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A Step-By-Step Tracking Program for a String of Photovoltaic Modules

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Abstract. The objective of this paper is to create a step-by-step tracking program which assures an increased energetic efficiency for a string of photovoltaic (PV) modules. This is achieved through various calculations, having as parameters: the solar angles, solar time, day of the year and turbidity factor, following to capture the maximum solar radiation, but with a small angular domain of the daily angle. For a motion law with high precision, the year is split into 8 time intervals and for each one it is found the optimum fixed elevation angle with the according daily angle field.

Key words

Photovoltaic, solar radiation, tracking, step-by-step, string.

1. Introduction

In the domain of producing electric energy, the fossil fuels can be successfully replaced with renewable energies (Sun, wind, water). The solar energy can be converted into thermal or electric energy (photovoltaic systems). The PV systems have no emission of pollutant gasses into the atmosphere and the energy provided can be used to supply remote areas or fed into the grid. In order to expand their usage, researchers try to improve their yield, conversion and energetic efficiency keeping a simple design and still being cost effective [1].

The tracking of PV systems can increase the energetic efficiency with 50% [2] more than fixed systems. This improvement is achieved through tracking mechanisms [3]-[5] designed to follow the Sun on the sky on the basis of certain control techniques (closed or opened loop).

In closed loop control systems, photo-sensors are used to determine Sun`s positions on the sky sending electrical signals to the motor source, thus actuating the motor to track the Sun. However, in unstable weather conditions (heavy rain or cloudy sky), it will be very difficult to find the real position of the Sun, generating errors.

In the opened loop control systems, mathematical algorithms [6]-[8] or programs are regarded as motion laws and used as input parameters for the motor sources. These algorithms are defined as functions of solar angles and can be computed for any given geographical area with specific formulas (case study: Braşov, România).

Considering the above mentioned conditions, the paper presents a tracking program designed to increase the energetic efficiency of a string of PV modules. The year is split into time intervals called seasons, and for each one there are computed the optimum angles for which is received the maximum quantity of solar radiation.

2. Calculation of optimum angles

In order to receive as much solar radiation as possible, the sunrays must always fall normal to the system`s plane. This is achieved through continuous tracking (ideal case), but, due to high operating time of the motor sources, necessity of performing large transmission ratios and to system behaviour under the influence of external non-stationary elements (ex. wind), the motion law is performed step-by-step (with an equal number of steps every hour) [9].

The motion law was designed to ensure the optimum positioning of the PV system relative to the Sun`s position on the sky, so that the received solar radiation is very close to the ideal case.

The PV system is orientated according to two angles: module tilt angle, γ^*, which is kept at a fixed value throughout the duration of a season or the entire year and the daily angle, β^*, around which the daily motion is performed. In turn, these depend on the following: the angles determining Sun`s position on the sky dome: latitude φ, declination δ, hour angle ω, altitude α [10]. From these angles were determined the angles used for the sunray orientation: elevation angle, γ and daily angle, β (fig. 1) [11].