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Behaviour of PV cell with variation in parameters

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Abstract : First electrical behavior i.e. short circuit current and open circuit voltage is observed. The effect of different parameters on I-V and P-V curve are studied considering uniform illumination. These parameters are insolation level, temperature, series resistance, shunt resistance, diode reverse saturation current. Variation on I-V and P-V curve are different with each parameter. With some parameters effect is significant while for others effect is not so significant. For the parameters whose effect is not so significant large variation of inputs are taken for showing the effect. Simulation work is done in MATLAB.

Keywords: Photo-Voltaic Cell, Temperature, Insolation, Uniform illumination, non-uniform illumination.

I. INTRODUCTION

PV cell is a device made up of semiconductor material that converts light energy to electrical energy. 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. 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).

PV cell characteristics are given by current-voltage (I-V) and power-voltage (P-V) curve. The voltage at which current is zero called open circuit voltage(Voc) and the current for zero voltage is called short circuit current(Isc).By multiplying current and voltage we can get corresponding power-voltage curve .I-V and P-V curve of PV cell are shown in figure 1 and figure 2.[1]

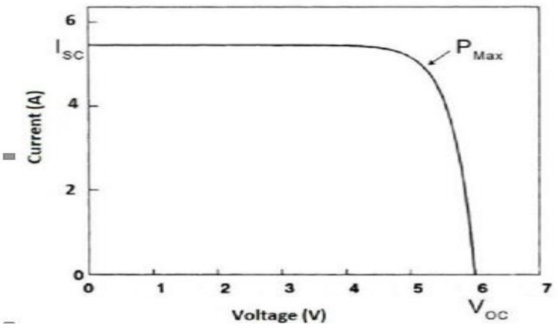

Figure1 I-V curve of PV cell

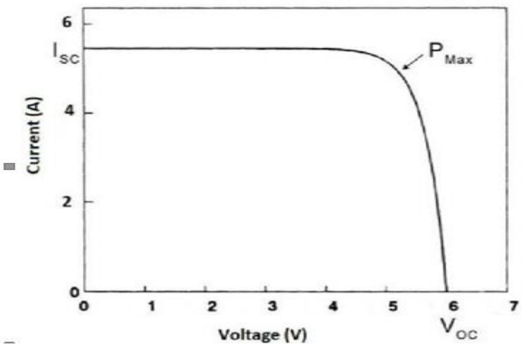

Figure 2 P-V curve of PV cell

II. SYSTEM DESCRIPTION

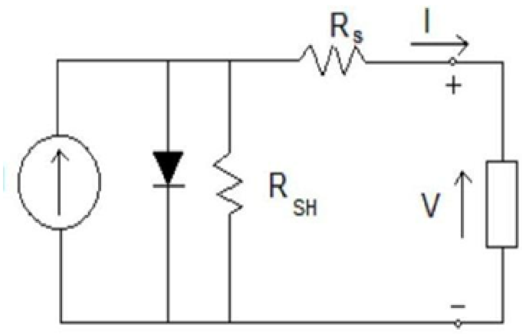

Figure 3 Mathematical model of PV module

The model of the general PV module [2] which consists of a photo current, a diode, a parallel resistor expressing a leakage current, and a series resistor describing an internal resistance to the current flow, is shown in figure 3.

PV cell output current is given by[3]

$$I = I_{ph} - I_s\left(e^{\left\{\frac{q(V+IR_s)}{k*Tc*\eta}\right\}} - 1\right) - \frac{V+IR_s}{R_{sh}}$$

Where
I_{ph} = a light-generated current or photocurrent,
I_s= cell saturation of dark current,
q = an electron charge = 1.602 x 10^{-19}C
k = Boltzmann's constant = 1.38 x 10^{-38}J/K
T_c= cell's working temperature,
A = an ideal factor here we are taken 1.498
R_{sh} = a shunt resistance we are taken 0.3 Ω
R_s = a series resistance we are taken 60Ω

The photocurrent mainly depends on the solar insolation and cell's working temperature, which is described as

$$I_{ph} = [I_{sc} + K_i(T_c - T_{ref})] * G$$

Where
I_{sc} = the cell's short-circuit current at a 25°C and 1kW/m^2
K_i = the cell's short-circuit current temperature coefficient, here we are taken $1.381*e^{-23}$
T_{ref}= the cell's reference temperature
G = the solar insolation in kW/m^2

On the other hand, the cell's saturation current varies with the cell temperature, which is described as

$$I_s = I_{rs}\left(\frac{T_c}{T_{ref}}\right)^3 e^{\left[\frac{qEg\left(\frac{1}{T_{ref}}-\frac{1}{T_c}\right)}{k\eta}\right]}$$

Where,

I_{rs} = the cell's reverse saturation current at a reference temperature and a solar radiation,

Eg = the band-gap energy of the semiconductor used in the cell.

III. RESULT AND DISCUSSIONS

A. Effect of insolation on I-V & P-V characteristics.

The effect of insolation on I-V and P-V characteristics is studied by using MATLAB.As the insolation level increases V_{oc} and I_{sc} increase.So corresponding power voltage curve increases. However with increasing insolation maximum point shifts towards the right but variation is very slight. For the different input value of 1000,1200,1400,1600 W/m^2 are

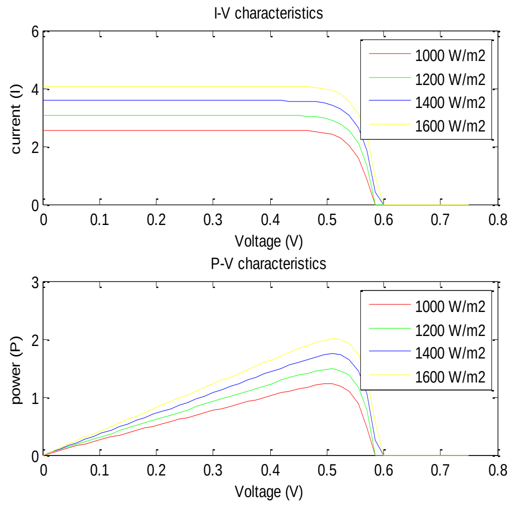

Figure 4.Effect of insolation on I-V and P-V characteristics

B. Effect of temperature on I-V and P-V characteristics.

As PV module temperature increases I_{sc} increases and Voc decreases. Under uniform illumination as the temperature increases the maximum power decreases and the maximum power point i.e. point at the P-V curve at which maximum power can be drawn, is shifted towards the left. For the different value of temperature 25,26,27,28°C I-V and P-V curve are

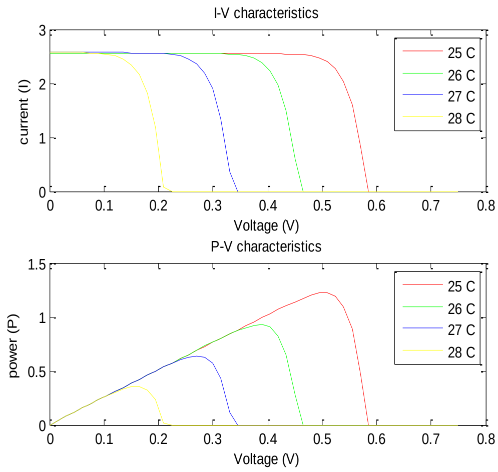

Figure 5.Effect of temperature on I-V and P-V characteristics

C. Effect of series resistance on I-V and P-V characteristics.

Although effect of series resistance is not so significant . With variation of series resistance short circuit current changes slightly and open current voltage remains same .By increasing value of series resistance current-voltage curve and power voltage curve decrease. For the value of 1 μΩ, 2 μΩ,3 μΩ,4 μΩ I-V and P-V curves are[4]

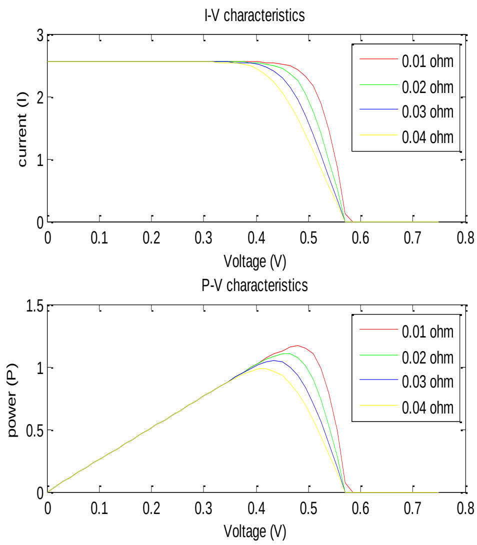

Figure 6.Effect of series resistance on I-V and P-V characteristics

D. **Effect of shunt resistance on I-V & P-V characteristics.**

With the increase of shunt resistance, short circuit current remains almost same but open circuit voltage increases.

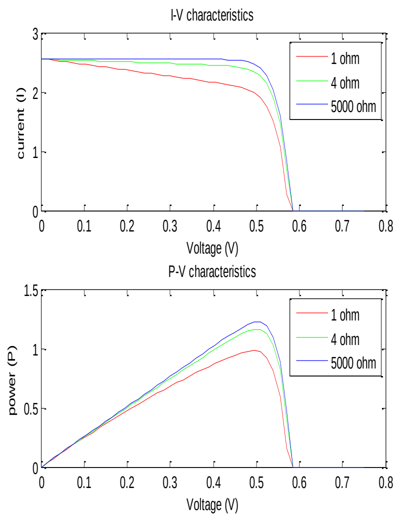

Figure7.Effect of shunt resistance on I-V and P-V characteristics

Observation are taken on different value of shunt resistance of 1ohm, 4 ohm, 5000 ohm .As we can see in the graph by varying series resistance Isc remains same and Voc changes but variation of Voc is also not so much significant.[5]

E. **Effect of diode reverse saturation current(Is) on I-V & P-V characteristics.**

Diode reverse saturation current is the maximum current that can flow in the reverse bias condition. With the increase of diode Is,Voc decreases and Isc remains almost same.

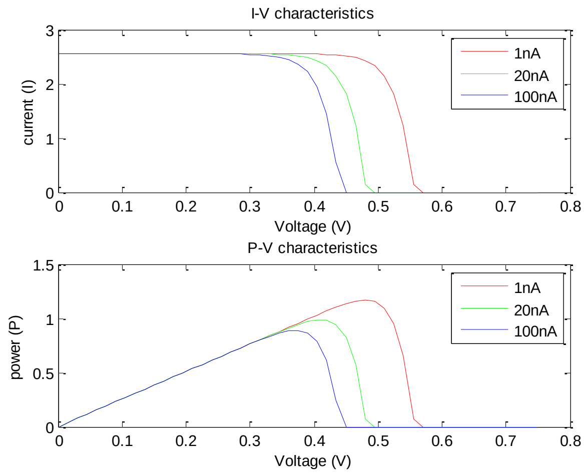

Figure 8.Effect of shunt resistance on I-V and P-V characteristics

Observation are taken on 3 different value of 1nA, 20nA and 100nA.As we can see maximum power point increases with increasing value of diode reverse saturation current.[6]

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