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Modeling Of an amorphous Photovoltaic Module outdoor tested in the north of Algeria region

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***Abstract*— the accuracy of a two-diode model for amorphous photovoltaic module is investigated in this work. I–V and P–V characteristics were simulated using the specifications given by the module's manufacturer at standard test conditions using an accurate technique for calculating all important points. To validate the model a comparison between the simulation results and the experimental data of the PV module tested outdoor has been carried out. A good agreement between the model and the experimental results, for both I–V and P–V curves was observed, under different environmental operating conditions regarding changes in temperature and irradiation during two different days.**

Keywords- *Photovoltaic; Amorphous module; modeling; outdoor;*

I. INTRODUCTION

This paper presents the results of a simulation and characterization modelling method to estimate the electrical performances of photovoltaic (PV) module. For the case treated, a two-diode model is used to get the electrical parameters of an amorphous PV module and see how the I–V characteristic varies by taking into account the influence of the environmental parameters such as temperature and irradiance. Several authors have studied PV module modeling using different methods [01–06].

This work is a part of a project whose objective is to model PV panels made by different technologies, in order to get their performances in diverse environmental conditions and then be able to predict their energy production for any given site. The model has been validated with outdoor experimental data of silicon amorphous module, using a simple iterative technique, as explained in [07] where the case of micromorphous module was investigated. The electrical characteristics; current-voltage I–V and power-voltage P–V of the module have been carried out in outdoor conditions of UDES's site (Development Unit of Solar Equipment). The validation of the model was done by evaluating the precision of the model by comparing the simulation results with the experimental measurements in two different days, a sunny and cloudy day.

II. EXPERIMENTAL SET UP AND SAMPLE

For the aim of testing outdoor different type of PV modules, a PV characterization outdoor bench was set up at UDES's site at Bou-Ismail region situated in the north west of Algeria, as shown in Figure 01. It is composed of two parts: The first part is a test platform on which are installed the PV modules to be tested, the reference PV cell and the temperature sensors. The second part is composed of an electronic load and a computer for the acquisition and the treatment of the data. The measured data are the current, the voltage, the temperature and the irradiance. The measurement uncertainty on the voltage the current is about +/- 0.5V and +/- 0.01A respectively, for the irradiance it is lower than 10W/m² and for the temperature it is about +/- 0.5°C.

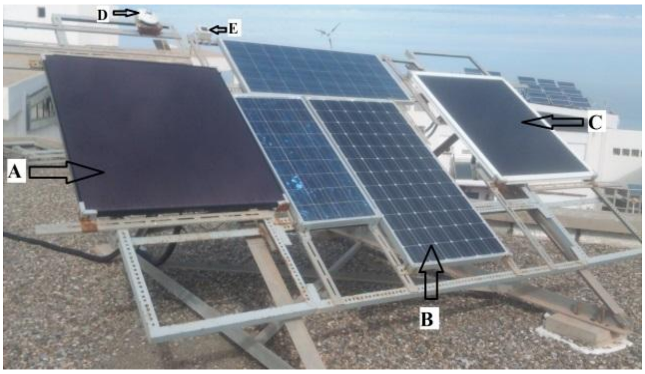

Figure 1. Outdoor test bench for PV modules characterization; A: Amorphous, B: Monocrystalline, C: Thin film, D: Pyranometer and E: Reference solar cell.

The amorphous module sample used is a "SCHOTT ASI 100" type, composed by 72 (3x24) amorphous silicon a-Si/a-Si tandem solar cells [08]. The module specifications under STC conditions (1000W/m^2 irradiation, 25℃ ambient temperature and AM1.5 air density) are given in Table 1 [08].

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TABLE I. "SCHOTT ASI 100" AMORPHOUS MODULE DATASHEET

Specifications	Value
Maximum power (Pm)	100W
Open-Circuit Voltage (Voc)	40,9V
Short-Circuit Current (Isc)	3,85A
Maximum power current (Vmpp)	30,7V
Maximum power voltage (Impp)	3,25A
Number of cells	72
Open-Circuit Voltage temperature coefficient (kv)	-0,33% / K
Short-Circuit Current temperature coefficient (ki)	0,08% / K

III. TWO DIODE MODEL SOLAR CELL

The two-diode equivalent circuit of a solar cell used in this paper is shown in Figure 02. The solar cell output current I is defined by the following equation [09]:

$$I= I_{ph}–I_{rs1} [\exp ((V+I_{Rs})/n_1V_{t1})–1]–I_{rs2} [\exp ((V+I_{Rs})/n_2Vt_2)–1]–(V+I_{Rs})/R_{sh} \quad (1)$$

Where I_{ph} is the photocurrent, I_{rs1} and I_{rs2} are the diode reverse saturation current of diode1 and diode2, respectively, where the I_{rs2} presents the recombination loss in the depletion region [09].V_{t1} and V_{t2} are the thermal voltages of the respective diodes d_1 and d_2. n_1 and n_2 are the diode ideality factors. R_s is the series resistance and R_{sh} is the shunt resistance. In this work the values of n_1 and n_2 are respectively 1 and 1.2 as suggested by [10].

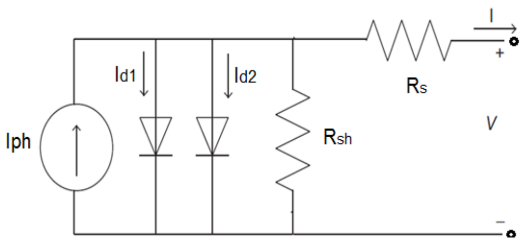


Figure 2. Two-diode model cell equivalent circuit

IV. RESULTS AND DISCUSSION

We have investigated the accuracy of the model of the amorphous PV module in the real conditions. Two different days were selected as presented in Figure 03 and 04 respectively. The experimental data were taken from 9am to 3pm, with a step of 2 minutes between every measurement. We have then conducted comparisons between the outdoor PV module test measurements and the simulated results, where six different conditions were selected for two different days; a sunny and a cloudy day. The I-V and P-V curves, obtained are presented in Figures 05 and 06.

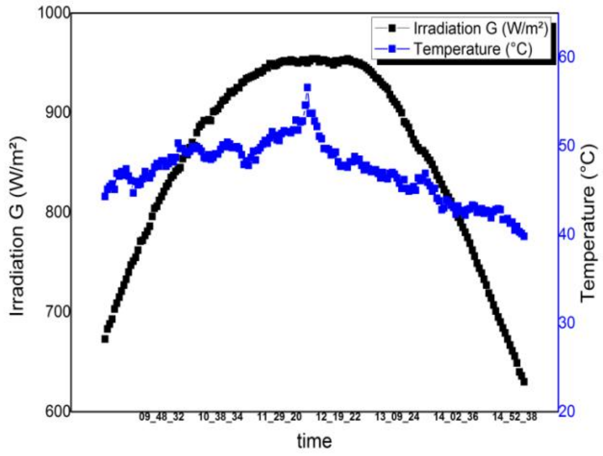


Figure 3. Irradiation and temperature during the sunny day.

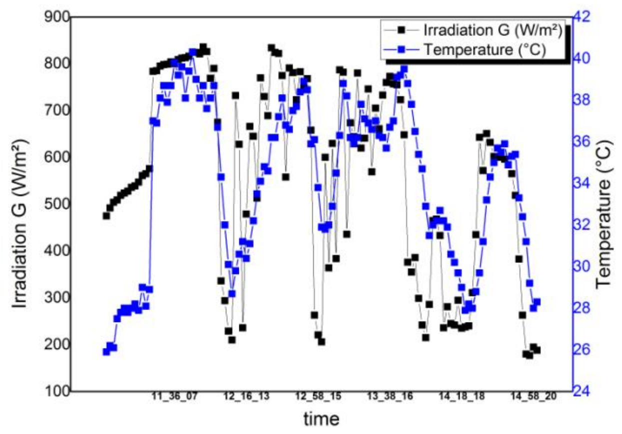
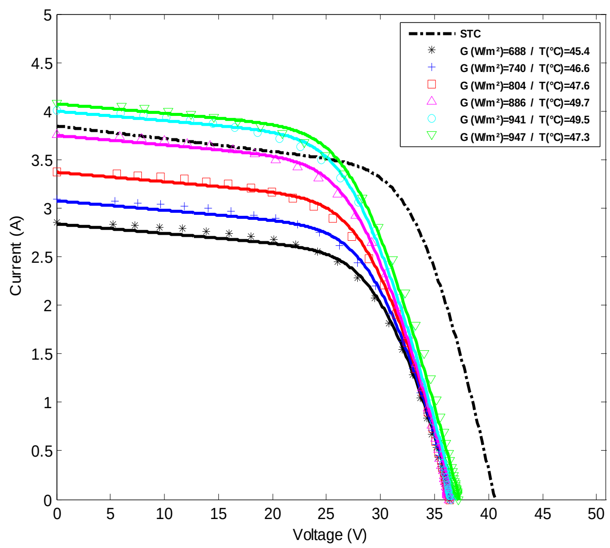


Figure 4. Irradiation and temperature during the cloudy day.



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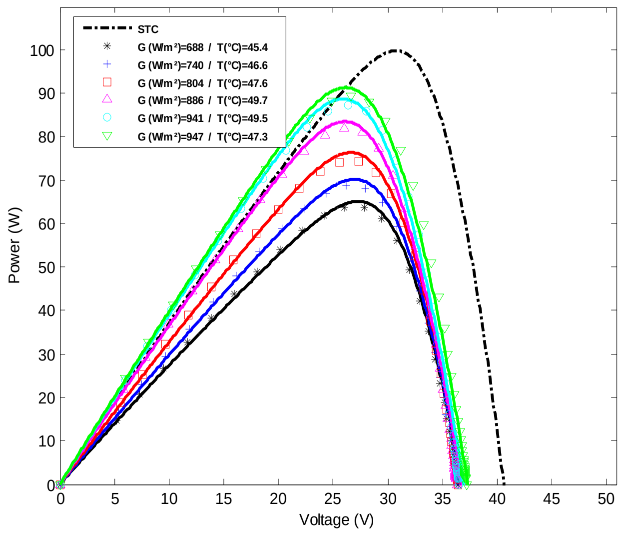
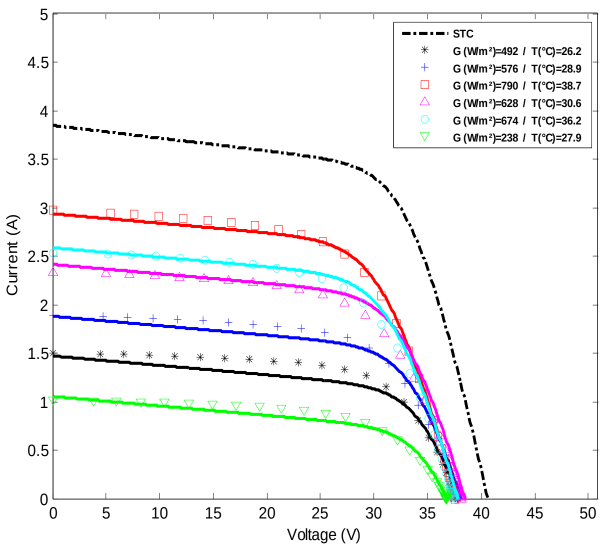
(a)



(b)

Figure 5. I-V (a) and P-V (b) measured (scattered points) and simulated (solid line) for the sunny day.



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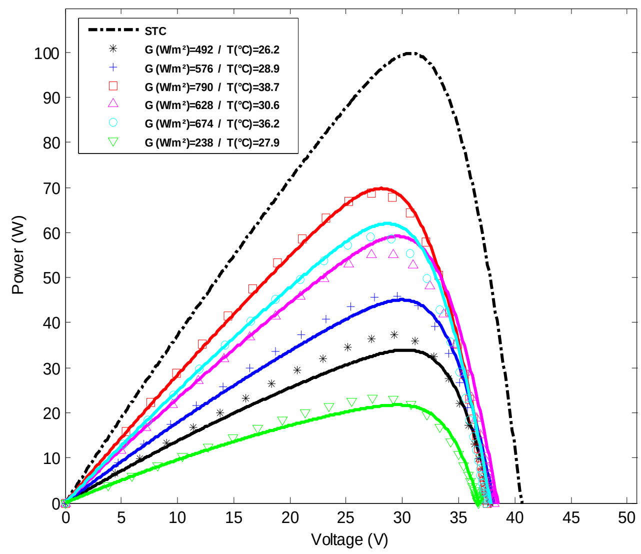

(b)

Figure 6. I-V (a) and P-V (b) measured (scattered points) and simulated (solid line) for the cloudy day.

TABLE II. EXPERIMENTAL AND SIMULATED PARAMETERS FOR THE AMORPHOUS MODULE IN THE SUNNY DAY (A) AND THE CLOUDY DAY (B).

	G (W/m²)	*T (°C)*	*Isc,m (A)*	*Isc,e (A)*	*Voc,m (V)*	*Voc,e (V)*	*Pmpp,m (W)*	*Pmpp,e (W)*
(a)	688	45,4	2,84	2,86	36,7	36,43	65,09	64,92
	740	46,6	3,08	3,09	36,7	36,39	70,17	69,73
	804	47,6	3,37	3,38	36,8	36,4	76,31	75,65
	886	49,7	3,75	3,77	36,8	36,3	83,46	83,02
	941	49,5	4	4,01	36,9	36,49	88,66	87,26
	947	47,3	4,08	4,08	37,3	37,2	91,29	90,43
(b)	492	26,2	1,47	1,5	37,9	37,84	33,96	37,22
	576	28,9	1,88	1,89	38,1	37,93	45,08	45,99
	790	38,7	2,94	2,97	37,7	37,56	69,8	68,7
	628	30,6	2,42	2,34	38,4	38,17	59,18	55,34
	674	36,2	2,59	2,54	37,8	37,42	61,98	59,22
	238	27,9	1,05	1,01	36,8	36,79	21,75	23,13

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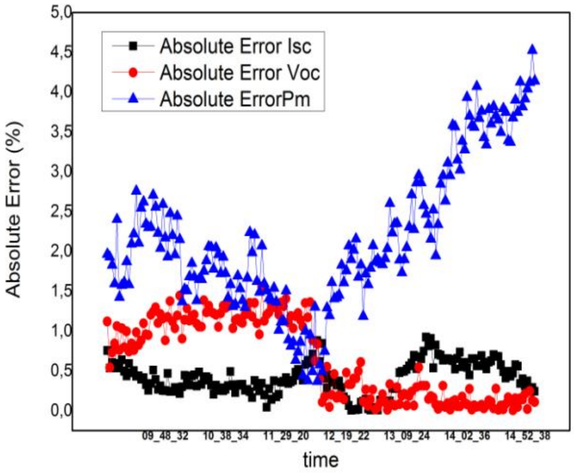


Figure 7. Absolute error of Isc, Voc and Pm during the sunny day..

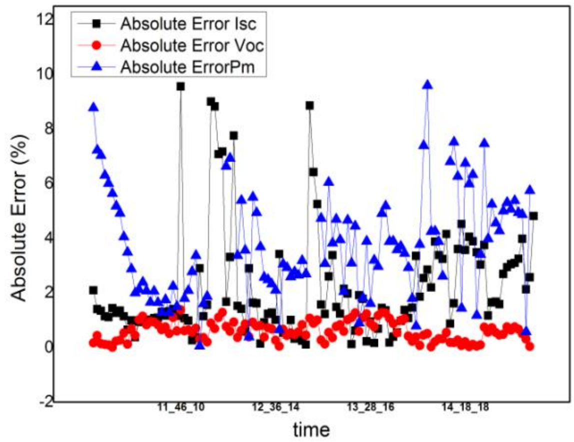
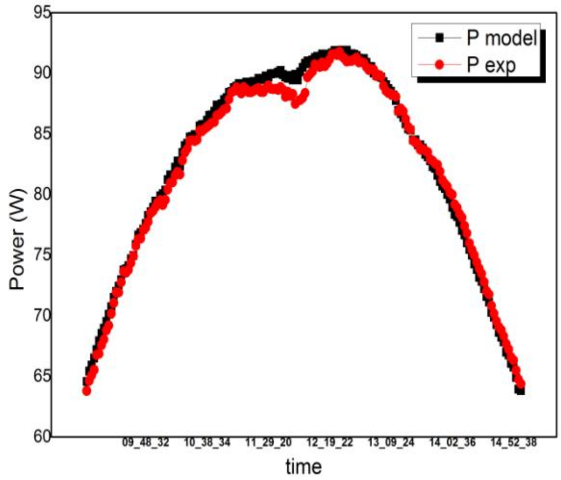
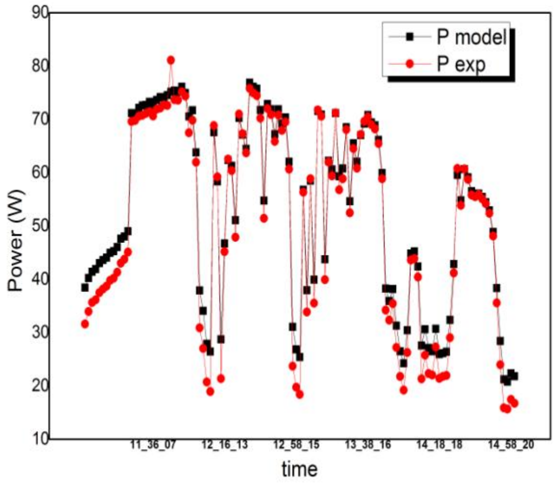


Figure 8. Absolute error of Isc, Voc and Pm during the cloudy day.



(a)



(b)

Figure 9. The experiemntal versus the model power. (a) sunny day, (b) cloudy day.

As shown on the figure 5 and 6 and table 2 a good agreement is found between the calculated and measured results, both in the I-V and the P-V curves and for the main points. The absolute error of I_{sc} is very small around 0.5%, the absolute error of V_{oc} is 1% in the morning and 0.3% in the afternoon approximatively and the absolute error of P_m is between 2 and 4% as presented in Figure 07 for the sunny day and reach 9% for the cloudy day as showed in Figure 08. Figure 09-a, shows a good agreement between the model and the experimental results of the power generated by the PV module during the sunny day, while Figure 09-b, shows that at low power the model still far from the experimental results. These results validate the accuracy of the simulation model used in this work, especially at high irradiation. In future researches, we propose the development of this model in order to minimize more the errors, by taking into account other correlation parameters, such as; the effect of partial shading or total cells of the photovoltaic module, the error measurement of the temperature modules caused by the thermocouples and modeling the R_s and R_{sh} by using the collected data of our PV platform.

V. CONCLUSION

In this paper, we have presented an accurate two diode model for PV module for an amorphous PV module; a comparison between the model results and the experimental ones was presented. This study was carried out in outdoor condition at UDES's site, in a two different days, regarding changes in solar irradiance and temperature. The comparison between the experimental and the simulated results for both the I–V and P–V curves shows that good model accuracy is reached during the sunny day. For the cloudy day, the model shows its limit at low value of power, so it is more suited for

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irradiance higher than 400 W/m² for the amorphous PV modules technology.

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