International Journal of Advance Research and Innovation
Vol. 5(2), Apr-Jun 2017, pp. 224-226
Doi: 10.51976/ijari.521737

Article Info
Received: 25 Jan 2017 | Revised Submission: 20 Feb 2017 | Accepted: 28 Feb 2017 | Available Online: 15 Jun 2017

Performance analysis of PV cell under uniform and non-uniform illumination

Aman Khurana, PV Ram Kumar** and RS Mishra****

ABSTRACT

The electrical behavior i.e. short circuit current and open circuit voltage is observed. The effects of different temperature and insolation on I-V and P-V curve are studied considering uniform illumination. The study shows that short circuit current and open circuit voltage increases with increase in the insulation. By multiplying these two powers curve is drawn. As the cell's working temperature increases short circuit current increases and open circuit voltage decreases and accordingly the power is obtained.
Then the effect of non-uniform illumination on PV cell with variable shape factor is studied and temperature variation with non-uniformity is observed. By approaching uniform illumination on PV cell mean temperature decreases and accordingly the current output with the variation of shape factor is studied.

Keywords: *Photo-Voltaic Cell; Temperature; Insulation; Illumination.*

1.0 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). Xing et al. [1] studied thermal and electrical performance analysis of solar cell under non-uniform illumination. The illumination on the cell was set to be uniform along X direction, which was the direction of current flowing in the cell, and the illumination was set to be only non-uniform along Y direction, which was perpendicular to X direction. Illumination is given by

$$S_{illumination} = S_m * A_m * e^{\frac{-y^2}{2S_0^2}} \quad (1)$$

Where,
So is the shape factor
Am is the normalization factor
Sm is the average illumination intensity is given by

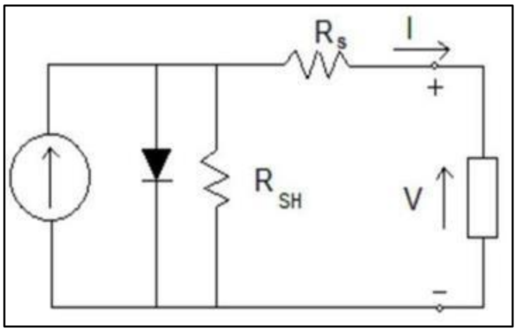
$$S_m = S_{sun} * C$$

Where, C is concentration ration realistic value is 500X and Ssun is fixed 1000 w/m21

Xing, Y et al. [2] studied the concentrator silicon solar cells and it is observed that increasing the temperature increases the current.

2.0 System Description

Fig 1: Mathematical Model of PV Module



The model of the general PV module [3] which consists of a photo current, a diode, a parallel resistor expressing a leakage current, and a series

**Corresponding Author: Department of Mechnical Engineering, Delhi Technological University, Delhi, India*
(E-mail: amankhurana1602@gmail.com)
**Department of Mechnical Engineering, Delhi Technological University, Delhi, India*
**Department of Mechnical Engineering, Delhi Technological University, Delhi, India*

resistor describing an internal resistance to the current flow, is shown in figure 1.

PV cell output current[4] is given by

$$I = I_{ph} - I_s\left(e^{\left\{\frac{q(V+IR_s)}{k*Tc*\eta}\right\}} - 1\right) - \frac{V+IR_s}{R_{sh}} \quad (2)$$

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

$$I_{ph} = [I_{sc} + K_i(T_c - T_{ref})] * G \quad (3)$$

Where
I_{sc} = the cell's short-circuit current at a 25°C and 1 kW/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

$$I_s = I_{rs}\left(\frac{T_c}{T_{ref}}\right)^3 e^{\left[\frac{qEg\left(\frac{1}{T_{ref}} - \frac{1}{T_c}\right)}{k\eta}\right]} \quad (4)$$

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.

I-V curve[5] for PV cell is shown in figure 2 and power curve is shown in figure 3.

Fig 2: I-V Curve of PV Cell

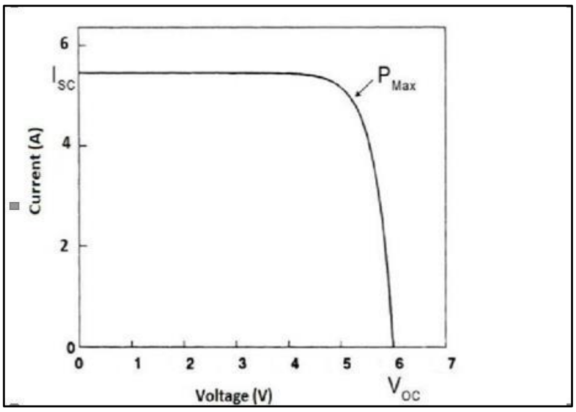
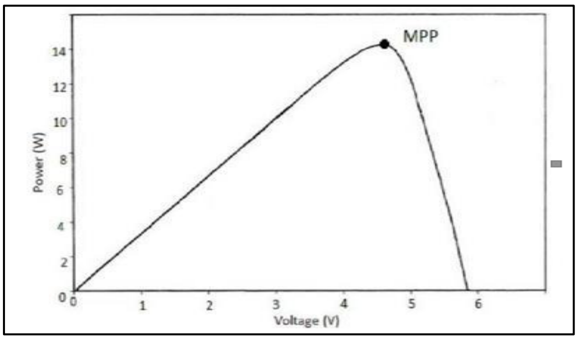


Fig 3: P-V Curve of PV Cell



3.0 Result and Discussions

3.1 Effect of insulation on I-V & P-V characteristics

The effect of insulation on I-V and P-V characteristics [6] is studied by using MATLAB and this is shown in figure 4. As the insulation level increases Voc and Isc increases. So corresponding power voltage characteristics is shown in figure 4. However with increasing insulation this point is shifted towards the right but variation is very slight.

Fig4: Effect of insolation on I-V and P-V characteristics

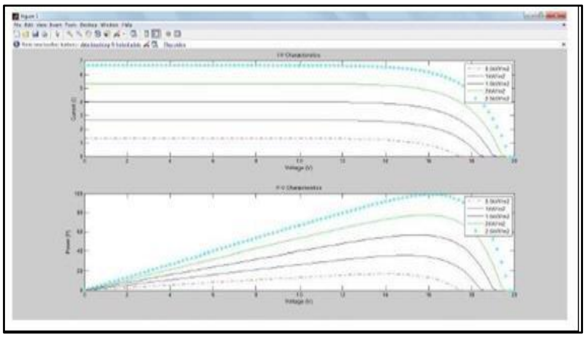
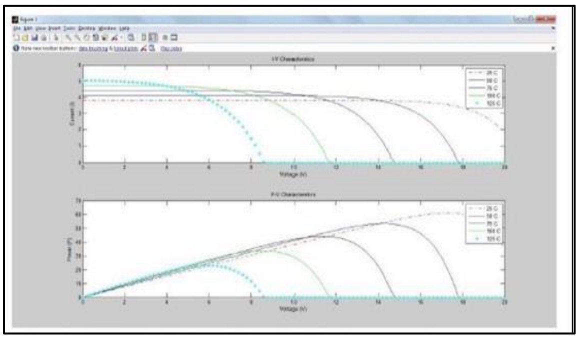


Fig 5: Effect of Temperature on I-V and P-V Characteristics



3.2 Effect of temperature on I-V and P-V characteristics

The effect of temperature on I-V and P-V characteristics is studied by using MATLAB and this is shown in figure 5. As PV module temperature increases Isc increases and Voc decreases. Under uniform illumination as the temperature increases the maximum power point i.e. point at the P-V curve at which maximum power can be drawn, is shifted towards the left.

4.0 Conclusions

Under uniform illumination as the temperature increases the maximum power point i.e. point at the P-V curve at which maximum power can be drawn, is shifted towards the left. with increasing insolation the maximum power point is shifted towards the right but variation is very slight.

References

[1] Y Xing, K Zhang, J Zhao, P Han. Thermal and electrical performance analysis of silicon vertical multi-junction solar cell under non-uniform illumination. Renewable Energy, 90, 2016, 77-82.

[2] Y Xing, P Han, S Wang, P Liang, S Lou, Y Zhang, Y Mi. A review of concentrator silicon solar cells. Renewable and Sustainable Energy Reviews, 51, 2015, 1697-1708.

[3] XH Nguyen, MP Nguyen. Mathematical modeling of photovoltaic cell/module/arrays with tags in Matlab/Simulink. Environmental Systems Research, 4(1), 2015, 24.

[4] H Bellia, R Youcef, M Fatima. A detailed modeling of photovoltaic module using MATLAB. NRIAG Journal of Astronomy and Geophysics, 3(1), 2014, 53-61.

[5] AK Gupta, NS Chauhan, R Saxena. Real time IV and PV curve tracer using LabVIEW. In Innovation and Challenges in Cyber Security (ICICCS-INBUSH), IEEE, 2016, 265-269

[6] IH Altas, AM Sharaf. A photovoltaic array simulation model for matlab-simulink GUI environment. In Clean Electrical Power, ICCEP'07,(IEEE), 2007, 341-345

Nomenclature

V_{oc}	Open circuit voltage
I_{sc}	Short circuit current
I	Load current
S_0	Shape factor