Effect of Temperature on the Solar Module Performances

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ABSTRACT

Photovoltaic system is established as a reliable and economical source of electricity in rural and Sahara areas, especially in developing countries where the population is dispersed, therefore requiring low energy consumption. Among solutions of producing decentralized electricity, the present renewable energies presents many advantages comparing to the classic sources (nuclear, oil, gas, etc). The solar energy is the most promising among other renewable energies and especially for developing countries where irradiance is very strong (Arabian countries). The results, which are illustrated by curves, are analyzed. The analysis of the performance concluded that this electrical parameters decrease with the temperature. A decrease of the output power (4 w/°K), of the open voltage (0.2 V/°C) and of the conversion efficiency (0.59 x10^{-3} % /°K) of the PV module with the temperature increase has been observed. The current increases approximately linearly with the temperature with 1.2 mA /°C.

KEYWORDS: Thermal effect, photovoltaic module, performance.

INTRODUCTION

The worldwide consumption represents 0.02 % of the theoretical solar flux intercepted by the earth that is about 3x 10^{17} kWh per year. For instance the average solar irradiance in Algeria is approximately 6 kWh/day/m².

The photovoltaic systems have been the subject of many studies and have known a fast development in the world; the worldwide production is greater than 1000 Mw/year (Saulnier, 1981), (Kazmerski, 1997).

The solar energy is renewable and the most promising source of energy. It is perfectly useful for the decentralized applications of low energy consumption, in particular in the freestanding and arid regions. The high photovoltaic solar system cost especially the price of the photovoltaic generator which is about 80% of the total cost of the whole system, incites us to optimize it's working capacity and to maximize the power transferred to the load, and finally to study the different external factor effects in order to minimize their effect on the performances of the generator (El-Hadi Bouguerra, 1997).

The photovoltaic energy production is not a steady energy. It depends on the local weather. The temperature is an important parameter, which is often neglected when the solar cells behavior is investigated.

The electrical performances of a silicon solar module are sensitive to temperature. In the present work the main electrical characteristics of the solar modules made of single crystalline are investigated by taking into account the temperature changes (Garg and Agarwal,1995), (Hausler and Rogass, 2000).

DESCRIPTION OF THE SYSTEM

The experimental device is composed of, (Figure 1):

- A solar module (0.147 cm^2) made of single crystalline silicon BPT010.
- A special fluid heater flowing below the cell.
- A stationary illumination source (sun simulator).
- An I(V) characteristic measurement.
- A pyranometer to measure the illumination flux and a thermocouple to measure the temperature.
- A data output tape.

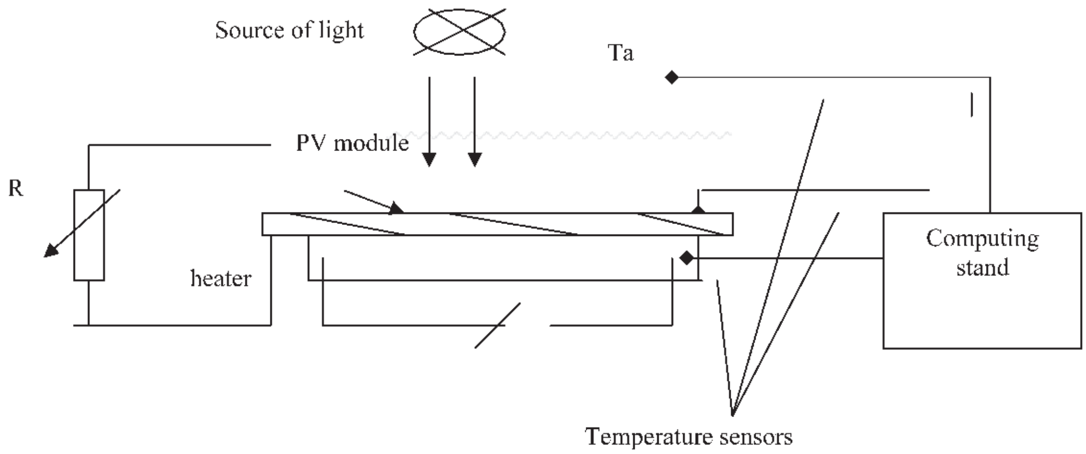

Figure 1. The Experimental stand

EXPERIMENT DESCRIPTION

A set of measurement has been done at the CIEMAT Laboratory (Spain) during several days and for different values of the temperature. In order to be able to study the performance of the solar cell, different temperatures ranging from 10° to 65 °CS (range of normal temperature on the site) have been used. To avoid the influence of temperature change, several hours are needed between two successive measurements.

The fluid that flows under the cell is heated each time to a stationary temperature to insure a homogeneous distribution of the temperature under and near the cell. Then the electrical characteristic of the cell I-V as well as the temperature and the illumination flux are measured (Radziemska et al., 1999).

In order to get good measurements, two thermocouples have been placed on the module and outside it .The global illumination is measured using a pyranometer. The whole measuring equipment is connected to a 20-canal tape recorder (Fluke) (Lorenzo, 1994).

RESULTS AND DISCUSSION

The temperature influences the I-V characteristic of the solar module (Figure 2), and provokes the displacement of the I-V curve, as well as the Optimal point MPT (Im, Vm) (Van Dyk et al, 2000).

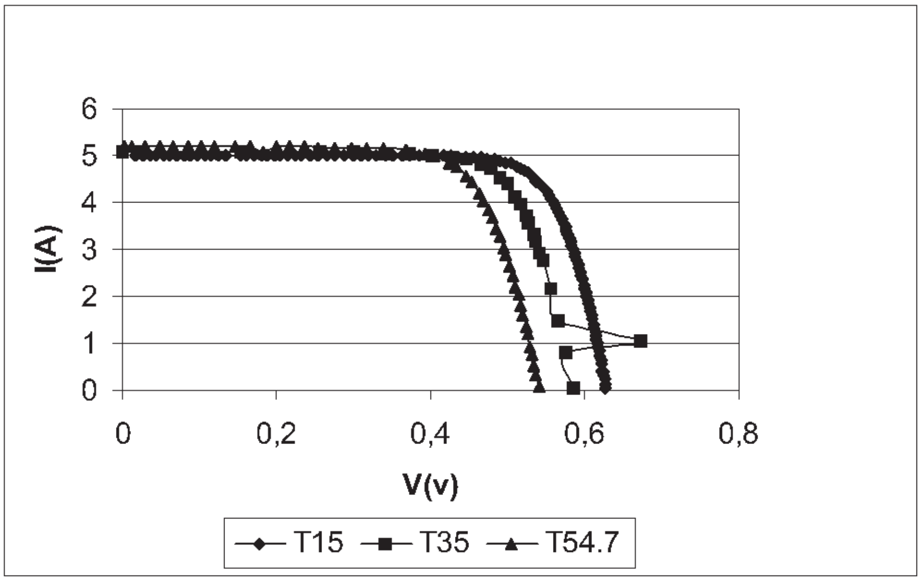

Figure 2. Characteristic I (V) for different temperatures

For low temperature applications, the current and voltage generated by the Photo voltaic cell is supposed linear. The electrical characteristic of the cell is measured for different temperature values. From these measurements, the performance (the efficiency and the maximum power (Im.Vm)) of the module can be determined (see Figures 3, 4).

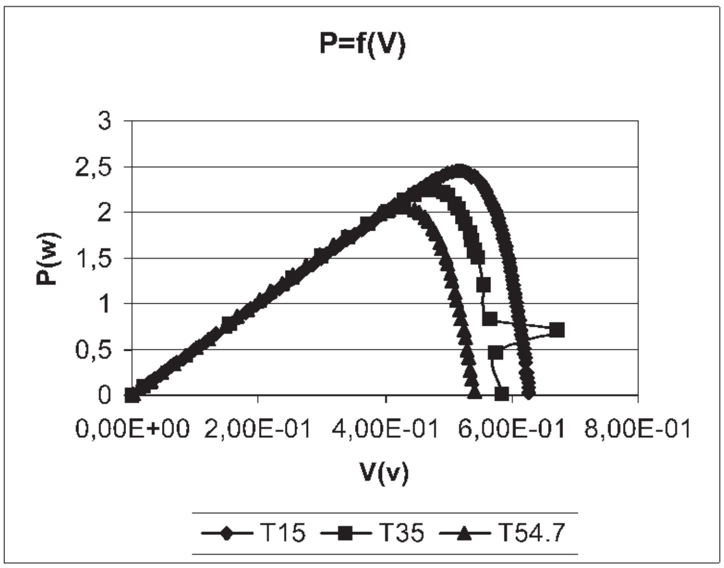

Figure 3. Maximum power versus voltage

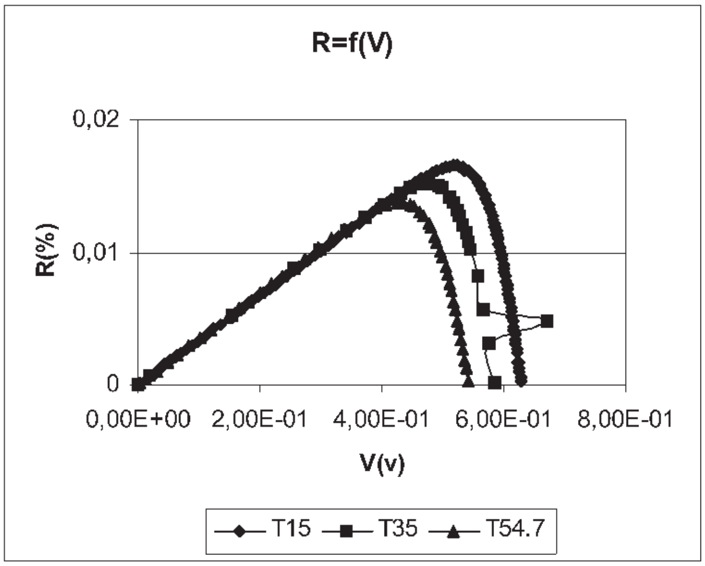

Figure 4. Efficiency versus voltage

The electrical performance evolution of the cell BPT010 is illustrated in the Figures 2, 3, and 4.

Figure 5 shows the short circuit current versus temperature; this current increases approximately linearly with the temperature with a slope of 15%, which lead to a decrease of 1.2 mA /°C in current. The temperature effect is to activate the free electrons in the cell which make the electron density increase on the grills giving therefore an increase in the short circuit current Isc.

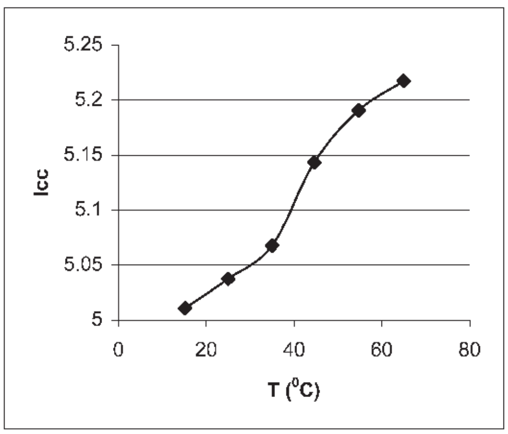

Figure 5. Short circuit current versus temperature

On the other hand, the other electrical cell parameters (Vco, Pm, Efficiency) decrease with temperature, leading to a power decrease of 3% therefore a reduction of 4 w/°cs (Figure 7). The power variation can be deducted using a linear approximation as follows: Pm = -0.01.T + 2.5992.

The open circuit voltage (Figure 6) decreases linearly with a 7% slope, therefore making the variation of about 0.2 V/°C .This decrease is due to a degradation of the electrical properties of the silicon with the temperature.

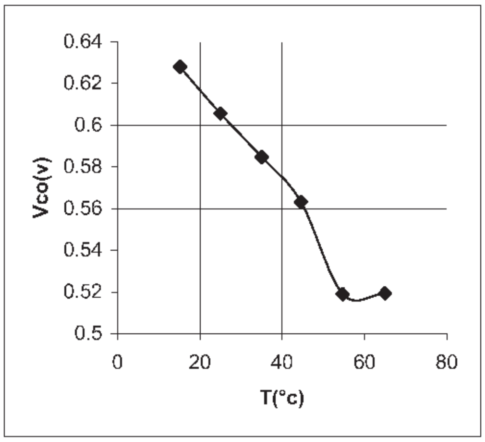

Figure 6. Open circuit voltage versus temperature

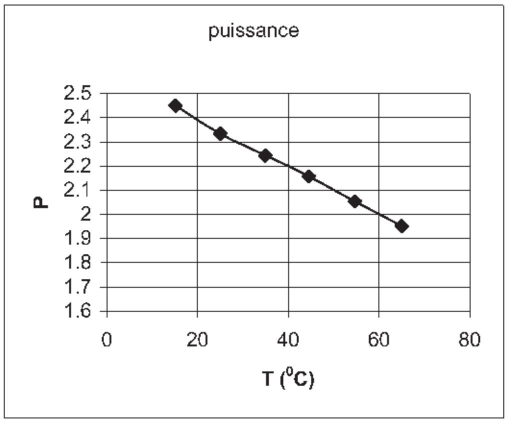

Figure 7. Maximum power versus temperature

The efficiency decreases with the temperature with a rate of 0.8 x10-^{7}%, this means a decrease of 0.59 x10^{-3} % /°c. This variation is calculated using the following linear variation (Figure 8):

η=-7 10-5.T+0.0176

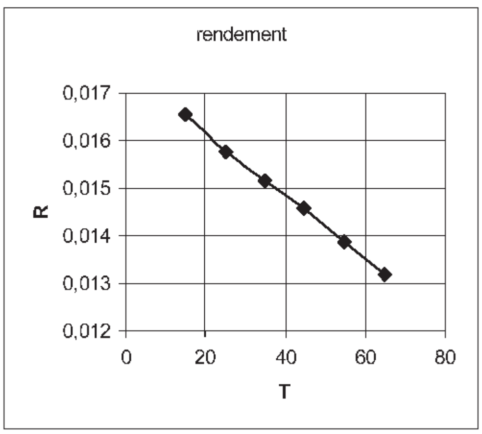

Figure 8. Efficiency versus temperature

CONCLUSION

In this study, the Photovoltaic solar cell performance was investigated. It was found that the effect of the working temperature of the cell is very significant regarding the power provided by the solar cell. The present results show that the Photovoltaic performances decrease with the temperature variations. The degradation is very important when the temperatures exceed 50°C. The variation of the power and efficiency are found to be linear functions of the temperature. The short circuit current varies slowly with the temperature. In hot regions (like the Sahara), it is essential to consider and take into account the thermal effect on the working and sizing of the systems.

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تأثير الحرارة في أداء المولد الكهروضوئي

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ملخص

لقد أثبتت المحطة الكهروضوئية أنها ذات كفاءة عالية واقتصادية لتوليد الكهرباء في المناطق الريفية والصحراوية، خاصة في البلدان النامية حيث الكثافة السكانية ضعيفة واستهلاك الطاقة قليل. ومن بين التقنيات المستخدمة للتوليد اللامركزي للكهرباء، فإن هذه الطاقة المتجددة لها عدة مزايا بالمقارنة مع الطاقات التقليدية (نفط، غاز، فحم، الخ). ومن بين الطاقات المتجددة، فإن الطاقة الشمسية لها مستقبل واعد خاصة في الدول العربية النامية ذات الإشعاع الشمسي المرتفع. ويمثل الاستهلاك العالمي للطاقة 0.02 % من القيمة النظرية للإشعاع الشمسي الذي يصل إلى الأرض والمقدر 3.107 كيلوواط. المعدل الحالي للإشعاع الشمسي المتوسط على الجزائر هو حوالي 2.6 كيلوواط.سا/يوم.

في هذه الورقة العلمية تم دراسة تأثير الحرارة في خواص وأداء المولد الشمسي الكهروضوئي.

تبين النتائج المحصل عليها بان اداء المولد الكهروضوئي يتاثر سلبيا بارتفاع دراجة الحرارة، حيث تنخفض المعاملات الكهربائية مع الارتفاع في دراجة الحرارة: الطاقة بـ 4 واط/° م ، كمون الدرة المفتوحة بـ 0.2 فولط/ °م و المردود بـ 0.59. 10^{-3} % /°م، بينما يرتفع تيارالدرة المغلقة خطيا بـ 1.2 ميلي آ/ °م.