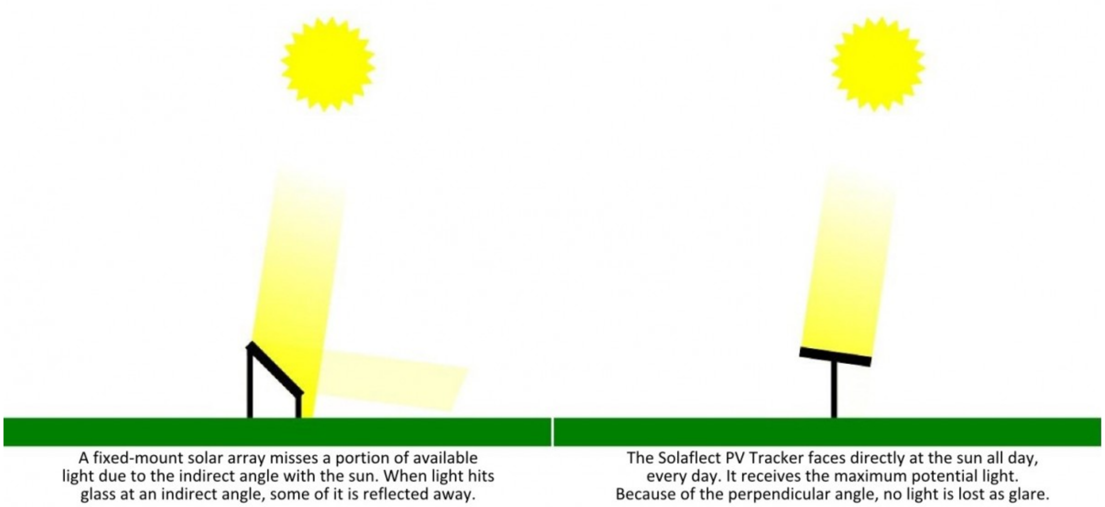
BCSE421L - Robotics

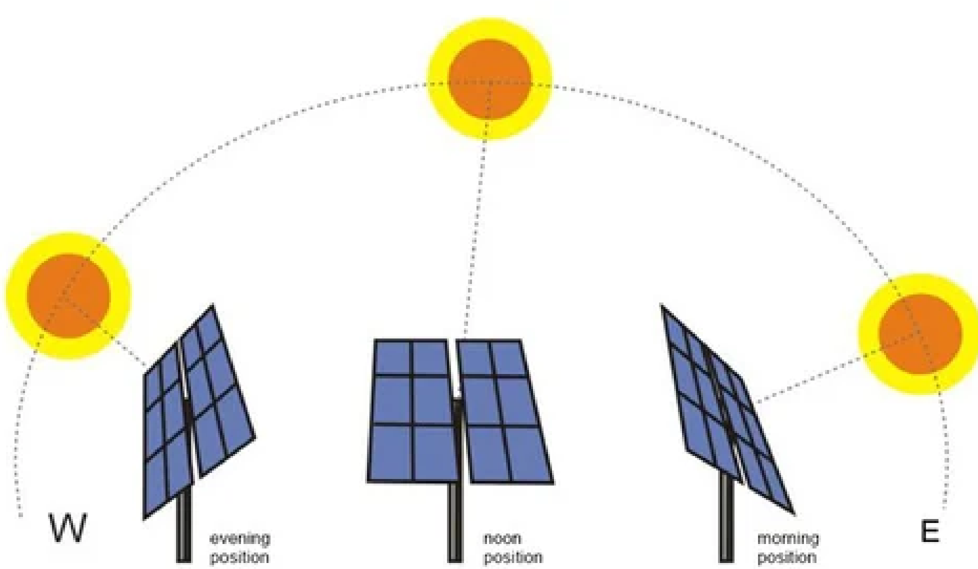
# The Solar Tracker


Chanakya Shivaji (21BRS1159)

Vishnu Sai.T (21BRS1221)

Sujitha.O (21BRS1271)

# Abstract

Solar energy being the largest renewable energy, we use solar panels to capture and use the solar radiation emitted by the Sun and convert it into electrical energy. The amount of sunlight falling on the solar panels determines the outcoming electrical energy. As most of the traditional solar panels are fixed in a single direction, the panel does not harness maximum energy most of the time.It is beneficial to set the solar panel facing the sun all the time to extract maximum energy.

In the following project we will be making a solar tracking system which helps to generate the maximum energy.

Solar tracker is basically minimizing the angle of incidence between the incoming sun rays and the solar panel.

We measure intensity of the light using LDRs (Light Dependent Resistor) with Arduino and compare the intensity of light falling on both LDRs.The LDRs are placed on the edges of the solar panel.The servo motor will be given a signal to initial a movement based on the light intensity falling on the LDR. When the light intensity captured by right LDR is higher than left, the servo motor turns the solar panel to the left and vice versa.

The solar tracking system increases the production of energy by 35%-40%.

In the following report we will see the construction and the working of the solar tracker in detail.

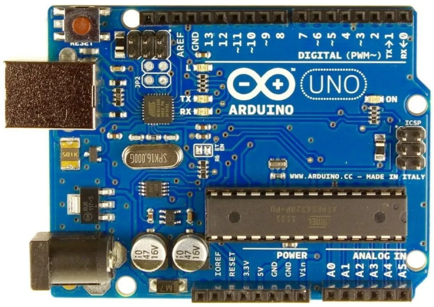
# Objective:

The main objective of this project is to maximize the usage of renewable energy and to reduce the consumption of non-renewable energy. This prototype helps in controlling climate change to an extent. And we focus on producing a solar tracker that can be easily installed on the current solar panel system without a lot of investing.

# Components

We use:

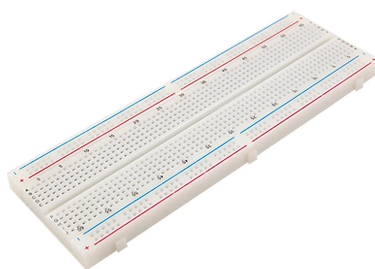
- Arduino Uno - microcontroller
- Servo motor - to initiate movement in the solar panel
- LDR - using resistance to measure the sunlight, the resistance of the LDR increases at high-intensity light
- Jumper wires
- Mini solar panel
- Resistors
- Breadboard





Arduino UNO Servo Motor LDR

Jumper wires Mini Solar panel



Resistors Breadboard

# Working:

In this project, we have presented the hardware and software used to make it a practical model. This prototype is an Arduino controlled dual-axis solar tracker. This solar tracker automatically rotates the solar panel based on the intensity of sunlight falling on the **4** LDR sensors and uses the servo motor to move the panels. An Arduino board is used to apply the software requirements to the system.

# Design:

The solar tracker consists of a PV panel, **4** LDR sensors, left-right rotating servo motors and up-down rotating servo motors. The solar tracker has **2 degrees of freedom,** left-to-right and up-and-down. The LDR sensors placed in the corners of the PV panel detect light through the dark tubes and pass the data to the microcontroller which then converts the analog signals into digital values. The dark tubes gather the light and work as radiation concentrators and increase the robustness(ability to overcome adverse conditions) of the solar tracker.

# Hardware:

Microcontroller connections:

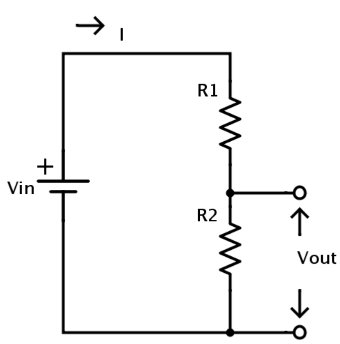
- Connect the 4 LDR sensors at A0, A1, A2, A3 analog pins of the microcontroller and convert them into digital values.
- Connect the left-right and up-down servomotors to 5 and 6 pins respectively, these servo motors are controlled using PWM signals.

## Servo motors:

- The two servo motors(left-right and up-down) with 180 degrees movement are used. (mention the model)
- Using these servo motors we can control the solar trackers about the vertical axis(left-right servo motor) and about the horizontal axis(up-down servomotor).
- To control the servo motors we don't need any drivers(a driver can control the robot that is connected to a computer, it uses a specific software interface to control the robot).
- The servomotors we used are controlled by the Arduino UNO board through 3-wire electrical cables, one wire for the Pulse-Width Modulation and 2 more wires for the voltage supply to control its position.

## LDR sensor:

- The LDR sensors are connected in the voltage divider circuit.(works as shown below).



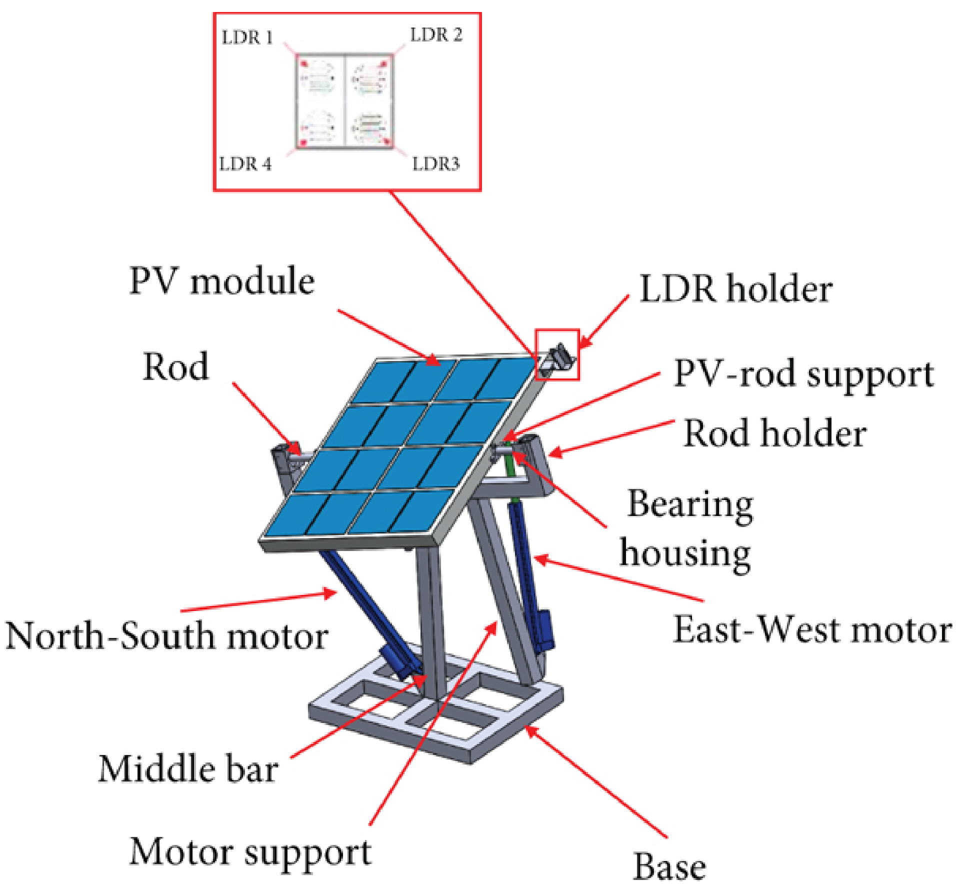

- The ground will be at 0V and the top of the potential divider will be at 5V, and the output of the divider is connected to an analog input of the microcontroller.

- The analog-to-digital converter(ADC) in the microcontroller reads the input from the analog pin and converts it into a digital value ranging from 0 to 1023 (total 1024=2^10 values). According to this value the light intensity is measured.

## Solar Panel:

- A solar panel is made up of many photovoltaic cells. “Photo” means “produced by light” and “voltaic” means “electricity produced by a chemical reaction”.
- In simple words, it’s the process of converting photons into electricity.
- A single PV device is also known as a solar cell.
- The photovoltaic cell contains a semiconductor most commonly silicon with a small number of impurities such as boron or phosphorus.
- A typical solar cell contains very thin semiconductor and is often less than the thickness of human hair.
- Each cell is connected by a circuit and designed into modules or panels. Sevel panels can be connected to form arrays. One or more arrays are connected to the electric grid.

## CAD Picturization:



## Software:

Code:

```
#include <Servo.h> // include Servo library


// 180 horizontal MAX

Servo horizontal; // horizontal servo

int servoh = 180;   // 90;     // stand horizontal servo


int servohLimitHigh = 180;

int servohLimitLow = 65;


// 65 degrees MAX

Servo vertical;   // vertical servo

int servov = 45;    //   90;     // stand vertical servo


int servovLimitHigh = 80;

int servovLimitLow = 15;


// LDR pin connections

//  name  = analogpin;

int ldrlt = 0; //LDR top left - BOTTOM LEFT    <--- BDG

int ldrrt = 1; //LDR top rigt - BOTTOM RIGHT

int ldrld = 2; //LDR down left - TOP LEFT

int ldrrd = 3; //ldr down rigt - TOP RIGHT
```

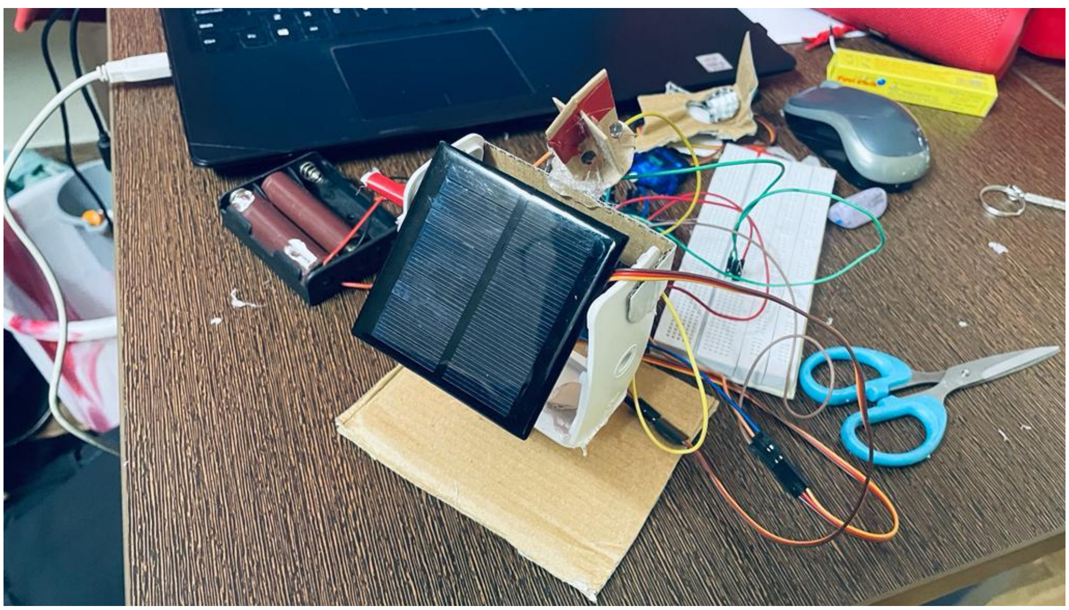
```
void setup()
{
  Serial.begin(9600);
// servo connections
// name.attacht(pin);
  horizontal.attach(9);
  vertical.attach(10);
  horizontal.write(180);
  vertical.write(45);
  delay(3000);
}

void loop()
{
  int lt = analogRead(ldrlt); // top left
  int rt = analogRead(ldrrt); // top right
  int ld = analogRead(ldrld); // down left
  int rd = analogRead(ldrrd); // down rigt

  // int dtime = analogRead(4)/20; // read potentiometers
  // int tol = analogRead(5)/4;
  int dtime = 10;
  int tol = 50;

  int avt = (lt + rt) / 2; // average value top
  int avd = (ld + rd) / 2; // average value down
  int avl = (lt + ld) / 2; // average value left
```

```
int avr = (rt + rd) / 2; // average value right


int dvert = avt - avd; // check the diffirence of up and down

int dhoriz = avl - avr;// check the diffirence og left and rigt




Serial.print(avt);

Serial.print(" ");

Serial.print(avd);

Serial.print(" ");

Serial.print(avl);

Serial.print(" ");

Serial.print(avr);

Serial.print("   ");

Serial.print(dtime);

Serial.print("   ");

Serial.print(tol);

Serial.println(" ");

if (-1*tol > dvert || dvert > tol) // check if the diffirence is in the tolerance else change vertical angle

{

if (avt > avd)

{

  servov = ++servov;

   if (servov > servovLimitHigh)

   {

    servov = servovLimitHigh;

   }
```

```
}
else if (avt < avd)
{
  servov= --servov;
  if (servov < servovLimitLow)
{
  servov = servovLimitLow;
}
}
vertical.write(servov);
}
if (-1*tol > dhoriz || dhoriz > tol) // check if the diffirence is in the tolerance else change horizontal angle
{
if (avl > avr)
{
  servoh = --servoh;
  if (servoh < servohLimitLow)
  {
  servoh = servohLimitLow;
  }
}
else if (avl < avr)
{
  servoh = ++servoh;
   if (servoh > servohLimitHigh)
   {
   servoh = servohLimitHigh;
```

```
    }
  }
  else if (avl = avr)
  {
    // nothing
  }
  horizontal.write(servoh);
  }
   delay(dtime);
}
```

## Our Working model:



## Research Gap:

- Despite the fact that there have been several studies on the design and implementation of 2-axis solar tracker, there is still a research gap in developing a low-cost2-axis solar tracker that can be easily integrated with the existing solar panel system.
- Recent research focuses on high-end, experimental solar tracking systems that are not easily accessible to the average consumer due to their high cost and complexity.
- On top of that, there is limited research on long-term, durable and reliable 2-axis solar tracker system
- Further research is needed to address these gaps and develop practical, working and cost-effective solar tracker solutions.

## Benefits:

- **Refined efficiency:** Solar trackers can improve the efficiency of solar panel system by redirectioning it towards maximum light capturing direction.
- **Increased energy Production:** A dual axis Solar tracker can increase the amount of energy produced by a solar panel system by 40% approximately, compared to a fixed solar panel system.
- **Reduced cost**: Though the solar tracker system is more expensive compared to the fixed panel system, the refined efficiency and increased energy compensate for the cost leaving us with more profit.
- **Reduction in usage of non-renewable resources:** Solar tracker can replace excess usage of non-renewable resources hence leading to reduction in carbon emissions. They can help to combat climate change and improve the air quality to an extent.
- **Reduction in water contamination:** Solar energy doesn't contaminate water unlike nuclear power plants, fossil fuels, etc.

## Real life application:

- When a sunflower follows the sun, it does that to get maximum sunlight. Hence in order to get maximum energy we need to follow the sun.
- A dual-axis solar tracker uses motors and gear trains to adjust the solar panels. They use a gearbox called slewing drive, which holds the radial and axis positions of the solar panel to manage their movement.
- The solar tracking systems are more suitable for large industrial installation than residential rooftop systems as industries need more efficient production of energy and these tracker systems require a lot of investment and maintenance.
- Also the tracker system needs to be offset from the rooftop as they need space and proper support to rotate the panels.
- A lot of engineers have come up with various ways to make use of solar tracking systems.
- The latest update is a “**Solbot**”. The Solbot is an AI robot that moves on a railroad-like trail checking each panel's position and correcting it, this prototype is built by Qbotix.
- Traditionally, the dual axis solar panels are connected to heavy motors and controllers to do the rotating. But using a Solbot, we don't need the costly motors and controllers.

- A Solbot needs to be charged for every 40 minutes, and in that 40 minutes it can manage up to 200 panels that can generate 300 kilowatts of energy.
- The dual-axis trackers can be expensive but are more efficient than single-axis trackers.
- Although these dual-axis trackers need high maintenance due to their complexity and have a shorter life span.
- Based on your need,budget and the climate at the solar fields, we need to choose the suitable solar tracker system.

## References:


https://www.researchgate.net/publication/353243579_Design_and_Implementation_of_Low_Cost_Dual_Axis_Solar_Tracking_System_using_Microcontroller

https://www.researchgate.net/publication/348146522_A_Microcontroller_Based_Dual_Axis_Tracking_System_for_Solar_Panel

https://www.researchgate.net/publication/304658624_Solar_Energy_-_The_physics_and_engineering_of_photovoltaic_conversion_technologies_and_systems

https://www.researchgate.net/publication/41117169_Solar_Energy_Engineering_Processes_and_Systems_Second_Edition