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Exploring and Assessment of Effect the Fast Changing of the External PV Parameters on the PV Characteristics

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Abstract: *In this paper, the effect of the external parameters on the PV characteristic were studied. These parameters are the radiance and the ambient temperature, which supposed the most two effected parameters on the PV behavior. In addition, the fast changing in these two parameters is also considered and studied. This study focused on all of the I-V characteristic, P-V characteristic and the P-I characteristic. The results extracted from this research showed that the effect of increasing the radiance was positive on the PV behavior for all of the I-V, P-V and the P-I characteristics. However, on the other hand, the effect of increasing the ambient temperature was negative on the PV behavior for all of the I-V, P-V and the P-I characteristics. Therefore, the results presented in this research could be a guideline for those who are interested in PV installation.*

Keywords: *photovoltaic parameters,environmental parameter, PV irradiance,PV temperature, PV characteristics.*

1. Introduction

The global depletion of fossil fuels has led to the growth of alternative energy resources such as renewable energies. Among renewable energy sources, solar energy is the famous one [1]. The solar energy utilizes photovoltaic (PV) modules to convert sunlight into electricity. Nevertheless, the performance of these PV modules is heavily dependent on the solar irradiance, ambient temperature and module temperature[2-4]. The solar irradiance represents the intensity of sunlight, whereas the ambient temperature and module temperature is related to the surrounding air temperature and solar cell temperature respectively. Unfortunately, these parameters are not fixed with respect to time as they depend severely on the weather conditions[5]. As a result, various measurement tools have been developed to instantaneously quantify these parameters. The most important parameters in quantifying the input to PV module are the solar irradiance and the solar temperature, whichrepresents the measure of incident solar radiation and temperature which fall on an area of a surface. The unit of solar irradiance is Watts per square meter, W/m^2[6]. The solar irradiance is usually measured using a device known as pyranometer[7-9] as shown in Figure 1 below.

Energy yield calculations of PV devices are gaining importance for PV users as, unlike the power rating under standard test conditions (STC), they take into account variations of environmental conditions. This is leading to more complete information on device performance in different climatic conditions and ultimately can improve the determination of the financial return of an installation. Currently, for characterization for energy yield prediction, devices are measured outdoors or indoors in a matrix of different irradiances (*G*) and temperatures (*T*). Energy rating derived from outdoor measurements can be accurate[10,11]. To solve this problem, one would need to study effect of each parameter alone one time and both of them another time (varying irradiance spectrum and value of temperature).These parameters based on simulator (MATLAB Simulink) that can closely reproduce realistic conditions with varying irradiance and temperature. Thus, it meets requirements to carry out characterization measurements in a *G-T* performance for more accurate energy yield prediction. The results of this paper confirm reports of spectral effects for these parameters. And the analysis also demonstrates a strong correlation between the performance influencing factors *G* and *T*, and thus the need for carrying out these measurements for an accurate energy yield prediction.

This paper is organized as follows: The distribution of the solar radiation within the earth's surface. Section 3 deals with the photovoltaic (PV) solar model will be discussed in section2. Section 4 presents the simulation of the solar PV system under different solar irradiations and temperatures. Finally, conclusion will be presented in section 5.

Fig1. *Pyranometer.*

2. DISTRIBUTION OF SOLAR RADIATION

The distribution of solar radiation is shown in Figure 2. As it shown in the figure, earth receives 342 W/m^2 of incoming solar radiation at the upper atmosphere. Approximately 31% is reflected back to space and 49% is absorbed by oceans and land masses. The spectrum of solar light at the Earth's surface is generally spread across the visible and near-infrared reason with a small part in the near-ultraviolet. The total solar energy absorbed by Earth's atmosphere, oceans and land masses is approximately 3,850,000 EJ per year. The intensity of solar radiation reaching earth surface which is 1369 watts per square meter is known as Solar Constant. It is important to realize that it is not the intensity per square meter of the sun at its center[12].

The efficiency of a PV device is dependent on the spectral distribution of solar radiation. The evaluation of PV devices is generally done with reference to a standard spectral distribution. There are two standard terrestrial distribution defined by the American Society for Testing and Materials (ASTM), direct normal and global AM1.5. The direct normal standard corresponds to the solar radiation that is perpendicular to a plane directly facing the sun.The global corresponds influenced by atmospheric conditions are called diffuse radiations. To measure the global radiations an instrument named pyrometer is used. Influenced by atmospheric conditions are called diffuse radiations. To measure the global radiations an instrument named pyrometer is used. Figure 3 shows Spectral distributions of black body radiation and sun radiation. The sun radiates energy in the spectral range from 280 to 4000 nm (Figure 3), with a maximum in the blue-green (480 nm). The three major regions of solar spectrum are:

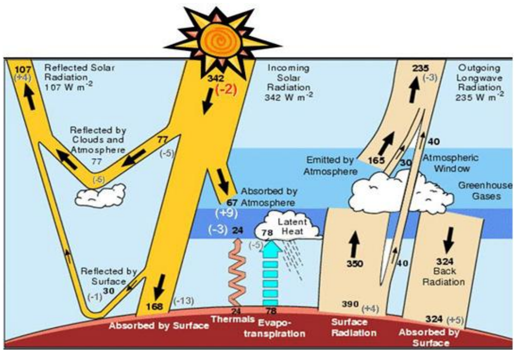

Fig2. *Solar radiation distribution (Global greenhouse warming).*

- Ultra violet region (wavelength less than 400nm): constitutes 9% of the irradiance.
- Visible region (wavelength ranging from 400nm-700nm): constitutes 45% of the irradiance.
- Infrared region (wavelength greater than 700nm): constitutes 46% of the irradiance.

The PAR in visible spectrum ranging from 400-700 nm is absorbed by plants to carry out photosynthesis.

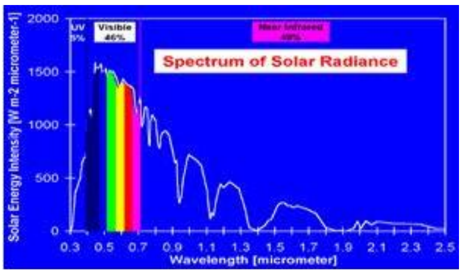

Fig3. *Spectral distribution of black body radiation and sun radiation (Solar in depth).*

3. Solar PV Model

In a PV characteristic there are basically three important points viz. open circuit voltage (*Vo*), short circuit current (*Io*) and maximum power point. The maximum powers that can be extracted from a PV cell are at the maximum power points. Usually manufacturers provide these parameters in their datasheets for a particular PV cell or module.

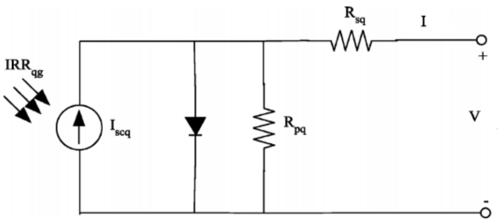

Fig4. *PV module single-diode model.*

The model is consist of one PV module connected to a resistance load to represent the actual case within normal condition, and based on mathematical equations and is described through an equivalent circuit including a photocurrent source, a diode, a series resistor and a shunt resistor as shown in Figure 2. The developed model allows the prediction of PV cell behaviour under different physical and environmental parameters. Matlab has been done to find the maximum power output, Pm, and voltage at maximum power output, Vm, of solar module. The model can also be used to extract the physical parameters for a given solar PV cell as a function of temperature and solar radiation. Effect of two environmental parameters of temperature and irradiance variations could be observed from simulated characteristics.

$$I = I_{scq} - I_0\left\{exp\left(\frac{V+IR_{sq}}{n_sV_t}\right) - 1\right\} - \frac{V+IR_{sq}}{R_{pq}} \qquad (1)$$

Where *V* and *I* are the module voltage and current respectively; I_{scq} and *Io* are the photo-generated current and the dark saturation current respectively; V_t is the junction thermal voltage, R_{sq} and R_{pq} are the series and parallel resistances respectively; n_s is the number of cells in the module connected in series.

The thermal voltage of the diode is related to the junction temperature as given by eq. (2):

$$V_t = \frac{kTA}{q} \qquad (2)$$

Where*k* is the Boltzmann's constant, *T* is the junction temperature, A is the diode quality factor, and *q* is the electronic charge. The model represented by (1) can be say that it is the wholePV model for any PV cell or module. The PV modeling objective is to estimate the model parameters at varying environmental conditions from. The PV model parameters are adjusted to consider the effects of changing temperature and irradiance, and then it is used to estimate the maximum power point (MPP) at given environmental conditions.

4. Results and Discussion

Two different types of simulation are performed, first varying irradiance with constant temperature and second varying temperature with constant irradiance.This section describes the procedure used for simulating theI–V, P–V, and P–I characteristics of a PV arraywith different irradiance and temperature.

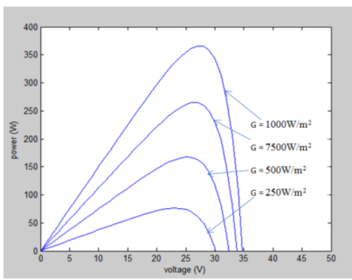

Fig5. *P–V Characteristics at different insolation level for a PV Module.*

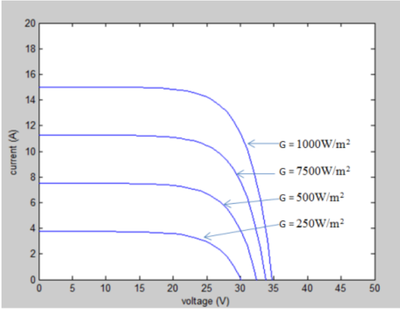

Fig6. *I–V Characteristics at different insolation level for a PV Module.*

The first simulation was done with varying the irradiance (1000W/m^2, 750W/m^2, 500W/m^2, and 250W/m^2) with constant temperature. Then second simulation was done with varying the temperature (*T* = 15℃,*T*= 25℃, *T* = 35℃, *T* = 45℃) with constant irradiance. The simulation results of I-V, P-V, and P-I, characteristics for the above two conditions shown in Figures (5, 6, 7, 8, 9, and 10). It is very clear that current generated increases with increasing solar irradiance and maximum output power also increases. On the other hand,the voltage is staying almost constant and it is not varying much. Similarly with increase in cell temperature the short circuit current of the PV module increases whereas the maximum power output decreases. The results thus confirm the non-linear nature of PV module.

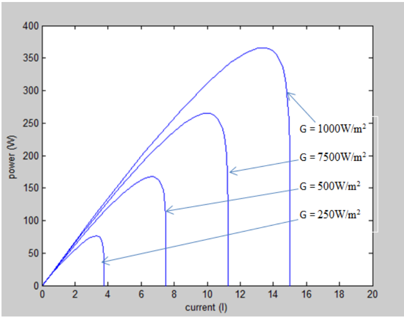

Fig7. *P–I Characteristics at different insolation level for a PV Module.*

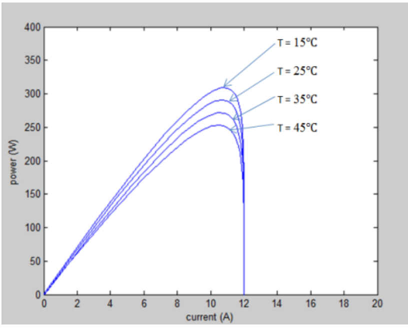

Fig8. *P–I Characteristics at different insolation level for a PV Module.*

Higher solar irradiance will lead to higher output current and therefore higher power output from a PV module[13]. On the other hand, the voltage of a PV module may decrease with the increase of ambient temperature and module temperature[14].

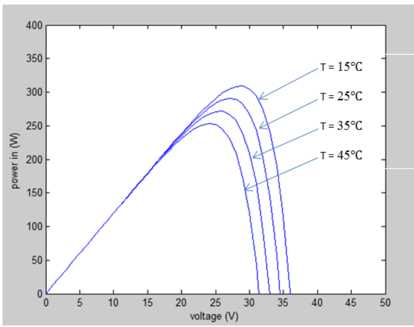

Fig9. *P – V Characteristics at different insolation level for a PV Module.*

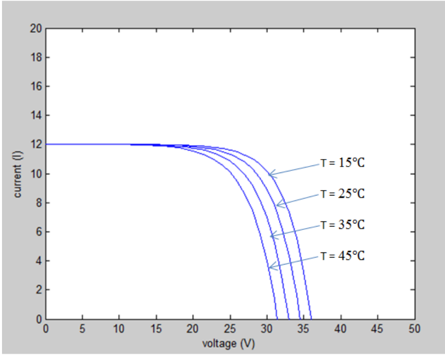

Fig10. *I–V Characteristics at different insolation level for a PV Module.*

5. Conclusions

The model has been used for energy yield determination based on the expected data of solar insolation. The energy yield of solar module is simulated different levels of the solar irradiation and different values of temperature. This is to find out the maximum power and energy yield that can be obtained from the PV module for a given surface area. This calculation helps to determine the size of the PV system in the outdoor condition more precisely.

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