Construction of dual-axis sun tracker controlled by Arduino

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Abstract. In this work a dual-axis sun tracker was constructed using an Arduino to control two DC electric motors. The motors together with gears move a structure that tracks the sun. To achieve that purpose, an arrangement of four photoresistors was made to input the sun position into the Arduino in form of electric signal. The output signal from the Arduino is used in four relays with their respective optocouplers to transmit power into two DC electric motors to move the tracker. The Arduino uses an algorithm that processes the photoresistors signal and produce it an output signal that is transmitted to the relays. The sun tracker was applied in parabolic dish with good performance.

1. Introduction
The sun is a source of energy that has fed the planet during geological ages, in addition, solar energy is responsible for the existence of other types of energy such as wind, biomass, marine currents, among others. The solar energy is plenty in our planet and do not produce gases that pollute the environment, by this reason is a good renewable energy to use [1]. At the present time, solar power systems are important devices that transform the solar radiation into heat or directly in electricity as photovoltaic systems. The solar radiation arrives out of the earth atmosphere with a solar constant Io = 1377 W/m², this is the available radiation, but not all this radiation is absorbed by the solar devices due to reflection, dispersion and absorption in the atmosphere, also the earth is rotating and then the sunlight is presented only during the day, being more intense when the sun is in the zenith and with less intensity when sunrise and sunset [2, 3]. There are solar systems that can work in fixed mode and the sun moves during all day changing the intensity captured by some receiver, but there is not efficient in reception because of only few hours per day high sun intensity is obtained in the receiver. To capture more time the solar energy during the day a sun tracker is used. There are two types of sun trackers, such as of one axis tracker that follows the sun from east to west and two axes tracker which follow the sun from east to west during the day and from north to south during the season of the year, applying a sun tracker could increase 40% per year compared with a fixed sun tracker devise [4, 5, 6]. The two-axis tracker consist of two linear actuators with DC electric motor which target the sun certain degree of accuracy. As mentioned before, during the day one axis follows the sun from east to west and during the night it turns east by itself for the next morning sun [4].

1 C Alvarez-Herrera
2. Sun tracker theory
A simple way to design one axis tracker as mentioned in [4], using two photovoltaic cells positioned at 45° respect the base as shown in the figure 1. when the sun is perpendicular at the base the cells are connected differentially in series then each current have the same magnitude but with opposite directions the total current is cero that is input in a DC electric motor is Im= 0, but if the sun is no perpendicular and there is a small angle deviation $\delta$ then the currents are expressed in the next form being $I_0$ the maximum output current of each photovoltaic cell.

$$I_1 = I_0 \cos(45^\circ + \delta)$$

$$I_2 = I_0 \cos(45^\circ - \delta)$$

$$I_m = I_1 - I_2 = I_0 \cos(45^\circ + \delta) - I_0 \cos(45^\circ + \delta)$$

using the Taylor series expansion

$$I_m = I_1 - I_2 = 2I_0 \sin(45^\circ)$$

Figure 1. In a) shows the sun illuminating perpendicular to de base and with the same intensity to each cell, b) shows an angle deviation of the arrangement illuminating at different intensities each cell.

3. Dual-axis sun tracker construction
In this section the sun tracker construction will be described. To control the dual-axis sun tracker four photoresists are needed as shown in figure 2 a). Then these are connected to the inputs of the Arduino using four resistors with 2.2 kΩ of resistance figure 2b) [4].

Figure 2. a) The four photoresistors arrangement to dual-axis sun tracker, b) Connection of photoresistors in series with a resistor.
To connect the control circuit with the DC motors, it is necessary to implement relays with optocouplers. As shown in figure 3 the Arduino outputs is connected in the four relays input then the relay output is connected in the two DC electric motors. As shown in figure 4.

**Figure 3.** Relays used to transmit signal and power to the electric motors. Some mechanical modifications were made so some gears were manufactured using wire cut electric discharge machining, then the electric motor were connected to the structure [6]. As shown in figure 4.

**Figure 4.** Electromechanical arrangement of the dual-axis sun tracker.
As is well known the Arduino uses open source code so some applications of the Arduino code could be used in other applications [5]. This research is based in a small device of two axes solar tracker explained in [7] and was scaled in a bigger devise to move parabolic dish with 2.4 m of diameter made of glass fiber.

4. Results
When all the components are connected, the electronic control was compacted as shown in figure 5, and the Arduino software were proved. All the system works and proved using a parabolic dish with specular surface achieving a temperature of 800 °C using a thermocouple type K to measure this temperature.

![Figure 5. a) Compact electronic control, b) Parabolic dish with specular surface.](image)

5. Conclusions
Move a heavy structure with electromechanical system was achieved. The structure tracked the sun using electronic control with Arduino, so the goal was accomplished. The electronic components are accessible and easy to implement, the Arduino software is in line only we must make some modifications. Future work is to modify the software and hardware to complete a cycle, that is, the solar tracker rotates on its own from the east towards sunset.

References
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