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Study on characteristics of photovoltaic cells based on MATLAB\SIMULINK simulation

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Abstract: *In the future solar energy will be very important energy source .This paper presents the implementation of a generalized photovoltaic model using Matlab/Simulink software package, which can be representative of PV cell, module, and array for easy use on simulation platform. The proposed model is designed with a user-friendly icon and a dialog box like Simulink block libraries. This makes the generalized PV model easily simulated and analyzed in conjunction with power electronics for a maximum power point tracker. Taking the effect of sunlight irradiance and cell temperature into consideration, the output current and power characteristics of PV model are simulated and optimized using the proposed model.*

Key words: *Photovoltaic modules, matlab/Simulink, PVmodel, characteristics of PV cells.*

1. Introduction.

In the last years, the constant grow of the renevlable electrical energy plants in electrical systems is due to the liberalization processes of the electrical energy European market and to the international engagement of Europe for the reduction of carbon gas emissions.

The photovoltaic effect shows itself by the appearance of a difference of potential in the junction between a metal and a semiconductor or between two semiconductors when the device receives a bright radiation of adequate wavelength. So a photovoltaic cell can convert the solar energy in electrical energy by putting at stake this physical optoélectronique phenomenon. Industrially the most used materials are with silicon. The performances of energy efficiency affected industrially are from 13 to 14 % for cells with single-crystal silicon, 11 in 12 % with some polycristallin silicon and finally 7 in 8 %.

Photons of light with energy higher than the band-gap energy of PV material can make electrons in the material break free from atoms that hold them and create hole-electron pairs. These electrons, however, will soon fall back into holes causing charge carriers to disappear. If a nearby electric field is provided, those in the conduction band can be continuously swept away from holes toward a metallic contact where they will emerge as an electric current [9].

Photovoltaic (PV) systems are increasingly used instead of traditional fossil energy in many situations since the solar power is widely considered to be a kind of “clean power” with un-limited capability. The main inconvenience of system PV consists of the fact that the power of production is strongly depended on the meteorological condition including the intensity of the radiation of sunlight and the temperature of environment, which contains non-linear Pi, V-I of the characters. This line makes PV systems a very low efficiency of conversion and an insufficient use of solar energy in the different weather. A strategy MPPT has to force solar cells to work in an optimal point, distributing the power maximal according to the meteorological condition at this moment [3].

2. Photovoltaic modules.

The electric field within the semiconductor itself at the junction between two regions of crystals of different type, called a p-n junction [6].

These carriers are swept apart under the influence of the internal electric fields of the p-n junction and create a current proportional to the incident radiation. When the cell is short circuited, this current flows in the external circuit; when open circuited, this current is shunted internally by the intrinsic p-n junction diode [8].
The characteristics of this diode thus put the characteristics of tension of circuit opened by the cell.

3. Model of a PV cell.

The electrical equivalent-circuit of a solar cell is shown in Fig.1. It is composed of a light-generated current source, diode, series resistance, and parallel resistance.

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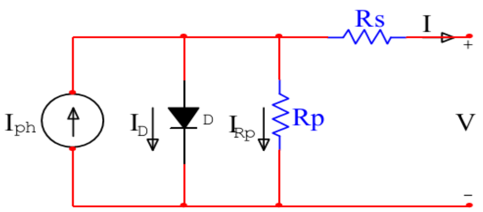

Fig. 1. Equivalent circuit of PV cell.

The basic PV cell is a generator of very low power for the needs of most domestic and industrial applications [1], they are formed by a series or parallel connection of PV cell that performs the conversion of solar energy photovoltaic electricity. The model for a diode is the most classic and most commonly used model; it involves a current generator for modeling the incident light flux and a diode for the phenomenon of polarization of the cell. To account for physical phenomena cell level, the model is completed by two series and shunt resistors R_s and R_p respectively [4], [2].

The series resistance is due to the contribution of the base resistors, the front of the junction and contact front and rear The shunt resistance characterizes the leakage current of the junction along the cell periphery;. It is reduced to the following the penetration of metallic impurities in the junction (especially if it is deep) during deposition of the metal grid or making contacts on the face of the broadcast cellule. We neglect R_p because it is very small compared with R_s [8].

Kirchhoff's law allows us to write the following equation:

$$I = I_{ph} - I_D$$

Where

- I is the current supplied by the cell
- I_{ph} is the photocurrent is proportional to ψ illumination, it also corresponds to the short circuit current I_{sc} defined as follows:

$$I_{ph} = I_{CC}\left(\frac{\psi}{1000}\right)$$

- I_D is the bias current of one diode is given by [3]:

$$I_D = I_S\left(e^{\frac{(V+R_S I)}{V_T}} - 1\right)$$

With:

I_s: dependent of the temperature T and technological electrical parameters of the junction.

V_T: thermodynamic potential defined by [3]:

$$V_T = \frac{AKT}{q}$$

T: effective cell temperature in Kelvin.

From relation, we obtain the expression of the characteristic I (V) of the chosen model:

$$I = I_{cc}\left(\frac{\psi}{1000}\right) - I_S\left(e^{\frac{(V+R_S I)}{V_T}} - 1\right)$$

4. Simulation of solar PV module in MATLAB/SIMULINK.

From equation (5), we set the Simulink model of the PV generator given by the following figure:

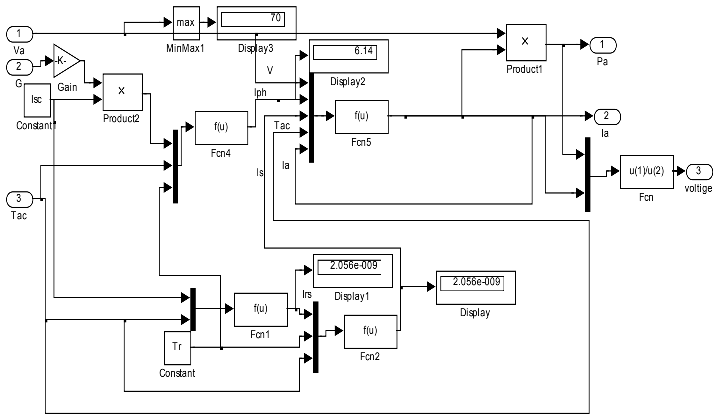

Fig. 2. Simulink model of the photovoltaic generator.

The parameters chosen for modeling corresponds to the SUNPOWER 315W module as listed in Table1.

TABELE I. THE KEY SPECIFICATIONS OF THE SUNPOWER 315W PV PANEL

Maximum power	P_{max}	315	W
Voltage at P_{max}	V_{max}	54.7	V
Current at P_{max}	I_{max}	5.76	A
Open circuit voltage	V_{co}	64.6	V
Short circuit current	I_{cc}	6.14	A
Coefficient de temperature (I_{cc})	a	3.5	mA/K

The voltage (V) is considered varying from 0 to open circuit voltage (Voc) corresponding to the variation in current from short circuit current I_{sc} to 0. Fig.3.a & 3.b shows the V-I & P-V characteristics with the variation in solar irradiation level at a constant cell temperature of 25 degrees respectively

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[5]. We can see it that the current of short circuit as well as the power increases with the increase of the level of irradiation, whereas very small change of the increase of the level of irradiation, whereas very small change of the tension of open circuit [6],[9].

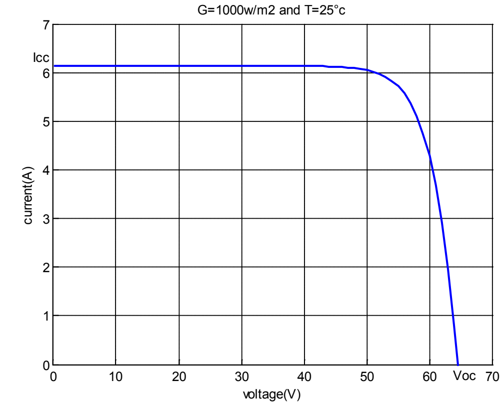

Fig. 3.a Current-voltage characteristics for (T=25°c and G=1000w/m2)

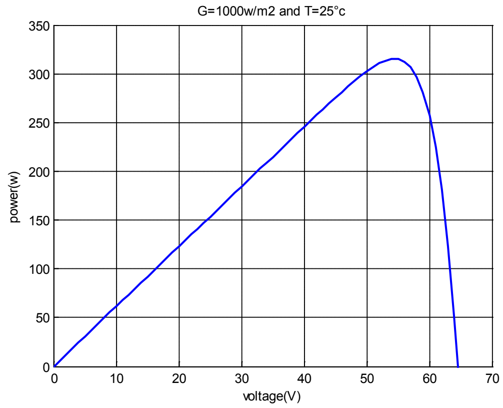

Fig. 3.b Power-voltage characteristics for (T=25°c and G=1000w/m2)

5. Simulation results.

A. Influence of temperature

The temperature is an important parameter in PV cells behavior; we below the I-V characteristic of a photovoltaic module for fixed illumination and different temperatures [4].

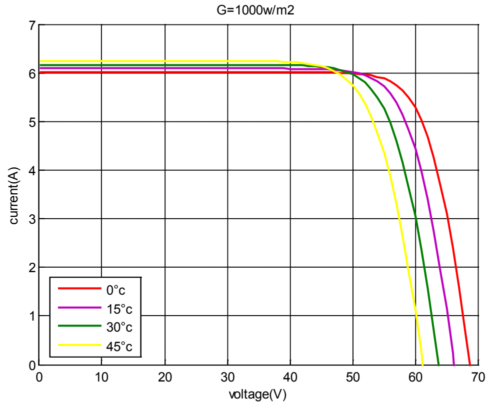

Fig. 4. Current-voltage characteristics for different temperatures

The temperature has a very important effect on the tension of open circuit and a not remarkable effect on the current of short circuit of the cell.
For the silicon, when the temperature increases, the current increases about 025.0 my / cm2 / °C while the tension decreases of 2.2 mV / °C cell. It is translated by a reduction in power about / 4.0 °C. This influence must be taken into account during the sizing of the photovoltaic generator [6].

B. Influence of irradiation

We varied the irradiance G and plot the I-V characteristics associated:

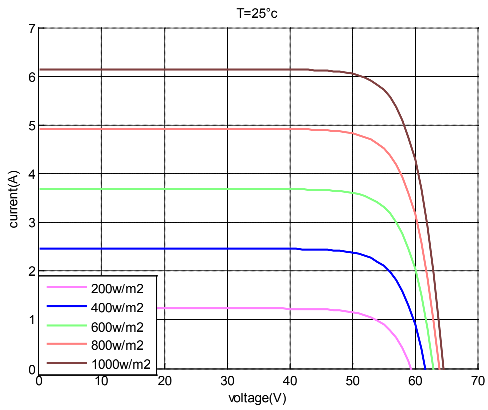

Fig. 5. Current-voltage characteristics for different irradiations

The figure shows that the open circuit, we note that the current is directly proportional to the levels of illumination [4].

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C. Influence of ideality factor

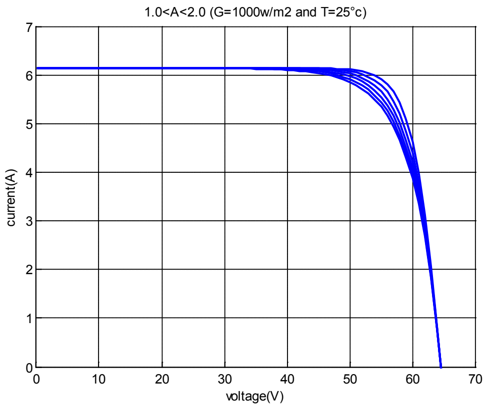

Fig. 6. Current-voltage characteristics for different ideality factors

Increasing the ideality factor of the diode inversely affects the area or the maximum power point, and this result in a power loss at the operating zone [7].

A value of 1.3 is suggested as a typical value in normal operation and can be used initially.

A more accurate value and estimated later by curve fitting, the effect of the change in the ideality factor can be seen in the model SPR 315E [7].

D. Influence of series resistance

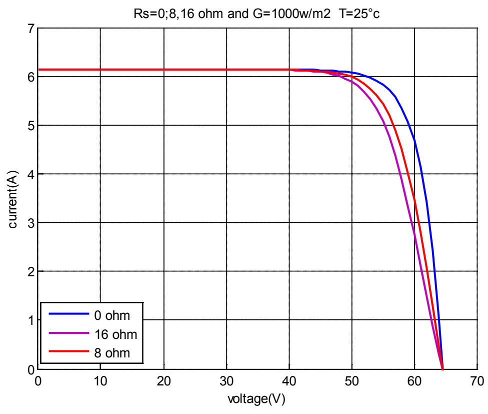

Fig. 7. Current-voltage characteristics for series resistance

The series resistance characterizes the losses by effects Joule of the appropriate resistance of the semi-conductor and the losses through the bars of collections and bad contact ohmic of the cell. The contacts semiconductor - electrodes with high resistance lower appréciablement the tension and the current of exit what is going to limit the yield on conversion.

6. Conclusion.

This paper establishes a kind of PV model based on the physical and mathematical models of photovoltaic array in application of Matlab/Simulink.

A generalized PV model which is representative of the all PV cell, module, and array has been developed with Matlab/Simulink and been verified with a PV cell and a commercial module. The proposed model takes sunlight irradiance and cell temperature as input parameters and outputs the I-V and P-V characteristics under various conditions.

In this article we chose the four parameter model to simulate the function of the PV model (SPR 315 E) for different solar conditions and temperature.

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