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# Matlab / Simulink Based Simulation of Monocrystalline Silicon Solar Cells

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**Abstract:** A solar cell is an electrical device that converts light into an electric current. Electron-hole pairs are generated inside the solar cell when light is absorbed. A two diodes equivalent model is used to describe the electronic properties of solar cells. The open-circuit voltage ($V_{OC}$) is created by the series resistance and the shunt resistant of the solar cell. The theme of modeling is based on the solar radiation, temperature of system and environment to determine the effect of cell parameters like photo generated current, saturation current, series resistance, shunt resistance and ideality factor on the performance of the solar cell. In this paper we study the influence of temperature, series resistance and shunt resistance on the current-voltage (I-V) characteristics simulated in Matlab / Simulink.

**Keywords:** Current-Voltage, Ideality Factor, Open-Circuit Voltage, Output Power, Solar Cells

## 1. Introduction

A solar module is a collection of a solar cell which is a device that converts the sunlight into an electric current [1]. The solar module of silicon was still the most widely used solar cells device because of the advantages of Silicon over any other materials [2-5]. The electrical output under illumination from the solar cell is described by the (I-V) characteristics whose parameters can be linked to the material properties [4, 6-9].

Most silicon solar cells are designed to work under normal sunlight and their performances are evaluated at $25^0$C under an AM1.5 solar irradiation of 100 mW/cm$^2$ intensity. Also, as stated earlier, the two diode model is most commonly used to describe the I–V characteristics of a cell [10].

Solar cell parameters including: short-circuit current ($I_{CC}$), open-circuit voltage ($V_{OC}$), efficiency, series resistance ($R_S$) , shunt resistance ($R_{Sh}$) and ideality factor (A) could be changed due to light intensity and temperature variations [11-14]. In the current paper we present the effect of temperature, $R_S$ and $R_{Sh}$ on the (I-V) characteristics simulated in Matlab / Simulink.

## 2. Theory

The two-diode model represents the recombination losses occurring in the junction of solar cell (Fig. 1).

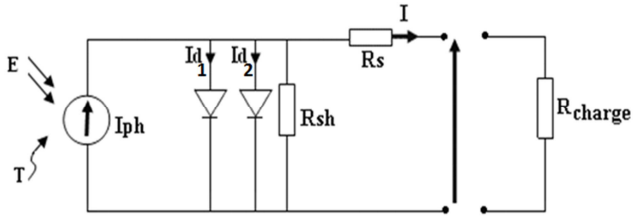


***Fig. 1.*** *Equivalent model of two diode.*

Using law of Kirchhoff's, the total output current from the solar cell is given by [15]:

$$I = I_{ph} - I_{d_1} - I_{d_2} - I_p$$

Where I is the net output current of the solar cell $I_{ph}$ is the net photo generated current from the solar cell, $I_{d1,2}$ is the diodes current flowing through the diode and $I_P$ is the current through the resistances. Expanding the current equation with its internal parameter it becomes:

$$I = I_{ph} - I_{d_1} - I_{d_2} - \left( \frac{V + I R_s}{R_{sh}} \right)$$

The two diodes model consist two saturation current i.e. $I_{s1}$ and $I_{s2}$.

$$\Rightarrow I = I_{ph} - I_{S_1} \left[ \exp\left( \frac{(V + R_s I)}{A U_T} \right) - 1 \right] - I_{S_2} \left[ \exp\left( \frac{(V + R_s I)}{A U_T} \right) - 1 \right] - \left( \frac{V + R_s I}{R_{Sh}} \right)$$

Where $I_{ph}$ is the light generated current, $R_{sh}$ is the shunt resistance, $R_s$ is the series resistance, A is the diode ideality factor. These cell parameters control the I–V characteristics of a cell at any given intensity of illumination and cell temperature and thus determine the values of the performance parameters: the short circuit current, open circuit voltage and curve factor. As the intensity of illumination changes the values of performance parameters change significantly. The dependence of performance parameters on illumination intensity can get affected if the values of the cell parameters $R_{sh}$, $R_s$, A and $I_s$ themselves change with illumination intensity.

## 3. Results and Discussion

Fig 2 shows the temperature effect on (I-V) characteristics of monocrystalline silicon solar cell. In constant irradiation the open circuit voltage $V_{OC}$ decreases with temperature. High temperature lowers the $V_{OC}$ and short circuit $I_{CC}$ current increases with temperature. This increase is much less than the voltage drops. The influence of temperature on the $I_{CC}$ can be neglected in the majority of cases.

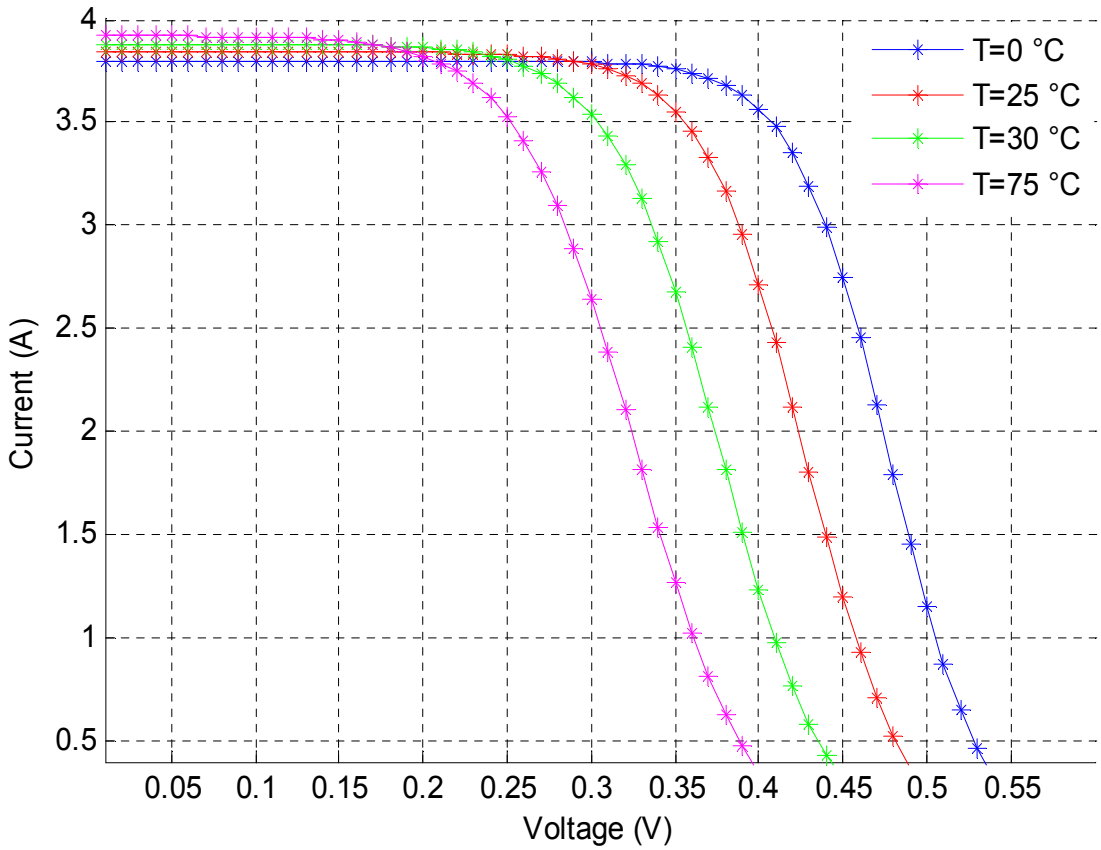


***Fig. 2.*** *(I-V) characteristics of monocrystalline silicon solar cell: Temperatures effect.*

Fig. 3 shows the $R_{Sh}$ effect on (I-V) characteristics of monocrystalline silicon results in a minor reduction of the open circuit voltage, and an increase in the slope of the (I-V) of cell in the area corresponding to operation as a power supply. This is because it should subtract the photocurrent, besides the diode forward current, an additional current which varies linearly with the developed tension.

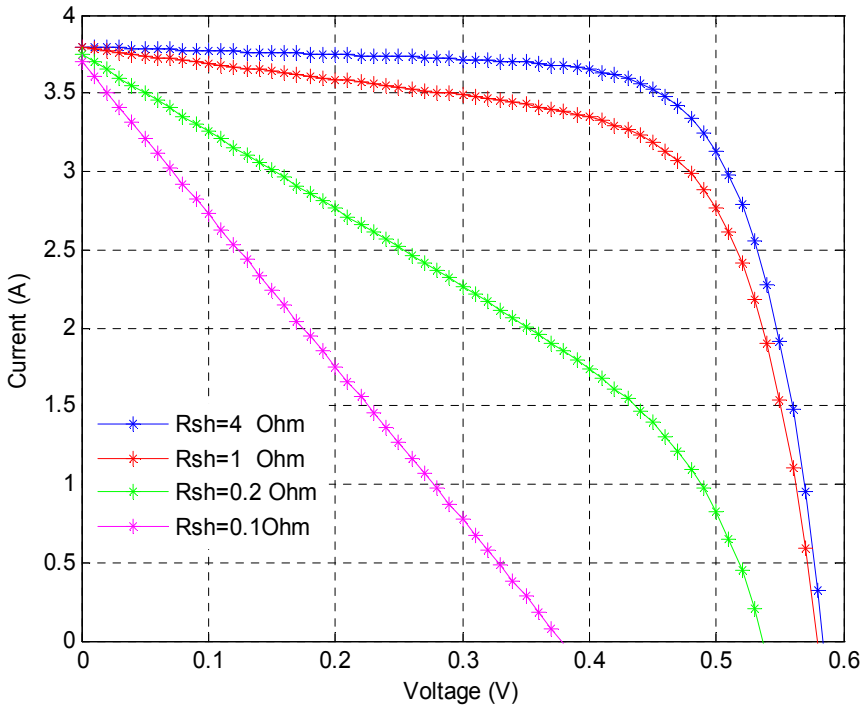


***Fig. 3.*** *(I-V) characteristics of monocrystalline silicon solar cell: $R_{Sh}$ effect.*

Fig. 4 shows the $R_S$ influence on the (I -V) characteristic of monocrystalline silicon solar cell. The series resistance is the slope of the characteristic in the area or the photodiode behaves like a voltage generator. It does not modify the open circuit voltage $V_{OC}$ and when it is high and decreases the value of the short-circuit current.

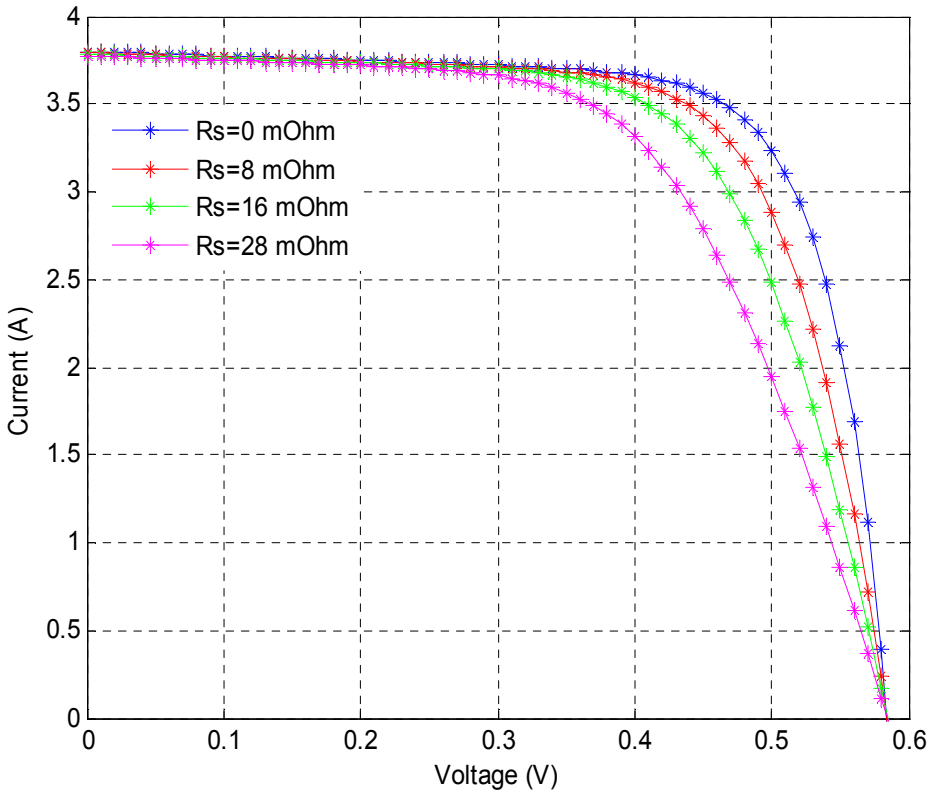


***Fig. 4.*** *(I-V) characteristics of monocrystalline silicon solar cell: $R_S$ effect.*

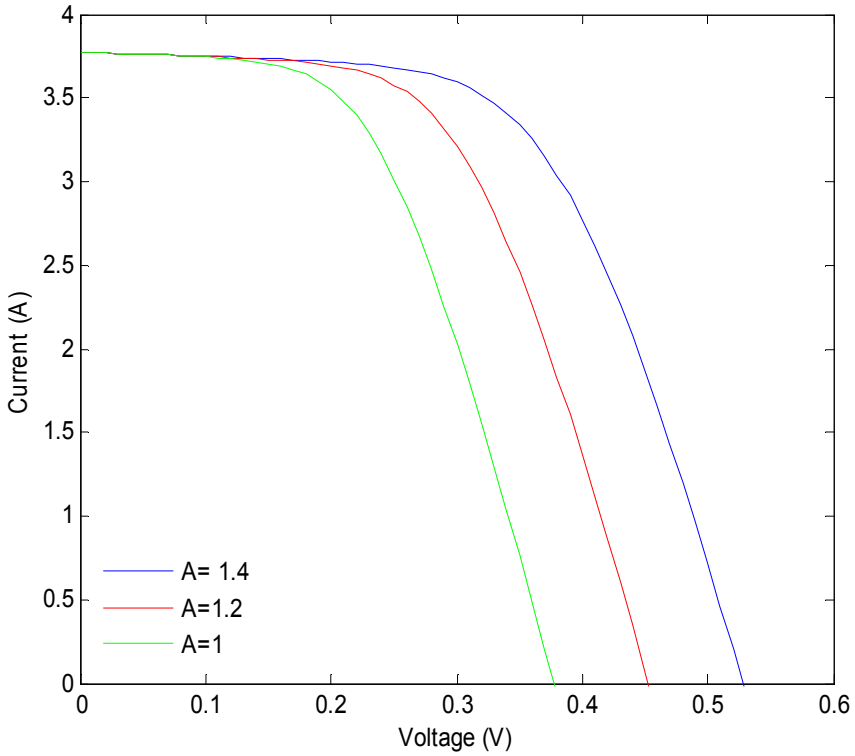


***Fig. 5.*** *(I-V) characteristics of monocrystalline silicon solar cell: A effect.*

Fig. 5 shows the A influence on the (I -V) characteristic of monocrystalline silicon solar cell.

A perfect match to theory is indicated when n = 1. The effect of changing ideality factor independently of all other parameters is shown for a monocrystalline silicon solar cell in the (I -V) curves displayed in the Fig. 5.

Most solar cells, which are quite large compared to conventional diodes, well approximate an infinite plane and will usually exhibit near-ideal behavior ($n \approx 1$).

## 4. Conclusion

We have investigated the effect of temperature, series resistance and shunt resistance on the current-voltage (I-V) characteristics simulated in Matlab / Simulink. From the results obtained, it can be concluded that the $V_{OC}$ decreases with temperature, $R_S$ does not modify the open circuit voltage and the $R_{Sh}$ effect that a minor reduction of the $V_{OC}$. Temperature impacts significantly on open circuit voltage but almost has no effect on short circuit current.

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