Experimental Studies on Electrical Characteristics of Solar PV Panel with Different Conditions

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Abstract *- Solar energy is most wanted thing for the daily uses. The current scenario the solar system is taking up because of the electric demand. It is also pollution free, no fuel requirements and less maintenance cost. By using the solar panels easy to produce electricity. The PV panels generate electric power from the radiation. PV modules use semiconductor materials to produce Direct Current (DC) electricity from sunlight. The solar photovoltaic (PV) electrical performance can be finding by its voltage-current (VI) characteristics curve. In this work, an investigation of the performance and device parameters of photovoltaic Mono-crystalline solar panel at different conditions of outdoor measurements such as Shadow, Dust accumulation and Thermal effect (water spray). Also determined the reports on the performance data of the solar panel, using standard V–I characteristic curves to obtain output parameters and to show that there are possible performance degrading defects presents.*

Keywords: photovoltaic cell, Mono-crystalline, solar panel Shadow, Dust accumulation and Thermal effect

1. INTRODUCTION

I n today's climate of growing energy needs and increasing environmental concern, alternatives to the utilization of non-renewable and polluting fossil fuels need to be investigated. One such alternative is solar power. Solar power is kind of simply the energy produced directly by the sun and picked up elsewhere, normally the planet. The sun creates its energy through a thermonuclear process that converts about 650,000,000 heaps of hydrogen to helium every second. The method creates heat and electromagnetic wave. The warmth remains within the sun and is instrumental in maintaining the nuclear fusion reaction. The electromagnetic wave (including visible radiation, infra-red light, and ultra-violet radiation) streams out into space all told directions.

This paper work involves electricity is produced from the solar power by photo voltaic solar cells, which converts the solar power on to electricity. The foremost significant applications of India are the energization of pump sets for irrigation, drinkable supply and rural electrification covering street lights, community TV sets, medical refrigerators and other small power loads. Electricity is directly generated by utilising solar power by the photovoltaic process. A photovoltaic power generation system consists of multiple components like cells, mechanical and electrical connections and mountings and means of regulating and/or modifying the electrical output. These systems are rated in peak kilowatts (kWp) which is an amount of electric power that a system is predicted to deliver when the sun is directly overhead on a transparent day, Various factors affected the ability generation of solar array in many solar energy plants, panels are arranged in on the subject of near that point one panels to a different screened by shadow. Affect the generation of power and dominion shadow by trees, near buildings. In desert areas are located in solar array suffering from dust formations in panel layer. Affect the generation of solar array. Those effects had been studied during this paper.

1.1 MAJOR TYPES OF SOLAR CELLS

Photovoltaic solar panels are mainly classified in below They are:

1. Mono crystalline
2. Poly crystalline
3. Amorphous Silicon also called "Thin Film"

1.2 MONO CRYSTALLINE PANEL

Mono crystalline panels use crystalline silicon, a basic semiconductor material. Crystalline silicon is produced in large sheets which will be move a selected size and used mutually large cell during a panel. Conducting metal strips are laid over the whole cell to gather electrons from the cell into an electrical current. These panels are dearer to supply than the polycrystalline panels that follow. However, they're highly efficient and are more cost effective within the end of the day as a result. Mono crystalline panels are typically 15-18% efficient, meaning that for each unit of alternative energy that hits the cell, the panel can convert 15-18% of this energy into electricity. Mono crystalline silicon (c-Si): often made using the Czochralski process. Single-crystal wafer cells tend to be expensive and, because they're cut from cylindrical ingots, don't completely cover a square solar-cell module without a considerable waste of refined silicon. Hence most c-Si panels have uncovered gaps at the corners of 4 cells.

1.3 POLY CRYSTALLINE SILICON PANEL

Polycrystalline, or multi crystalline, photovoltaics use a series of cells in situ of the only large cell utilized in mono crystalline panels. Polycrystalline photovoltaic are the lease expensive style of photovoltaics available today, though the prices of manufacturing individual cells can still be high. The disadvantage of those panels is that they need lower efficiency rates than mono crystalline panels, at 12-14% efficiency. There are several differing types of polycrystalline panels. Poly- or multi crystalline silicon (poly-Si or mc-Si): made of cast square ingots – large blocks of molten silicon carefully cooled and solidified. These cells are more cost-effective to supply than single-crystal cells but are less efficient. Polycrystalline silicon wafers are made by wire sawing block-cast silicon ingots into very thin (180 to 350 micrometre) slices or wafers. The wafers are usually lightly p-type doped. To create a cell from the wafer, a surface diffusion of n-type dopants is performed on the front side of the wafer. This forms a tangency many hundred nanometres below the surface.

1.4 AMORPHOUS SILICON OR THIN FILM PANEL

Thin-film panels are different from crystalline panels in their very makeup. Rather than mol ding, slicing, or drawing crystalline silicon to make a cell, amorphous silicon has no crystalline structure and may be applied as a skinny semiconductor film on different materials. Additionally to silicon, copper indium diselenide (CIS) and cadmium telluride (CdTe) are often utilized in amorphous or thin film panels. This film is then connected to metal conductor strips, but because the film is attached to a different structural material it doesn't always require a similar parts necessary for crystalline panels.

2. LITERATURE REVIEW

Bhubaneswari Paridaa conducted experiments on various type of solar photovoltaic technologies used in trends. A review of major solar photovoltaic technologies comprising of PV power generation, Hybrid PV generation, various light absorbing materials, performance and reliability of PV system, sizing, distribution and control is presented. **St�hane VighettiIn** discussed in the article, a topology of power electronics balancer for a PV system is presented. This topology is able to balance the PV current to permit every PV generator to work at its own Maximum Power Point. To study the interest of this Current Balancing System, a model of the power losses in this topology has been developed. **A. Ibrahim** analyse the experiments on Cold temperatures produce more efficient photo con- version for single-crystal solar cells. The efficiency for single-crystal solar cell decreases as the operating temperature of cells increases. It is reported in the literature that the decrease in the efficiency is approximately 0.06 in absolute value per �C increase for the same irradiance level, the output power, and therefore the efficiency, decreases with the increasing cell temperature. The output rating of a solar cell decreases with in-crease of the cell temperature. In order reduce the cell. **Arbi Gharakhani Sirak** discussed the experiments Knowledge of the optimum tilt angle is important to obtain the highest possible annual or seasonal energy yield. In order to use the proposed method to calculate the optimum tilt angle for the panel installed. **A. K. Sharma** Conducted some experimental studied on the solar array performance under shadow conditions could not be accurately explained on the basis of the existing theories. The main drawback of earlier studies is the consideration of identical series resistances for illuminated and diode across each solar cell must be included in array design for better shadow tolerance. **Shaharin A.** proposed the effect of presence of dust was studied using artificial dust (mud and talcum) under a constant irradiance conducted in an indoor lab. Dust has an effect on the performance of solar PV panel. The reduction in the peak power generated can be up to 18%. It was also shown that under greater irradiation, the effect of dust became slightly reduced but not negligible. **Suresh Kumar E.** Studies related to dust accumulation is critical as a further decrease in the (practical) system efficiency will tend to make PV systems an unattractive alternative energy source. Taking into account the effect of gravity, horizontal surfaces usually tend to accumulate more dust than inclined ones. This however is dependent on the prevalent wind movements.

2. METHODOLOGY:

Observe and Record the P_{max} of solar arry under conditions

- Shadow effect
- Dust accumulation
- Thermal effect(water spray)

According to the circuit connections experiment was Begin with open-circuit voltage. Short the output terminals of the PV panel with a wire. Measure the tangency current and panel output voltage. Record both the voltage and current. Connect the heavy-duty variable resistors to the panel, ranging from higher resistance to lower one so the panel current increases from zero toward tangency. Measure the voltage and current for every resistor and record them. Repeat step 1 in two varies the various conditions. Using Excel to plot V-I and P-V (P = V • I) curves of the solar arry.

SHORT CIRCUIT CURRENT (I_{SC})

Short circuit current is that light-generated current or photo current, IL. It's this within the current when the load is zero within the circuit. It is often achieved by connecting the positive and negative terminals by copper wire.

OPEN CIRCUIT VOLTAGE (V_{OC})

Open circuit voltage is obtained by setting I=0 within the expression for overall Current i.e. I=0 when V=Voc.

$$V_{oc} = KT/e\ [\ \ln (I_L/I_0)+1] \qquad (1)$$

The circuit voltage is that the voltage for maximum load within the circuit.

IV Characteristics

The current equation for a photovoltaic cell is given by $I=I_0 ((\exp(ev/kT))-1)-I_L$ For a decent photovoltaic cell, the series resistance, should be very small and therefore the shunt (parallel) resistance, Rp, should be very large. For commercial solar cells, Rp is far greater than the forward resistance of a diode in order that it may be neglected and only Rs is of interest. The subsequent are many of the characteristics parameters that are discussed. The optimum load resistance RL (Pmax) = Rpmax is connected, if the PV generator is ready to deliver maximum power.

Pmax = VP max IP max (4)

P max= I max *V max (2)

The maximum possible output can also be given as

$P_{max}= V_{oc} * I_{sc} * FF$ (3)

And RPmax = VPmax / IPmax

The efficiency is defined as

$\eta = P / \phi$ (5)

Where,

P=V* I is the power delivered by the PV generator.

$\phi = I_T * A$ is the solar radiation falling on the PV generator.

I_T is the solar intensity and A is the surface area irradiated.

FILL FACTOR (FF)

The fill factor, also known as the curve factor is a measure of sharpness of the knee in an I-V curve. It indicates how well a junction was made in the cell and how low the series resistance has been made. It can be lowered by the presence of series resistance and tends to be higher whenever the open circuit voltage is high. The maximum value of the fill factor is one, which is not possible. Its maximum value in Si is 0.88.

$FF = P_{max} / V_{oc} * I_{sc} = I_{max} * V_{max} / V_{oc} * I_{sc}$ (6)

MAXIMUM POWER (P_{MAX})

No power is generated under short or open circuit. The power output is defined as

Pout = V out * I out (7)

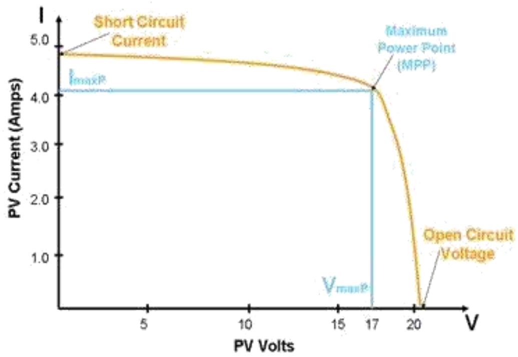


Chart – 1: V-I Curve

The maximum power P_{max} provided by the device is achieved at a point on the characteristics, where the product IV is maximum. Thus

4 .EXPERIMENTAL DETAILS

The setup conducted in Thanjavur .Latitude 10.783 / Longitude 79.131of the place. The system Consists of solar panel positive terminal is connected to the ammeter positive terminal .ammeter negative and voltmeter positive terminal is connected to the rheostat of the one side. Another side of rheostat is connected to voltmeter negative and panel of the negative side by using the connecting wires.

Fig – 1: Experimental Setup of Solar Panel

4.1 SOLAR PANEL SPECIFICATIONS:

P_{max}=80 V_{mp}=18V I_{mp}=4.44A

I_{sc}=4.70A V_{oc}=22.03V P_{min}=75W

Under shadow:

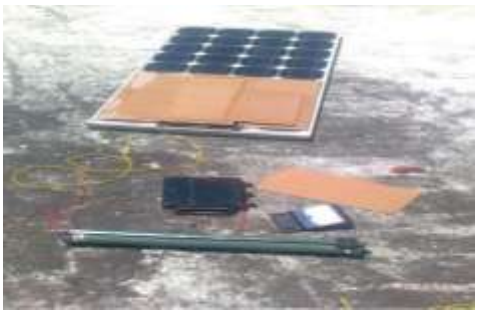


Fig – 2: Shadow by 1/2area of solar panel

Fig – 3: Shadow by □ area of solar panel

The experiment was screened by card board in the area of quarter portion (9 cells) of solar panel that time note the electrical parameters values. Analyze the maximum power of solar panel. Similarly the experiment was screened by card board in the area of Half Portion (18 cells) of solar panel that time noted the electrical parameters values.

4.2 UNDER DUST ACCUMULATION:

Fig – 4: Sp**r**ead the 10g dust spread the 20g dust

Spread the talcum powder quantity of 10 g in the solar panel that time measure the electrical parameters such as (Current, voltage).similarly Spread the talcum powder quantity of 20 g in the solar panel that time measure the electrical parameters such as (Current, voltage).

4.3 THERMAL EFFECT (WATER SPRAY):

In the water flow rate can be done by three steps Low, Medium, High flow rates

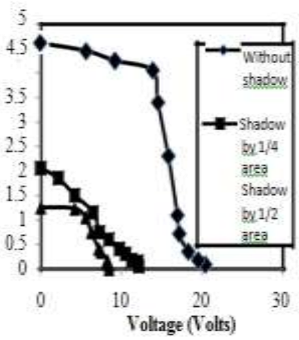
Fig – 5: High flow rate at 0.05 m^3/s

Spray the water flow rate at 0.019m^3/s. that time investigate the electrical parameters. To increase the flow of water efficiency also increased. Spray the water flow rate at 0.026m^3/s. that time investigate the electrical parameters. Spray the water flow rate at 0.05m^3/s. that time investigates the electrical parameters.

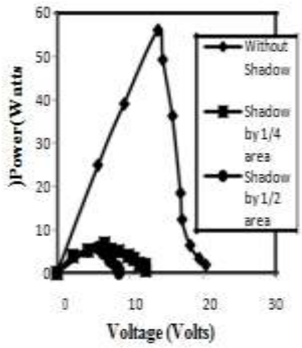
5. RESULTS AND DISCUSSIONS:

Experiments are done with three methods. First one is covering the solar panel by card board to obtain the shadow effects .second experiment is conducted by spreading the talcum powder over the surface of the PV panel to obtain the effects of dust accumulation. Third experiment the is conducted by flowing water over the surface of the panel to evaluate the thermal effects on the panel. The results of these experiments are discussed below

SHADOW CONDITION:



V-I curve

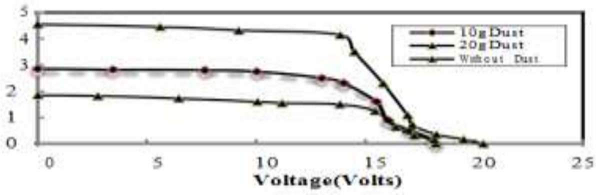


P-V Curve

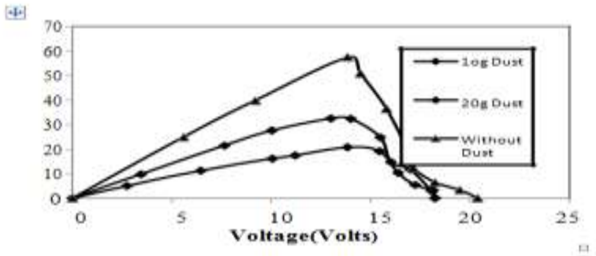
The output power of the PV panel is 87.87% higher than the same panel covered with the card board having area the area of □ th of the surface area of the PV panel .reduction is due to the temperature, intensity of solar radiation. The output power of the PV panel is 89.8% higher than the same panel covered with the having the area of the $1/2_{th}$ area of the PV panel. Due to the band gap energy is decreases voltage is increases. Also current is increases.

DUST ACCUMULATION

Various types of artificial dusts are there. Suchas Mud, plastics, Talcum powder. Used the talcum powder various quantity of 10g and 20g.analyse the maximum output power of the solar panel. The output power of the PV panel is 42% higher than the same panel spread the 10g powder having the surface area of the PV panel. The output power of the PV panel is 63% higher than the same panel spread the 20g having area of the surface area of the PV panel. Reduction of output power due to the density of the particles, temperature incident solar radiation.



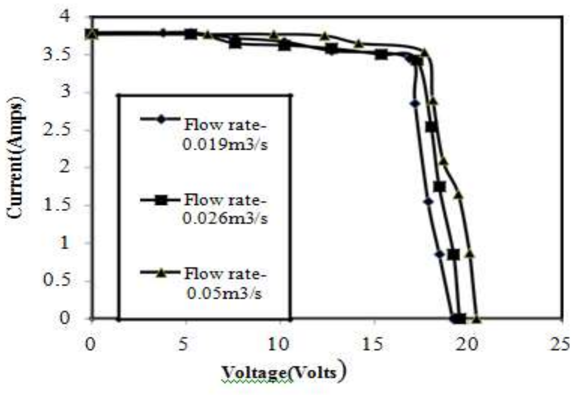
V-I curve



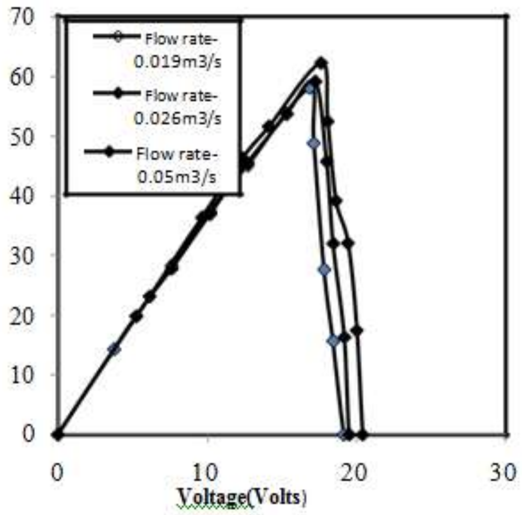
P-V curve

WATER SPRAY

To analyse the report of under varoius flow rates flow of water in the solar panel.the solar panel is tilted 10̊ investigate the maximum power of the solarpanel various flow rates. Under low flow rate panel tempratur is 44̊c atmospheric temprature is 34̊c power is to be increased compared with without water flow in the solar panel.(52W-58.13W).Medium flow rate the panel temperature is reduced 3̊c than low flow rate of the panel. And power also increased. High flow rate condition the panel temperature is reduced 7̊c compared to low flow rate of the solar panel. And power also increased.



V-I Curve



P-V Curve

6. CONCLUSIONS

From the Experimental Process the subsequent observations were obtained,

1. Shadow conditions

Maximum power obtained from the electrical device P_{max}= 56.09W .The maximum power obtained by covering ⍰ area of the electrical device P_{max}=6.8W and by covering ⍰ area of the electrical device is P_{max}=5.7 W.

2. Dust accumulation

Initially when the panel is clean without dust particles P_{max}=56.5W. When the panel is roofed by 10g of dust particles P_{max}=32.5W. Similarly, P_{max} obtained with 20g dust is 20.76W.

3. During water flow rate

When the flow rate of water is 0.09m^3 /s , P_{max}=52.13W. simultaneously, P_{max}=58.13W and 59.16,when the flow rates are 0.026m^3/s and 0.05m^3/s.

The conclusion obtained is that shading effects are only of importance during the winter season at this latitude which the yearly energy loss is tiny at ratios of panel row distance to panel height solar photovoltaic module performance is adversely affected if all its cells don't seem to be equally illuminated.

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