Renewable Energy 35 (2010) 1484–1492

Contents lists available at ScienceDirect

Renewable Energy

journal homepage: www.elsevier.com/locate/renene

Design and development of a data acquisition system for photovoltaic modules characterization

Hocine Belmili [a], Salah Med Ait Cheikh [b,*], Mourad Haddadi [b], Cherif Larbes [b]

[a] Unité de développement des équipements solaires (UDES), Route nationale N° 11, Bou-Isamil BP 365, Tipaza 42415, Algérie

[b] Ecole Nationale Polytechnique, Laboratoire de dispositifs de communication et de conversion photovoltaïque (LDCCP), 10 avenue Hassen Badi, El Harrach 16200 Alger, Algeria

ARTICLE INFO

Article history:
Received 26 April 2009
Accepted 8 January 2010
Available online 12 February 2010

Keywords:
Photovoltaic module
Data acquisition system
Characterization
Meteorological test conditions

ABSTRACT

Testing photovoltaic generators performance is complicated. This is due to the influence of a variety of interactive parameters related to the environment such as solar irradiation and temperature in addition to solar cell material (mono-crystalline, poly-crystalline, amorphous and thin films). This paper presents a computer-based instrumentation system for the characterization of the photovoltaic (PV) conversion. It based on a design of a data acquisition system (DAQS) allowing the acquisition and the drawing of the characterization measure of PV modules in real meteorological test conditions.

1. Introduction

Semiconductor solar cells are the source of energy in photovoltaic systems. These systems consist of series and/or parallel combinations of solar cells. The performances of PV modules can be characterized in a variety of ways [1]. In general, the manufacturer provides the characteristics of PV module under selected operating conditions. These are obtained, under controlled conditions, among them light and temperature, in a laboratory environment [2]. There are several commercial systems for testing PV modules under field conditions but they are very expensive [3]. The data acquisition system (DAQS) developed in this work, has a low cost and low consumption. It has been designed to be the laboratory basic element for the photovoltaic generators characterization. This DAQS is designed to acquire temperature (T) and solar irradiation (S) and then records the current versus voltage and power versus voltage characteristics of the PV modules for each value of T and S. It calculates the maximum power available from the maximum power point (MPP) current and voltage. In addition, it is equipped with an autonomous memory. The control of the data collection in the acquisition system memory is done thru an USB or RS-232 interface connection of the system with a compatible IBM computer with the specified communication software.

2. DAQs description

Fig. 1 shows the block diagram of the data acquisition system developed for the photovoltaic modules characterization. Block 1 concerns the current and voltage measurement, block 2 temperature and irradiance measurement, block 3 is the electronic load and block 4 the power supply.

This test stand is made up of the PV module, the data acquisition system linked to a graphical user interface. The basic element of the hardware parts of the DAQS is the electronic load.

3. The electronic load

3.1. Definition and theoretical analysis

The electronic load is a device, which permits to simulate a static or dynamic load. It can be used to test PV modules. It replaces the classical resistive loads. It allows an electronic control of the current load (or sometimes the voltage). The electronic load developed in this work is based on linear metal oxide semi conductor field effect transistors (MOSFET). Contrarily to the power bipolar transistors, MOSFET is more easily controllable [4]. It offers many advantages such as:

- Significant currents [3].
- Not exposed to the phenomenon of the second breakdown or thermal rapid rise, contrarily to bipolar transistors [5].

* Corresponding author.
E-mail addresses: belmilih@yahoo.fr (H. Belmili), aitch_sal@hotmail.com (S.M. Ait Cheikh), mourad_haddadi@yahoo.fr (M. Haddadi), larbes_cher@yahoo.fr (C. Larbes).

0960-1481/$ – see front matter © 2010 Elsevier Ltd. All rights reserved.
doi:10.1016/j.renene.2010.01.007

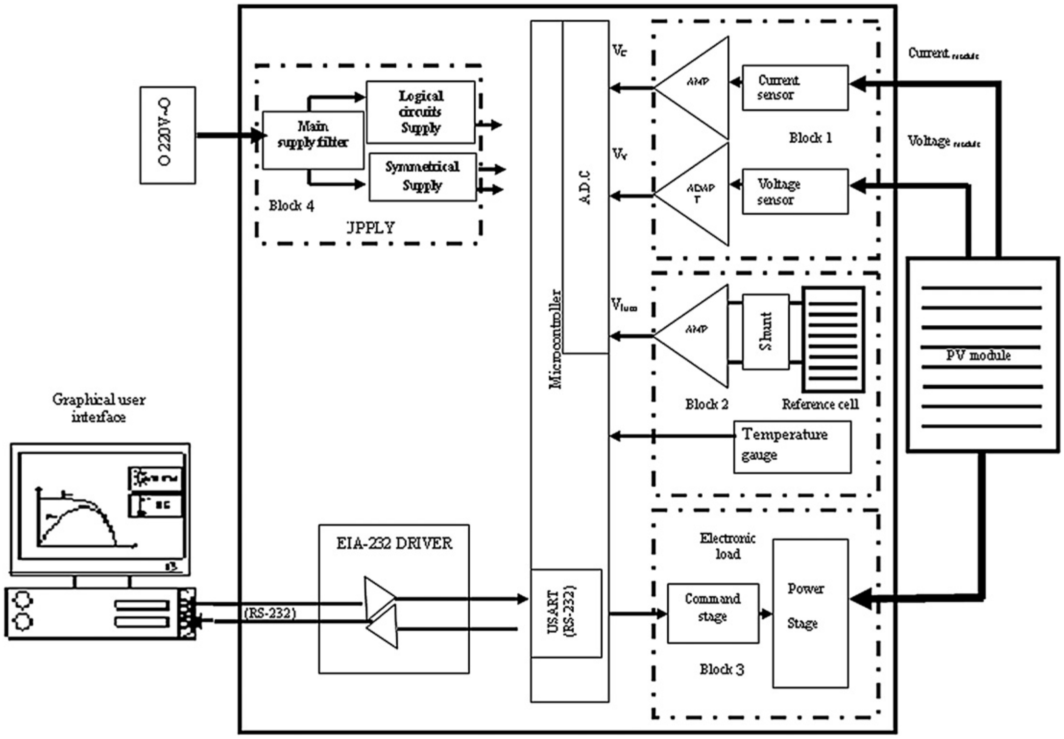

Fig. 1. Block diagram of PV module testing unit.

○ Its minimal drain-source resistance $R_{DS(ON)}$ may be very small, some milliohms, makes it ready to treat high currents without a significant drop voltage[6,7]. For example, a 10 A current through a 2N3055 (bipolar) products a significant drop voltage (in the range of volts), while for an IRF150 (MOSFET) it would be a few millivolts [8].

Fig. 2 shows the principle of the electronic load based on MOSFET's.

From Fig. 2, it follows that:

$$\begin{cases} I_P = I_{DS} \\ V_P = V_{DS} \end{cases} \quad (1)$$

This electronic load comprises two stages: a power and control stage.

3.1.1. Power stage

The power stage is connected directly to the PV module. It acts as a controllable impedance which is able to operate in the operating point of the PV module and thus collect two measures of I_P and V_P. This stage, composed of MOSFET's, operates in its saturation zone as a current generator controlled by the command voltage V_{COM} which is equivalent to V_{GS}. In this area, the current I_{DS} can be expressed by [9]:

$$I_{DS} = K_N (V_{GS} - V_{th})^2 \quad (2)$$

where K_N is the device constant for the MOSFET.

When $V_{GS} < V_{th} - V_{DS}$, the MOSFET acts in its ohmic region and behaves like a resistance controlled by the voltage V_{COM} (or in other terms V_{GS}). I_{DS} will then be given by [9]:

$$I_{DS} = K_N \left(2(V_{GS} - V_{th})V_{DS} - V_{DS}^2 \right) \quad (3)$$

With these parameters, the operating point of the PV module is located on the intersection of its characteristic and those of the MOSFET, Fig. 3. For a given V_{GS}, the output characteristic is fixed. We can then measure the pair (I_P, V_P) which represents the operating point of the module. Consequently, it will be enough to act on V_{GS} to sweep the characteristic of the module [7].

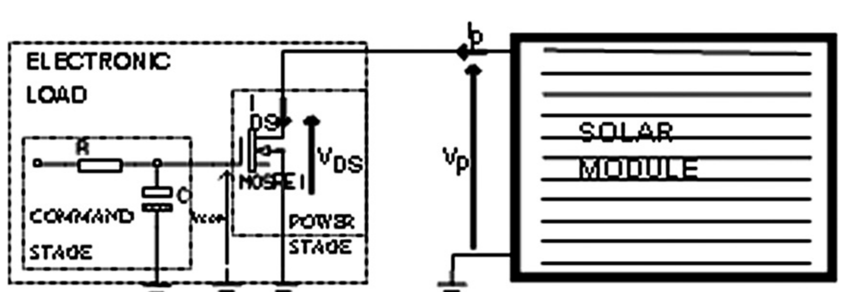

Fig. 2. Schematic diagram of the electronic load principle.