International Journal of Engineering Research
Volume No.4, Issue No.12, pp : 643-647
ISSN:2319-6890)(online),2347-5013(print)
01 Dec. 2015

Step-By-Step Check Response of PV Module Modeling Tested by Two Selected Power Reference Modules

***A.M. Soliman, **K. Abdel-Aty**
* Electronics Research Institute, Power Electronics & Energy Conversion Dept, Egypt;
** AIN Shams University, Electric Power & Machines Dept, Egypt;
*aymansoliman3000@yahoo.com , **khldoooon@gmail.com

Abstract: Photovoltaic (PV) systems are becoming nowadays an attractive solution to overcome energy demands and pollution reduction. Several issues under research such as PV MPPT, PV Distributed generation, PV On-Grid systems, and PV off Grid systems need a modeling of PV module as an important initial step in these researches. This paper presents a mathematical model of a PV module using Matlab which this model was checked in response step by step to be guidance for researchers understanding in these areas. In the mean time, the modeling final results are compared by two different commercial reference models for verification purpose which results had been well matched.

Keywords: PVMathematical Modeling, Matlab /Simulink, Step-by-Step Modeling.

I. Introduction

It becomes necessary to study well, investigate and enhance performances of all Renewable energy resources applications regarding technicality, cost, and integration with conventional fossil fuel energy sources. From this point of view and especially for photovoltaic systems, researchers provide their ideas and solutions for several applications such as MPPT [i], Stand Alone PV systems [ii-iv], On-grid PV systems [v], and smart grid systems [vi]. In fact, the first initial step to investigate and analyze all optimization techniques for these different applications is to be assured from the PV module modeling which considered the start of line. Indeed, a lot of researchers introduce the mathematical modeling of the PV modules in details [vii-x], but they didn't expose to check the response in steps. Hence the main aim of this paper is to provide a researcher/reader with the knowledge on the building blocks check response gradually based on mathematical equations to be satisfied with his final results. Two particular reference PV modules are selected for the analysis of developed model. Characteristics curves obtained from simulation for the selected modules with the output power of 250 W and 320 W are compared with the curves provided by the data sheet which are well matched. The principle, operation, and mathematical model of PV cell are described in section II. Section III provides a selected two reference module parameters. The simulation model, step-by-step check response and final results are presented and discussed in section IV. Finally, conclusions are drawn in section V.

II. Photo Voltaic Module Modeling

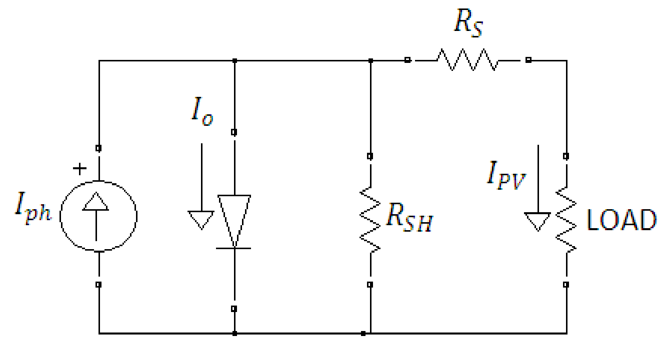

Fig. 1 PV Cell Model

The solar cell is a PN junction where there are diffusion currents and drift currents for the direct and reverse polarization, respectively. When the PN junction is exposed to light, photons with energy greater than the gap of energy are absorbed, causing the emergence of electron-hole pairs. These carriers are separated under the influence of electric fields within the junction, creating a current that is proportional to the incidence of solar irradiance [x]. The equivalent circuit of a PV cell is as shown in Figure 1.

The cell photocurrent can be represented by a current source Iph. Rsh and Rs are the intrinsic shunt and series resistances of the cell. Rsh is very large and Rs is very small, hence Rsh can be neglected for the analysis simplicity. PV cells are grouped to construct PV modules. The PV module can be modeled mathematically as the following equations [viii]:-

$$I_{ph} = [\, I_{scr} + K_i(T-298)] * {}^{\lambda}/_{1000} \qquad (1)$$

$$I_{rs} = I_{scr} / [\, e^{(qV_{oc}/N_S KAT)} - 1] \qquad (2)$$

$$I_o = I_{rs}\, [\tfrac{T}{T_r}]^3\, e^{[\frac{q*E_{go}}{B\,K}\{\frac{1}{T_r}-\frac{1}{T}\}]} \qquad (3)$$

$$I_{PV} = N_P * I_{ph} - N_P * I_o[\, e^{\{\frac{q*(V_{PV}+I_{PV}R_S)}{N_S AKT}\}} - 1 \qquad (4)$$

Equation (1) represents a module photo current I_{ph} while the module reverse saturation current I_{rs} can be expressed by equation (2). Equation (3) represents module saturation current I_o while the current output of a PV module I_{PV} is given by equation (4).

III. Selected Two Reference Module Parameters

First selected particular reference PV modules SW 250 mono from solar world USA has the following specifications:-

International Journal of Engineering Research ISSN:2319-6890)(online),2347-5013(print)
Volume No.4, Issue No.12, pp : 643-647 01 Dec. 2015

Maximum power Pmax	250 Wp
Open circuit voltage Voc	37.8 V
Maximum power point voltage Vmpp	31.1 V
Short circuit current Isc	8.28 A
Maximum power point current Impp	8.05 A

Second selected particular reference PV modules SW 320 mono from solar world USA has the following specifications:-

Maximum power Pmax	320 Wp
Open circuit voltage Voc	45.9 V
Maximum power point voltage Vmpp	36.7 V
Short circuit current Isc	9.41 A
Maximum power point current Impp	8.78 A

Which all above specifications are under standard test conditions (STC) of irradiance of 1kw/m2, spectrum of 1.5 air mass and cell temperature of 25℃.

IV. Analysis, Simulation Results and Discussion

A. Step by Step Modeling and check response at each step

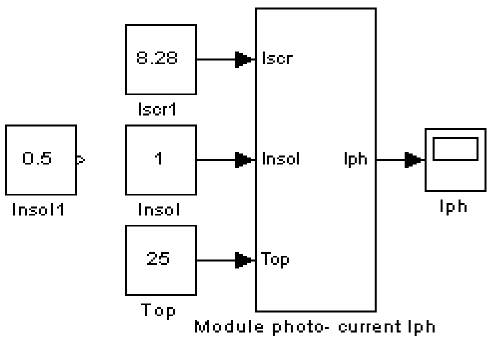

Fig. 2 Module photo current simulink blocks

Figure 2 shows the matlab modeling for module photo current based on equation(1) and the parameters are taken for the first selected particular reference PV modules 250 W Which the simulation output for this step is shown in figure 3.

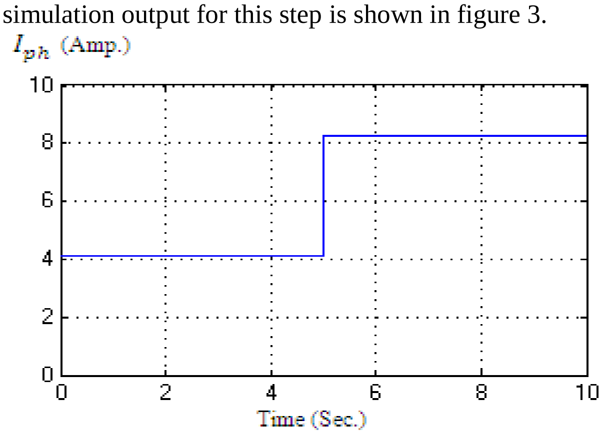

Fig. 3 Output of module photo current Matlab/Simulink blocks

Figure 3 shows the simulation output response for module photocurrent simulink block when insolation changed from 0.5 kW/m2 to 1 kW/m2 and reflect of these changes on the photocurrent. The aim here is to stand at values for the reader as guidance for him to be checked for his research building as well as in all next steps. Figure 4 shows the Matlab/Simulink modeling for the module reverse saturation current I_{rs} current based on equation(2) and the parameters are taken for the first selected particular reference PV modules 250 W Which the simulation output for this step is shown in figure 5.

Figure 5 shows the simulation output response for module reverse saturation current Matlab/Simulink blocks at specific parameters for the first selected reference module at standard test conditions which the current value I_{rs} is very low.

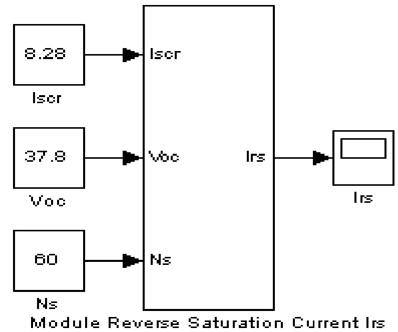

Fig. 4 Module reverse saturation current Matlab/Simulink blocks

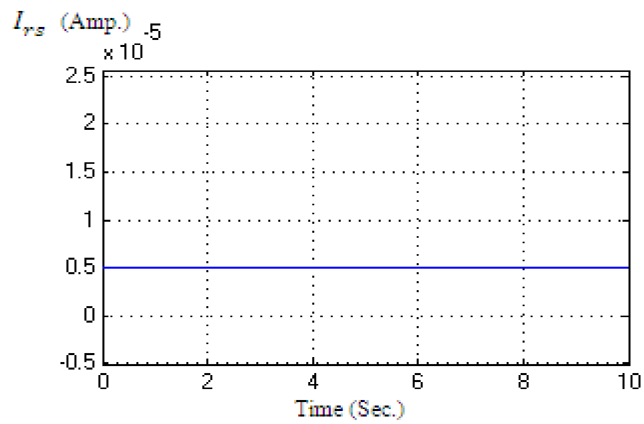

Fig. 5 Output of module reverse saturation current Matlab/Simulink blocks

Figure 6 shows the matlab modeling for module saturation current I_o based on equation(3) and the parameters are taken for the first selected particular reference PV modules 250 W Which the simulation output for this step is shown in figure 7.

Figure 7 shows the simulation output response for module saturation current Matlab/Simulink blocks. The figure shows the changes on the module saturation current when the operating temperature is changed from 25℃ to 40℃ and all other parameters at STC. It is noted that the values of $I_o$are very low.

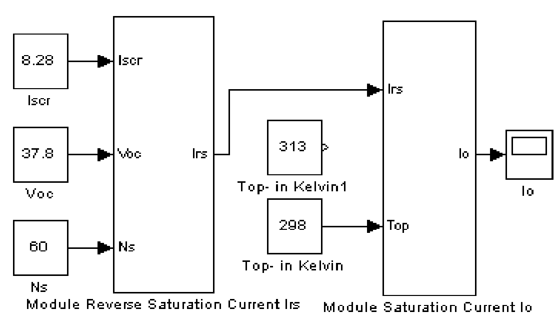

Fig. 6 Module saturation current Matlab/Simulink blocks

ISSN:2319-6890)(online),2347-5013(print)
01 Dec. 2015

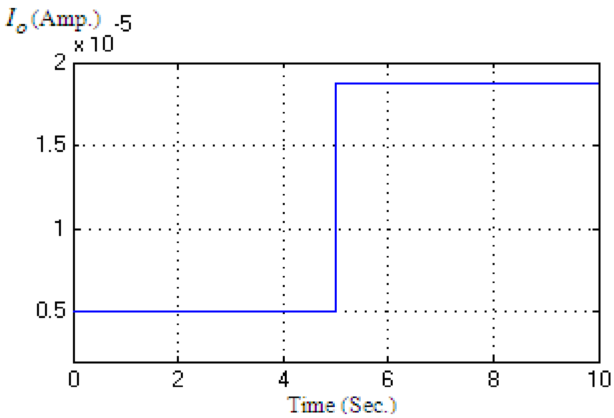

Fig. 7 Output of module saturation current Matlab/Simulink blocks

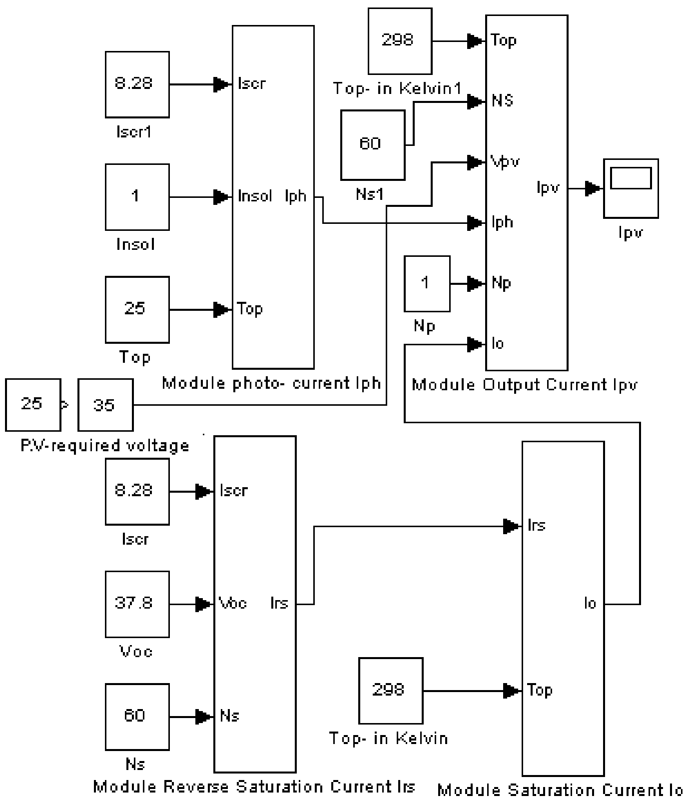

Fig. 8 Module current output Matlab/Simulink blocks

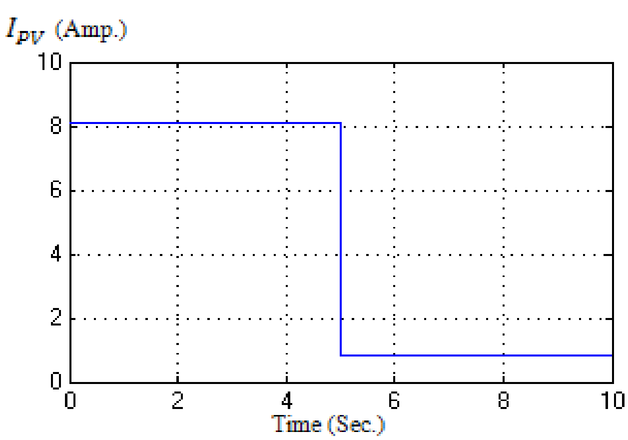

Fig. 9 Output of module current Matlab/Simulink blocks

Figure 8 shows the matlab modeling for module current output I_{PV} based on equation(4) and the parameters are taken for the first selected particular reference PV modules 250 W Which the simulation output for this step is shown in figure 9.

Figure 9 shows the simulation output response for module current output Matlab/Simulink blocks. The figure shows the changes on the module current output when the required PV voltage changed from 25 to 30 volts and all other parameters at STC. It is noted that the output current is decreased significantly.

B. Obtained Characteristics for the Two Selected Reference Module

All the following figures (10-13) show the obtained results from the simulation which indicates the characteristics of PV module based on mathematical modeling and these obtained curves were compared with the data sheet of the two references selected modules which well matched with them

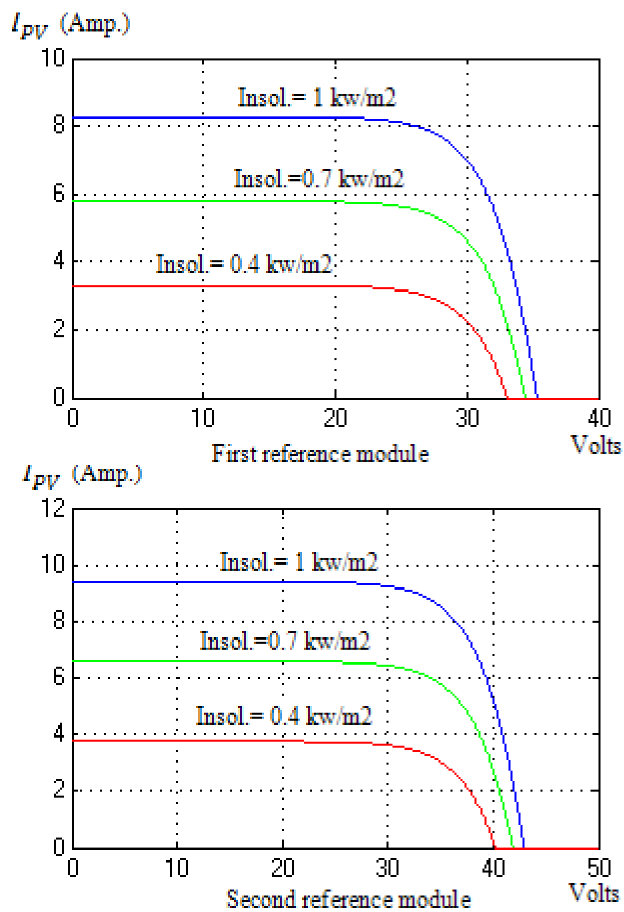

Fig. 10 I-V curves for the two reference modules at temperature =25 ℃

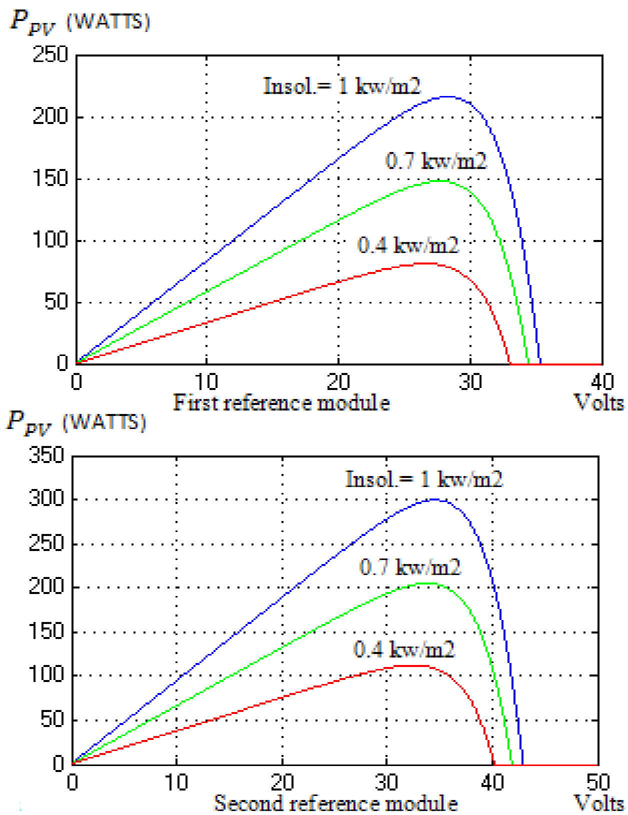

Fig. 11 P-V curves for the two reference modules at temperature =25 °C

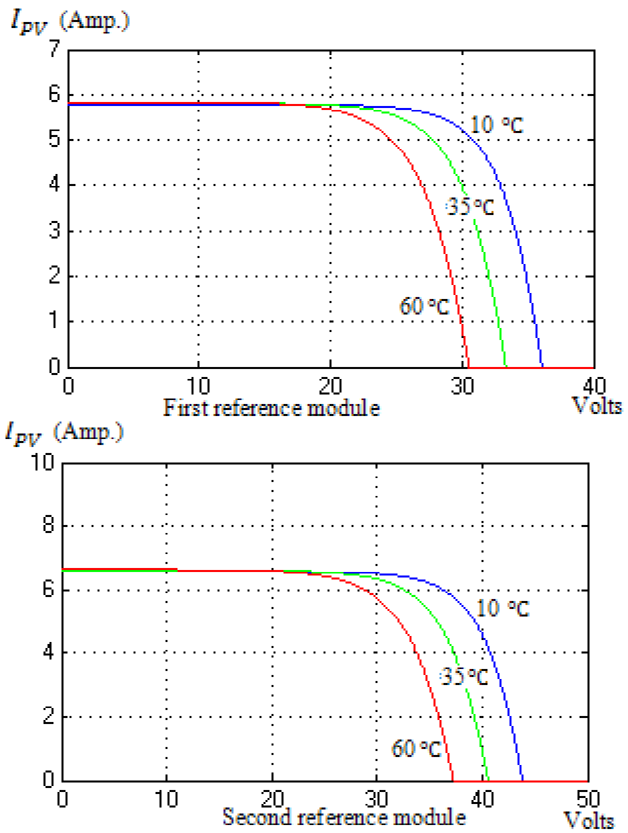

Fig. 12 I-V curves for the two reference modules at Insol. =0.7 kw/m2

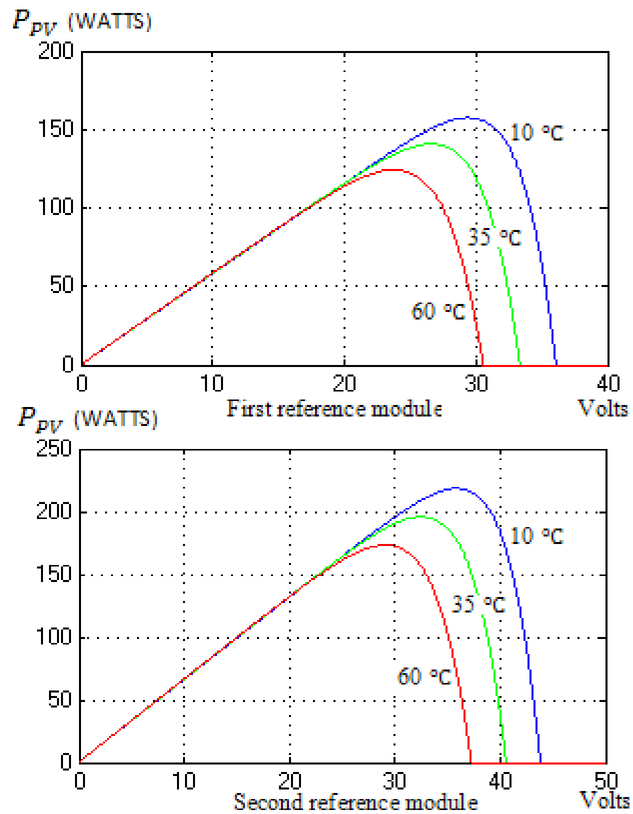

Fig. 13 P-V curves for the two reference modules at Insol. =0.7 kw/m2

V. Conclusion

In This paper, check response for Matlab/Simulink PV module model building step-by step is presented and results appear well matching with data sheet of the two selected references modules. The obtained responses give the researcher /reader knowledge, confirmation and satisfaction to proceed in with his system application building up. In the mean time, the aim here was to stand at reference values for the reader as guidance for him to be checked for his research building.

References

i. Abdulaziz M. S. Aldobhani and Robert John, " Maximum Power Point Tracking of PV System Using ANFIS Prediction and Fuzzy Logic Tracking", Proceedings of the International Multi Conference of Engineers and Computer Scientists 2008 Vol II IMECS 2008, 19-21 March, 2008, Hong Kong.

ii. Sree Manju B, Ramaprabha R, and Mathur B.L, " Design and Modeling of Standalone Solar Photovoltaic Charging System", International Journal of Computer Applications, Volume 18– No.2, March 2011, pp. 41-45.

iii. F. Al Riza, S. I. Ul Haq Gilani, M. Shiraz Bin Aris, "Measurement and Simulation of Standalone Solar PV System for Residential Lighting in Malaysia", EFEEA'10 International Symposium on Environment Friendly Energies in Electrical Applications, 2-4 November 2010, Ghardaïa, Algeria.

iv. S. Kebaili, and A. Betka, "Design and Simulation of Stand Alone Photovoltaic Systems", WSEAS TRANSACTIONS on POWER SYSTEMS, Issue 4, Volume 6, October 2011, pp. 89-99.

v. Ahmed M. Kassem, " Fuzzy-logic Based Self-tuning PI Controller for High-Performance Vector Controlled Induction Motor Fed by PV-Generator", WSEAS TRANSACTIONS on SYSTEMS, Issue 1, Volume 12, January 2013, pp. 22-31.

vi. Stephens, J., Wilson, E.J. and Peterson, T.R. (2015) Smart Grid (R) Evolution. Cambridge University Press, Cambridge.

vii. K. Ishaque, Z.Salam, and H. Taheri, "Accurate MATLAB Simulink PV System Simulator Based on a Two-Diode Model", Journal of Power Electronics, Vol. 11, No. 2, March 2011, pp. 179-189.

viii. S. Sheik Mohammed, "Modeling and Simulation of Photovoltaic module using MATLAB/Simulink", International Journal of Chemical and Environmental Engineering, October 2011, Volume 2, No.5, pp. 350-355.

ix. J. Sahu, M. Ashfaque Khan, and S. K. Sahu, "Comprehensive evaluation of photovoltaic system using MATLAB/Simulink", International Journal of Engineering Research & Technology (IJERT), Vol. 2, Issue 1, January- 2013.

x. G. Richhariya and A. Pachori, "Modeling of Solar Cell", International Journal of wind and Renewable Energy, Volume 1, Issue 1, pp. 31-34.