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Software solution implemented on hardware system to manage and drive multiple bi-axial solar trackers by PC in photovoltaic solar plants

P. Visconti [a,*], P. Costantini [a], C. Orlando [a], A. Lay-Ekuakille [a], G. Cavalera [b]

[a] Department of Innovation Engineering, University of Salento, Lecce, Italy
[b] Cavalera s.r.l., Galatone, Lecce, Italy

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ABSTRACT

Solar energy is available almost everywhere but in some circumstances and locations it is necessary to optimize the dimensions of plants, avoiding large surface of PV modules installed on the ground, preferring modules located on solar trackers to increase the efficiency by at least 35%. However, even in this latter case, there are still margins for increasing the PV plant's efficiency. For this purpose, we have developed and tested an electronic system for controlling and driving bi-axial solar trackers of a PV plant, managed by a PC software application with a user-friendly graphical interface. The designed software is able to calculate the sun circadian orbit and consequently to move the solar panels in order to maintain the panel's surface always perpendicular to solar rays, improving the efficiency in energy production. In particular, the object of this work consists in optimizing an existing, designed by us, fully-hardware setup which didn't allow a simple and rapid plant management, completely replacing the Master electronic board with the designed software, so as to be able to communicate, by means of PC's RS232 serial port, with Slave electronic boards for tracker motors driving.

1. Introduction

Project planning of a photovoltaic (PV) plant is preliminarily correlated to the choice between two different available types: fixed or motorized plant. In the fixed type, the incidence angle of the solar rays, on the panel surface, is conditioned by the panel inclination set during installation, the geographic latitude, the year period, the daytime and it cannot change. In the motorized type, exposure angle can change dynamically during day cycle with heliotropic movements that allow to keep the incident solar rays perpendicular to the photovoltaic panel surface, in order to maximize efficiency in electricity production. This system type is commonly said *solar tracker*; solar trackers can be classified according to freedom degrees, type of power supply for orientation mechanism and type of electronic control. Regarding to freedom degrees, solar trackers can provide a movement to the PV panels along a single or double axis and then they can be classified into single-axis trackers on tilt axis oron azimuth axis, roll trackers and bi-axial trackers. In this work we used a bi-axial solar tracker on tilt and azimuth axis (Fig. 1), since, following the sun's circadian orbit, it exhibits major advantages in terms of efficiency gain regarding the energy production (35–40% more than a static system with respect to a 15–20% increase obtained with a single axis tracker) [1].

Plots reported in Figs. 2a and 2b show a comparison between energy production in a fixed plant and in a PV

* Corresponding author.
E-mail address: paolo.visconti@unisalento.it (P. Visconti).

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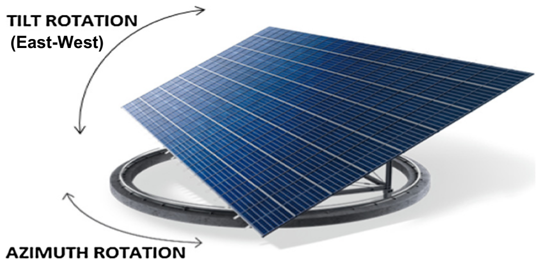

Fig. 1. Example of solar panel with bi-axial (full tacking) solar tracker.

plant with bi-axial solar trackers during daytime (Fig. 2a) and in different months of a year (Fig. 2b).

The greatest production benefits occur in the hours just after sunrise and before sunset. In fact, when solar radiation is more inclined on earth's surface, the solar tracker effect, that maintains the panel orthogonal to the solar radiation, gives the maximum improvement.

In this work a software, that runs on PC with master role, has been implemented in order to control slave electronic boards that drive motors for panels' biaxial movement. In order to obtain an algorithm on PC for driving, through the slave boards, the engines of solar trackers, mathematical formulas were used to calculate solar position during daylight hours in any day of the year, depending on the installation place of the photovoltaic plant, for maintaining panels always perpendicular to the sun. By a PC application with a simple interface, the common user can manage, control and reset the system parameters by PC software, without the technician intervention, however necessary in old non-informatized fully-hardware system. This user-friendly software interface for PV plant management represents the most innovative factor of the system presented in this work.

Gregor et al. [2] developed a similar system for biaxial solar tracking, based on Information and Communication Technologies (ICTs) and a GPS for the acquisition of sun's geographic coordinates in real time in order to improve the efficiency of the photovoltaic system. Bortolini et al. [3] implemented a system which follows Sun's apparent motion thanks to a proper combination of both a forward and a feedback control loop, using a completely automatic real-time monitoring platform based on LabView platform. Zubair et al. [4] designed a hardware system based on a microcontroller which automatically keeps the solar solar panels aligned with the sun in order to maximize efficiency. Khan et al. [5] developed another hardware microcontroller-based control system for solar tracking management based on light dependent resistors which are used as brightness sensors.

2. Block diagram of designed electronic equipment and its electrical behavior compared to previous fully-hardware system

The goal of this work consists in optimizing an existing fully-hardware apparatus [6] for controlling and driving a solar tracker system, which didnot allow a simple and rapid plant management, completely replacing the Master electronic board with a software, running on PC with an appropriate application, able to communicate with Slave boards for tracker motors driving. Fig. 3 shows a block diagram of the previously designed system and fully functioning on several installed photovoltaic plants. This system consists of:

- C107 Master control board, manufactured by Cavalera srl, equipped with a Microchip microcontroller programmed with an algorithm able to calculate the sun position at the PV plant's latitude and longitude.

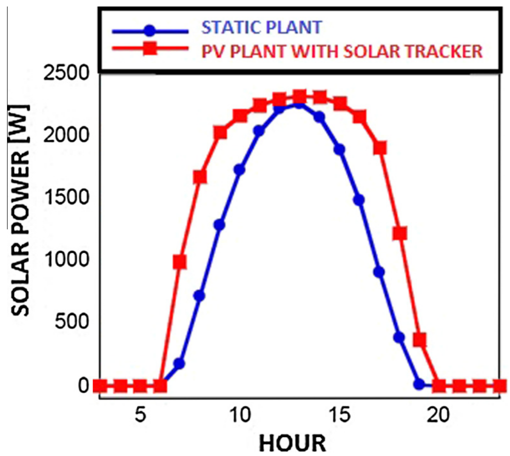

Fig. 2a. Comparison between solar power production from a fixed photovoltaic plant (blue line) and from a dynamic photovoltaic plant with bi-axial solar tracker (red line) in different hours of a day. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

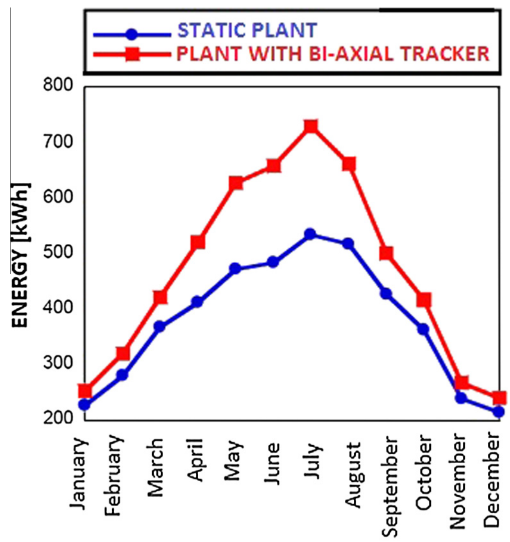

Fig. 2b. Produced energy by a static photovoltaic solar plant (blue line) and by a dynamic plant with bi-axial solar tracker (red line) in different months of a year. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)