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Fabrication, Design, and Analysis of Dual Axis Solar Tracking System

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Abstract - Energy crisis is one of the prime issues in the third world developing country like Bangladesh. There is an enormous gap between generation and demand of electrical energy. Nearly 50% of the population of the country is extremely isolated from this blessing. Renewable energy is the only answer to solve this issue. Solar energy is one of the most effective resources of renewable energy which could play a significant role in solving this crisis. This research presents a performance analysis of the dual axis solar tracking system using Arduino. The main objective of this research is whether a static solar panel is better than a solar tracker or not. This work is divided into two parts, hardware, and software system. In the hardware part, four light dependent resistors (LDR) is used to detect the utmost light source from the sun. Two servo motors conjointly used to move the solar panel to maximum light source location perceived by the LDRs. In the software part, the code is written by using C programming language and has targeted to the Arduino UNO controller. The outcome of the solar tracker system has analyzed and compared with the fixed or static solar panel found better performance in terms of voltage, current and power. Therefore, the solar tracker has proved more practical for capturing the maximum sunlight supply for star harvesting applications. The result showed dual-axis solar tracking system produced extra 10.53-watt power compared with fixed and single axis solar tracking system.

***Key Words*:** Solar Pannel, Servo Motor, LDR

1.INTRODUCTION

The use of renewable energy resources in power generation has increased as they are environmentally friendly and abundant. These resources are alternatives to fossil fuels whose supply is in constant decline. Among renewable resources solar is the most vital resource as it is widely and easily accessible. Hence, the current significant research interest in solar energy resources, especially photovoltaic (PV) systems. Photovoltaic systems convert solar energy into electrical energy with the use of semiconductors. Though the use of PV is commonly associated with low conversion rates, years of testing and research have led to improvement of the conversion output of the PV system. Improved solar cells have been developed. Moreover, solar tracking systems have developed and preferred over conventional fixed PV systems. Design methods are a series of technical procedures employed in the generation of new or refining existing engineered systems/products. The use of design methods has the desired effect of bringing rationality and order to the otherwise ill-defined and ill-structured (1) process of systems' generation. Very important to this process is the functionalized approach. In the approach, design problems are conceptualized as Functions and the designed products as Structures. Thus, all design activities are functions. For instance, design objectives are restricted to functional objectives, so are design requirements (or product design specifications), and the functional analysis diagram leading to the morphological chart. Results from the two situations indicate a more organized and focused approach to parameters that bear on the ultimate performance of the product to be designed.

USES

Dual-axis solar trackers are mechanisms used in solar panel installations to orient solar panels, so they continuously face the sun, maximizing energy generation. Here are some of the key uses and benefits of dual-axis solar trackers:

1. 1. Increased Energy Production: Dual-axis trackers allow solar panels to follow the sun's movement both horizontally (azimuth) and vertically (elevation), optimizing the angle of incidence throughout the day. This results in increased energy capture compared to fixed installations or single-axis trackers.
2. Improved Efficiency: By continuously adjusting the orientation of solar panels to face the sun directly, dual-axis trackers maximize the amount of sunlight hitting the panels. This improves the overall efficiency of the solar power system, leading to higher energy yields.

3. Adaptability to Variable Sun Positions: Unlike fixed solar panel installations or single-axis trackers, which are optimized for specific times of the day or year, dual-axis trackers can adapt to the changing position of the sun throughout the day and across seasons. This flexibility ensures consistent energy production under varying solar conditions.
4. 4. Suitability for High-Latitude Locations: Dual-axis trackers are particularly beneficial in regions with high latitudes where the angle of the sun changes significantly throughout the day and across seasons. By continuously adjusting panel orientation, these trackers can capture more sunlight even at extreme latitudes, where the sun's path varies greatly.

2. LITERATURE REVIEW

1. Ashraf Balabel et al., (2013), International Journal of Control, Automation and Systems 26 2165–8285, reports on design and testing of control system to achieve optimal operational efficiency of solar photovoltaic module using a mathematical analysis. The proposed solar tracking system design was tested, based on calculated data of the altitude angle at Taif city, Saudi Arabia. The obtained system response results show the simplicity, accuracy and applicability of design in meeting different operational conditions.it is shown that the sun tracking algorithm can be classified into closed-loop and open-loop systems, according to its control mode.
2. K.S. Madhu et al., (2012) International Journal of Scientific & Engineering Research vol. 3, 2229–5518, states that a single axis tracker tracks the sun east to west, and a two-axis tracker tracks the daily east to west movement of the sun and the seasonal declination movement of the sun. Concentrates solar power systems use lenses or mirrors and tracking systems to focus a large area of sunlight into a small beam. PV converts light into electric current using the photoelectric effect. Solar power is the conversion of sunlight into electricity. Test results indicate that the increase in power efficiency of tracking solar plates in normal days is 26 to 38% compared to fixed plate.
3. K. Sreenivasa Rao et al., (2012), IJMER Vol. 2, 2012, 2249-6645 describes a project using ARM7TDMI processor, which does the job of fetching input from sensor and gives command to the motor to track the sun. The monitoring controller based on the closed loop algorithm is designed and implemented with ARM7 TDMI processor based LPC2148 controller in embedded system domain. Because of this maximum current is obtained from solar panel to maximize energy production.
4. Bhavesh Pandey (2012), IJIRSET, 2012, Vol. 1, discusses a system using a Programmable system on chip device to control a small model of solar tracker. Voltage across the solar panel and a photo resistor is fed as an input to the PSoC (Programmable System on Chip) to be processed and the output is fed to the geared DC motor. One microcontroller can be used to control many solar panels; only correct almost by a factor of information needs to be sent. Efficiency is increased.

3. SOLAR TRACKING

A solar tracking system is a mechanism designed to orient solar panels or solar collectors towards the sun to maximize the amount of sunlight they receive throughout the day. By tracking the sun's movement, these systems can optimize energy capture and improve the overall efficiency of solar power generation. Here's an overview of solar tracking systems:

Types of Solar Tracking Systems:

1. **Single-Axis Tracking:** These systems adjust solar panels along one axis (usually either horizontal or vertical) to track the sun's daily movement from east to west. Single-axis trackers can be either horizontal-axis or vertical-axis trackers.
2. **Dual-Axis Tracking:** Dual-axis trackers adjust solar panels along two axes, both horizontally (azimuth) and vertically (elevation), allowing for more precise tracking of the sun's position throughout the day and across seasons.

4. Components of Solar Tracking Systems

1. Support Structure: The framework or mounting system that holds the solar panels and allows them to move.
2. Actuators: Mechanical or motorized devices that drive the movement of the solar panels.
3. Sensors: Devices that detect the position of the sun or measure solar irradiance to control the tracking mechanism.
4. Controller: The control unit that processes input from sensors and commands the actuators to adjust the orientation of the solar panels.
5. Power Supply: Typically, solar tracking systems are powered by photovoltaic panels or grid-connected electricity.

5. METHODOLOGY

1. Resistance of LDR depends on intensity of the light and it varies according to it.
2. The higher the intensity of light, lower will be the LDR resistance and due to this the output voltage lowers and when the light intensity is low, higher will be the LDR resistance and thus higher output voltage is obtained.
3. A potential divider circuit is used to get the output voltage from the sensors (LDRs).
4. The LDR senses the analog input in voltages between 0 to 5 volts and provides a digital number at the output which generally ranges from 0 to 1023.
5. Now this will give feedback to the microcontroller using the Arduino software (IDE).

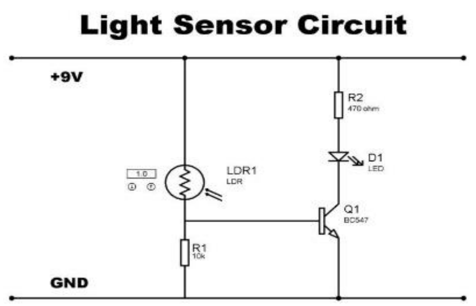


Fig -1: Circuit

BLOCK DIAGRAM OF SOLAR TRACKING SYSTEM

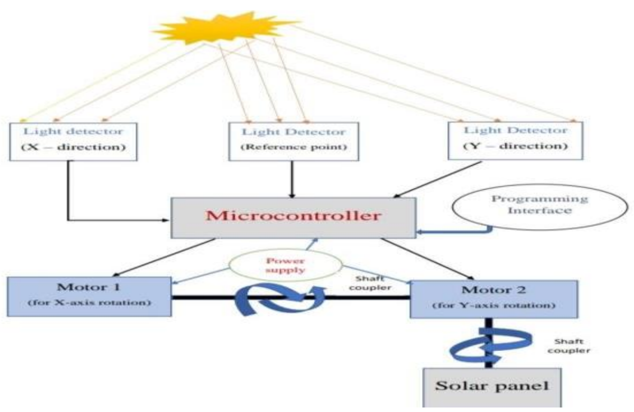


Fig -2: Block Diagram

As we see in the block diagram, there are three Light Dependent Resistors (LDRs) which are placed on a common plate with solar panel. Light from a source strike on them by different amounts. Due to their inherent property of decreasing resistance with increasing incident light intensity, i.e. photoconductivity, the value of resistances of all the LDRs is not always same. Each LDR sends equivalent signal of their respective resistance value to the Microcontroller which is configured by required programming logic. The values are compared with each other by considering a particular LDR value as reference. One of the two dc servo motors is mechanically attached with the driving axle of the other one so that the former will move with rotation of the axle of latter one. The axle of the former servo motor is used to drive a solar panel. These two-servo motors are arranged in such a way that the solar panel can move along X-axis as well as Y-axis. The microcontroller sends appropriate signals to the servo motors based on the input signals received from the LDRs. One servo motor is used for tracking along x-axis and the other is for y-axis tracking.

DESIGN OF SOLAR TRACKING SYSTEM

The Solar Tracking System assembly is created by using assembly modules, and the Solar Tracking System parts are modelled using part drawing characteristics. And the Design of this Solar Tracking system is carried out using the Solid Works – 2021 Software.

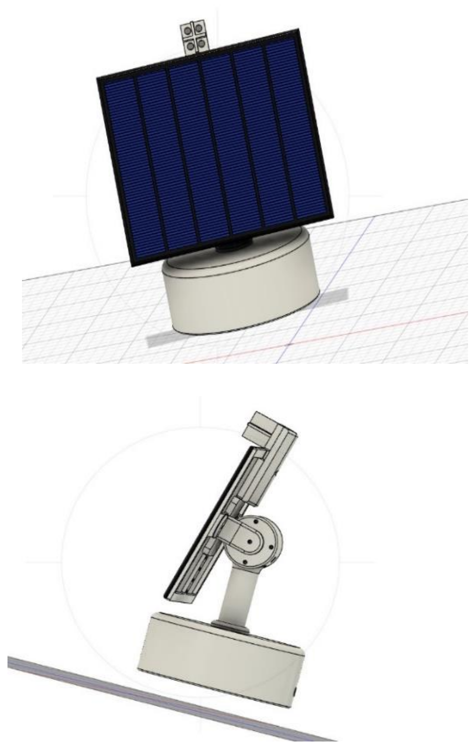


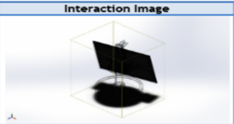
Fig -4: Design

ANALYSIS OF SOLAR TRACKING SYSTEM

Thermal Loads

Load name	Load Image	Load Details
Heat Power-1		Entities: 64 Solid Body (s) Heat Power Value: 200 W
Convection-1		Entities: 57 face(s) Convection Coefficient: 25 W/(m^2.K) Time variation: Off Temperature variation: Off Bulk Ambient Temperature: 300 Kelvin Time variation: Off

Interaction Information

Interaction	Interaction Image	Interaction Properties
Global Interaction		Type: Bonded Components: 1 component(s) Options: Independent mesh

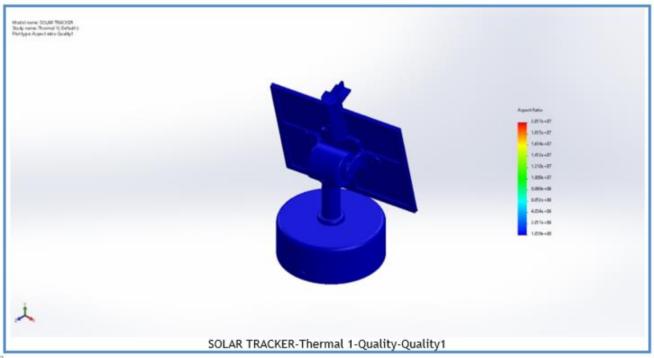


Fig -3: Thermal Analysis

6.OBSERVATION

In this Dual Axis Solar Tracker, when source light falls on the panel, the panel adjusts its position according to maximum intensity of light falling perpendicular to assistance of LDR depends on intensity of the light and it varies according to it. The objective of the project is completed. This was achieved through using light sensors that are able to detect the amount of sunlight that reaches the solar panel. The values obtained by the LDRs are compared and if there is any significant difference, there is actuation of the panel using a servo motor to the point where it is almost perpendicular to the rays of the sun. This was achieved using a system with three stages or sub systems. Each stage has its own role. The stages were.

1. An input stage that was responsible for converting incident light to voltage.
2. A control stage that was responsible for controlling actuation and decision making
3. A driver stage with the servo motor. It was responsible.

The input stage is designed with a voltage divider circuit so that it gives the desired range of illumination for bright illumination conditions or when there is dim lighting. The potentiometer was adjusted to cater for such changes. The LDRs were found to be most suitable for this project because their resistance varies with light. They are readily available and are cost effective. Temperature sensors for instance would be costly. The control stage has a microcontroller that receives voltages from the LDRs and determines the action to be performed. The microcontroller is programmed to ensure it sends a signal to the servo motor that moves in accordance with the generated error. The final stage was the driving circuitry that consisted mainly of the servo motor. The servo motor had enough torque to drive the panel. Servo motors are noise free and are affordable.

7. CONCLUSIONS

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 of 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. After a lot of trial and errors we've successfully completed our project and we are proud to invest some effort in our society. Now, like every other experiment, this project has a couple of imperfections.
(i) Our panel senses the light in a sensing zone, beyond which it fails to respond.
(ii) If multiple sources of light (i.e. diffused light source) appear on panel, it calculates the vector sum of light sources & moves the panel in that point.
This project was implemented with minimal resources. The circuitry was kept simple, understandable and user friendly.

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