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Cheap two axis sun following device

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Abstract

A sun following system was constructed and tested. The tracker gives the possibility for automatic measuring of direct solar radiation with a pyrheliometer. The mechanism is operated by a digital program in the control system, situated separately from the mechanical part. The position of the sun is calculated, and the pointing errors appearing during its daily work are stored for later analysis. Additionally, in the active operation mode, the tracker uses the signal of a sun detecting linear sensor to control the pointing. Two stepper motors move the instrument platform, keeping the sun's beam at the center of the sensor. The mechanism was created at the Laboratory "Evaluación Solar" of the Technical University Federico Santa Maria (UTFSM) in Valparaiso, Chile. The experiments show good results. The described sun tracker gives similar results as the Swiss sun tracker INTRA at a very much lower price.

Keywords: Two axis sun tracker; Sensors; Pyrheliometer; Measurements

1. Introduction

The efficiency of any solar array can be improved significantly using sun tracking. Tracking flat plate photovoltaic arrays provide about 33% more power than fixed arrays [1]. Advances in solar

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cells have resulted in high concentration ratio silicon types with up to 28% efficiency [2]. For concentrating collectors, pyrheliometer data is needed, measured with pyrheliometers mounted on solar trackers.

Three main types of sun trackers exist: passive, microprocessor and electro-optically controlled units. Passive systems track the sun without any electronic controls or motors. These trackers contain a fluid, such as Freon, within a frame of pipes. When the array is misaligned the sun heats the Freon on one side of the frame more than the other. This temperature difference causes the heated Freon to evaporate. It may push a piston or may simply flow to the other side of the array and move it by gravity, such as in the Zomeworks system [3]. These trackers are simple but can only provide moderately accurate tracking.

Microprocessor controlled sun tracking units use mathematical formulae to predict the sun's location and need not sense the sunlight. To determine position, they use stepper motors or optical encoders. They are often used in large systems in which one controller controls many arrays [1]. Many microprocessor controlled trackers use electro-optic sensors for self-calibration [4]. They can also be self-calibrated without sensors by using a current maximizing search routine [5]. This type of tracker is highly accurate but requires a very precise installation, often difficult to achieve.

The electro-optical trackers give very good results during good weather conditions. Rumala created a system using four photo resistors with cylindrical shades as a sun sensor. Its controller contains differential amplifiers, comparators and output components [6]. Lynch described an electro-optical unit utilizing both fixed and moving sensors to provide fairly good accuracy and reliable operation [7]. Poulek and Libra made a sun tracker based on an arrangement of auxiliary bifacial solar cells connected directly to a DC motor whereby the auxiliary solar cells can sense and provide energy for tracking [8,9]. The operation of these sun trackers has serious problems at cloudy days.

The construction and use of a mechanism that follows the sun is already a tradition in the Technical University Federico Santa Maria, Valparaiso, Chile. The first tracker constructed was completely mechanically, done by Finster in 1962 [10]. One year later, Saavedra presented a mechanism with automatic electronic control, which was used to orient an Eppley pyrheliometer [11]. Maldonado designed and built a sun tracker at UTFSM [12]. The position of the sun was calculated with a computing program or sensed by a servo control, and the system ensured reliable automatic orientation of a pyrheliometer. A Swiss solar tracking unit INTRA was recently installed at the UTFSM. It is a representative of a new generation of sun following systems [13]. It combines the advantages of both microprocessor and electro-optically controlled systems and is very convenient for precise measurements.

The objective of the present article is to show a new sun tracker, designed and built recently at the UTFSM. Although it has the same mechanical base as the Maldonado tracker (Fig. 1a and b), some important novelties are available:

- the old DC motors were replaced by stepper motors, the four quadrant sensor for seeking the sun position was replaced by a simpler, effective linear sensor built by Boudinov in Brazil;
- the electronics unit is completely new. A last generation microprocessor is used to operate the sun tracker instead of the old Z80 used before;
- the control system uses software situated on a PC, which makes it supple for sun tracker work and for future progressive changes;