Design and Developement of Prototype of Dual Axis Solar Panel

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by

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CERTIFICATE

Certified that **ABHISHEK PATEL** (1705220002), **RAM GOPAL** (1705220038) and **SUDHANSHOO SINGH** (1705220052) have carried out the project work presented in this project entitled **"DUAL AXIS SOLAR PANEL"** for the award of **Bachelor of Technology** in **Electrical Engineering** at **Institute of Engineering & Technology, Lucknow** under my supervision. The project embodies results of original work, and studies are carried out by the students themselves and the contents of the project do not form the basis for the award of any other degree to the candidates or to anybody else from this or any other University/Institution.

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ABSTRACT

As we know energy demand is increasing rapidly and conventional sources are being depleted at fast rate ,so to meet the energy demand the need of renewable energy sources are essential. Renewable sources is abundance in nature. Solar Energy is also a renewable energy we can convert solar energy into electricity with the help of solar photovoltaic cell. For the conversation into electricity solar panel are the best equipment because it can be installed anywhere. To increase the output of solar panel we use the solar tracking techniques which improve the efficiency. Solar Tracker are of two types which are single axis solar tracker and dual axis solar tracker

In this project we had design and implemented the dual axis solar panel. Dual axis solar panel has some advantages compare to other type solar tracker . However , the dual axis solar tracker has a complex design ,we try to make it at lower lost .Hardware used in designing Dual axis Solar Panel are Arduino Uno board , four LDR sensors and two servo motor and Arduino software has been used for coding. For simulation we used Proteus software .

We also calculated it's output power and compare it with single axis solar panel and then we have plotted the graph in MATLAB. We also estimated it's cost for 1kW and analyze why dual axis solar tracker is not implemented in Solar Power Plant . We plotted the output of dual axis solar panel and single axis solar panel using MATLAB and concluded that dual axis solar panel are more efficient. We have also find out the future scope of Dual axis Solar Panel.

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LIST OF SYMBOL AND ABBREVIATIONS

AC: Alternating Current

DC: Direct Current

IDE: Integrated Development Environment

LDR: Light dependent Resister

PV: Photovoltaic

PWM: Pulse Width Modulation

VOM: Volt-Ohm-Milliammet

CHAPTER 1
INTRODUCTION

1.1 INTRODUCTION

The demand of electricity and its price is continuously increased over the time. Solar energy has become a preferred alternative to meet the electricity demand because of its availability, abundance, and sustainability, regardless the intermittency of sunlight, solar energy is widely available and completely free of cost. The technical solution for the conversion of solar energy into electricity is well known the PV conversion. PV systems can deliver energy on a large scale at a competitive price. The efficiency of the PV systems depends on the degree of use and conversion of the solar radiation. The energy balance refers to the surface that absorbs the incoming radiation and to the balance between energy inflow and energy outflow. The rate of useful energy leaving the absorber is given by the difference between the rate of incident radiation on the absorber and the rate of energy loss from the absorber

In solar thermal power plant a parabolic concentrator is used. A parabolic concentrator is a device which is used to converge the sun rays to a particular point known as a focus. Dual axis solar tracker with parabolic concentrator implemented on it track the sun motion in such a way that maximum sun rays falls on the parabolic concentrator and the parabolic concentrator converge the sun rays to a point known as a focus. This lead to increases the temperature of that point up to 500 °C. So these heat can be used to raise the temperature of water and convert it into steam which is then used to turn turbine and thus electricity is produced. In any solar application, the conversion efficiency is improved when the modules are continually adjusted to the optimum angle as the sun traverses the sky. As improved efficiency means improved yield, use of trackers can make quite a difference to the income from a large plant. Commercial purpose of solar tracking system to increase the solar panel output and maximize the power output per unit area.

In this project we make a model of dual axis solar tracker with possible minimum complexities & more feasible in terms of cost and operation. It also provides the enhancement in the performance of energy harnessing through the PV panels by using solar tracker in compared to the fixed panels.

1.2. Brief overview of project

The project has two parts simulation and hardware implementation.

For simulation we use proteus software . In this we simulate the circuit on Proteus Software.

In hardware part we made dual axis solar panel using Arduino , servo motor and ldr. We check its response toward sun. We calculated output power and compare it with single axis solar panel and we also analyse its cost and output for 1kW dual axis solar panel and try to find it whether it is feasible for company to implement dual axis solar panel.

1.3. Importance of this project

Our Project topic is based on Dual axis solar Tracker. It is used to track the motion of sun. It consists of two axis i.e. horizontal axis and a vertical axis. It track the sun direction in such a way that maximum sun rays fall into the solar panel so that maximum power can be generated. However, Due to cost issue dual axis solar tracker is not implemented in solar power plant but it has a great advantage in solar thermal power plant.

In solar thermal power plant a parabolic concentrator is used. A parabolic concentrator is a device which is used to converge the sun rays to a particular point known as a focus. Dual axis solar tracker with parabolic concentrator implemented on it track the sun motion in such a way that maximum sun rays falls on the parabolic concentrator and the parabolic concentrator converge the sun rays to a point known as a focus. This lead to increases the temperature of that point up to 500°C . So these heat can be used to raise the temperature of water and convert it into steam which is then used to turn turbine and thus electricity is produced.

1.4. Advantage of this project

Higher degree of flexibility-In a single axis system the panel is moved in an east to west direction with respect to the sun and it has better efficiency than panels in fixed form. But in a dual axis system the panel is made to rotate in all four directions in accordance with the sun. which give them more flexibility to rotate compare to single axis and static solar tracker.

Higher efficiency-Dual axis has proved to have more efficiency than both fixed panels and single axis system. A typical dual axis solar panel can generate up to 40% more electricity than a static type, but costs perhaps 100% more and has larger maintenance costs. The amount of power required to move the solar panel must be deducted from the total amount of power gained in order to accurately record the total power gain.

Higher degree of accuracy in directional pointing- Dual axis solar panel can rotate in both (horizontal and vertical) direction . Due to this it can not only track the sun from east to west ,it can also compensate the seasonal variation. It always faces the sun perpendicular so it has higher degree of accuracy in directional pointing.

1.5. Objective of this project

1. To design and implement a dual axis solar panel and compare dual axis with static

solar panel..
2. To find out the problem occurring infront of industry while implementing dual axis solar panel.
3. To know about future scope of dual axis solar tracker and study the research paper on dual axis solar panel.

1.6. Organization of thesis

Chapter 1- It deals with the introduction i.e. overview of the project, its importance, its advantages and objectives.

Chapter 2- It deals with the required theory to understand our project and type of solar tracker used in solar panel.

Chapter 3- It deal with all the component used in modelling of dual axis solar panel in detail

Chapter 4- In this chapter we discuss the basic logic used to drive the LDR circuit. We have simulated it using PROTEUS software and verified it’s code using ARDUINO software.

Chapter 5- It discuss the block diagram and methodology of our project which include mechanical design ,its collection and hardware system

Chapter 6- It contain the output reading and plotted it using MATLAB Simulation .
In this we also compared its output with static solar panel and discuss about improved efficiency and cost modelling of 1kW solar panel. It also explain the problem occurring in industries in implementing dual axis solar panel

Chapter 7- It deals with all the future scopes related to the project and includes concluding statement of our work .

CHAPTER 2

BACKGROUND THEORY

2.1. What is solar energy

Solar energy is defined as the sun " s radiation that reaches the earth. It is the most readily available source of energy. Ninety-three million miles from Earth, our sun is 333,000 times the size of our planet. It has a diameter of 865,000 miles, a surface temperature of 5,600°C and a core temperature of 15,000,000°C. It is a huge mass of constant nuclear activity.
Directly or indirectly, our sun provides all the power we need to exist and supports all life forms. The sun drives our climate and our weather. Without it, our world would be a frozen wasteland of ice covered rock. Solar electricity is a wonderful concept. We take power from the sun and using it to power electrical equipment to generate electricity. Solar energy is widely utilized in the form of Solar Lamps, Solar Water heater, Solar Cooker and also solar pumps and solar energy is used for heat buildings and to provide low temperature heat for Industry and Agriculture.

2.1.1. Advantages of solar energy

Solar energy are easily available in nature and easily accessible. It can be harness free of cost. It can be installed virtually anywhere; in a field to on a building. Solar energy can be used to heat water, power homes and buildings, even power cars. It is pollution free and easily available in bulk.

2.2. Why we need solar tracking panel

Sun is an abundant source of energy and this solar energy can be harnessed successfully using solar photovoltaic cells and photovoltaic effect to convert solar energy into electrical energy but the conversion efficiency of a normal PV cell is low.
One of the main reason for this is that the output of PV cell is dependent directly on the light intensity and with the position of the sun in the sky changing continuously from time to time. In photovoltaic systems, trackers help minimize the angle of incidence (the angle that a ray of light makes with a line perpendicular to the surface) between the incoming light and the panel, which increases the amount of energy the installation produces.

2.3. Solar tracking panel

Solar Tracking System is a power generating method from sunlight. This method of power generation is simple and is taken from natural resource. This needs only maximum sunlight to generate power. solar panels harvest sunlight and actively convert it to electricity. Solar Cells, or photovoltaic cells, are arranged in a grid-like pattern on the surface of the solar panel. Solar panels are typically constructed with crystalline silicon, which is used in other industries. These solar cells function similarly to large semiconductors and utilize a large area p-n junction diode. When the solar cells are exposed to sunlight, the p-n junction diodes convert the energy from sunlight into usable electrical energy. The energy generated from photons striking the surface of the solar panel allows electrons to be knocked out of their orbits and released, and electric fields in the solar cells pull these free electrons in a directional current, from which metal contacts in the solar cell can generate electricity. The more solar cells in a solar panel and the higher the quality of the solar cells, the more total electrical output the solar panel can produce.

A solar tracker is a device that orients a payload toward the sun. The use of solar trackers can increase electricity production compare to modules at a fixed angle. In any solar application, the conversion efficiency is improved when the modules are continually adjusted to the optimum angle as the sun traverses the sky. As improved efficiency means improved yield, use of trackers can make quite a difference to the income from a large plant. Commercial purpose of solar tracking system to increase the solar panel output and maximize the power output per unit area.

There are mainly two type of solar tracker

1.Single axis solar tracker

2. Dual axis solar tracker

2.3.1. Single axis solar tracker

In single axis solar panel we rotate the panel on one axis only. Generally we place it in a way it rotate from east to west for tracking. According to the results of the calculation of the rotation angle of the sun, the collectors rotate around the axis of rotation to track the sun. At high noon, the angle between the incident direction of the sun and the normal direction of the collector's aperture is the smallest; collectors can then obtain the maximum heat flux. In the morning or afternoon the sunlight is oblique. Single-axis tracking has the advantage of simple structure. The disadvantage is that the incident light cannot always be perpendicular to the collector's aperture, so the collection of solar energy is not enough to maintain the maximum.

2.3.2. Dual axis solar tracker

The dual-axis in service is as good as to single axis however it captures the solar energy more productively by rotating within the horizontal as well as the vertical axis. The device is able to track the daytime motion of the sun precisely and shift in the vertical axis accordingly. The device also effectively tracks the seasonal displacement of the sun and moves the entire mechanism in the horizontal plane or in a lateral. The pivotal arrangement allows the panel mounts to move on a circular axis over almost 360 degree. A motor gear mechanism as shown in the diagram is fitted just at the corner of the pivotal axis in such a way that when the motor rotates the entire solar panel shifts proportionately about its central pivot, either anticlockwise or Clockwise, depending upon the motion of the motor which in turn depends on the position of the sun.

In a single axis system, the panel is moved in an east to west direction with respect to the sun and it has better efficiency than panels in fixed form. But in a dual axis system the panel is made to rotate in all four directions in accordance with the sun. Dual axis has proved to have more efficiency than both fixed panels and single axis system. A typical dual axis solar panel can generate up to 40% more electricity than a static type, but costs perhaps 100% more and has larger maintenance costs. The amount of power required to move the solar panel must be deducted from the total amount of power gained in order to accurately record the total power gain.

CHAPTER 3

HARDWARE COMPONENT

3.1. Hardware Component

In this project we have used the following component

S.R. No.	COMPONENT	No. of Component	Rating
1.	Solar panel	1	8V, 100mA
2.	ARDUINO	1	Model number - uno004
3.	LDR	4	
4.	Resister	4	10 kohm
5.	Servo Motor SG90	2	Torque-1.8kg-cm Speed-0.10sec/60
6.	Jumper wire		
7.	Soldering Kit	1	
8.	Battery	1	10000mah
9.	Bread Board	1	840 point
10.	Multimeter	1	10 A max 500V max

Table 3.1 hardware component

These component are explained below

3.1.1. Solar Cell

Solar cell is photovoltaic devise that covert light energy in electrical energy. This device work on principles of photovoltaic effect . the photovoltaic effect is the photogeneration of charge carriers in alight absorbing material as a result of absorption of light radiation.

Solar cell (crystalline Silicon) consists of a n-type semiconductor (emitter) layer and p-type layer (base). The two layers are there is formation of p-n semiconductor sandwiched and hence junction. The surface is coated with anti-refection coating to loss of incident light energy due to avoid the reflection. A proper metal contacts are made on the n-type and p-type side of the semiconductor for electrical connection.

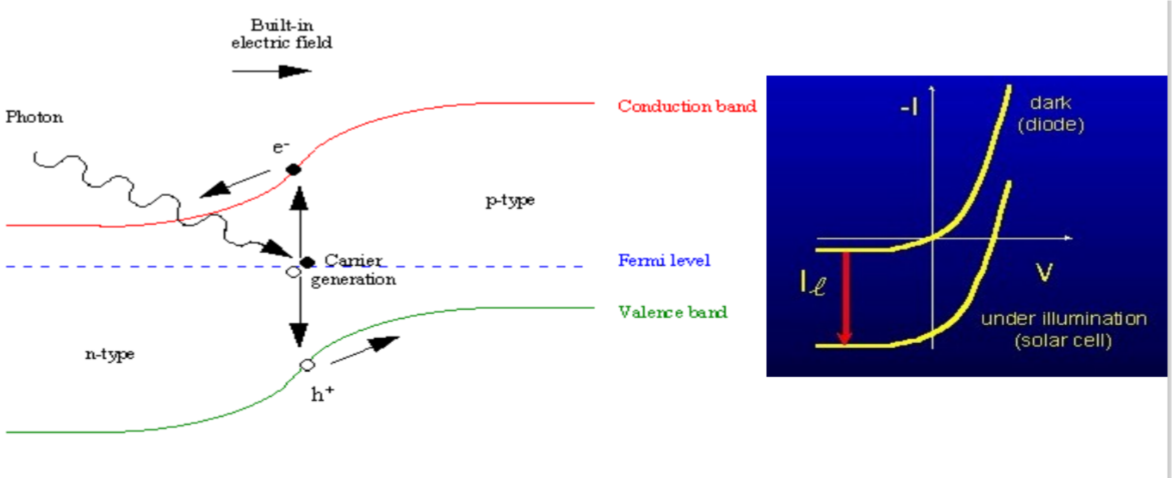


Figure3.1.1. Solar Cell Principle

When a solar cell exposed to sunlight , the light energies are absorbed by a semiconductor materials. Due to this absorbed energy, the electrons are liberated and produce the external DC current. The DC current converted into 240-volt AC current using an inverter for different applications.

The solar panel (or) solar array is the interconnection of number of solar cell to get efficient power.

• A solar module consists of number of interconnected solar cells.

• These interconnected cells embedded between two glass plate to protect from the bad weather.

• Since absorption area of module is high, more energycan be produced.

3.1.1.1. Type of Solar Cell

Based on the types of crystal used, solar cells can be classified as,

1. Monocrystalline silicon cells

2. Polycrystalline silicon cells

3. Amorphous silicon cells

1. The Monocrystalline silicon cell is produced from pure silicon (single crystal). Since the Monocrystalline silicon is pure and defect free, the efficiency of cell will be higher.

2. In polycrystalline solar cell, liquid silicon is used as raw material and polycrystalline silicon was obtained followed by solidification process. The materials contain various crystalline sizes. Hence, the efficiency of this type of cell is less than Monocrystalline cell.

3. Amorphous silicon is obtained by depositing silicon film on the substrate like glass plate.

•The layer thickness amounts to less than 1µm – the thickness of a human hair for comparison is 50-100 µm.

•The efficiency of amorphous cells is much lower than that of the other two cell types.

• As a result, they are used mainly in low power equipment, such as watches and pocket calculators, or as facade elements.

3.1.1.2. Efficiency

Monocrystalline silicon 14-17%

Polycrystalline silicon 13-15%

Amorphous silicon 5-7%

3.1.2. LDR

The Working principle of an Light Dependent Resistor depends on the principle of photoconductivity. When the light rays fall on the material of Light Dependent Resistor its conduEctivity enhances which result in decrease in its resistance. When the light falls on the material then electrons in valence band absorb the energy from the light and are eager to move to conduction band which enhances conductivity and leads to decrease in resistance.

Fig 3.1.2 LDR

3.1.2.1. Construction

The construction of an LDR includes a light-sensitive material that is placed on an insulating substrate like ceramic. The material is placed in a zigzag pattern to get the required power rating and resistance. The area of zigzag separates the metal-placed areas into two regions.

Where the Ohmic contacts are made either on the edges of the area. The resistances of the contacts must be as low as possible, to make sure that the resistance, mainly varies due to the light effect. Lead & cadmium materials are avoided because they are harmful to the environment.

3.1.3. AURDINO

ARDUINO is a tool for making computers that can sense and control more of the physical world than your desktop computer. It is an open-source physical computing platform based on a simple microcontroller board, and a development environment for writing software for the board.

ARDUINO can be used to develop interactive objects, taking inputs from a variety of switches or sensors, and controlling a variety of lights, motors, and other physical outputs.

ARDUINO projects can be stand-alone, or they can be communicating with software running on your computer. The ARDUINO programming language is an implementation of Wiring, a similar physical computing platform, which is based on the Processing multimedia programming environment.

Fig3.1.3. ARDUINO

ARDUINO is a popular open-source single-board microcontroller, descendant of the open-source Wiring platform designed to make the process of using electronics in multidisciplinary projects more accessible. The hardware consists of a simple open hardware design for the ARDUINO board with an Atmel AVR processor and on-board input/output support. The software consists of a standard programming language compiler and the boot loader that runs on the board.

ARDUINO hardware is programmed using a Wiring-based language (syntax and libraries), similar to C++ with some slight simplifications and modifications, and a Processing-based integrated development environment. ARDUINO programs are written in C/C++, although users only need define two functions to make a run-able program:

setup () – a function run once at the start of a program that can initialize settings

loop() – a function called repeatedly until the board powers off

The code which goes inside the microcontroller is known as ‘HEX’ code. This code is generated by compilers. The process of loading the code into the (flash memory of) microcontrollers is known as ‘Burning’ the microcontroller. There are several methods of burning microcontroller like using ‘ISP’ method, using ‘High Voltage Programming’ using ‘Boot-loaders’ etc. Each method has its own merits and demerits.

3.1.4. SERVO MOTOR

Servo motors are part of a closed-loop system and are comprised of several parts namely a control circuit, servo motor, shaft, potentiometer, drive gears, amplifier and either an encoder or resolver. A servo motor is a self-contained electrical device, that rotate parts of a machine with high efficiency and with great precision. The output shaft of this motor can be moved to a particular angle, position and velocity that a regular motor does not have. The Servo Motor utilizes a regular motor and couples it with a sensor for positional feedback. The controller is the most important part of the Servo Motor designed and used specifically for this purpose.

Servo motors are controlled by PWM(pulse width modulation), through the control wire. Its angle of rotation is controlled by the duration of pulse applied to its control PIN. A servo motor is a closed-loop servomechanism that uses position feedback to control its motion and final position.

The motor is consist of some type of encoder to provide position and speed feedback. first, we measure only the position. Then the measured output position is compared with the command position, the external input to controller. Now If the output position deviate from the expected output, an error signal generates. Which then causes the motor to rotate in either direction, as per need to bring the output shaft to the appropriate position. As the position approaches, the error signal reduces to zero. Finally the motor stops

We use gear assembly to lower the motor's speed and enhance its torque. Let's say the location of the potentiometer knob at the start of the servo motor shaft is such that no electrical signal is created at the potentiometer's output port. An electrical signal is now sent to the error detection amplifier's other input terminal. Now the difference between these two signals, one comes from the potentiometer and another comes from other sources, will be processed in a feedback mechanism and output will be provided in terms of error signal. This error signal acts as the input for motor and motor starts rotating. The potentiometer is now linked to the motor shaft, and as the motor rotates, so does the potentiometer, which generates a signal. As the angular location of the potentiometer changes, so does the output feedback signal. After a while, the position of the potentiometer reaches a point where the output of the potentiometer is the same as the external signal. Because there is no difference between the external applied signal and the signal created at the potentiometer, there will be no output signal from the amplifier to the motor input in this circumstance, and the motor will stop rotating.

3.1.5. BREAD BOARD

Breadboard is a thin plastic board used to hold electronic components (transistors, resistors, chips, etc.) that are wired together. Used to develop prototypes of electronic circuits, breadboards can be reused for future jobs. They can be used to create one-of-a-kind systems but rarely become commercial products. See printed circuit board.

The breadboard contains spring clip contacts typically arranged in matrices with certain blocks of clips already wired together. The components and jump wires (assorted wire lengths with pins at both ends) are plugged into the clips to create the circuit patterns. The boards also typically include metal strips along the side that are used for common power rails and signal buses.

A breadboard is used to make up temporary circuits for testing . Since no soldering is required, changing and replacing connections is simple.

A bread board is just an array of conductive metal clips contained in a white ABS plastic box, with each clip insulated by another clip. The plastic box has a number of holes that are organised in a specific pattern. A typical bread board layout consists of two types of region also called strips. Bus strips and socket strips. Bus strips are usually used to provide power supply to the circuit. It consists of two columns, one for power voltage and other for ground. Socket strips are used to hold most of the components in a circuit. Generally it consists of two sections each with 5 rows and 64 columns. Every column is electrically connected from inside.

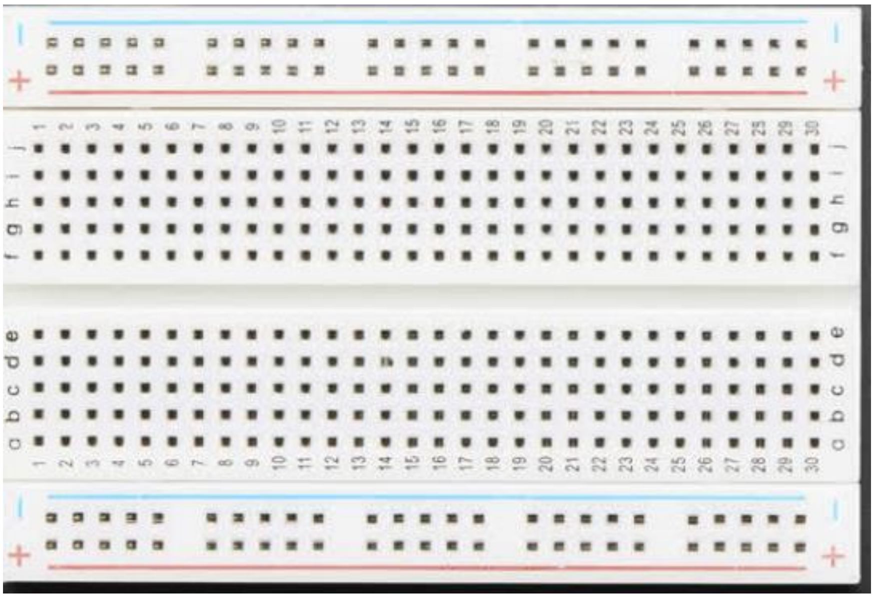


Fig3.1.5. breadboard

3.1.6. Resistor

The opposition offered by a substance to the flow of electric current is called its resistance.

Since current is the flow of free electrons, resistance is the opposition offered by the substance to the flow of free electrons. This opposition occurs because atoms and molecules of the substance obstruct the flow of these electrons. Certain substances offer very little opposition to the flow of electric current and are called conductors. On the other hand, those substances which offer high opposition to the flow of electric current (i.e. flow of free electrons) are called insulators. It may be noted here that resistance is the electric friction offered by the substance and causes production of heat with the flow of electric current. The moving electrons collide with atoms or molecules of the substance, each collision resulting in the liberation of minute quantity of heat.

Unit of resistance- The practical unit of resistance is ohm

The resistance R of a conductor

(i) is directly proportional3.1.6 to its length

(ii) is inversely proportional to its area of X-section

(iii) depends upon the nature of material.

(iv) depends upon temperature.

From the first three points (leaving temperature for the time being), we have,

R is proportional to l/a or $R = \rho * l/a$

where ρ (Greek letter 'Rho') is a constant and is known as resistivity or specific resistance of the material. Its value depends upon the nature of the material.

3.1.7. Multimeter

A multimeter is an electronic tool used to measure voltage, amps and resistance across circuits. By attaching two leads to different parts of an electrical system, professionals can use multimeters to detect levels of voltage and resistance, or changes in electrical currents. This tool may also be known as a volt-ohm meter or volt-ohm-milliammeter (VOM).

New digital multimeters have advanced to the point that they can measure extremely tiny differences or fluctuations. Experts point out that although some multimeters test higher ranges of voltage, it will be less possible to detect smaller changes in these higher ranges. Multimeters have a lot of practical applications in IT. Hardware troubleshooting is an area where professionals may use a multimeter to figure out whether individual hardware devices are getting enough current, or whether anything has changed in an existing IT setup. Although many think of the multimeter as something that is in a residential or commercial electrician's toolbox, this tool can also be something that IT professionals use in diagnosing energy supply issues behind advanced data systems.

Fig3.1.7. multimeter

3.1.8. Jumper Wire

Jumper wires are simply wires that have connector pins at each end, allowing them to be used to connect two points to each other without soldering. Jumper wires are typically used with breadboards and other prototyping tools in order to make it easy to change a circuit as needed. Jumper wire has two type of pin. One is male pin and other is female pin

The difference between each is in the end point of the wire. Male ends have a pin protruding and can plug into things, while female ends do not and are used to plug things into. Male-to-male jumper wires are the most common and what you likely will use most often.

Fig3.1.8. jumper wire

CHAPTER 4

SIMULATION & CODING

4.1. Simulation

The main purpose of simulation is to verify our circuit. We have modelled our circuit on Proteus Software to verify whether the circuit is correct or not. Here, We change the value of LDR manually with the help of keyboard and according to Code which we used in our project Motor rotate in a particular Direction and if motor rotate in a particular prescribed direction then our code is also verified. Proteus Software is just used to verify our circuit Diagram and code. For Plotting the Graph and comparing it with hardware result we have to opt another software and yet also proper comparison won't be possible as the efficiency of Photovoltaic Cell which we are using in hardware may not match to the efficiency of solar Panel which we will be using in Software for Comparison.

When the LDR1 is getting the light source in position 1 (left and bottom), then the ARDUINO is getting the signal from the LDR1 and hence the ARDUINO will send the signal to both of servo motors. The first servo motor (bottom) will rotate anticlockWise and the second servo motor (top) will also turn anticlockwise. The same thing will happen when the LDR2 is getting the light source in position 2 (right and bottom). This is because from the coding that has been set in the software part. For position 3, when the LDR4 is getting the light source (right and top), same thing happen to the ARDUINO which is getting the signal from LDR4 then the ARDUINO will send the signal to both of servo motor. The opposite will happen compare to the position 1 and 2, for the first servo motor (bottom) will rotate the lockwise and for the second servo motor (top) will also turn clockwise.

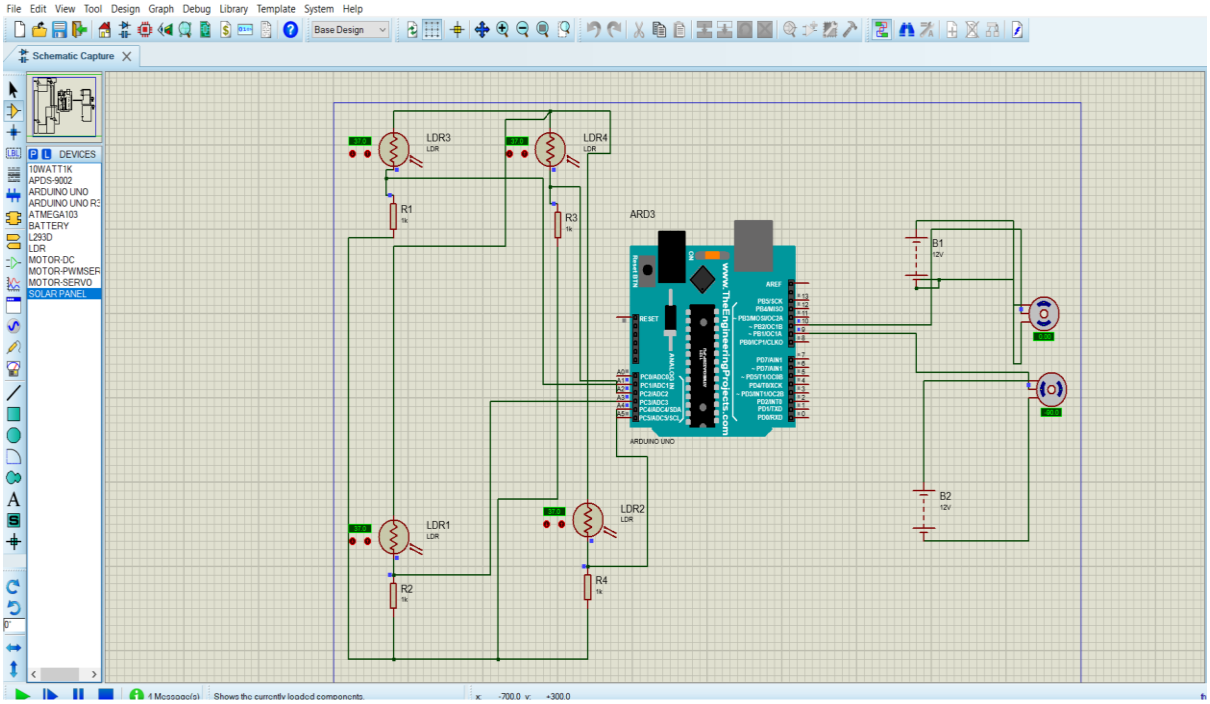


Fig 4.1. Simulation

4.1.1. Result

As the value of LDR change motors rotate accordingly. Hence our circuit diagram and its code is verified.

4.2. Coding

4.2.1 Algorithm

Step1: Start

Step 2: Declare Variable servohori and servovrti, ldrtopl, ldrtopr ,ldrbotr ,ldrbotl, servohLimitHigh, servohLimitLow, servovLimitHigh, servovLimitLow

Steps 3: Initialize variable ldrtopl, ldrtopr ,ldrbotr ,ldrbotl, servohLimitHigh, servohLimitLow, servovLimitHigh, servovLimitLow

Step 4: Attach pin 10 of Arduino to servo motor (horizontal) and reset it. Attach pin 9 of Arduino to servo motor (vertical) and reset it.

Step 5: Read the value of both servo motor, ldrtopl, ldrtopr ,ldrbotr ,ldrbotl.

Step 6: avgtop= (topl+topr)/2

avgbot= (botl + botr) /2.

avgleft = (topl+ botr)/2

avglight = (topr + botl)/2.

Step 7: if (avgtop < avgbot) then servoverti.write (servov+1) else, go to Step 9

Step 8: if (servov >servoLimitHigh) then servov = ServovLimitHigh

Step 9: if (avgbot <avgtop) then servoverti.write (servov-1) else, go to step 11
Step10: If (servov < servobLimitLow) then servov=servovLimitLow
Step 11: servoverti.write(servov)
Step 12: if (avgleft>avgright) then servohori.write(servoh+1) else go to Step 14
Step 13: if (servoh>servohLimitHigh) then servoh=servohLimitHigh
Step 14: if (avgright>avgleft) then servohori.write (servoh-1) else go to Step 16
Step 15: if (servoh< servohLimitLow) then servoh=servohLimitLow
Step 16: servohori.write (servoh)
Step 17: Stop

4.2.2. Flow Chart

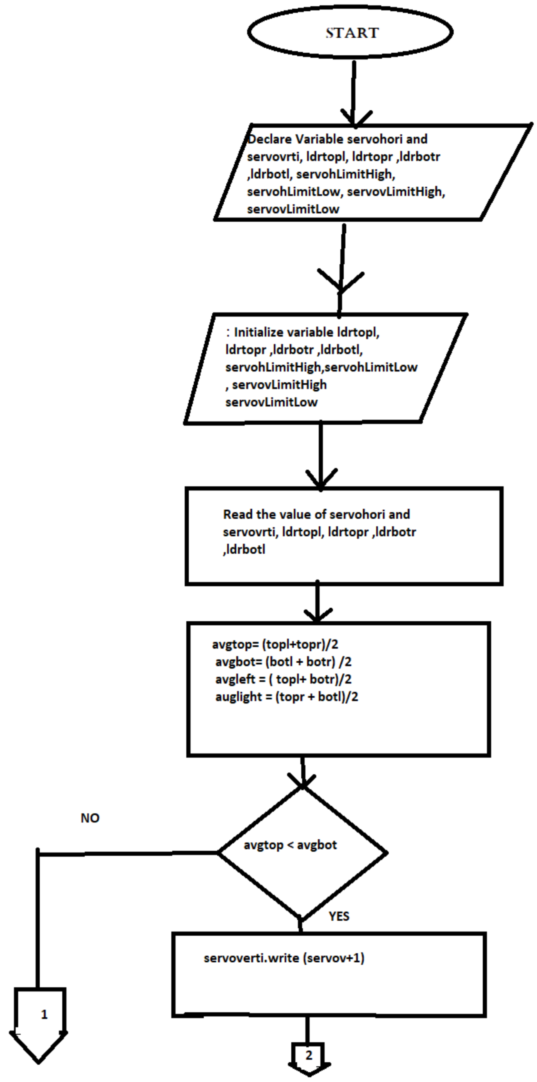


Fig 4.2.2. Flow Chart

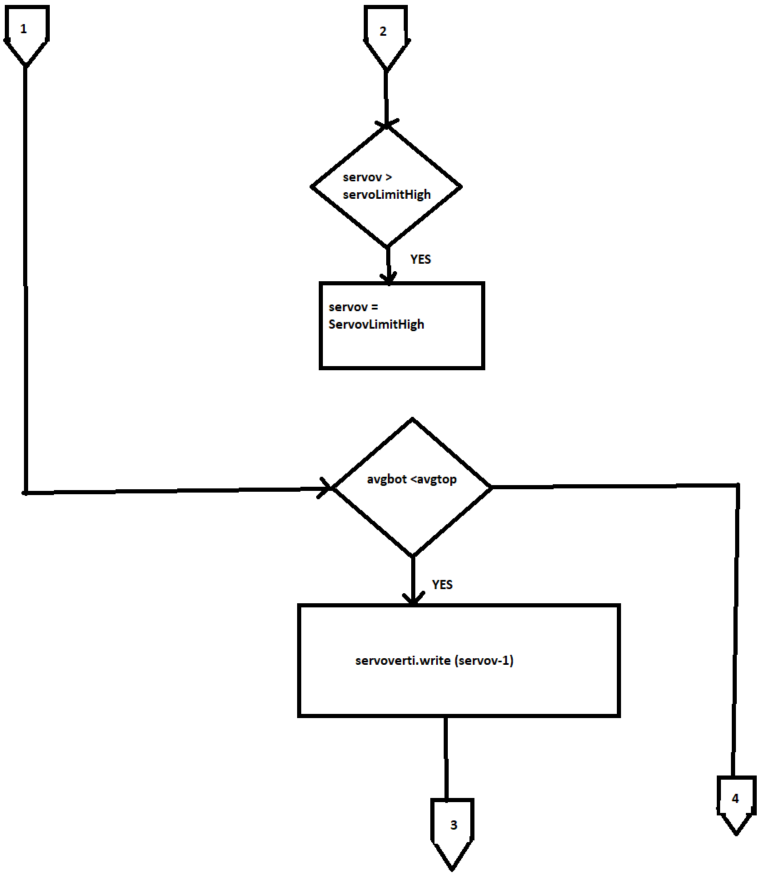


Fig4.2.2. Flow Chart

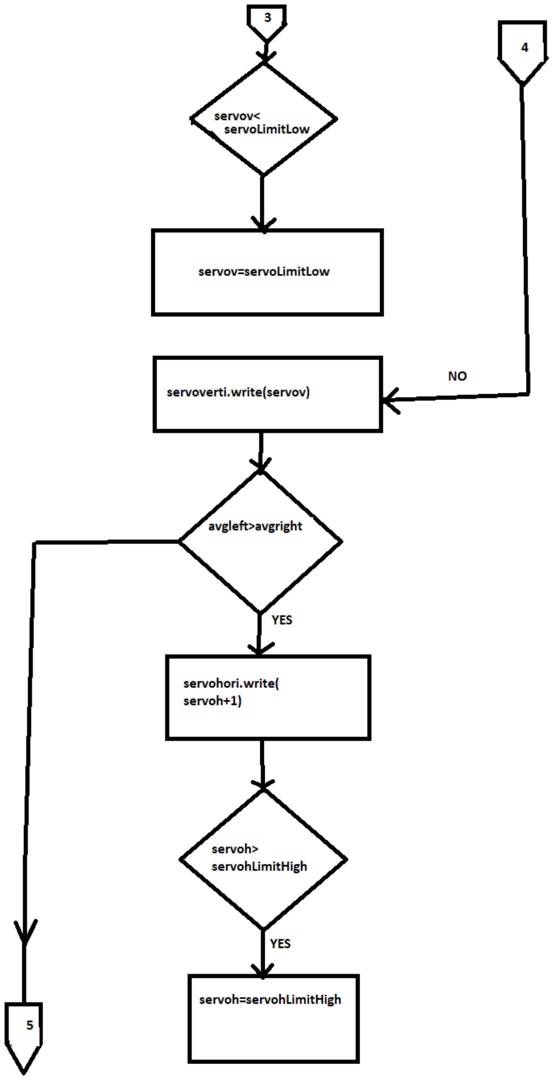


Fig 4.2.2. Flow Chart

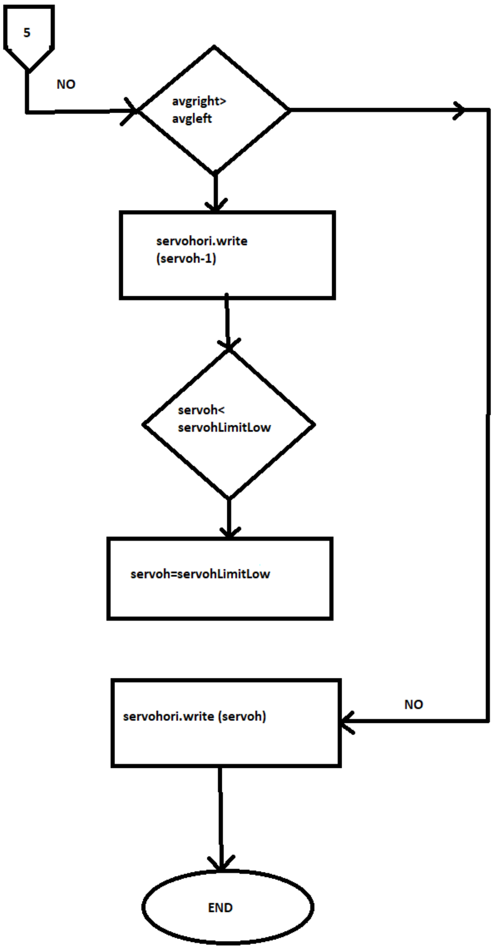


Fig 4.2.2. Flow Chart

4.2.3. Coding

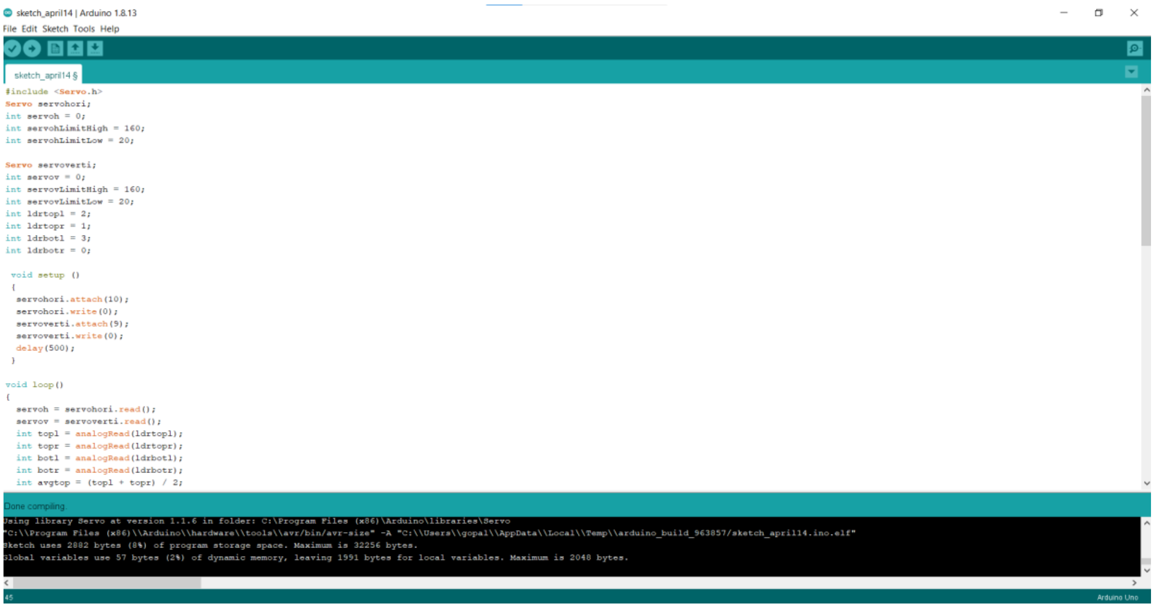


Fig 4.2(a) coding

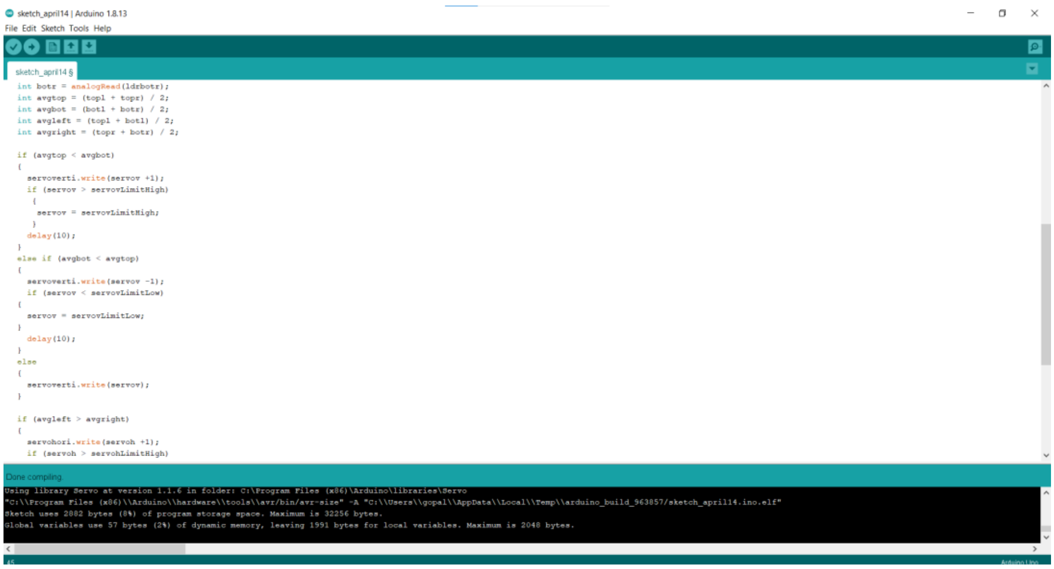


Fig 4.2(b) coding

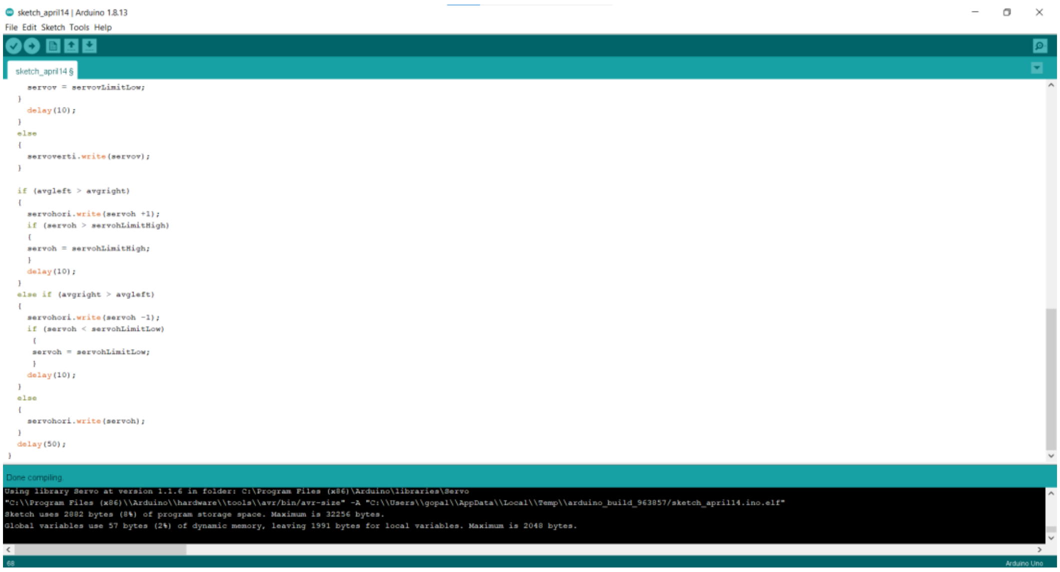


Fig 4.2(c) coding

CHAPTER 5

HARDWARE

5.1. Block Diagram

Figure 5.1 shows the block diagram of a dual axis solar tracker. 4 LDR sensors are placed adjacent to the solar panel and will be activated when light is detected. An activate signal will be sent to the microcontroller and when the signal is received, the ARDUINO microcontroller will activate the 2 motors. As ARDUINO give signal to servo motor will rotate and solar panel will rotate with it.

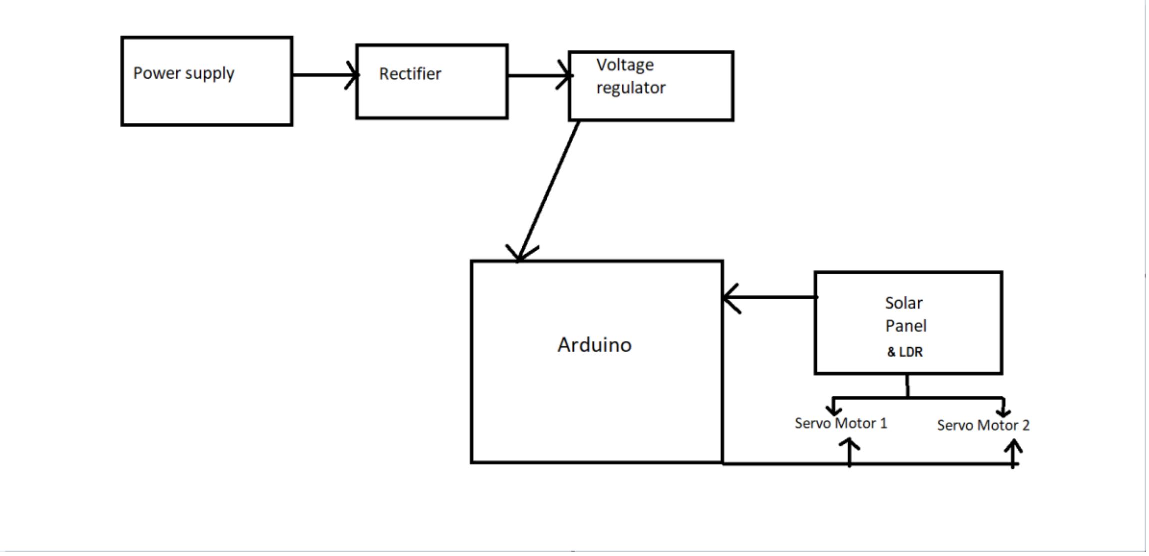


Fig5.1. block diagram

Since it is a hardware based project the main comments are light dependent resistor (LDR), servo motor , ARDUINO Uno main controller.

LDR- LDR is mainly used for sensing purpose in order to catch the solar energy and provide analog input to ARDUINO.

SERVO MOTOR-Servo motor is 3 wired dc motor which works on the principal of servo mechanism . Which can rotate upto maximum 180° .servo motor are powered by PWM output received from the ARDUINO

ARDUINO Uno-ARDUINO Uno is a type of microcontroller the purpose of microcontroller is to control the position of motor.

In this project we use two servo motor for horizontal and vertical rotation. Resistance of LDR depends on intensity of the light and it varies according to it. The higher is the intensity of light, lower will be the LDR resistance and due to this the output voltage lowers and when the light intensity is low, higher will be the LDR resistance and thus higher output voltage is obtained.

A potential divider circuit is used to get the output voltage from the sensors (LDRs).
The LDR senses the analog input in voltages between 0 to 5 volts and provides a digital number at the output which generally ranges from 0 to 1023.Now this will give feedback to the microcontroller using the ARDUINO software(IDE).
The tracker finally adjusts its position sensing the maximum intensity of light falling perpendicular to it and stays there till it notices any further change.
The sensitivity of the LDR depends on point source of light. It hardly shows any effect on diffuse lighting condition.
The 5V supply is fed from an USB 5V dc voltage source through ARDUINO Board.
Servo X: Rotates solar panel along X direction
Servo Y: Rotates solar panel along Y direction

5.2. Mechanical Design

It is composed of the PV panel, the left-right and up-down servomotors, and four LDR sensors. For the horizontal axis, a bearing is fixed in parallel with the up-down servomotor for better flexibility. The solar tracker is designed to have two degrees of freedom, from east to west by the left-right servomotor and from south to north by the up-down servomotor. The LDR sensors are placed in the four corners of the PV panel and are put in dark tubes with a small hole on the top to detect the illumination of the sun. These dark tubes are also considered a concentrator of radiation and are used to increase the solar tracker robustness.

5.3. Hardware System

For automatic mode, the microcontroller converts the analogs values of LDR sensors (pins A0 to A3) into digitals. Then it controls two servomotors(up-down and left-right) using two Pulse-Width Modulation (PWM) signals (pins 5and 6) to track the sun. The rotation movements occur in two axes, in azimuth from east to west according to the daily sun's path and in elevation from south to north according to the seasonal sun's path. For manual mode, a potentiometer (pin A4) is used to control the movement of the two servo motors, a push-button (pin 11) is deployed to connect the potentiometer either to up-down servomotor or left-right servomotor. Besides, another pushbutton (pin 12) is used to switch between the two modes. Furthermore, the PV voltage is measured through the analog pin A5 of the ARDUINO, then the PV current is calculated since the resistor of the load is already known. Next, the PV current, voltage and power versus time and the actual mode are sent to the computer to present them in real-time on MS Excel.
The LDR sensor circuitry is designed as a voltage divider circuit. The variation in the light intensity is proportional to the variation of the divider output voltage. The top of the potential divider is 5 V, the ground is at 0 V, and the output of the voltage divider is connected to an analog input (A0 for instance) of the microcontroller. Subsequently, the

Analog to Digital Converter(ADC) of the microcontroller converts the analog value read by A0 into a digital value between 0 and 1023 because the ADC is coded in 10 bits, and according to this value, it is possible to know the level of light. The value of resistors used in voltage dividers is 10k ohm.

Two 180 degrees servomotors are used. A servomotor to control the solar tracker according to the vertical axis, which is the left-right servomotor. And a micro servo motor to control the solar tracker according to the horizontal axis, which is the up-down servomotor. The advantage of the servomotor is that we can control its stop, run, the direction of rotation and speed using a single low current wire connected directly to an output of the microcontroller without needing any drivers. The used servo motors are controlled by the ARDUINO UNO board via 3-wire electrical cable.

two wires for supply and one wire for PWM to control its positions.

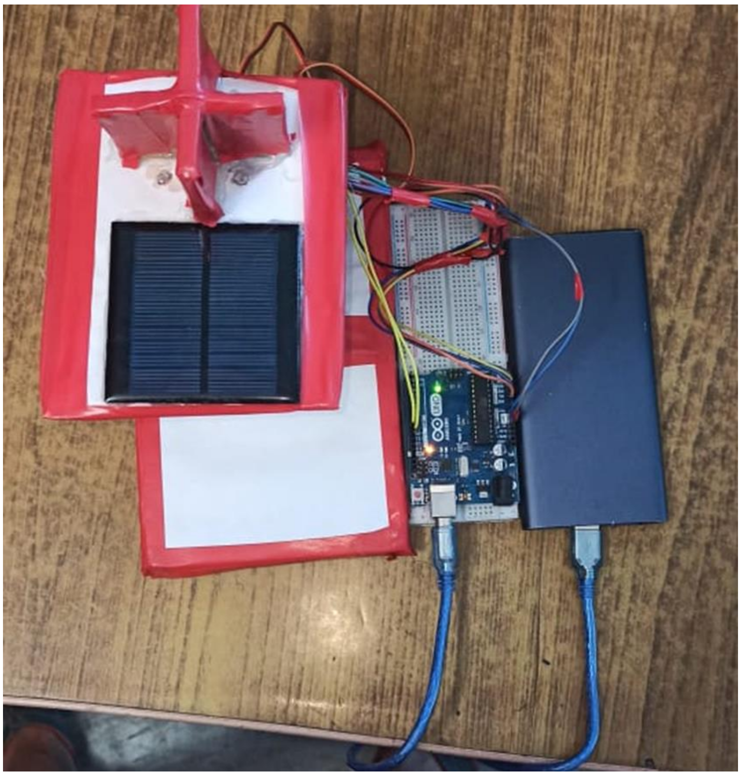


Fig5.2. dual axis solar panel

5.4. Connection

We connect the power pins of both vertical and horizontal servo motor to the 5 volt. Similarly we connect ground pin of the both horizontal and vertical servo motor to the ground .

Now we connect the signal pin of the vertical servo motor to the digital pin number 10 of the ARDUINO.

Again, we connect the signal pin of the horizontal servo motor to the digital pin no 9 of the ARDUINO.

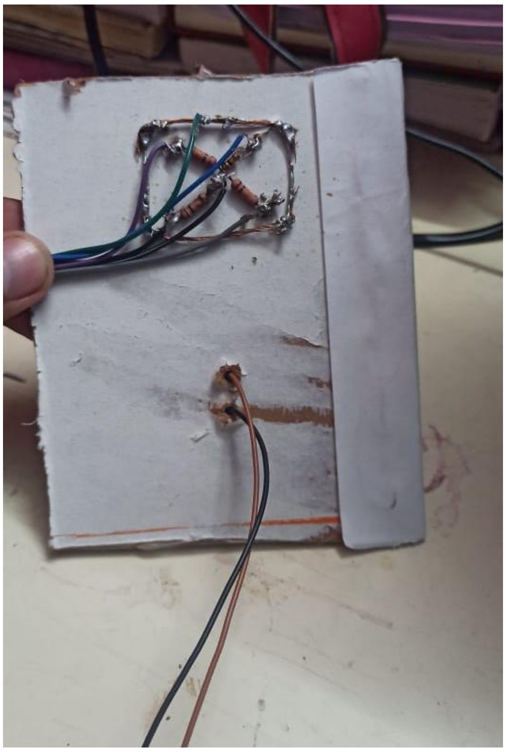
Now we connect all LDRs one terminal to the 5 volt and other terminals to the ground through 10k ohm resistor.

Now we connect bottom left LDR voltage divider point to A1 pin of ARDUINO .

Again, connect top left LDR voltage divider point to A0 pin of the ARDUINO.

Similarly top right LDR voltage divider point to the A2 pin .

Finally, we connect the bottom right voltage divider point of LDR to the A3 pin of the ARDUINO.



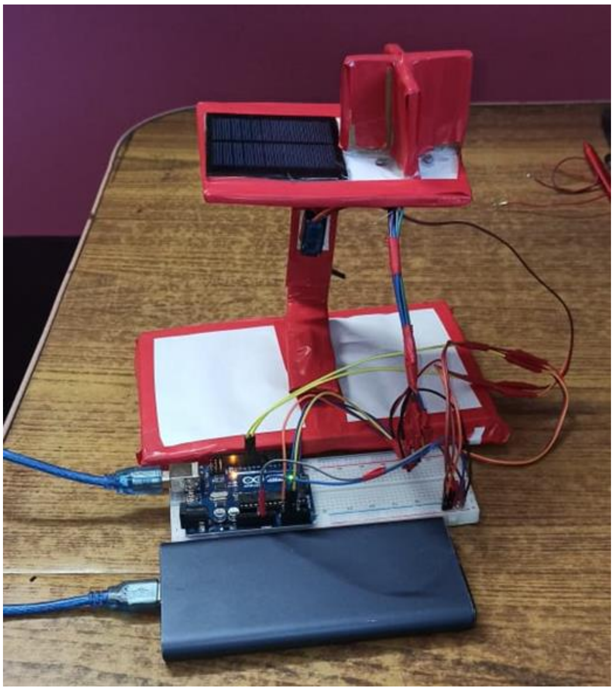


fig5.3(a) LDR connection

fig5.3(b) ARDUINO connection

CHAPTER 6

RESULT & ANALYSIS

6.1. Reading

After taking the reading manually , the voltage ,current and power of single axis solar panel and single axis solar panel are shown below in table

6.1.1. Static solar panel

Time	**Current (mA)**	**Voltage (V)**	**Power (mW)**
08.50	0.22	6.15	1.353
10.00	0.32	7.21	2.2351
11.50	0.35	7.45	2.6075
13.50	0.30	6.81	2.043
15.00	0.25	6.41	1.6023
17.00	0.10	4.82	0.682

Table 6.1.1 reading of static solar panel

6.1.2. Dual axis solar panel

Time	**Current (mA)**	**Voltage (v)**	**Power (mW)**
08.50	0.25	6.80	1.7
10.00	0.33	7.3	2.404
11.50	0.36	7.51	2.7036
13.50	0.32	6.92	2.2144
15.00	0.26	6.90	1.794
17.00	0.13	4.84	0.6292

Table 6.1.2 Reading of Dual axis solar panel

6.2. Graph plotting

To plot output(current , voltage and power) vs time we have written following code in MATLAB

6.2.1. Static solar panel

6.2.1.1Current Vs Time

Code & Plot of current vs time is shown below

```
syms time;
syms current;
time=[8.50 10.00 11.50 13.50 15.00 17.00];
current=[0.22 0.32 0.35 0.30 0.25 0.10];
xlabel('time');
ylabel('current in milliamp');
plot(time,current);
grid on;
```

Fig 6.2.1.1.(a) code for current vs time in static axis solar panel

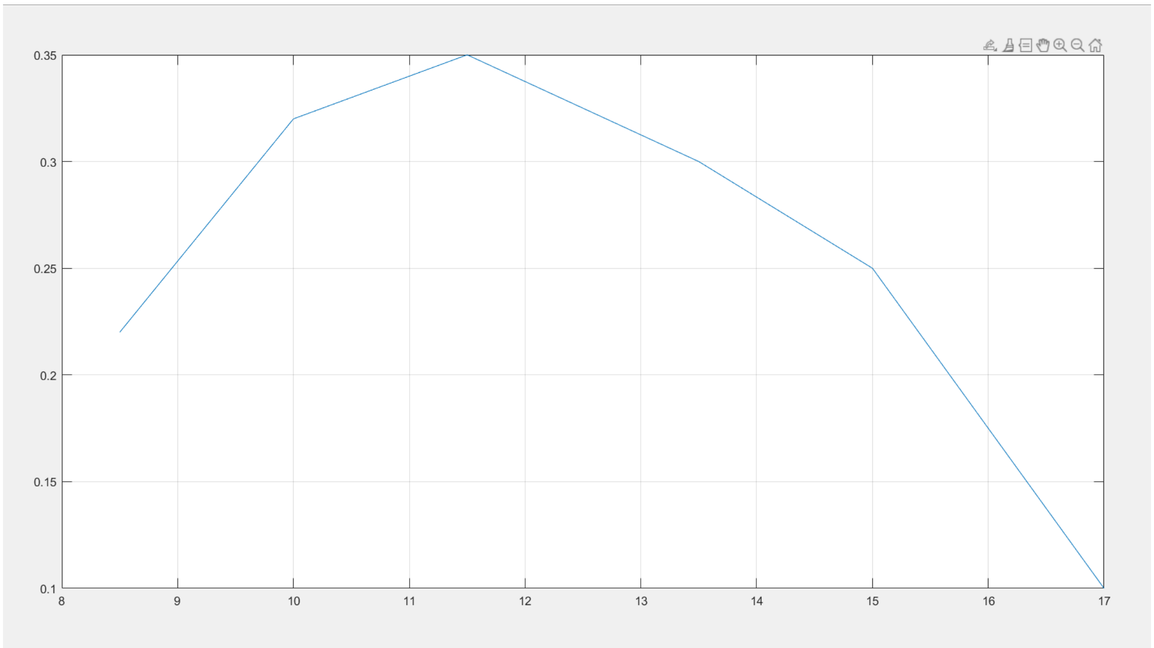


Fig 6.2.1.1(b) plot of current vs time in static solar panel

6.2.1.2. Voltage Vs Time

Code & Plot of voltage vs time is shown below

```
syms time;
syms voltage;
time=[8.50 10.00 11.50 13.50 15.00 17.00];
voltage=[6.15 7.21 7.45 6.81 6.41 4.82];
xlabel('time');
ylabel('voltage');
plot(time,voltage);
grid on;
```

Fig 6.2.1.2.(a) code for voltage vs time in static solar panel

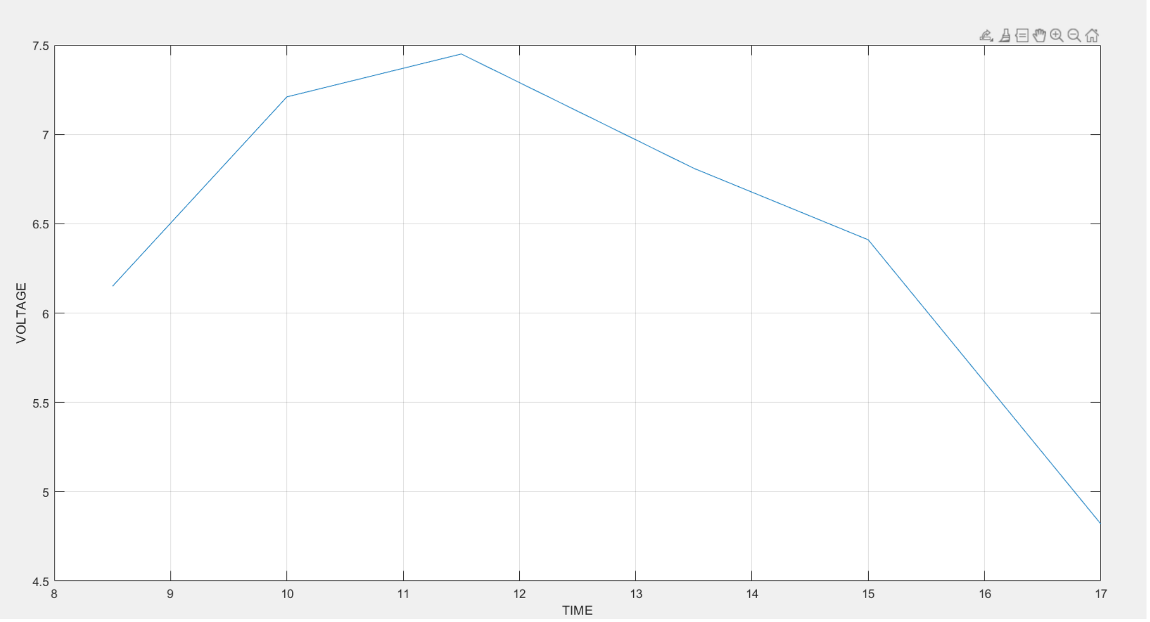


Fig 6.2.1.2.(b) plot of voltage vs time in static solar panel

6.2.1.3. Power Vs Time

Code & Plot of power vs time is shown below

```
syms time;
syms Power;
time=[8.50 10.00 11.50 13.50 15.00 17.00];
Power=[1.353 2.2351 2.6075 2.043 1.6025 0.682];
xlabel('time');
ylabel('power in milliwatt');
plot(time,Power);
grid on;
```

Fig 6.2.1.3.(a) code for power vs time in static solar panel

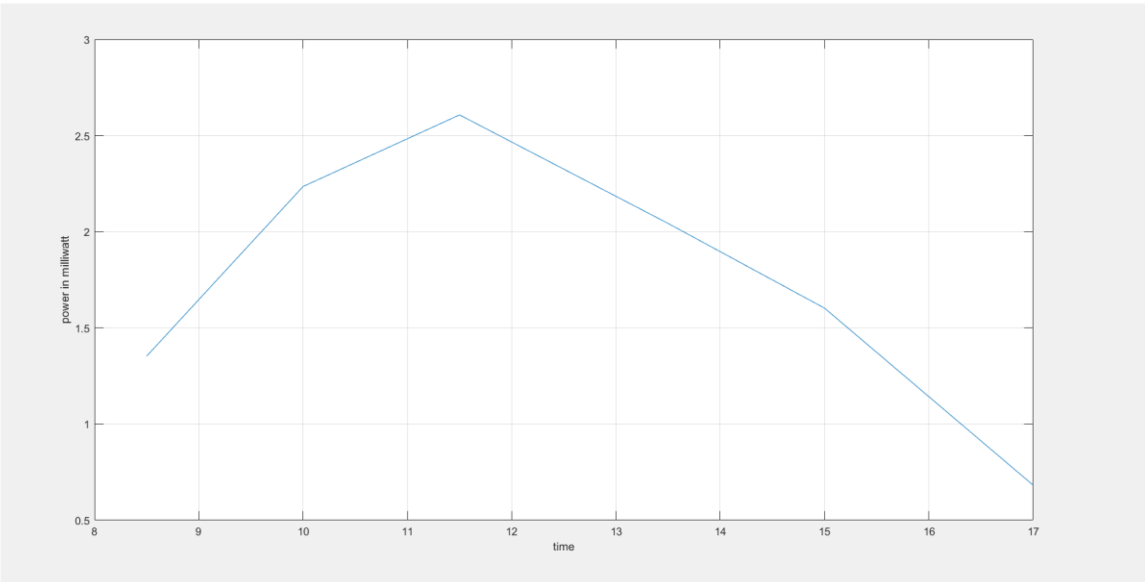


Fig 6.2.1.3.(b) plot of power vs time in static solar panel

6.2.2. Dual Axis solar panel

6.2.2.1. Current Vs Time

Code & Plot of current vs time of dual axis solar panel and its comparison with static axis solar is shown below (red color for single axis and green color for dual axis)

```
syms time;
syms current;
syms current2;
time=[8.50 10.00 11.50 13.50 15.00 17.00];
current=[0.22 0.32 0.35 0.30 0.25 0.10];
current2=[0.25 0.33 0.36 0.32 0.26 0.13];
xlabel('time');
ylabel('current in milliwatt');
plot(time,current,'r',time,current2,'g');
grid on;
```

Fig 6.2.2.1.(a) code for current vs time in dual axis solar panel

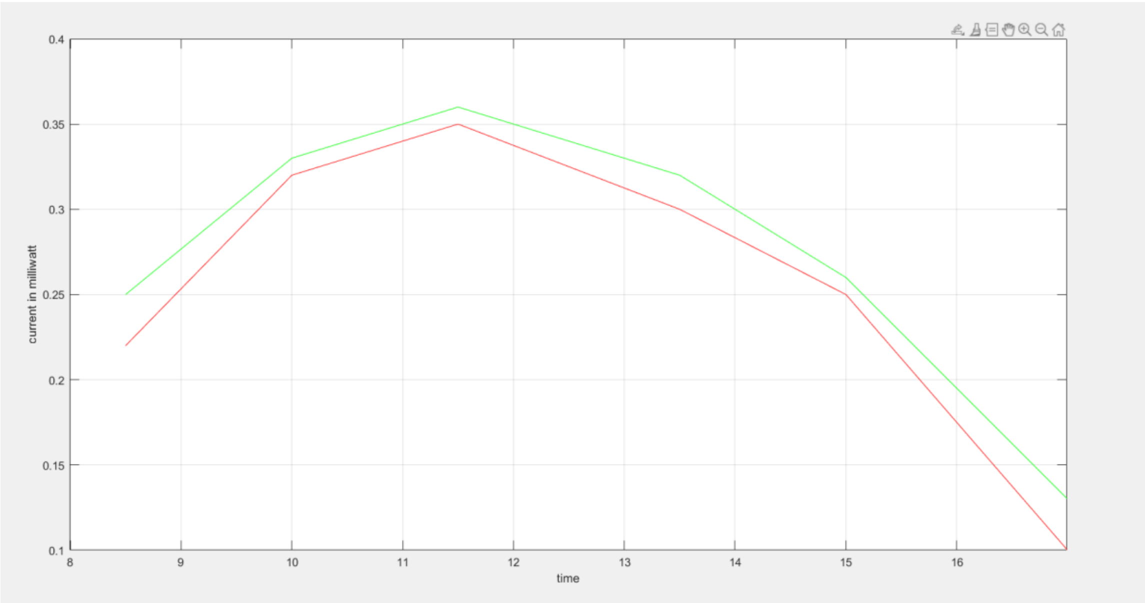


Fig 6.2.2.1.(b) plot of current vs time in dual axis solar panel

6.2.2.2. Voltage Vs Time

Code & Plot of voltage vs time of dual axis solar panel and its comparison with static axis solar is shown below (red color for single axis and green color for dual axis)

```
Editor - Untitled*
Untitled*
syms time;
syms voltage;
syms voltage2;
time=[8.50 10.00 11.50 13.50 15.00 17.00];
voltage=[6.15 7.21 7.45 6.81 6.41 4.82];
voltage2=[6.80 7.3 7.51 6.92 6.90 4.84];
xlabel('time');
ylabel('voltage');
plot(time,voltage,'r',time,voltage2,'g');
grid on;
```

Fig 6.2.2.2.(a) code for voltage vs time in dual axis solar panel

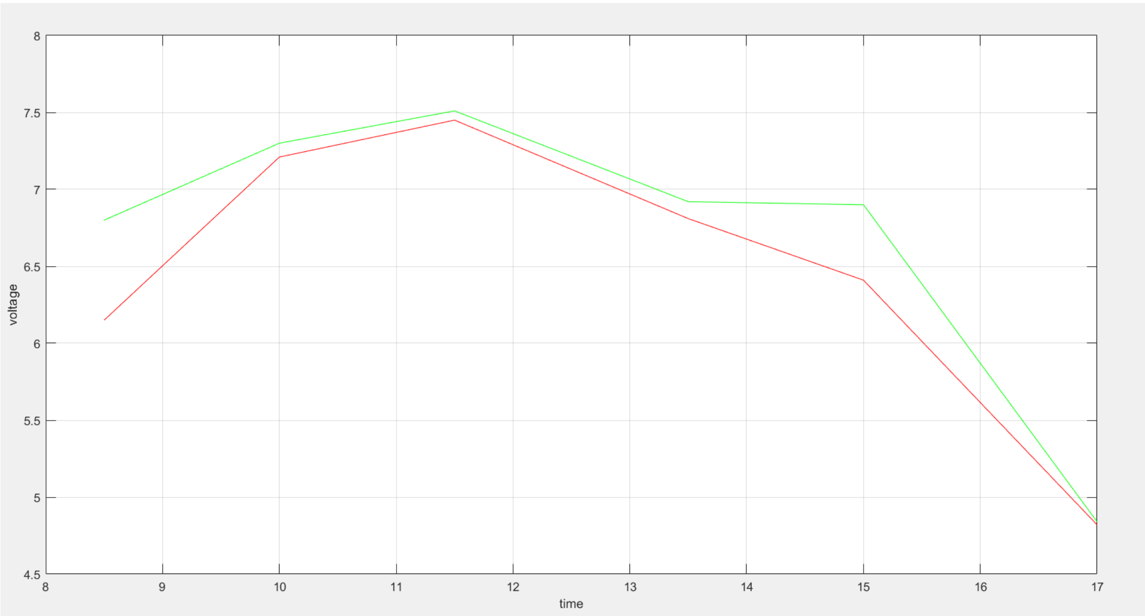
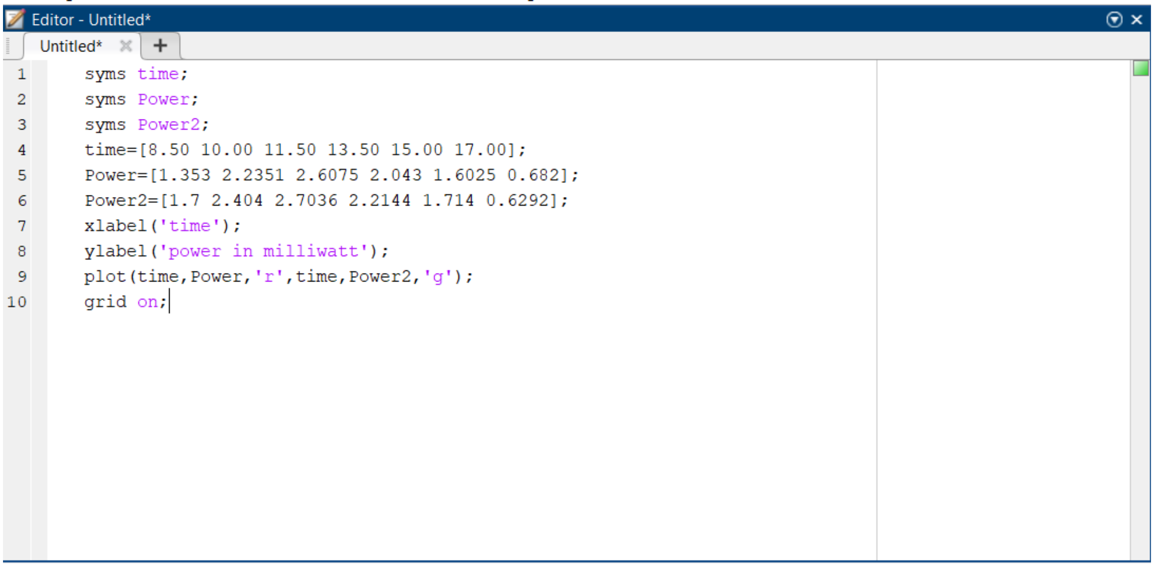


Fig 6.2.2.2.(b) plot of voltage vs time in dual axis solar panel

6.2.2.3. Power Vs Time

Code & Plot of power vs time of dual axis solar panel and its comparison with static axis solar is shown below (red color for single axis and green color for dual axis)




```
syms time;
syms Power;
syms Power2;
time=[8.50 10.00 11.50 13.50 15.00 17.00];
Power=[1.353 2.2351 2.6075 2.043 1.6025 0.682];
Power2=[1.7 2.404 2.7036 2.2144 1.714 0.6292];
xlabel('time');
ylabel('power in milliwatt');
plot(time,Power,'r',time,Power2,'g');
grid on;
```

Fig 6.2.2.3.(a) code for power vs time in dual axis solar panel

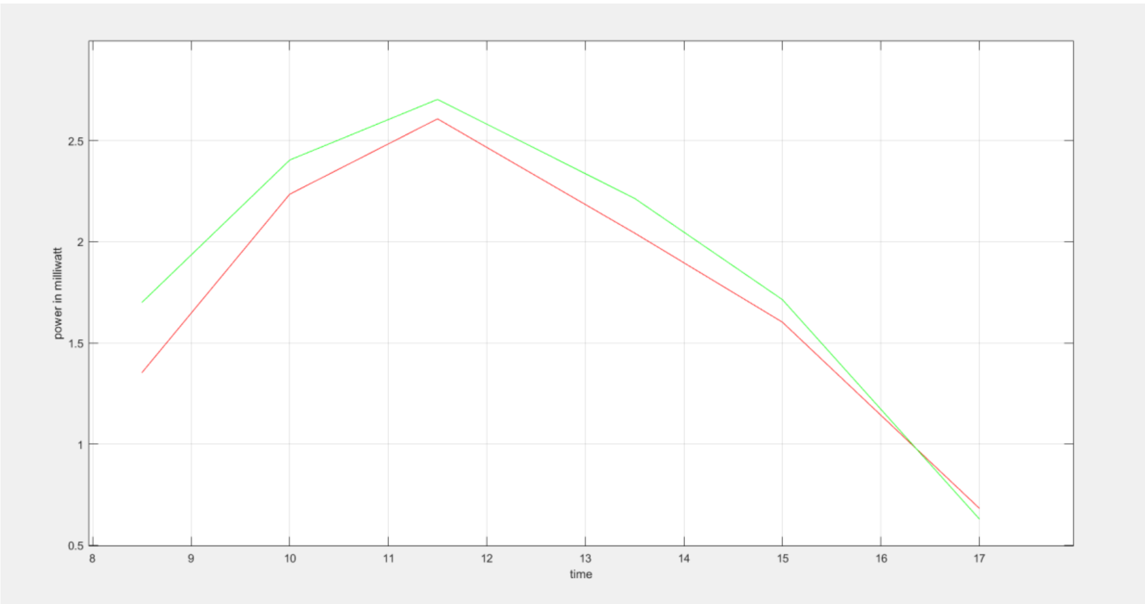


Fig 6.2.2.3.(b) plot of power vs time in dual axis solar panel

From the above reading and graphs ,we can conclude that dual axis solar tracker will give more output power than static axis solar panel .hence, dual axis solar panel is more efficient.

6.3. ANALYSIS FOR 1KW SOLAR PANEL

Our Hardware kit is of 0.8 Watt i.e. It's maximum power generation is of 0.8 Watt.
Static Solar Panel Average power output during a day=(1.353+2.2351+2.6075+2.043+3.6023+0.682)/6=1.64015mW.
Dual Axis solar Panel average power output=(1.7+2.404+2.7036+2.2144+1.794)/6=1.80266
% Power output increased by implementating dual axis solar panel of 0.8 W =1.80266/1.64015*100
=109.90%
Roughly 10% more power is generated from dual axis solar panel.
Cost of solar Panel is 28 rs per watt.(Considering poorest quality solar Panel) Amorphous Solar Panel has least efficiency so cost of these solar Panel is least
So, cost of 1 KW Amorphous Crystalline solar Panel is around 28000 rs.
Weight of 1kW solar Panel is around 100kg.
For Implementing two dual axis solar Panel we require two servo motor which can rotate 100kg rotate at a distance about 1cm or a motor which can generate a torque about 981 Nm at a distance about 1 cm from the axis of rotation.
Price of Single servo motor is Rs 7495
Price of 2nd servo Motor is Rs 7495
Price of ARDUINO =Rs 600
Miscellaneous Cost comprising cost of wire, Structure on which solar panel will be mounted =Rs 1000.
So,if we implement static solar Panel of 1kW cost is around 28000rs
If we implement dual axis solar Panel of 1kW cost is around 44,590rs
So cost is increased by **59.25%** but power output is increased by **10%** only

6.4.Dual Axis Solar Panel in Industries

In our Analysis we have seen that cost of implementing dual axis solar panel is 60% more costly than static solar panel but the energy prduction increases by 10% .So it is not cheaper.This is the main reason why company don't implement dual axis solar Panel because every companay want to make profit.
However , dual axis solar tracker has shown some advantages in Solar Thermal Power Plant. In Solar thermal power Plant a Parabolic Concentrator is used which is used to concentrate the sun rays to a particular point known as a focus.Parabolic Concentrator track the motion of a sun with the help of dual axis solar tracker such that sun rays always fall perpendicular to it and Parabolic Concentrator concentrate maximum sun light to a particular point thus leading to acheive the temperature upto 500 ℃.

CHAPTER 7

CONCLUSIONS AND FUTURE SCOPE FOR WORK

7.1. Conclusion

Dual axis solar panel has higher efficiency and flexibility than other panel . It gives 10% more electrical power than static solar but it's cost increases by 59.25% . as we have shown in analysis.

Power is how much energy something uses, i.e. how many joules of energy it absorbs while it is working. For instance, a 200W light bulb turned on for 10 seconds would use up 2000J of power / electrical energy.

Efficiency measures how effectively a device can convert input energy into output energy. An innefficient devices requires more energy to produce a result. With the light bulb, although the bulb is using up 2000J of power in 10 seconds it may only have an efficiency of 30%, so only 600J of power is emitted as useful light energy. The rest is wasted, most likely in the form of heat.

Dual axis solar panel is not a cost efficient panel but it area efficient so we can use dual axis solar panel where area is limited to gain maximum output . Dual axis solar tracker use 2 motor which can be driven by output power of solar tracker .For driving motor with output power , dual axis solar panel should be Large enough. Dual axis solar panel can be used in crowded area where big power plant is not possible we can use this tracker to gain more output and Dual axis Solar Panel is widely used in Solar Thermal power Plant.

7.2. Future Scope of Project

The future scope of dual axis solar Panel will be in Solat Thermal Plant.Now,Coal based thermal power plant is slowly replaced by Renewable based thermal power Plant.In Solar thermal power Plant a Parabolic Concentrator is used which is used to concentrate the sun rays to a particular point known as a focus.Parabolic Concentrator track the motion of a sun with the help of dual axis solar tracker such that sun rays always fall perpendicular to it and Parabolic Concentrator concentrate maximum sun light to a particular point thus leading to acheive the temperature upto 500 ℃

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APPENDIX

Code For ARDUINO

```
#include <Servo.h>
Servo servohori;
int servoh = 0;
int servohLimitHigh = 160;
int servohLimitLow = 20;
Servo servoverti;
int servov = 0;
int servovLimitHigh = 160;
int servovLimitLow = 20;
int ldrtopl = 2;
int ldrtopr = 1;
int ldrbotl = 3;
int ldrbotr = 0;
 void setup ()
 {
  servohori.attach(10);
  servohori.write(0);
  servoverti.attach(9);
  servoverti.write(0);
  delay(500);
 }
void loop()
{
  servoh = servohori.read();
  servov = servoverti.read();
  int topl = analogRead(ldrtopl);
  int topr = analogRead(ldrtopr);
  int botl = analogRead(ldrbotl);
  int botr = analogRead(ldrbotr);
  int avgtop = (topl + topr) / 2;
  int avgbot = (botl + botr) / 2;
  int avgleft = (topl + botl) / 2;
  int avgright = (topr + botr) / 2;
  if (avgtop < avgbot)
  {
    servoverti.write(servov +1);
    if (servov > servovLimitHigh)
```

```
   {
    servov = servovLimitHigh;
   }
  delay(10);
}
else if (avgbot < avgtop)
{
  servoverti.write(servov -1);
  if (servov < servovLimitLow)
{
  servov = servovLimitLow;
}
  delay(10);
}
else
{
  servoverti.write(servov);
}
if (avgleft > avgright)
{
  servohori.write(servoh +1);
  if (servoh > servohLimitHigh)
   {
  servoh = servohLimitHigh;
   }
  delay(10);
}
else if (avgright > avgleft)
{
  servohori.write(servoh -1);
  if (servoh < servohLimitLow)
   {
   servoh = servohLimitLow;
   }
  delay(10);
}
else
{
  servohori.write(servoh);
```

```
  }
 delay(50);
}
```

Code for Current vs Time in Static Solar Panel

```
syms time;
syms current;
time=[8.50 10.00 11.50 13.50 15.00 17.00];
current=[0.22 0.32 0.35 0.30 0.25 0.10];
xlable(‘time’);
ylable(‘current in miliampire’);
plot( time ,current);
grid on;
```

Code for Voltage vs Time in Static Solar Panel

```
syms time;
syms voltage;
time=[8.50 10.00 11.50 13.50 15.00 17.00];
voltage=[6.15 7.21 7.45 6.81 6.41 4.82];
xlable(‘time’);
ylable(‘voltage’);
plot( time ,voltage);
grid on;
```

Code for Power vs Time in Static Solar Panel

```
syms time;
syms power;
time=[8.50 10.00 11.50 13.50 15.00 17.00];
power=[1.353 2.2351 2.6075 2.043 1.6025 0.682];
xlable(‘time’);
ylable(‘power in miliwatt’);
plot( time ,power);
grid on;
```

Code for Current vs Time in Dual Axis Solar Panel

```
syms time;
syms current;
syms current2;
time=[8.50 10.00 11.50 13.50 15.00 17.00];
```

```
current= [0.22 0.32 0.35 0.30 0.25 0.10];
current2= [0.25 0.33 0.36 0.32 0.26 0.13];
xlabel('time');
ylabel('current in milliwatt');
plot (time, current, 'r', time, current2, 'g');
grid on;
```

Code for Voltage vs Time in Dual Axis Solar Panel

```
syms time;
syms voltage;
syms voltage2;
time [8.50 10.00 11.50 13.50 15.00 17.00]; voltage [6.15 7.21 7.45 6.81 6.41 4.82];
voltage2=[6.80 7.3 7.51 6.92 6.90 4.84];
xlabel (time');
ylabel('voltage');
plot (time, voltage, 'r', time, voltage2, 'g');
grid on;
```

Code for Power vs Time in Dual Axis Solar Panel

```
syms time;
syms Power;
syms Power2;
time=[8.50 10.00 11.50 13.50 15.00 17.00];
Power [1.353 2.2351 2.6075 2.043 1.6025 0.682];
Power2-[1.7 2.404 2.7036 2.2144 1.714 0.6292];
xlabel ('time');
ylabel('power in milliwatt');
plot (time, Power, 'r',time, Power2, 'g');
grid on;
```