International Journal of Scientific Engineering and Technology ISSN : 2277-1581
Volume No. 6, Special Issue 1, PP : 04-06 22-23 Dec. 2017

Modeling, Simulation and Performance Analysis of Monocrystalline and Polycrystalline Panel

Neelam Rathore, N.L. Panwar, Surendra Kothari, Kirtika Sharma
Renewable Energy Engineering Department, M.P.U.A.T, Udaipur, India
Corresponding Author: E-mail: neelamrathore79@gmail.com

Abstract: This paper presents the modeling and simulation of photovoltaic model using MATLAB/Simulink software package. Modeling and simulation is done for monocrystalline panel and polycrystalline panel of 40 Watt having total 37 cells in which 36 cells were connected in series and 1 cell in parallel. For both type of panels electrical characteristics is plotted and temperature effect is analyzed. Performance analysis of mono-crystalline and poly-crystalline solar photovoltaic panels was done considering certain parameters i.e. analysis of V-I curve, effect of variation in tilt angle on PV module power, effect of shading on PV module power, effect of increase of temperature on PV module power, efficiency, space efficiency and cost. Both the panels were compared on the basis of above parameters. The proposed model is very useful for engineers who are dealing with PV system designing.

INTRODUCTION

Photovoltaic (PV) is a method of generating electrical power by converting solar radiation into direct current electricity using semiconductor by photovoltaic effect. The modeling and simulation of photovoltaic (PV) have made a great transition and form an important part of power generation in this present era **[1].** The cost and the performance of PV plants strongly depend on the modules. The ideal photovoltaic module consists of a single diode connected in parallel with a light generated current source (I_{SC}) as shown in Figure 1 [**1-2]:**

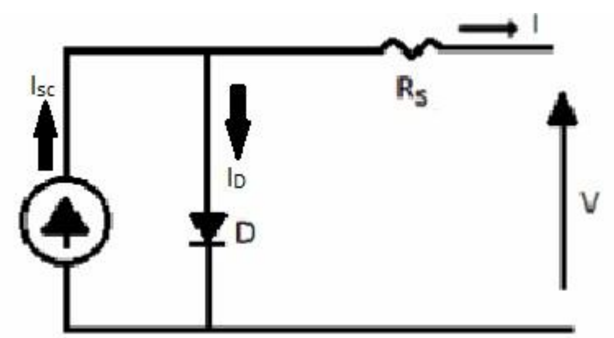

Fig 1: Solar cell model using single diode with R_S

1. MATHEMATICAL MODELLING

Following equations were written in MATLAB for the figure shown above Fig 1**:**
The ideal photovoltaic module consists of a single diode connected in parallel with a light generated current source (I_{SC}) as shown in Fig 1:

$$I = I_{SC} - I_{RS}$$

Where I_{SC} is photocurrent which is the light-generated current at the STP condition (25°C and 1000W/m^2).
The equations of Reverse Saturation Current and photocurrent are given by **[3 -4]:**

$$I_{RS} = I_{scref}\left[e\left(\frac{qvoc}{NsKAT}\right) - 1\right]$$

$$I_{SC} = [I_{scref} + K(T - T_{ref})]\frac{s}{1000}$$

The equation that describes the I-V characteristic of the circuit in Fig1 is given by

$$I_{SC} - I_D - V_D / R_P - I_{PV} = 0$$

Output of PV Module: It represents the output current generated which depends on the PV module voltage, solar irradiance on PV module, wind speed, and ambient temperature**. [4 -5]**

$$I_{PV} = N_P I_{SC} - N_S I_O\{\exp(q(V_{PV} + I_{PV} R_S)/ N_S AKT) - 1\} - V_{PV} + (I_{PV} R_S / R_P)$$

Where k is the Boltzmann constant (1.38 x 10 ^ -23 J K-1), q is the electronic charge (1.602 x 10 ^ -19 C), T is the cell temperature (K), A is the diode ideality factor, the series resistance R_S (Ω) and is the shunt resistance R_P (Ω). N_S is the number of cells connected in series = 36. Np is the number of cells connected in parallel and $V_{OC} = V_{PV}$.
Theoretically observations were recorded using MATLAB and practically characteristics were plotted using "Solar PV Training and Research Kit" shown in fig 2. Circuit diagram to analyze V-I Characteristics is shown in figure3.

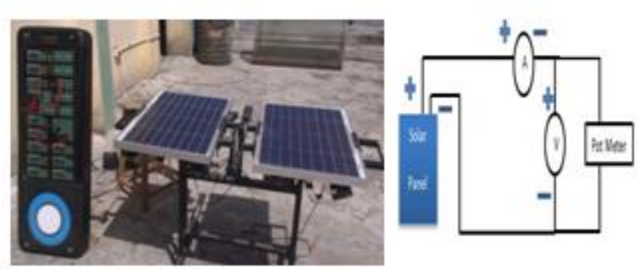

Fig 2: Circuit diagram to analyze V-I characteristics

ISSN : 2277-1581
22-23 Dec. 2017

2. RESULTS AND DISCUSSION

3.1 V-I CHARACTERISTICS

V-I and P-I characteristics at 25˚C for both types of panel were observed so that power can be observed at any radiation using MATLAB as shown in below figure 3 and 4.

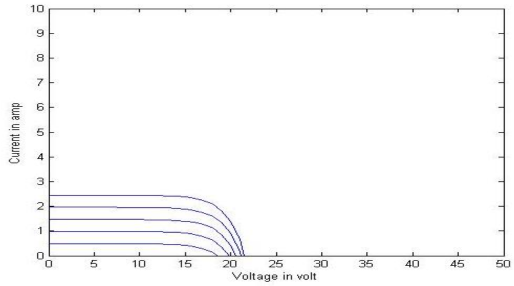

Fig 3: MATLAB V-I characteristic for varying irradiance at 25° C (polycrystalline panel)

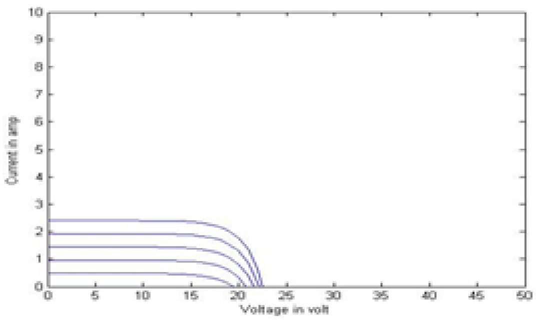

Fig 3: MATLAB V-I characteristic forfor varying irradiance at 25° C (Monocrystalline panel)

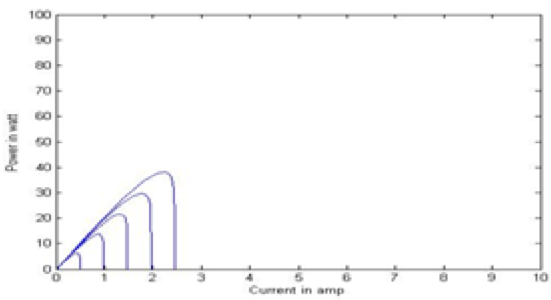

Fig 6:MATLAB P-I characteristics for Varying Irradiance at 25° C (Mono Panels)

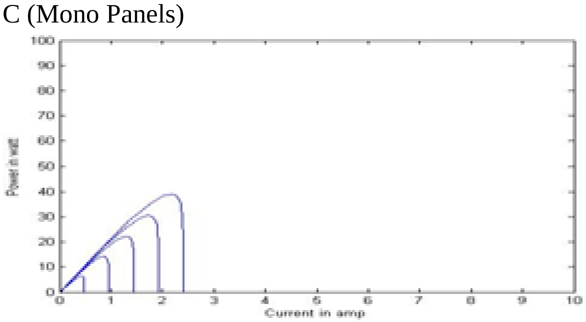

Fig 7:MATLAB P-I characteristics for varying Irradiance at 25° C (Mono Panels)

As it can be seen from graphs, at constant module temperature, it can be observed that with increase of solar irradiance, the short-circuit current and open circuit voltage increases. Therefore, higher the irradiation, greater is the current. Contrary to the influence of the solar irradiance, the increase in the temperature around the solar module has a negative impact on the power generation capability. Table 1 shows that as temperature increases power decreases but the decrement of power is more for monocrystalline panel as compared to polycrystalline panel. Another parameter that gets affected is open circuit voltage. As temperature increases open circuit voltage decreases while short circuit current does not very much.

Table 1: **Effect of variation of temperature on power (MATLAB results)**

Temperature	Open Circuit voltage (Volt)		Power(watt)	
	Polycrystalline Panel	Monocrystalline Panel	Polycrystalline Panel	Monocrystalline Panel
25° C	22	22	37	39
50° C	21	17	35	28
75° C	19	15	31	24

3.2 EXPERIMENTAL ANALYSIS

(using "Solar PV Training and Research Kit")

3.2.1 Effect of increase of temperature on PV module power

Fig 7 is showing effect of increase of temperature on PV module power for monocrystalline and polycrystalline PV panel. Here temperature is operating temperature of solar panel which is always 25˚C greater than ambient temperature. As temperature increases power decreases but the decrement of power is slightly lower for polycrystalline panel as compared to monocrystalline panel.

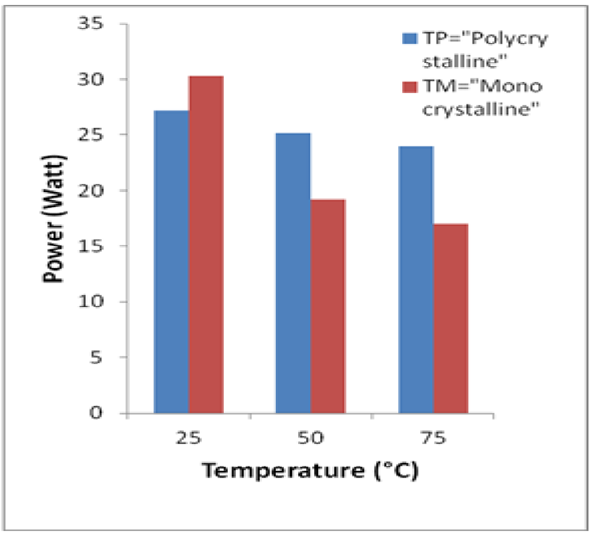

Fig 8: Curve showing effect of increase showing effect of shading for both panels

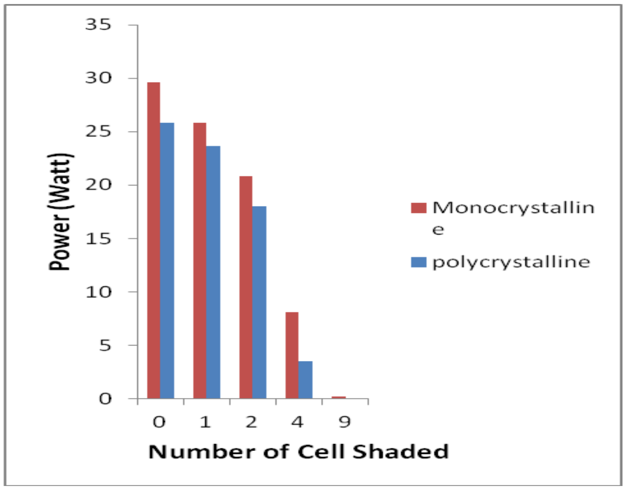

Fig 9: Comparison Curve of temperature on PV panels

3.2.2 Effect of shading on PV Module power

Readings were taken for 0 cell shading, 2 cell shading, 4 cell shading, 9 cell shading and power was observed at different shading. In case of shading power decrement of 23.9% was observed in polycrystalline while only 19.37% of power was reduced in monocrystalline panel. Monocrystalline panel is less affected by shading and works well in shady condition as compared to polycrystalline panel as power drop was more in case of polycrystalline panel during shading as shown fig 8.

Efficiency:

Power was observed for full day (i.e. 7 a.m. to 5 p.m.) hence efficiency was calculated . Efficiency of monocrystalline varies between 3% to 14% whereas from polycrystalline panel it is 2.5% to 9.5%.

3.2.3 Space Efficiency:

As two panels were considered while taking observations for different parameters and the area of monocrystalline panel was 0.18 m^2 while for that of polycrystalline panel was 0.20 m^2 for 40 watts. Monocrystalline panel occupies small space as compared to polycrystalline panel for the same amount of power. Monocrystalline panels supply power about 222 Watt/m^2 while polycrystalline supplies power about 200 watt/m^2.

3.2.4 Cost:

Now a days cost of both panels is decreasing. Monocrystalline solar panels are expensive because of its purity. Polycrystalline cells are made up of multiple crystals and are generally less expensive to manufacture than mono cells.

3. CONCLUSIONS

Power output from monocrystalline panel is more than polycrystalline so Monocrystalline panel tends to perform better than similarly rated polycrystalline at low light conditions.

Theoretically and Practically "Effect of increase of temperature on PV module power was observed and it was concluded as temperature increases power decreases but the decrement of power is slightly lower for polycrystalline panel as compared to Monocrystalline panel. When temperature was increased from 25°C to 50°C power decreases by 5.40 % in case of polycrystalline while in case of monocrystalline power decrement of 28.20 % was observed.

Effect of shading on PV Module power was done and it was observed that monocrystalline panel is less affected by shading and works better in shady condition as compared to polycrystalline panel. In case of shading power decrement of 23.9% was observed in polycrystalline while only 19.37% of power was reduced in monocrystalline panel

Both monocrystalline and polycrystalline panels are good choices but polycrystalline panel tends to be less space efficient as Monocrystalline panel occupies small space as compared to polycrystalline panel for the same amount of power.

REFERENCES

i. *Abdulkadir, M., Samosir, A.S. and Yatim, A.H. M. 2012. Modeling and Simulation Based Approach of Photovoltaic System in Simulink Model, ARPN Journal of Engineering and Applied Sciences, Vol. 7: 616-623.*

ii. *Adamo,F., Attivissimo, F., Nisio,A.D., Lanzolla, A.M.L. and Spadavecchia, M. September 6−11, 2009. Parameters Estimation for A Model of Photovoltaic Panels, XIX I MEKO World Congress Fundamental and Applied Metrolog: 964-967.*

iii. *Basim Alsayid . 2012. Modeling and Simulation of Photovoltaic Cell/Module/Array with Two-Diode Model, International Journal of Computer Technology and Electronics Engineering, Vol. 1, Issue 3: 6-11.*

iv. *Bikaneria,J. Joshi,S.P. and Joshi, A.R. 2013. Modeling and Simulation of PV Cell Using One Diode Model, International Journal of Scientific and Research Publications, Vol. 3, Issue 10: 1-4.*

v. *Chouder, A ., Silvestre,S., Taghezouit ,B. and Engin Karatepe . 2012. Monitoring, modeling and simulation of PV systems using LabVIEW, Solar Energy ,1-12.*

vi. *Das, D. and Pradhan, S.K. 2011. Modeling and simulation of PV array with boost converter: an open loop study, Unpublished B.Tech project report submitted to Department of Electrical Engineering, National institute of technology, Rourkela.*

vii. *Dev, A. and Jeyaprabha, S.B. 2013. Modeling and Simulation of Photovoltaic Module in MATLAB, Proceedings of the International Conference on Applied Mathematics and Theoretical Computer Science: 268-273.*

viii. *Dunford ,W.G., Xiao, W. and Capel, A. 2004. A Novel Modeling Method for Photovoltaic Cells, 35th Annual IEEE Power Electronics Specialists Conference: 1950-1956.*

ix. *Hadjab, M., Berrah, S. and Abid, H. 2012. Neural network for modeling solar panel, International Journal of Energy, Vol. 6, Issue 1: 9-16.*