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Design and simulation of MATLAB / Simulink. Influence of external and internal parameters of photovoltaic cells

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Abstract

This article is devoted to the simulation of a model of a single photovoltaic cell described by mathematical equations comprises a photoelectric generator, a diode, a series resistance and shunt resistance. The goal is to draw IV and PV characteristics under Changes five parameter, external (temperature settings, illumination) and internal (series resistance, shunt resistance, factor ideality and the saturation current) and the influence of each parameter on the model.

Keywords: photovoltaic cell, MATLAB Simulink, characterization, modeling, electrical parameters.

1. Introduction

The principle of the photoelectric effect (Direct transformation energy from light into electricity) was applied in 1839 by Antoine Becquerel and his son Edmond Becquerel who noted that a chain of elements conduct electricity gave to a current spontaneous electric when she was enlightened. [1].
Later, selenium and silicon (which finally for reasons of cost supplanted cadmium-tellurium or cadmium-indium-selenium also tested) were shown capable of producing the first cells photovoltaic (exposure meters for photography soon 1914, and 40 years later (in 1954) for an electricity production). Research also carries today on organic polymers and materials (possibly flexible) which could replace silicon. [1]

2. Photovoltaic module Msx60

The photovoltaic cell is made of a material semiconductor that absorbs light energy and transformed directly into electric current [2] [3] [4] [5].

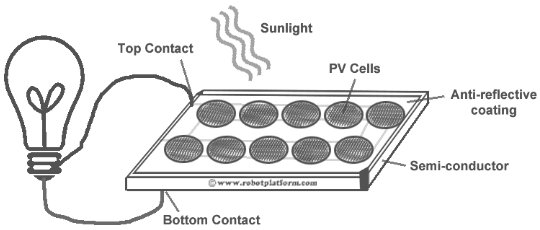


Fig.1: The principle of solar cell work

The different cells PV according to their performance are:

2.1 Mono-crystalline cell [2] [3] [4]
Mono-crystalline silicon cells are formed a silicon single crystal.
2.2 polycrystalline Cell
Cells in polycrystalline silicon are formed of several silicon crystals.
2.3 Amorphous Cell
The amorphous silicon cells made with amorphous silicon, not crystallized, spread on a plate of glass.
2.4 Tandem cell
There are also other types of cells, such as tandems, consisting of several cells and cells in plastiques.

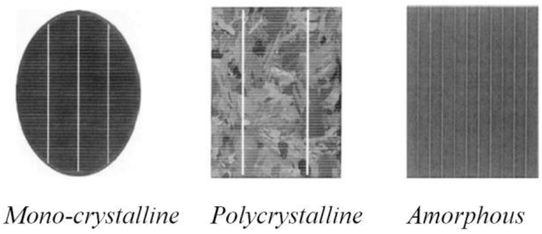


Fig.2: types of PV cells [6]

The following table shows the different cells PV according to their performance:

Technology	Efficiency	Efficiency	Efficiency
Mono-crystalline	24.7	21.5	16.9
polycrystalline	20.3	16.5	14.2
Amorphous	13	10.5	7.5

3. Modelling of the photovoltaic cell

An evaluation of the operation of PV modules and design of the power systems is based on the electric current-voltage characteristic of the cells and PV modules. The modelling of these generators can be performed by means of equations which provide different degrees of approximation to the real device. In this article exponential model of the PN junction was chosen for the PV cell. Fig.1 shows the circuit equivalent. This circuit requires five parameters are known: enlightenment, the current Iph, the current reverse saturation of the diode, the series resistance Rs and shunt resistance Rsh [6] [7] [8] [9].

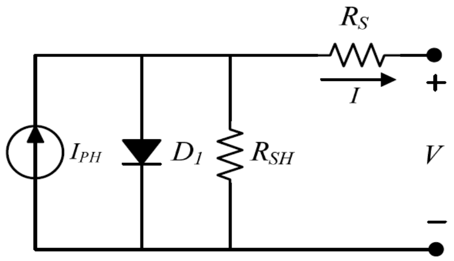


Fig.3: Standard equivalent model of the PV cell

The equation that describes its behavior to temperature and fixed solar radiation [1-13]:

$$I = Iph - Is\left(exp\left(\frac{V+RsI}{a}\right)-1\right)-\frac{V+RsI}{Rsh} \quad (1)$$

For irradiation and temperature data, equation (1) has different combinations of a, Rs and Rsh allowing passage near the same points ISC, IM, VM and VOC curve I-V. Taken separately, these values of a, Rs and Rsh only are not appropriate. What really makes the significant is the ratio consisting of three parameters.

The relationship of power for a module PV is given by:

$$P = IV \quad (2)$$

Thermal voltage is expressed by:

$$\boldsymbol{a} = \frac{\boldsymbol{NsKT}}{\boldsymbol{q}}A \quad (3)$$

Where:

q: elementary charge 1,607 10 -19 C
A: coefficient of ideality of the cell; it depends on the material.
K: Boltzmann's constant = 1.380 10 -23 J / K
T: temperature in degreesKel
Rs: series resistance of the cell (Ω).

Rsh: shunt resistance (Ω).

NS :the number of series connected cells.

Applying the short-circuit conditions in equation (1),

Iph is obtainable by:

$$\text{Iph} = \text{Isc}\left(1+\frac{Rs}{Rsh}\right)+Is\left(exp\left(\frac{Rs}{Rsh}\right)-1\right) \quad (4)$$

Equations (3) and (4) induce

$$\text{Is} = \frac{\text{Isc}\left(1+\frac{\text{Rs}}{\text{Rsh}}\right)-\frac{\text{Voc}}{\text{Rsh}}}{\exp\left(\frac{\text{Voc}}{\text{a}}\right)-\exp\left(\frac{\text{IscRs}}{\text{a}}\right)} \quad (5)$$

exp (Voc/a) >>exp (Isc.Rs/a), equation (5) is simplified in:

$$Is = \left(Isc - \frac{Voc}{Rsh}\right) exp\left(-\frac{Voc}{a}\right) \quad (6)$$

ISC and Voc represent respectively the current short circuit and open circuit voltage..

4. Photovoltaic module Msx60

We chose a mono-crystalline silicon cells module composed of 36 Msx60 with a maximum power of 60connected in series .W is considered in standard conditions G = 1000W / m2, T = 25 ° C. To realize the modelling of this module, we used MATLAB as a tool for testing and simulation.

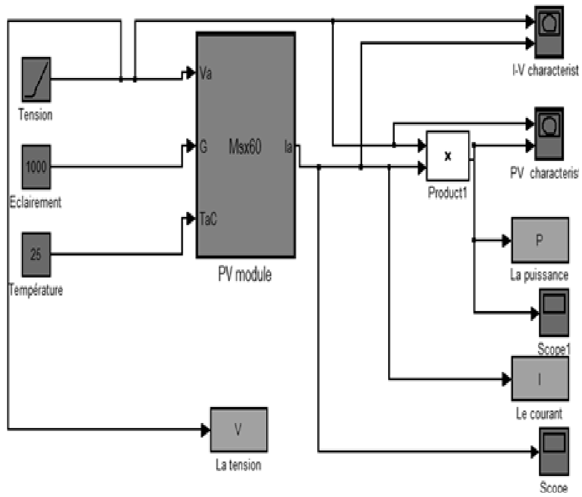
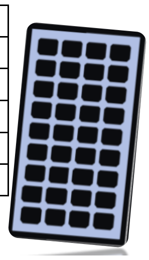


Fig.4: PV cell Matlab/SIMULINK model.

Table 3 Solarex MSX 60 PV Module specifications at 25 ° C [13].

Typical peak power (Pp)	60 W
Voltage at peak power (Vpp)	17.1 V
Current at peak power (Ipp)	3.5 A
Short-circuit current (ISC)	3.8 A
Open-circuit voltage (Voc)	21.1 V
Number of series cells	36



The shape of the current-voltage characteristics I(V) and frequency power P (V) obtained using the electric model equations presented in Figure (5) and figure (6).

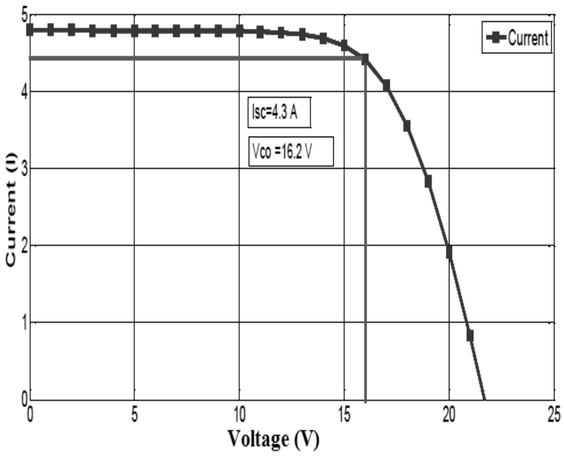


Fig.5: Current-voltage characteristics of the PV cell

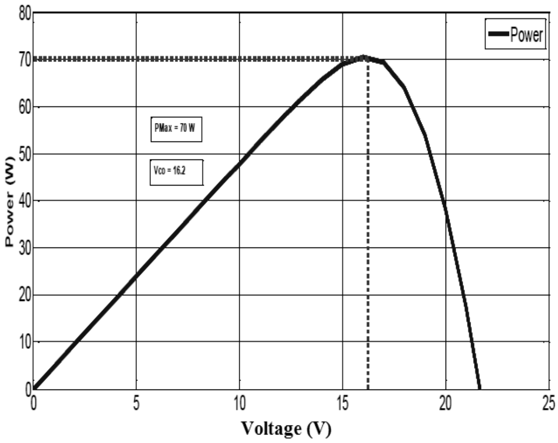


Fig.6: Power-voltage characteristics of the PV cell

5. Influence of the internal and external parameters of the characteristic (Ipv -Vp) of a photovoltaic cell

5.1. External parameters

5.1.1. Effect of radiation

The increase of the illumination with a temperature fixed causes an increase or generator operates as a current generator, but it is one of the increase in the voltage to égerment open circuit, the current is directly proportional to sunlight where the short-circuit current (Isc) is clearly sensitive to sunlight, For against the voltage is relatively un degraded. We deduce so that the cell can provide a voltage near that correct, even in low lighting.

Finally, when the sun raises, the intensity of short circuit increases, the curves characteristics shift to values growing, allowing the module to produce an largest electric power.

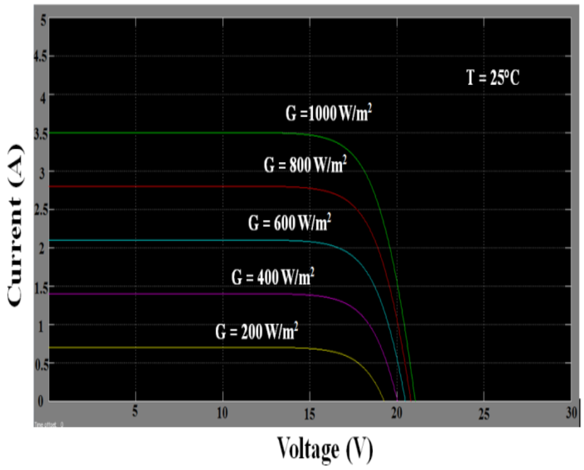


Fig.7: Current-voltage Characteristics for different irradiationat T = 25 ° C.

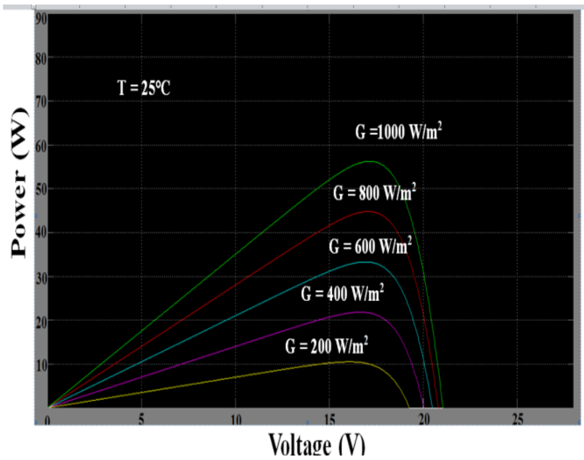


Fig.8: Power-voltage Characteristics for different irradiation at T = 25 ° C.

5.1.2. Influence of temperature

Temperature is an important parameter in the cell behavior. Increasing temperature with a fixed illumination causes net reduction of the open circuit voltage (Voc) and an increase in the short-circuit current (Isc), and a reduction of the maximum power (Pmax). The influence of temperature is reduced compared to the sun, but it is not negligible on the current / voltage characteristic of a generator. To a temperature which changes from 0 to 100 ° C, it can be seen that the variation of the voltage changes much more than the current. It varies very slightly. Unlike voltage, short-circuit current, meanwhile, increases with an increase in temperature.

This is due to better absorption of light, the optical gap with lowering the increase. However, this increase in intensity is very low; it can be neglected to the point of maximum power.

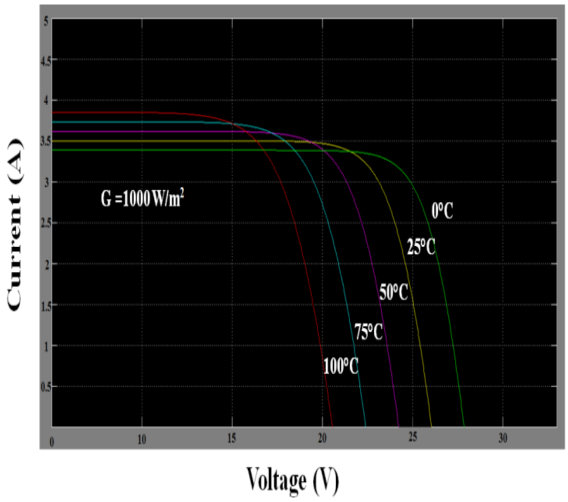


Fig.9: Current-voltage Characteristics for different temperature at G= 1000 W /m².

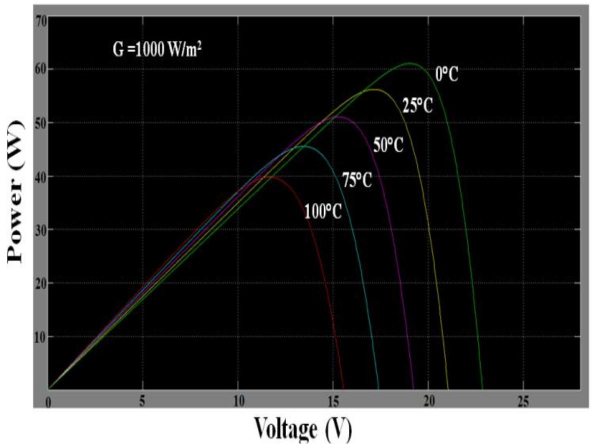


Fig.10: Power-voltage Characteristics for different temperature at G= 1000 W /m².

5.2. Internal parameters

5.2.1. Influence of series resistance

The series resistance is the slope of the characteristic in the area where the photodiode acts as a voltage generator, and when it is high, it decreases the short circuit current value (Icc).

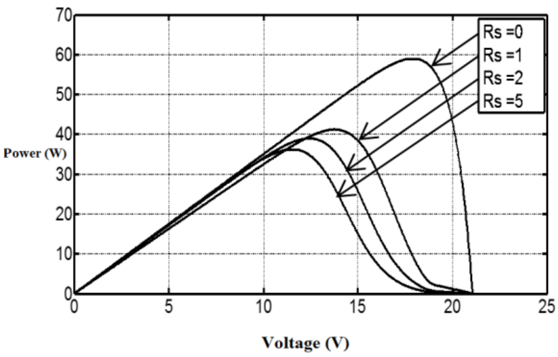


Fig.11 Influence of series resistance on P (V)

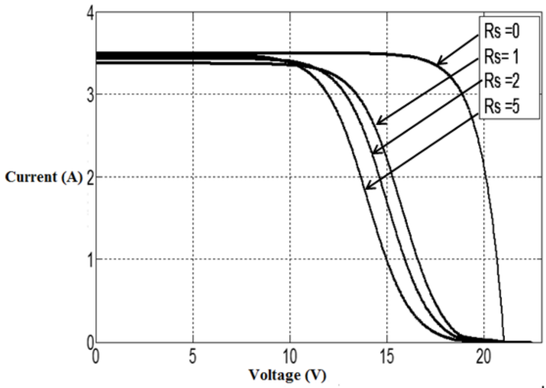


Fig.12: series resistance Influence on I (V)

5.2.2. Influence of the quality factor

The increase of the diode ideality factor inversely affects the area or point of maximum power and this is reflected by a decrease power level of the area of operation. [18]

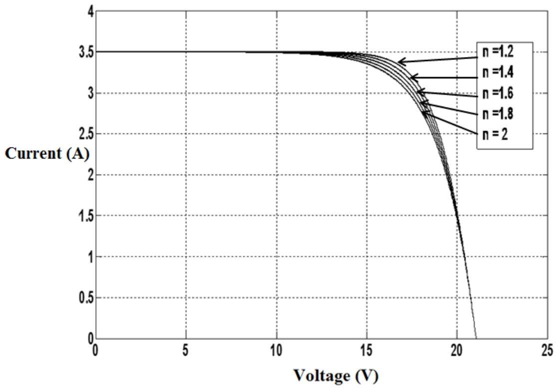


Fig.13: Quality factor influence on I (V)

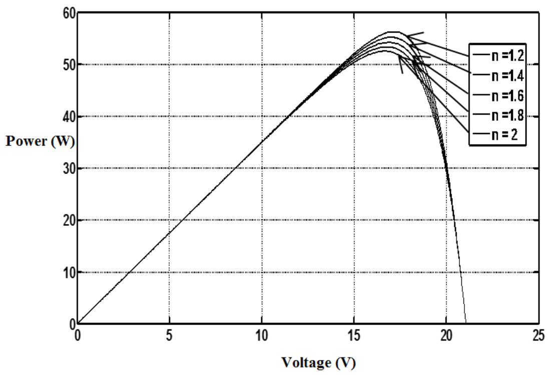


Fig.14: Quality factor influence on P (V)

5.2.3. Influence of saturation current Is

Figures (15 and 16) below illustrate the effect of saturation current Is on the characteristic I(V) and P(V) of the solar cell under illumination; It is found that increasing the saturation current (Is) for the diode causes a reduction of the open circuit voltage

(VCO) by against the short-circuit current (Isc) remains constant.

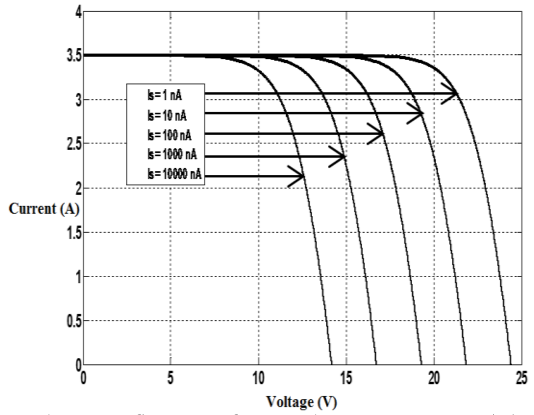


Fig.15: Influence of saturation current on I (V)

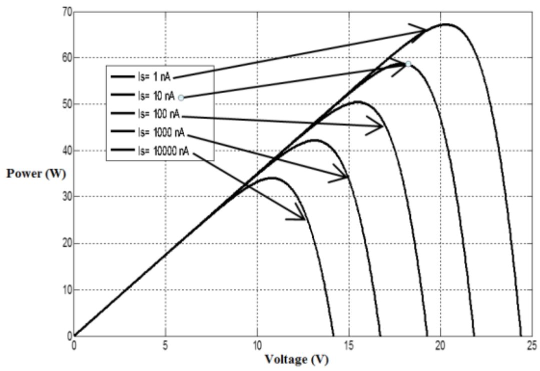


Fig.16: Influence of saturation current on P (V)

5.2.4. Influence of the shunt conductance (parallel)

Figures (17 and 18) below illustrate the effect of the resistance Rp parallel on the I(V) and P(V) characteristic of the cell under solar illumination. Note that the voltage open circuit (Vco) and the short-circuit current (Isc) does are not changed; but the characteristic deforms very quickly, this influence is reflected in increase in the slope of the I(V) characteristic of the cell in the area corresponding to an operation as a power source (low voltage).

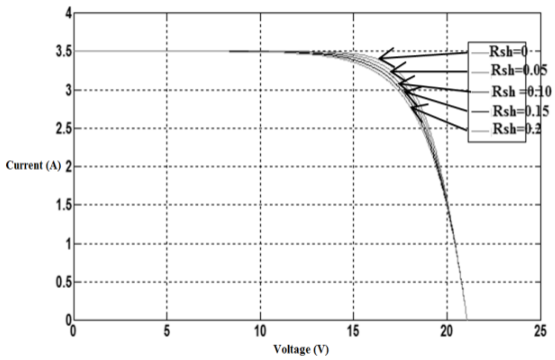


Fig.17 Influence of quality of the shunt resistance on I (V)

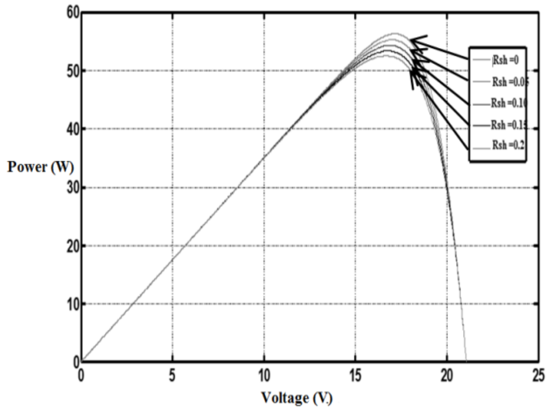


Fig.18 Influence of quality of the shunt resistance on P (V)

6. Conclusion

In this article, we presented the various simulations of the electrical characteristics of the model electrical equivalent of the photovoltaic cell, we can note that the power output of a solar panel does not depend only on the radiation and temperature of the exposure, but also parameters internal (series resistance, shunt resistance, idealityfactor, and the saturation current).

References

[1] Wikipedia, http://fr.wikipedia.org.

[2] j.a. ramos-hernanzet all, «two photovoltaic cell simulation models in matlab/Simulink»,International Journal on Technical and Physical Problems of Engineering,March 2012, pp:45-51.

[3] TarakSalmi et al « MATLAB/Simulink Based Modeling of Solar Photovoltaic Cell », international journal of renewable energy research,Vol.2, No.2, 2012.

[4] FilippoAttivissimo, «Uncertainty Analysis in Photovoltaic Cell Parameter Estimation» IEEE transactions on instrumentation and measurement, vol. 61, no. 5, may 2012.

[5] Samer Said, Ahmed Massoud«A Matlab/Simulink-Based Photovoltaic Array Model Employing SimPower Systems Toolbox», Journal of Energy and Power Engineering 6 (2012) 1965-1975.

[6] Makhloufisalim, «contribution à l'optimisation des installations photovoltaïques par des commandes intelligentes», thèse de doctorat, univ de Batna ,2013.

[7] Ali chermitti, Mohamed Bencherif, Hassane«Évaluation des paramètres d'un panneau solaire», 16èmes Journées Internationales de Thermique (JITH 2013) Marrakech (Maroc), du 13 au 15 Novembre, 2013.

[8] Fayrouzdkhichi, Benyounesoukarfi, « Utilisation des réseaux de neurones artificiels pour la détermination des paramètres électriques de la cellule photovoltaïque». 16èmes Journées Internationales de Thermique (JITH 2013) Marrakech (Maroc), du 13 au 15 Novembre, 2013.

[9] Hallali kamelia «Modélisation d'une cellule photovoltaïque : Etude comparative», thèse de magistère, univ de Tizi-Ouzou, 2012.

[10] Q.Caprasse, E.matagne«un modèle de cellule photovoltaïque à double exponentielle établi sur base des valeurs nominales», revue des sciences et de la technologie RST, Volume 1 N°1, 2009.

[11] Bendjellouli Zakaria, contribution à la modélisation d'une cellule solaire, thèse de magistère, univ de Béchar, 2008/2009.

[12] Abbassen Lyes, Etude de la connexion au réseau électrique d'une centrale photovoltaïque, thèse de magistère, univ Tizi-Ouzou, 2011.

[13] Salaheddinebensalem,«Effets de la température sur les paramètres caractéristiques des cellules solaires»,these de magistereuniv sétif,2011.