Microcontroller based Industrial Applications

Project Report

Project Title: Dynamic Solar-Panel Positioning System

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Introduction

A solar panel is a device that uses photovoltaic (PV) cells to transform sunlight into electricity. Materials used to create PV cells produce electrons when exposed to light. Direct current (DC) electricity is created when electrons go through a circuit; this electricity can power various devices or be stored in batteries. PV modules, solar electric panels, and solar cell panels are further names for solar panels.

With the use of solar photovoltaic cells, we can easily generate solar power from the sun, which is a bountiful supply of energy. Additionally, the photovoltaic effect transforms solar energy into electrical energy. So, in order to harness this solar energy even more effectively, we deployed sun trackers, which can adjust their function in accordance with the sun's rays and create routes that are parallel to the sun.

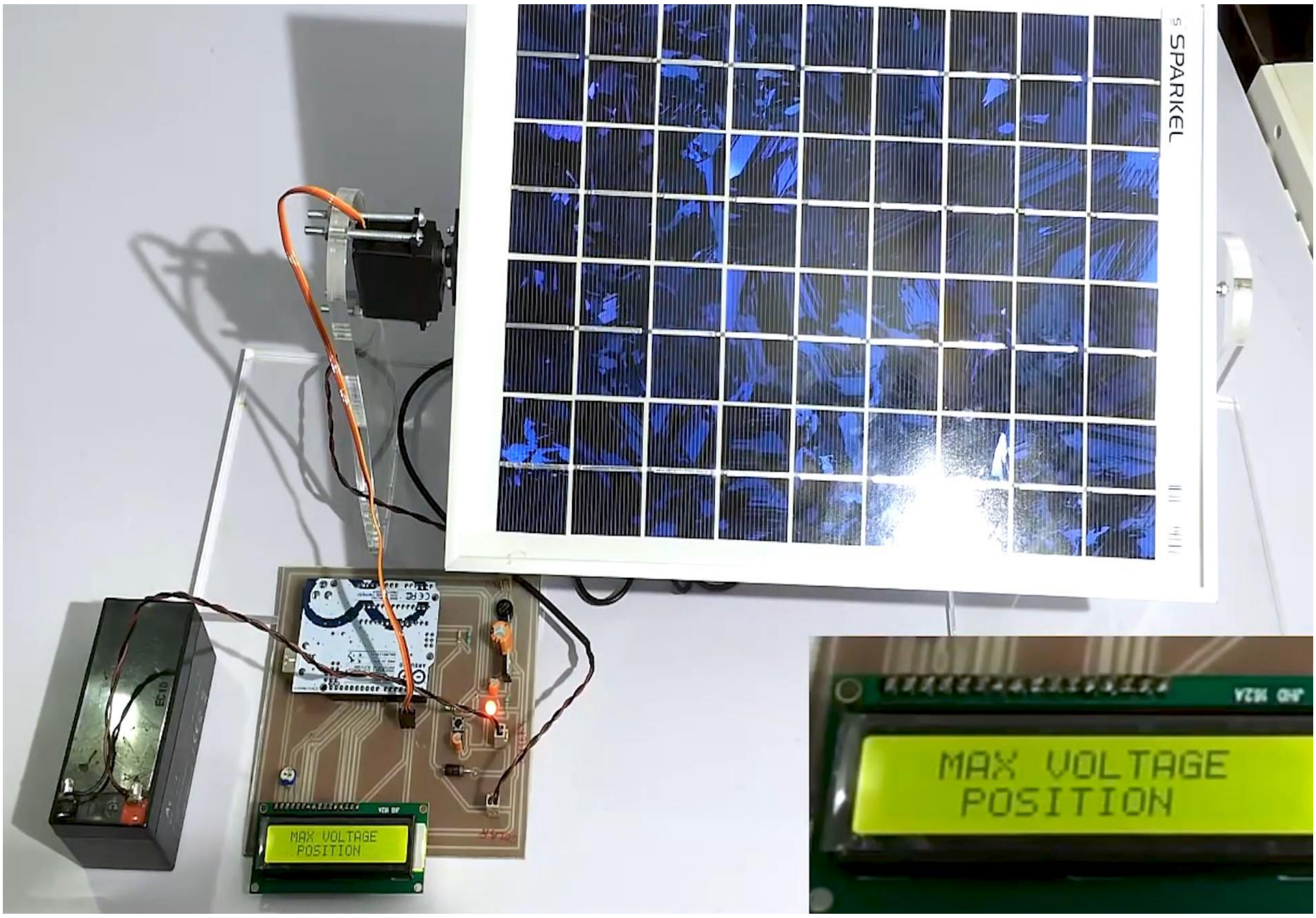
Solar-Panel Positioning System (Solar Tracker) provides the low-cost gadget using software-based solutions. One of the main obstacles the operation must overcome of photovoltaic panels (PV) is overheating as a result of extreme ambient temperatures and excessive sun radiation.

Solar-Panel Positioning System

A device that tracks the sun's path across the sky is called a solar panel positioning system (solar tracker). Solar panels that are connected to solar trackers can track the sun's path and generate additional renewable energy for your use. Because less light is reflected in this way, more solar energy is captured by the panels. A solar PV panel may produce more energy the narrower the angle of incidence.

Surprisingly, more light enters the panels when they are positioned perpendicular to the sun.

For positioning solar PV panels so they face the sun and can absorb as much sunlight as possible, solar panel positioning system (solar tracker) is utilized. Because fixed systems are not intended to trace the sun and orient to an ideal angle, their total energy productivity has historically been compromised. New systems called solar trackers can move to "track" the sun's path over the entire sky, allowing them to capture the sun's maximum light and increase the panel system's energy output.



I. Problem Description:

Develop a microcontroller-based solar panel positioning system that offers maximum energy capture from sun-light.

A Solar Panel Positioning System is primarily designed to ensure that solar panels are oriented in the most optimal position to capture maximum sunlight, thereby producing maximum electricity.

These systems can range from basic manual adjusters to sophisticated tracking systems that automatically adjust the panel's position based on the sun's trajectory.

Energy demands in the recent years have been recorded to be growing at an exponential rate by the commercial and as well as domestic markets. While the non-renewable resources are rapidly getting depleted, it leaves no other option but to use renewable resources to produce usable energy. One of these resources, the Solar energy is the most abundant and easy to harness resource through Solar panels. This project makes this process of harnessing solar energy more efficient.

A Solar Panel Positioning System is crucial for harnessing the maximum potential of solar panels, ensuring consistent energy output.

Such systems play a pivotal role in making solar energy more competitive and viable as a primary energy source.

Solar Panel Positioning System (Solar Tracker)

1) A solar tracker is a tool that orients a solar panel closer to the Sun.

2) The reason of a monitoring mechanism is to follow the solar as it moves across the sky.

3) Trackers are used to limit the perspective of prevalence between the incoming sunlight and a photovoltaic panel.

4) Reducing this perspective increases the amount of power produced.

5) There are important forms of sun trackers to be had within the market: single-axis and dual-axis

Keep in mind to include a suitable feedback mechanism to guarantee the system's durability and responsiveness.

II. Scope of the Solution:

The scope of the solution is to develop the Solar Panel Positioning System (Solar Tracker) is to make it possible to automatically follow the position of the Sun. It can also adjust the orientation of the solar panels according to the Sun's position. This solar tracker system will help you to maximize the energy output of your solar panels by moving them perpendicular to the Sun. More energy than solar panels which are used without the tracking system.

The amount of solar energy collected by solar systems that follow the sun's trajectories throughout the day is much higher, and as a result, they produce much more power. According to their mode of rotation, it has been demonstrated that these sun tracking systems can be generically categorised as single axis and dual axis.

There are two main types of solar panel trackers: single-axis and dual-axis. Single-axis trackers follow the sun from east to west, while dual-axis trackers can also adjust for seasonal variations in the sun's elevation.

Single Axis

1) Single-axis trackers have one axis of movement

2) It rotates on an unmarried point.

3) Single-axis trackers will accumulate less power.

4) Less performance.

Dual Axis

1) Dual-axis trackers have two axes of motion

2) It rotates on two factors.

3) Dual-axis trackers will gather more power

4) More efficiency.

The main purpose of a solar panel positioning system is to make sure that solar panels are oriented in the best possible way to capture the most sunlight and thereby generate the most electricity. These systems can be as simple as manual adjusters or as complex as tracking systems that move the panel automatically based on the path of the sun.

III. Required Components to Develop Solution:

Hardware:

- Arduino Board
- Servo Motor
- Solar Panel
- Solar Panel Mount
- Resistors
- Capacitors
- Photoresistor
- Potentiometer
- Temperature Sensor
- Driver
- Breadboard
- Diodes
- Screws

Arduino Board

Arduino is an open-source electronics platform which tell what exactly we can do by programming the board using IDE.

Servo Motor

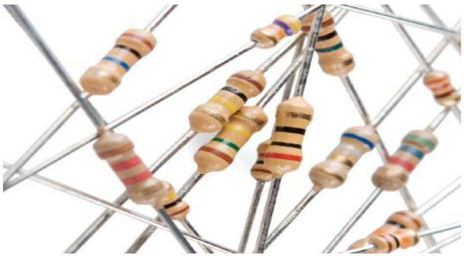
A servomotor is a rotary actuator or linear actuator that allows for precise control of angular or linear position, velocity, and acceleration in a mechanical system.

Solar Panel

A solar panel is a device that converts sunlight into electricity by using photovoltaic (PV) cells. PV cells are made of materials that generate electrons when exposed to light.

Resistors

A resistor is a passive two-terminal electrical components that results in providing impedance to electrical flow of current. In this prototype we use 220ohm resistor in LED bulb so that it doesn't get override.



Capacitors

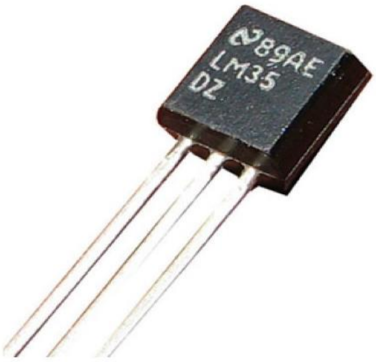
A capacitor is a two-terminal electrical device that can store energy in the form of an electric charge.

Photoresistor

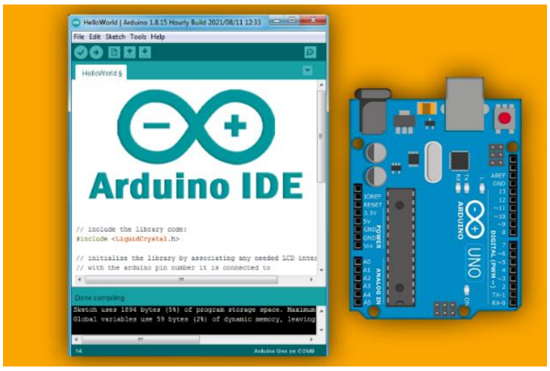
Photoresistors, also known as light dependent resistors (LDR), are light sensitive devices most often used to indicate the presence or absence of light, or to measure the light intensity.

Temperature Sensor

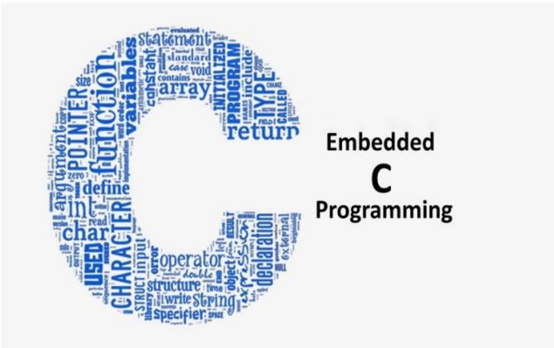
A temperature sensor is a device that detects and measures hotness and coolness and converts it into an electrical signal.



Software:



Arduino IDE



Embedded C

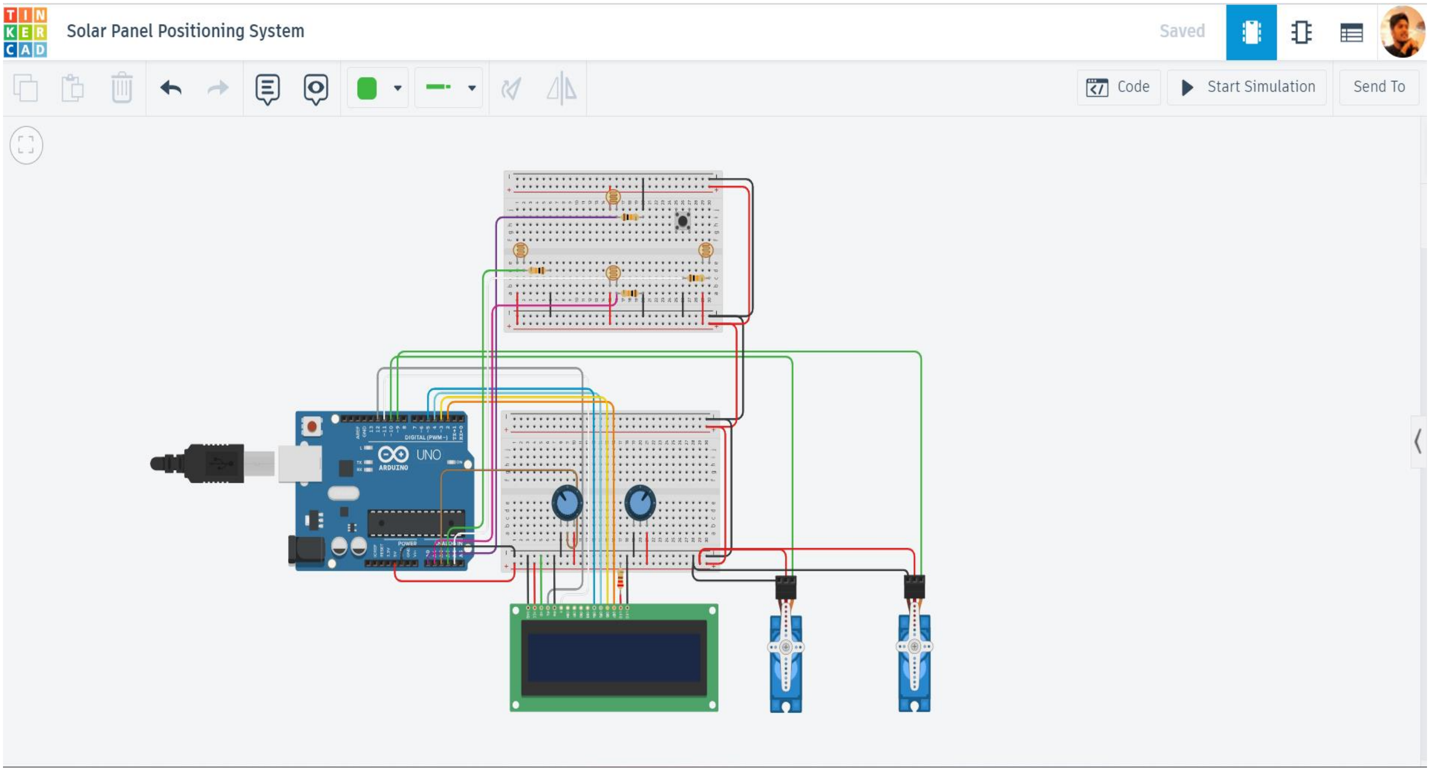
TINKERCAD

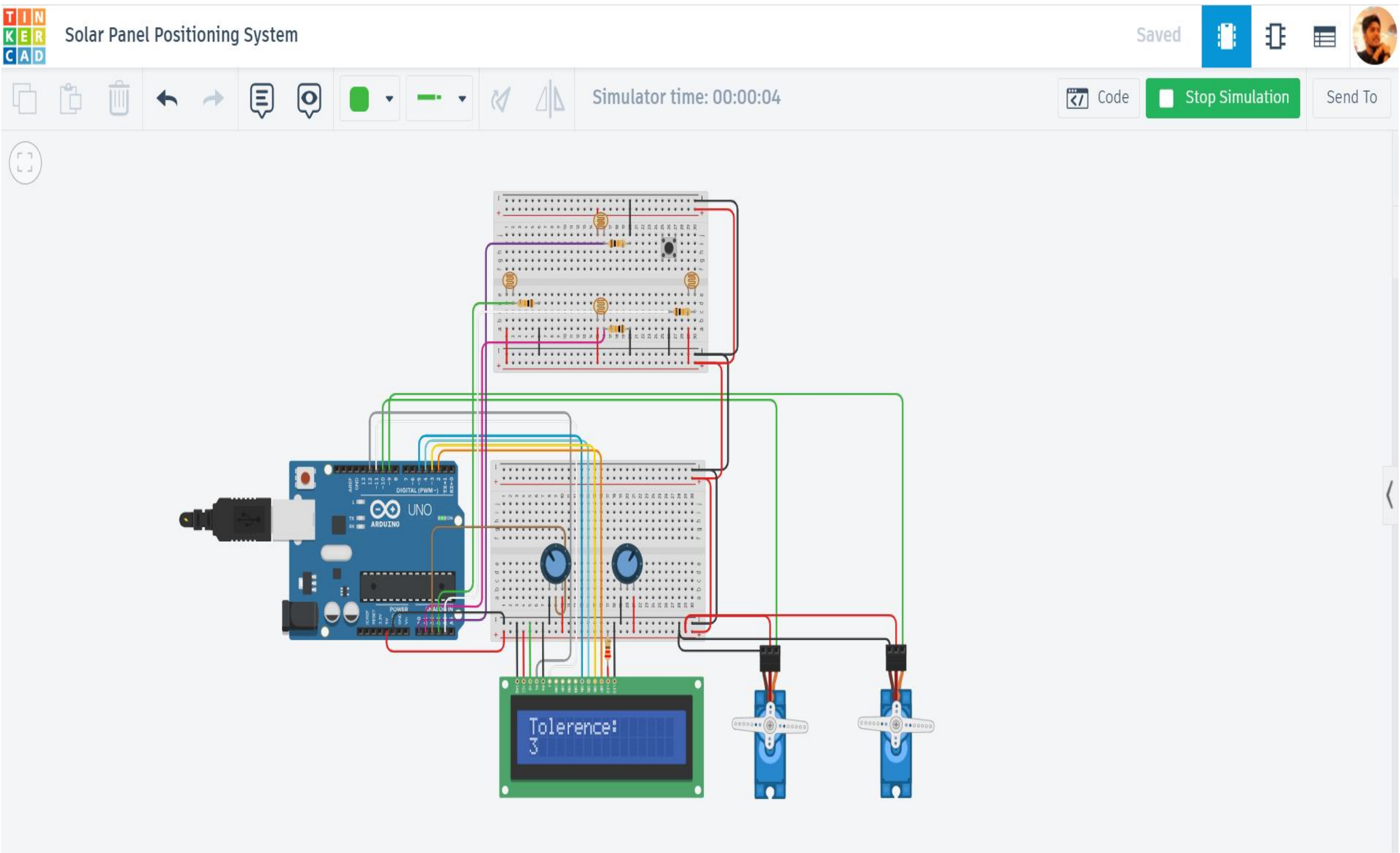
TinkerCad

Algorithm – It is used to calculate the sun's position from algorithms using the time, date, and geographical location.

IV. Simulated Circuit (TinkerCad):

- A circuit diagram illustrating the connections.
- Simulated using TinkerCad.
- Simulated circuit diagram using TinkerCad.





This circuit is designed in Tinker Cad Software which describes about the connections are made:

- We use 2 servo motor which basically helps in precise control of angular or linear position, velocity, and acceleration in a mechanical system.
- We use **Photoresistors**, also known as light dependent resistors (LDR), are light sensitive devices most often used to indicate the presence or absence of light, or to measure the light intensity. The light will be detected by light-dependent resistors (LDR).
- We use a **temperature sensor** that detects and measures hotness and coolness and converts it into an electrical signal.
- The tolerance between the sensors can be adjusted by a variable resistor to prevent the solar panel constantly trying to face the sun.
- We use LCD display which basically helps in to show the tolerance value.

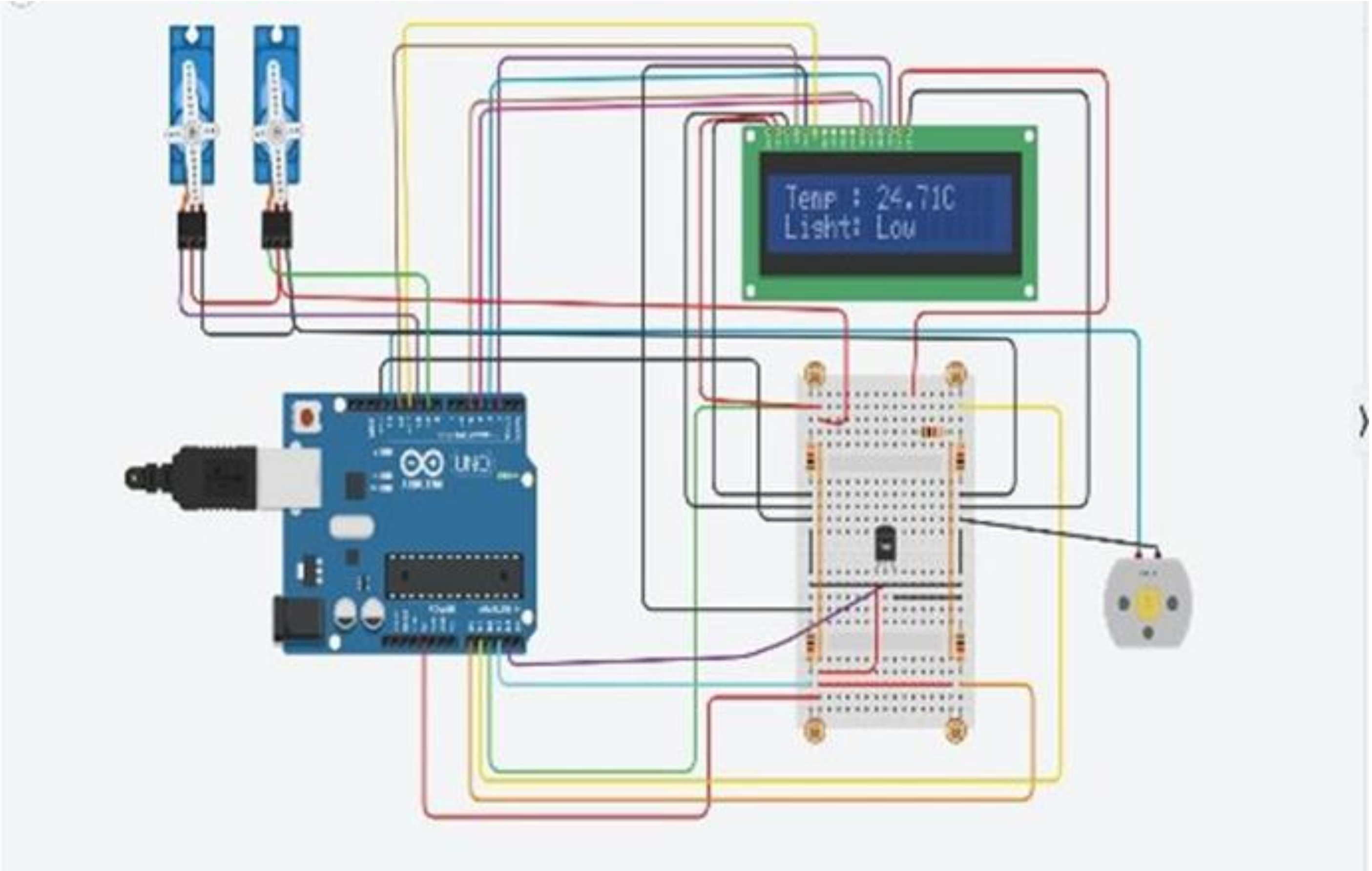
The Solar Panel That Rotates The goal of the Arduino project is to use a solar panel mounted on a platform that can rotate with the aid of a motor to charge a 12VDC battery.

An Arduino Uno Board mounted on an Atmega328 microcontroller that is mounted on the PCB controls this motor.

To determine the current position of the sun and, consequently, the location from which the most solar energy can be captured, the rotating solar panel system scans from one horizon to the next. The Battery is charged in the position with the greatest energy capacity. By setting the solar panel to consistently face directly toward the Sun, we can get the most out of it.

ATmega328 Microcontroller

ATmega328 is an AVR family micro controller. It is based on advanced RISC architecture. It is an 8-bit controller. It has 32K Bytes of Programmable Flash memory, 1K Bytes of EEPROM and 2K Bytes of SRAM. It has 23 programmable I/O pins. It supports peripheral features like two 8-bit timers, one 16-bit timer, 6 channel ADC with 10-bit resolution, programmable USART, Serial Peripheral Interface, 2 wire serial interface (I2C), etc.



Approach:

I use different approach by adding Potentiometer and Temperature sensor in circuit. In essence, adding a potentiometer and a temperature sensor can improve the accuracy, security, and effectiveness of a solar panel positioning system. These elements can aid in ensuring that the panels are always in the most productive orientation, maximizing energy production and extending the panel life.

A few intriguing possibilities are raised by using a potentiometer and a temperature sensor in a solar panel positioning system. Here is a description of how each of these elements might be used:

Potentiometer:

Manual Adjustment: The solar panels' position can be changed manually using a potentiometer. For instance, the positioning system can read the resistance value from the potentiometer and determine the desired angle if the user wants to set a specific angle for the panels.

Feedback Mechanism: The potentiometer can also serve as a feedback mechanism if the solar panel system is powered by an electric motor. The resistance value alters as the panel rotates. The system can determine the panel's current angle or position by keeping an eye on this value.

Temperature Sensor:

Efficiency Optimization: If solar panels get too hot, they may lose some of their effectiveness. The positioning system could change the angle to optimize performance based on thermal conditions by measuring the panel's temperature. For instance, the panels could be slightly angled to reduce direct sunlight and cool down if they become too hot.

Safety Measures: The integrity of the solar panels may also be at risk from overheating. The system can alert users or even move the solar panels to avoid damage with the help of a temperature sensor.

Combining Both:

One possible combined approach could be to use the temperature sensor to monitor the efficiency of the solar panels and the potentiometer for manual adjustments or feedback.

For instance:

- The system could first place the panels at the best angle possible based on where the sun was in the sky.
- The system could move the panels to improve efficiency or cool them down as the day goes on if their temperature exceeds a predetermined threshold.
- The potentiometer could be used for manual adjustments if the user wants to change the angle (possibly for maintenance or because of local conditions).
- The system may always be aware of the panel's position thanks to the potentiometer's feedback.

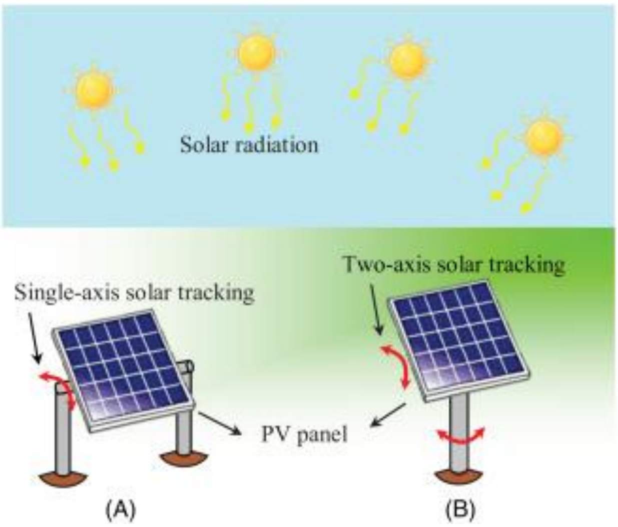
Implementation:

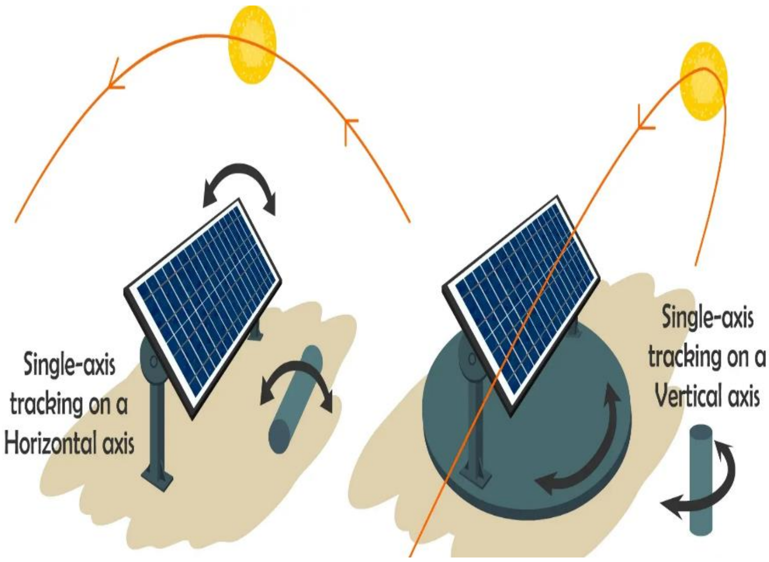
- A microcontroller (like an Arduino)'s analog pin should be connected to the temperature sensor.
- Potentiometer should be connected to another analog pin.
- In the programming environment of your microcontroller, read the values from both devices.

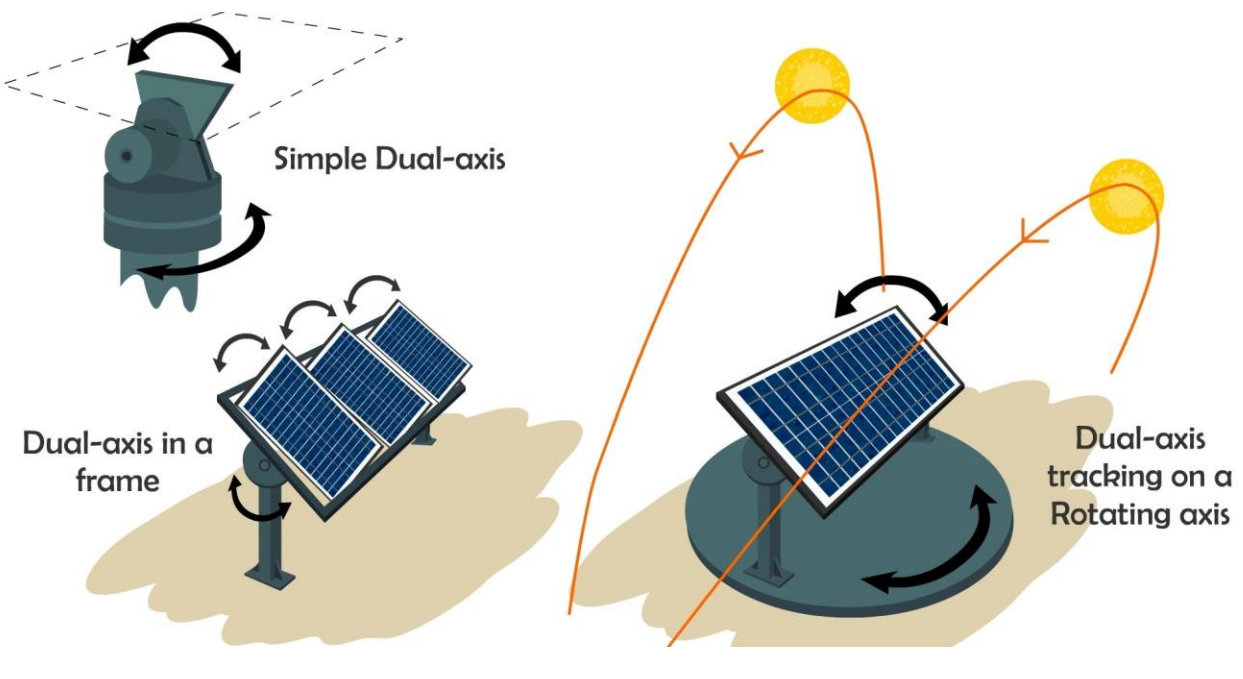
- Control the motor or actuator that moves the solar panel's position using these readings.
- Use the logic in your program to determine when and how to move the panel based on the temperature sensor and potentiometer readings.

The use of both devices provides a dual layer of control – allowing for both automated efficiency improvements and manual control or feedback.

These are different types of Solar Panel Positioning System and how they work.







V. Video of the Demo

The Video Link is provided here:

https://drive.google.com/file/d/1-v8g6wmg4R1oHFXJMq5V98AaY0Lr78Ej/view?usp=drive_link

Working

1) Take mini breadboards, vicinity them for this reason and connect power and ground deliver to them from Arduino.

2) Place four LDR at the breadboards for that reason.

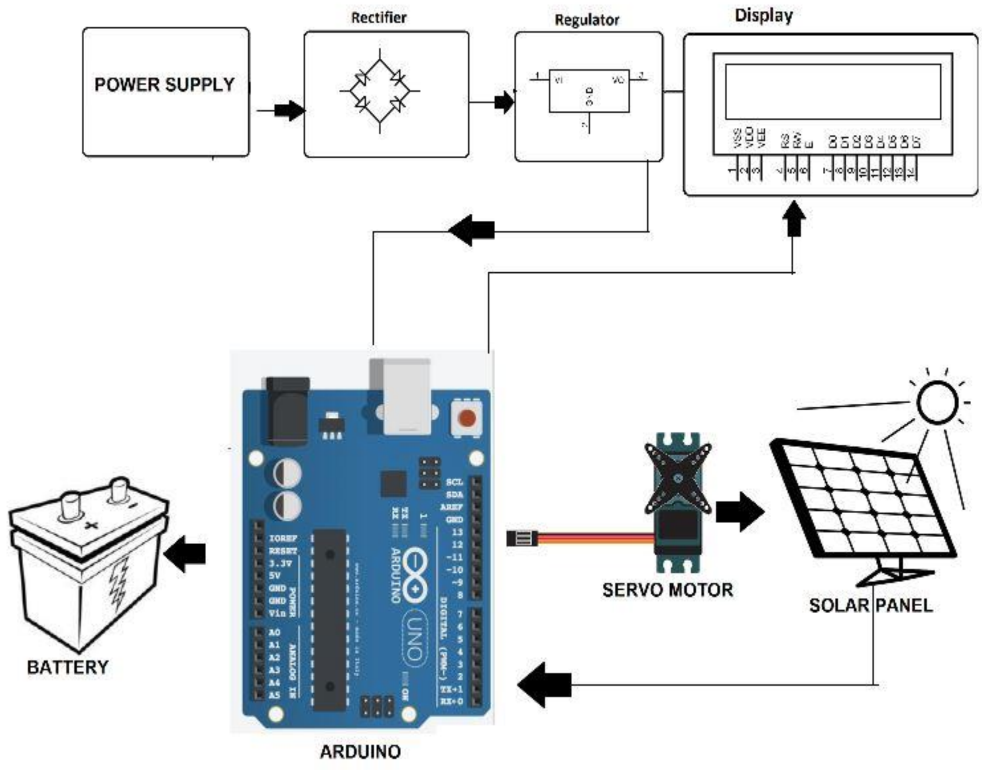
3) Connect one pole of all LDR to Arduino and equal pole to ground the usage of resistor and other pole to the power deliver.

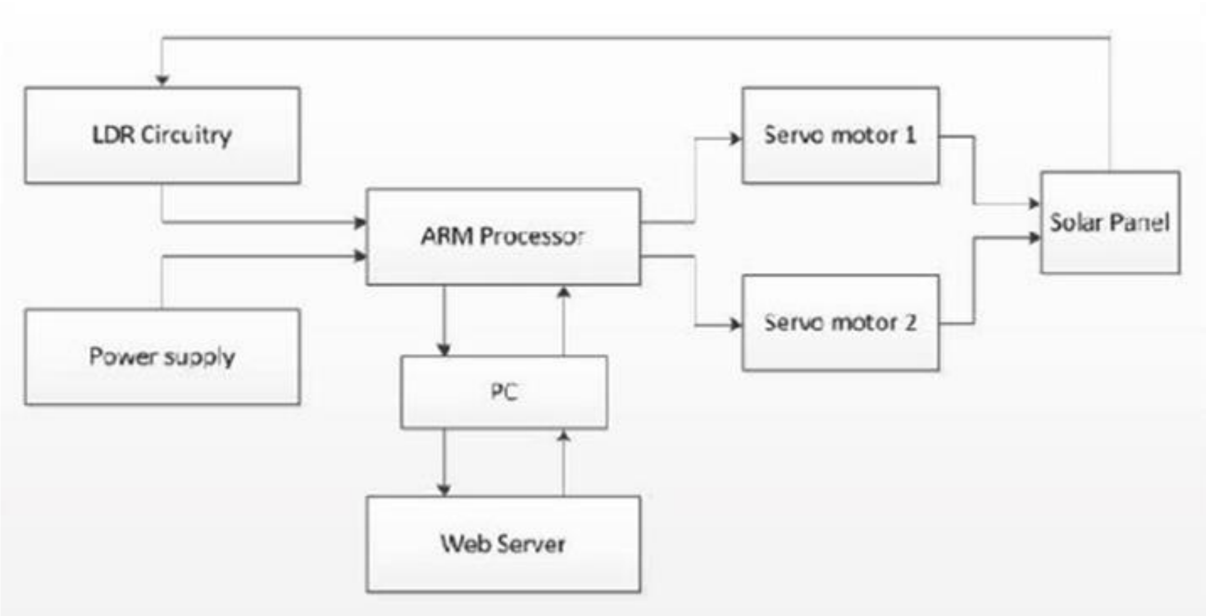
4) Place a temperature sensor on breadboard and join that to ground, energy supply and Arduino.

5) Connect 2 servo and 1 dc motor to Arduino.

6) Also be a part of an LCD for that reason just so it may display temperature and mild depth.

7) Write code





Detailed Explanation:

Single-axis Solar Trackers

The role of the single-axis tracker is to move or adjust the solar panels by rotating around one axis. Its movement is usually aligned in North and South directions.

This device helps in enabling the PV panels to move in the direction of the sun from East to West.

A single-axis tracker enhances the efficiency of a solar system without making the installation of PV modules. The owner must make the installation of the single-axis tracking system on a flat area of land which is sunny and dry in nature.

A single-axis solar tracking system has a high initial cost of installation, which can further improve the productivity of your solar system.

Hence, the system can promptly recover the amount and other expenditures.

Dual Axis Solar Tracker

An ATmega328P microcontroller was used in the system to direct the motion of two servo motors, which rotated the solar panel in two axes. The microprocessor calculated the rotational speed based on data gathered from four photo sensors placed close to the sol ar panel.

An operational solar panel positioning system (solar tracking) was created and put into use at the project's conclusion. It was able to repeatedly position the solar panel with the sun or any other

source of light. The design of the solar panel positioning system (solar tracker) can be used as a model and a jumping-off point for the creation of more sophisticated systems in the future.

A solar panel positioning system (solar tracking) based on the Arduino UNO that allows solar panels to be moved in the direction of the most sun light incidence. As a result, we get a more effective system that is small, affordable, and simple to use. When compared to solar modules at a fixed angle, the usage of solar trackers can improve electricity generation by around a third, and some claim by as much as 40% in some climates. And a dual axis tracking system that can move the panel in the direction of the most solar light incidence while sensing the solar light that strikes it.

There are two different drivers that dictate the motion of the trackers:

The very first one is passive, and the other one is active.

- **Passive trackers** are solely dependent on solar heat to guide and move the tracker. Basically, a low boiling point compressed gas fluid is driven at one side or the other to move the tracker in response to the imbalance created by the heat from the sun.

- The usage of controllers is made by the active trackers that monitor the position of the sun’s movement to direct motor the movement of the trackers.

- In **active solar trackers**, Light Dependent Resistors (LDRs) are used as a part of the sensor. Their difference in output is used to generate error signals. A processor calculates the position of the sun with the help of formulae or algorithms using its time/date and geographical information to transmit signals to the motor orientation.

• In high-end solar trackers, a feedback system is also deployed wherein the output signal of various processes is sent back as the input to the system that it is controlling. Consequently, corrections can be made to any errors and compensate for disturbances in the system.

TEMPERATURE COOLING SYSTEM

- Overheating reduces the performance of the panels dramatically.
- Temperature is the critical issue to acquire maximum efficiency.
- For enhancing efficiency of solar panel device temperature cooling device is required.
- The temperature ought to be maintained low through cooling it down throughout its operation length.

ADVANTAGES

1) Intensity of sun electricity era will increase because of direct publicity to daylight.

2) Solar Trackers are clean to evolve and flexible for set up.

3) Solar trackers generate greater electricity in roughly the equal quantity of space wanted for constant-tilt structures, making them

perfect for optimizing land utilization.

4) Advancement in technology and reliability in electronics and mechanics have extensively decreased long term maintenance

concerns for tracking system.

Sun Solar Panel Positioning System Applications

- These panels can be used to power the traffic lights and streetlights
- These can be used in home to power the appliances using solar power.
- These can be used in industries as more energy can be saved by rotating the panel.

FUTURE SCOPE

1) Improving the mechanical structure.

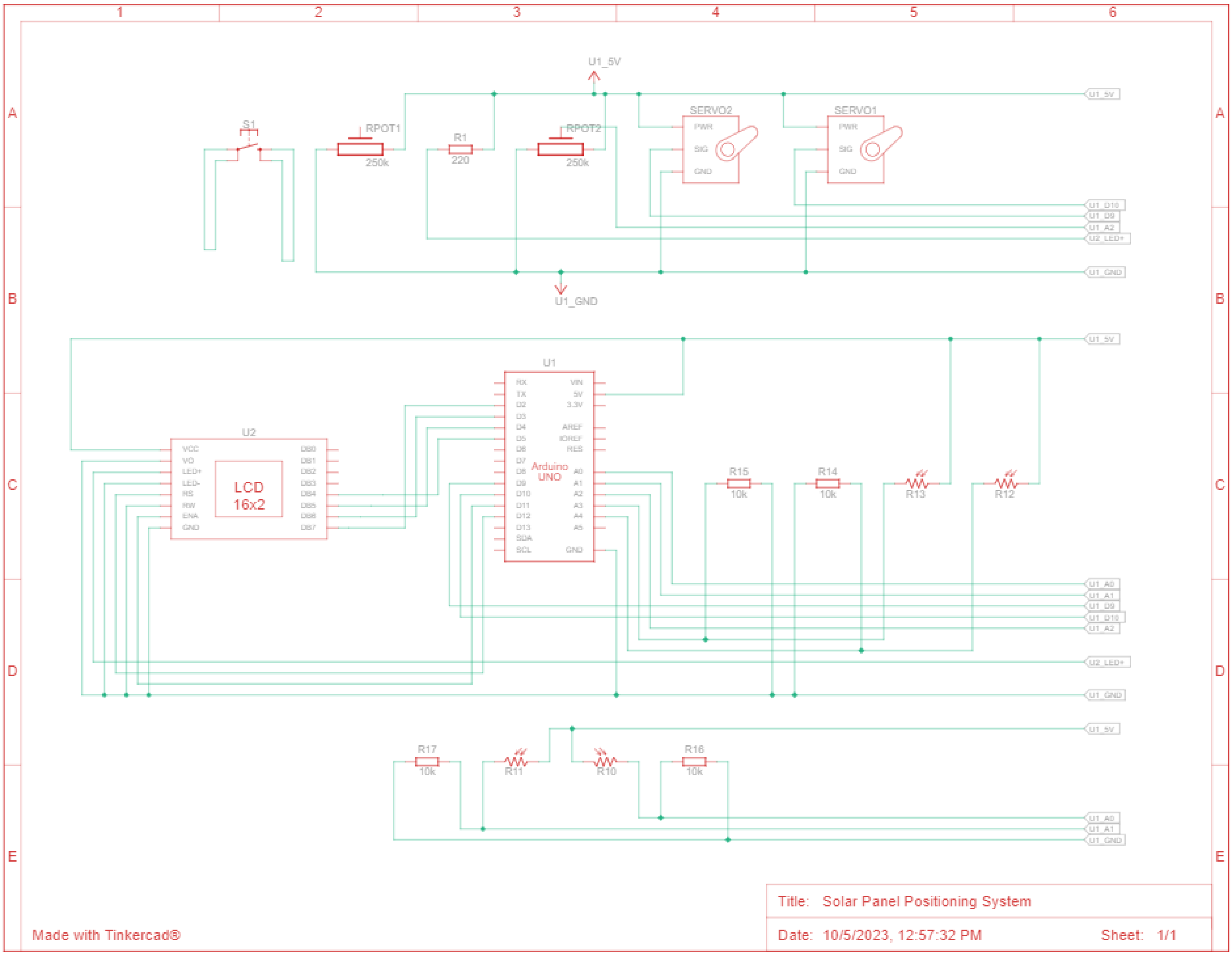
2) Increasing the burden carrying ability and placing a sun panel with the whole gadget.

3) Adjusting the tools ratio to save you power loss.

4) Slowing down the fee of rotation while there's no want of power to save you wear and tear of the gadget.

5) Reducing the price of mechanical structure.

VI. <u>Gerber File:</u>



This Circuit diagram how exactly the connections are made.

VII. Code for the Solution:

//INFO

```
/* This program controls the orientation of s solar panel to face the sun.
This will mean the solar panel will produce power at maximum efficiency.
It does this by comparing how much light is hitting the top and bottom of the solar panel rotating the solar panel on the x-axis towards the light.
The light will be detected by light-dependent resisotors (LDR.
The same happens for the left and right-hand sides of the panel and rotating the solar panel in the z-axis.
The tolerance between the sensors can be adjusted by a variable resistor to prevent the solar panel constantly trying to face the sun.
The tolerance value is displayed on an LCD display.*/
```

//Load

```
// Load in libary for the liquid crystal display
#include <LiquidCrystal.h>
// load in libary for the servo motors
#include <Servo.h>

void UpDown();// initialize the functon to move the sensor up and down
void LeftRight();// initialize the functon to move the sensor up and down

Servo servo1;
Servo servo2;
```

//Initialize

```
// Initialize the library with the numbers of the interface pins
LiquidCrystal lcd(12, 11, 5, 4, 3, 2);
```

//Set up

```
// set up loop
void setup() {

  lcd.begin(16, 2); // Initialize the LCD with 16 characters long on each line and 2 lines.
  lcd.print("Tolerence: "); // Print "Tolerence on the first line of the LCD.
  servo1.attach(9);// conect servo 1 to interface pin 9
  servo2.attach(10); // conect servo 2 to interface pin 10

  servo1.write(90); // sets the angle of servo 1 to 90 degrees
  servo2.write(90); // sets the angle of servo 2 to 90 degrees
}

```

//MAIN

```
// main loop
void loop(){

 int Tolerence = 0;// set tolerence to 0

 int sensorTop = analogRead(A0);// set the top LDR input to analog pin 0
 int sensorBottom = analogRead(A1);// set the bottom LDR input to analog pin 1
 int sensorLeft = analogRead(A3);// set the left LDR input to analog pin 3
 int sensorRight = analogRead(A4);// set the right LDR input to analog pin 4

 int sensorTest1 = sensorTop - sensorBottom;// Compares the difference in top and bottom
 int sensorTest2 = sensorBottom - sensorTop;// Compares the difference in top and bottom
 int sensorTest3 = sensorLeft - sensorRight;// Compares the difference in left and right
 int sensorTest4 = sensorRight - sensorLeft;// Compares the difference in left and right

 int TolerenceValue = analogRead(A2);// Reads the variable resistor value to get tolerence
 Tolerence = (TolerenceValue * (5.0 / 1023.0))*2;// sets tolerence value and changes value between 1 and 10

 lcd.setCursor(0,1);// sets the lcd to write on the second line
 lcd.print(Tolerence);// write the tolerence value to the lcd.
```

```
 if ((sensorTest1 >= 0)&&(sensorTest1 >= Tolerence)) // checks to see if sensor test 1 is greater then or equal to the tolerance and that sensor test 1 is a po
    {
     UpDown(sensorTop, sensorBottom);// calls function to move the solar panel up or down towards the sun. Also pass the values of top and bottom sensors
    }

 if((sensorTest2 >= 0)&&(sensorTest2 >= Tolerence)) // checks to see if sensor test 2 is greater then or equal to the tolerance and that sensor test 2 is a pos
    {
     UpDown(sensorTop, sensorBottom);// calls function to move the solar panel up or down towards the sun. Also pass the values of top and bottom sensors
    }

 if((sensorTest3 >= 0)&&(sensorTest3 >= Tolerence)) // checks to see if sensor test 3 is greater then or equal to the tolerance and that sensor test 3 is a pos
    {
     LeftRight(sensorLeft, sensorRight);// calls function to move the solar panel left or right towards the sun. Also pass the values of left and right sensors
    }

 if((sensorTest4 >= 0)&&(sensorTest4 >= Tolerence)) // checks to see if sensor test 4 is greater then or equal to the tolerance and that sensor test 4 is a pos
    {
    LeftRight(sensorLeft, sensorRight);// calls function to move the solar panel Left or right towards the sun. Also pass the values of left and right sensors
    }

 delay(10); //wait 10 millie seconds before moving back to the start of the main loop.
}
```

//check direction to move up or down

```
// function to check what direction to move up or down and turn towards the sun. Also take the value of top and bottom from the main loop and return nothing.
void UpDown(int sensorTop, int sensorBottom){

  int pos1= servo1.read();// reads the current angle of servo 1

  if(sensorTop < sensorBottom) // checks to see if the bottom sensor is grater than the top tehn enter the loop.
    {
     pos1 = --pos1; // change the angle by -1
    }
     else// if the bottom is not greater than the top then enter this loop
      {
       pos1 = ++pos1;// change the angle by +1
      }
  servo1.write(pos1); // write the new angle to servo 1
}
```

//check direction to move left or right

```
// function to check what direction to move left or right and turn towards the sun.Also take the value of left and right from the main loop and return nothing.
void LeftRight(int sensorLeft, int sensorRight){

 int pos2= servo2.read();// reads the current angle of servo 1

 if(sensorLeft < sensorRight)// checks to see if the left sensor is grater than the right tehn enter the loop.
   {
    pos2 = --pos2;// change the angle by -1
   }
    else// if the left is not greater than the right then enter this loop
    {
     pos2 = pos2 + 1;// change the angle by +1
    }
  servo2.write(pos2); // write the new angle to servo 1
}
```

Conclusion

A solar panel positioning system is essential for maximizing solar energy capture effectiveness. While tracking systems can significantly increase energy production, especially in locations with high solar potential, fixed mounts are still an affordable option for many applications. Future positioning systems are anticipated to be smarter, more effective, and more integrated with other elements of the solar energy ecosystem as a result of technological advancements.

A solar tracker positions the solar panels at an angle directed to the sun. It is an advanced sun monitoring system that can rotate the panels to track the movement of the sun across the sky.

It facilitates the panel system to trap the maximum sunlight and optimise the energy output. There are considerable advantages to using a solar energy tracker.

The development of the Solar Panel Positioning System **(**Solar Tracking) allows us to easily and sustainably improve the performance of PV solar equipment. Using a different solar energy philosophy.

Created a model for an automatic monitoring device to maintain the vertical alignment of solar panels and daylight. Increased the utility cost for solar energy and the effectiveness of solar-powered structures.

In order to utilize solar energy to its fullest potential, solar panels must be positioned as efficiently as possible. While tracking systems, both single-axis and dual-axis, offer a significant boost in energy capture, fixed mounts often provide a simple and affordable solution. These systems make sure that panels operate at maximum efficiency throughout the day and throughout the seasons by continuously or sporadically adjusting to the position of the sun. Innovations in solar panel positioning will be essential in ensuring the viability and profitability of solar energy installations as the demand for renewable energy sources increases. Investing in cutting-edge positioning systems is a futuristic move to maximize the advantages of solar energy in a time that emphasizes sustainability and energy independence.

Overall, a microcontroller-based solar panel positioning system is a way that offers maximum energy capture from sun-light.

THANK YOU