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DUAL AXIS SOLAR TRACKING SYSTEM FOR MAXIMUM SOLAR POWER GENERATION

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Abstract - *The problem with fixed panel is that they do not rotate. The orientation of the solar panel is kept unchanged during the entire year. Our aim is to create an efficient, inexpensive dual axis solar tracker for commercial uses. This tracker is an active tracker which is controlled by computer program (via an Arduino). This means that we use LDR sensors to find the brightest source of light at all times. If a flashlight is used and is shine, at the sensors the tracker would follow it around. This is the most interactive and exciting kind of tracking; it's also used for larger setups. This system is a scheduled tracker. It uses a computer program that changes the angle of the panel based on the date, time, and physical location. This method is far more efficient provided everything is set up properly.*

Keywords- *Arduino UNO, Solar Panel, Tracker, Servo motors, light dependent resistors (LDRs), Jumper wires, Acrylic sheet, Printed circuit board (PCB)*

I. INTRODUCTION

There can be no denying in the fact that solar energy is an effective source of power, one that is going to serve us for long. Despite the need to harness this energy, very little research has been conducted to make photovoltaic cells cost effective and thereby available for utilization by masses for their various devices.

Photovoltaic cell convert sunlight directly to electricity without leaving any residual elements that can pollute the environs. Besides being used in power generation, photovoltaic cells find applications in other non-space application programs.

In the case where solar cells are used for conversion of solar energy into electricity, maximum efficiency is possible when solar panels are held perpendicular to the sun's rays where tracking comes into picture. Trackers are devices used to change the orientation of the PV panels towards the sun to capture maximum energy.

photovoltaic (PV) solar systems can be made rotating, so that it can able to follow the sun's path throughout the year (and the day...).

The idea behind Dual Axis Solar Tracking System is simple: to allow sunlight to hit the collectors at a better angle, for a longer period; they can improve the efficiency of solar systems up to 20% or 30%.

II. COMPONENTS OF DUAL AXIS SOLAR TRACKING

2.1 PROPOSED SYSTEM

(a) **Solar Panel:** Solar panel is a device that convert light into electricity. The word solar is used as they derive energy for operation from the sun. The cells are connected in series to increase the power and voltage ratings above that from a single solar cell. They are sometimes called photovoltaic which means "light-electricity". Solar cells rely on the photovoltaic effect to absorb the energy of the sun and cause current to flow between two oppositely charge layers. A solar panel is connected assembly of photovoltaic cells. The voltage of the panel is determined by the number of solar cells whereas the current by the size of the cell. They can communicate with software. For this, Arduino UNO is used as the microcontroller.

(b) **Arduino UNO:** Arduino UNO is an open-source prototyping Microcontroller board based on the ATmega32S. It consists of both physical programmable circuit board and piece of software, or IC that runs on computer, used to write and upload computer code to physical board. It has 14 digital I/O pins 6 for PWM output, 6 analog inputs. a 16 MHz ceramic resonator, a USB connection, a power jack, as ICSP header and a reset button. This signal from LDR is given to Arduino UNO which is already programmed. It works on DC power supply.

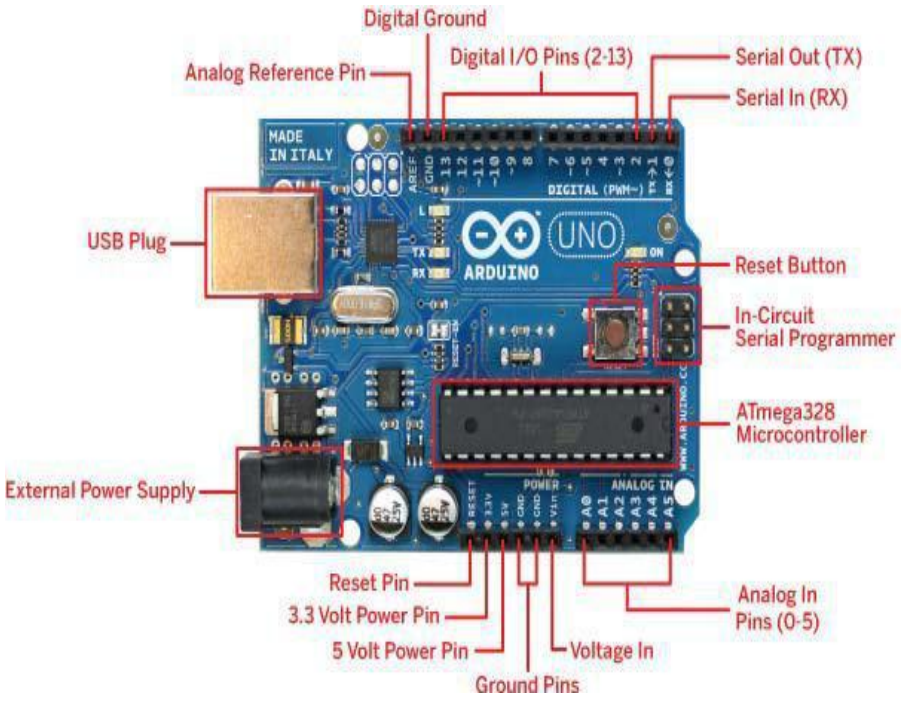

Figure 1: Arduino UNO

(c) **PWM motor driver circuit:** There are many ways to control speed of the motor but simple way is PWM technique. PWM uses digital signals to control power applications as well as easy to convert back to analog with a minimum of hardware.

In this IC 555 is used and is operated in stable mode. In this mode circuit can be used as pulse width modulator. Thus speed control is obtained using PWM. PWM generation is done using Microcontroller. PWM is method for binary signals generation which has two signal periods, high and low. Width of pulse varies from 0 to 1 main control of power is varying duty cycle conduction time to the load to be controlled.

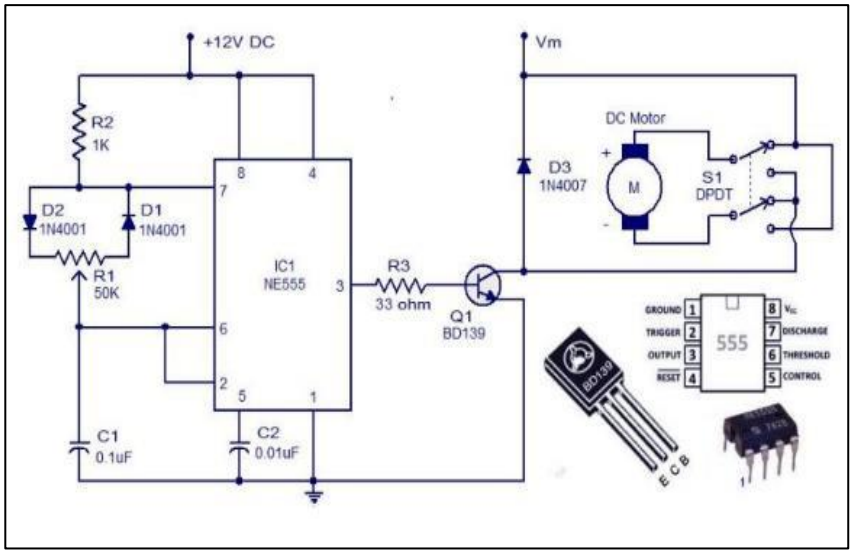

Figure 2: PWM motor driver circuit

(d) **LDR sensor:** The tracker uses four light sensitive (detecting) resistors, also known as LDRs. They work by changing their resistance level based on how much light is falls on them. The more light, the less resistance they have. The program works by comparing the resistance of the four sensors and moving our servos. How sensitive the sensors are, completely depends on code. The same goes for the servos.

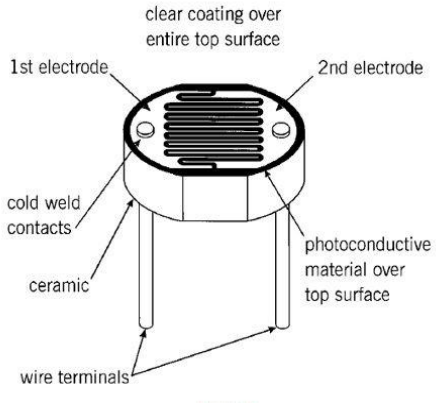

Figure 3: Construction of LDR sensor

(e) **Servo motors:** Three "micro" servos in the 9g size are used for movement of the tracker. Servo motors with metal gears are used for the project to last a very long time. The metal gear version also provides a bit more torque than the plastic geared version. The code for this is set up so that the servos can only move within a certain predefined area (as to not damage the rest of the project) and at a set speed. This motor is used for slow rotation of the tracker. The rating of the motor is decided as per the weight of the assembly. Two servo motors are used for the motion of tracker. Stepper motor can also be used but it has low efficiency as compared to servo motor. A servo motor consumes power as it rotates to the commanded position but then it rests. Stepper motor continue to consume power to lock in and hold the commanded position. Servo motor also gives good speed, power and accuracy.

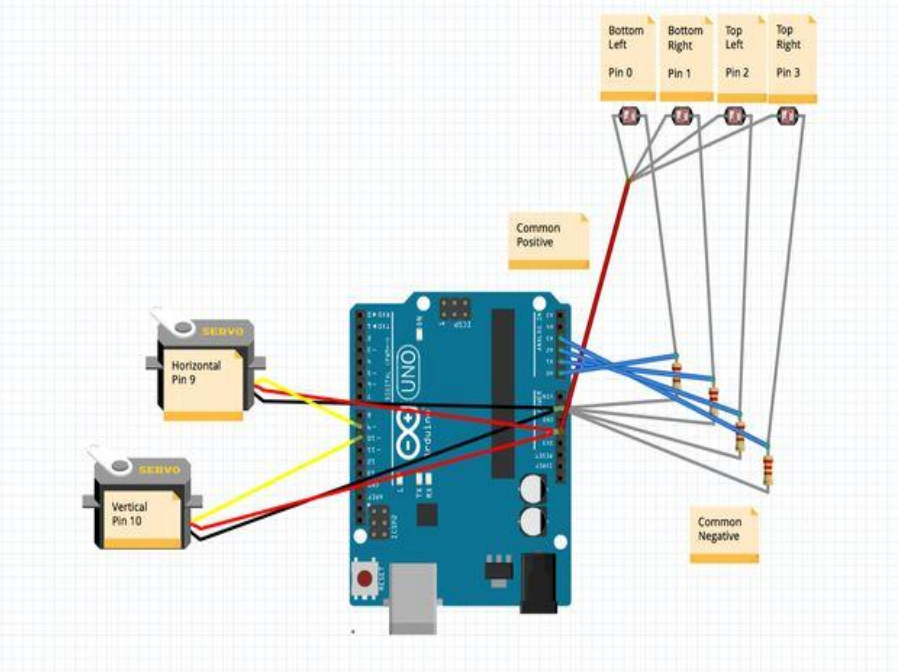

Figure 4: Connection of resistors and servo motors with Arduino UNO

Table 1: Table of components

Sr No.	Component	Quantity
1	Acrylic Sheet	1
3	Cable Wrap Or Twist Ties	2
5	Arduino Uno + USB Cable	1
8	9g Metal Gear Servos	3
9	4 Port Terminal Block (Or 3 Port)	1
10	10k Ohm Resistors	4
11	Light Detecting Resistors	4
12	Jet Socket Connector Cables	4
13	Jumper Wires	15
14	5.5 V Solar Cell	1
15	Led Volt Meter	1
16	The Screws With Servos (3 Per Servo)	
17	M3 Screws + Nuts In Around 14-16mm Length	4
18	Size 2 Screws At A 1/4th Inch Length, Or Some M1 Screws Of Similar Length	4
19	8-32 Screws At 1/2 Inch Length Plus Nuts	20
20	8-32 Screw At 3 Or 4 Inches In Length, And An Optional Nut	1

III. WORKING MECHANISM

The construction of the tracker circuit is divided in following steps,

Step 1: Cut the acrylic sheet according the required dimensions of the solar Panel. Make the base of the stand of the project. Attach servo motors to their mount of the stand. Grab the base plate, the four legs, and the large round piece that now has a Servo attached to it. Here total of 8 of the 6-32 Screws and 8 nuts are needed.

Step 2: First attach the four legs to the round shaped acrylic. The Servo needs to be inside all the legs, between the base plate and the round servo holder. The screws are not tightened all the way, instead they left a bit loose. Next the four legs are fitted into the base plate. When this is done, the servo wire is positioned so that it's coming out towards the back where all the electronics will be. Once all the legs are screwed into the base plate we tighten all the four screws that attach the legs to the round servo holder.

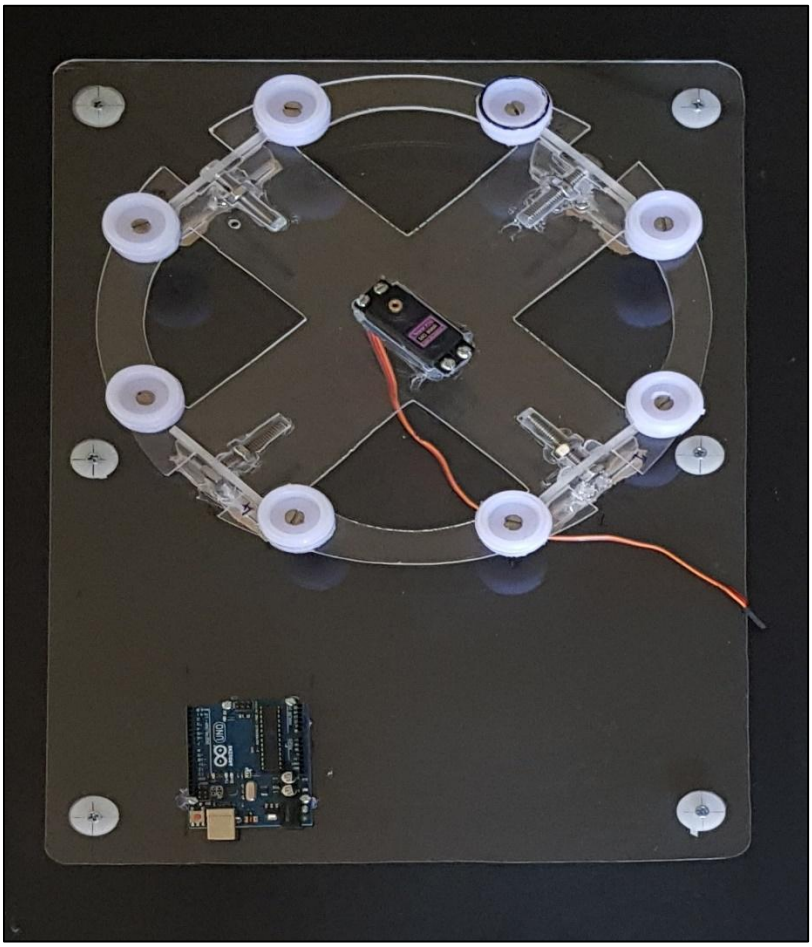

Figure 5: Mounting the first part of tracker

Step 3: According to the size of the solar panel, the base to place the solar panel is made which is the top of the stand. Now build the centre of the mount. Take the other servo mount and the required pieces of the sheet. By keeping all of these together put them into place on the round board. At this point there are three structures assembled independently of each other, one very large and long screw, and the two little servo machine screws remaining. Before attaching all the structures to each other, servos need to be in the correct position first, otherwise they'll be "backwards" compared to what the software is expecting. Home the servo motors in the centre position of the base.

Step 4: Servos move in 180 degrees. The Servo knows where "zero" degree is. Here there is no need of full 180 degree range so on our servos we want to set our "zero" degree to some very specific locations.
Start with the Base Plate Servo. Without using the little screws push the Servo Arm that attached to the Centre into the servo. Once together, slowly rotate the Centre counter clockwise until there servo stops. This is "zero" degree on the Servo. Then take centre off Servo. The second Servo is near where our Arduino will go, and the Centre is at a 45-degree angle compared to the Base.

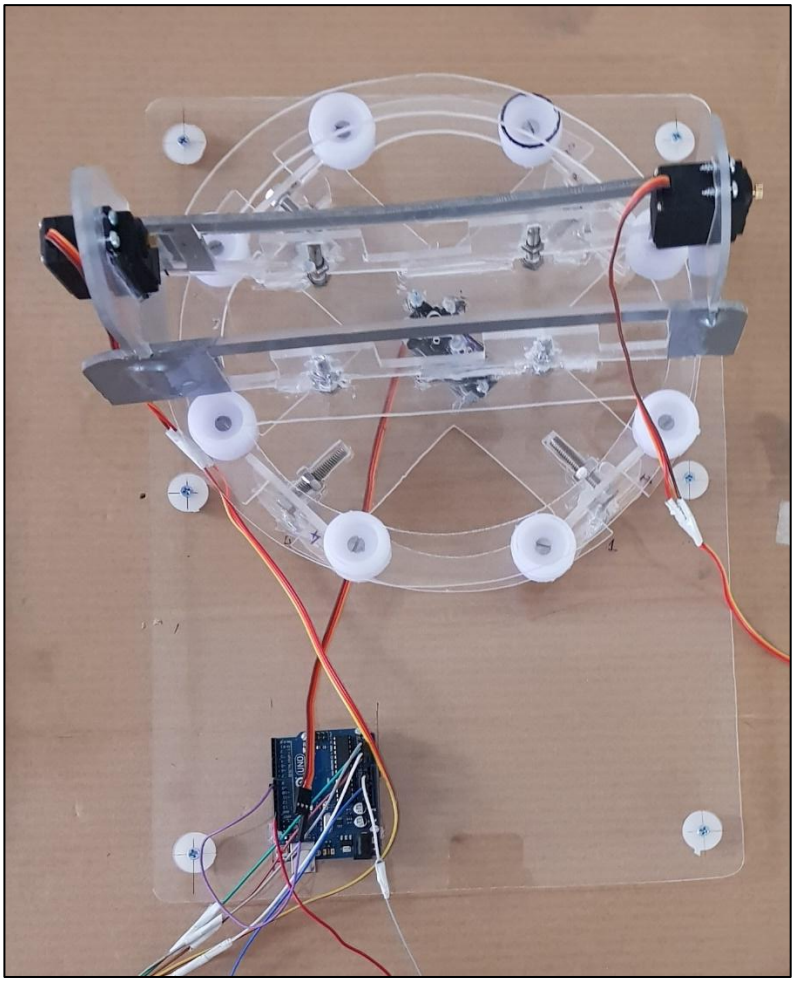

Figure 6: Mounting the second part and the servo motors

Step 5: Use one of the two small Servo Machine Screws to secure the Centre and Base together. Then screw the Arduino into place using at least 2 of the M3 Screws and Nuts. Take four Female JST Connectors. Push one Light Sensitive Resistor (LDR) into each of the four Female JST Connectors. Thread one Female JST Connector through each of the four holes around the LDR Sensor Divider. All the terminals of the connection are then connected to the multiport terminals.

Step 6: Now attach the Servos to Arduino. Then hook up all six Jumpers coming off the Terminal Blocks. Common Negative can go to any of the GND (Ground) pins. Common Positive can go to any of the 5V pins.
Fixing all the structures and connection in an appropriate manner according to the construction decided, the Dual Axis Solar Tracker is ready.

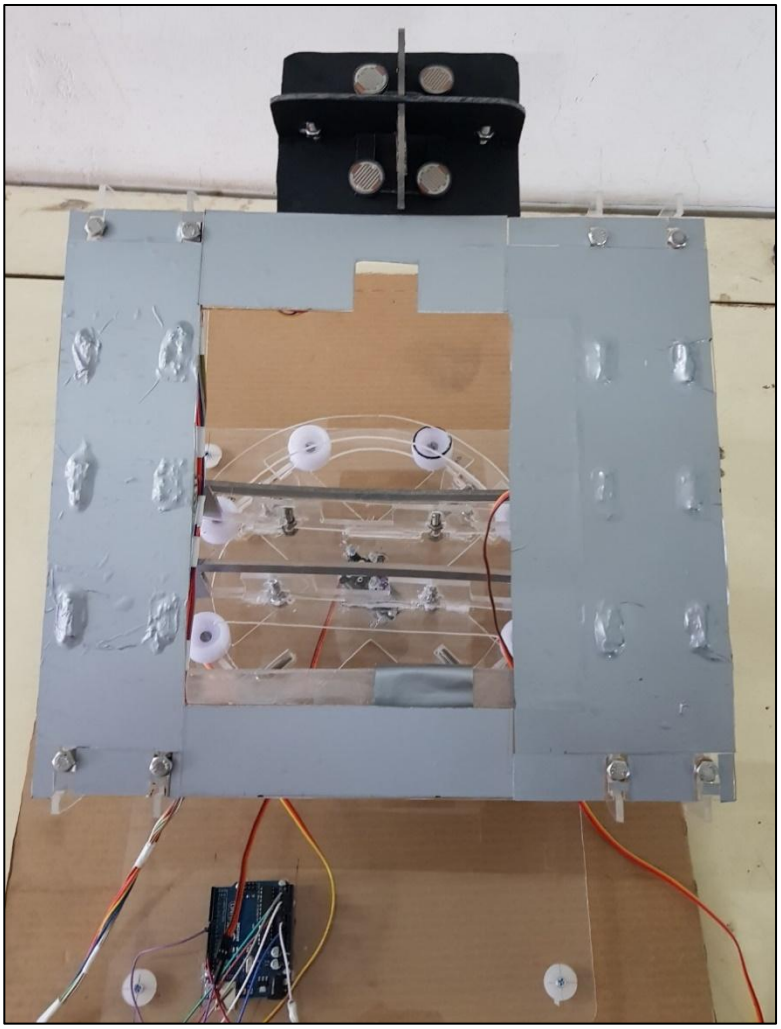

Figure 7: Mounting LDR sensors and stand for the panel

Step 7: Figure 8 is the developed closed-loop solar tracking system which describes the composition and interconnection of the system. For the closed-loop tracking approach, the solar tracking problem is how to cause the solar panel to follow the sunlight as closely as possible.

The sensor-based system consists of the LDR sensor, comparator and microcontroller. In the tracking operation, LDRs are utilized to sense the sun's position and then send the feedback error signal to control system to continuously receive the maximum solar radiation on the panel as a reference input signal.

The unbalance in voltages generated by the LDR sensor generates a feedback error voltage. The error voltage is proportional to the difference between the sunlight location and the solar panel location. The comparator compares the error voltage with a specified threshold voltage.

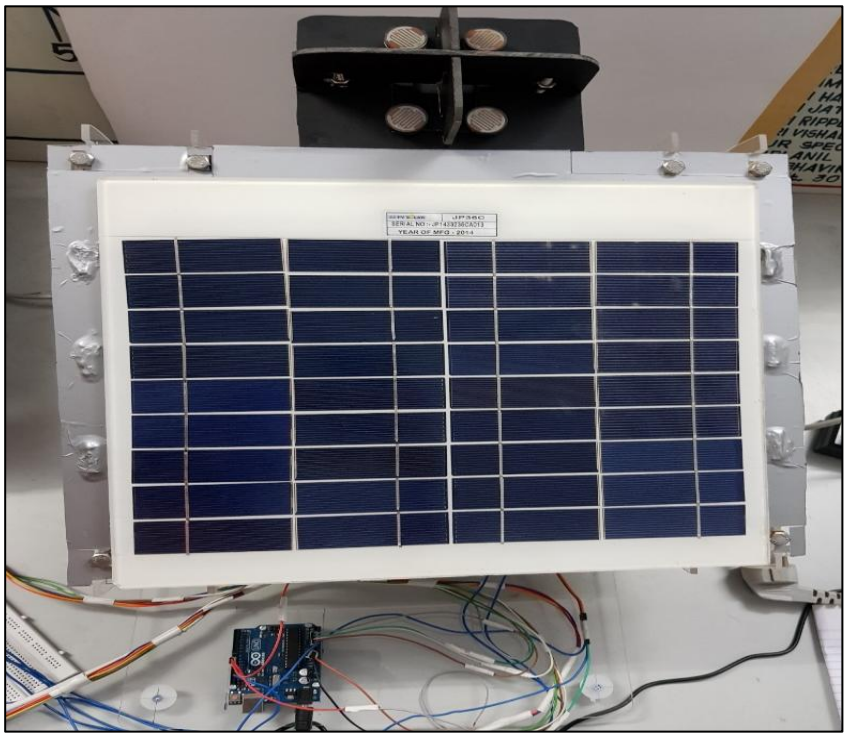

Figure 8: Dual axis solar tracker

If the comparator output goes high state, the motor driver is activated so as to rotate the dual-axis (azimuth and elevation) tracking motor and bring the PV panel to face the Sun. Accordingly, the feedback controller performs the important functions: PV panel and sunlight are constantly monitored and send a differential control signal to drive the PV panel until the error voltage is less than a pre-specified threshold value.

IV. Advantages of Dual Axis Solar Tracker

- More efficient as compared to static and single axis tracker arrangement.
- Proposed system has high degree of accuracy.
- After spending the initial capital cost of building a solar power plant, maintenance cost is extremely low compared to existing power technologies.
- Dual axis solar tracking system is very useful as the sun's position in the sky will change gradually over the course of a day and over the seasons throughout the year.
- The power obtained by dual axis solar tracking is almost constant over a period of time as compare to the output obtained by a Stand- alone (without tracking) solar panel.

Future Scope:

Connecting number of solar tracker assemblies will able to produce sufficient large quantity of power which will be able to supply power to medium size village. Making use of solar panels common in day to day life i.e. for street lighting, in mobile phone chargers, water heaters, etc.

V. CONCLUSION

A solar panel that tracks the sun was designed and implemented. The required program was written that specified the various actions required for the project to work. As a result, tracking was achieved. The system designed was a single axis tracker. While dual axis trackers are more efficient in tracking the sunlight. Maximum power point tracking is achieved. Dual trackers are most suitable in regions where there is a change in the position of the sun. This project was implemented with minimum resources. It allows sunlight to hit the collectors at a better angle, for a longer period; they can improve the efficiency of solar systems up to 20% or 30%.

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