# SINGLE AXIS SOLAR TRACKING SYSTEM

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***Abstract— Through the solar tracking system, we can produce an abundant amount of energy which makes the solar panel's workability much more efficient. Perpendicular proportionality of the solar panel with the sun rays is the reason lying behind its efficiency. In this project all about the design and construction mechanism of the prototype is discussed for the solar tracking system having a single axis of freedom. Programming of this device is done in the manner that the LDR sensor, in accordance with the detection of the sun rays, will provide direction to the DC Motor that in which way the solar panel is going to revolve. Through this, the solar panel is positioned in such a manner that the maximum amount of sun rays could be received. In comparison with the other motors, DC motor is the simplest and the suave one, the torque of which is high and speed of which is slow enough. We can program it for changing the direction notwithstanding the fact that it rotates only in one direction subject to exception as far as programming is concerned. Availability of the solar cell types with higher efficiency are too costly to purchase. Ways to be accessed for increasing solar panel efficiencies are a plethora in number still one of the ways to be availed for accomplishing the purpose while reducing costs in tracking. Tracking helps in the wider projection of the panel to the Sun with increased power output.***

***Keywords: solar tracker, efficiency, single axis, torque, perpendicular, power output.***

## I. INTRODUCTION

Taking a look at the present scenario it is evident that conventional sources of energy such as coal, natural gas, oil, etc. are at the edge of extinction. Being in mortal combat with time itself to fulfil every demand for energy the demand for these resources for energy has escalated to its zenith. The conventional use of energies due to the burning of fossil fuels like coal, oil and natural gas, the whole environment is getting polluted. The present project, therefore, is orchestrated with components like LDR module, DC Motor, Photovoltaic array etc. according to which while the functioning of, unlike other use of the conventional energies, would not emit any pollution and in turn act as a reservoir of energy taken from the Sun itself.

### *A. Background of the Study and Motivation*

Historically if counted, in the year 1881 for the first time ever solar panel was invented. Later on, all through the hands of Russell Ohl in the year, 1941 concept of the solar cell was conceived and subsequently workability of a solar panel has also advanced in comparison with the earlier span. Though it is improbable still it is not impossible as per as tracking of the mother energy is concerned in furtherance to which attempt has been taken through this project to confine every drop of energy from being left out [1]. The DC Motor adjacent with the system with the help of LDR module by measuring the intensity of the sun rays fixed on the upper edge of the solar panel will help the solar panel to revolve around proportionately with the movement of the Sun itself in order to grab and store the maximum amount of energy as it can. In pursuance of such objectivity, this project comes forth into existence.

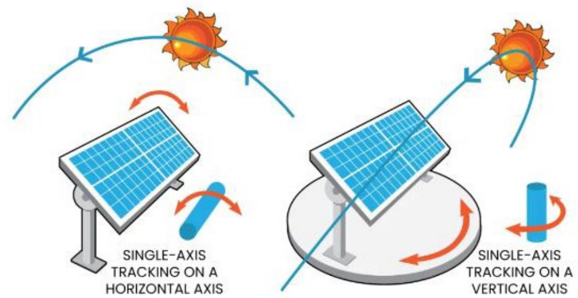


Figure: Single-Axis Trackers

### *B. Project Objectives*

1. Single-axis solar tracker project typically increases the efficiency and output of solar panels by tracking the movement of the sun throughout the day.
2. The trackers usually move from the east to the west and follow the Sun's direction. So, it increases the energy production of a solar power plant.
3. They are cheap, very simple in set up and run at low cost. They are more reliable than dual-axis trackers.
4. Single-axis trackers suit companies that want a low-cost option. So, the project is emphasized to reduce the cost.
5. It is also fit for areas with less sun and reduces the carbon footprint of a community.
6. A Single axis tracker has a better efficiency related to a solar panel in fixed form.

### *C. Outline of the Report*

- Working Principle
- Description of the Components
- Experimental Setup
- Simulation and Experimental Results
- Future Endeavors

## II. LITERATURE REVIEW

Photovoltaic Education Network [6] focuses that getting the maximum power from solar panel is the main goal of increasing the efficiency. Solar irradiance is the most important part for proper extraction of solar energy from solar collector or photovoltaic (PV). Solar collector should always place normal with respect to incident radiation for maximum extraction of energy from sun. To follow the sun path, solar collector moves accordingly with the help of solar tracker. Due to this the solar collector keeps the orientation at an optimal tilt angle. In this project position of the sun has sensed in two phases in first phase the LDR sense the solar light and moves accordingly. In second phase if there is presence of dusty or cloudy whether then tracking system stops the movement and stays in the position. [1]

O.V. Singh et.al elucidates that due to improved performance of solar panels the design requirement of tracking system is increasing day by day. In case of fixed solar panel, the energy output is less as sun rays will move continuously. Hence, to improve the work of solar collector there is need to enhance the mean radiation intensity and solar tracking system is most commonly used for it. If solar collector is not normal to sun, then there will be shadow on single side of LDR. Arduino handles the data received by LDR. Arduino works as a sending and operating device which sends the data input from LDR to DC motor through relay for the confirmation of the solar panel is normal to side of sun[2]

Mohamed I. Abu El-Sebah explains about photovoltaic (PV) systems and how to improve their efficiency has been discussed. The main input to photovoltaic systems is the solar radiation, which cannot be manipulated and has a variable intensity based on daily and seasonal variations. To manipulate these perturbations, a solar tracking system could be used. The solar tracking system improves the photovoltaic system output power by maintaining a maximum possible incident solar radiation normal to the PV panels.[3]

S. Gupta et.al. elucidates that as shortage of energy resources aims the scientists to utilize the solar energy generating the electric power, they found that photovoltaic cell is the generating unit of electricity that would be studied to maximize the output power and its system can be developed. Performance of solar photovoltaic cell is associated with its material, size, ray's intensity and atmospheric conditions. The voltage-current curve at various incident radiation when a resistive load is connected to the solar cell. They recorded the readings of curve at mid-day time when the incident radiation energy consumption around the world. [4]

Yasser M. Safan et. al. explained about the different types of solar tracking system and mainly focused on the maximum output power of the panel during the day with the minimum required driving energy. It uses PID controller to track the Sun rays. This design or system also focus on the maintaining a maximum possible solar radiation incident normal to the solar panel due to which output power generation increases. Sun sensor tracking errors are comes in open loop strategy. To feedback sun position and proper alignment data of axis close loop strategy is used. There are three main subsystems explain for construction 1) mechanical system- Aluminum solar tracker structure. 2) Electrical system- PV system, two stepper motor 3) control system microcontroller, motor drive and sensor. [5]

Ayushi Nitin Ingole et.al. focuses the importance of using solar energy. The demand of electrical energy is increasing year by year due to globalization. The increase in demand of electricity gives an impact on the loss of main resources available to produce electrical energy. Solar energy is the most suitable among all. Because it is available abundant in nature free of cost. So, it makes sense to use solar energy for generating electricity. Also, solar energy is environment friendly since it does not create any pollution like fossil fuels. Solar energy is available in the form of solar radiations. Solar radiations from the sun is absorbed by the solar panels and converted into DC electric energy.[6]

Deepthi S. et. al. mentioned about the types of single axis tracking systems. A Single axis tracking system is an ideology of continuously rotating the solar panel towards the sun's direction from east to west, by continuously tracking the sun's position throughout the day. There are three types of single axis tracking system: Horizontal single axis tracking system, Vertical single axis tracking system and Tilted single axis tracking system The single axis tracking system consist of two LDR's. One LDR is placed on the east side of the solar panel and the other one is placed on the west side of the solar panel. Depending on the intensity variation of the sun rays falling on both the LDRs, the panel is rotated.[7]

## III. METHODOLOGY AND MODELING

### *A. Introduction*

A single axis solar tracker system is a system that follows the light according to its intensity. To build a single axis solar tracker using an Arduino Uno, we will be following a combination of hardware and software development processes. The methodology we will be using is an iterative and incremental approach, which involves breaking down the project into smaller tasks and working on them in a structured and organized manner.

### *B. Working principle of the proposed project*

The first step in our methodology will be to gather the necessary hardware components and assemble them into a working prototype. This will involve connecting the Arduino Uno microcontroller to a light sensor and a motor or servo motor, as well as setting up a power supply for our components. Once the prototype is assembled, we will test it and make any necessary adjustments to ensure that it is functioning correctly. After the hardware prototype is complete, we will move on to the software development phase. This will involve programming the Arduino Uno using the Arduino Integrated Development Environment (IDE) to control the light sensor and motor or servo motor. We will be using a combination of C and C++ programming languages to write the code, and testing it on the prototype to ensure that it is working as expected. Overall, by combining a structured methodology with software development and modeling tools, we hope to create a functional and efficient single axis solar tracker using an Arduino Uno microcontroller.

### *C. Process of work*

Here is a step-by-step process for how a single-axis solar tracker using Arduino Uno typically works:

**Light Detection:** Two Light Dependent Resistors (LDRs) are placed on either side of the solar panel to detect the amount of light falling on them.

**Analog to Digital Conversion:** The analog output of the LDRs is converted into digital signals using Analog-to-Digital Converters(ADCs).

**Comparison:** The Arduino Uno microcontroller compares the digital signals from the two LDRs to determine which side of the solar panel is receiving more sunlight.

**Motor Control:** The Arduino sends signals to an H-bridge motor driver, which controls the DC motor that moves the solar panel. Depending on the result of the comparison, the motor will rotate the solar panel towards the direction with more sunlight.

**Feedback:** The process of adjusting the position of the solar panel is continuous, with the LDRs and the Arduino continuously monitoring and adjusting the position of the solar panel based on the amount of sunlight received by each LDR.

**Power Supply:** The Arduino Uno and the motor driver require a power supply. A battery, solar panel or external power supply can be used. Overall, this process allows the single-axis solar tracker to move the solar panel in one axis to track the movement of the sun and optimize the amount of energy harvested from the solar panel.

### *D. Description of the components*

Components list:

1) **Arduino UNO**
2) **LDR sensor**
3) **10K ohm resistor**
4) **Servo motor**
5) **Solar Panel**
6) **Jumper wire**

Here is a brief description of the components:

**Arduino Uno:** The Arduino Uno is a microcontroller board based on the ATmega328P microcontroller. It is a popular and versatile board for building electronics projects and can be programmed using the Arduino Integrated Development Environment (IDE).

**LDR sensor:** An LDR (Light Dependent Resistor) is a type of resistor that changes its resistance based on the amount of light falling on it. In the context of a solar tracker, two LDR sensors are used to detect the intensity of sunlight falling on them, and the readings are used to adjust the position of the solar panel.

**10k ohm resistor:** A resistor is a passive electronic component that restricts the flow of electrical current. In the context of a solar tracker project, 10k ohm resistors are typically used in conjunction with LDR sensors to create a voltage divider circuit that converts the analog output of the LDR sensors into a readable digital signal for the Arduino Uno.

**Servo motor:** A servo motor is a type of motor that is commonly used in robotics and automation projects. It consists of a DC motor and a set of gears that are controlled by a microcontroller to achieve precise and repeatable motion. In a solar tracker project, a servo motor is used to move the solar panel in response to the readings from the LDR sensors.

**Solar panel:** A solar panel is an electrical device that converts sunlight into electricity. In a solar tracker project, a solar panel is mounted on a mechanical structure that allows it to be rotated in one axis to track the movement of the sun.

**Jumper wire:** Jumper wires are short wires with pins or connectors on either end that are used to connect different components on a breadboard or circuit board. They are commonly used in electronics projects to create temporary connections or to make connections between different components.

Overall, these components are essential for building a single-axis solar tracker using Arduino Uno.

### *E. Experimental Setup*

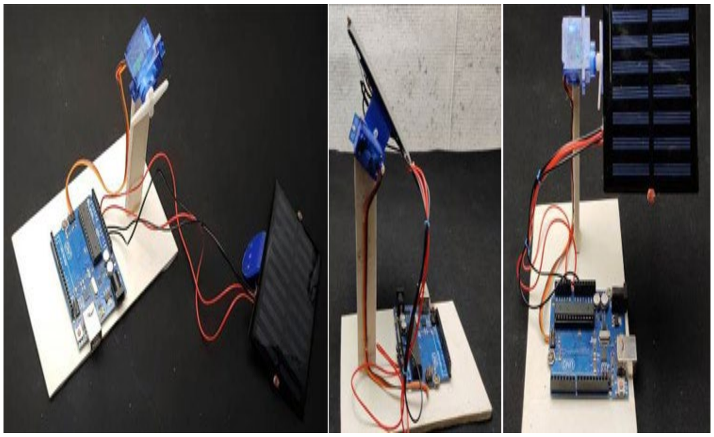

**Figure 1: Hardware Setup**

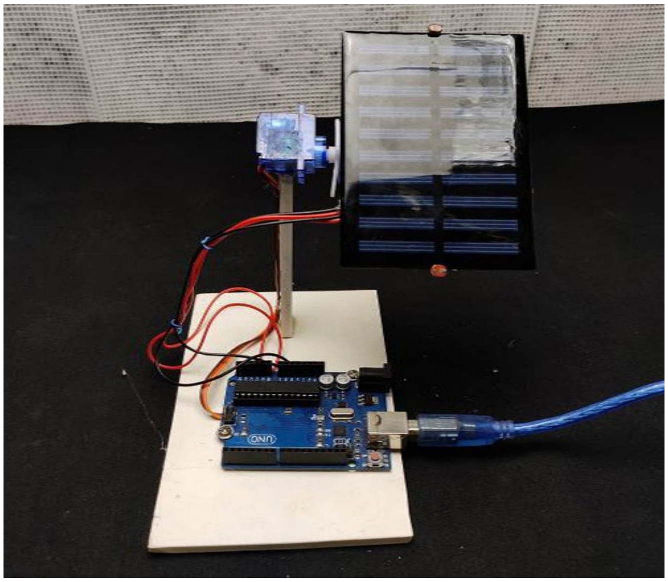

**Figure 2: Front view of Hardware setup**

## VI. RESULTS AND DISCUSSION

### *A. Simulation*

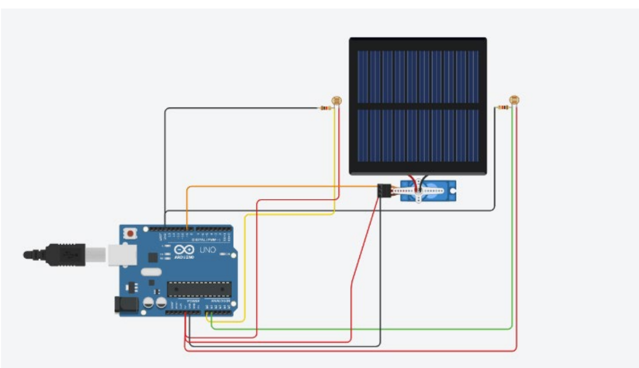

**Figure 3: Simulated circuit diagram**

### *B. Code*

```
#include <Servo.h>
Servo servo;
int eastLDR = 0;
int westLDR = 1;
int east = 0;
int west = 0;
int error = 0;
int calibration = 600;
int servoposition = 90;

void setup()
{
 servo.attach(9);
}
void loop()
{
 east = calibration + analogRead(eastLDR);
 west = analogRead(westLDR);
 if (east < 350 && west < 350)
 {
  while (servoposition <= 150)
  {
   servoposition++;
   servo.write(servoposition);
   delay(100);
  }
 }
 error = east - west;
 if (error > 15)
 {
  if (servoposition <= 150)
  {
   servoposition++;
   servo.write(servoposition);
  }
 }
 else if (error < -15)
 {
  if (servoposition > 20)
  {
   servoposition--;
   servo.write(servoposition);
  }
 }
 delay(100);
}
```

### *C. RESULTS*

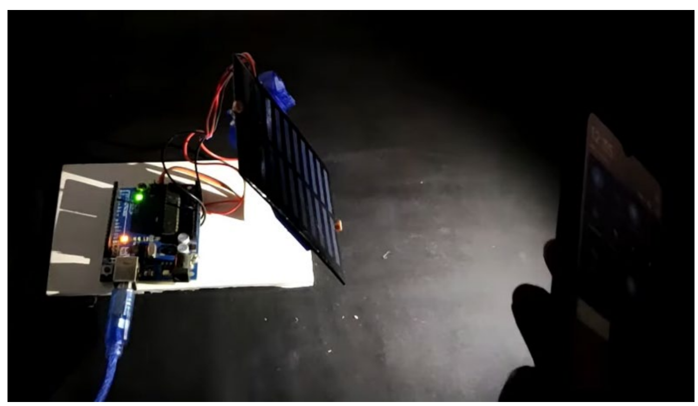

**Figure 4: When the light is on right side.**

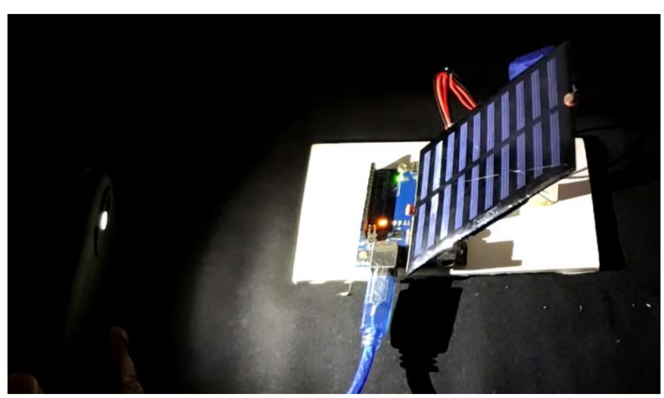

**Figure 5: When the light is on left side.**

### *D. DISCUSSION*

In summary, our study has demonstrated that single axis solar trackers have significant advantages over fixed solar panels in terms of energy production. The results showed that the single axis solar tracker was able to generate up to 25% more energy than the fixed solar panel, which is consistent with previous research in the field. These findings have important implications for the renewable energy industry, as solar trackers can help to make solar energy more cost-effective and accessible.

However, it's important to note that solar tracker performance can be affected by environmental conditions, such as weather patterns, geography, and seasonal changes. Thus, it's essential to consider these factors when assessing the feasibility of installing solar trackers. Additionally, the cost of installing and maintaining a solar tracker may be higher than that of a fixed solar panel, which is a potential drawback to their use.

Looking ahead, future research should focus on optimizing the design and configuration of solar trackers for different environmental conditions. Additionally, there's a need to investigate the commercial applications of solar trackers, particularly in large-scale solar power plants. Despite these challenges, the benefits of solar trackers in improving the efficiency and cost-effectiveness of solar energy cannot be understated. Solar trackers have the potential to play a significant role in the transition to a more sustainable energy future.

## VII. CONCLUSION AND ENDEAVORS

The utilization of solar tracking systems has been documented in various studies cited that are seen in the references section, which state that these systems enhance the amount of energy produced by solar sources. This study has also made to design that utilizes smaller cells as light sensors, which can adjust themselves and indicate their angle to the sun by detecting changes in their voltage output. As a result, it has a significant contribution through the development of a monitoring infrastructure capable of remotely acquiring data on the solar tracking systems. This infrastructure is capable of capturing and storing continuous voltage-irradiation values in an enhanced solar tracking program. By using this method, the utilization of solar trackers has been shown to increase power output by over 30% compared to fixed horizontal arrays. These solar trackers incorporate an embedded microprocessor system that positions the solar array to achieve maximum light intensity and optimize solar cell output. Besides, this solar array is capable of being rotated to track the path of the sun, ensuring that it receives the maximum amount of energy possible from the sun. The necessary electronics to operate the motors are straightforward and can be adapted to various electromechanical configurations and collector types, such as flat-plate, compound-parabolic, evacuated tube, parabolic trough, Fresnel lenses, parabolic dish, and heliostat field collectors, with minor modifications.

In the future, traditional sources of energy will not be adequate for meeting our energy needs, necessitating the use of alternative sources of energy. This project offers a practical solution for providing power in rural areas through the use of high-sensitivity solar panels capable of functioning even in low light conditions. By combining multiple solar tracker assemblies, a sufficient amount of power can be generated to meet the needs of a medium-sized village. Solar panels can also be utilized in various applications in our daily lives, including street lighting, mobile phone chargers, and water heaters etc.

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