# A Model of Photovoltaic Module of Solar Station

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ABSTRACT

This paper define a circuit-based simulation model for a PV cell in order to allow estimate the electrical behavior of the cell with respect changes on environmental parameter of temperature and irradiance. An accurate PV module electrical model is presented based on the mathematical equations. The general model was implemented on MATLAB/Simulink environment, and accepts irradiance as variable parameters and outputs the I-V characteristic

**Keywords:** *Photovoltaic (PV), PV Cells, Matlab, PV Module, Modelling.*

## 1. Introduction

Research and development efforts are under way to improve efficiency and reduce cost of photovoltaic power systems in applications ranging from roof-top residential to large industrial or electric utility sites. Photovoltaic systems have become globally accepted as a practical and feasible tool for power generation. Researchers' efforts for facilitating PV systems utilization and their integration to currently available systems have been always inspired by the national goal of having renewable and clean energy sources. In the present work we define a circuit-based simulation model for a PV cell in order to allow estimate the electrical behavior of the cell with respect changes on environmental parameter of temperature and irradiance. An accurate PV module electrical model is presented based on the mathematical equations. The general model was implemented on MATLAB/Simulink environment, and accepts irradiance as variable parameters and outputs the I-V characteristic [1-3].

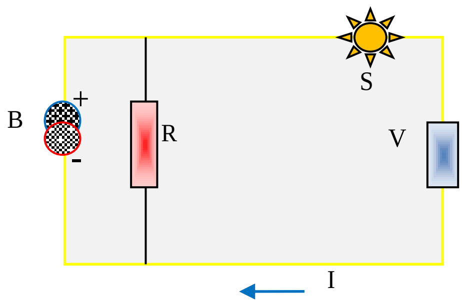


Fig.1. The building block of PV arrays is the solar cell

**2. Modelling of I-P-V array:**

The building block of PV arrays is the solar cell, which is basically a p-n junction that directly converts light energy into electricity: it has a equivalent circuit as shown below in Figure 1. PV cells are grouped in larger units called PV modules which are further interconnected in series-parallel configuration to form PV arrays or PV generators[3].The PV mathematical model used to simplify our PV array is represented by the equation:

$$I = n_p I_{ph} - n_p I_{rs} \times \left( \exp\left( \frac{q}{kTA} \frac{V}{n_s} \right) - 1 \right) \qquad (1)$$

where ehe current source $I_{ph}$ represents the cell photo current; I is the PV array output current; V is the PV array output voltage; $n_s$ is the number of cells in series and $n_p$ is the number of cells in parallel; q is the charge of an electron; k is the; A is the p-n junction ideality factor; T is the cell temperature (K); $I_{rs}$ is the cell reverse saturation current. The factor A in equation (1) determines the cell deviation from the ideal p-n junction characteristics; it ranges between 1-5 but for our case A=2.46 [1]. The cell reverse saturation current Irs varies with temperature according to the following equation:

$$I = I_{rr} \left( \frac{T}{T_r} \right)^3 \times \exp\left( \frac{qE_g}{kA} \left[ \frac{1}{T_r - T} \right] \right) \qquad (2)$$

$$E_g = E_g(0) - \frac{\alpha T^2}{T+\beta}$$

Where $T_r$ is the cell reference temperature, Irr is the cell reverse saturation temperature at $T_r$ and $E_g$ is the band gap of the semiconductor used in the cell. Equation (10) is able to be extended for a single PV array which consists of a number of PV modules and for a PV farm with many arrays.

**3. I-P-V array characteristic curves**

| N | | Rs | Vs | Is | P |
|---|---|---|---|---|---|
| Power | 150 W | 0.021 | 22.06 | 0.63 | 150.14 |
| Voltage | 20 V | 0.018 | 22.06 | 0.63 | 150.14 |
| Current | 18 A | 0.016 | 22.06 | 0.63 | 150.14 |
| Opey Current | 10 A | 0.014 | 22.06 | 0.63 | 150.14 |
| Open Voltage | 22 V | 0.011 | 22.06 | 0.63 | 150.14 |
| Temp | 0.058 C | 0.009 | 22.06 | 0.63 | 150.14 |
| Cells | 36 | 0.005 | 22.06 | 0.63 | 150.14 |

The current to voltage characteristic of a solar array is non-linear, which makes it difficult to determine the MPP. The Figure below gives the characteristic I-V curve for fixed level of solar irradiation and temperature.

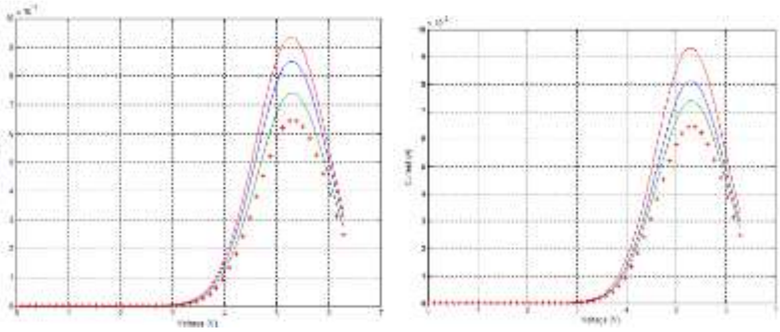

Fig. 2. P-V characteristics under varying irradiation at constant temperature 25° C.

Fig. 2 and Fig. 3, represent current – voltage and voltage -power characteristics (I-V & P-V curve) respectively, under different irradiation with temperature keeps constant based on the modeling equations.

In the present work, the solar irradiation changes with values of 1000, 800,600,400,200 and 550 W/m$^2$ and this is the average irradiance in Jordan [5], while temperature at standard condition at 25°C. The Figures shows, the PV cell current is dependent on the radiation with constant temperature. However, when the irradiation increased the current and voltage of PV cell increase. This results in rise in power output in this operating condition.

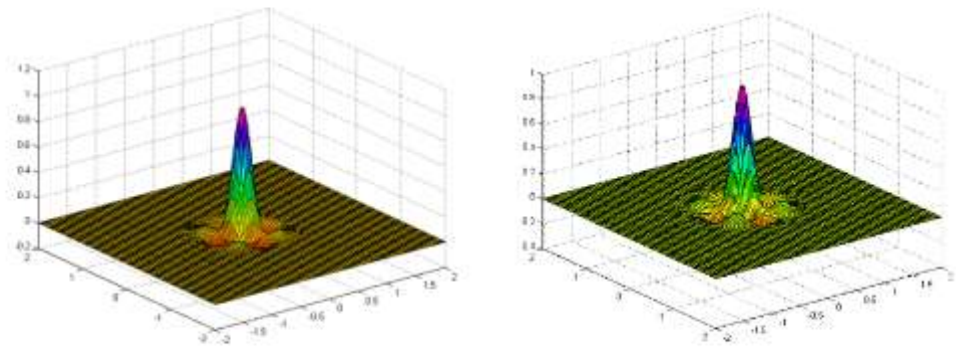

Fig.2. Current – voltage and voltage -power characteristics

In this case for P-V characteristics, when the operating temperature Increase, the current output is increased marginally while the voltage output decrease drastically and that will affect the net power output reduction with rise in temperature.

**4. P-V characteristics**

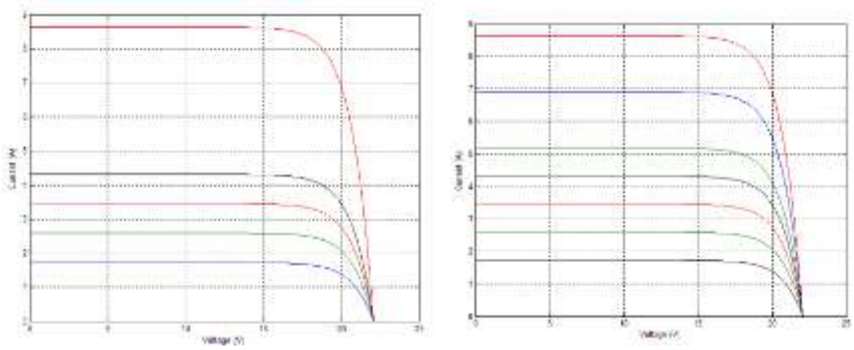

Fig. 3. I-V characteristics under varying irradiation at constant temperature 25° C.

According to the analysis and results finding, I-V characteristics under varying shunt resistance with keep temperature and irradiation constant at STC 1000 w/m2 and 25co respectively. In this case, the effect of shunt resistance resulting in a deviation of the maximum power point for large value. The effect is very low and in some case, it can be neglected as shown in Appendix B. Usually the value of Rsh is very large, hence it may be neglected.

## 5. Conclusion

Thus, we define a circuit-based simulation model for a PV cell in order to allow estimate the electrical behavior of the cell with respect changes on environmental parameter of temperature and irradiance. An accurate PV module electrical model is presented based on the mathematical equations.

## References

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