Journal of Fundamental and Applied Sciences

ISSN 1112-9867

Available online at http://www.jfas.info

Research Article

EFFECT OF THE PHOTOVOLTAIC MODULE TYPE ON THE PERFORMANCE OF AN ARDUINO (I-V) ACQUISITION DEVICE

M. A. Ouaridhene[1*], A. Benmoussat[1], K. Bouchouicha[2], B. Lasker[3], M. Benatallah[3]

[1]Sciences and Environment Laboratory, Institution of Sciences and Technology, Department of Science, University Center of Tamanrasset, B.O Box 11000 Tamanrasset, Algeria

[2]Unité de Recherche en Energies Renouvelables en Milieu Saharien (URERMS), Centre de Développement des Energies Renouvelables (CDER), 01000 Adrar, Algeria

[3]Institution of Sciences and Technology, Department of Science, University Center of Tamanrasset, B.O Box 11000 Algeria

Received: 29 September 2019 / Accepted: 31 December 2020 / Published online: 01 January 2020

ABSTRACT

The demand increase for the energy and the world's challenge to decrease the consummation of fossil fuels has oriented many research works toward the development and investigation in the renewable energy sources (RES) like solar energy. In fact, an adequate parametrisation of the performance of photovoltaic (PV) modules starts by their characterisation. In this study we focus on measuring the current-voltage (I-V) and power-voltage (P-V) curves for two types of PV modules – Monocrystalline and Amorphous that were tested under different temperature. A developed low-cost acquisition device based on Arduino board is used to monitor and trace those data. The performance and the quality of this later is analysed in term of solar panel characteristics and show that the developed acquisition device is especially suitable for amorphous (PV) modules.

Keywords: photovoltaic module; Monocrystalline; Amorphous; Arduino.

Author Correspondence, e-mail: ouaridhene.med@cu-tamanrasset.dz

doi: http://dx.doi.org/10.4314/jfas.v12i1.30

Journal of Fundamental and Applied Sciences is licensed under a Creative Commons Attribution-NonCommercial 4.0 International License. Libraries Resource Directory. We are listed under Research Associations category.

1. INTRODUCTION

The huge expansion of the photovoltaic PV system plants all over the continents signifies their importance as one of the most popular renewable energy sources [1]. The PV plant is based on assumption that PV array [2] will operate in a maximum power point region. Evaluation of performance parameters of PV modules is assumed to be important, and the most important parameter of PV module is the I-V characteristic curve, which provides important information about PV modules performance. The measurement of the IV-PV characteristic of photovoltaic arrays is the greatest interest among PV installers, operators, users and researchers. It allows for accurate determination of the behavior electric of the PV device within real conditions and enables validation of performance and comparison with either previous data or expected data. Many programmable loads can be found on the market that can be used as IV- tracers [1] for PV devices in laboratories [3].

1.1. Rational

This paper presents the design and development of a low cost and portable current-voltage (I-V) PV modules measurement devise that is able to extract the PV module characteristics parameters within real operate conditions of irradiance [4] and temperature, by the collection the I-V data [5]. The recorded data can be retrieved and used later in the performance comparisons. Two types of available modules: Amorphous and Monocrystalline silicon PV Modules were the samples investigated test with the developed I-V tracer. Measurement of the global solar irradiance at the same angle of the PV module is realized with pyranometer and the data collection has been carried out using acquisition data based on Arduino board.

1.2. Procedure

The Arduino MEGA board based on the ATmega2560 Microcontroller is composed of current, voltage and temperature sensors. The board provides a group of digital and analogue Input/output pins which can interface to multiple expansion boards and other circuits (Figure. 1). With the Python Graphical user interfaces software, a special program was developed in order to control the data-collecting, monitoring and visualizing process of PV module I-V Tracer. The PV conversion has been estimated according to the model of four parameters:

Photonic current I_{Ph} (A), Quality factor (γ), Resistance series RS (Ω) and reverses saturation current (I_0).

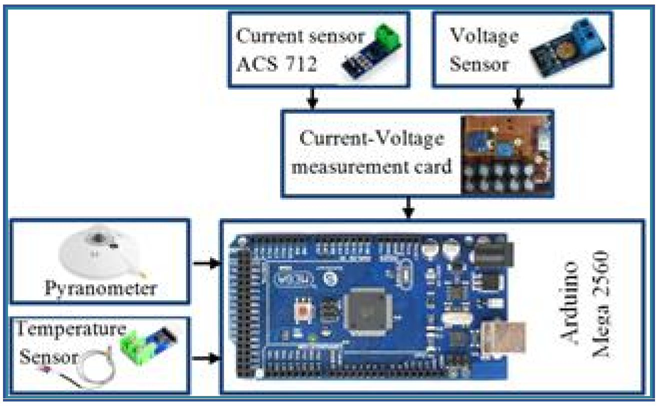

Fig.1. Schematic diagram of the PV panel instrumentation system

PV panels are intended to recover the energy of solar radiation to transform it into continuous electrical energy, the features at standard test conditions (STC) of the used PV panel are summarized in the following Table 1.

Table 1. Technical specification of the considered PV modules

PV Module	**Amorphous Solarex MSX60**	**Monocrystalline Koncar 12W**
Maximum Power Pmax (W)	60	12
Short-circuit current Isc (A)	3.8	0.99
Open-circuit voltage Voc (V)	21.1	22.5
Current of Maximum power IPMax (A)	3.5	0.827
Voltage of maximum power UPMax (V)	17.1	14.5
Module dimension	1295x325	310x920

1.3. .Principe of Current-Voltage (I-V) measurement

The IV-PV tracer use as a basis the capacitive load and electrical sensors connected with Arduino board. The load capacitor [1] is the most usual method by commercial equipment for the IV-PV curve measuring devices. An implemented electronic circuit is used in order to make the process of charge and discharge of the load capacitor and to measure the output voltage-current, output current and operating temperature, this, by using suitable sensors. The extracted data are stored in the computer memory.

The basic electronic circuit of the Current-Voltage measurement is shown in Figure 2. Under normal operation the relay is open and the capacitor is discharged, once the relay is closed by signal coming from digital pin D9 the PV array is connected to the capacitor load thus charging from 0 to V_{OC}. Current and voltage are taked during the charging process, which correspond to the I-V characteristics of the PV module. After that, the relay will be close, and the load capacitor discharged into a resistor for the trace of the next measurement [2].

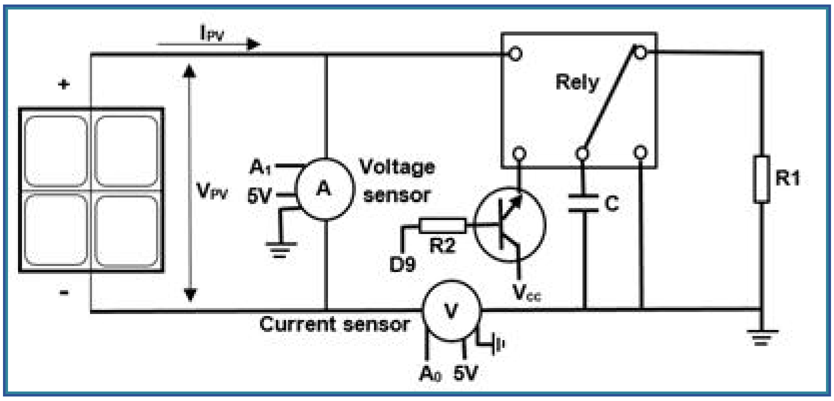

Fig.2. Descriptive of the electronic circuit of the photovoltaic module

The equation 1 describes the dependence of the capacitor charging time t_c on its capacitance C, and the instantaneous values of short-circuit current I_{SC} and V_{OC}

$$t_c = \frac{V_{OC}}{I_{SC}}.C \qquad Eq(1)$$

The Current-Voltage measurement card is mounted in based on the previous electronic circuit, and this kind of card is adapted and integrated in Arduino board. Through Python programing tool, the internal code was developed in order to control the data-collecting, monitoring and visualizing process of PV module I-V Tracer. [6]

1.4. Solar cell modeling

An illuminated solar cell can be modelled by an electrical circuit composed of a single diode, a generator of photonic current I_{Ph}, a series resistance R_s and shunt resistance R_{SH} [6]. The output voltage (V) is linking with the terminal current (I) by the equation delivered by a solar cell

$$I = I_{Ph} - I_0\left(\exp\left(\frac{V + R_S I}{nV_{th}}\right) - 1\right) - \frac{V + R_S I}{R_{SH}} \qquad Eq(2)$$

Where I_0 is the diode reverse saturation current, n is the ideality factor and V_{th} is the thermal voltage given as follow: $V_{th} = k_B T/e$ Where e is the electron charge, k_B the Boltzmann constant and T the operating temperature.

1.5. Solar module modeling

PV module contains (m_p) parallel branches composed of (m_s) cells connected in series and can be modeling using a single diode model. The output current (I_M) of the PV module is written as a function of output voltage (V_M) as

$$I_M = I_{phM} - I_{0M}\left(\exp\left(\frac{V_M + R_{SM}I_M}{n_M V_{th}}\right) - 1\right) - \frac{V_M + R_{SM}I_M}{R_{SHM}} \qquad Eq(3)$$

The physical parameters of the PV module are

$R_{SM} = (m_s/m_p)R_S$; $n_M = n \cdot m_s$; $R_{SHM} = (m_s/m_p)R_{SH}$; $I_{0M} = m_p I_0$; $I_{phM} = m_p I_{ph}$

2. RESULTS AND DISCUSSION

Data values and validation

During the acquisition procedure, the measured data of global solar radiation and the current-voltage are plotted. the variation of selected parameters were measured in the time range (from 10:00 AM to 04:20 PM). From figure 3 we can see that the global solar radiation plot take a gaussian form whit a correlation with temperature in the range from 36-43°C. A fall in the irradiance is observed beyond this range of temperature. This can be explained by the fact that the accuracy of the current voltage sensor and the used resistance are very sensitive to the temperature elevation.

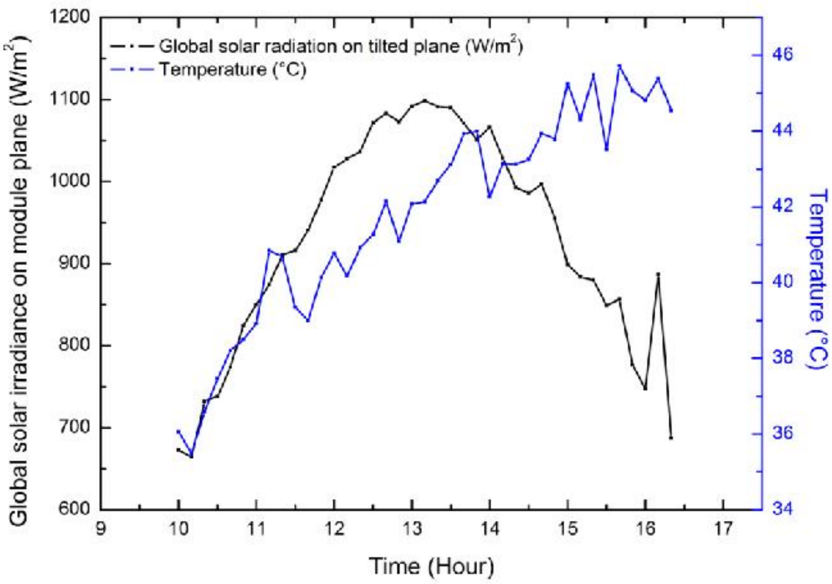

Fig.3. Correlation between the global solar radiation and temperature

The representation of the current as function of the voltage will result in the characteristic of PV module. As illustrated in figure 4 the I-V curves series registered for the Amorphous and monocrystalline PV modules for different temperature and irradiance are nonlinear. The shapes of the two curves series depend on the working condition, the solar irradiation and the ambient temperature. We can see that that for the same range of temperature and irradiance, the operating points for both PV panel are very different. For example the amorphous curves (Fig 4 panel (a)) have the same and homogeny behaviour under different conditions of temperature and irradiance, but have short-circuit current (Ics) values smaller than those registered for the monocrystalline PV panel. This is a logic consequence of the nature pf the PV panel. The monocrystalline curves registered for the temperatures and irradiance (T = 37,1°C, 844Wm^2 : blue curve), (T=38,9°C, 989 W/m^2 : red curve) and (T=40.8°C, 1090 W/m^2 : cyan curve) (Fig 4 panel (b)) have a same open circuit voltage (Voc) which is equal respectively to 19,18 (V), 18,98 (V) and 18,97 (V). However for the curve registered for the temperature and irradiance (T=34.1°C, 664 W/m^2: black curve) the Voc is equal to 20,14 (V).

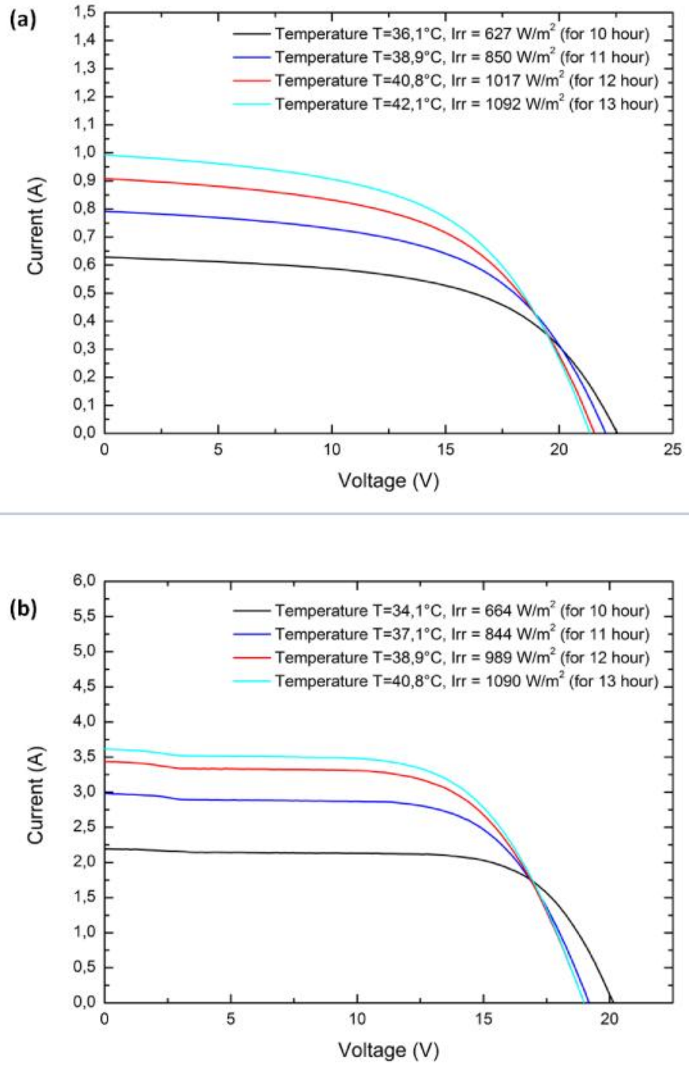

Fig.4. Experimental I-V characteristics of the amorphous (panel (a)) and monocrystalline (panel (b) PV modules taken at neighbouring values of temperature and irradiance

The short-circuit current (Ics) values for the curves (T=38,9°C, 989 W/m^2) : red curve) and (T=40.8°C, 1090 W/m^2 : cyan curve) are very similar and respectively equal to 3,462 (A) and 3,637(A). We can say that at higher temperature the monocrystalline PV have nearly the same performances when he is subject to different irradiance.

4. CONCLUSION

A photovoltaic tracer instrument system of PV panel based on Arduino board was used to monitor and trace under real operating conditions the I-V and P-V curves of monocrystalline and Amorphous PV panel. The hardware components were coupled with a developed computer routine written in Python programing language. Results indicated that real time data collected for the Amorphous PV are more reliable and accurate compared to the Monocrystalline ones confirming the high performance of the used resistance and the accuracy of the current voltage sensor used with the amorphous PV panel.

6. REFERENCES

[1] F. Spertino, J. Ahmad, A. Ciocia, P. Di Leo, A. F. Murtaza, and M. Chiaberge, "Capacitor charging method for I–V curve tracer and MPPT in photovoltaic systems," *Sol. Energy*, vol. 119, pp. 461–473, 2015, doi : https://doi.org/10.1016/j.solener.2015.06.032

[2] J. Muñoz and E. Lorenzo, "Capacitive load based on IGBTs for on-site characterization of PV arrays," *Sol. Energy*, vol. 80, no. 11, pp. 1489–1497, 2006, doi : https://doi.org/10.1016/j.solener.2005.09.013

[3] R. García-Valverde, S. Chaouki-Almagro, M. Corazza, N. Espinosa, M. Hösel, R.R. Søndergaard, M. Jørgensen, J.A. Villarejo and F.C. Krebs, "Portable and wireless IV-curve tracer for >5kV organic photovoltaic modules," *Sol. Energy Mater. Sol. Cells*, vol. 151, pp. 60–65, 2016, doi : https://doi.org/10.1016/j.solmat.2016.02.012

[4] Y. El Mghouchi, A. El Bouardi, Z. Choulli, and T. Ajzoul, "New model to estimate and evaluate the solar radiation," *Int. J. Sustain. Built Environ.*, vol. 3, no. 2, pp. 225–234, 2014, doi : https://doi.org/10.1016/j.ijsbe.2014.11.001

[5] F. C. Krebs, N. Espinosa, M. Hösel, R. R. Søndergaard, and M. Jørgensen, "25th Anniversary Article: Rise to Power – OPV-Based Solar Parks," *Adv. Mater.*, vol. 26, no. 1, pp. 29–39, 2014, doi : 10.1002/adma.201302031

[6] L. Guo, Z. Meng, Y. Sun, and L. Wang, "Parameter identification and sensitivity analysis of solar cell models with cat swarm optimization algorithm," *Energy Convers. Manag.*, vol. 108, pp. 520–528, 2016, doi : https://doi.org/10.1016/j.enconman.2015.11.041

How to cite this article:
Ouaridhene MA, Benmoussat A, Bouchouicha K, Lasker B, Benatallah M. Effect of the photovoltaic module type on the performance of an arduino (I-V) acquisition device. J. Fundam. Appl. Sci., 2020, *12(1), 508-515.*