Design And Modeling of SPV System And Its Performance Analysis 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 . 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, Modeling of solar PV system is also done under shadowing and performance is measured by radiation variation. Result shows that increase in the temperature of SPV module result in less current and power generation. . 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:

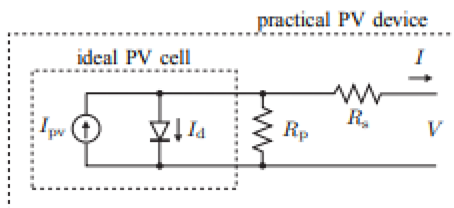

Fig. 1 : equivalent circuit of the ideal photovoltaic cell

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

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

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

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.

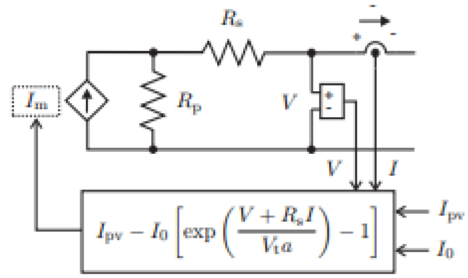

Fig. 2. Photovoltaic array model circuit with a controlled current source, equivalent resistors and the equation of the model current (Im).

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.

Circuit model work perfectly and may be used in the simulation of power electronics converters for photovoltaic systems. The Fig. 3 shows the interconnection of two series connected PV module in which one PV module is unshaded and the other is selected for shading conditions.

The net output voltage is the sum of the output voltage of these two solar module and the output current is same. Rate transition block handle transfer of data between ports operating at different rates. Configuration options allow you to trade off transfer delay and code efficiency for safety and determinism of data transfer. “PS Simulink Converter converts the unit less Simulink input signal to a physical Signal. The unit expression in 'Input signal unit' parameter is associated with the unitless Simulink input signal and determines the unit assigned to the Physical Signal”[22].

Fig. 5 and 6 shows the Modelling of SPV System under shading effect and

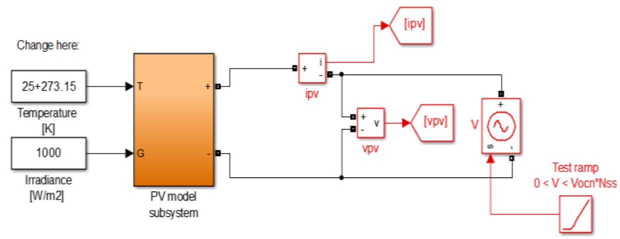

Fig.3 Photovoltaic System model built with MATLAB/SIMULINK

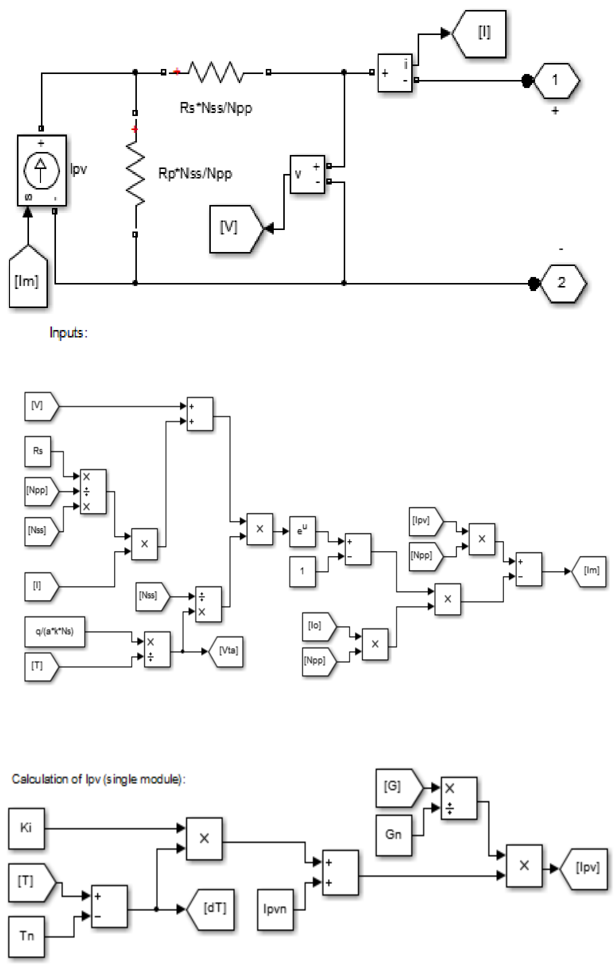

Fig.4 Photovoltaic subsystem model built with MATLAB/SIMULINK

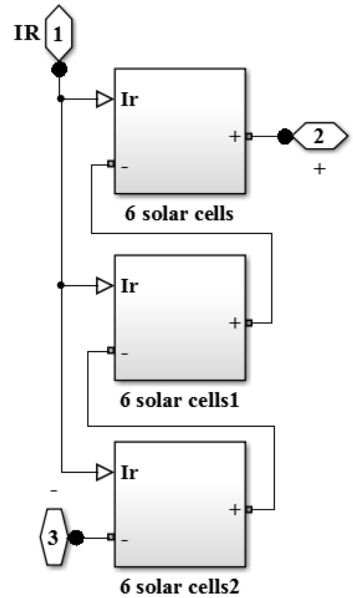

Fig. 5 Modelling of SPV System under shading effect

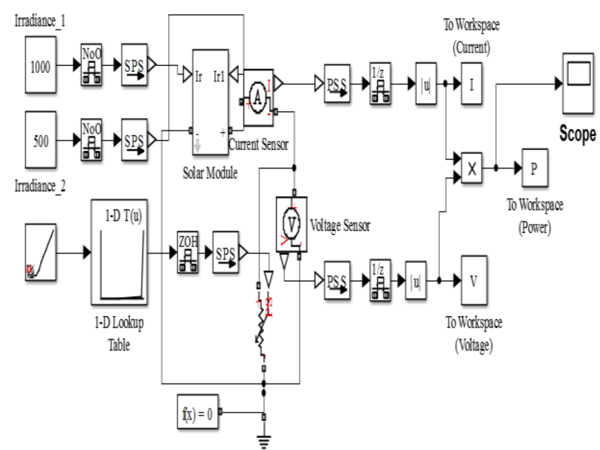

Fig. 6 Modelling of SPV System under shading effect

III. RESULT

Figure 7 and 8 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 8, X-axis represent Voltage(V) Y-axis represents Power(P). Fig. 9 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. 10 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. 11 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.12 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.

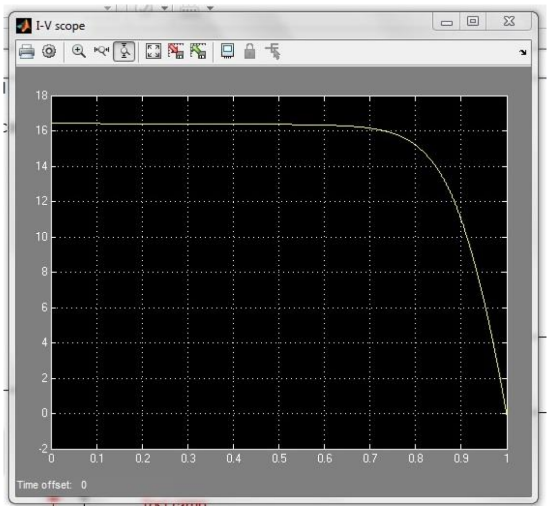

Fig. 7: V-I characteristic of PV System

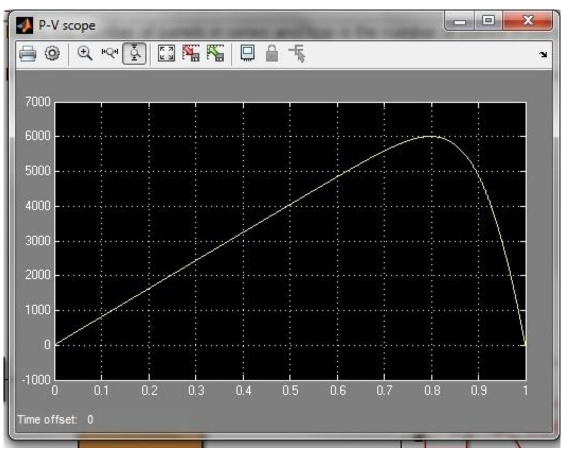

Fig. 8: P-V characteristic of PV System

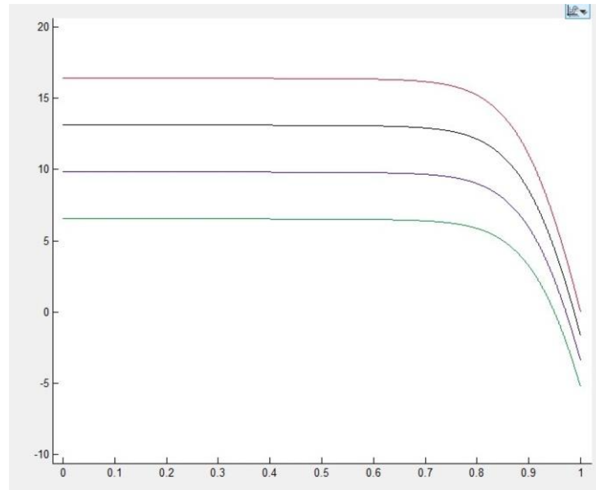

Fig. 9: V-I characteristic of PV System at different irradiation

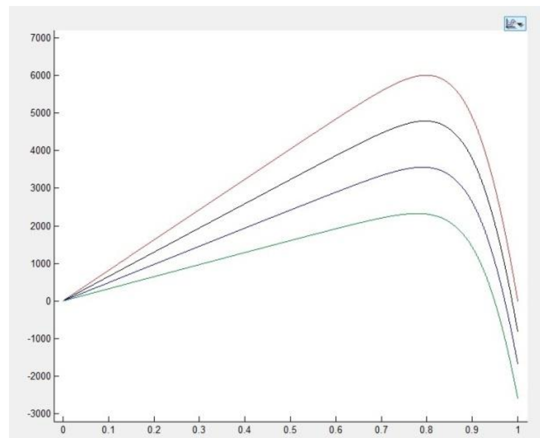

Fig. 10: P-V characteristic of PV System at different irradiance

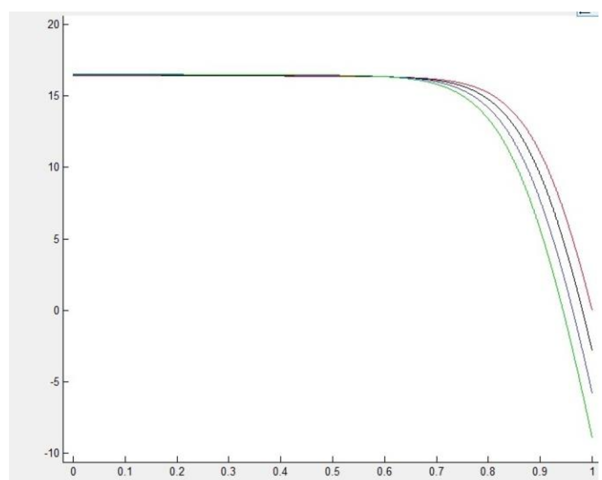

Fig. 11: V-I characteristic of PV System at different temperature

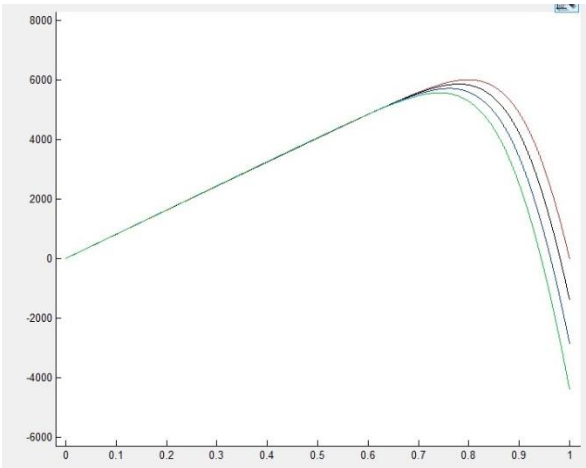

Fig. 12: P-V characteristic of PV System at different temperature

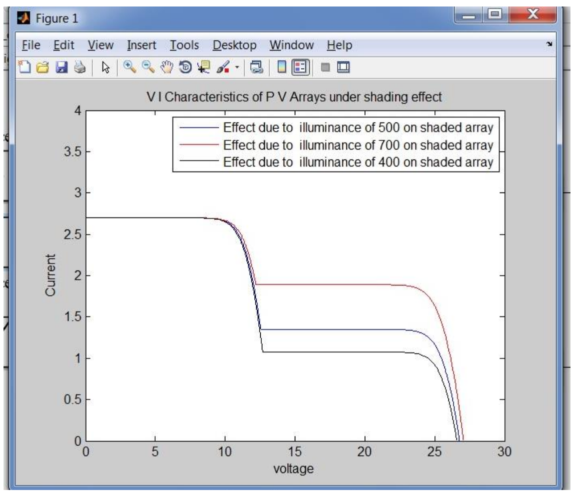

Figure 13: V I Characteristics of PV array under illuminance effect

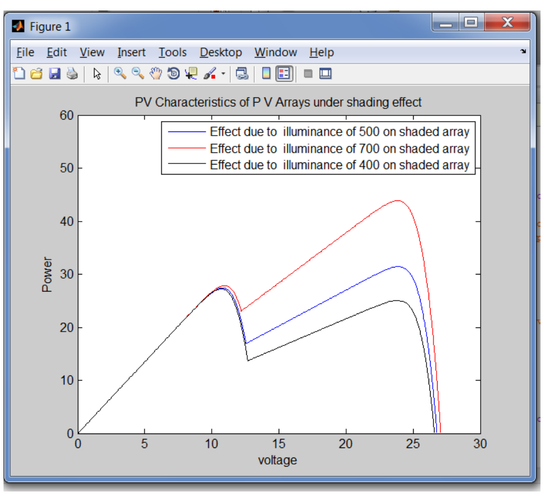

Figure 14: PV Characteristics of PV array under illuminance effect

Fig . 13 shows V I Characteristics of shaded PV array under illuminance of 400 W/m2, 500 W/m2 and 700 W/m2 and Fig. 14 shows P V Characteristics of shaded PV array under illuminance of 400 W/m2, 500 W/m2 and 700 W/m2.

IV. CONCLUSION

This research work has described the I-V and P-V characteristics of a PV system connected in various configurations. The performance analysis of PV system has been carried out under uniform conditions such as change in temperature, solar irradiation. In PV System current depends heavily on solar irradiation and the voltage increases just by .5 V once the irradiance is increased from 200W/m2. 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.

From the above analysis it is observed that even under uniform conditions, maximum output power is obtained when the modules are connected in parallel, in this case there are no multiple steps and multiple peaks were seen in PV characteristic curves and thereby it is easy to track the maximum power.

The proposed model is more accurate when applied to analyze SPV system characteristics under partial shaded conditions at different temperatures. This model is more accurate when applied to analyze SPV module characteristics under partial shaded conditions. It can be interfaced with power electronics circuits to see the impact of shading and can be used to develop new methods to reduce the adverse effects of partial shading. Series connection of solar cells in an array is essential to get practically utilizable voltage. In series connection, the shaded cells may get reverse biased, acting as loads, draining power from fully illuminated cells. The impact of partial shading with temperature is studied and it is observed that performance of system is decrease with increase in module temperature

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