Performance of Appropriate Photovoltaic Model

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Abstract—**Energy is very important key to improve human life. Due to the global warming and pollution, the new energy source is developed. Photovoltaic is one of these sources that growth in recent decades and has several models. Using the practical and simple model to compare with other models is necessary, to this purpose in this paper at first the ideal model of photovoltaic is described then appropriate model by using MATLAB software is presented. On other hand knowing the effect of environment of PV characteristics to predict its behavior is important. These models included diode-(diodes), series resistor and source. The temperature and solar irradiation were inputs variable parameters and I-V and P-V characteristic were the outputs. At end, effect of each parameter is presented.**

Keywords: equivalent circuit, Matlab, Photovoltaic, Solar irradiation, Temperature

I. INTRODUCTION

Renewable energy is undoubtedly an important part of life in the future constitute. These energy are source such as wind energy, solar energy, bio-energy and others that reloaded by natural and it will be one of the important part of power generation in the new millennium. Due to the global warming and critical condition about fuels such as gas, oil and etc and damage to environment the new energy source is increased (1). Renewable energy has many advantages, including being free, producing no pollution, sending out no emissions or noise.The Photovoltaic (PV) is one of the more important device that growth in past two decades. This suitable energy has well known advantages (it is free and available). PV receives photon energy from sun and converts the sunlight into electrical energy without pollution in PN junction. Depending on interaction with network, PV is grouped in grid connected, hybrid and stand alone.

The generated voltage is about 0.5 to 0.8 volts and it's depending on the semiconductor and cell technology (2, 3). The rate of generation of electric carriers depends on the flux of incident light and the capacity of absorption of the semiconductor. Principle of PV is shown in Figure 1:

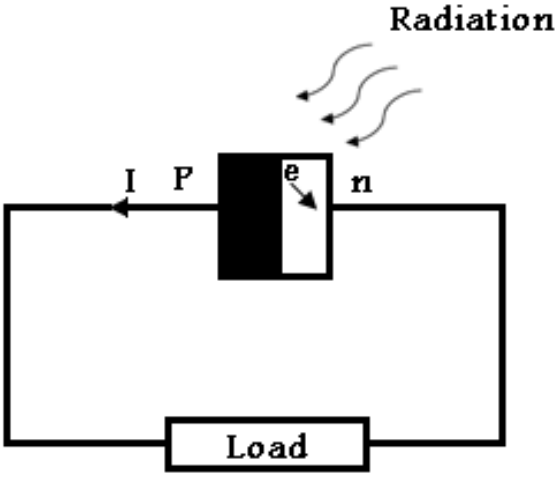


Figure 1. Photocurrent generation principle

To form a PV module the PV cells are interconnected. To match the requirements of DC current and voltage the PV are connected in parallel and series (4).

The efficiency of a PV device depends on the spectral distribution of the solar radiation. The Sun is a light source whose radiation spectrum may be compared to the spectrum of a black body near 6000 K. The study of the effect of the solar radiation on PV devices is difficult because the spectrum of the sunlight on the Earth's surface is influenced by factors such as the variation of the temperature on the solar disc and the influence of the atmosphere (5).

The aim of this paper is to provide the reader with all necessary information to develop photovoltaic models and circuits that can be used in the simulation of power converters for photovoltaic applications and shows the effect of environmental parameter (temperature & sun irradiation) to allow estimate the electrical behavior of the cell.

PV has several models. The general model is PV with one diode but some authors to have better accuracy uses this model with an extra diode(double exponential model) , in (6, 7, 8) an extra diode is used to show the impact of the recombination of carriers and in (9) three diode is used in the model. In this paper the ideal model, and appropriate model is described in details and simulation for appropriate models is presented.

II. PV MODEL

The equivalent circuit of ideal photovoltaic cell is showed in figure 2 (10).

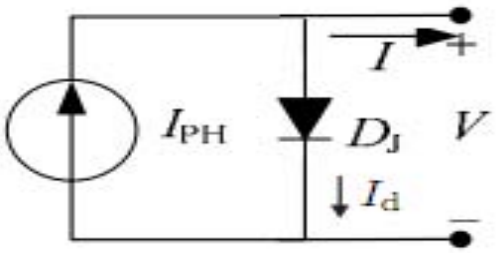


Figure 2. Ideal PV cell

The equation that describes the current-voltage characteristic for ideal photovoltaic is:

$$I = I_{ph} - I_s \left[\exp\left(\frac{qV}{NkT}\right) - 1\right] \quad (1)$$

Where:

I_{ph}: photocurrent

I_s: reverse saturation current of diode (A)

q: electron charge ($1.60217646\times 10^{-19}$ C)

T: the temperature of p-n junction

N: diode ideality constant

K: Boltzmann constant (1.3806503×10^{-23})

Current-Voltage curve from equation 1 is showed in figure 3:

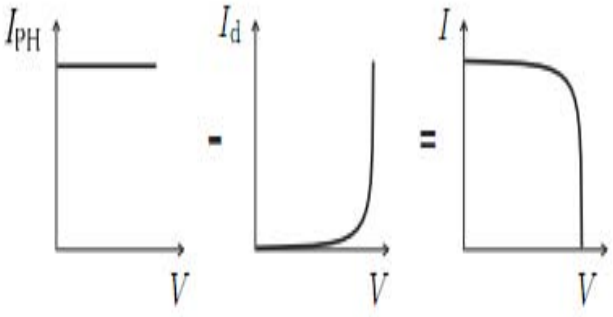


Figure 3. I-V curve

That model is ideal and so we can't use it in practice. In most of model a shunt resistor and series resistor is added to the ideal model to describe real performance of PV, but the shunt resistor don't have many effect of PV cell characteristics and we can neglect that on other hand the R_s has effective role on the photovoltaic output power and with small variation on that, the photovoltaic output power has significantly variation.

Appropriate model is showed in figure 4(11):

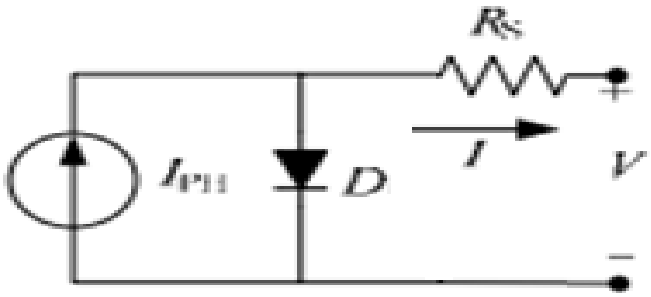


Figure 4. Appropriate model

It is clear by adding the series resistor the equation (1) should be rewritten. The Rewritten of (1) that can use for this model that explained current-voltage characteristic is equation as follow:

$$I = I_{ph} - I_s \left[\exp\left(\frac{q.(V+IR_s)}{NkT}\right) - 1\right] \quad (2)$$

$$I_{PH} = (I_{sc} + K_I \Delta T)\frac{G}{1000} \quad (3)$$

Where K_I is cell's short-circuit current temperature coefficient, I_{sc} is the short-circuit current at nominal condition, G is irradiation on the surface of device.

$$\Delta T = (T - T_n)$$

T_n is cell's reference temperature.

Reverse saturation current of diode is depending on the temperature and can express as:

$$I_s(T) = I_s \left(\frac{T}{T_n}\right)^3 \exp\left[\frac{E_g}{V_t}\left(\frac{T}{T_n} - 1\right)\right] \quad (4)$$

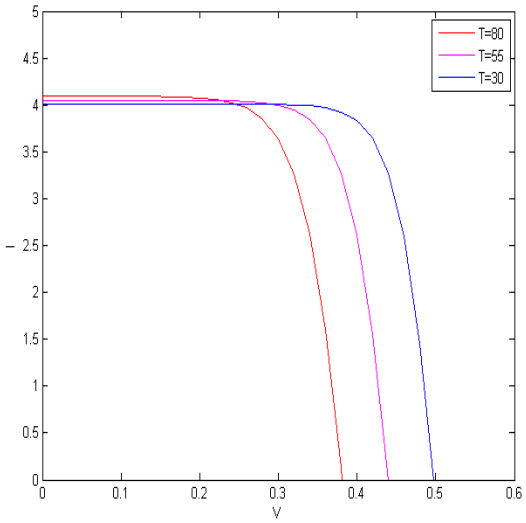
E_g is the band gap energy of semiconductor, T_n is nominal temperature and V_t is the thermal voltage. The mathematical formulation of thermal voltage is:

$$V_t = kT/q$$

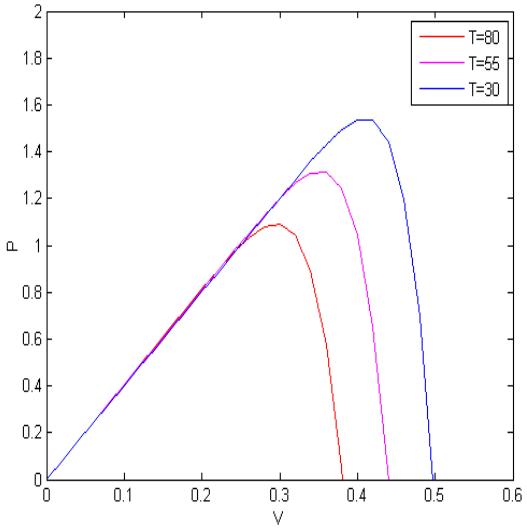
III. SIMULATION RESULTS

To perform the required simulations the MATLAB software has been used. The simulation result for appropriate Model is presented in this part. Temperature and solar irradiation are used as input parameter and current-voltage and power-voltage characteristics are output. Figures 5 and 6 are showed the effect of these different parameters corresponding to temperature and solar irradiation respectively. The temperature is changed from 30℃ to 80℃.

Effects of several temperatures on current-voltage and power-voltage curves are as follow:



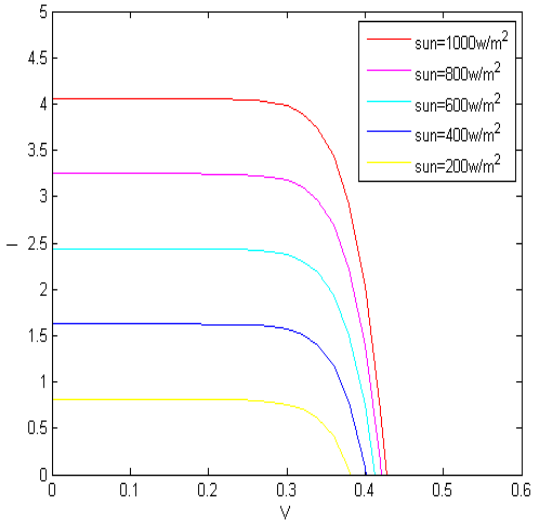
A: I-V curve for different temperature



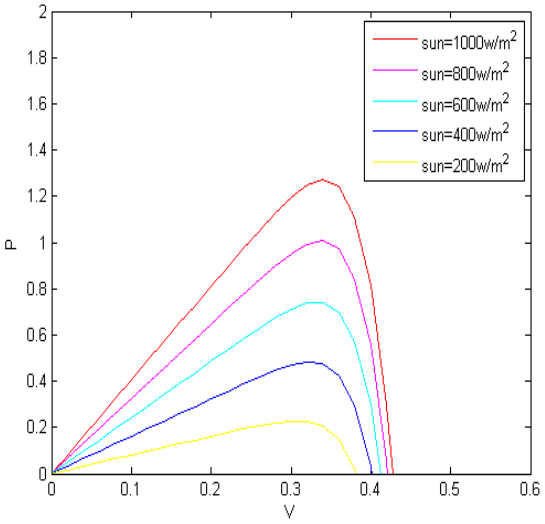
B: P-V curve for different temperature
Figure 5. Effect of different temperature

With increase the working temperature, the short-circuit current of cell is increased and open-circuit voltage is decreases.

Sun irradiation is the variable and the effect of that on appropriate model is presented in figure 6:



A: I-V curve for different solar irradiation



B: P-V curve for different solar irradiation
Figure 6. Effect of different solar irradiation

The above characteristics shows the effect of different values on the sun irradiation on current is very high and it is more than the voltage, by increasing the sun irradiation, the amount of voltage and current will be increase.

IV. CONCLUSION

The photovoltaic generator converts the solar energy to the electricity. The temperature and solar irradiation are input parameters and I-V and P-V characteristic are outputs. By increasing the temperature from 30℃ to 80℃ open-circuit voltage is decreases and short-circuit current is increased and by Increasing the solar irradiation, the short-circuit current and open-circuit voltage are increased, in fact the solar irradiation has power full effect on PV current, and the maximum power output increases. So by know this result, estimate the PV behavior is easy.

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