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Developing a mobile stand alone photovoltaic generator

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Abstract

This paper describes a recent work developed to create a mobile stand alone photovoltaic generator that can be easily relocated in remote areas to evaluate the feasibility of photovoltaic energy applications. A set of sensors were installed to monitor the electric current and voltage of the energy generated, the energy stored and the energy used by the loads that may be connected to the system. Other parameters like solar radiations (both on the horizontal and on the photovoltaic generation planes) and temperatures (of both the environment and the photovoltaic module) were monitored. This was done while considering the important role of temperature in the photovoltaic module performance. Finally, a measurement and communication hardware was installed to interface the system developed with a conventional computer. In this way, the performance of the overall system in real rural conditions could be evaluated efficiently. Visual software that reads, visualizes and saves the data generated by the system was also developed by means of the LabVIEW programming environment.

Keywords: Stand alone photovoltaic system; Monitoring software; Photovoltaic characterization; Mobile electric generator

1. Introduction

Designs of stand alone photovoltaic power systems have been reported not only for residential appliances such as certain kinds of lamps and fans [1] but also for mobile applications like laptop computers [2] and electric welding [3]. Similarly, several works have been made to develop control and management strategies for stand alone renewable energy systems in order to improve the performance of the overall system [4–6].

To predict accurately the production of electricity and to optimize the performance of stand alone photovoltaic systems, it is necessary to consider the actual environmental conditions in the installation site [4,7,8]. Therefore, measurement strategies should be implemented to characterize simultaneously the performance of the generation system and its separate components under actual operating conditions. It is also required that continuous monitoring of the weather data be done.

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Particularly, it is very important to consider the influence of temperature on the electrical parameters of photovoltaic modules. Several works have found that the performance of photovoltaic systems is strongly affected when the temperature of the module is higher than room temperature [9,10].

Performance assessment of photovoltaic systems is usually done by means of data loggers or data acquisition cards, which serve as an interface between a conventional PC and a set of sensors for measuring both meteorological and electrical parameters [11,12].

In terms of software tools, taking into account their graphical resources, several authors have used LabVIEW as an application for the control and acquisition of data [4,12]. In this paper, LabVIEW is used as a programming tool to develop an autonomous application that can operate as the software to monitor, store, and visualize data taken from the system developed.

Considering the results mentioned and the lack of practical, dependable tools to evaluate the operational performance of the stand alone photovoltaic generator in the local environmental conditions of Eastern Mexico, the Energy Laboratory of the Faculty of Engineering of the Autonomous University of Yucatan decided to develop a research project to create a set of tools that satisfy the main purposes that follow:

- Design and build a stand alone photovoltaic system containing all the components required to produce electricity from solar radiation.
- Develop a set of measuring and analyzing tools in order to evaluate the operation of the stand alone system including the related environmental conditions.
- Design and build a device, integrated to the stand alone system, that allows it to be transported to remote sites in order to evaluate its performance in specific environmental conditions.

This paper presents the development of the stand alone photovoltaic generator designed to accomplish the goals mentioned.

2. General description of the energy generation system

As stated in the previous section, the generation system was conformed by a stand alone photovoltaic electric generator. This system also allows monitoring the operational parameters of the generated photovoltaic energy, stored energy and load energy consumption. In addition, basic environmental variables that affect the photovoltaic generation were also monitored. A database was also created to store all measured parameters; and thus, operational analysis could be made later to evaluate the photovoltaic generation performance and its efficiency.

Another important feature added to this stand alone photovoltaic generation system was the mobility option. This option was added by means of four supporting wheels that allow easy transportation of the system as a whole and, therefore, make operational field studies possible in remote places where a photovoltaic system could be a potential energy solution.

In order to classify the parts of the energy generation system, considering its main functions, three main blocks were defined:

- Photovoltaic generator.
- Measurement system.
- Monitoring software.

In this manner, Fig. 1 shows a diagram representing the general parts considered in the system design. The gray dashed squares were drawn around the three main blocks of the system.

3. Photovoltaic generator

The photovoltaic generator is the heart of the generation system. It was designed to contain the principal equipment that allows the electrical generation process in any conventional stand alone photovoltaic generator. Consequently, this generation block is formed by three main areas: