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Dual Axis Solar Tracking System Design and Implementation

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ABSTRACT: Solar energy is rapidly gaining notoriety as an important means of expanding renewable energy resources. As such, it is vital that those in engineering fields understand the technologies associated with this area. Solar tracking allows more energy to be produced because the solar array is able to remain aligned to the sun. For extraction of maximum energy from the sun, the plane of PV panel should always be normal to the incident solar rays. The seasonal movement of the earth affects the radiation intensity received on the PV panel. Sun trackers move the PV panel to follow the sun trajectories and keep the orientation of the solar panel at an optimal tilt angle. The efficiency of this system has been tested and compared with a single axial solar tracker. As a result, the two-axis solar tracking system generates more power, voltage and current.

KEYWORDS: solar panel, solar system, maximum power point tracking, dual axis tracking, charger controller.

1. INTRODUCTION

Solar energy system is the essential renewable energy sources especially for solarised countries. The green energy, also called renewable energy, has gained much attention nowadays. Some renewable energy types are solar energy, hydro potential energy, wind energy, biomass energy, terrestrial heat, temperature difference of sea, sea waves, morning and evening tides, etc [1].

Despite of solar energy being a good source of energy, it is needed to improve the methods to harness this energy. This can be achieved by using dual solar tracking system that has two degrees of freedom that act as axes of rotation. The axis that is fixed with respect to the ground can be considered a primary axis and the other axis that is referenced to the primary axis can be considered a secondary axis [4].

The current amount generated by a solar cell depends on its efficiency, its size (surface area) and the intensity of sunlight striking the surface [2].

One of the main methods of increasing efficiency is to maximise the duration of exposure to the Sun. Tracking systems help achieve this by keeping PV solar panels aligned at the appropriate angle with the sun rays at any time [3]. In dual-axis solar trackers track the sun position based on its solar azimuth and solar elevation angle. The solar azimuth angle is the horizontal angle measured between observer position and the vertical plane of the sun whereas solar elevation.

II. DEVELOPMENT OF DUAL AXIS SOLAR TRACKER SYSTEM

Human history ensures the man is closely linked to sun rays along the day time. Shortage of energy resources aims the scientists to utilize the solar energy generating the electric power. Two-axis tracking system changes both azimuth (horizontal) and altitude (vertical) degrees of solar panel. Schematic block diagram of the proposed solar tracker is shown in Fig. 1. Four LDR sensors are used to feedback from DC motors. LDR1 and LDR2, LDR3 and LDR4 are taken as pairs (please see Fig. 5). If one of the LDR in a pair gets more light intensity than the other, a difference will occur on node voltages sent to the respective ADC channels of the microcontroller [1].

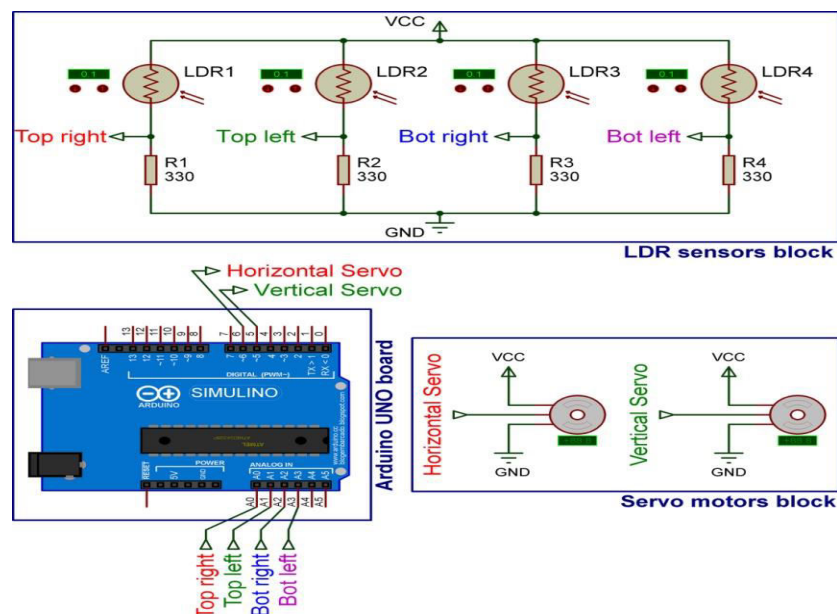


Fig.1. Block diagram of the solar tracker

Solar panel is fixed and erected with inclined angle. This angle is designed to utilize the sun rays for most hours of the day time. Researches design modified solar panel that is converted to tracker solar panel to move towards the sun rays during day hours by using light sensors. This denotes by single axis tracking solar panel system which includes dc converter to control the output power. Also, battery charger for power storage and controller is connected to fix the output voltage from the solar system [2].

Flow of Experimental Model :

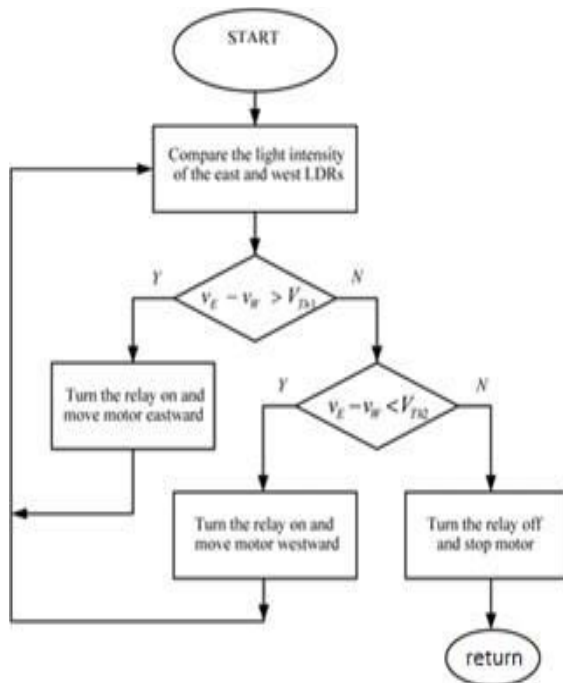


Fig. 2 Flowchart of south – north the tracking movement.

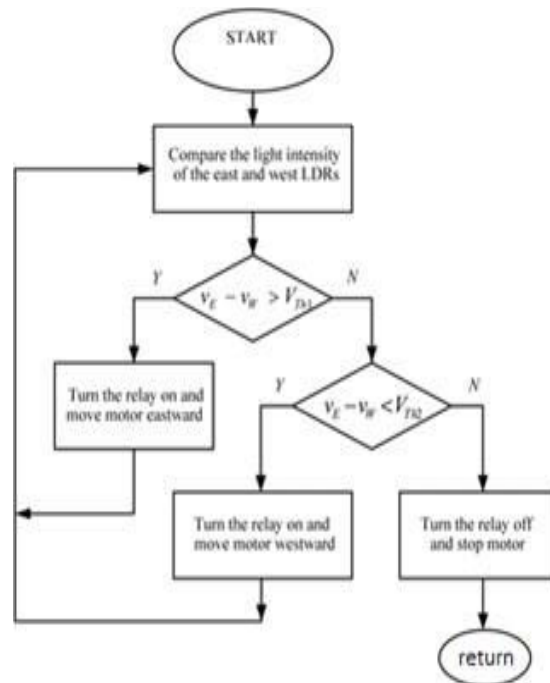


Fig. 3 Flowchart of east - west the tracking panel movement.

The electric system is included four sensors fixed on the panel. They detect the largest irradiation of sun rays and convert it into transferred signal to programmable unit which find the direction of motors movement in horizontal east-west or vertical north- south directions. Therefore, the panel is adjusted in the optimum position. Fig. 3 and Fig. 4 show the Flowcharts for tracking system activated by Arduino program and the block diagram of solar system [2].

III.EXPERIMENTAL SETUP

The proposed tracking system does tracking of sunlight more effectively by providing Solar panel rotation in two different axes. In dual-axis tracking system optimum power is achieved by tracking the sun in four directions. In this way we can capture more sun rays. Movement in two axes is explained with the help of figure which is explaining basic idea behind dual axis tracking. [5].

The dual axis working is similar as single axis solar tracker system but it capture the solar energy more effectively by rotating in horizontal as well as in vertical manure. The tracker model is composed of four LDR's sensors shown in, two gear motor. One set of sensors and one motor is used to tilt the tracker in sun's east west direction and the other set of sensors and other motor is fixed at bottom of the tracker is used to tilt the tracker in son's north-south direction [6]. Along with Solar panel, LDR sensor and gear motor we also required L298 Motor Driver.

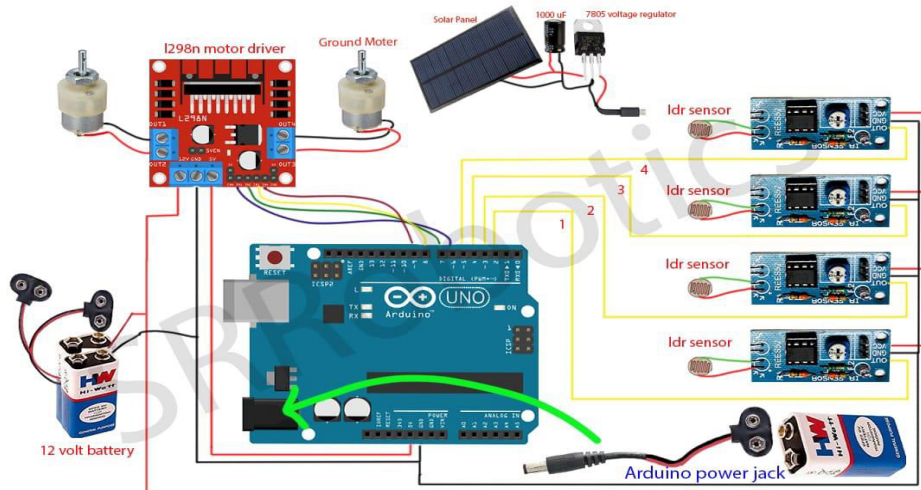


Fig. 4 Circuit diagram of Dual Axis Solar Tracker

With the help of above circuit diagram we design the hardware module of “Dual Axis Solar Tracker. Following are the steps of Hardware model Implementation of “Dual Axis Solar Tracker”.

Step 1: The miniature prototype tracker was constructed using materials like Particle board, Double-sided Tape and a few cutting tools [10]. For practical implementation of Dual Axis Solar Tracker, first take the wooden board base.

Step 2: Now take the 2 gear motors having speed of 10 rpm and 1 wheel for rotation. Grab the first gear motor under the wheel. Cut the wooden plane in small horizontal 3 strips and grab those wooden 3 strips on the rotating wheel.

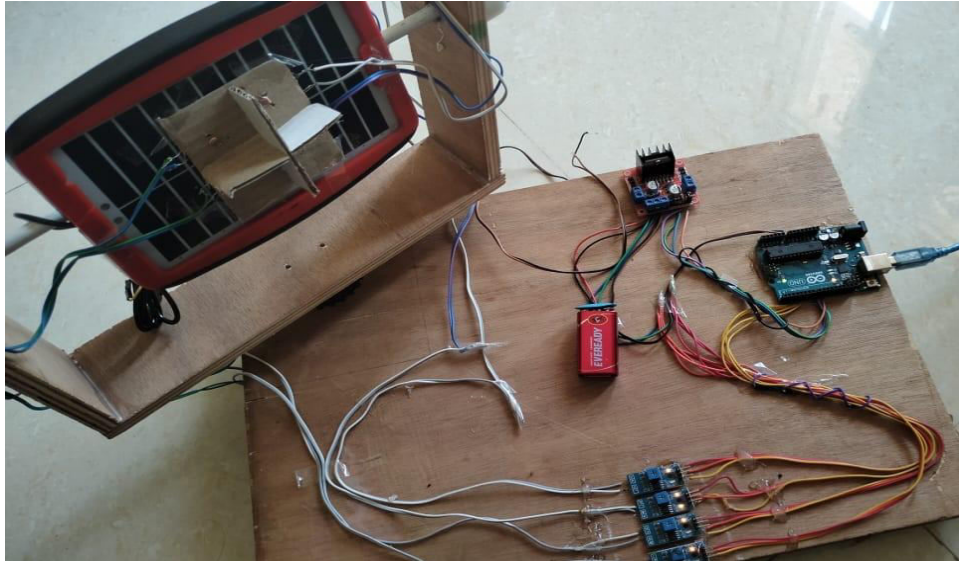
Step 3: Take another gear motor and 1 aluminium rod, connect the gear motor to the aluminium rod. Fix the aluminium rod in two wooden strips. Now take our solar panel and place the four LDR sensors in the centre of four side of solar panel. Grab the solar panel having 4 LDR sensor on the aluminium rod.

Step 4: Grab the 4 Port Terminal Block and the four 10,000ohm Resistors. Twist all four Resistors together and put them into one of the holes on the 4 Port Block. In the opposite hole screw in a Jumper. That jumper is our common Negative.

Step 5: Screw the Arduino into place using at least 2 of the M3 Screws and Nuts. One screw in front and one screw in back. We can also attach the Sensor Shield at this time. At this time, be careful not to break the pins on the Sensor Shield, but it might be necessary to slightly bend them into place.

Step 6: Attach the Servos to Arduino. This is easy to do via Shield's many inner pin rows. The Bottom gear motor goes to Pin 10. The Top gear motor goes to Pin 9. Make sure that we hooked up correctly with Red going to Positive, Black to Negative, and Yellow to Signal. Now we're going to hook up all six Jumpers coming off our Terminal Blocks.

Step 7: Common Negative (from the Five Port Block) can go to any of the GND (Ground) pins. Common Positive (from the four port block) can go to any of the 5V pins. Look at 5 Port Block. It should be in this order from left to right. Common Negative TL, BL, TR, BR. TL goes to Pin 2, BL goes to Pin 0, TR goes to Pin 3, BR goes to Pin 1.



Dual Axis Solar Tracker System Model.

IV. EXPERIMENTAL RESULT ANALYSIS

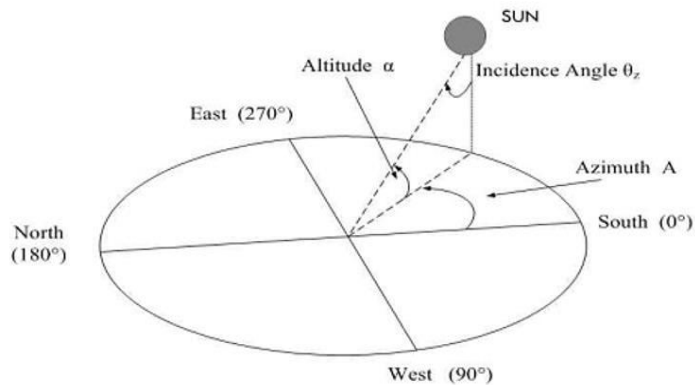


Fig. 5: Azimuth and Altitude angles.

Figure 7 shows the Azimuth and Altitude angles of from sun to the surface of earth. While testing the Voltage, Current and Power it is very important to know that the angle of Dual Axis Solar Panel from the sun. According to the change in direction of Sun the Current, Voltage and Power are varies.

OBSERVATION:

This was achieved using a system with three stages or subsystems. Each stage has its own role. The stages were:

- An input stage that was responsible for converting incident light to a voltage.
- A control stage that was responsible for controlling actuation and decision making.
- A driver stage with the gear motor. It was responsible for actual movement of the panel.

The input stage is designed with a voltage divider circuit so that it gives desired range of illumination for bright illumination conditions or when there is dim lighting. The control stage has a microcontroller that receives voltages from the LDRs and determines the action to be performed. The final stage was the driving circuitry that consisted mainly of the servo motor.

V. ADVANTAGES AND DISADVANTAGES

5.1 Advantages:

- Higher degree of flexibility, allowing for a higher energy output on sunny days.
- Solar energy is a clean and renewable energy source.
- Higher degree of accuracy in directional pointing.
- Dual axis solar system can store more energy than normal solar system.
- Solar cells are free of any noise. On the other hand, various machines used for pumping oil or for power generation are noisy.
- Dual axis solar system can fetch the solar energy from east to west as well as north to south.

5.2 Disadvantages:

- Solar panels can be costly to install resulting in a time lag of many years for savings on energy bills to match initial investments.
- Generation of electricity from solar is dependent on the country's exposure to sunlight. That means some countries are slightly disadvantaged.

VI. CONCLUSION

In this 21st century, as we build up our technology, population & growth, the energy consumption per capita increases exponentially, as well as our energy resources (e.g. fossils fuels) decrease rapidly. So, for sustainable development, we have to think alternative methods (utilization of renewable energy sources) in order to fulfill our energy demand.

In this project, Dual Axis Solar Tracker, we've developed a demo model of solar tracker to track the maximum intensity point of light source so that the voltage given at that point by the solar panel is maximum. Dual axis tracker perfectly aligns with the sun direction and tracks the sun movement in a more efficient way and has a tremendous performance improvement. Power Captured by dual axis solar tracker is high during the whole observation time period and it maximizes the conversion of solar irradiance into electrical energy output.

This project was implemented with minimal resources. The circuitry was kept simple, understandable and user friendly.

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