Solar Tracker for Solar Panel

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Abstract

Solar energy is the main energy source in the solar system, its potential as an energy source has not been fully realized because of low efficiency of solar Photovoltaic cells. The main objective of this project is to increase the efficiency of solar Panels by using a micro-controller based solar tracking mechanism.

The project involved design and implementation of an automatic microcontroller based solar tracker system expected to be used with photovoltaic solar panels. The proposed single-axis solar tracker device functions to ensure the solar panel is optimally directed in accordance with the real position of the sun and therefore increasing the efficiency of solar panels.

The operation of experimental model of the device was based on a servo motor which is intelligently controlled by the pulse width modulated signals received from a microcontroller unit (MCU). The microcontroller receives input from light sensors which measure the intensity of the sun, and enables the motor to move the panel to a position at which it receives optimal power.

The performance and characteristics of the solar tracker device are experimentally analyzed in order to determine the efficiency of the fixed panel and the panel attached to the solar tracker, hence, enabling the determination of efficiency improvement when using the single- axis solar tracker.

Introduction

General Background

Although Solar power is considered as a very viable potential renewable energy source because the largest energy source available is the sun, which supplies practically limitless energy. The energy available from the sun far exceeds any foreseeable future demand.

The sun provides energy to sustain life in our solar system. According to [2], in one hour, the earth receives enough from the sun to meet its energy needs for a year, this is 5000 times the input to the earth's energy budget from all other sources.

Despite the immense energy output if the sun, harvesting solar energy has proved to be a great challenge because of the limited efficiency of solar cells. The efficiency of solar cells has been estimated to be between 10-20 percent. This project is based on the concept of improving this efficiency by means of a solar tracking mechanism.

The main purpose of a solar tracking system is to track the position of the sun in order to expose a solar panel to maximum radiation at any given time of the day, as mentioned. This is because the position of the sun with respect to the earth changes in a cyclic manner in the course of the year.

Solar tracking is seen to improve the efficiency of solar energy production. It has been shown that use of solar tracking improves the efficiency of solar energy production by up to 30-40%.

There are various types of trackers that can be used for increase in the amount of energy that can be obtained by solar panels. Dual axis trackers are among the most efficient, though this comes with increased complexity. Dual trackers are the best option for places where the position of the sun keeps changing during the year at different seasons. Single axis trackers are a better option for places around the equator where there is no significant change in the apparent position of the sun.

Problem Statement

The problem that is posed is the implementation of a solar tracking system that is capable of enhancing the efficiency of solar power collection by photovoltaic cells by up to 30-40%.

The circuit used a Micro-controller unit to control a motor which positions the solar panel optimally.

Project Justification

The main aim of this project is to implement a solar tracking system that ensures the sun rays fall perpendicularly on the solar PV panel and thus harness the maximum amount of solar energy possible. In doing so, increases the efficiency of solar cells.

The project seeks to solve the problem of accurate, efficient and economical micro-controller based solar tracking system that can be implemented within the available time and using available resources so as to track the motion of the sun.

Motor control using pulse width modulated (PWM) signals is generated by the MSP430G2553 micro-controller is effected to move the solar panel, directing it towards the sun.

Objectives

The project was aimed at achieving the following objectives

1. To design and implement a micro-controller based solar ultra-violet light tracking system that can direct a solar panel towards the sun
2. To show that the use of solar tracking increases the efficiency of solar panels considerably

Scope of the Project

The design of the project was limited to single axis tracking because of two reasons, firstly, there was the issue of cost and mechanical structure complexity. Secondly, there was the issue that since the tracker was to be used in Kenya, which is situated within the tropics, then the sun€s position does not vary significantly during the various seasons, in Polar Regions (North and south), then dual axis tracking becomes a necessity because of the changing position of the sun during various seasons.

The project also used servo motors because of the various advantages it poses, such as, low cost, smooth rotation at low speeds, usage of no power at stand-still, and high peak torque.

Also, embedded software was programmed into the MSP430 Micro-controller IC. The programming language used was C++ which is an object oriented language.

Literature Review

As mentioned in [1], solar power is considered as a very viable potential renewable energy source because the largest energy source available is the sun, which supplies practically limitless energy. The energy available from the sun far exceeds any foreseeable future demand.

The sun provides energy to sustain life in our solar system. Possible solar-energy systems may include home heating or power production systems, orbiting-space systems and steam- driven electrical power systems. The position of the sun in the sky is varied both with seasons and time of day as the sun moves across the sky.

The Orbit and Rotation of the Earth

The earth revolves around the sun once per year in an ellipti bit with the sun at one foci. As mentioned in [2], s uch distance from the sun is given by

9
1.5 ×

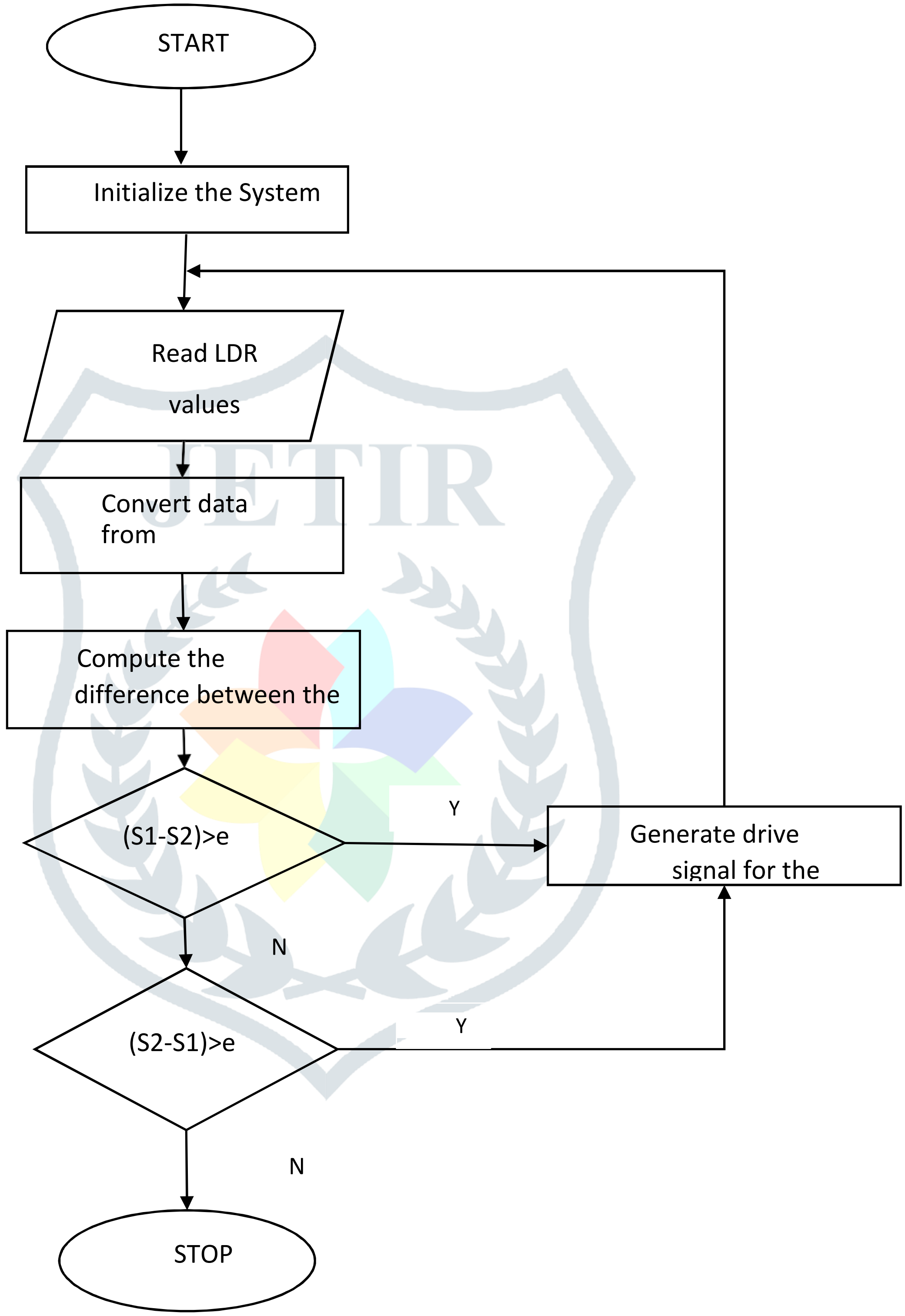
$$d == 1^{11}\left[1 + 0.0.0\ Sin\left(\frac{360(n -}{365}\right)\right]$$

Where n represents the day of the year, with January 1st as day 1. The earth also rotates on its own polar axis per day.

The polar axis of the earth is inclined at 23.45 degrees to the plane of the earth’s orbit around the sun. This inclination causes the sun to be higher in the sky in the summer than in the winter. It is also the cause of longer summer sunlight hours and shorter winter sunlight hours. The figure below shows the orbit of the earth around the sun, and declination at different times of the year.

Design and Implementation

The Flowchart for the Motor Control



Algorithm for the motor control

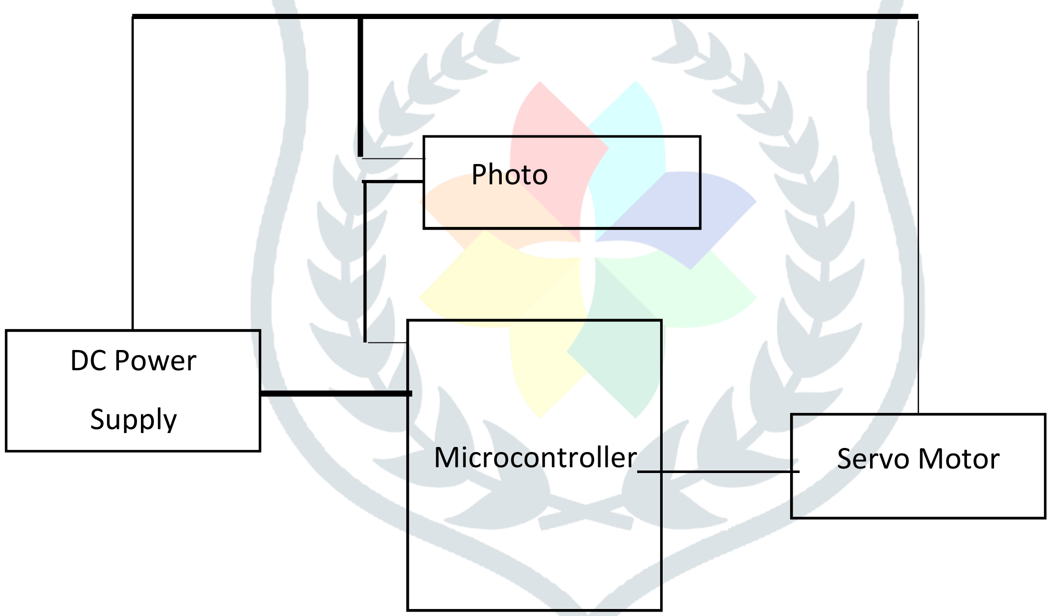
From the readings of the two Light Dependent Resistors (LDRs) are taken as input by the micro- controller.

The inputs are analog, they are converted to digital value in the range between 0-1023. The larger of the two values corresponds to the direction with more light intensity.

The two digital values are compared and the difference between them is obtained. This difference is the error that is proportional to the angle of the rotation of the servo motor.

The servo motor rotates until the difference becomes zero. That is, the two LDR voltages are the same. The PV panel is now facing the direction with the greatest light intensity.

Hardware Block Diagram



3.4 Light Sensor Design

These input stage of the solar tracker was designed keeping in mind that the MSP430G2553 microcontroller has a low supply voltage range of 1.8V to 3.6 Volts. A voltage divider circuit was used with the Light Dependent resistor connected to a voltage Vcc of 3.6V.

5.1 Conclusion

The aim of this project was to improve the efficiency of solar PV panels by use of a microcontroller-based solar tracking system. The designed and implemented single axis solar tracking system proved to be sufficient and was seen to improve the efficiency sufficiently.

The project was done within the allocated time and using the available resources to produce a low-cost but effective prototype that solves the problem at hand.

5.2 Recommendations

Since a simple and effective prototype of a solar-tracking system was implemented, several improvements can be done on it in future works to make it even better.

1. Use of a more powerful servo-motor in order to effectively carry commercial size solar panels. Since this was a prototype, a small servo was used due to cost constraints.
2. Incorporating sensors at the back of the panel mounting so as to detect sunlight during sunrise and sunset. With a few modifications to the algorithm, the solar tracking system can be made to turn off at sunset and turn-on at sunrise. This can effectively decrease the power consumption of the solar tracking system making it even more efficient.
3. Improving the design of the mounting and use steel which is strong enough to support more weight and can be made smaller, in order to allow more freedom of movement of the panel. The mounting used in the prototype limited movement to a span less than 120 degrees instead of the available 180 degrees allowed by the servo motor.