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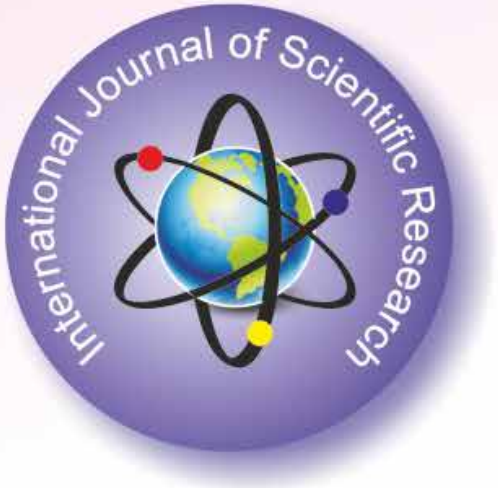

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Research Paper

Engineering

KEYWORDS : Photovoltaic model, solar panel, photovoltaic cell, Photovoltaic modeling and behavior.

Modeling Of Pv Module And Examining The Effect Of Irradiance In Matlab

Sangita S. Kondawar C/o P. N. Tammewar, Dhanora Road, Gadchiroli (M.S.), India

Prof. U.B. Vaidya RCERT, Chandrapur (M.S.), India

ABSTRACT

Unity is a really important thing among people in a nation because it promotes peace and love in a nation. The other importance's are, unity is strength where united people can put efforts in elimination of vices like corruption and tribalism and also to fight diseases by adopting more hygienic standards of living, unity enhance political stability in a nation, unity minimizes and eventually eliminates intercommunity suspicions where it gives people a sense of security for they are able to know each other better and understand each other's ways. Unity promotes collective responsibility in times of need like in funding for the disabled and lastly unity reduces incidence of fear, suspicions and power struggles which reduce incidents like civil war which may affect social economic activities like trade. We can develop unity through physical education activities also. Physical Education is one of the major factors to achieve National unity ie to develop National Integration.

I INTRODUCTION

Photovoltaic System Components

Photovoltaic cell

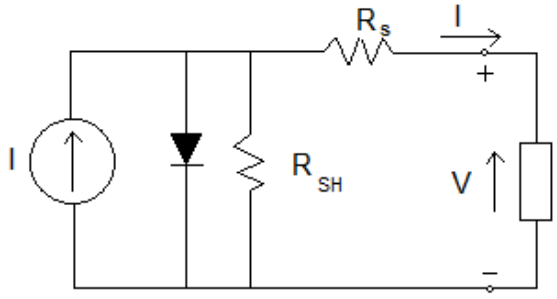
A photovoltaic cell or photoelectric cell is a semiconductor device that converts light to electrical energy by photovoltaic effect. If the energy of photon of light is greater than the band gap then the electron is emitted and the flow of electrons creates current. However a photovoltaic cell is different from a photodiode. In a photodiode light falls on n channel of the semiconductor junction and gets converted into current or voltage signal but a photovoltaic cell is always forward biased.

PV module

Usually a number of PV modules are arranged in series and parallel to meet the energy requirements. PV modules of different sizes are commercially available (generally sized from 60W to 170W). For example, a typical small scale desalination plant requires a few thousand watts of power.

PV modeling

A PV array consists of several photovoltaic cells in series and parallel connections. Series connections are responsible for increasing the voltage of the module whereas the parallel connection is responsible for increasing the current in the array. Typically a solar cell can be modeled by a current source and an inverted diode connected in parallel to it. It has its own series and parallel resistance. Series resistance is due to hindrance in the path of flow of electrons from n to p junction and parallel resistance is due to the leakage current.



In this model we consider a current source (I) along with a diode and series resistance (Rs). The shunt resistance (RSH) in parallel is very high, has a negligible effect and can be neglected.

The output current from the photovoltaic array is

I=Isc – Id

(1)

Id= Io (eqVd/kT - 1)

(2)

Where Io is the reverse saturation current of the diode, q is the electron charge, Vd is the voltage across the diode, k is Boltzmann constant (1.38 * 10-19 J/K) and T is the junction temperature in Kelvin (K)

From eq. 1 and 2

I = Isc – Io (eqVd/kT - 1)

(3)

Using suitable approximations,

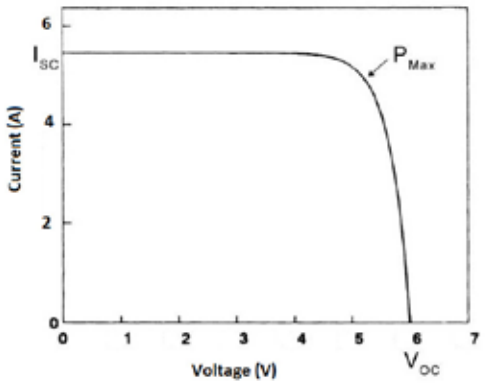
I = Isc – Io (eq((V+IRs)/nkT) - 1) **(4)**

where, I is the photovoltaic cell current, V is the PV cell voltage, T is the temperature (in Kelvin) and n is the diode ideality factor In order to model the solar panel accurately we can use two diode model but in our project our scope of study is limited to the single diode model. Also, the shunt resistance is very high and can be neglected during the course of our study.

PV Characteristics

Figure 2 : I-V characteristics of a solar panel

The I-V characteristics of a typical solar cell are as shown in the Fig.2.



When the voltage and the current characteristics are multiplied we get the P-V characteristics as shown in Fig. 3. The point indicated as MPP is the point at which the panel power output is maximum.

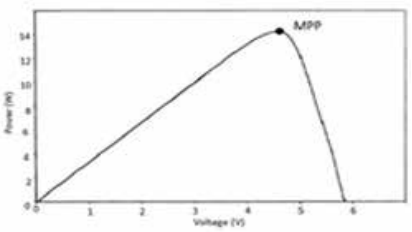


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Figure 3 : P-V characteristics of a solar panel

Temperature and Irradiance effects

Two important factors that have to be taken into account are the irradiation and the temperature. They strongly affect the characteristics of solar modules. As a result, the MPP varies during the day and that is the main reason why the MPP must constantly be tracked and ensure that the maximum available power is obtained from the panel.

The effect of the irradiance on the voltage-current (V-I) and voltage-power (V-P) characteristics is depicted in Figure 4 & 5, where the curves are shown in per unit, i.e. the voltage and current are normalized using the VOC and the ISC respectively, in order to illustrate better the effects of the irradiance on the V-I and V-P curves. As was previously mentioned, the photo-generated current is directly proportional to the irradiance level, so an increment in the irradiation leads to a higher photo-generated current. Moreover, the short circuit current is directly proportional to the photo generated current; therefore it is directly proportional to the irradiance. When the operating point is not the short circuit, in which no power is generated, the photo generated current is also the main factor in the PV current, as is expressed by equations (1) and (2). For this reason the voltage-current characteristic varies with the irradiation.

In contrast, the effect in the open circuit voltage is relatively small, as the dependence of the light generated current is logarithmic, as is shown in equation (4).

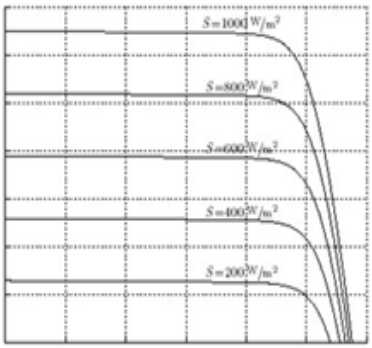


Fig 4. V-I curves at constant temperature (25°C) and five different insolation values

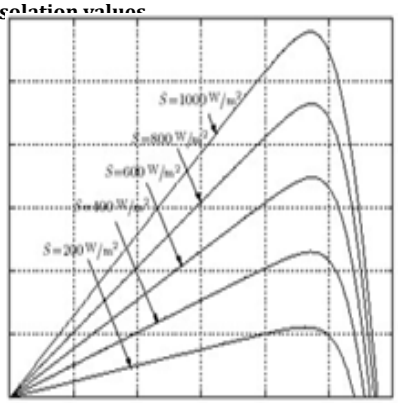


Fig. 5 - V-P curves at constant temperature (25°C) and five different insolation values.

Fig. 5 shows that the change in the current is greater than in the voltage. In practice, the voltage dependency on the irradiation is often neglected. As the effect on both the current and voltage is positive, i.e. both increase when the irradiation rises, the effect on the power is also positive: the more irradiation, the more power is generated.

The temperature, on the other hand, affects mostly the voltage. The open circuit voltage is linearly dependent on the temperature, as shown in the following equation:

$$Voc(T) = VocSTC + \frac{Kv}{100}(T - 273.15) \quad (5)$$

According to (5), the effect of the temperature on VOC is negative, because Kv is negative, i.e. when the temperature raises, the voltage decreases. The current increases with the temperature but very little and it does not compensate the decrease in the voltage caused by a given temperature rise. That is why the power also decreases. PV panel manufacturers provide in their data sheets the temperature coefficients, which are the parameters that specify how the open circuit voltage, the short circuit current and the maximum power vary when the temperature changes. As the effect of the temperature on the current is really small, it is usually neglected. Fig. 6 & 7 shows how the voltage-current and the voltage-power characteristics change with temperature. The curves are again in per unit, as in the previous case.

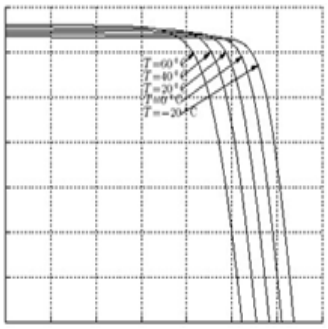


Fig. 6 V-I curves at constant irradiation (1 kW/m2) and five different temperatures.

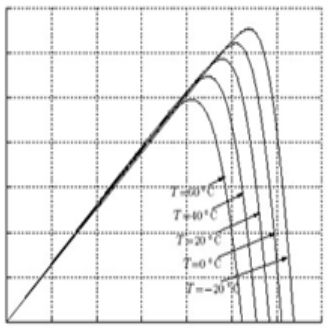


Fig. 7 - V-P curves at constant irradiation (1 kW/m2) and five different temperatures.

As was mentioned before, the temperature and the irradiation depend on the atmospheric conditions, which are not constant during the year and not even during a single day; they can vary rapidly due to fast changing conditions such as clouds. This causes the MPP to move constantly, depending on the irradiation and temperature conditions. If the operating point is not close to the MPP, great power losses occur.

Hence it is essential to track the MPP in any conditions to assure that the maximum available power is obtained from the PV panel. In a modern solar power converter, this task is entrusted to the MPPT algorithms.

II MODELING OF PV MODULE

Solar Panel

The PV simulator has been implemented in Simulinkr, using the principle shown in the block diagram in Fig. 8

A PV system with a capacity of a few kW can contain thousands of cells, with series and parallel interconnections, and bypass diodes. Modeling the behavior of every cell in such a system, even though it would offer a very high level of flexibility, is not feasible, as this would require enormous computational capacity, thereby certain simplifications are needed in order to create

a useful model. The following assumptions have been made:

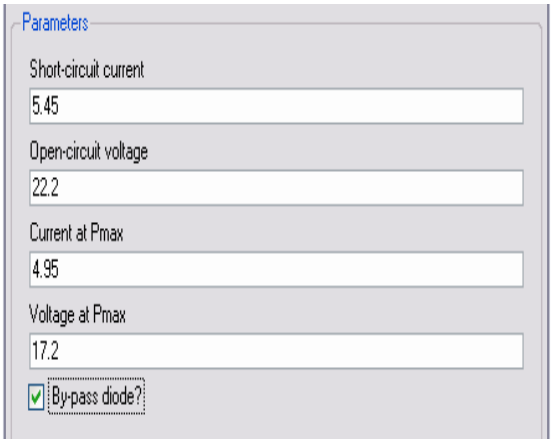
- All the cells in the system have identical physical properties, i.e. the same I-V characteristics. In reality, not all the cells are the same in a system, there are small deviations in their physical properties, which slightly reduce the overall output power..
- The temperature was considered uniform over the entire system.

In accordance with the above, the simulator contains PV cell model, which generate the forward and reverse I–V characteristics of the fully illuminated. I – V curves, according to the specifications of the user. The computation-intensive parts of the model are the generation of the characteristics of the cells and then the construction of the array's I – V curves. However, this part is needed to run only when the environmental conditions are changing, hence it can be executed with low sampling rate. Therefore the environmental conditions (G and T) for the simulation have been adjusted in order to create the same short-circuit current and open-circuit voltage to the measurement.Model parameters, in both cases (Current Input Model & Voltage Input Model), are the standard.

PV module data-sheet parameters:

- short-circuit current Isc
- open-circuit voltage Voc
- rated current IR at maximum power point (MPP)
- rated voltage VR at MPP

under standard test conditions (1kW/m2, 1.5 AM, 25oC). A bypass diode (a single diode across the entire module) can be included. Temperature effects are not modeled.



Unmasked Block Diagram of Inside Current Input Model :

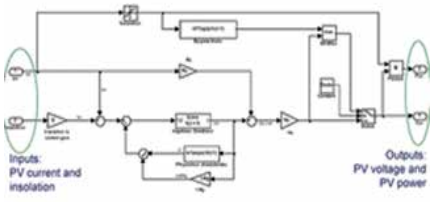


Fig. 8. Unmasked block diagram of the modeled solar PV panel (Current Input Model)

Model Musk Initialization

The MATLAB code computes model parameters Io, Rs, Rp based on the model parameters (short-circuit current Isc, circuit voltage Voc, rated voltage Vr, and rated current Ir)



III APPLICATION EXAMPLE

Here 6 PV modules connected in series shown in Fig. 9 and O/p I-V and P-V Characteristics are plotted shown in Fig. 12 and Fig. 13.

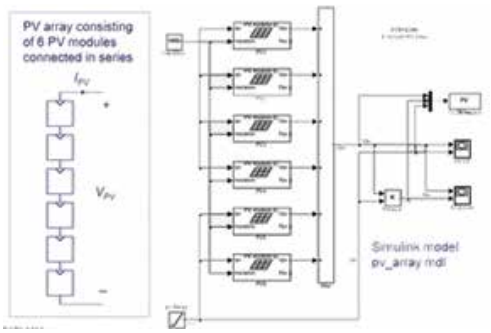


Fig. 9. 6 PV Module connected in series.
Inside Voltage Input PV Model

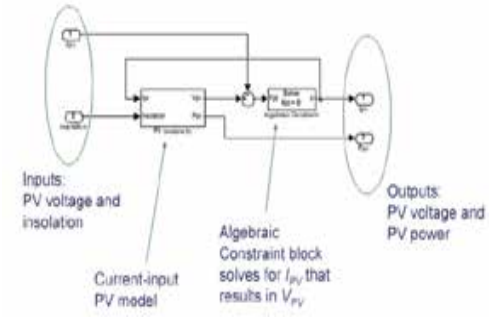


Fig. 10. Unmasked block diagram of the modeled solar PV panel (Voltage Input Model)

IV PV MODULE CHARACTERISTICS

The PV current is the function of shining values of the site where panel is placed. The current increases or decreases as per the shining values increases or decreases.

For any solar panel, the output power is function of the temperature and the sunshine values of the site where the panel is placed. This power can decrease or increase as result of any temperature or shining variations.

Fig. 11 represents that the calculation of curves, the temperature stayed constant at 250C varying the different irradiance (200, 400, 600,800, 1000 W/m2) generating the curves below.

More ever the curves shows that the current – voltage curves relations at various solar irradiations are obtained for photovoltaic panel working. For the radiation level between 400-1000 W/m2, the PV module output increases in range of 4-10%.

Fig. 10 shows the content of operational functional block diagram. Indicated modeling stages is designed according to the photovoltaic solar formulations and results are observed.

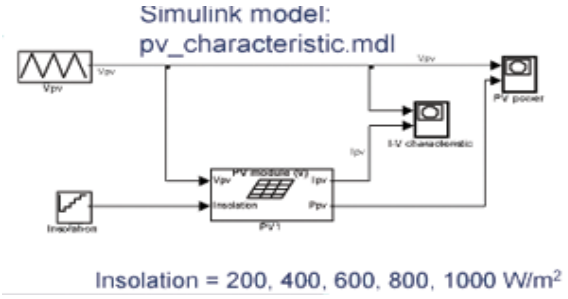


Fig. 11. PV Characteristics

V RESULT

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Output I-V characteristics and P-V characteristic of the application example when 6 PV modules are connected in series is shown in fig. From result output Pmax= 510 W and Vmax=103 V

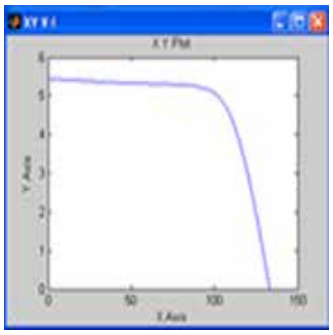

Fig. 12. I-V Characteristic of PV Module

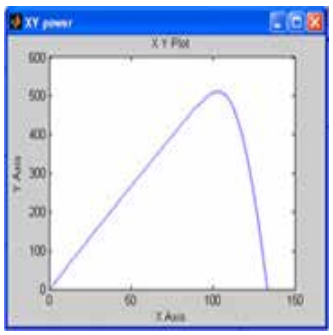

Fig. 13. P-V Characteristics of PV Module

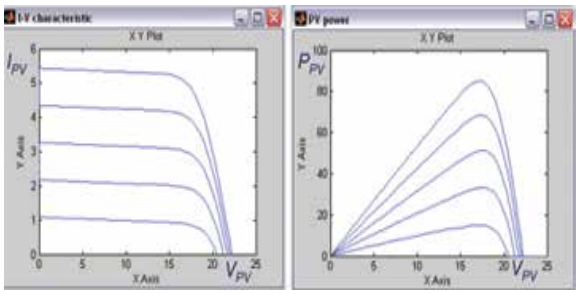

Fig. 14 O/P of PV module Characteristics at different irradiance(200, 400,600,800,1000 W/m2) at constant temperature 250C.

Fig.14 shows the output of PV module characteristics from Fig. at different solar irradiation (200,400, 600, 800 & 1000 W/m2) at constant temperature 250C.

VI CONCLUSION

An accurate PV module electrical model is presented and demonstrated in Matlab for typical 60W solar panel. Given solar insolation and temperature, the model calculates current for a given voltage. The results from the Matlab model shows excellent correspondence to manufacturer have published curves. Finally the model development is used to show the effect of insolation on current and voltage when the constant temperature. i.e. With increase in insolation, Current increases and there is slightly increase in voltage.

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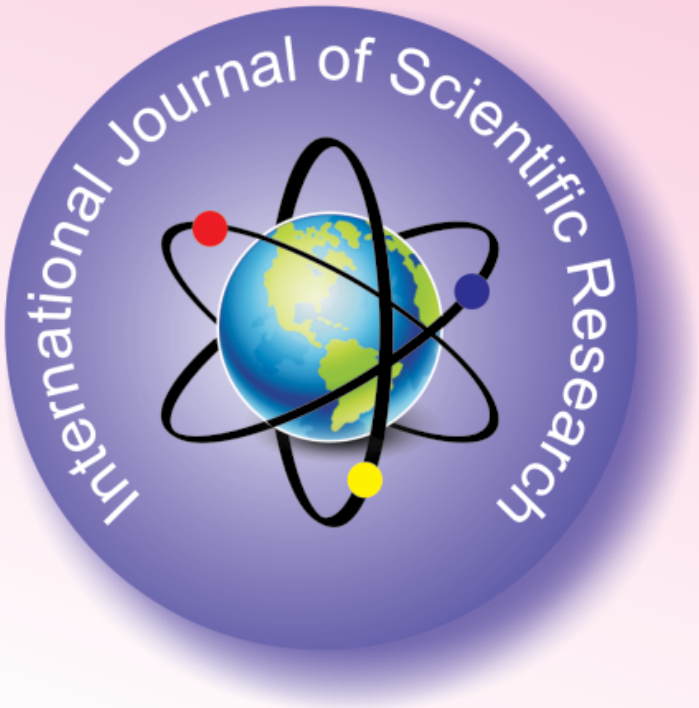

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