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Modelling and Simulation of a Photovoltaic

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Abstract- the fossil fuel energy sources such as gas, oil and… has some disadvantage and bad effect such as pollution and global warming in our life. It is necessary to use renewable source such as wind, sun and photovoltaic to have better life. In this paper effect of different environmental condition (irradiation & temperature) and diode parameter of the photovoltaic device (PV) by using MATLAB software to allow estimate the electrical behavior of the cell is presented. At first the PV model is and its parameters are described and then the simulation result to show the effect of each parameter is presented.

Keywords- *Irradiation, MATLAB, Photovoltaic, Temperature*.

I. Introduction

Due to the some disadvantage of fossil fuel energy have a new source energy is necessary and it will be very important part for life in future. One of these sources is photovoltaic (PV) that has many advantaged such as reliability and the cost of that [1], [2].

The photovoltaic generator converts the solar energy to the electricity. 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 [3], [4]. The electricity is available at photovoltaic terminals to feed the small load such as DC motor without converter. Some application need converter to use the energy that produced by photovoltaic. The photovoltaic has nonlinear characteristic. This paper presents the equations that form the I-V model. 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 each parameter to allow estimate the electrical behavior of the cell. PV has several models. These models included diode-(diodes), shunt resistor, series resistor and source The practical model is PV with one diode but some authors to have better accuracy uses this model with an extra diode, in [5], [6], [7] an extra diode is used to show the impact of the recombination of carriers and in [8] three diode is used in the model.

II. PV Modeling

In this study the double exponential model and its equation and circuit and its parameters is described in details. Before that the ideal model is explained:

The equivalent circuit for ideal photovoltaic cell is showed in figure 1 [9].

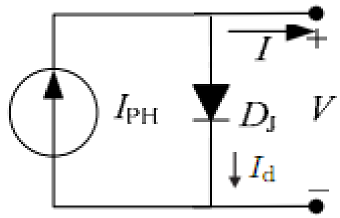


Figure 1: Ideal PV cell

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})

The double exponential model has extra diode that is parallel with other diode. Extra diode is used to represent the effect of recombination of carriers [13]. Figure 2 shows the double exponential model.

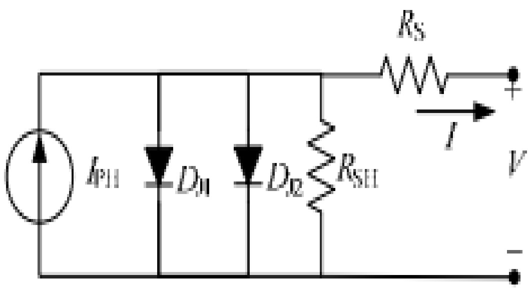


Figure 2: Double exponential model

It is clear by using extra diode the (1) should be rewritten. The current-voltage characteristic equation that can explain the model is as follow:

$$I = I_{ph} - I_{s1}\left[\exp\left(\frac{q.(V+IR_s)}{NkT}\right) - 1\right] - I_{s2}\left[\exp\left(\frac{q.(V+IR_s)}{NkT}\right) - 1\right] - \frac{(V+IR_s)}{R_{sh}} \quad (2)$$

Extra diode current is added to the (1). Is1 is the saturation current of diode D1 due to diffusion mechanism; Is2 is the saturation current due to recombination in space charge layer.

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

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

$$\Delta T = (T - T_n) \quad (4)$$

T_n is cell's reference temperature.

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

$$I_s(T) = I_s\left(\frac{T}{T_n}\right)^3 \exp\left[\frac{E_g}{V_t}\left(\frac{T}{T_n} - 1\right)\right] \quad (5)$$

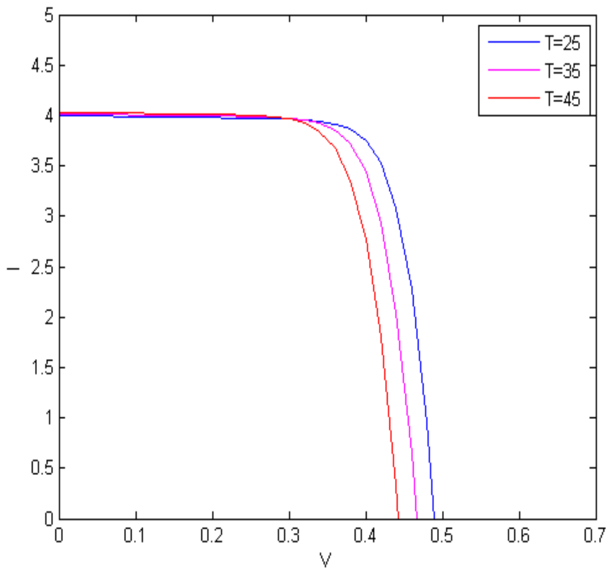
E_g is the band gap energy of semiconductor, T_n is nominal temperature and V_t is the thermal voltage. The mathematical formulation of thermal voltage is:

$$V_t = kT/q \quad (6)$$

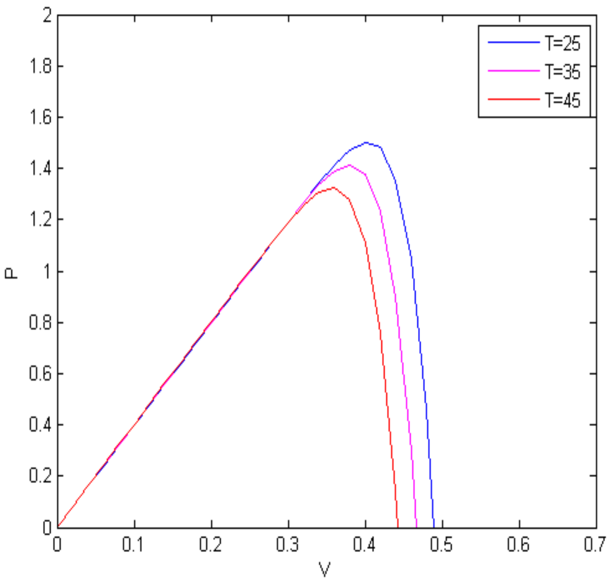
III. SIMULATION RESULTS

The simulation result for double exponential model is presented in this part. Temperature, solar irradiation, and ideality factor of diode is as input parameter and I-V and P-V characteristics is output. Figures 3, 4 and 5 are showed the effect of three different parameters corresponding to temperature, solar irradiation and diode ideality constant respectively.

Effect of several temperatures on I-V and P-V curves are as follow:



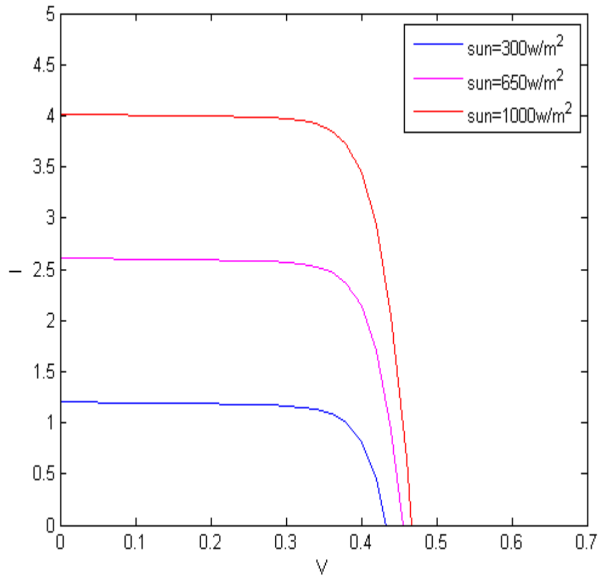
A: I-V curve for different temperature



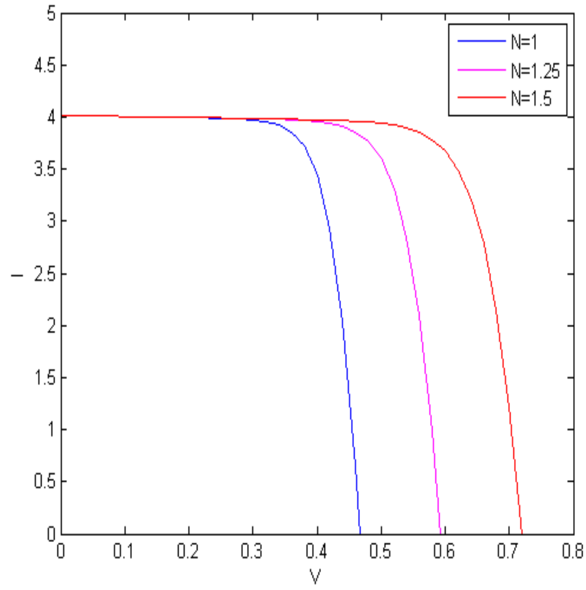
B: P-V curve for different temperature
Figure 3: effect of different temperature

The figure shows by increasing the temperature from 25℃ to 45℃ open-circuit voltage is decreases and short-circuit current is increased. These changes reduce the peak of power.

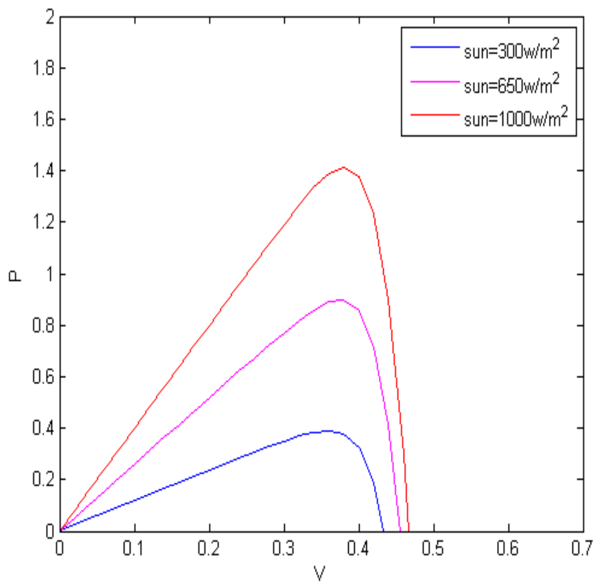
Solar irradiation effect is showed in figure 4.



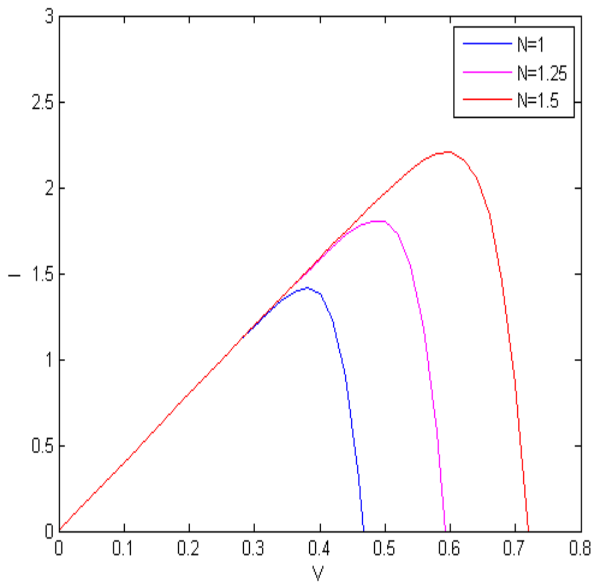
A: I-V curve for different solar irradiation



A: I-V curve for different N



B: P-V curve for different solar irradiation
Figure 4: effect of different solar irradiation



B: P-V curve for different N
Figure 4: effect of different N

It is clear from figure 4, value of solar irradiation has powerful effect on PV cell behavior and its characteristics. By Increasing the solar irradiation, the short-circuit current and open-circuit voltage are increased, and the maximum power output increased too. The effect of reduced solar irradiation is actually to shift diode characteristic curve downward along current axis.

Effect of variation of N on PV behavior for both I-V and P-V characteristics is showed in figure 5:

Figure 4 (a) shows V-I characteristics of a PV for three different values of N corresponding to 1, 1.25 and 1.5 respectively. It can be observed that by increase value of N, the open circuit-voltage of cell is increased, and this fact may effectively be used in simulation of a PV module, which is a congregation of many cells in series. By increase value of N, the open circuit-voltage of cell is increased.

IV. COCLUSSION

The photovoltaic generator converts the solar energy to the electricity. The temperature, solar irradiation and diode ideality constant are input parameters and I-V and P-V characteristic are outputs. By increasing the temperature from 25℃ to 45℃ 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, and the maximum power output increases and by increase value of N, the open circuit-voltage of cell is increased.

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