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# Single Axis Sun Tracking Photovoltaic system using Microcontroller

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**ABSTRACT:** When it comes to energy resources, the question of sustainability always arises as a major deciding factor. It is important that resources provide enough energy to meet our needs - lighting homes, empowering our cities, and driving our cars. However, it is also important to consider how these resources can be used in the long run. Some resources will never run out. These are known as renewable resources. Renewable resources also produce clean energy, which means less pollution and greenhouse gas emissions, which contribute to climate change. Solar energy is gaining importance as a major source of renewable energy among the other sources. Solar tracker system helps us in generating electrical energy from sunlight by using photovoltaic solar cells. The amount of power generated can be increased by aligning the panels according to the position of the sun. Maximum amount of energy can be harnessed when the orientation of the solar panels is perpendicular to the incident radiation. In this paper a one axis solar tracker is designed and implemented to track the sun horizontally by using an AVR microcontroller. The implemented system consists mainly of the ATmega328P controller, Servo motor, light dependent resistors, LED and a solar panel. The results show that the designed Single Axis Sun Tracking Photovoltaic system increases the output power gain by 18-25% as compared to the panel fixed at a certain angle.

**KEYWORDS:** Single axis tracker, Solar panel, Light Dependent Resistor, Microcontroller, Servo motor.

## I. INTRODUCTION

This project deals with the research and development of a Single Axis Sun Tracking Photovoltaic system. Scientists and researchers all over the world are continuously working to find ways to replace conventional energy sources with renewable ones. Conventional methods of energy generation play a major role in causing the greenhouse effect and global warming [1,2]. Renewable energy solutions are becoming increasingly popular among everyone. A Solar panel harvests sunlight and converts it to electricity. The conversion of sunlight to usable electrical energy is called the Photovoltaic Effect. A Photovoltaic cell generates maximum electricity when rays from the sun are directly incident over it. Generally, a sun tracking system is used to harness the energy of the sun to maximum extent [3]. These types of mechanisms are used in space vehicles and as stand alone units in distress conditions. A solar tracker is a device that orients the panel in a direction towards the sun. The use of solar trackers can increase electricity production by around as much as 40% in some regions, compared with panels fixed at a certain angle. In solar applications, the efficiency is improved when the panels are continually adjusted to the optimum angle as the sun travels across the sky. As improved efficiency is directly proportional to the yield, use of trackers make a major difference to the income of a large plant.

Primary functions of a Sun Tracking System are:

- Increasing Power Output of the panels.
- Maximizing efficiency of the panel.
- Maximizing Power per unit area.

The position of the sun in the sky varies with seasons and time of day as the sun travels across the sky. Hence there are majorly two types of solar tracker:

- Single Axis Solar Tracker
- Dual Axis Solar Tracker

Single axis solar trackers can either have a horizontal or a vertical axis of rotation/ movement. The horizontal type is used in tropical regions such as India where the sun gets very high at noon, but the days are short. The vertical type of systems are used in high latitudes where summer days are very long.

## II.METHODOLOGY

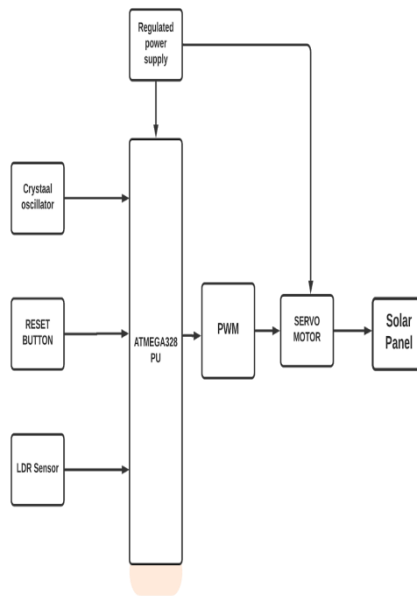


Fig 1: Block Diagram of Single Axis Sun Tracking Photovoltaic system.

## III.SOFTWARE REQUIREMENTS

Arduino Software (IDE) , Coding Language:- C++

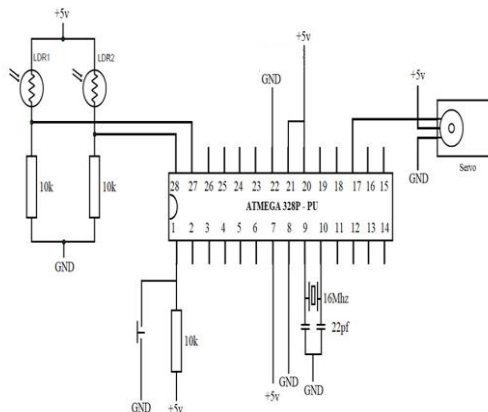


Fig. 2 Shows the circuit diagram of the Single Axis Sun Tracking Photovoltaic system.

## IV.HARDWARE REQUIREMENTS

ATMEGA328P Microcontroller, Dummy Solar Panel, Servo Motor, 5V DC Voltage Source, Light Dependent Resistors, Ceramic Capacitors , Arduino Nano (for programming), Crystal Oscillator, Connecting Wires.



**A. ATmega328P**

ATmega328P is a high performance, low power controller from Microchip. ATmega328p is an 8-bit microcontroller based on AVR RISC architecture. It is the most popular of all AVR controllers because of its compatibility with Arduino Boards. The microcontroller receives the information from the light dependent resistors and then, based on the defined algorithm, instructs the servo motor to change the angle accordingly.

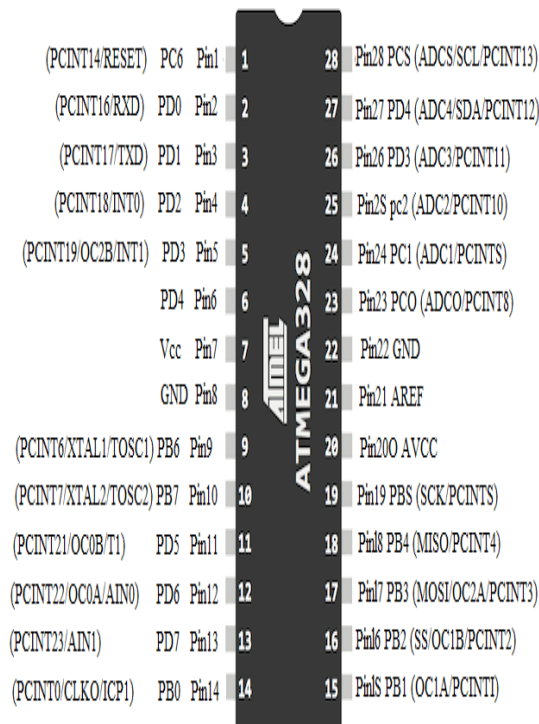


Fig. 3 Shows the pin diagram of the Microcontroller(ATMEGA328P)

**B. Servo Motor**

Servo motor is a rotary actuator that allows for precise control of angular or linear position, velocity and acceleration. It consists of a suitable motor coupled to a sensor for position feedback. It also requires a relatively sophisticated controller, often a dedicated module designed specifically for use with a servo motor. In this project the role of the motor is to rotate the solar panel based on the information received from the microcontroller.

**C. Light Dependent Resistor**

Light Dependent Resistor is made up of semiconductor materials that have high resistance. Their resistivity is a function of the incident electromagnetic radiation. They are light sensitive. Photoresistors work on the principle of photoconductivity. Photoconductivity is an optical phenomenon in which the material's conductivity is increased by the adsorption of the light.

**D. Solar Panel**

All the components of the system work to keep the solar panel directed towards the sun, the solar panel generates the DC voltage by harnessing the energy from sunlight.

**E. Input power**

This system is powered using +5V DC power . The microcontroller used in this project works on 5V DC supply only . The motor also works on a 5V DC power supply.

**SOFTWARE:-**

For uploading the code on ATMEGA328P we use the bootloader method.



Step 1 - Install Mini-core

Mini-core is a hardware package which adds support for a range of ATmega devices in the Arduino IDE

Step 2 - Installing ArduinoISP

Step 3 - Wiring Up

To make the ATmega328 work, four additional components are required

- A 10k pull-up resistor
- Two 18-22pF ceramic capacitors
- A 16Mhz or 8Mhz Crystal

Step 4 - Select the device, crystal and programmer

Step 5 - Burn the Bootloader

Now the sketch can be uploaded on ATMEGA328P using an FTDI cable that connects the microcontroller to the computer's USB socket.

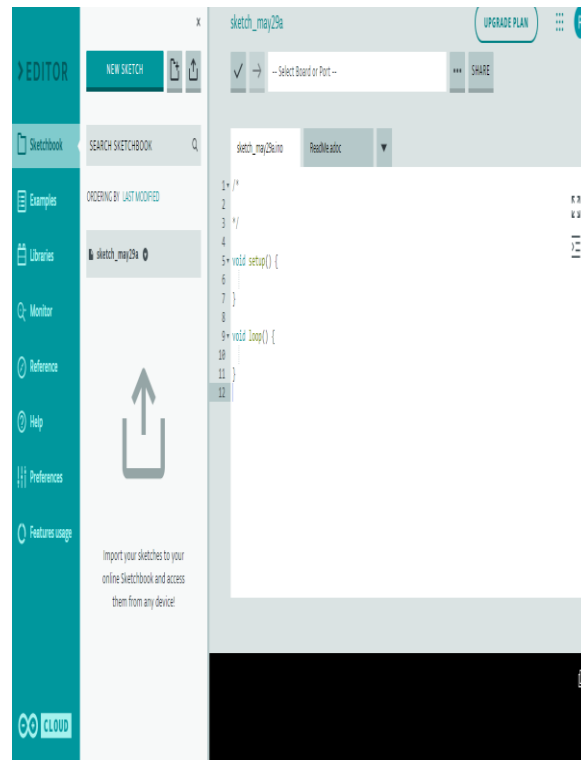


Fig. 4 Arduino IDE interface



```

sketch_may29b.ino  ReadMe.adoc
13 Serial.begin(9600);
14 myservo.write(pos);
15 }
16
17
18 }
19 void loop()
20 {
21   val1 = analogRead(Ldr1);
22   val2 = analogRead(Ldr2);
23   val1 = map(val1, 0, 1023, 0, 180);
24   val2 = map(val2, 0, 1023, 0, 180);
25   if(val1 > (val2+50))
26   {
27     if(pos<180)
28       pos=pos-1;
29     myservo.write(pos);
30     Serial.println("backward");
31     delay(10);
32   }
33   else if(val2 > (val1+50))
34   {
35     if(pos>0)

```

Fig. 5 Sketch in Arduino IDE.

**FLOWCHART:-**

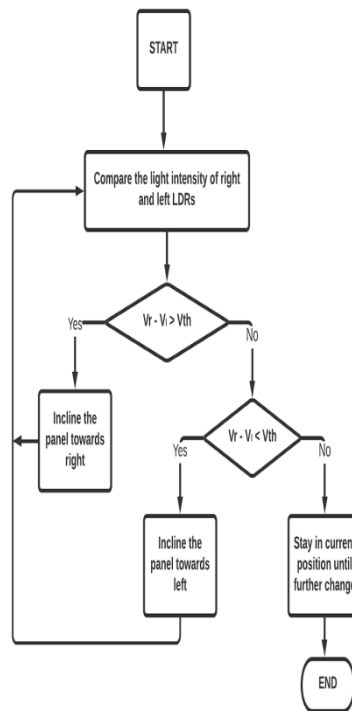


Fig. 6: Flowchart of tracking algorithm for Single Axis Sun Tracking Photovoltaic system



**V.IMPLEMENTATION AND RESULTS**

```
#include <Servo.h>

Servo myservo;
int ldr1 = 4;
int ldr2 = 5;
int val1;
int val2;
int pos=90;

void setup()
{
  myservo.attach(11);
  Serial.begin(9600);
  myservo.write(pos);
}

void loop()
{
  // ...
}
```

Done compiling

Sketch uses 3353 bytes (10% of program storage space. Maximum is 32256 bytes.  
Global variables use 251 bytes (12% of dynamic memory, leaving 1797 bytes for local variables. Maximum is 2048 bytes.

Fig.7: Program for ATMEGA328P on Arduino IDE

**Working:-**

In this project an ATMEGA328P microcontroller is used, which works as a controlling unit. Two LDR’s (Light Dependent Resistor) are connected in voltage divider configuration along with 2 resistors to the analog pins of the ATMEGA328P. A solar plate is attached in parallel to the axis of the servo motor and both the LDR’s (Light Dependent Resistor) are kept on the solar plate as shown in the figure below.

**VOLTAGE DIVIDER CONFIGURATION:-**

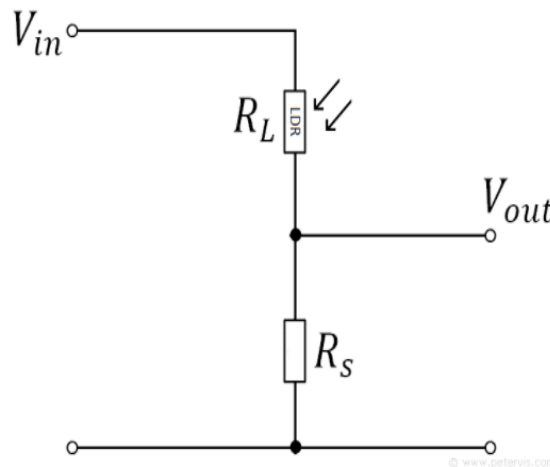


Fig. 8: Voltage divider configuration

Here both the LDRs are connected in series with the 10 Kilo-Ohms resistor and supplied with a steady 5V power



supply. Which results in the output voltage to be in the form  $V_{out} = \frac{R_L}{R_s + R_L} \times V_{in}$ .  
 The output voltage from both the LDRs are then given to the Analog input pin of the ATMEGA328P microcontroller , which takes the decision to rotate the panel clockwise or anticlockwise based on the original orientation of the panel.

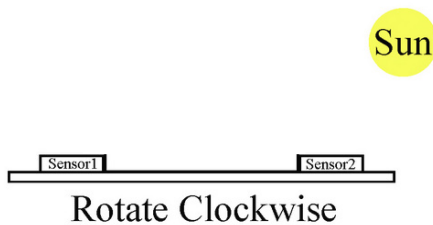
There are overall 3 conditions and the conditions are:-

**Condition 1- Sun is on the left side**



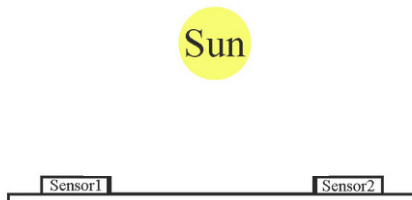
Since the sun is on the left side , the Output Voltage from the Light sensor on the left side is higher than that on the right side . Based on the difference of the value between the Output Voltage, the microcontroller sends a Pulse to the servo motor resulting in the panel being rotated towards left (AntiClockwise direction).

**Condition 2- Sun is on the right side**



Since the sun is on the right side , the Output Voltage from the Light sensor on the right side is higher than that on the left side . Based on the difference of the value between the Output Voltage, the microcontroller sends a Pulse to the servo motor resulting in the panel being rotated towards right (Clockwise direction).

**Condition 3- Sun is in the middle**



Since light on both sensors are equal, the plate will not rotate in any direction as the Output voltage from both the sensors would be equal and the difference between the values would not exceed the set threshold value.



Hardware setup :-

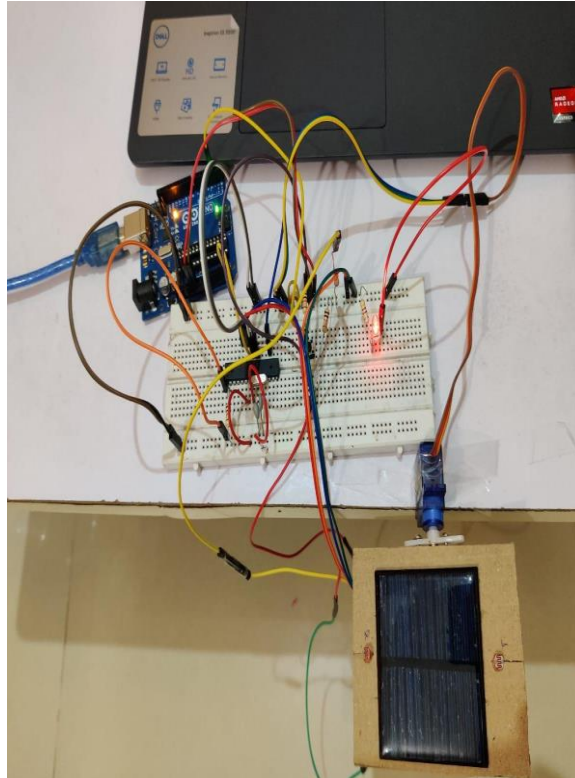


Fig. 9: Complete hardware of the proposed system

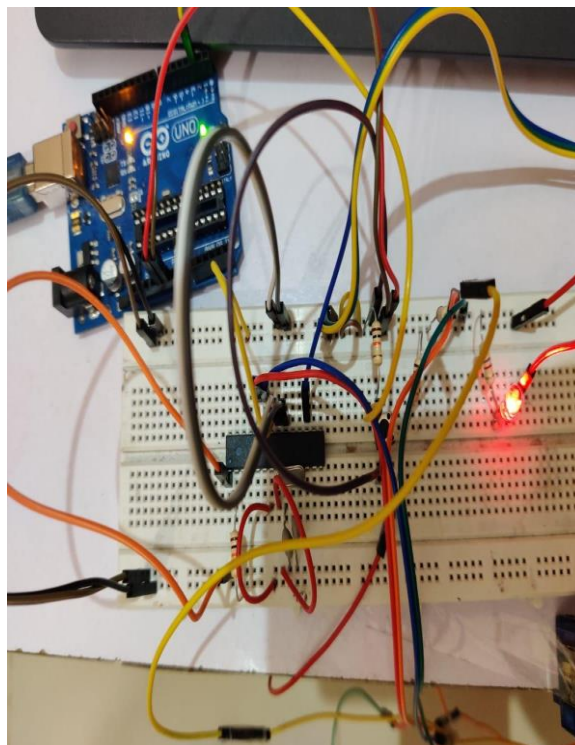


Fig. 10 Control unit of the proposed system



## VI.CONCLUSION

By Applying the proposed system using the ATmega328P MC, an efficient Single Axis Sun Tracking Photovoltaic system is developed and described. The proposed system provides an indication of the relative angle of the panels with respect to the sun by comparing the measured readings obtained from the light sensors. The tracking mechanism is capable of tracking the sun automatically so the direction of beam propagation of solar radiation is perpendicular to the PV panel thus increasing the efficiency. The mechanical structure was very simple and reliable. The controller circuit has been designed with a minimal number of components thus making it cost effective as well. The proposed design is achieved with low power consumption, high accuracy and low cost. The proposed constructed system can be applied in the rural area with no electricity supply for electricity generation especially for low power appliances/emergency use.

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