Performance Analysis of SPV Systems Under Different Parameter

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Abstract- *In current scenario, solar energy is most economical and alternate source of energy . It is also independent of power grid connected power supplies . It is very important for developing country and useful in developed countries as it is connected with power grid. The power generated by Solar Photovoltaic System (SPV) system mainly depends on various parameters such as temperature, material used and radiation of sun. In this paper we design and simulate the photovoltaic system using matlab simulink. The Performance of SPV system is measured by temperature variation and radiation variation. These parameter are very important as weather changes effect the performance of system. In this paper, step by step designing is explained and the output data is analyzed. After analysis of the it is found that the solar power system is very useful and economical if we consider it for long time (about 20 year).*

Keywords- Solar PV system, , PV array, Solar Cell, MATLAB.

I. INTRODUCTION

A SPV system converts sunlight into electricity. The photovoltaic cell is the basic device of SPV System. Cells may be grouped and arranged to form panels or modules. Panels can be grouped to form large photovoltaic arrays. The term array is usually employed to describe a photovoltaic panel or a group of panels[1-5]. Most of time one are interested in modeling photovoltaic panels, which are the commercial photovoltaic devices. In this paper modeling of photovoltaic modules is done. The term array used for photovoltaic device which composed of several basic cells. The electricity available at the terminals of SPV System may directly feed small loads such as lighting systems and DC motors[5-10]. Some applications require electronic converters to process the electricity from the photovoltaic device. Photovoltaic arrays present a nonlinear I-V characteristic with several parameters that need to be adjusted from experimental data of practical devices. In this paper, mathematical model of the photovoltaic array is modeled and simulated . The objective of this paper is to provide all required information to develop photovoltaic array models and circuits that can be used in the simulation of power converters for photovoltaic applications.

II. SYSTEM MODEL

Fig. 1 shows the equivalent circuit of the ideal photovoltaic cell. The basic equation from the theory of semiconductors [1] that mathematically describes the I-V characteristic of the ideal photovoltaic cell is:

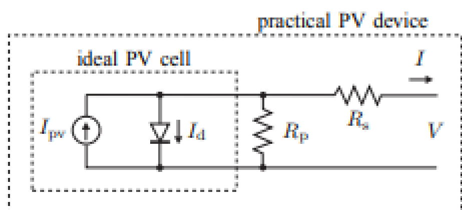

Fig. 1 : equivalent circuit of the ideal photovoltaic cell

$$I = I_{cell} - I_0\left[\exp\left(\frac{qV}{akT}\right) - 1\right] \quad (1)$$

where I_{cell} is the current generated by the incident light , I_d is the Shockley diode equation, I_o [A] is the reverse saturation or leakage current of the diode , q is the electron charge [1.60217646 · 10^{-19}C], k is the Boltzmann constant [1.3806503 · 10^{-23}J/K], T [K] is the temperature of the p-n junction, and a is the diode ideality constant.

Modeling of Photovoltaic Array:

The basic equation (1) of the elementary photovoltaic cell does not represent the I-V characteristic of a practical photovoltaic array. Practical arrays are made of several photovoltaic cells and the observation of the characteristics at the terminals of the photovoltaic array requires additional parameters to the basic equation

$$I = I_{cell} - I_0\left[\exp\left(\frac{V+RsI}{Vta}\right) - 1\right] - \frac{V+RsI}{Rp} \quad (2)$$

where I_{cell} and I_0 are the photovoltaic and saturation currents of the array and Vt = N_skT/q is the thermal voltage of the array with Ns cells connected in series. Cells connected in parallel increase the current and cells connected in series provide greater output voltages. If the array is composed of Np parallel connections of cells the photovoltaic and saturation currents may be expressed as: $I_{cell}=I_{cel}N_p$, $I_0=I_{0,cell}Np$. In (2) R_s is the equivalent series resistance of the array and R_p is the equivalent parallel resistance.

Two and three-diode models are proposed to include the influence of effects which are not considered by the one diode model. Simplicity of the single-diode model with the method for adjusting the parameters and this paper model is perfect for power electronics designers who are looking for an easy and effective model for the simulation of photovoltaic devices with power converter

Two parameters remain unknown in (2), which are Rs and Rp. It may be useful to have a mathematical formula to determine these unknown parameters, any expression for Rs and Rp will always rely on experimental data. In this paper proposes a method for adjusting Rs and Rp based on the fact that there is an only pair {Rs,Rp} that warranties the maximum power calculated by the I-V model of (2)[14]. The relation between Rs and Rp, the only unknowns of (2), may be found by making $P_{max,m} = P_{max,e}$ [12].

$$P_{max,m} = V_{mp}\left\{I_{pv} - I_0\left[\exp\left(\frac{q}{kT}\frac{V_{mp}+R_sI_{mp}}{aN_s}\right)-1\right] - \frac{V_{mp}+R_sI_{mp}}{R_p}\right\} = P_{max,e}$$

$$R_p = V_{mp}(V_{mp}+I_{mp}R_s)/\left\{V_{mp}I_{pv} - V_{mp}I_0\exp\left[\frac{(V_{mp}+I_{mp}R_s)}{N_sa}\frac{q}{kT}\right] + V_{mp}I_0 - P_{max,e}\right\}$$

means that for any value of Rs there will be a value of Rp that makes the mathematical I-V curve cross the experimental (V_{mp},I_{mp}) poin.

Simulation Model:

The photovoltaic array can be simulated with an equivalent circuit model based on the photovoltaic model of Fig. 1.

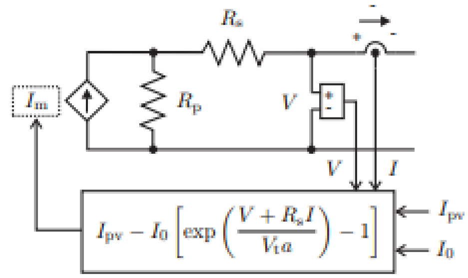

Fig. 2. Photovoltaic array model circuit with a controlled current source, equivalent resistors and the equation of the model current (Im).

Fig. 2 shows a circuit model using one current source (I_m) and two resistors (Rs and Rp). This circuit can be implemented with any circuit simulator. The value of the model current Im is calculated by the computational block that has V , I, I_0 and I_{pv} as inputs. I_0 is obtained from [18-19]

$$I_0 = I_{0,n}\left(\frac{T_n}{T}\right)^3 \exp\left[\frac{qE_g}{ak}\left(\frac{1}{T_n}-\frac{1}{T}\right)\right]$$

I_{vp} is obtained from [32]

$$I_{pv} = (I_{pv,n} + K_I\Delta_T)\frac{G}{G_n}$$

This computational block may be implemented with any circuit simulator able to evaluate math functions.

Figs. 3 and 4 show the photovoltaic model circuits implemented with MATLAB/SIMULINK.

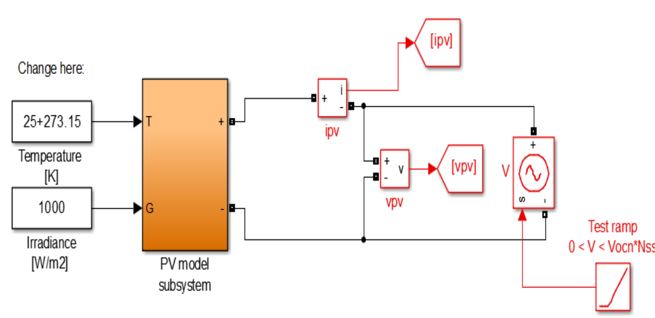

Fig.3 Photovoltaic System model built with MATLAB/SIMULINK

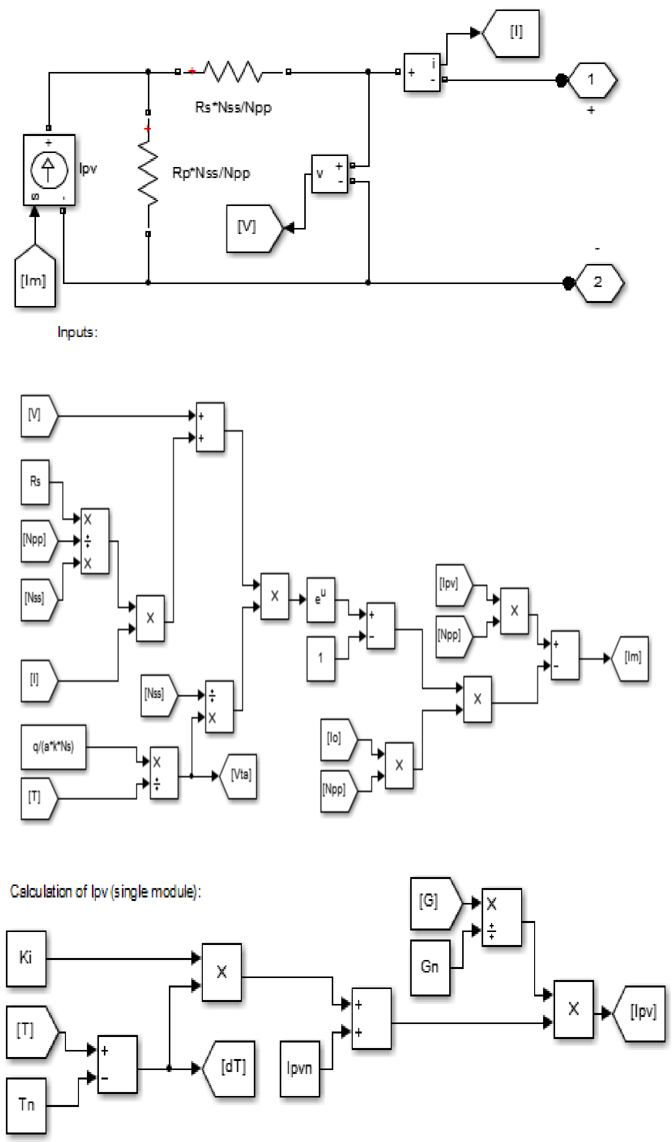

Fig.4 Photovoltaic subsystem model built with MATLAB/SIMULINK

Circuit model work perfectly and may be used in the simulation of power electronics converters for photovoltaic systems.

III. RESULT

Figure 4 and 5 show the V-I and P-V characteristic of PV System. In fig 4, X-axis represent Voltage(V) Y-axis represents current(I). . In fig 5, X-axis represent Voltage(V) Y-axis represents Power(P). Fig. 6 shows the V-I characteristic of PV system at irradiance 1000 W/m^2, 800 W/m^2, 600 W/m^2 and 400 W/m^2 represented by Red, Black, Blue and Green color respectively. It shows that current decreases with decrease in irradiance. Fig. 7 shows the P-V characteristic of PV system at irradiance 1000 W/m^2, 800 W/m^2, 600 W/m^2 and 400 W/m^2 represented by Red, Black, Blue and Green color respectively. It shows that power decreases with decrease in irradiance. Fig. 8 shows the V-I characteristic of PV system at irradiance 1000 W/m^2, and temperature 25,30,35 and 40 degree Centigrade represented by Red, Black, Blue and Green color respectively. It shows that voltage decreases with increase in temperature. Fig.9 shows the P-V characteristic of PV system at irradiance 1000 W/m^2, and temperature 25,30,35 and 40 degree Centigrade represented by Red, Black, Blue and Green color respectively. It shows that voltage decreases with increase in temperature.

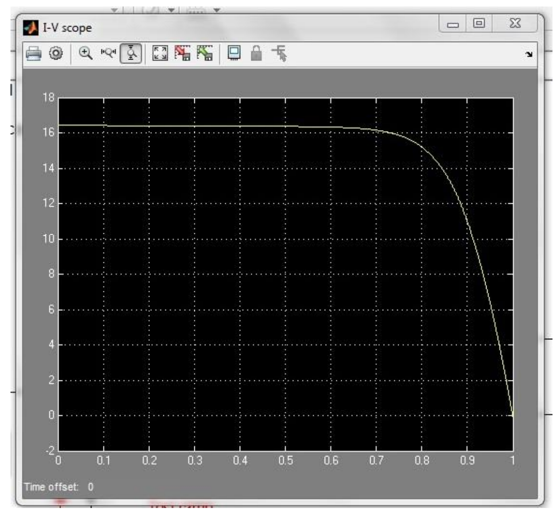

Fig. 4: V-I characteristic of PV System

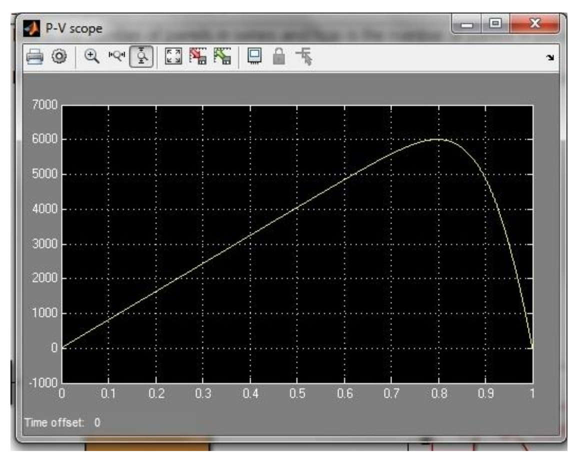

Fig. 5: P-V characteristic of PV System

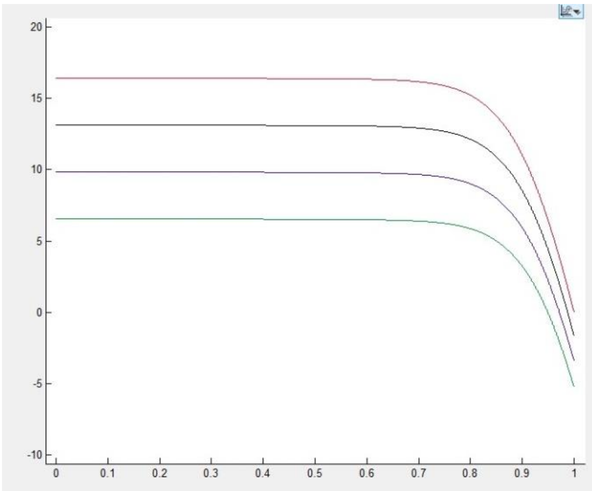

Fig. 6: V-I characteristic of PV System at different irradiation

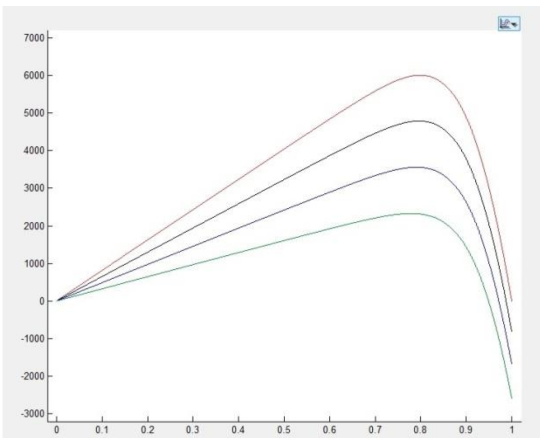

Fig. 7: P-V characteristic of PV System at different irradiance

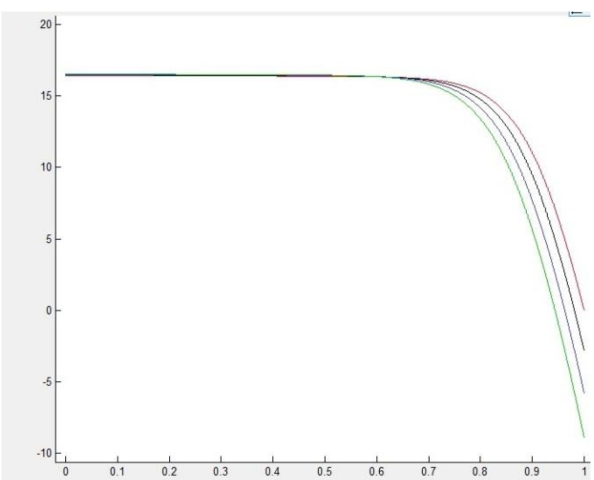

Fig. 8: V-I characteristic of PV System at different temperature

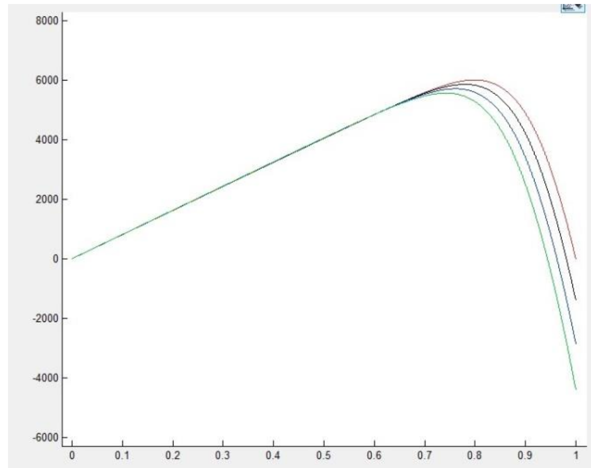

Fig. 9: P-V characteristic of PV System at different temperature

IV. CONCLUSION

In PV System current depends heavily on solar irradiation and the voltage increases just by .5 V once the irradiance is increased from 200W/m^2. For a fixed solar irradiation and when the temperature increases, the open-circuit voltage decreases and the short-circuit current increases with a little value. Therefore, the temperature change affects strongly the PV panel voltage

REFERENCES

[1] H. Patel and V. Agarwal, "MATLAB-based modeling to study the effects of partial shading on PV array characteristics," IEEE Transactions on Energy Conversion, vol. 23, no. 1, pp. 302–310, 2008.

[2] S. Motahhir, A. Chalh, A. Ghzizal, S. Sebti, and A. Derouich, "Modeling of photovoltaic panel by using proteus," Journal of Engineering Science and Technology Review, vol. 10, no. 2, pp. 8–13, 2017.

[3] S. Motahhir, A. El Ghzizal, S. Sebti, and A. Derouich, "Proposal and implementation of a novel perturb and observe algorithm using embedded software," in 2015 3rd International Renewable and Sustainable Energy Conference (IRSEC), pp. 1–5, Marrakech, Morocco, December 2015.

[4] H. S. Rauschenbach, Solar Cell Array Design Handbook, Van Nostrand Reinhold, 1980.

[5] N. Barth, R. Jovanovic, S. Ahzi, and M. A. Khaleel, "PV panel single and double diode models: optimization of the parameters and temperature dependence," Solar Energy Materials and Solar Cells, vol. 148, pp. 87–98, 2016.

[6] K. Nishioka, N. Sakitani, Y. Uraoka, and T. Fuyuki, "Analysis of multicrystalline silicon solar cells by modified 3-diode equivalent circuit model taking leakage current through periphery into consideration," Solar Energy Materials and Solar Cells, vol. 91, no. 13, pp. 1222–1227, 2007.

[7] N. Yıldıran and E. Tacer, "Identification of photovoltaic cell single diode discrete model parameters based on datasheet values," Solar Energy, vol. 127, pp. 175–183, 2016.

[8] K. Ishaque, Z. Salam, S. Mekhilef, and A. Shamsudin, "Parameter extraction of solar photovoltaic modules using penalty-based differential evolution," Applied Energy, vol. 99, pp. 297–308, 2012.

[9] K. Ishaque and Z. Salam, "An improved modeling method to determine the model parameters of photovoltaic (PV) modules using differential evolution (DE)," Solar Energy, vol. 85, no. 9, pp. 2349–2359, 2011.

[10] M. F. AlHajri, K. M. El-Naggar, M. R. AlRashidi, and A. K. AlOthman, "Optimal extraction of solar cell parameters using pattern search," Renewable Energy, vol. 44, pp. 238–245, 2012

[11] Mathworks, PV Array, 2015, Mai 2017, https://fr.mathworks. com/help/physmod/sps/powersys/ref/pvarray.html.

[12] C. Carrero, J. Amador, and S. Arnaltes, "A single procedure for helping PV designers to select silicon PV modules and evaluate the loss resistances," Renewable Energy, vol. 32, no. 15, pp. 2579–2589, 2007.

[13] T. Radjai, L. Rahmani, S. Mekhilef, and J. P. Gaubert, "Implementation of a modified incremental conductance MPPT algorithm with direct control based on a fuzzy duty cycle change estimator using dSPACE," Solar Energy, vol. 110, pp. 325– 337, 2014.

[14] J. Ahmed and Z. Salam, "A modified P&O maximum power point tracking method with reduced steady-state oscillation and improved tracking efficiency," IEEE Transactions on Sustainable Energy, vol. 7, no. 4, pp. 1506–1515, 2016.

[15] A. Amir, J. Selvaraj, and N. A. Rahim, "Study of the MPP tracking algorithms: focusing the numerical method techniques," Renewable and Sustainable Energy Reviews, vol. 62, pp. 350–371, 2016.

[16] A. Gupta, Y. K. Chauhan, and R. K. Pachauri, "A comparative investigation of maximum power point tracking methods for solar PV system," Solar Energy, vol. 136, pp. 236–253, 2016.

[17] D. Verma, S. Nema, A. M. Shandilya, and S. K. Dash, "Maximum power point tracking (MPPT) techniques: recapitulation in solar photovoltaic systems," Renewable and Sustainable Energy Reviews, vol. 54, pp. 1018–1034, 2016.

[18] J. P. Ram, T. S. Babu, and N. Rajasekar, "A comprehensive review on solar PV maximum power point tracking techniques," Renewable and Sustainable Energy Reviews, vol. 67, pp. 826–847, 2017.

[19] S. Motahhir, A. El Ghzizal, S. Sebti, and A. Derouich, "Shading effect to energy withdrawn from the photovoltaic panel and implementation of DMPPT using C language," International Review of Automatic Control, vol. 9, no. 2, pp. 88–94, 2016.

[20] K. S. Tey and S. Mekhilef, "Modified incremental conductance MPPT algorithm to mitigate inaccurate responses under fastchanging solar irradiation level," Solar Energy, vol. 101, pp. 333–342, 2014.

[21] Solarex MSX60 and MSX64 photovoltaic panel, datasheet1998, April 2017, https://www.solarelectricsupply.com/ media/custom/upload/Solarex-MSX64.pdf