

Autonomous photovoltaic power supply system

Anton Andonov*, Valery Todorov

*Department of Electrical Engineering and Electronics,
University of Chemical Technology and Metallurgy, 8 Kl. Ohridski, 1756 Sofia, Bulgaria*

Received 15 March 2016, Accepted 05 September 2016

ABSTRACT

This work presents an autonomous low power photovoltaic (PV) power supply system. It is used for training students and studying the various parameters and characteristics of the basic elements.

Keywords: off-grid PV system, PV module, I-V and P-V characteristics.

INTRODUCTION

One of the main priorities of the energy policy of the European Union is the development and use of renewable energy sources (RES) (Directive 2009/28/EC of the European Parliament) [1]. It defines the compulsory national targets referring to the renewable energy share in the final consumption and transport. For Bulgaria they are equal to 16 % and 10 %, correspondingly. The energy efficiency has to increase by 20%. All these values are expected to be achieved until 2020. This is the reason for the rapid development and use in our country of renewable energy sources, solar energy in particular, and photovoltaic (PV) power plants. This in turn reflected in the introduction in almost all technical universities (as well as UCTM) of new disciplines, courses and specialties related to renewable energy and energy efficiency.

This work presents the existing autonomous low power photovoltaic (PV) power supply

system. It is mainly used for training students. It is also used to demonstrate the use of PV sources as well as to study the operation characteristics of the PV system components. The autonomous (island) PV power systems are not connected to the usual electricity networks. Generally they are of a low power and produce electricity of low DC voltages. Upon transformation into 220VAC/50Hz it is used for domestic consumers' supply, communication devices, signaling and security systems, etc.

EXPERIMENTAL

The autonomous PV system is DC and contains the following main blocks (Fig. 1) – a PV generator, a controller-charger, a battery and an electrical load. Low-power electrical consumers can be supplied with rated voltage of 12VDC.

The PV generator is composed of two thin-film amorphous silicon panels (type SOLARPRO SP44, manufactured in Bulgaria) [2] with the

* Correspondence to: Anton Andonov, University of Chemical Technology and Metallurgy, 8 Kl. Ohridski, 1756 Sofia, Bulgaria, E-mail: andonov@uctm.edu

following passport data: $I_{SC} = 1,26\text{A}$ (a short circuit current), $V_{OC} = 62,5\text{V}$ (an open circuit voltage), $I_{MPP} = 0,957\text{A}$, $V_{MPP} = 46\text{V}$, $P_{MPP} = 44\text{W}$. P_{MPP} is the power at V_{MPP}/I_{MPP} coordinates of the panel I-V characteristic diagram and corresponds to the maximum power point from a P-V characteristic chart (Fig. 2) [3]. The catalogue data given by the manufacturer under standard test conditions (STC) refers to: solar radiation of $1000\text{W}/\text{m}^2$, temperature of 25°C , light spectrum air mass AM of 1,5 [4]. Photovoltaic panels are the basic element of the photovoltaic installation, as they convert directly the sun light into an electrical energy with DC voltage. The latter value is determined by the battery and is usually 12VDC or 24VDC. It can be equal to 48VDC in case of larger systems. The operating voltage must be high enough to recharge the batteries after losses in cables, charge-controllers, etc. The PV panels used have relatively high values of V_{OC} and V_{MPP} because they are designed for high power photovoltaic power plants [2]. The two panels of the PV generator are connected in parallel, which provides the same output voltage but double current output. Thus they can be connected directly to the controllers of the low power autonomous

systems, whose input voltage is lower.

The photovoltaic controller-charger is an irreplaceable part of the autonomous photovoltaic system providing optimum charging of the battery. It extends its life.

The controllers have other important functions – they prevent reverse current emergence in the PV modules at night and provide overload protection of the system. Some controllers include tracking devices maintaining their work in the zone of maximum power (at MPP point). This increases significantly the performance of the photovoltaic panels and optimizes their performance. The process described is known as MPPT (Maximum Power Point Tracking). The controller of the PV installation used is ivt MPPT-10 (12/24V/10A) – see Fig. 1. It includes also a voltage rechargeable battery 12VDC/24VDC. The voltage of the photovoltaic panel ranges from 5VDC to 70VDC, its maximum current is 10A, while the maximum current load is 10A [5]. An electronic recorder with LCD indicator can be remotely turned on by the controller. Thus data related to the: date, the current time, the PV module current and voltage, and the battery current and voltage can be reported. This information

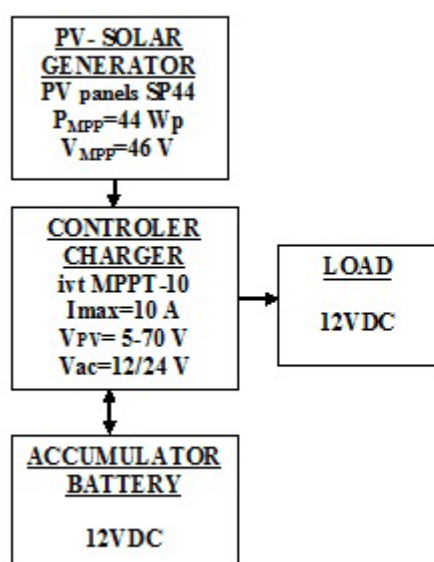


Fig. 1. A block scheme of an autonomous DC current PV system.

can be recorded on external media (a SD card for an example).

The purpose of the battery is to store the excess energy generated during day time and provide constant power supply to the consumers in the course of the night. The solar systems batteries are expected to have a lasting life under conditions of repetitive charging and discharging pro-

cesses, i. e. complete (deep) «charge-discharge» cycles. It is worth noting that the recommended depth of discharge is 50%. A 12V/44Ah lead-acid battery is used in the system described.

Economical light sources like a compact fluorescent lamp 23W, LED lighting, electronic devices, etc. can be used as electrical loads in view of 12VDC consumers.

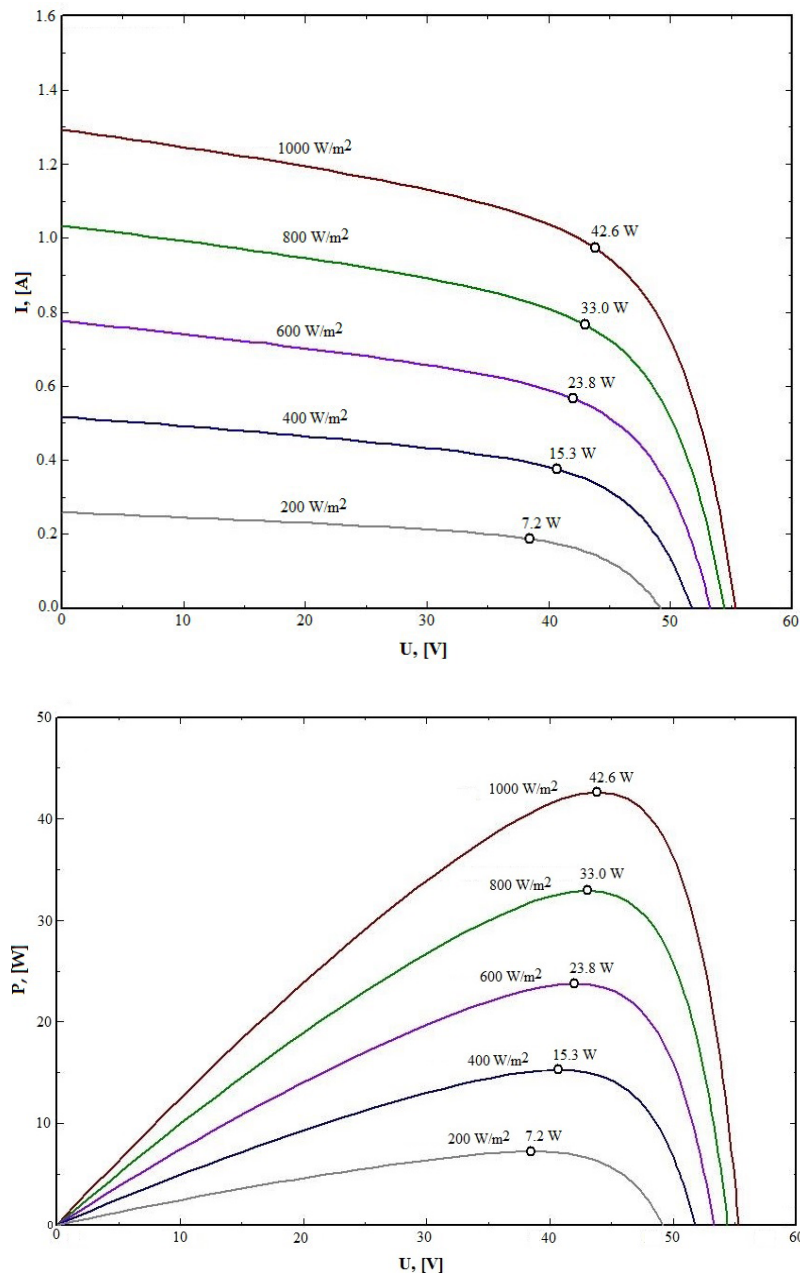


Fig. 2. Simulated I-V and P-V characteristics of SP44 panel at 45°C as a function of the irradiation applied.

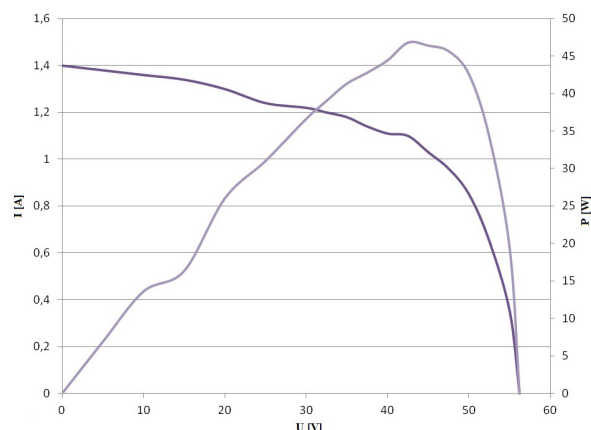


Fig. 3. Experimental I-V and P-V curves of the PV array (2xSP44) at an irradiation of 550 W/m² and a temperature 50°C.

RESULTS AND DISCUSSION

The effective use of the PV panels requires the identification of their characteristics under different conditions referring to the solar radiation, the temperature, the angle relative to the incident light, etc. The parameters of the panels used are investigated with the application of the diode model [5]. Some of the main characteristics are simulated by the software product PVSYST.

Fig. 2 presents the resulting current-voltage (I-V) and power-voltage (P-V) characteristics of panel SP44 at a temperature of the cells of 45°C and an incident solar radiation varying from 200 W/m² to 1000 W/m² at steps of 200 W/m².

The current-voltage (I-V) and power-voltage (P-V) characteristics of the PV generator composed of two SP44 panels connected in parallel were experimentally obtained. They are shown in Fig. 3. The measurements were carried out on a warm day (20.06.2013) at a level of the incident

solar radiation of 550 W/m² and panels temperature of 50°C (measured with an infrared thermometer JT-550C). An active variable resistance was used as an electrical load. The results show that a maximum power of 47W can be reached at a current of 1.1 A and a voltage of 42V.

CONCLUSIONS

An autonomous laboratory PV system supplying electrical loads with a low power and a voltage of 12VDC is built. An array of two SP44 panels is used. The corresponding current-voltage and power-voltage characteristics are experimentally obtained. The data obtained in the course of simulating the I-V and P-V characteristics of the system at a varying solar radiation is presented.

The PV system described has an open structure. New units and drives (inverters, DC/DC converters, etc.) of different parameters and control systems can be added to it.

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