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Effect of Irradiance on Performance for Poly-Crystalline Photo-voltaic Cell

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Abstract:

In this paper, simulation of 60 Cells Eldora Ultima Silver 1500 V Series by Vikram Solar Panel using Matlab Simulink approach is presented. The method is used to determine the PV & I-V characteristics of proposed module in various conditions especially in different levels of irradiation. In addition, all results from Matlab Simulink are verified with the data sheet of Eldora Ultima Silver 1500 V Series by Vikram Solar Panel.

Keywords — **Solar photovoltaic cell, mathematical model, modeling, PV module, standard test condition (STC), PV characteristic; simulink/matlab.**

I. INTRODUCTION

Studies of polycrystalline silicon are numerous especially through the technical development of characterization methods in order to raise the performance of solar cells made of this material document is a template. The polycrystalline PV cell (solar cell) converts the sunlight into the electrical energy by the photovoltaic effect. Energy from PV modules offers several advantages, such as, requirement of little maintenance and no environmental pollution. The polycrystalline PV module typically consists of a number of PV cells in series. The conventional technique to model a PV cell is to study the p-n junction physics. The polycrystalline PV cell has a non-linear voltage-current (*V-I*) characteristic which can be modelled using current sources, diode(s) and resistors. Single-diode and double-diode models are widely used to simulate PV characteristics. The single-diode model emulates the PV characteristics fairly and accurately. The manufacturer provides information about the electrical characteristics of PV by specifying certain points in its *V-I* characteristics which are called remarkable points.

In this paper, a simplified polycrystalline PV equivalent circuit with a diode (The single-diode model) equivalent as model is proposed. The main contribution of this work is the implementation of a generalized polycrystalline PV model with Matlab/simulation.

II. A MATHEMATICAL MODEL OF PHOTOVOLTAIC MODULE

A solar cell is basically a p-n junction fabricated in a thin wafer of semiconductor. The electromagnetic radiation of solar energy can be directly converted to electricity through photovoltaic effect. Being exposed to the sunlight, photons with energy greater than the band-gap energy of the semiconductor creates some electron-hole pairs proportional to the incident irradiation. The equivalent circuit of a Poly-Crystalline PV Cell is shown in figure 1.This model is known as a single diode model of solar cell. The current source I_{ph} represents the cell photo-current. R_{Sh} and R_S are the intrinsic shunt and series resistances of the cell respectively. Usually the value of R_{Sh} is very large and R_S is very small, hence shunt resistor may be neglected to simplify the analysis. The poly-crystalline PV panel can be modelled mathematically with the equations [(1) to (4)] given below:

$$I_{ph} = [I_{SC} + K_i(T_C - T_R) * \frac{S}{1000} \quad (1)$$

$$I_{rs} = I_{SC}/[\exp\left(\frac{qV_{oc}}{N_S kAT_C}\right) - 1] \quad (2)$$

$$I_S = I_{rs}[\frac{T_C}{T_R}]^3 \exp\left(\frac{qE_g}{kA(\frac{1}{T_R}-\frac{1}{T_C})}\right) \quad (3)$$

$$I_{pv} = N_P * I_{Ph} - N_P * I_S [\exp\left(\frac{qV_{Pv}+I_{Pv}R_S}{N_S kAT_C}\right) - 1] \quad (4)$$

Where,

I_{ph} = photo current

I_{rs} = reverse saturation current

$I_S = I_D$ = Saturation current

I_{pv} = output current

N_P = No. of parallel branches of the Cell

A = Diode Ideality Factor

k = Boltzmann's Constant = 1.3805×10^{-23} J/K

Ki = Short Circuit Temperature Coefficient mA/°C

N_S = Number of Cells Connected in series

q = Magnitude of Charge on the Electron = 1.6×10^{-19} C

R_S = Series Resistance (Ω)

R_{Sh} = Shunt Resistance (Ω)

S = Solar irradiation Intensity (W/m2)

T_C = Working Cell Temperature (K)

T_R = The Reference Temperature = 298 K

V_{oc} = Open Circuit Voltage (V)

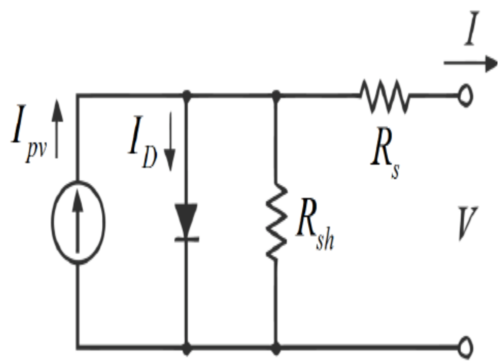

Fig.1: Equivalent circuit of PV cell.

III. REFERENCE MODEL

60 Cell Eldora Ultima Silver 1500 V Series by Vikram Solar is taken as reference model for simulation and above equations are simulated. The data sheet is given below:

Table-I

Datasheet at STC: 1000 W/m2 irradiance, 25°C cell temperature.

Parameters	Values
Peak Power	280 W
Open Circuit Voltage	38.7 V
Short Circuit Current	9.32 A
Temp. Coeff. for Short Circuit Current	0.00058
NOCT	45°C ± 2°C

IV. SIMULINK MODEL FOR POLYCRYSTALLINE PV CELL

A generalized PV model is built using Matlab/Simulink according to Equations (1) to (4). Solar module [60 Cell Eldora Ultima Silver 1500 V Series by Vikram Solar Panel] is taken as a reference model for simulation of poly-crystalline PV cell. The proposed model is implemented using Matlab/Simulink along with PV & I-V characteristics.

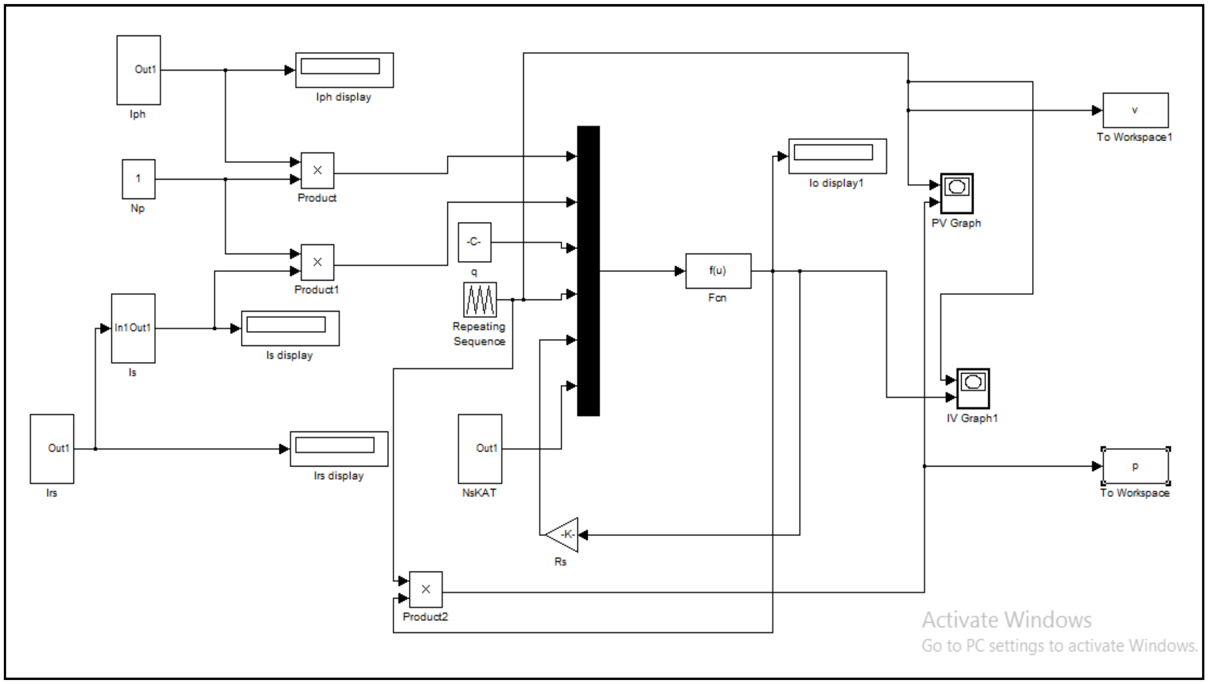

Fig.2: Simulink Model For Poly-Crystalline PV Cell

V. SIMULATION RESULTS

In this paper, PV & I-V Graphs have been plotted by varying irradiance parameter for polycrystalline PV Cell. The PV & I-V graphs are plotted at irradiance G=1000 $^{W}/_{m^2}$ as shown in figure-3 & 4. At G=1000 irradiance, the maximum power is 240.34 watt in figure-3 and the maximum current is 9.32 Ampere as shown in figure-4.

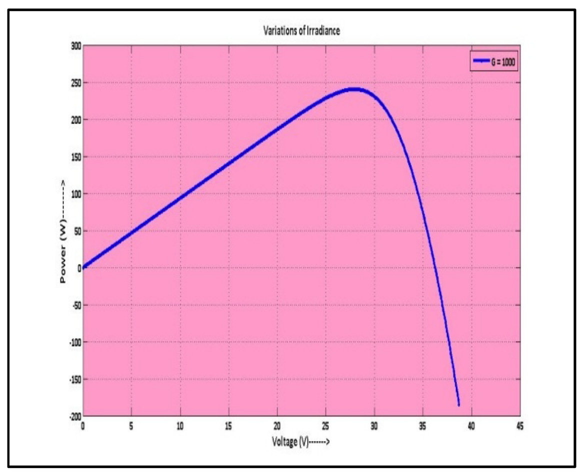

Fig. 3: PV Graph for Irradiance G=1000 $^{W}/_{m^2}$

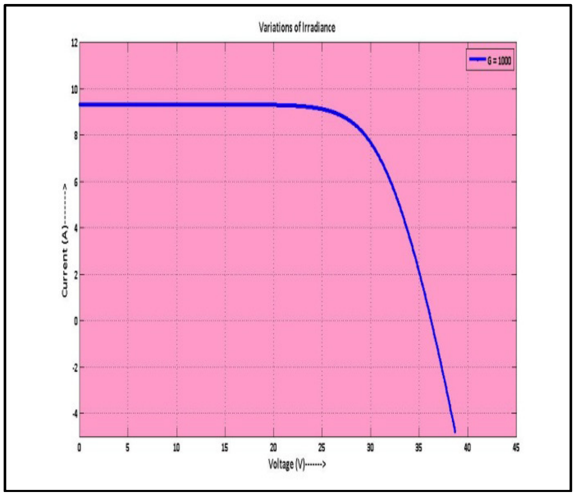

Fig. 4: I-V Graph for Irradiance G=1000 $W/_{m^2}$

Now figures 5 & 6 show the PV& IV Graph on decreasing the value of irradiance to G=800 $W/_{m^2}$ as shown in figure 5 & 6. At G=800 irradiance, the maximum power is 192.90 watt in figure 5 and the maximum current is 7.47 Ampere as shown in figure 6.

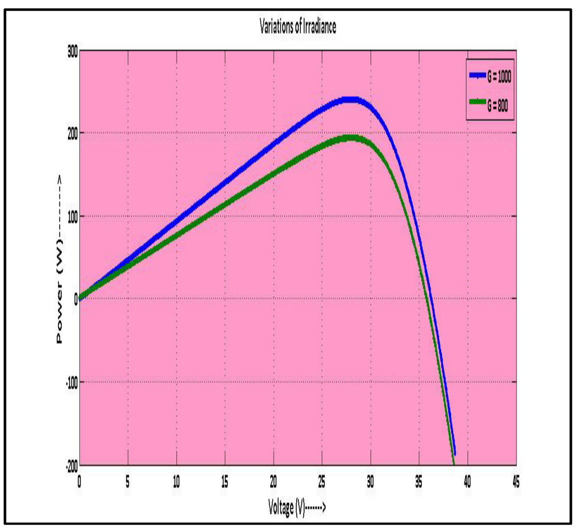

Fig. 5: PV Graph for Irradiance G=800 $W/_{m^2}$

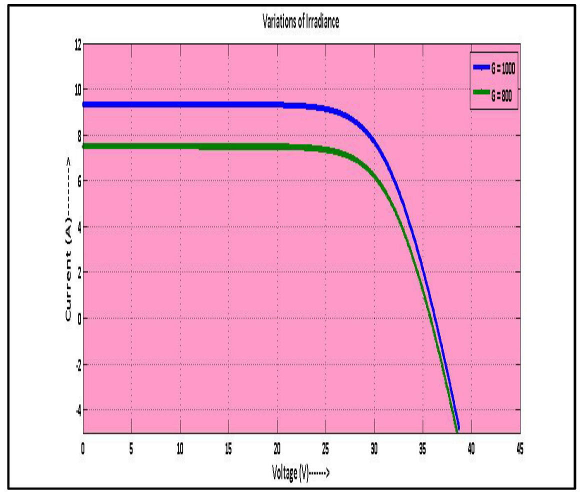

Fig. 6: I-V Graph for Irradiance G=800 $W/_{m^2}$

Figures 7 & 8 show the PV & I-V Graph on decreasing the value of irradiance to G=600 $W/_{m^2}$ as shown in figure 7 & 8. At G=600 irradiance, the maximum power is 144.43 watt in figure 7 and the maximum current is 5.60 Ampere as shown in figure 8.

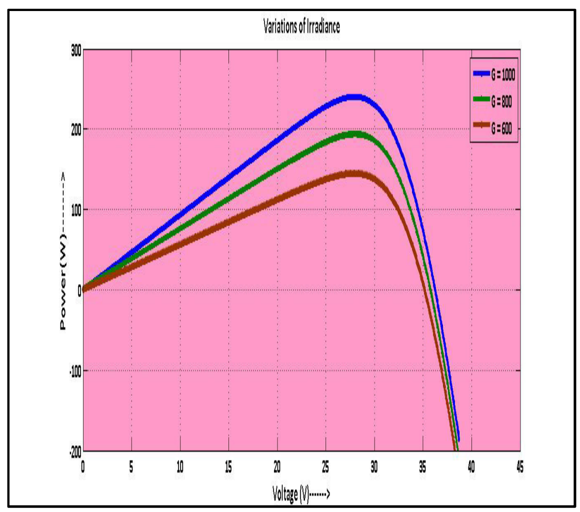

Fig. 7: PV Graph for Irradiance G=600 $W/_{m^2}$

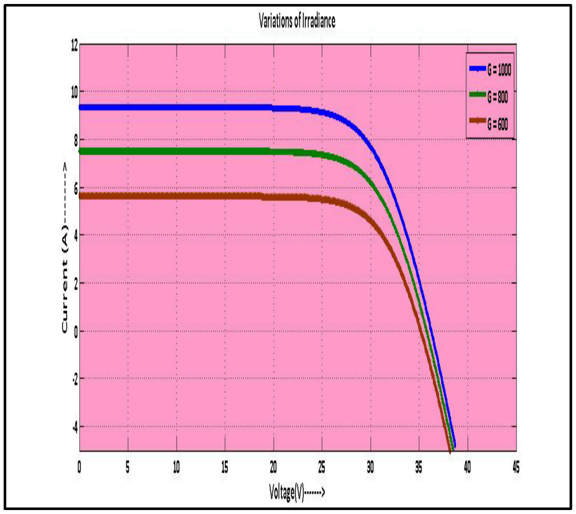

Fig. 8: I-V Graph for Irradiance G=600 W/m^2

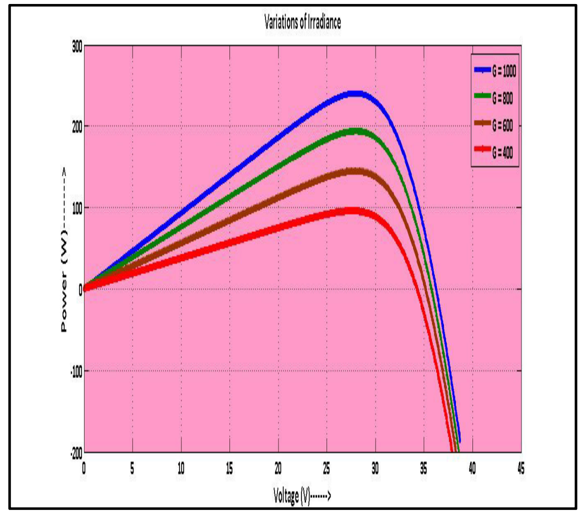

Fig. 9: PV Graph for Irradiance G=400 W/m^2

In the last, figures 9 & 10 show the PV & I-V Graph on decreasing the value of irradiance to G=400 W/m^2 as shown in figure 9 & 10. At G=400 irradiance, the maximum power is 95.26 watt in figure 9 and the maximum current is 3.73 Ampere as shown in figure 10. The different values of maximum power and maximum current are also shown in tabular form in Table II, at irradiance G= 1000,800,600 and 400 W/m^2 at 25°C cell temperature for STC.

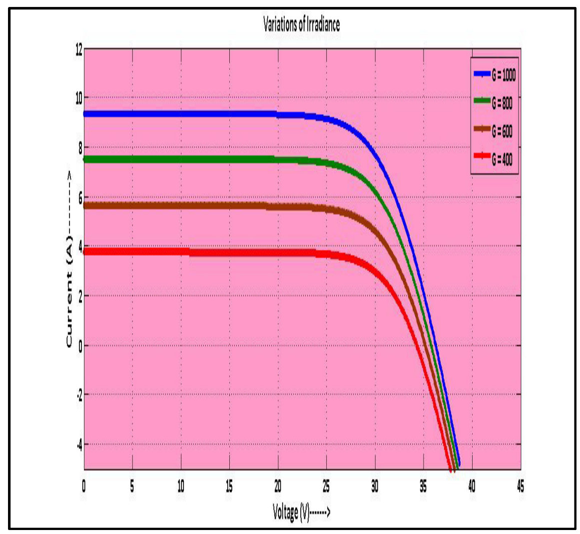

Fig. 10: I-V Graph for Irradiance G=400 W/m^2

Table-II

Maximum Power & Current Values for Different Irradiance Values.

Irradiance (W/m2)	Maximum Power (in Watts)	Maximum Current (in Ampere)
1000	240.34	9.32
800	192.90	7.47
600	144.43	5.60
400	95.26	3.73

VI. CONCLUSION

Figures and table show the simulation results of PV & I-V characteristics at the varying solar irradiance (1000 W/m^2 to 400 W/m^2) with constant module temperature (25^oC).The PV and I-V curves of a polycrystalline solar cell are highly dependent on the solar irradiation values. It is very clear that current generated and maximum output power decreases with decreasing solar irradiance. The accurateness of the simulation results is verified with manufacturer results viz. PV and I-V characteristics of poly-crystalline PV cell.

REFERENCES

1. *Ami Shukla et.al, "Modeling and Simulation of Solar PV Module on MATLAB/Simulink" ISSN(Online): 2319 – 8753,ISSN (Print) :2347 – 6710, Vol. 4, Issue 1, January 2015,source: www.ijirset.com*
2. *Amit Anand, A. K. Akella," Modelling and Analysis of Single Diode Photovoltaic Module using MATLAB/Simulink", Source: www.ijera.com.*
3. *Chetan Singh Solanki,"Solar Photovoltaic Technology and Systems", EEE Book Company.*
4. *David Toub,"A Review of Photovoltaic cells", pdf, Source: http://www.ece.rochester.edu.*
5. *Deepti Sharma, Prof. Kaushal Nayak," MATLAB Simulation of Perturb and Observe Method of Maximum Power Point Tracking in Solar Photovoltaic System", Vol. 2 Issue 4, April-2013,Source: www.erpublications.com.*
6. *Digvijay Sarvate, M.K. Bhaskar et.al." Performance of Mono-Crystalline Photo-voltaic Cell on the Variations of Irradiance", International Journal For Science And Advance Research In Technology (IJSART), ISSN [ONLINE]: 2395-1052, Vol. 3, Issue 12 in December, 2017.*
7. *Forrest M. Mims III, "Solar Cell Projects (RadioShack)",From Engineer's Mini Note Book, pdf ,Source: http://dl.lux.bookfi.net.*
8. *Green, A. and Martin (1982), "Solar Cells: Operating Principles, Technology and System Applications", Prentice-Hall: Englewood Cliffs, NJ, Source: http:// www. Researchinventy .com/papers/v3i12/ C0312010014.pdf.*
9. *He Tang , Shengsheng He, Chuangwei Peng, "A Short Progress Report on High-Efficiency Perovskite Solar Cells", Nanoscale Research Letters (2017) 12:410 DOI 10.1186/s11671-017-2187-5.*
10. *Huan-Liang Tsai,et.al," Development of Generalized Photovoltaic Model Using MATLAB / SIMULINK", ISBN: 978-988-98671-0-2.*
11. *Krismadinata et.al," Photovoltaic module modeling using simulink/matlab",Source: www.sciencedirect.com.*
12. *P. M. Kurwade , S. S. Dandge , K. R. Gawande," Thermal Evaluation And Optimization Of Monocrystalline Silicon Solar Cell With Respect To Temperature", International Journal For Engineering Applications And Technology(IJFEAT), June-15 ISSN: 2321-8134*
13. *Shruti Sharma, Kamlesh Kumar Jain, Ashutosh Sharma, "Solar Cells: In Research and Applications—A Review", Materials Sciences And Applications, 2015, 6, 1145-1155.*
14. *Tarak Salmi, Mounir Bouzguenda,et.al," MATLAB /Simulink Based Modelling of Solar Photovoltaic Cell" International Journal Of Renewable Energy Research , Vol.2, No.2, 2012.*
15. *Usha Mandadapu, et.al," A Detailed Matlab Modeling of Photovoltaic Module", 30th IRF International Conference, 21st August,2016, Bengaluru, India, ISBN: 978-93-86083-84-5.*
16. *Venkatakrishnan, G. R. ,Dr. Rengaraj, "OVERVIEW OF SOLAR ENERGY IN INDIA", International Journal of Development Research Vol. 4, Issue, 3, pp. 605-608, March, 2014.*