SOLAR SIMULATOR KIT

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ABSTRACT

Renewable technologies are playing an increasingly important role in supplying the world's electricity demands. In particular, the photovoltaic (PV) generation system, a promising source of energy for the future, is evolving rapidly and showing an Industrial growth of approximately 40% per year worldwide. Photovoltaic (PV) generation is gaining increased importance as a renewable source due to its advantages like absence of fuel cost, little maintenance, no noise and wear due to absence of moving parts, etc. Thus Solar simulators has been developed which is used in the production testing of PV modules.

Basically A Solar simulator kit is an important tool to measure the performance of solar cell. The purpose of the solar simulator kit is to provide a controllable indoor test facility under laboratory conditions, used for the testing of solar cells. At present Xenon and Halogen lamps are mostly used in the laboratories, but we used different artificial light sources and sunlight in our methodology which is low cost, easy to operate, portable, ecofriendly, long life and has good capability. This methodology presents the design, fabrication and realistic model of solar simulation for practical applications to measure I-V and P-V characteristics of solar cell under different conditions like series and parallel connections, effect of temperature, effect of various filters and at different elevation angles are also studied.

Due to the interesting features of solar simulator, It can be used in PV module manufacturing industries for PV testing in future. Research and development efforts in solar and other renewable energy technologies are required to continue for, improving their performance, establishing techniques for accurately predicting their output and reliably integrating them with other conventional generating sources.

Keyword: - *Photovoltaic (PV), Current Voltage (I-V), Power Voltage (P-V).*

1. INTRODUCTION

A solar simulator kit is a device that provides illumination approximating natural sunlight. The purpose of the solar simulator kit is to provide a controllable indoor test facility under laboratory conditions, used for the testing of solar cells, sun screen, plastics, and other materials and devices. Solar simulators can be divided into three broad categories: continuous, flashed, and pulsed. The first type is a familiar form of light source in which illumination is continuous in time. The specifications discussed in the previous section most directly relate to this type of solar simulator. This category is most often used for low intensity testing, from less than 1 sun up to several suns. In this context, 1 sun is typically defined as the nominal full sunlight intensity on a bright clear day on Earth, which measures 1000 W/m2. Continuous light solar simulators may have several different lamp types combined (e.g. an arc source and one or more halogen lamps) to extend the spectrum far into the infrared.

Static parameter of solar cells is normally determined from their illuminated current - voltage characteristics under standard solar simulator. Based on flash lamps or distributed light sources, or outdoor conditions they are used in assessing solar cell efficiency and fill factors. Solar simulator is classified on three features of irradiance, spectral match with sun spectrum, spatial uniformity and temporal stability. Solar simulator provides testing at nonstandard test condition. The direct conversion of solar energy into electrical energy by use of

the photovoltaic effect are called solar cells, the conversion of light(or other electromagnetic radiation) in to electricity. In solar simulator, characterized the performance of solar cell can be determined under different conditions like series and parallel connections, effect of temperature, effect of various filters and at different elevation angles. For design of solar simulator, different components are used which are described below.

1.1 Proposed System

The solar simulator systems usually consists of the following sections –

A. Lamp unit including control device and lamp housing.
B. Accessories such as light reducers or spectral filters.
C. I-V data acquisition unit including reference/monitoring cell and devices for measuring the module temperature

1.2 Schematic Diagram

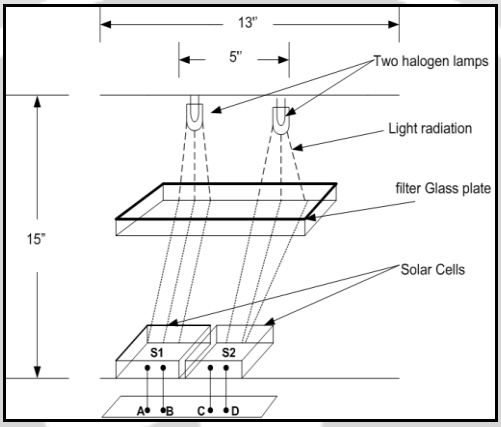

Fig -1: Schematic diagram

1.3 Description

Light spectrum simulation is a challenging job that demands accuracy and thorough consideration of light characteristics. Most of the literature on light simulation has focused on simulating sunlight for photovoltaic (PV) testing, sunlight simulation is also used to treat Seasonal Affective Disorder and to support research on photosynthetic organism.

In this study, solar simulator is developed and used to measured performance of solar cell and panel at different circumstances. It is use for laboratory purpose. Then two halogen lamps are used as light source. It provides theoretical and experimental studies of photovoltaic cell. Photovoltaic (PV) generator generates power by changing the light intensity and temperature and provides a maximum power to the load.

The schematic design of solar simulator is shown in fig. solar simulator consists of main three part illustrated in a simplified fig. in solar simulator, two quart halogen lamp use as a source, distance between two lamps is 5 inch. Two solar cell S1 and S2 are located at bottoms. A,B,C,D is positive and negative terminals of solar cells, which is used for series and parallel connections of solar cells. The glass plates inserted between the lamps and solar cells for different light intensity. In solar simulator, changing halogen lamp intensity by changing the level of lamps and also use different types of glass plate (CLEAR GLASS, FROSTED GLASS, and TINTED GLASS) for different light intensity.

Solar simulator study is carried out, to measure P-V and I-V characteristics of single solar cell under halogen lamp (solar simulator) and under natural sunlight at different intensity. Than two solar cells are connected in series and measured P-V and I-V characteristics of series connected cells at different light intensity. At last two solar cells are connected in parallel, its P-V and I-V is measured.

2. EQUIPMENT REQUIRED FOR HARDWARE IMPLEMENTATION

The following equipment is required to design of solar simulator –

- Two solar panel – 10 watt each.
- Two halogen lamp-50 watt, 230v each.
- Three glass plates.
  1. Clear glass plate
  2. Frosted glass plate
  3. Tinted glass plate
- Thermometer
- Voltmeter
- Ammeter
- Exhaust fan

- **Solar Panel –**

  Solar photovoltaic (PV) system convert solar energy directly into electrical energy. Solar PV module is not solar cell, but solar PV module that are in the field to supply the power. Solar PV modules are made of solar cells by connecting many cells in series and parallel. A solar PV module can be considered as a big solar cell with larger voltage and current output.

- **Halogens Lamps –**

  Halogen lamps provide a compact, high output, crisp, white light that delivers superior color reproduction, excellent color rendering, light close to natural (100% CRI) long lasting bright light -more than 90% lumen maintenance. We used halogen lamp in solar simulator because, it produces a fairly parallel output beam with a close spectrum matching to sun light and it also provides illumination approximately equal to natural sunlight, it is also called as artificial sun. The wavelengths and spectrum of halogen lamp is measured with help of spectroscope.

- **Different Glass Plates –**

  In solar simulator halogen lamp are used light source and measure P-V and I-V characteristics of solar cell under different light intensity. Here we have change the intensity of halogen lamp by using different glass plates. There are three types of glass plate use as a filter, clear glass plate, frosted glass plate, tented glass plate.

- **Thermometer –**

  A thermometer is a device that measures temperature or a temperature gradient. .Mercury is the only one in liquid state at room temperature, and has high coefficient of expansion. Hence, the slightest change in temperature is notable when it's used in thermometer.

  A thermometer is a device that measures temperature or a temperature gradient. A thermometer has two important elements: (1) a temperature sensor (e.g. the bulb of a mercury-in-glass thermometer) in which some physical change occurs with temperature, and (2) some means of converting this physical change into a numerical value (e.g. the visible scale that is marked on a mercury-in-glass thermometer). Thermometers are widely used in industry to control and regulate processes, in the study of weather, in medicine, and in scientific research.

- **Exhaust Fan –**

  An exhaust fan is a fan which is used to control the interior environment by venting out unwanted odors, particulates, smoke, moisture, and other contaminants which may be present in the air. Exhaust fans can also be integrated into a heating and cooling system. Using an exhaust fan can be an alternative to air conditioning or a supplement to an air conditioning system.

3. DESIGN STEPS OF SOLAR SIMULATOR

Following steps are used for hardware implementation of solar simulator for understanding the characteristics of solar cell at different circumstances.

Step 1: The two quartz halogen lamps used as light source in the solar simulator, rated at 50watt, (230V) each. They are located in the top compartment as shown in the fig below and their connections can be accessed by removing the top cover, if necessary.

Step 2: A glass plate can be inserted between the lamps and the lower chamber as shown in the fig below. Three glass plates are provided: 1) clear glass plate. 2) Frosted glass plate. 3) Tented glass plate. The glass plates are toughened to avoid breakage from heat of the lamps. The glass plates reduce the heat from the lamps reaching the solar cells.

Step 3: The solar cells located at the bottom of the chamber as shown in fig. below the two solar cells are connected to terminals 4 terminals A,B,C,D as shown in fig below terminals A & C are positive terminals of solar cells and B & D are negative terminals of solar cells. A fan is provided for cooling of the solar cells to reduce the heat from the lamps. Fan should be kept on at all times when the lamps are on.

4. PROPOSED METHODOLOGY

4.1 Overview –

Light sources are especially developed and used to simulate solar radiation and therefore are called solar simulator. They produce a uniform collimated (parallel) output beam with a close spectrum match to sun light. We use halogen lamps as radiation source because they provide the closest spectral match to solar spectrum available from any commercial source. Solar simulator is device that uses halogen lamp and LEDs to mimic the spectrum and intensity of natural sunlight. Solar simulator is design for testing of solar cell under different condition.
Solar simulator produced high intensity, uniform illumination on a target area. Typically, high power solar simulators use an ellipsoidal reflector to capture light form an arc lamp source (usually halogen) inside the reflector, an arrangement that result in a light pattern with a bright outer region and a dark centre. Many solar simulator designs use diffusers to reduce the non-uniformity, but this result in a reduction in intensity and a distortion of the spectrum on the target area.

4.2 Single Solar Panel Mode –

To measure P-V &I-V characteristics of single cell under halogen lamp (solar simulator) and sun light.

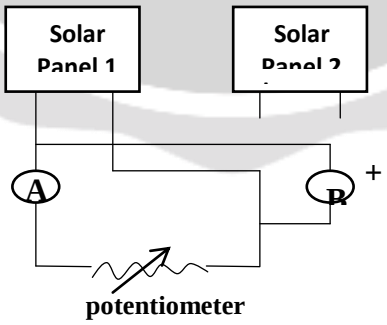

Fig -1: Circuit diagram of single solar cell

Solar cell or SPV are tested under a sun simulator at different conditions. The sun simulator used in solar panels division contains Halogen lamps (T=58000 K), which produces a spectrum closest to the sun spectrum. If necessary, suitable filter allow reaching the AM0, AM1 and AM1.5 specification. A halogen lamp uses to produce a

bright white light that is similar to natural daylight. Fig above connection diagram of single solar cell which produces voltage and current when variable load connected across it.

4.3 Series- Mode of Solar Cell –

Two solar cells are connected in series, P-V & I-V characteristic of solar cell are measured under halogen lamp (solar simulator) and sun light at different light intensity.

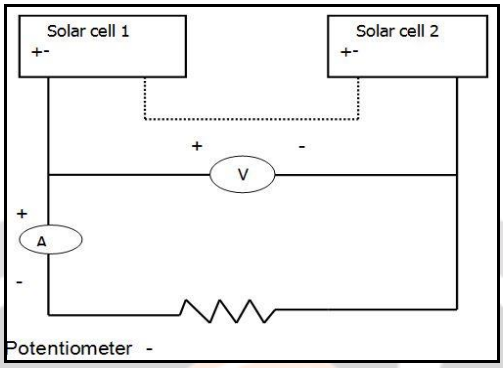

Fig -1: Circuit diagram of two solar cells in series

When two cells with mismatched characteristics are connected in series and a load is applied, both cells are bound to carry same current, fig. above show the series connection of two solar cell. The composite characteristics of the combination can be obtained by adding the individual output voltage of cell corresponding to a common current, for all operating points as shown in fig .below at particular operating point, one cell may be operating at peak power, the other may not. Thus, peak power of the combination is always less than the sum of individual peak power of each cell. If a combination is short-circuited, equal and opposite voltages V'_1 and V'_2 are produced by individual cells, one cell will be generating power while the other will be dissipating it.

4.4 Parallel-Mode of Solar Cell –

Two solar cell are connected in parallel and P-V & I-V characteristics of solar cell are measured under halogen lamp (solar simulator) and sun light at different light intensity

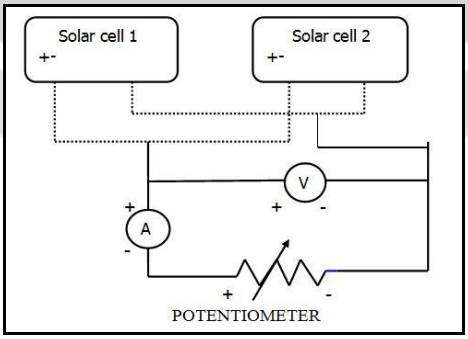

Fig -1: Circuit diagram two solar cell in parallel

Parallel connection of solar cell is shown in fig. above, when two cells with mismatched characteristics are connected in parallel and a load is applied, the of the cells are bound to be equal, but current will be different and different maximum operating point, fig. above, parallel connection of solar cells.

5. Analysis of result under various light sources

5.1 Voltage Readings for Sunlight

Table -1: Voltage Reading for Sunlight 0 degree

0 degree or perpendicular panel angle				
Glasses	Panel 1	Panel 2	Series	Parallel
Transperant	20 v	20.2 v	40 v	19.8 v
Frosted	18.7 v	19 v	37.7 v	18.8 v
Tinted	18.4 v	18.8 v	37.1 v	18.5 v

Table -2: Voltage Reading for Sunlight at 22 degree

22 degree panel angle				
Glasses	Panel 1	Panel 2	Series	parallel
Transperant	19.3 v	19.7 v	30 v	19.3 v
Frosted	18.6 v	18.9 v	37.5 v	18.7 v
Tinted	18.3 v	18.7 v	37 v	18.4 v

5.2 Voltage Readings for halogen Light (100 watt)

Table -3: Voltage Reading for Halogen at 0 degree

0 degree or perpendicular panel angle				
Glasses	Panel 1	Panel 2	Series	parallel
Transperant	16.3 v	16.1 v	33 v	16.3 v
Frosted	13.8 v	17.3 v	31 v	15 v
Tinted	13.7 v	17.2 v	30.9 v	14.9 v

Table -4: Voltage Reading for Halogen at 22 degree

22 Degree panel angle				
Glasses	Panel 1	Panel 2	Series	parallel
Transperant	15.1 v	18.1 v	33.1 v	16.2 v
Frosted	13.4 v	17.3 v	30.6 v	14.5 v
Tinted	13.3 v	17.2 v	30.5 v	14.7 v

5.3 Current Readings for Sunlight -

Table -5: Current Reading for Sunlight at 0 degree

0 degree or perpendicular panel angle				
Glasses	Panel 1	Panel 2	Series	parallel
Transperant	440 mA	100 mA	110 mA	550 mA
Frosted	170 mA	130 mA	130 mA	360 mA
Tinted	230 mA	130 mA	160 mA	330 mA

Table -6: Current Reading for Sunlight at 22 degree

22 degree panel angle				
Glasses	Panel 1	Panel 2	Series	parallel
Transperant	300 mA	130 mA	110 mA	430 mA
Frosted	220 mA	150 mA	160 mA	370 mA
Tinted	190 mA	130 mA	150 mA	320 mA

5.4 Current Readings for Halogen -

Table -7: Current Reading for Halogen at 0 degree

0 degree or perpendicular panel angle				
Glasses	Panel 1	Panel 2	Series	parallel
Transperant	40.8 mA	30.6 mA	32.7 mA	71.7 mA
Frosted	30.6 mA	23.5 mA	24.6 mA	54.1 mA
Tinted	29.2 mA	21.4 mA	22.3 mA	49.7 mA

Table -8: Current Reading for Halogen at 22 degree

22 degree panel angle				
Glasses	Panel 1	Panel 2	Series	parallel
Transperant`	36.6 mA	21.7 mA	33.6 mA	68.4 mA
Frosted	26.8 mA	24.5 mA	25.3 mA	51.3 mA
Tinted	25.2 mA	23.3 mA	23.1 mA	47.9 mA

6. P-V and V-I Characteristic of solar panel.

It is observed that, at same intensity less current is produced under halogen lamp as compare to sun light, which is shown in above characteristics. To generated same current from solar cell under halogen lamp, more intensity is required

Following figures shows I-V & P-V characteristics of single cell which gives is shows the similarity between current produced by halogen lamp and sun light.

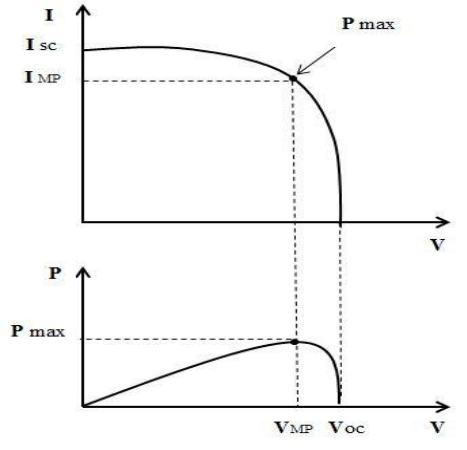

Chart -1: P – V Characteristic and I – V Characteristic

7. FUTURE SCOPE

Due to the interesting features of solar simulator, it can be used in PV module manufacturing industries for PV testing in future. Filter to be used, which gives radiation which exactly matches with sun radiation.

Research and development efforts in solar and other renewable energy technologies are required to continue for, improving their performance, establishing techniques for accurately predicting their output and reliably integrating them with other conventional generating sources .

8. CONCLUSION

The usage of renewable energy has been steadily increasing to help solve acute problems of energy and environment concerns. Study of solar power system can be useful for further research as well as the real adoption of the proposed systems. For isolated areas where the new in installation of conventional plant is very expensive and tedious, renewable is the solution.

A solar simulator designed for solar cell characterization, P-V characteristics of solar cells at different radiation are obtained under halogen lamp and under sunlight. From this, It is observed that maximum power is obtain at maximum intensity light.

By comparing results under halogen lamp and sunlight at same intensity, less current and hence less power have been generated under halogen lamp. To generate the same current from solar cell under halogen lamp, 15-50% more light intensity is required for series and parallel connected solar cells. Solar simulator design has lower initial cost, reduced operating cost required less space. It has the potential to approach the goal of matching intensity of sun.

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