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Mini-Project Report

on

"SINGLE AXIS SOLAR TRACKING SYSTEM"

Submitted in partial fulfillment of the requirements for the award of degree of

Bachelor of Engineering

in

Electronics & Communication Engineering

Submitted

by

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CERTIFICATE

Certified that the Mini-Project work entitled **"SOLAR TRACKING SYSTEM"** carried out by **Mr. ANAND R (USN: 4MN19EC002), Mr. CHANDAN M (USN: 4MN18EC004), Mr. VARUN JOSHI (USN: 4MN19EC030),** bonafide students of Maharaja Institute of Technology, Thandavapura, in partial fulfillment for the award of the degree of **Bachelor of Engineering in Electronics & Communication Engineering** of the **Visvesvaraya Technological University**, Belagavi, during the year **2021-2022.** It is to certify that all the corrections/suggestions indicated for the internal assessment have been incorporated in the report and has been approved as it satisfies the academic requirements.

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ABSTRACT

Solar energy is rapidly advancing as an important means of renewable energy resource. It is radiant light and heat from the Sun that is harnessed using a range of ever-evolving technologies such as solar heating, photovoltaic, solar thermal energy, solar architecture, molten salt power plants and artificial photosynthesis. The utility of a tracking system greatly improves the power gain from solar radiation. Solar energy is rapidly gaining notoriety as an important means of expanding renewable energy resources. Development of solar panel tracking systems has been progressed several years now. As the sun moves across the sky during the day, the solar tracking system is advantageous. Dual axis solar tracker trails the location of the sun anywhere in the sky. To produce the maximum amount of energy, a solar panel must be perpendicular to the light source. Because the sun moves both throughout the day as well as throughout the year, a solar panel must be able to trace the sun's movement to produce the maximum possible power. Design of the solar tracker from this project is also a reference and a starting point for the development of more advanced systems in the future.

CHAPTER 1

INTRODUCTION

In recent decades there is increase in demand for reliable and clean form of electricity derived from renewable energy sources. One such example is solar power. The system will tend to maximize the amount of power absorbed by Photo Voltaic systems. It has been found that making the use of a Single axis tracking system, over a fixed system, can increase the power output by 40% - 60%. Solar energy systems have emerged as possible source of renewable energy over the past two or three decades, and are now utilized for a variety of household and industrial applications. Such systems are based on a solar collector, it is designed to collect the sun's energy and to convert it into either electrical power or thermal energy. In general, the power developed in such applications depends upon the amount of solar energy captured by the collector, and thus the difficulty of developing tracking schemes capable of following the trajectory of the sun throughout the course of the day on a year-round basis has received significant coverage in this system. An eco-friendly method of utilizing solar energy for maximum energy consumption is Single axis solar tracking system.

1.1 PROBLEM STATEMENT

While solar panels are an effective means of collecting energy, their efficiency at doing so is directly related to their angle with the sun. The problem that this project addresses is the inefficiency associated with fixed solar panels. Meaning, panels that do not track the sun across the sky. The fixed solar panels do not aim directly to the sun due to the constant motion of earth. As the result the power produced by this device is not the maximum it should produce.

1.2 PROPOSED SOLUTION

The better solution for this system to get the maximum output power is solar tracking system. This is the main reason the project solar tracker is made. The solar tracker will follow the sunlight to get more output power. Indirectly it will reduce the cost of buying more solar panels. These systems also reduce the time for users to change the position of solar panel to face the sun.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Among the renewable energy sources is electrical solar energy from the sun can be harnessed using solar panels or solar cells to convert solar irradiation into electrical current. Most photovoltaic cells employ photoelectric effect. This is a process by which electrons are emitted from some materials, such as a metal, as a result of being struck by photons. Some substances, such as selenium, are particularly susceptible to this effect and if used in solar cells, they can generate some electric potential through photoemission.

Sun rays come in form of UV-light, a form of electromagnetic radiation and once they fall of solar panel surface made of materials such as silicon, the irradiation is absorbed and converted into electrical energy through photo emission. Maximum absorption occurs when the solar panels and solar cells directly face the sun, so that the sun's rays fall perpendicular on the absorption surface.

This absorption and conversion may not be optimal given that the solar panels and solar cells are mounted in fixed positions usually on rooftops with slants. For viable solar energy generation using single installation, its efficiency has to be improved and therefore various solar tracking methods are devised to closely track sun movement during the day.

2.2 Types of Solar Trackers and Solar Tracking Techniques

2.2.1: Single Axis Solar Tracking System

This method is usually used for solar trackers aimed to be used in the tropics where the focus to track the angle of altitude (angle of tilt) of the sun along a single axis. A single linear actuator is used, such as a motor to drive the panel according to sun movements. A set of two LDRs on opposite sides of the solar panel may be used to measure the intensity of the solar irradiation by measuring the voltage drop across them which is then compared by a drive circuit until the two LDR voltages are equal and the motion of the panel is SS

Fig 2.1 Single Axis Solar Tracking System

Fig 2.2 Dual Axis Solar Tracking System

2.2.2: Dual Axis Solar Tracking System

This method is mainly designed for localities outside the tropics or areas beyond 10^0 N and 10^0 S of equator. In this technique, both angle of azimuth and angle of tilt of the solar tracker are used to track the sun movements throughout the year. Consequently, a set of two actuators, usually motors is used to move the solar panel accordingly by receiving voltage control signals from a set of four LDRs (two on opposite sides of solar panel) and when the voltage drop on all the four LDRs is equal then the panel is experiencing the maximum solar irradiation and therefore the motion stops. This ensures the solar panel is at right angles with sunlight at all times

2.2.3: Active Solar Tracking

This technique involves the continuous and constant monitoring of the sun's position throughout daytime and when tracker is subjected to darkness it stops or sleeps according to its design. This can be done using of light sensitive sensors, such as photo resistors (LDRs) whose voltage output are input into a microcontroller which then drive actuators (motors) to adjust the solar panels position.

2.2.4: Passive Solar Tracking

This method involves trackers that determine the sun's position by means of a pressure imbalance created at two ends of the tracker. This imbalance is caused by solar heat creating gas pressure on a low boiling point compressed gas fluid that is driven to one side or the other which then moves the structure.

2.3: A Review of Solar Tracking Methods

2.3.1: Introduction

As stated above, there is an urgent need for better solar tracking technologies to be developed to harness vast amounts of electrical solar energy in large scale to cater for the ever-growing power demand. Of concern too is the reduction in the environmental pollution due to use of fossil-based fuels. To construct a cost effective, efficient and effective solar tracking system, it is necessary to understand the rotation and revolution of the earth with respect to the locality in question so as to know the specification of the solar tracker to be constructed. Since any solar tracker follows the motion of the sun in the sky, it is very necessary to understand rotation & revolution of the earth, Solar irradiation and efficiency of tracking systems which will be shown in later in this project.

2.3.2: Solar Tracking in Relation to Rotation and Revolution of the Earth

The earth rotates about its own axis taking 24 hours to complete one rotation of 360 degree and at the same time it revolves around the sun in a year of 365¼ days or 366 in a leap year. Revolution takes place in an elliptical orbit called ecliptic. In addition to the revolution of the earth, it is observed that the relative position of the midday sun at different times of the year varies. The inclination of the sun from the earth is referred to as the solar altitude angle.
This is the vertical angle between the projection of sun's rays on the horizontal plane and direction of sun's rays passing through the point. Usually this is estimated to be a decline of 23½ degrees northwards and southwards, in one complete revolution about the sun. The earth also has an axial tilt of about 23.4^0. The altitude of the sun can also be explained by use of solar zenith angle ($\theta z = 90-\alpha$). Solar azimuth angle (γs) is the horizontal angle measured from south (in the northern hemisphere) to the horizontal projection of the Sun's rays.

2.4 Nature of Solar Irradiation and The Solar Constant

Sunlight contains UV light which is a solar radiation in form of an electromagnetic radiation given off by the Sun. Resulting from the intense temperature and pressure at the core of the sun, solar fusion takes place. Protons are converted into helium atoms at a rate of 600 million tons per second. Since the output of this process has a lower energy than the protons that began, the fusion gives off a tremendous amount of energy in the form of gamma-rays. These

gamma rays are observed by particles in the sun, and then re-emitted over the course 200000 years, photons of light make their energy through the radiation zone of the sun. Solar irradiation is the measure of the solar radiation transmitted to the surface of the earth atmosphere in the given unit of time. Solar radiation from the sun can be direct, diffuse nor reflected. Direct radiation, also called beam radiation, is the solar radiation travelling on a straight line from the sun down to the surface of the earth. Diffuse radiation refers to the sunlight that has still made it scattered by molecules and particles in the atmosphere but that has still made it down to surface of earth. Unlike direct radiation, diffuse radiation doesn't have a definite direction. Reflected radiation describes the sunlight that has been reflected off of non-atmosphere surfaces such as the ground. The solar radiation data are usually given in the form of global radiation on a horizontal surfaces and solar and PV panels are usually positioned at an angle to the horizontal plane.

2.4.1: Sunlight

Photometry enables determine the amount of light given by the sun in the terms of brightness perceived by the human eye. In photometry, a luminosity functions is used for the radiant at the power of each wavelength give a different weight to a particular wavelength that models human brightness sensitivity. Photometric measurements began as early as the end of 18th Century resulting in many different units of measurement, some of which cannot even be converted owing to the relative meaning of brightness. However, the luminous flux (or lux) is commonly used and is the measure of the perceived power of light. Its unit, the lumen, is concisely define as luminous flux of light produced by a light source that emits 1 candela of luminous intensity over a solid angle of 1 steradian. The candela is the SI unit of luminous intensity & it is the power emitted by a light source in a particular direction, weighted by a luminosity function whereas a steradian is SI unit for solid angle; the two-dimensional angle in the three-dimensional space that an object subtends at a point.

2.4.2: The Solar Constant

This is defined as the amount of solar energy received upon a unit surface by the earth's atmosphere, perpendicular to the sun's direction and is usually expressed in calories per square centimetre per minute, in this units, common values are in the range 1.89 to 1.9cm/minute. The determination of solar constant is facilitated by solar spectral-irradiance

curves. This are obtained with a recording spectrobolometer (a combined spectroscope and bolometer for determining the wavelength distribution of a radiant energy emitted by a source) and referenced to a measurement obtained from a pyrheliometer that determines the total radiation at the same time.

2.5 Fixed and Tracking Collectors

2.5.1 Fixed Collectors

Harnessing of solar energy can be done either fixed or movable collectors. Fixed collectors are mostly mounted on the places with maximum sunlight and at a relatively good angle in relation to the sunlight such as rooftops. The aim is to expose the panel for maximum hours in a day without necessarily involving tracking technologies and therefore considerable reduction in installation and maintenance cost is realized. As such, majority of the collectors are fixed type. For fixed solar collectors therefore is very necessary to know the position of the sun at various seasons and the times of the years so as to give the optimum orientation of the collector during installation to give the maximum solar energy all the year around

2.5.2: Tracking Collectors: Improved Efficiency

For a tracking collector, the theoretical extracted energies calculated assuming the maximum radiation intensity I=1100w/m^2 is falling on the area which is oriented perpendicularly to the direction of radiation. Taking the length of day t=12h=43200s, the intensity on the tracking collector which is always optimally oriented facing the sun is compared to that of a fixed collector which is perpendicular to the direction of radiation only at noon.

CHAPTER 3

OBJECTIVES & HARDWARE UNITS

3.1 OBJECTIVE

The objectives for the solar tracker are as follows:

- To develop a tracking system that constantly tracks the sun during daytime
- To generate power from solar panel using Single axis tracker.
- To develop a tracking system that maximize the solar power generation.

3.2 COMPONENTS REQUIRED

1.SOLAR CELL

2.L293D MTOR DRIVE IC

3.7805 TRANSISTOR

4.100RPM GEAR MOTOR

5.RESISTOR (1K ohm and 10K ohm)

6. LDR SENSORS

7. 9v BATTERY

8. 0.1µF CAPACITOR

9. PRINTED CIRCUIT BOARD

3.3 COMPONENTS DESCRIPTION

1.SOLAR CELL

A photovoltaic cell, regularly known as a sun-based cell, is the innovation utilized for transformation of sun oriented specifically into electrical power. The photovoltaic cell is a non- mechanical gadget made of silicon amalgam. One cell can however deliver just 1

or 2 watts that isn't sufficient for generally machines. Execution of a photovoltaic cluster relies upon daylight. Climatic conditions like mists and mist essentially influence the measure of sun-oriented vitality that is gotten by the exhibit and in this manner its execution. The vast majority of the PV modules are in the vicinity of 10 and 20 percent effective.

Fig 3.1 Solar Cell

2. L293D MOTOR DRIVE IC

L293D IC is a typical Motor Driver IC which allows the motor to drive on any direction. This IC consists of 16-pins which are used to control a set of two DC motors instantaneously in any direction. It means, by using a L293D IC we can control two DC motors. As well, this IC can drive small and quiet big motors.

This L293D IC works on the basic principle of H-bridge, this motor control circuit allows the voltage to be flowing in any direction. As we know that the voltage must be change the direction of being able to rotate the DC motor in both the directions. Hence, H-bridge circuit using L293D ICs are perfect for driving a motor. Single L293D IC consists of two H-bridge circuits inside which can rotate two DC motors separately. Generally, these circuits are used in robotics due to its size for controlling DC motors.

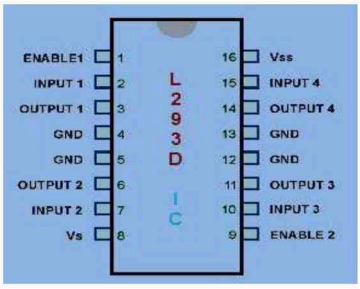

Fig 3.2 Pin Diagram of L293D

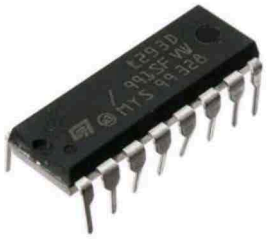

Fig 3.3 L293D Motor Drive IC

L293D IC Pin Configuration

- Pin-1 (Enable 1-2): When the enable pin is high, then the left part of the IC will work otherwise it won't work. This pin is also called as a master control pin.
- Pin-2 (Input-1): When the input pin is high, then the flow of current will be through output 1
- Pin-3 (Output-1): This output-1 pin must be connected to one of the terminals of the motor
- Pin-4 & 5: These pins are ground pins
- Pin-6 (Output-2): This pin must be connected to one of the terminals of the motor.
- Pin-7 (Input-2): When this pin is HIGH then the flow of current will be though output 2
- Pin-8 (Vcc2): This is the voltage pin which is used to supply the voltage to the motor.
- Pin-16 (Vss): This pin is the power source to the integrated circuit.
- Pin-15 (Input-4): When this pin is high, then the flow of current will be through output-4.
- Pin-14 (Output-4): This pin must be connected to one of the terminals of the motor
- Pin-12 & 13: These pins are ground pins
- Pin-11 (Output-3): This pin must be connected to one of the terminals of the motor.
- Pin-10 (Input-3): When this pin is high, then the flow of current will through output-3
- Pin-9 (Enable3-4): When this pin is high, then the right part of the IC will work & when it is low the right part of the IC won't work. This pin is also called as a master control pin for the right part of the IC.

3. 7805 VOLTAGE REGULATOR

Fig 3.4 7805 Voltage Regulator

Definition: IC 7805 is a **linear voltage regulator** and it includes three terminals including 5V of the fixed output voltage. This voltage is used in a variety of applications. At present, the manufacturing of this voltage regulator can be done by different manufacturing companies like STMicroelectronics, ON Semiconductor, Texas Instruments, Infineon Technologies, Diodes incorporated, etc. These ICs are available in different packages namely TO-3, TO-220, TO-263, and SOT-223. But the most frequently used package is TO-220. The equivalent ICs of this voltage regulator are IC LM7809, IC LM7806, TC LM317, IC LM7905, IC XC6206P332MR & IC LM117V33.

4.100RPM GEAR MOTOR

Fig 3.5 100RPM Gear Motor

DC Motor – 100RPM – 12Volts geared motors are generally a simple DC motor with a gearbox attached to it. This can be used in all-terrain robots and variety of robotic

applications. These motors have a 3 mm threaded drill hole in the middle of the shaft thus making it simple to connect it to the wheels or any other mechanical assembly.

DC geared motors with robust metal gearbox for heavy-duty applications, available in the wide RPM range and ideally suited for robotics and industrial applications. It is very easy to use and available in standard size. Nut and threads on the shaft to easily connect and internally threaded shaft for easily connecting it to the wheel.

5. RESISTOR (1K ohm and 10K ohm)

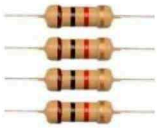

Fig 3.6 1K OHM

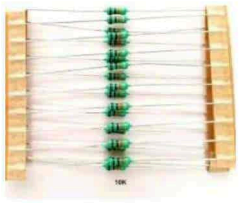

Fig 3.7 10K OHM

A resistor is a passive two-terminal electrical component that implements electrical resistance as a circuit element. In electronic circuits, resistors are used to reduce current flow, adjust signal levels, to divide voltages, bias active elements, and terminate transmission lines, among other uses. High-power resistors that can dissipate many watts of electrical power as heat, may be used as part of motor controls, in power distribution systems, or as test loads for generators. Fixed resistors have resistances that only change slightly with temperature, time or operating voltage. Variable resistors can be used to adjust circuit elements (such as a volume control or a lamp dimmer), or as sensing devices for heat, light, humidity, force, or chemical activity.

6. LDR SENSORS

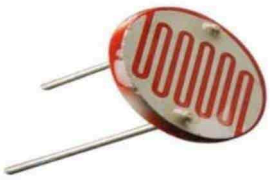

Fig 3.8 LDR Sensor

As its name implies, the Light Dependent Resistor (LDR) is made from a piece of exposed semiconductor material such as cadmium sulphide that changes its electrical resistance from several thousand Ohms in the dark to only a few hundred Ohms when light falls upon it by creating hole-electron pairs in the material.

The net effect is an improvement in its conductivity with a decrease in resistance for an increase in illumination. Also, photo resistive cells have a long response time requiring many seconds to respond to a change in the light intensity.

7. 9v BATTERY

Fig 3.9 9V Battery

Batteries are a collection of one or more cells whose chemical reactions create a flow of electrons in a circuit. All batteries are made up of three basic components: an anode (the '-' side), a cathode (the '+' side), and some kind of electrolyte (a substance that chemically reacts with the anode and cathode).

The nine-volt battery, or 9-volt battery, is a common size of battery that was introduced for early transistor radios. It has a rectangular prism shape with rounded edges and a polarized snap connector at the top. This type is commonly used in smoke detectors, gas detectors, clocks, walkie-talkies, electric guitars and effects units.

8. PRINTED CIRCUIT BOARD

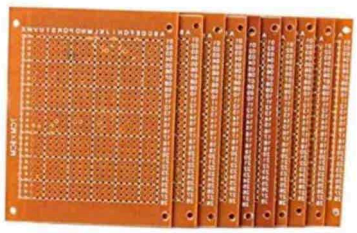

Fig 3.11 Printed Circuit Board

A printed circuit board (PCB) or printed wiring board (PWB) is a laminated sandwich structure of conductive and insulating layers. PCBs have two complementary functions. The first is to affix electronic components in designated locations on the outer layers by means of soldering. The second is to provide reliable electrical connections (and also reliable open circuits) between the component's terminals in a controlled manner often referred to as PCB design. Each of the conductive layers is designed with an artwork pattern of conductors (similar to wires on a flat surface) that provides electrical connections on that conductive layer. Another manufacturing process adds vias, plated through holes that allow interconnections between layers.

CHAPTER 4

METHODOLOGY

4.1 Circuit Diagram

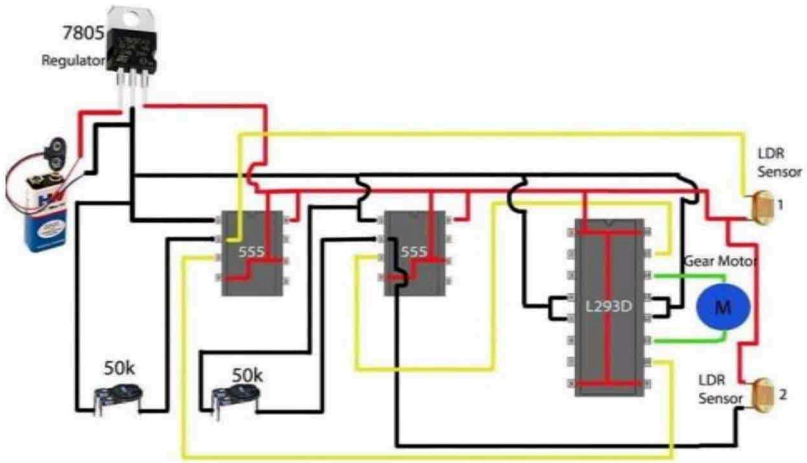

Fig 4.1 Circuit Diagram of Single Axis Solar Tracking System

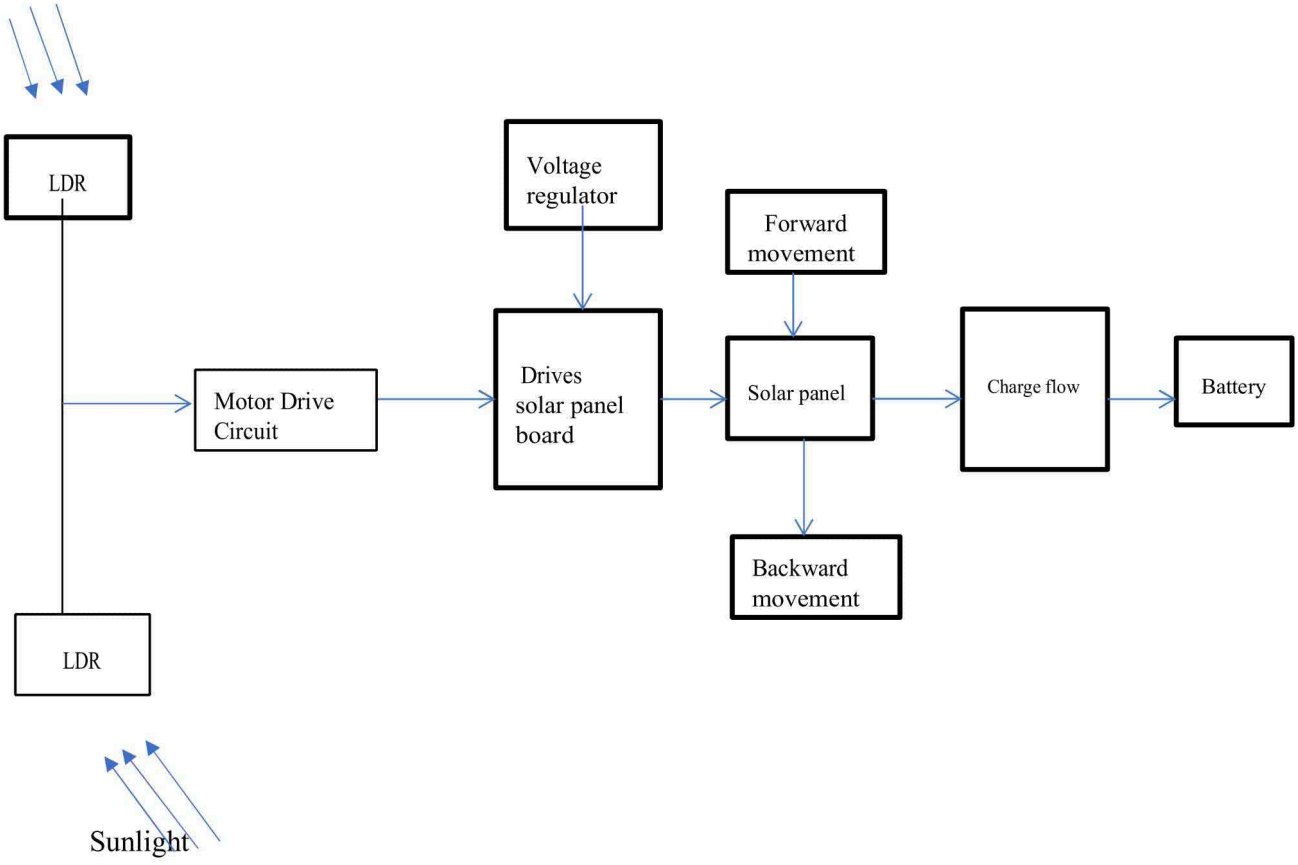

Fig 4.2 Block Diagram of Single Axis Solar Tracking System

- As we see in the block diagram, there are two Light Dependent Resistors (LDRs) which are placed on a common plate with solar panel. Light from a source strike on them by different amounts. Due to their inherent property of decreasing resistance with increasing incident light intensity, i.e., photoconductivity, the value of resistances of all the LDRs is not always same.
- Each LDR sends equivalent signal of their respective resistance value to the L293D Micro controller motor drive which is configured by. The values are compared with each other by considering a particular LDR value as reference.
- The dc 100rpm gear motor is mechanically attached with the driving axle of the other one so that the former will move with rotation of the axle of latter one. The axle of the former gear motor is used to drive a solar panel. This gear motors are arranged in such a way that the solar panel can move along Y-axis in both movement forward and backward movement.
- The microcontroller L293D motor drive IC sends appropriate signals to the gear motors based on the input signals received from the LDRs. The gear motor is used for tracking along y-axis.
- If the LDR is receiving the sun light signal form east direction the solar panel automatically face towards the east direction. As soon as the panel moves the solar panel is attached with connecting link rod it's also starts moving. If the solar panel is moving in forward movement the connecting link will move in opposite way that is backward direction and vice versa. So, by this the link connection given to the other solar panels will as move in same direction as like movement of the first main solar panel.
- In this way the solar tracking system is designed.

4.1 FLOWCHART

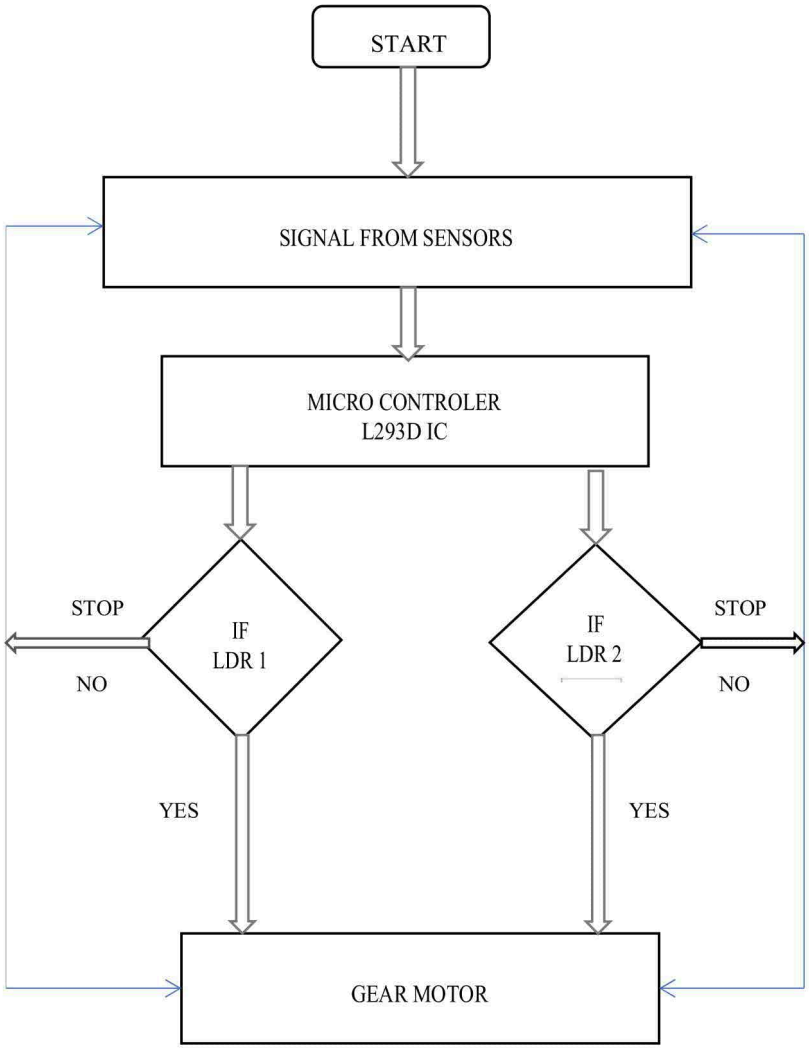

Fig 4.3 Flowchart of single axis solar tracking system

4.2 WORKING PRINCIPLE

- The proposed prototype follows the daylight all the more adequately by giving PV board revolution in one diverse pivot.
- DC motor are essentially performing capacity of sun following. Upper board holder dc motor tracks sun directly and base stepper engine tracks the allegorical uprooting of sun.
- These dc motor and sensors are interfaced with a microcontroller which is controlling dc motor -based on sensors input. LDR sensor sense the light and sends flag to microcontroller L293D IC.
- Microcontroller is doing correlation of signs got from LDR sensors and based on more grounded signals it is choosing pivot heading of dc motor. Single hub tracker control is clarified with the assistance of piece chart appeared in figure.
- The square outline demonstrating that LDR sensors subsequent to detecting the light forward the flag to motor drive L293D IC.
- L293D is astute gadget which is taking activities based on sensor information and initiating engine drivers circuit as needs be.
- Presently assume if sun changes its area and moves from east to west, it will make light force be diverse on one sensor when contrasted with other one.
- Based on light force contrast on sensor, controller enacts driver circuit and moves dc Motors new position where light falling on sensor sets is same.
- A similar procedure is keep on with on changes suns area in the sky. Therefore, this proposed demonstrate can catch more sun beams and frameworks sun powered vitality transformation ability is enormously improved.

CHAPTER 5

RESULT

In this Single Axis Solar Tracker, when source light falls on the panel, the panel adjusts its position according to maximum intensity of light falling perpendicular to it. The objective of the project is completed. This was achieved through using light sensors that are able to detect the amount of sunlight that reaches the solar panel. The values obtained by the LDRs are compared and if there is any significant difference, there is actuation of the panel using a gear motor to the point where it is almost perpendicular to the rays of the sun. This was achieved using a system with three stages or subsystems. Each stage has its own role. The stages were;

- An input stage that was responsible for converting incident light to a voltage.
- A control stage that was responsible for controlling actuation and decision making.
- A driver stage with the servo motor. It was responsible for actual movement of the panel. The input stage is designed with a voltage divider circuit so that it gives desired range of illumination for bright illumination conditions or when there is dim lighting. The potentiometer was adjusted to cater for such changes. The LDRs were found to be most suitable for this project because their resistance varies with light. They are readily available and are cost effective. Temperature sensors for instance would be costly.

  The control stage has a microcontroller L293D IC that receives voltages from the LDRs and determines the action to be performed. The microcontroller L293D is to ensure it sends a signal to the geared motor that moves in accordance with the generated. The final stage was the driving circuitry that consisted mainly of the gear motor. The gear motor had enough torque to drive the panel. gear motor are affordable, making them the best choice for the project.

5.1 SINGLE AXIS MOVEMENT OF SOLAR TRACKER

- The single axis solar tracker is device which senses the light and positions towards the maximum intensity of light. It is made in such a way to track the light coming from any direction.
- To simulate the general scenario of the Sun's movement, the total coverage of the movement of the tracker is considered as 120° in both east to west directions.
- The initial position of the panel are chosen at 90°i.e, for east-west gear motor .
- The position of the tracker ascends or descends only when the threshold value is above the tolerance limit.

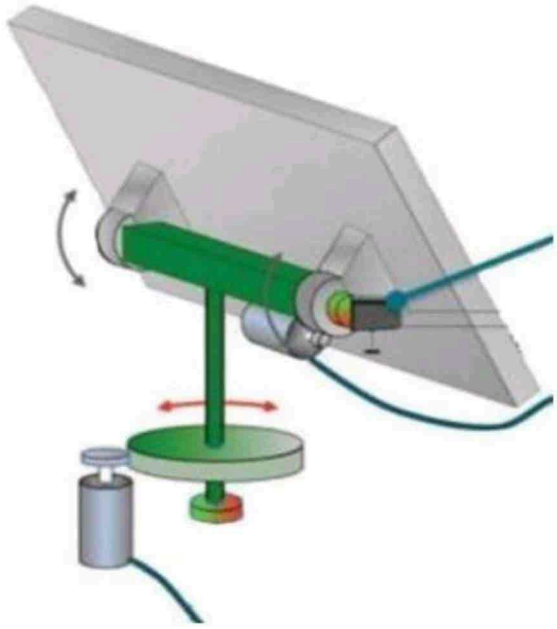

Fig 5.1 Single Axis Solar Tracking System

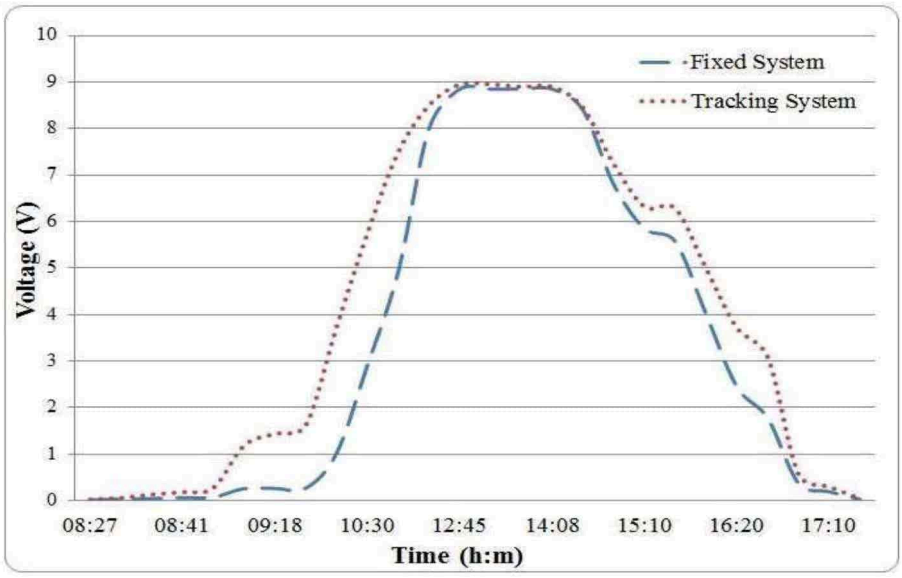

Fig 5.2 The voltage values of the tracking and fixed systems

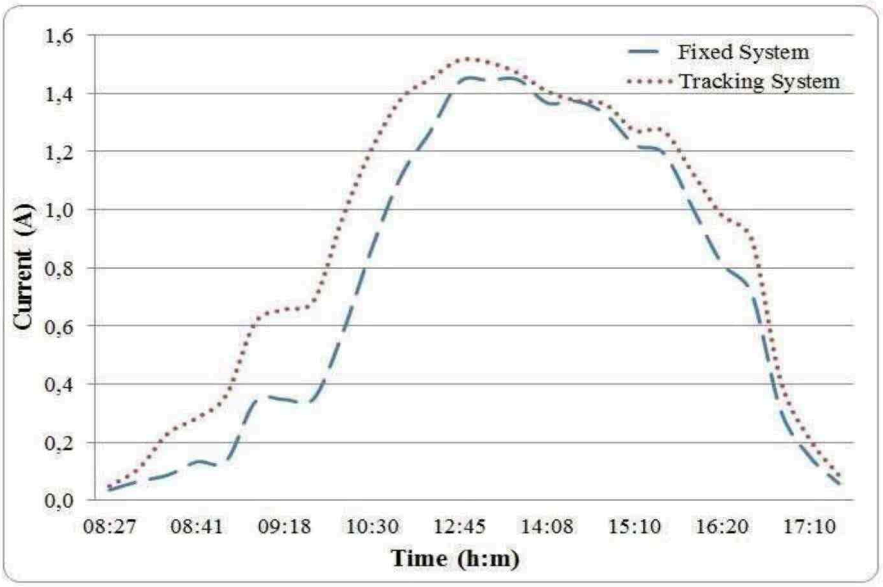

Fig 5.3 The current values of the tracking and fixed systems

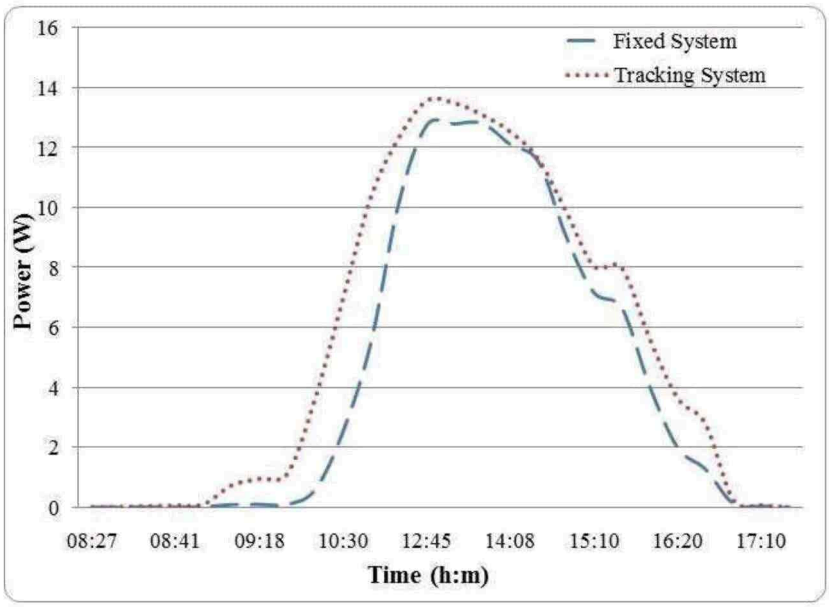

Fig 5.4 The power values of the tracking and fixed system

5.2 Final Working Model

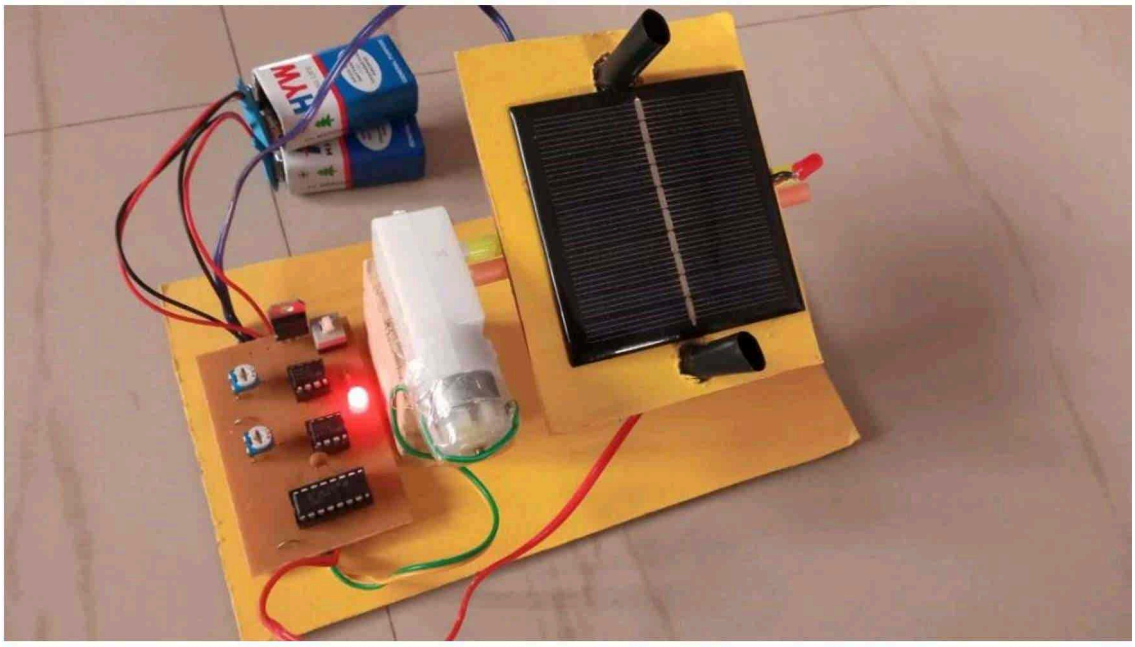

Fig 5.5 Final Working Model

CHAPTER 6

CONCLUSION

Single axis solar tracker flawlessly lines up with the sun heading and tracks the sun development in a more productive manner and has an enormous execution change. Power Captured by single axis sun-based tracker is high amid the entire perception day and age and it augments the change of sun-based irradiance into electrical vitality yield.

Based on the data collected, it can be concluded that the single axis solar tracking system is better than the static solar panel in terms of output voltage, current and power. For this reason, the system has been proven effective for capturing maximum sun light source for solar harvesting applications. The economically and environmentally friendly single axis solar tracking system also can be a great technique in utilizing the superiority of solar energy thus solving the increasing demand of electricity problem.

6.1 ADVANTAGES

- Trackers generate more electricity than their stationary counterparts due to increased direct exposure to solar rays. This increase can be as much as 10 to 25% depending on the geographic location of the tracking system.
- There are many different kinds of solar trackers, such as single-axis and dual-axis trackers, all of which can be the perfect fit for a unique jobsite. Installation size, local weather, degree of latitude and electrical requirements are all important considerations that can influence the type of solar tracker best suited for a specific solar installation.
- Solar trackers generate more electricity in roughly the same amount of space needed for fixed-tilt systems, making them ideal for optimizing land usage.
- In certain states, some utilities offer Time of Use (TOU) rate plans for solar power, which means the utility will purchase the power generated during the peak time of the day at a higher rate. In this case, it is beneficial to generate a greater amount of electricity during these peak times of the day. Using a tracking system helps maximize the energy gains during these peak time periods.

- Advancements in technology and reliability in electronics and mechanics have drastically reduced long-term maintenance concerns for tracking systems.

6.2 APPLICATIONS

The increasing demand for energy, the continuous reduction in existing sources of fossil fuels and the growing concern regarding environment pollution, have pushed mankind to explore new technologies for the production of electrical energy using clean, renewable sources, such as solar energy, wind energy, etc. Among the non-conventional, renewable energy sources, solar energy affords great potential for conversion into electric power, able to ensure an important part of the electrical energy needs of the planet. Solar energy is rapidly gaining notoriety as an important means of expanding renewable energy resources. More energy is produced by tracking the solar panel to remain aligned to the sun at a right angle to the rays of light.

Solar trackers are devices used to orient photovoltaic panels, reflectors, lenses or other optical devices toward the sun. Since the sun's position in the sky changes with the seasons and the time of day, trackers are used to align the collection system to maximize energy production. Several factors must be considered when determining the use of trackers. Some of these include: the solar technology being used, the amount of direct solar irradiation, feeding tariffs in the region where the system is deployed, and the cost to install and maintain the trackers.

6.3 FUTURE ENHANCEMENTS

For further research in the future, some improvement to the system can be made in order to improve the outcome. It is recommended that the analysis to be done with a higher intensity solar panel that produces higher output voltage and current. By doing this the output power will be larger compared to using small solar panel. It's also recommended that the measurement is improved by using a data tracker. All the readings will be automatically recorded the data tracker.

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