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Study of IV Charcteristics of Solar Panel Using Arduino-Based IV Swinger

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ABSTRACT

Most of the commercially available Solar IV curve tracers are of high cost. There is the need to design and construct economically affordable and reliable solar IV tracers. The IV swinger is low cost solar cell/solar panel IV tracer. To understand the basics of photovoltaic systems and study the solar IV characteristics, the IV Swinger is constructed using Arduino Uno and commercially available low cost electronic components. The main intension of the present work is to validate the application of Arduino- based IV Swinger to study the IV characteristics of low power solar panel. In this work the IV characteristics of a solar panel are first studied in a conventional method called resistive load method. The IV curves are then extracted using the IV Swinger. The saturated current (Isc), Open circuit voltage (Voc), Maximum power (Pmax) and Fill Factor (FF) are calculated by the IV curves traced using the IV Swinger. The results obtained using the IV Swinger is found accurate and better than the results obtained by the resistive load method.

KEYWORDS—Arduino Uno; the IV Swinger; the saturated current;open circuit voltage; Fill Factor.

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INTRODUCTION

Photovoltaic is the method of conversion of light energy into useful electric energy using solar cells made-up of photovoltaic material. The Electric power generation from Photovoltaic technology will contribute about 20% of renewable electricity from all the renewable energy resources [1] . In the solar panels, the solar cells are connected in series or parallel according to the need of power generation. The solar panels generate electric power without emitting green house gases. Hence the photovoltaic power generation is clean and environment friendly. The solar panels produce electric power without any noise and hence it is the best renewable energy system for residential application.

The PV panels are rated according to the short circuit current (Isc), Open circuit voltage (Voc), Maximum power point (Pmax) and Fill Factor (FF). All these parameters can be obtained by extracting IV characteristic of solar panel. The easiest way of extracting IV characteristics of PV panel is the use of variable resister[2]. In this variable resister method load resistance is increased in steps in order to extract IV characteristics from short circuit to open circuit by manually recording the values of current and voltage. However, this method is not suitable for high power rating PV panels because of difficulty in getting resisters with high power capacity. The capacitive load method is used to obtain the I-V characteristics of PV panel[3]. Some researchers have employed the principle of the charging capacitive load for extracting I-V characteristics[4]. The third method is the using of electronic load. It consists of an electronic fast varying load based on MOSFET[5, 6]. In the present work, the IV swinger is used to extract the IV characteristics of solar panel. The IV swinger was first built by Chris Satterlee[7]. The basic principle used in the IV swinger is the charging of capacitive load. This Arduino based IV Swinger uses single relay and capacitor as the load. The Arduino controls the relay, reads and records the values of voltage and current. The results are displayed in real time on a laptop. The IV swinger is a low cost device. Both hardware design and software are open source. The software and open source licensing files are available in the open source repository. In the view point of low cost, portability and faster response, the IV Swinger may found to be an ideal device for the study of solar IV characteristics and understanding the basics of Photovoltaic systems.

EXPERIMENTAL WORK

About the IV Swinger: The IV Swinger works on the principle of charging capacitor. When solar panel is connected to the IV Swinger, the capacitor gets charging. As the capacitor charges its apparent resistance increases. The fully charged capacitor is equivalent to open circuit; at this point open circuit voltage is measured. On the other hand when the capacitor is fully discharged, it is equivalent to short circuit at this point short circuit current is measured. When light of sufficient energy is incident on a given solar panel, the capacitor will quickly charges up to open circuit voltage within a fraction of second. For the present application, the IV Swinger is constructed using the following main electronic components:

- 2mF load resistance (two 1mF capacitors are connected in parallel).
- The breed resister that is used to charge the capacitor.
- Relay, that is used to connect the breed resister with capacitor.
- The MCP3202. The MCP3202 is a 12-bit Analogue-to-Digital Converter (ADC) that supports the SPI protocol The Analog to digital converter is used to read voltage and current.
- The shunt resister that is used to measure the current.
- The TLV2462. The TLV2462 is a low-power rail-to-rail operational amplifier. TLV 2462 is used to scale the voltage across the ammeter shunt resistor up to the range supported by theADC.
- Arduino Uno that is used to control the relay and also to read and record the values of current and voltage.

Resistive load method: Before studying the IV characteristics of solar panel using IV Swinger, the IV characteristics are studied using manual resistive load method. The commercial solar panel used in this work is of dimension 5cm$\times$ 5cm.

The circuit diagram for study the IV characteristics using the resistive load method is shown in the Figure (1). Light from white LED lamp is allowed to fall on the solar panel. The intensity of light incident on the solar panel is measured using LX-101A Lux meter. In the beginning experiment is carried with intensity of light 500lux. First the measurements of the voltage and current are carried out with zero load resistance. When the load resistance is zero the current is measured is short circuit current. At this point PV voltage is zero. The resistance is increased in steps and corresponding values of voltage and current are recorded. The recorded values of voltage and current are then used to plot the IV characteristics of the solar panel. The same procedure is followed for measurements of voltage and current with incident light intensity 600lux.

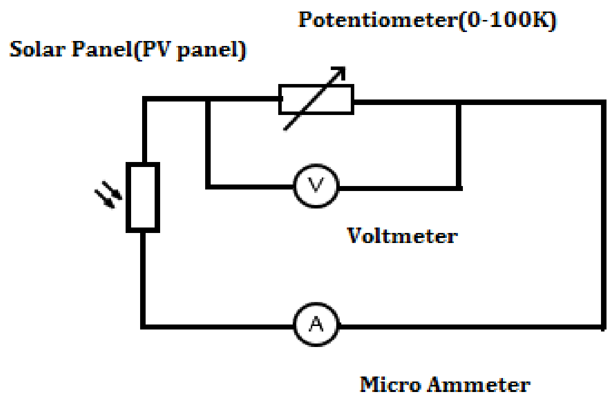

Figure 1: Circuit diagram for resistive load method.

IV measurements using IV Swinger: Before connecting the IV Swinger to computer, load IV Swinger Arduino sketch and install the IV Swinger application. The version of the IV Swinger software presently used is v2.1.1. When the IV Swinger app is opened, IV swinger menu appears on the computer screen. The IV swinger main menu contains submenus; file menu, USB port menu, calibrate menu and help menu. The file menu contains 'view log file' and view config file'. This file menu is not used for general purpose. The USB port menu shows the USB port that connects the IV swinger with the software. The calibrate menu is used for the current and voltage calibration. The help menu gives the information regarding the use of IV Swinger software. The IV swinger constructed for studying the solar IV characteristics is shown in the Figure (2). The Schematic of the experimental setup for extracting IV characteristics of the solar panel is as shown in the Figure (3). Open the IV swinger application. When the IV Swinger application is opened, flash screen with logo and title is displayed on the computer screen. To extract the IV characteristics, the 'Swing' button is clicked. When the swing button is clicked, within a fraction of second, the IV characteristics is traced and displayed on the screen.

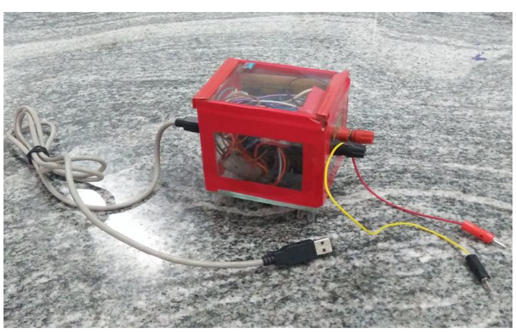

Figure 2: The Arduino – based IV swinger IV measurements

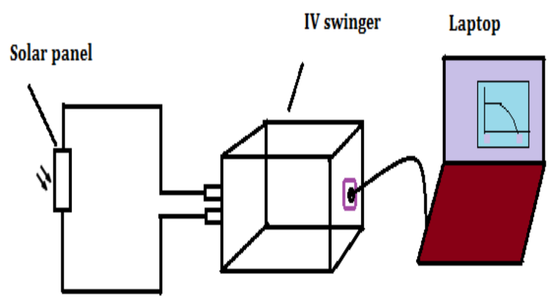

Figure 3: Schematic diagram for with IV swinger.

The IV Swinger is initially calibrated for open circuit voltage and short circuit current with those measured by digital Multimeter using the calibrate menu. After the calibration the IV swinger becomes ready for extracting the further IV characteristics with different intensity of light falling on the solar panel. Then the IV characteristics are extracted using the IV Swinger with same intensity of light as used in the resistive load method i.e., 500lux and 600lux. The results of the previous IV characteristics are stored in the selected folder. Each run of IV characteristics contains of multiple files in the folder named for date and time. The file containing tabular columns of voltage, current, power and resistance in a spread sheet for each run is opened and the results are used to analyze and plot the IV characteristics. The Isc and Voc of the solar panel are estimated using IV curve and Maximum power point, Pmax of the solar panel is estimated using PV curve. The Fill Factor, FF of the solar panel can be determined by the Equation; FF = $\frac{Pmax}{Isc \times Voc}$.

RESULTS AND DISCUSSION

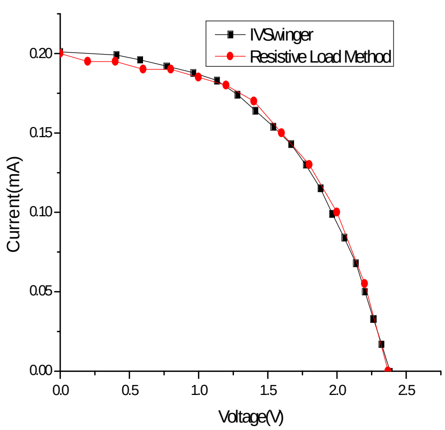

Figure 4: IV Curves for light intensity 500lux

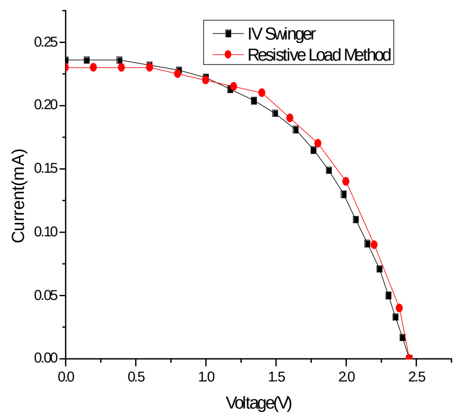

Figure 5: IV Curves for light intensity 600lux.

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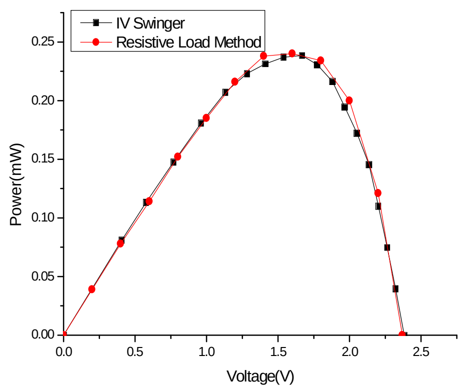

Figure 6: PV Curves for f light intensity 500lux.

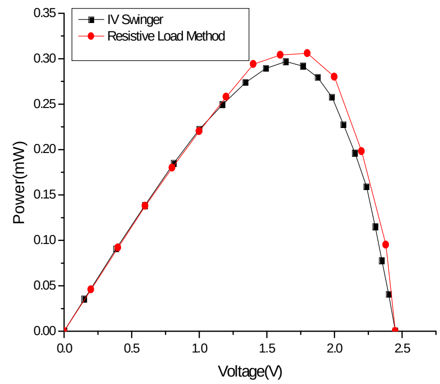

Figure 7: PV Curves for light intensity 600lux

Table (1): Fill Factor of the Solar panel.

Incident intensity of Light(lux)	Fill factor From the Resistive load method	Fill Factor from the IV Swinger
500	0.506	0.500
600	0.561	0.530

The Figure (4) shows the IV curves extracted with the incident light intensity 500lux. From this figure it is seen that Isc is found to be 0.20mA from both resistive load method and the IV Swinger. The Voc is found to be 2.37V from the resistive load method and 2.38 V from the IV Swinger. The Figure (5) shows the IV curves extracted with light intensity 600lux. From this figure it is seen that Isc is found to be 0.23mA from the resistive load method and 0.236mA from the IV Swinger. The Voc is 2.37 V from the resistive load method and 2.38V from the IV Swinger. The Figures (6) and (7) show the PV curves obtained with incident light intensity 500lux and 600lux respectively. From the figure (6), the Pmax is respectively 0.24mW and 0.238mW from the resistive load method and IV Swinger. From the Figure (7), Pmax is respectively 0.306mW and 0.297mW from resistive load method and the IV Swinger. The values of Fill factor (FF) estimated by the resistive load method and the IV Swinger are tabulated in the Table (1).

CONCLUSION

The Arduino- based IV Swinger is very sensitive device to study the characteristics of solar systems. It reads and records the values of photo current and voltage very effectively. The Isc, Voc, Pmax and Fill Factor (FF) estimated from the IV Swinger are compared with those values estimated from the manual load resistive method and both the results are in close agreement. The manual resistive load method is slow and tedious. It is very difficult to reproduce the results with the load resistive method. The IV Swinger results are found accurate and reliable. Most of the available solar IV curve tracers are not economically affordable. The Arduino-based IV Swinger is an ideal low cost and effective device for studying the Photovoltaic systems such as solar cell/solar module/solar panel.

REFERENCES

1. International Energy Agency (IEA), Technology Roadmap-Solar Photovoltaic Energy, 2014.
2. Mahmoud M M. Transient Analysis of a PV Power Generator Charging a Capacitor for Measurement of the I-V Characteristics Renew. Energy, 2006; 31: 2198–2206.
3. Muñoz J, Lorenzo E. Capacitive Load Based on IGBTS for On-Site Characterization of PV Arrays, Sol. Energy, 2006; 80: 1489 – 1497.
4. Erick M. da S. Brito, Adriano da S. Antônio, Allan F. Cupertino, Heverton A. Pereira. Characterization of Solar Panel Using Capacitive Load, *Proc. 11th Int. Conf. Ind. Appl.* Dec. 2014; 1-7.
5. Van Dyk E E, Gxasheka A R, Meyer E L. Monitoring Current–Voltage Characteristics and Energy Output of Silicon Photovoltaic Modules", Renew. Energy, 2005; 30: 399 – 411.
6. Kuai Y, Yuvarajan S. An Electronic Load for Testing Photovoltaic Panels, Journal of Power Sources, 2006; 154: 308–313,
7. http://www.instructables.com/.id/IV-Swinger-2-a-50-IV-Curve-Tracer/