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Design and Development of a Prototype for a Dual-Axis Solar Tracking System to Detect Maximum Power

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Abstract- **Solar panels are devices that convert light energy into electricity. These devices use sunlight to generate power. The Solar Panels work best when the sun's intensity is maximum. As the angle of the sun varies throughout the day and seasons, this affects the amount of electricity a solar power system will generate. To make the solar power systems work more efficiently, this project will include the design and construction of a microcontroller-based solar panel tracking system. Solar tracking allows more energy to be produced because the solar array can remain aligned to the sun. In this project, we will design a dual-axis solar tracker that allows solar panels to move on two axes, aligned both north-south and east-west. This type of system is designed to maximize solar energy collection throughout the year. This project will make use of the Light Dependent Resistor (LDR) which is important to detect the sunlight by following the source of the sunlight location. Arduino Uno microcontroller is used to control the motors based on LDR. This project discusses the development of a prototype for a dual-axis solar tracking system.**

1. INTRODUCTION

In this project electrical energy from solar panels is derived by converting energy from the sun rays into electrical current. To achieve maximum solar energy through solar panels digital automatic sun tracking system is proposed.

This system is built by using balanced concept of four signals from the different sensors. In this project we used Light Dependent Resistor (LDR) as a light sensor which is optoelectronic device is mostly used in light varying sensor circuit and in light and dark activated switching circuits. If the solar panel is not perpendicular to the sun it will create a variation in light intensities sensed by the light sensors, which are actually separated by divider who creates a shadow on one side of light sensor. Data will be received from the sensors and then the microcontroller Arduino will help in control the movement of the motors via motor driver IC (L298n). To confirm the solar panel is perpendicular towards the Sun Arduino will send the processed data to the Bi-directional DC-geared motor via motor driver IC (L298n). This Motor driver IC(L298n) controls the rotation of the motor either to rotate clockwise or anticlockwise, so solar panels attached to the motors will be reacted according to the direction of the motors. The position of the panel must always be perpendicular to the light source to get maximum intensity of light and zero voltage difference. The position of the sun will changes according to the position of installed solar tracker and make the panel no more perpendicular to the sun which affects the output power. Therefore, dual-axis solar tracking moves the solar panel to be always perpendicular to the sun. The tracker will track the sun throughout the years and maintain the output power generated by the solar panel.

The solar panel is aligned according to the intensity of sunlight under the control of the microcontroller. This microcontroller uses much less voltage than a DC motor, so, we need to Interface a DC motor with the microcontroller, usually H-bridge is the preferred way of interfacing a DC motor. An LDR is a component that has a (variable) resistance that changes with the light intensity that falls upon it.So in this project we have used four LDRs to sense the light falling on the solar panel is perpendicular to all four directions. So, the values of all four LDR should be the same to achieve the correct direction for the solar panel.

A DC geared motor is a device that uses DC electricity to produce mechanical energy. The energy in electric current causes the DC geared motor to spin. Any devices attached to the motor can then take advantage of this spinning motion to create another type of motion. In a gear motor, the magnetic current turns gears that are either in a gear reduction unit or an integrated gearbox. A second shaft is connected to these gears. Gear head or gear motor was used in solar trackers which has the advantage of producing high torque.

The amount of power available to a solar panel is proportional to the amount of light that reaches it. The more light it gets, the more power it produces. By using a single-axis solar tracker can only capture the minimum power tracking sunlight in one

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direction which is the elevation movements from east to west by rotating the structure along the vertical axis. The use of single-axis tracking can increase the electricity yield by as much as 27% to 32%, but by using a dual-axis solar tracker, it can capture the maximum sunlight in two movements at the same time, so, dual-axis tracking increases the electricity output as much as 35% to 40%. Dual-axis solar trackers allow for two degrees of flexibility, offering a much wider range of motion. The primary and secondary axes work together to allow these trackers to point the solar panels at specific points in the sky.

Figure 1 : Solar Tracking along both axes

II. LITERATURE REVIEW

For preparing the best design of Dual Axis Solar Tracker System, a lot of technical papers and reduction processes were studied before deciding upon the most feasible process for the project. The following list presents a list of the main papers referred to till now regarding the project. M.M. Abu Khader observed an experiment under Jordanian climate on the cause of utilizing two-axis sun tracking systems. They found that the power outcome improved by 30-45% compared to a static system for a particular day. Dhanalakshmi.V, Lakshmi Prasanna H.N presented a smart dual axis solar tracker. They used arduino uno for the development of their proposed model. After the experiment, they observed that maximum voltage was tracked about 25% to 30% and the generating power increased by 30% compared to a static system. Kacira overlooked the cause of a dual axis solar tracking with development of power energy compared to a fixed PV panel in Sanliurfa, Turkey. They found that everyday power gain is 29.3% in solar radiation and 34.6% in power generation for a particular day in the month of july. In 2017, Chaitali Medhane, Tejas Gaidhani implemented a microcontroller based dual axis model working on a solar panel. Through this model, they observed that the solar panel extracted maximum power if the solar panel was aligned with the intensity of light received from the sun. It improves the power output and also precautions necessary for the system from rain and wind. S.B. Elagib, N.H. Osman describes the development of a solar tracking system based on solar maps using microcontroller, which can forecast the real detectable position of the sun by latitude's location for maximizing the efficiency of energy level. Their main motive of this design was to work with minimal operator interaction in the isolated areas where there is lack of network coverage.

III. OBJECTIVE

1. To design a solar tracker that can work in X and y direction (dual axis).
2. Design with systems that work at most efficiency to give the desired output.
3. To install different kinds of sensors that will act as a feedback loop for proper functioning of the overall system.
4. The goal is to design in such a way that different components can be easily added and replaceable if required.
5. Aim is to design to have a simple and efficient algorithm which can better form in any circumstances.

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6.More Simplicity in design so that we can add additional panels in case required.

IV. PROBLEM DEFINITION

1. Problem is that solar trackers do not fluctuate continuously, which leads to use of unnecessary energy to drive the motors.

2. The constraint is to study different parameters and to summarise their data and to restrict solar plate motions motion in either direction to get maximum sunlight.

3. Challenges are how it works in case there is obstacle in direction of sunlight i.e. clouds in the sky or in case of lighting the idea is to make a smart system that will automatically gets shut down to save energy, the system will have to react wisely in rainy or lightning conditions

4. The different sections of design do not cause hurdles in order to add necessary components which are part of simple and compact design.

V. USED METHODOLOGY

During our project we have been through the following steps-

1. Study the literature related to Solar tracker design and its improvement in performance referring to various resources.
2. Obtaining design data of existing models of dual axis solar tracker and selecting the preferable design.
3. Selection of all hardware and software aspects of the system.
4. Modelling of the system as per design objectives.
5. Assembling the system as per designed model.
6. Checking the system performance under various conditions.
7. Rectifying any issues and finalizing the system.

VI. DESIGN AND DEVELOPMENT

The dual axis solar tracking system is divided into two sub parts: the electrical and mechanical system. The electrical system consists of all the electronic components connected to each other forming a circuit. While the mechanical system consists of all the mechanical components assembled to produce the required motion of the PV panel.

Electrical System- The electrical system performs three main tasks i.e sensing the signal, analyzing the signal and commanding the movement of the PV panel. The main components in this system are LDRs, Microcontroller, Motor Driver, Geared Motor and PV panel. This system can be explained easily by using a Flowchart.

Mechanical System- The solar panel rotates in horizontal and vertical direction and to provide this rotation the mechanical system is designed. This system includes Shaft, Support Plates and Base Plate. The shaft is placed between the two support plates and is connected to a gear motor. The PV panel is glued to the shaft to provide vertical movement to the panel. The horizontal movement is provided by the support plates and base plate in which the Support plates are glued perpendicular to the opposite sides of the base plate. To connect these components with the Gear motor a hole is drilled on the base plate to move the whole system on the horizontal axis.

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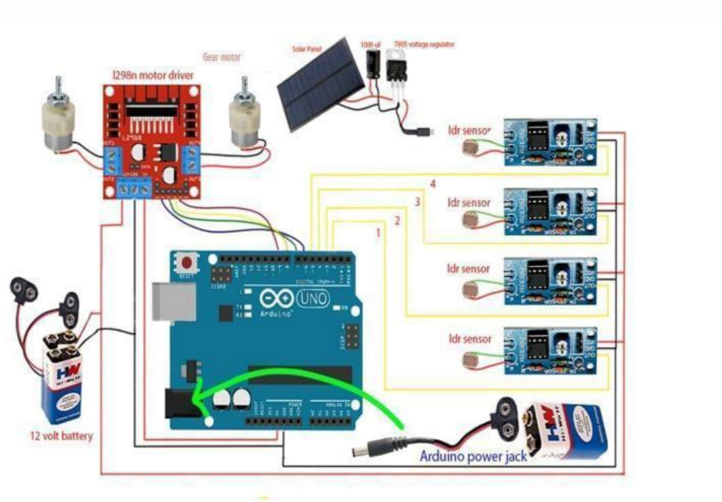

Fiureg 2 : Circuit Diagram

VII. SOFTWARE AND EQUIPMENTS

Assembly language is considered to be the best for projects that need minimum memory, the highest execution speed, and precise control of peripheral devices but since writing in this language is a tedious task with more knowledge in C programming, we choose to write our source code in the C language.This section is intended to give some basic introduction and useful information about the software and tools that we employed in to develop our system.

Software Implementation

The software implementation consists of coding the algorithm of the tracking system in the Arduino UNO environment and uploading it in the microcontroller. The algorithm is based on the analog values returned by the left LDR and the right LDR, as well as the top LDR and bottom LDR. For tracking, the average values from two right LDRs and two left LDRs are compared and if the left set of LDRs receive more light, the horizontal gear motor will move in that direction (Rotates Clockwise(CW)). The gear motor will continue to rotate until the difference result is between a positive threshold value (10) and a negative threshold value (-10), which means that the solar tracker is approximately perpendicular to the light source. If the right set of LDRs receive more light, the horizontal servo motor moves in that direction (Rotates Counterclockwise (CCW)) and will continue to rotate until the difference result is between 10 and -10. The same way is used for elevation tracking. We also determined the average radiation between the four LDRs, the idea being that at the end of the day, when the solar projection is null, the solar tracker returns to its initial position, waiting for a new day. At noon, when the sunlight is at maximum, the gear motors must be stopped. However, we found that the resistance values of the LDRs are not the same, even if they have the same reference and have been placed at the same right at noon in front of the sun. This means that the readings of the LDR voltages are not equal. Therefore, the difference between the average value of the left set of LDRs and the average value of the right set of LDRs will be unstable around zero, in which case the gear motor will constantly turn. This explains the use of the threshold value as a hysteresis band in the algorithm, which aims to reduce the power consummation and assuring smooth moves of the gear motor. That means if the difference result is in the hysteresis band, the horizontal gear motor always stops. And if the difference result is outside the hysteresis band ([-10, 10]), the gear motor will start to rotate CCW or CW.. The same principle is used for vertical gear motor operation. The use of the average values and the threshold in the algorithm make the solar tracker robust and also does not consume too much energy. The used algorithm is based on simple instructions that do not require extensive calculations. Low- cost microcontrollers can easily implement this algorithm in order to reduce the system cost.

VIII. RESULT ANALYSIS

The proposed model of the dual axis solar tracker is capable of tracking the sun throughout the year. The dual axis tracker provides higher output power when compared to single axis tracker and fixed panel. According to the measured readings the efficiency of the dual axis tracker is found to be 81.68% higher than that of fixed panel.

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	8	9	10	11	12	13	14	15	16	17	18
Static Panel	5.74	9.66	11.22	18.42	21.85	26	31.67	27.22	21.84	17.38	11.36
Dual Axis System	29.63	31.2	31.55	33.6	33.8	35.99	36.33	34.42	34.74	32.24	29.87

Figure 3: Graphical representation

IX. CONCLUSIONS

From this study the main conclusions obtained are:

1. Proposed system is low cost and compact as compared to the other tracking systems in use for the same application.
2. It is very easy to program and modify because it is Arduino based and no external programmer is required.
3. The designed system is automatic and provides better efficiency of the panel.
4. Reflection on the Solar panel has been decreased and the efficiency of solar energy generation is increased .
5. Solar trackers are slightly more expensive than their stationary counterparts, due to the more complex technology and moving parts necessary for their operation. But solar trackers generate more electricity in roughly the same amount of space needed for fixed tilt systems, making them ideal for optimizing land usage.

The purpose of renewable energy from this paper offered new and advanced ideas to help the people. It has been proved through previous research that a solar tracking system with single-axis freedom can increase energy output by approximately 20%, whereas the tracking system with double axis freedom can increase the output by more than 40%. Therefore, this work in this paper is to develop and implement a dual-axis solar tracking system with both degree of freedom and the detection of the sunlight using sensors. The proposed system is eco-friendly.

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