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Optimization of photovoltaic energy by a microcontroller: Arduino Solar Tracker

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Abstract

One of the major challenges of all nations today is to find new energy sources to meet the needs for continued growth in Energy Term. The conversion of sunlight into electricity via photovoltaic solar cells is becoming a necessity in particular through the observation of a global evolution in clean energy that respects the environment. The main challenge is to optimize as much as possible the cost / energy (\$/watt) ratio thus boosting both energy performance and at the same time take full advantage of the sun's rays throughout the day. In this context the sun trackers are such devices for efficiency improvement.

Introduction

The solar panels are placed at a fixed angle and the amount of the solar radiation is less efficient. Therefore is a big loss due to the changing of the sun angle relative to the panels [1]. To compensate that loss, the systems require increase the amount of the panel or the size, but the solar panel is quite expensive. The operation of a solar panel presents a performance varied throughout the day by the angles with respect to the sun, caused by the movement of the Earth's rotation, and throughout the year this angle also is affected by the translation movement [2]. A solar tracker can increase the output of a photovoltaic panel (PV) up to 30% / 40% more than a fixed panel [2].

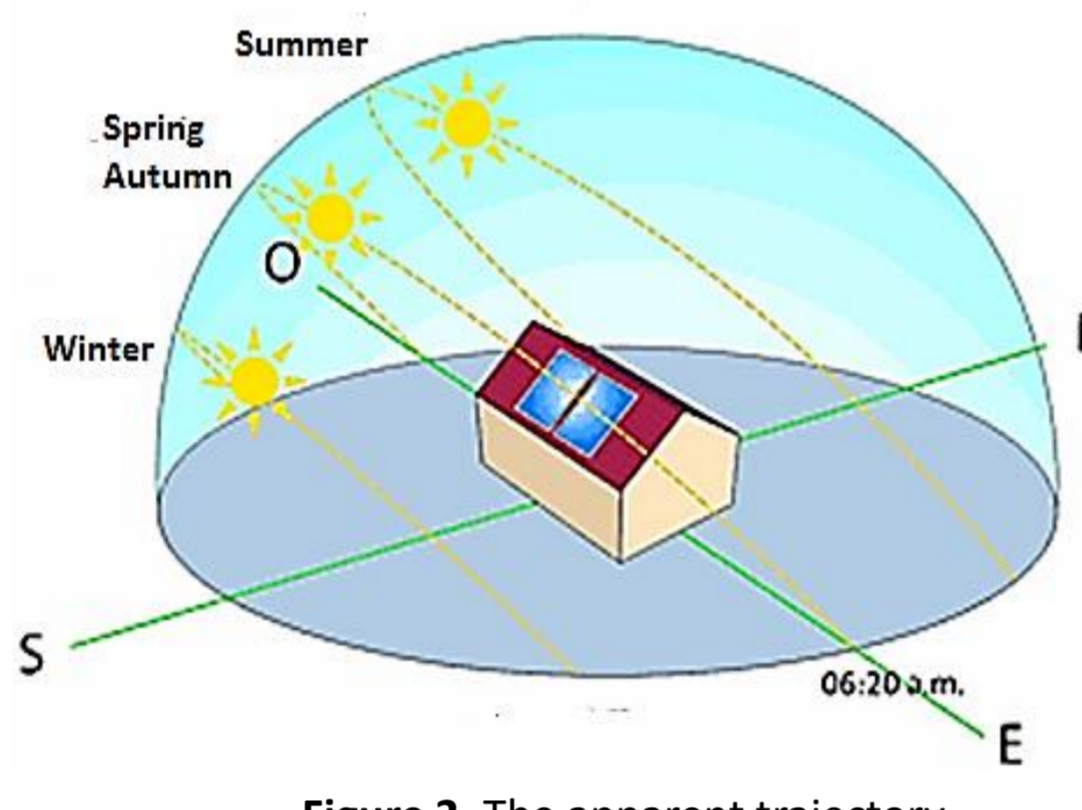
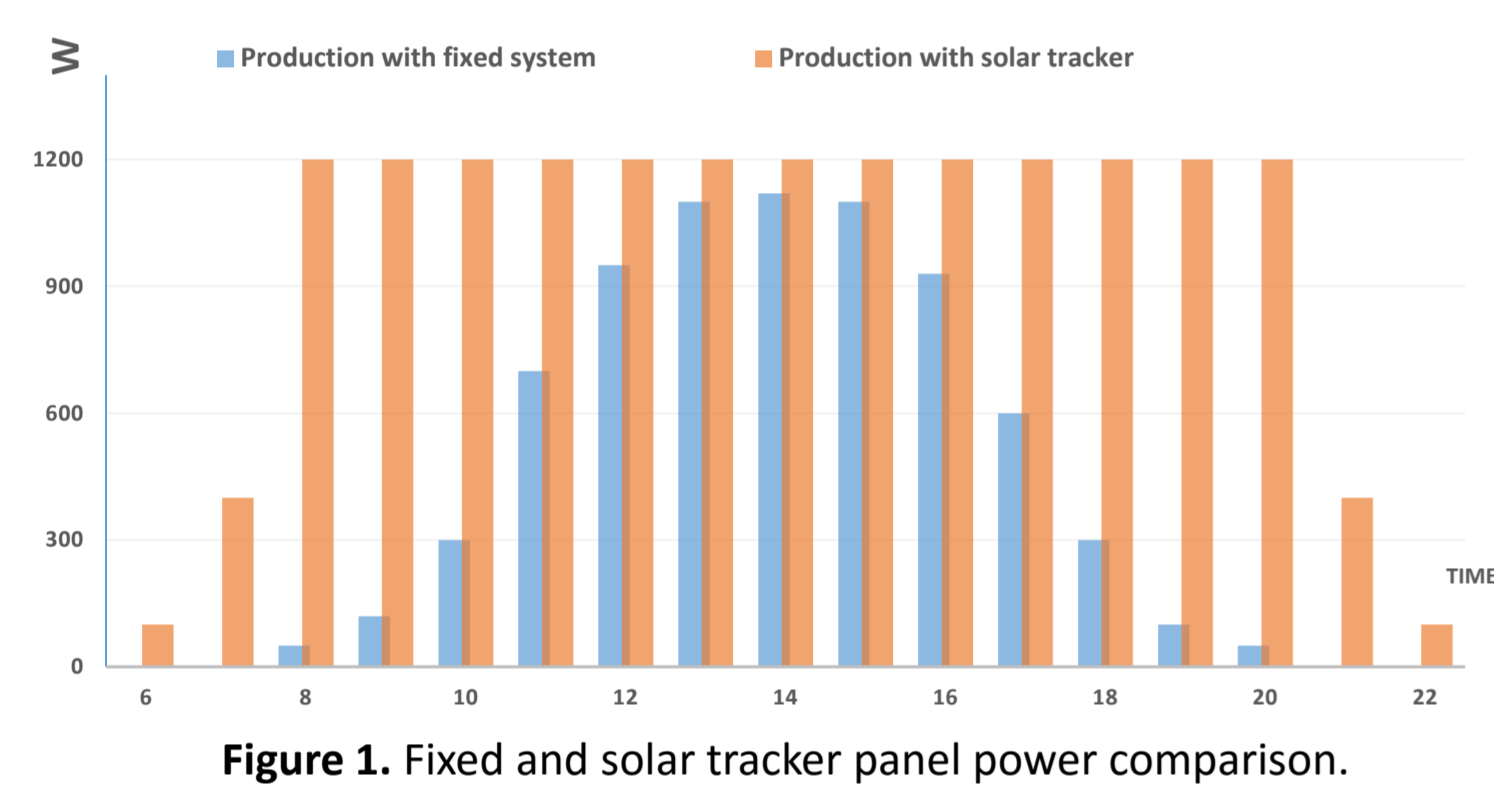


Figure 1. Fixed and solar tracker panel power comparison.
"The panel with solar tracker produces a higher power output as compared to the static PV panel system."

Figure 2. The apparent trajectory of the sun in the sky.

Project Specification

Design and build a low-cost active dual axis solar tracker. The solar irradiance is detected by four light dependent resistor (LDR) sensors. The PV panel rotates automatically based on the sun irradiance during the day, while at night the system in "sleep" mode in order to reduce the energy consumption.

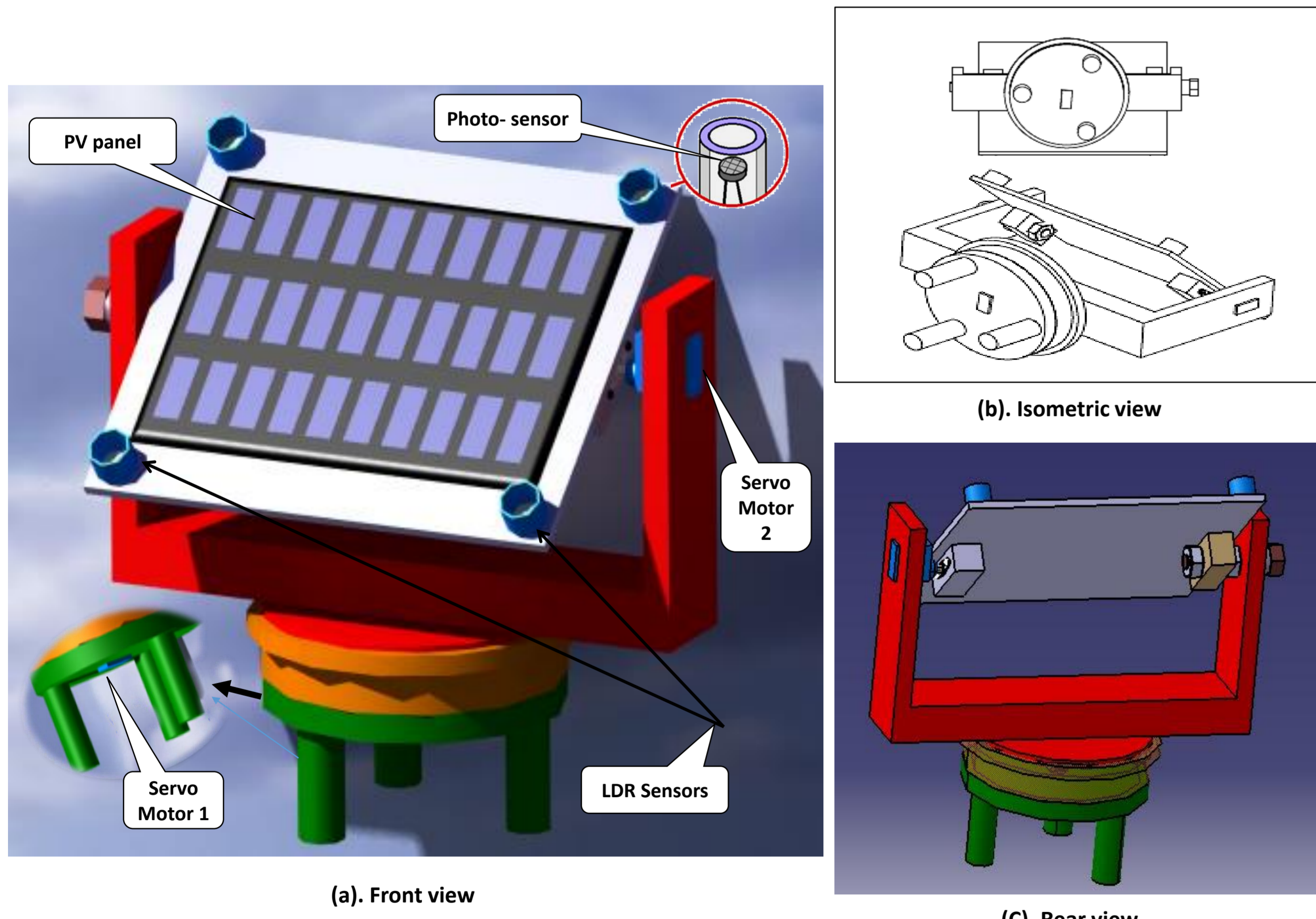


Figure 3. Dual-axis solar tracker design in CATIA (3D modeling).

Our realization is mainly based on an automaton capable of following a light source by orienting optimally in the direction of the sun's light rays (Figure 4. (b)). The rotational movements therefore occur along two axes, in azimuth (east / west) and in elevation (south / north). We therefore use two servomotors controlled by the microcontroller. The objective of this work is to optimize the photovoltaic energy by the use of a microcontroller (ATMEGA328).

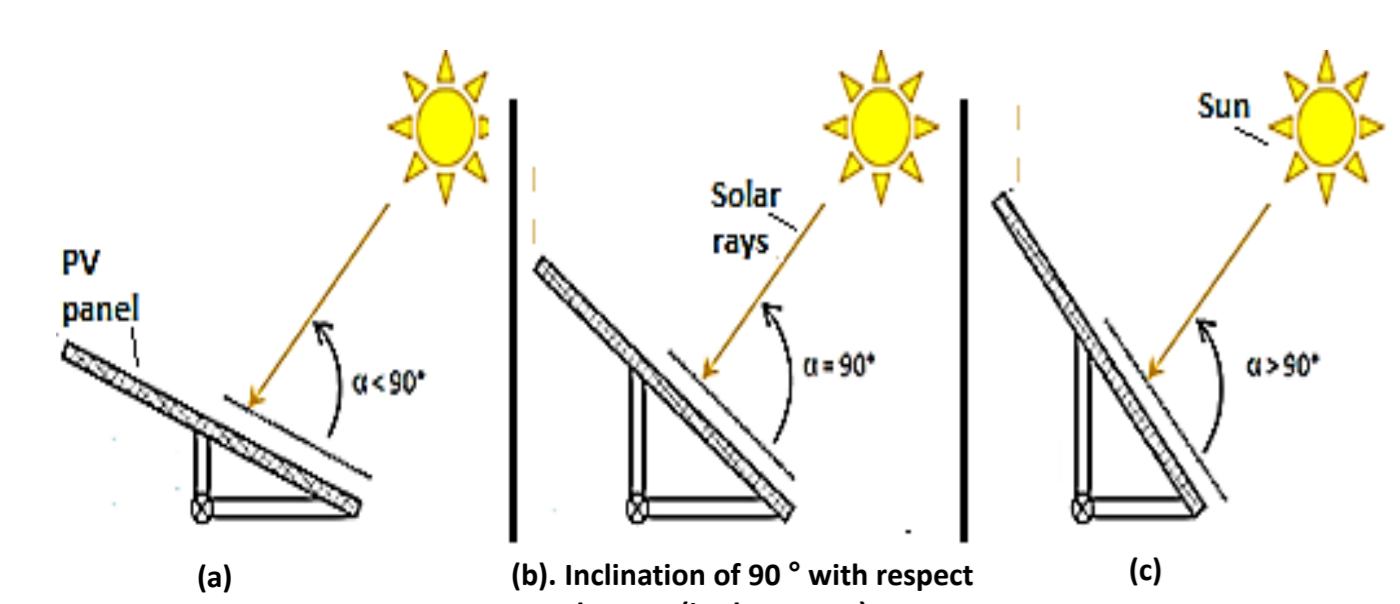


Figure 4. Inclination of the solar panel with respect to solar rays.
"The angle formed by the rays of the sun and the solar panel is called angle of incidence (denoted α). Production is maximal if the sun's rays reach the surface of the panel perpendicularly (Figure 4. (b))."

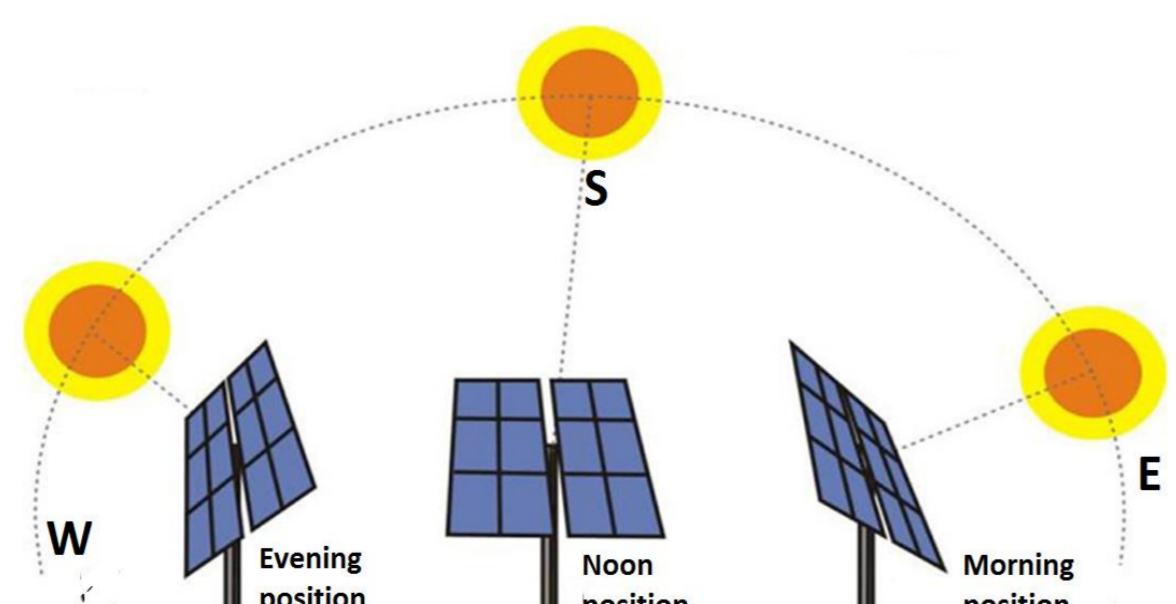


Figure 5. Solar panel tracking the sun from East to West.
"Solar panel that follows the sun from east to west. The same principle for the north/ south movement."

Schematic diagram of the standalone solar tracker system

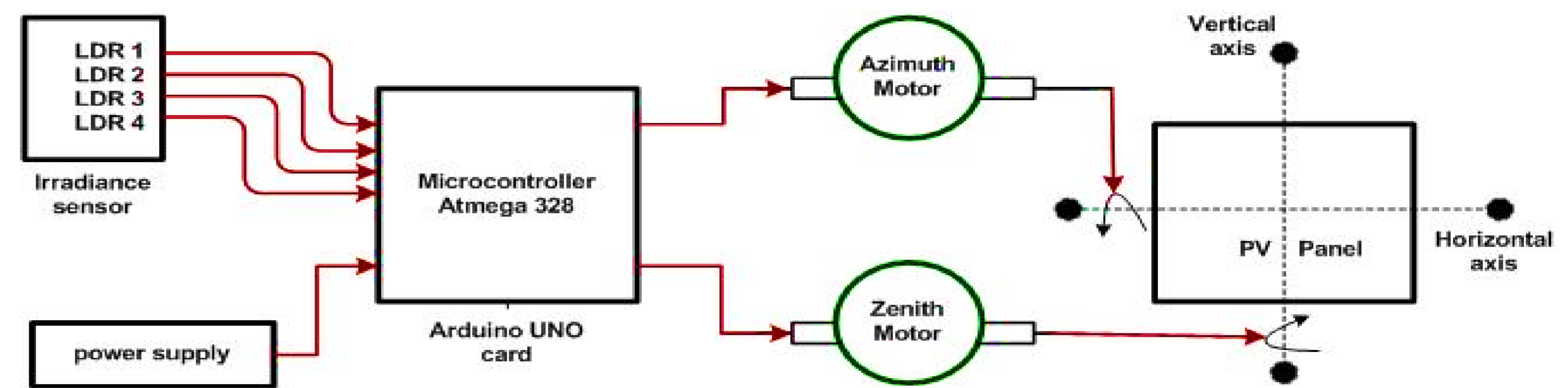


Figure 6. Configuration of the proposed smart dual axis automatic solar tracking system.

Circuit diagram of the standalone solar tracker system

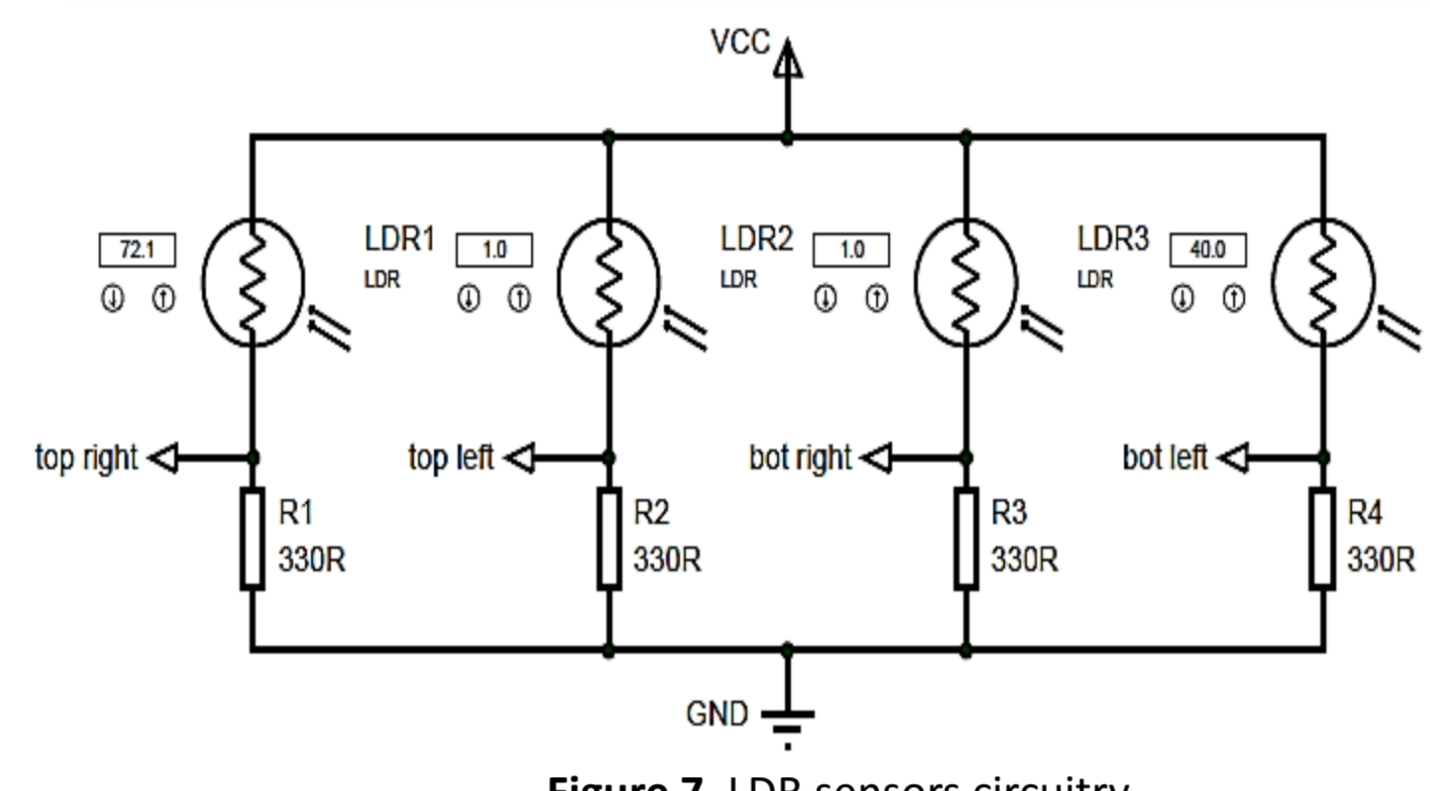


Figure 7. LDR sensors circuitry.

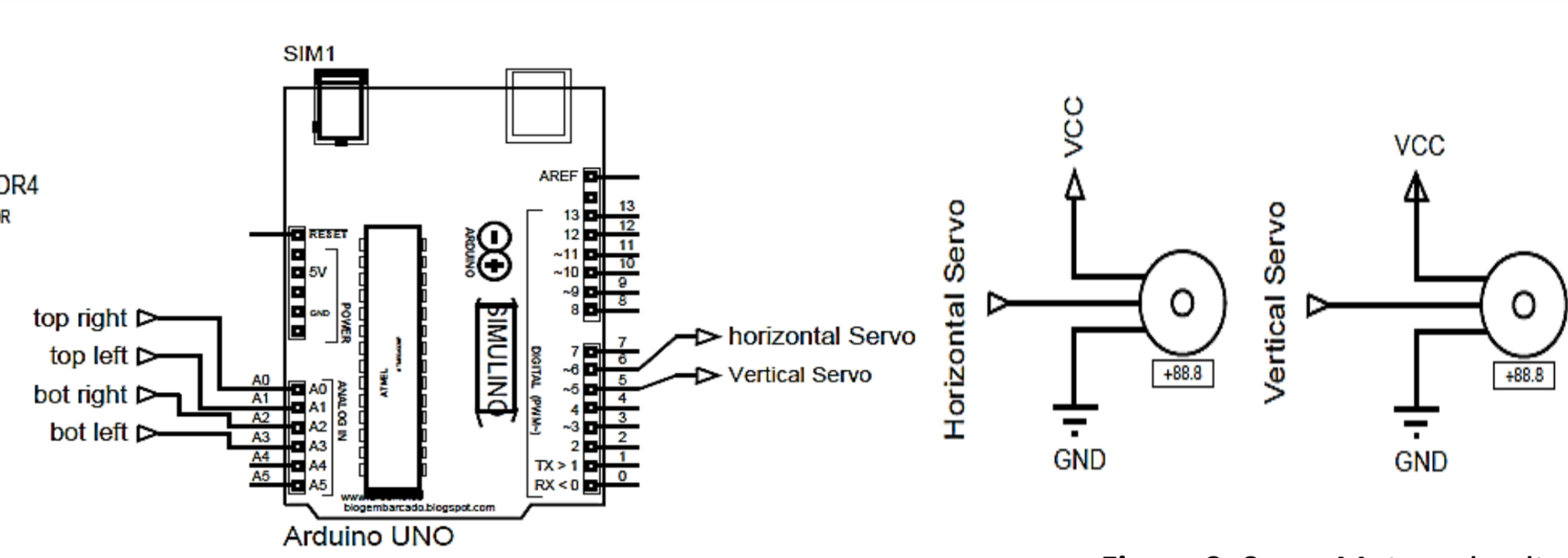


Figure 8. Connecting of the LDR sensors and the servo motors with the microcontroller ATmega328 (Arduino card).

Figure 9. Servo Motors circuitry.

Flow-chart

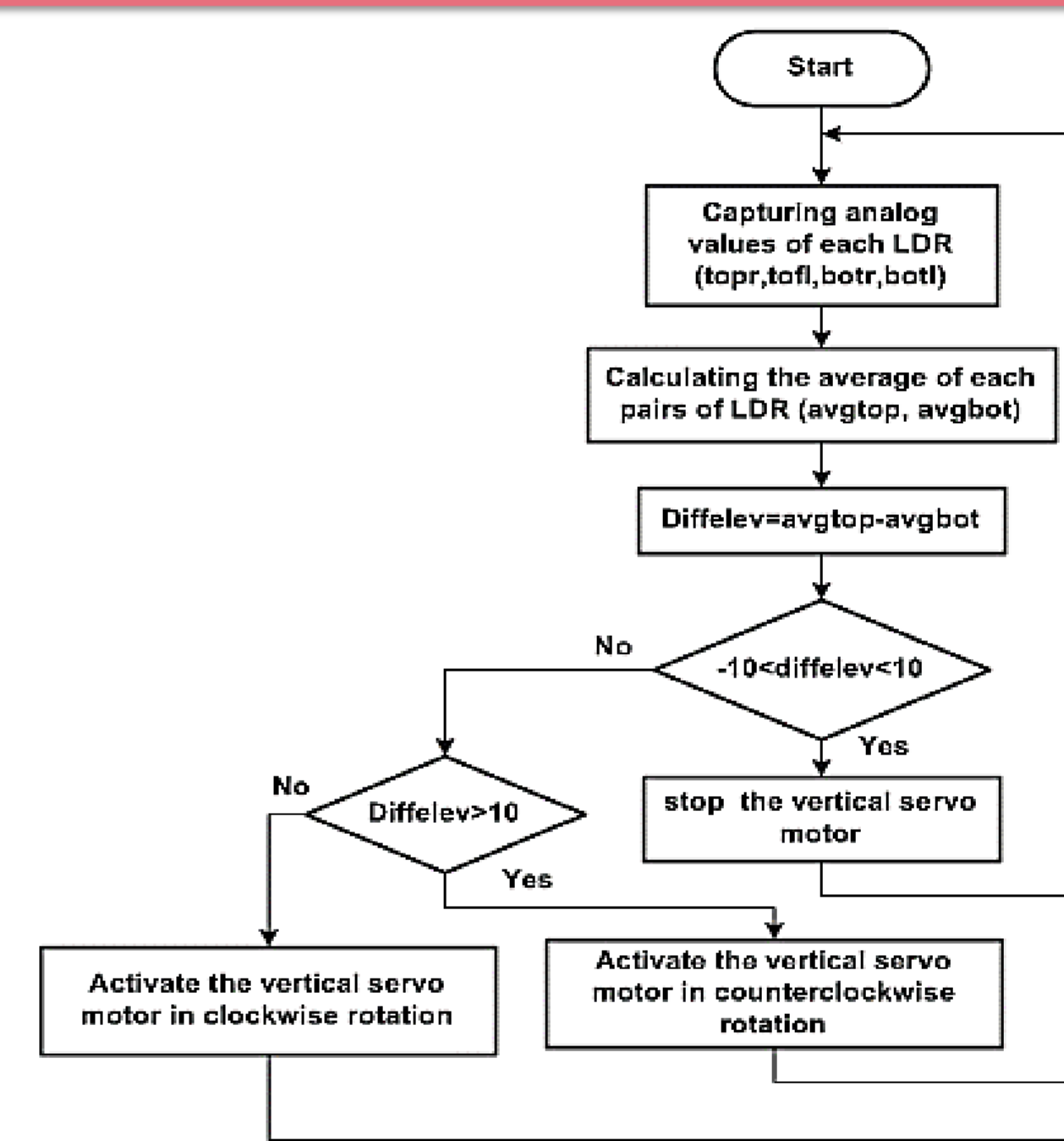


Figure 10. Process flow-chart for the microcontroller operation for movement in the vertical axis.

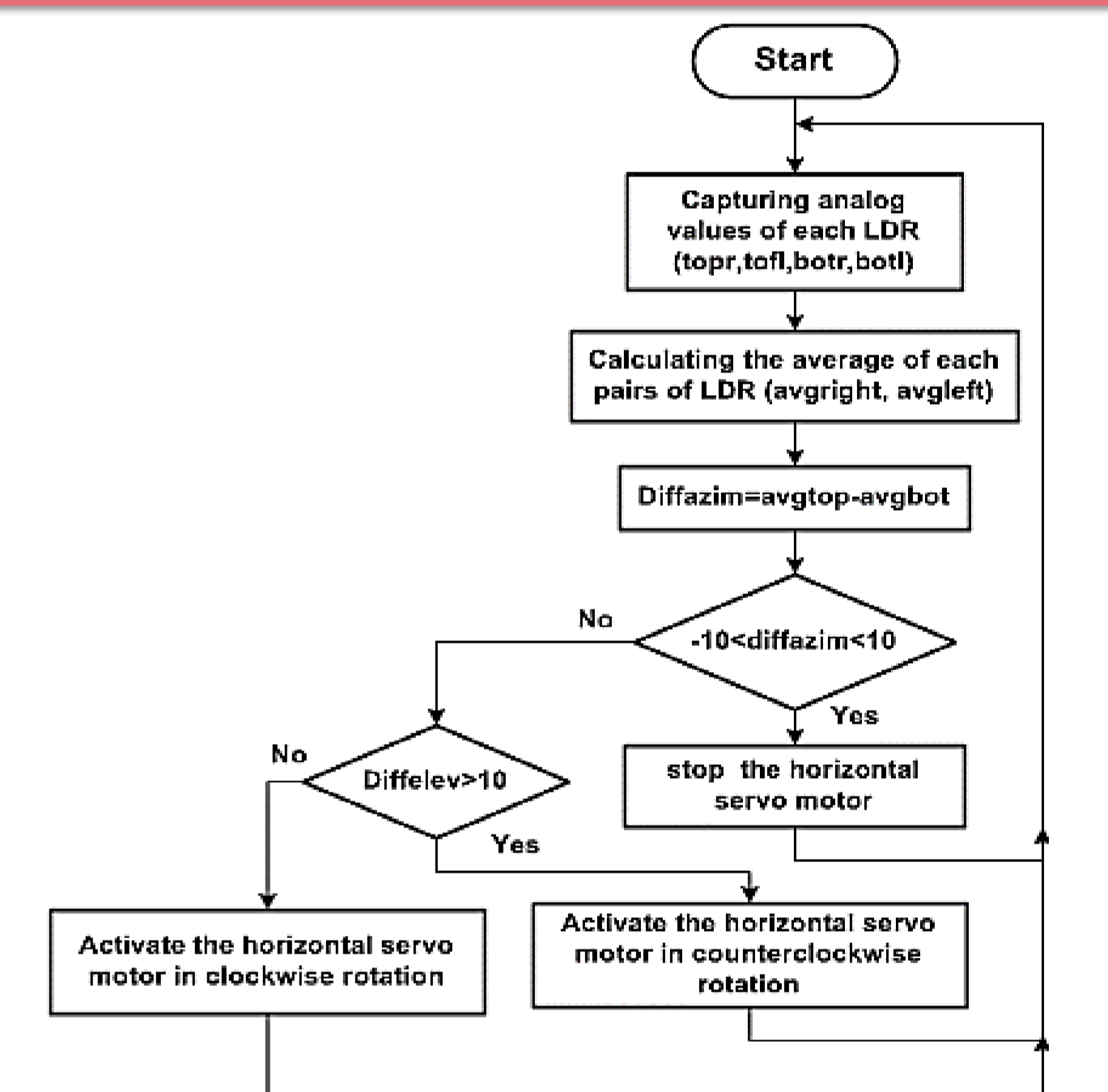


Figure 11. Process flow-chart for the microcontroller operation for movement in the horizontal axis.

Results

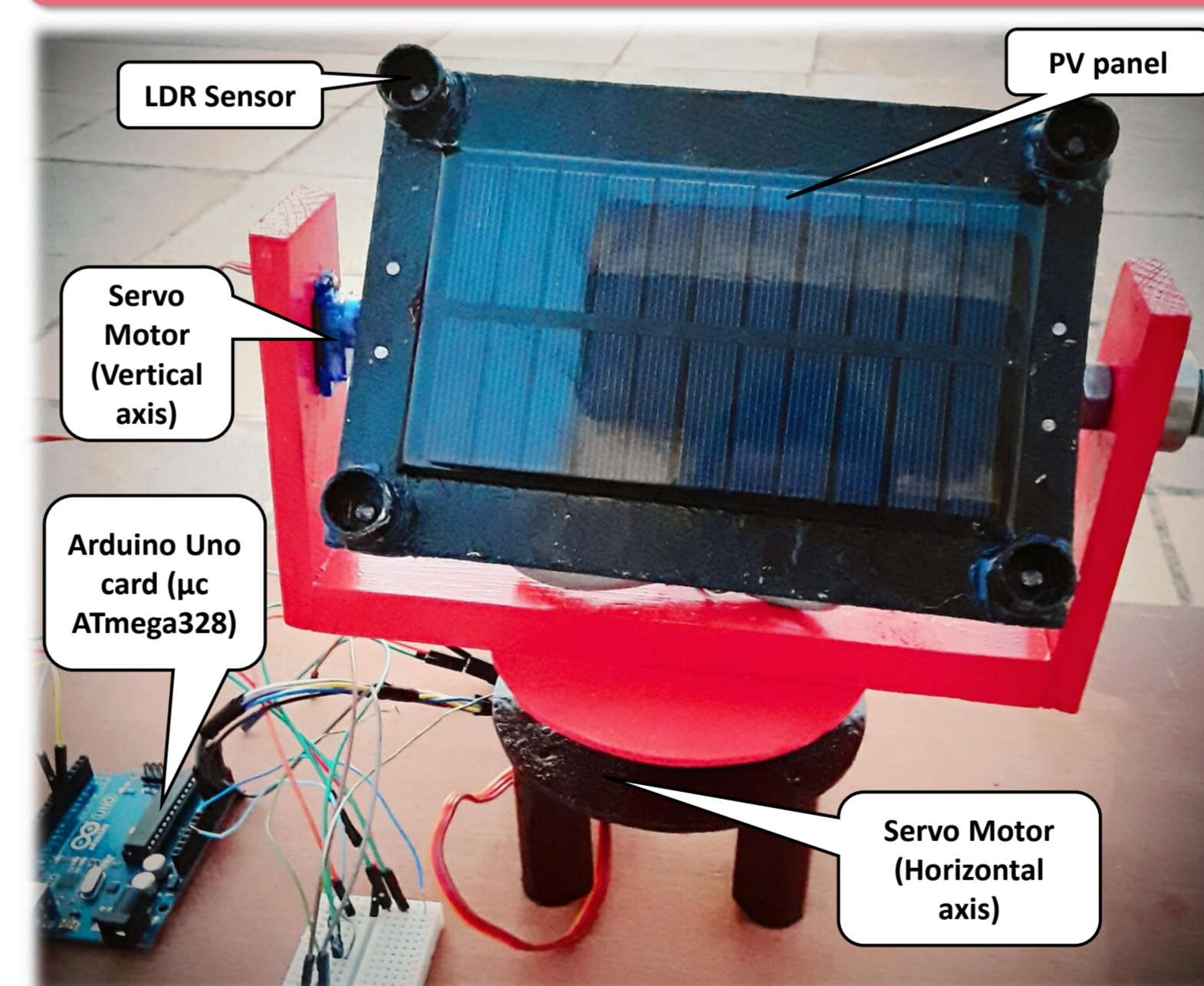


Figure 12. Proposed dual-axis solar tracker design (actual fabrication).

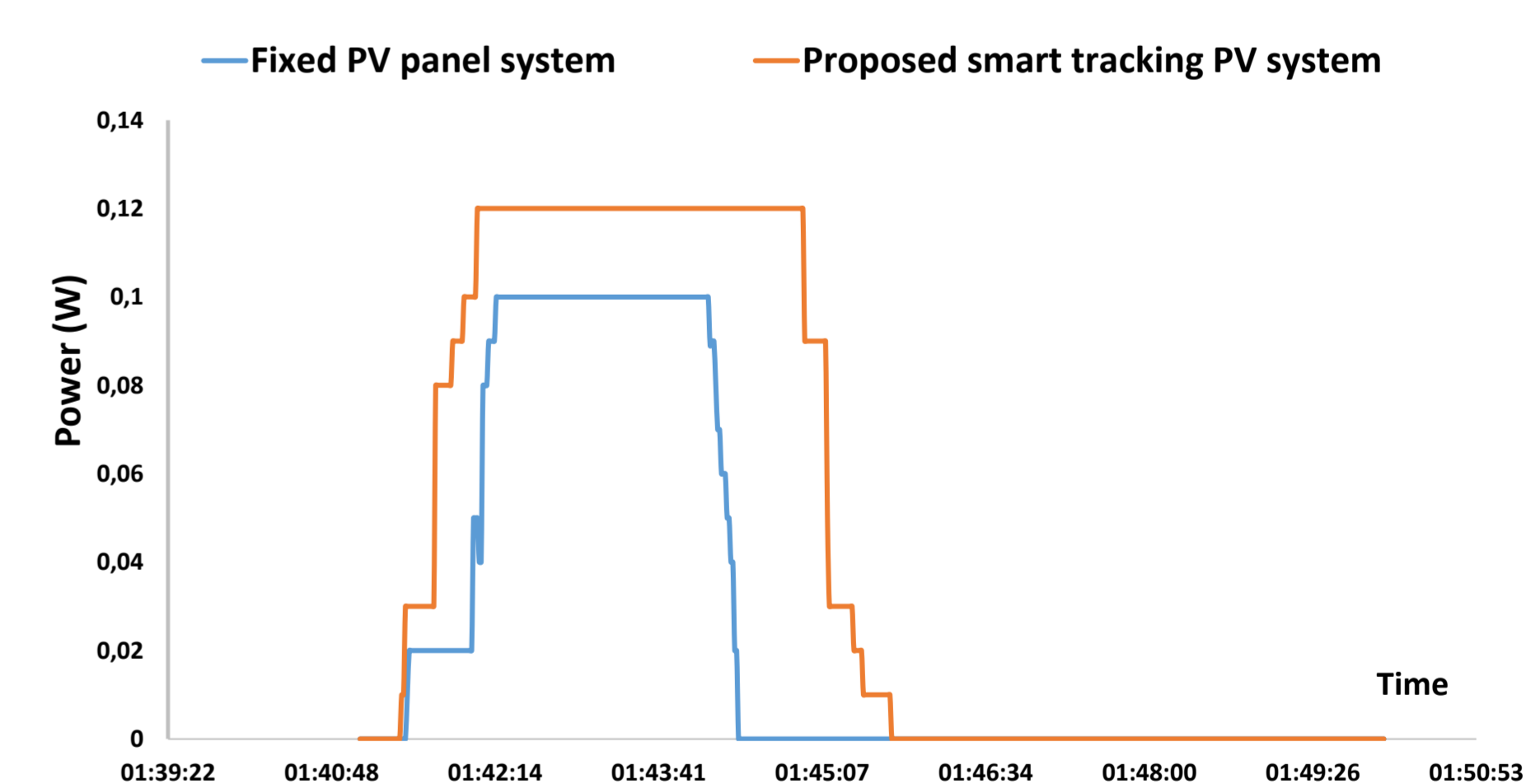


Figure 13. Fixed and dual-axis panel power comparison.

"From the experimental results (Figure 13), it is observed that the generation of the PV system, using the proposed smart tracker, is increased up to 44,57% when compared to the traditional fixed PV panel system."

Conclusion and Perspectives

The objective proposed at the beginning of this project was completed, achieving a higher efficiency than that of a fixed panel with the use of the solar tracking device.

The proposed intelligent solar tracking model is developed using the ATmega328 microcontroller. On the basis of the results obtained, it can be concluded that the system will react at its best, since maximum voltage is produced compared to a traditional fixed system. A good efficiency (44.57%) is obtained compared to the fixed PV panel.

With regard to the prospects for improvement, we can develop the following points: design of a complete double-axis solar tracking system (solar tracking, charge controller, battery ...) with a large panel, connect our system Via Internet "IOT" (i.e. make the system as a connected object).

References

Please, for more details and information, refer to our full papers:
1. Hammoumi, A. E., Motahhir, S., Ghzizal, A. E., Chalh, A., & Derouich, A. (2018). A simple and low-cost active dual-axis solar tracker. Energy Science & Engineering, 6(5), 607-620. <https://doi.org/10.1002/ese3.236>
2. Motahhir, S., Hammoumi, A. E., Ghzizal, A. E., & Derouich, A. (2019). Open hardware/software test bench for solar tracker with virtual instrumentation. Sustainable Energy Technologies and Assessments, 31, 9-16. <https://doi.org/10.1016/j.seta.2018.11.003>