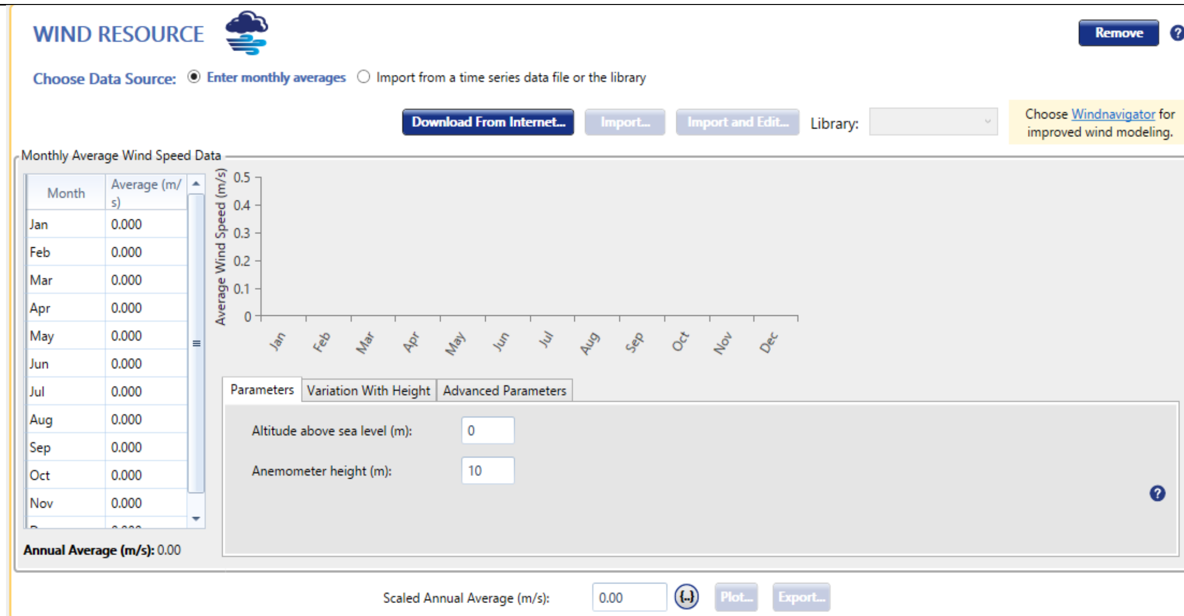


Fig 6: Exporting or downloading of Wind resource.

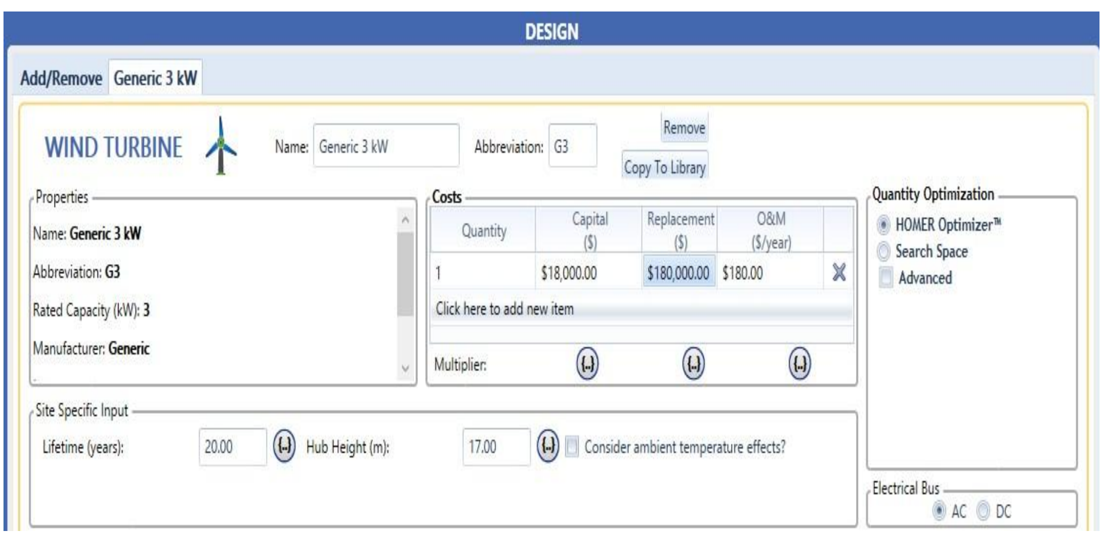


Fig 7: Adding/ rating of wind turbine

Simulation of Solar PV and Wind Turbine combination System

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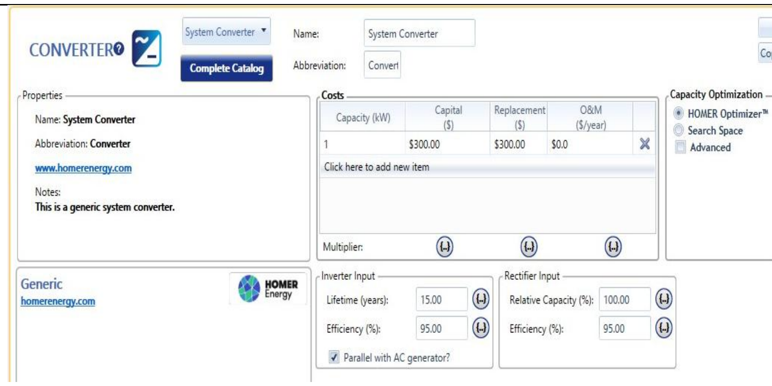

Fig 8: Adding of converter to the model.

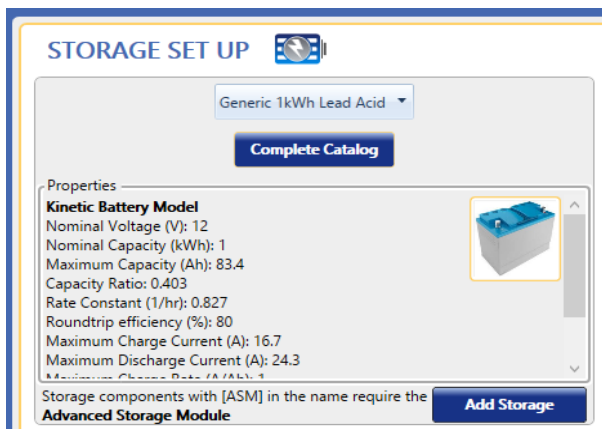

Fig 9: Adding of storage device.

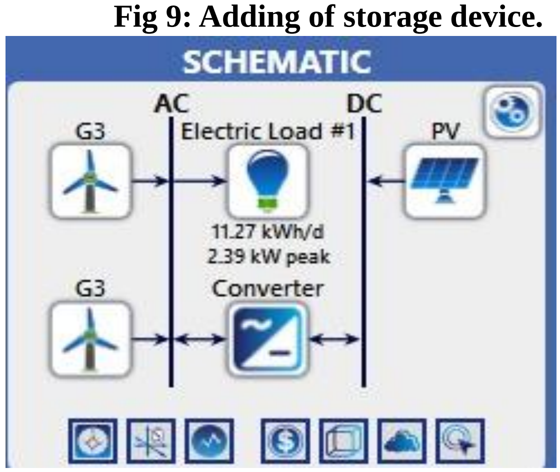

Fig 10: Schematic diagram/model of solar PV and Wind turbine system using HOMER Pro software

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Result:

Post Test Questions (Viva);

1. What types of load selection are available in Homer? Explain briefly about them.
2. What is Global Horizontal Irradiance (GHI) and Direct Normal Irradiance (DNI)?
3. What is the minimum wind speed required to generate the power and why?

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