الجامعة الإسلامية للتكنولوجيا
UNIVERSITE ISLAMIQUE DE TECHNOLOGIE
ISLAMIC UNIVERSITY OF TECHNOLOGY
DHAKA, BANGLADESH
ORGANISATION OF ISLAMIC COOPERATION

‘ Automatic Solar Tracker’

A thesis report submitted to the department of mechanical and production Engineering (MPE), Islamic University of Technology (IUT)

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Dedication:

To

Nenne Hawawou

&

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CERTIFICATE OF RESEARCH

This thesis title '**Automatic solar tracker'** submitted by **Abdoul-Enziz Imamou** (160010004) and **Mohamadou Moustapha** (160010008) has been accepted as satisfactory in partial fulfilment of the requirement for Higher Diploma in Mechanical and Chemical Engineering.

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CANDITATE'S DECLARATION

We hereby declare that the project report entitled '**AUTOMATIC SOLAR TRACKEER'** submitted by us to the department of **Mechanical and Production Engineering** at **ISLAMIC UNIVERSITY OF TECHNOLOGY** , is a record project work carried out by us under the guidance of **Mr Nagib Mehfuz**. We further declared that this thesis or any part of it has not been submitted elsewhere for the award of any degree or diploma.

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ACKNOWLEGEMENT

‘It is not possible to prepare a project report without the assistance & encouragement of other people. This one is certainly no exception.’

On the very outset of this report, we would like to express my sincere & heartfelt obligation towards all the personages who have helped us in this endeavour. Without their active guidance, help, cooperation and encouragement, we will not have made headway in the project.

We are ineffably indebted to our supervisor Mr **Nagib Mehfuz** for conscientious guidance and encouragement to accomplish this project.

We are extremely thankful and pay our gratitude to our faculty teachers for their valuable guidance and support on completion of this project in its presently.

We also acknowledge with a deep sense of reverence, our gratitude towards our parents and member of our families, who have always supported us morally as well as economically.

At last but not least gratitude goes to all of our friends who directly or indirectly helped us to complete this project.

Any omission in this brief acknowledges does not mean lack of gratitude.

Thanking You

Abdoul-Enziz Imamou

&

Mohamadou Moustapha

Abstract:

Energy crisis is the most important issue in today’s world. Conventional energy resources are not only limited but also the prime culprit for environmental pollution. Renewable energy resources are getting priorities in the whole world to lessen the dependency on conventional resources. Solar energy is rapidly gaining the focus as in important means of expanding renewable energy uses. The energy extracted from solar photovoltaic (PV) or solar thermal depends on solar insulation. For the extraction of maximum energy from the sun, simple tracking solar system using servo motors and light dependent sensors has been developed. A microcontroller is based designed based design technology of an automatic solar tracker is presented in this work. Sun trackers move the solar collector to follow the sun trajectories and keep the orientation of the solar collector at an optimal tilt angle.

In this work, two axis solar tracking has been implemented through microcontroller. This method is increasing power collection efficiency by developing a device that tracks the sun to keep the panel at a right angle to its rays.

Chapter 1: Introduction

Nowadays, climate change on globe is at a critical level. Global warming or climate changes can be seen through some of them natural phenomenon like the effect on crops and extreme weather conditions around the world. Renewable-energy is an energy which comes from natural resources such as sunlight, wind, rain, tides, and geothermal heat, which are renewable (naturally replenished). Solar energy is rapidly advancing as an important means of renewable energy resource in many applications like thermal energy storage systems and electric power generation systems. As the demand of electricity keeps increasing by years, solar energy is the alternative for those electricity problems. Solar energy is the energy derived from the sun through the form of solar radiation. The sun is the most inexhaustible, renewable source of energy known to man. Solar energy provides light, heat and energy to all living things. There is no price and also no air pollution created by solar energy, environmentally friendly and the solar energies are interminable supplies. By using solar arrays, a series of solar cells electrically connected, a DC voltage is generated which can be physically used on a load. Solar arrays or panels are being used increasingly as efficiencies reach higher levels, and are especially popular in remote areas where placement of electricity lines is not economically viable. The average solar energy intercepted by a fixed collector, during the whole day, is less than maximum attainable. This is due to the static placement of the collector which limits their area of exposure to direct solar radiation. More energy can be extracted in a day, if the solar collector is installed on a tracker, with an actuator that follows the sun like a sunflower. Usually, the single-axis tracker follows the sun's east-west movement while two-axis tracker also follows the sun's altitude angle. If a flat solar panel is mounted on level ground, it is obvious that over the course of the day the sunlight will have an angle of incidence close to 90° in the morning and the evening. At such an angle, the light gathering ability of the cell is essentially zero, resulting in no output. As the day progresses to midday, the angle of incidence approaches 0°, causing a steady increase in power until at the point where the light incident on the panel is completely perpendicular, and maximum power is achieved. From this background, we see the need to maintain the maximum power output from the panel by maintaining an angle of incidence as close to 0° as possible. By tilting the solar panel to continuously face the sun, this can be achieved. This process of sensing and following the position of the sun is known as Solar Tracking. It was resolved that real-time tracking would be necessary to follow the sun effectively, so that no external data would be required in operation.

Chapter 2 : Theory

2.1 Photovoltaic technology

The principle of operation of a PV cell is shown in Fig 2.1. The most abundant and convenient source of renewable energy is solar energy, which can be harnessed by photovoltaic cells. Photovoltaic cells are the basic of the solar system. The word photovoltaic comes from "photo" means light and "voltaic" means producing electricity. Therefore, the photovoltaic process is "producing electricity directly from sunlight". The output power of a photovoltaic cell depends on the amount of light projected on the cell. Time of the day, season, panel position and orientation are also the factors behind the output power. The current-voltage and power-voltage characteristics of a photovoltaic cell are shown in Fig 2.2. Photovoltaic cells are the smallest part of a solar panel. Solar panel gives maximum power output at the time when sun is directly aligned with the panel.

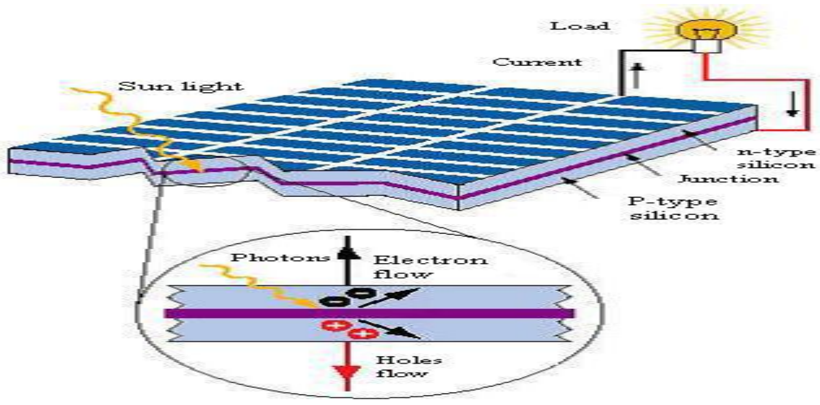


Fig 2.1. Principle of photovoltaic cell [1]

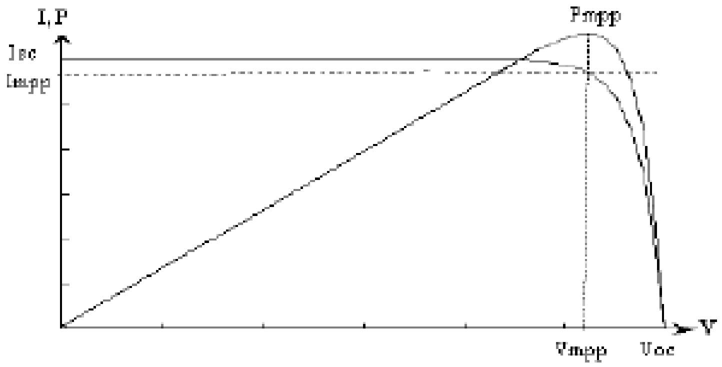


Fig 2.2: Curve of solar panel [2]

2.2 Solar Tracking system

Solar tracking is a widely-applied proven technology that increases energy production by directing or concentrated the photovoltaic to track the sun on its path from dawn until dusk. Instantaneous solar radiation collected by the photovoltaic modules, assembled in a tracking system, is higher than the critical irradiance level for a longer number of hours than in fixed systems. There are numerous types of solar trackers, of varying costs, performance and sophistication. There are static solar panels, single-axis and dual-axis solar tracker as shown in Fig.2.3.

A single-axis solar tracking system uses a tilted PV panel mount, and a single electric motor to move the panel on an approximate trajectory relative to the Sun's position. It has been estimated that the yield from solar panels can be increased by 30 - 60 % by utilizing a tracking system instead of a stationary array. Up to 40% extra power can be produced per annum using a variable elevation solar tracker. In this work, the use of high efficiency is due to dual-axis solar tracker. This work continues with specific design methodologies pertaining to Light Dependent Resistor (LDR), servo motors, solar panel, programme selection and a software/system operation. The paper concludes with a discussion of results and future work. The dual-axis tracker is a very compatible system to be developed with the usage of Arduino as a programming platform. From the overall system, the main controller received an analogue input from the Light Dependent Resistor (LDR) and converts it into digital signal by Analogue-to-Digital converter. The output given to the servo motor will determine the movement of the solar panel.

Fig 2.3 : various types of solar tracker [3]

2.3.Two axis solar tracking

On a long-term basis, the most solar energy can be obtained from a given area of solar modules by having the modules mounted in a 2-axis tracking system. In such a tracking system, the modules are positioned such that the angle of incidence of incoming beam radiation with the solar module is 90^0. Some systems use active tracking methods, in which the motors and/or hydraulic devices are used to position the modules, while others use passive methods, in which normally unused energy, such as heating of a fluid, is used to

provide module alignment with the sun. In addition, some use sensors with new techniques to find the solar disk in the sky which is our case study, while others use computer programs that calculate the astronomical position of the sun from well-known algorithms (solar time-position calculations), and the calculations are used to control motors and gears that align the solar collector with the solar disk. Combinations of the various sub-systems are utilized in some tracking systems. Because up to 90% of the solar radiation is beam radiation sunny day, 2-axis tracking can provide a substantial gain in the solar energy harvested.

2.4: Schematic arrangement

Two-axis tracking system accommodates both degrees of freedom: azimuth and altitude. Schematic block diagram of the proposed automatic solar tracker is shown in the Fig:2.4.

Four LDRs sensors module are used and circuits are implemented in both degrees of freedom. If one of the LDR gets more light intensity than other, the microcontroller will receive a signal. And the microcontroller analyzes this data and generates a signal to actuate the motor, to move the sensor module to a position where equal light is being illuminated on pair of LDRs . The arduino is programmed to generate through azimuth as well as altitude tracking and motor rotation either clockwise or anti-clockwise direction depending on the shadow on the LDRs. If all the ten LDRs are equally illuminated by the sun, then the microcontroller will not generate any signal to actuate the motors. The signal generated by the microcontroller causes to energize the driving circuit, for the movement of server motor.

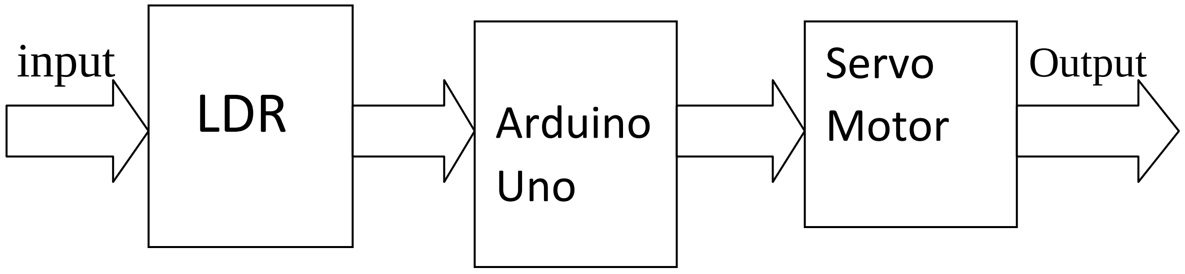


Fig. 2.4 Schematic block diagram

2.5 The sensing element and signal processing

To track the sun it is necessary to sense the position of the sun and for that electro-optical sensor is needed. Ten LDRs have been used for tracking the azimuth and altitude angle. If light falling on the device is of high frequency, photons absorbed by the semiconductor gives enough energy to bound electrons to jump into the conduction band. The resulting free electron conducts electricity, thereby lowering the resistance. In this work Ten LDRs are enough for providing the complete view of the sky and two-axis tracking. Each LDR is placed in series with a resistor of 100kΩ and Wheatstone bridge circuit is formed using all ten LDRs and ten resistors. A voltage divider circuit is formed at the respective node between LDR and a series resistor of 100kΩ. The LDR that detect the high intensity of light will send a signal to the microcontroller and the microcontroller will generate a signal that will cause the motor to rotate depending on the shadow of the LDR.

2.6 Functionality and mechanism of the system

The LDR sensor is a variable resistor that changes the resistance according to the intensity of incident ray illuminated onto it. As the intensity of sunlight changes, the resistance and the voltage of LDR Sensors change. The output voltage across the resistor is converted

Into digital signal at the input of the microcontroller. Based on the output of the microcontroller the DC servo motor rotates clockwise (CW) or counter clockwise (CCW).

The smart tracker panel in our project was installed with four LDRs sensors. When the sunlight falls onto the PV panel, the LDR sensors generate different voltages to move the PV panel.

The control unit is the intelligent part of the system. It consists of an Arduino UNO based on Atmega328 which receive data sent by the sensors. This data describe the sun presence sensors status, sun position sensors and butted of race end status. The treatment of the data by the control unit lets the later send the suitable control signals towards the operative part.

The driving mechanism here is the servo motors. It was controlled using the microcontroller which receives a signal from the LDRs and the analogue voltage is converted into digital signal for processing.

Chapter 3: Method

The main intention of this project is to design a high quality solar tracker. The project is divided into two parts: hardware and software.

3.1 Hardware

The main components of hardware in this project are solar panel, Light Dependent Resistor (LDR), Servo Motor and Arduino-Based Controller.

3.1.1 Light dependent resistor (LDR)

Photo resistor or light dependent resistor (LDR) showing in Fig 3.1 is a resistor in which the resistance decreases with increasing incident light intensity or exhibit photoconductivity. LDR output voltages for light intensity are shown in Table 3.1. The resistance of an LDR is extremely high, sometimes as high as 1 Mohms. The light resistances will drop dramatically when illuminated.

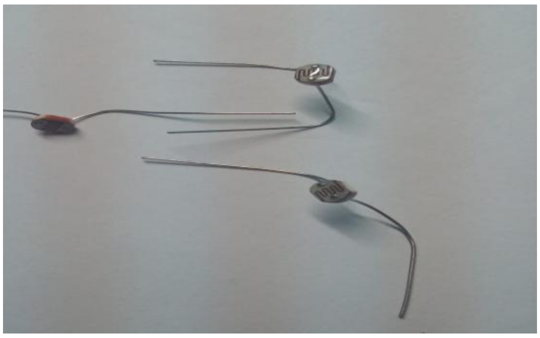


Fig 3.1. Light Dependent Resistor

Table 3.1: Light intensity measurement

Light intensity	LDR output (v)
dark	0.6
average	4.0
bright	4.6

3.1.2 Solar panel

Solar panels are devices that convert light into electricity. They are called "solar" panels because the most powerful source of light available is the sun. Fig 3.2 is a solar panel packaged, connected assembly of photovoltaic cells. The solar panel can be used as a component of a larger photovoltaic system to generate and supply electricity in commercial and residential applications.

Fig 3.2. Solar Panel

3.1.3. Servo motor

A servo motor is an electrical device which can push or rotate an object with great precision. It rotates an object at some specific angles or distance. A servo motor showing in Fig 3.3 is just made up of simple motor which run through servo mechanism. It can reach a very high torque in a small and light weight packages. Due to these features they are being used in many applications like Robotics, machines, cars etc. A servo motor can usually only turn 90^0 in either direction in for a total of 180^0 movement. Servo motors are rated in Kg/cm (kilogramme per centimetre). This Kg/cm tells how much weight the servo motor can lift at a particular distance. The position of a servo motor is decided by electrical pulse and its circuitry is placed beside the motor.

Fig 3.3. Servo Motor

3.1.4. Arduino

The Arduino Uno shown in Fig. 3.4 is a microcontroller board based on the Atmega328. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analogue inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started. Arduino Uno has open source software that is why it’s quiet easy to implement control logics on this microcontroller board. Following table shows some specification of the microcontroller board

Fig 3.4. Arduino UNO board

Arduino features:

- Microcontroller: ATmega328
- Operating Voltage: 5V
- Input Voltage (recommended): 7-12V
- Input Voltage (limits): 6-20V
- Digital I/O Pins: 14 (of which 6 provide PWM output)
- Analogue Input Pins: 6
- DC Current per I/O Pin: 40 mA
- DC Current for 3.3V Pin: 50 mA
- Flash Memory: 32 KB (ATmega328) of which 0.5 KB used by boot loader
- SRAM: 2 KB (ATmega328)
- EEPROM: 1 KB (ATmega328)

3.2 . Software

The software part consists of a programming language that is constructed using C programming. The codes are targeted to Arduino UNO to be compiled and uploaded. The flow of the software procedure is shown in Fig 3.5.

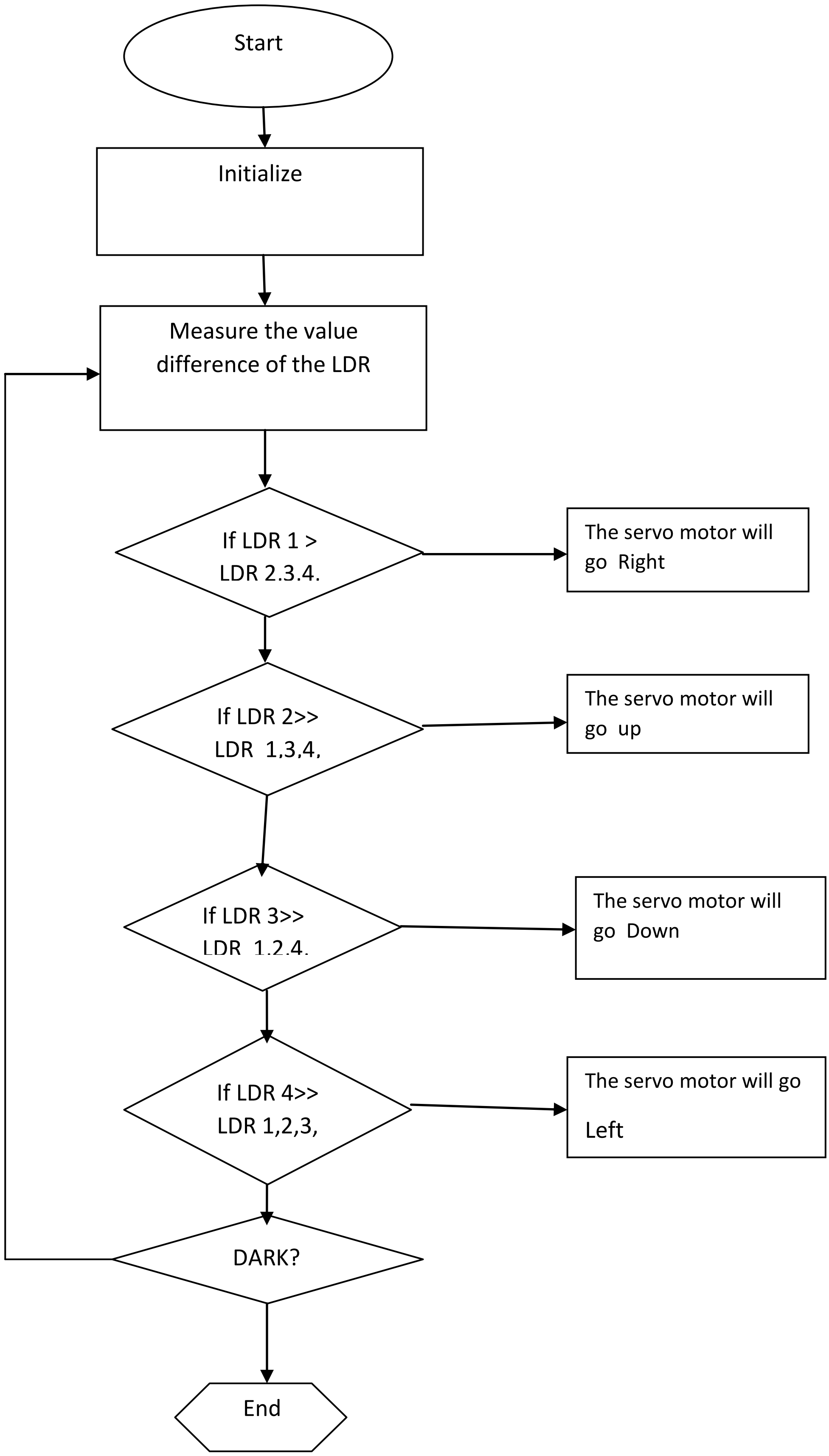


Fig 3.5. Flowchart for the overall process

3.3. Circuit Diagram

The circuit design of solar tracker is simple but setting up the system must be done carefully. Four LDRs and four 100KΩ resistors are connected in a voltage divider fashion and the output is giving to 4 Analogue input pins of Arduino. The PWM inputs of the two servo motors are given from digital pins 9 and 10 of the Arduino. The circuit diagram of this project is shown in Fig 3.6.

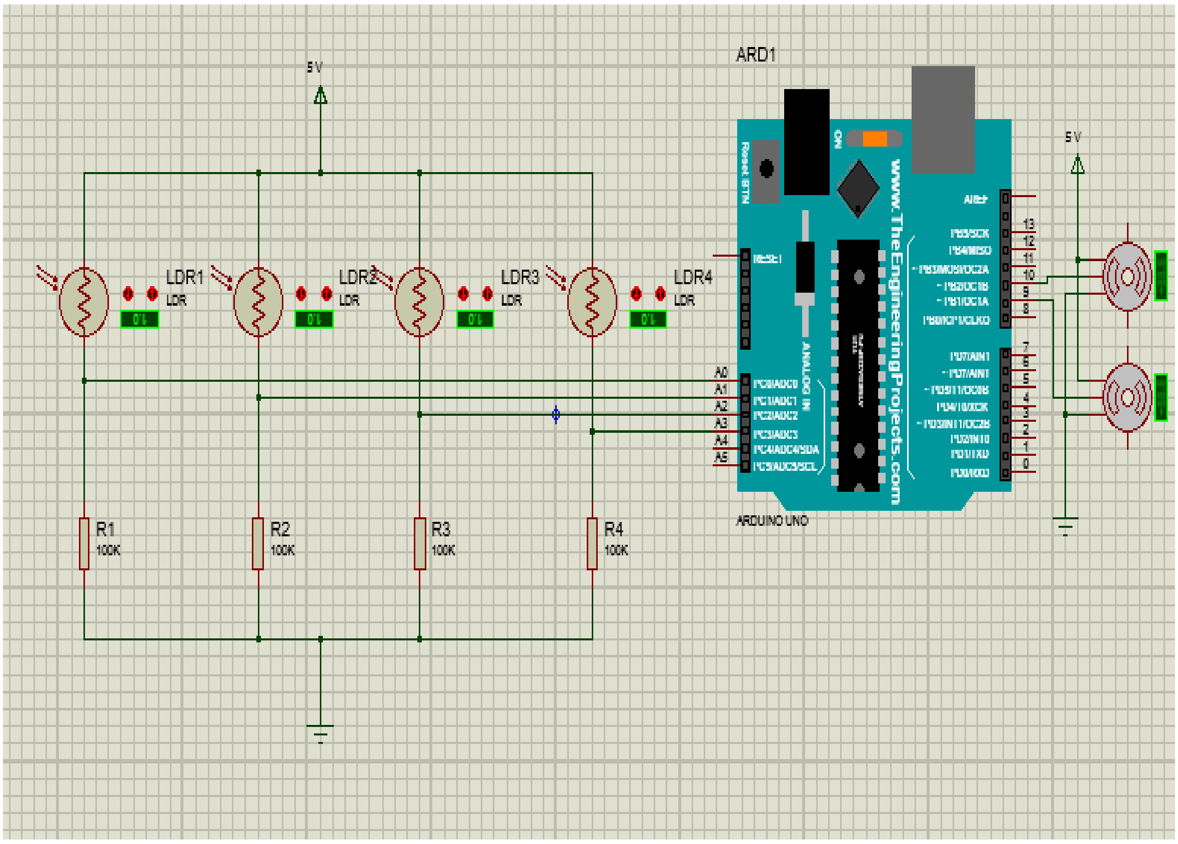


Fig 3.6: Circuit Diagram

3.4. Setup

Step 1

- Take the placard and measure according to the design
- Cut the different part of the measured placard
- Cut four tubes which support the top and bottom plaque
- Sticks the different parts accordingly

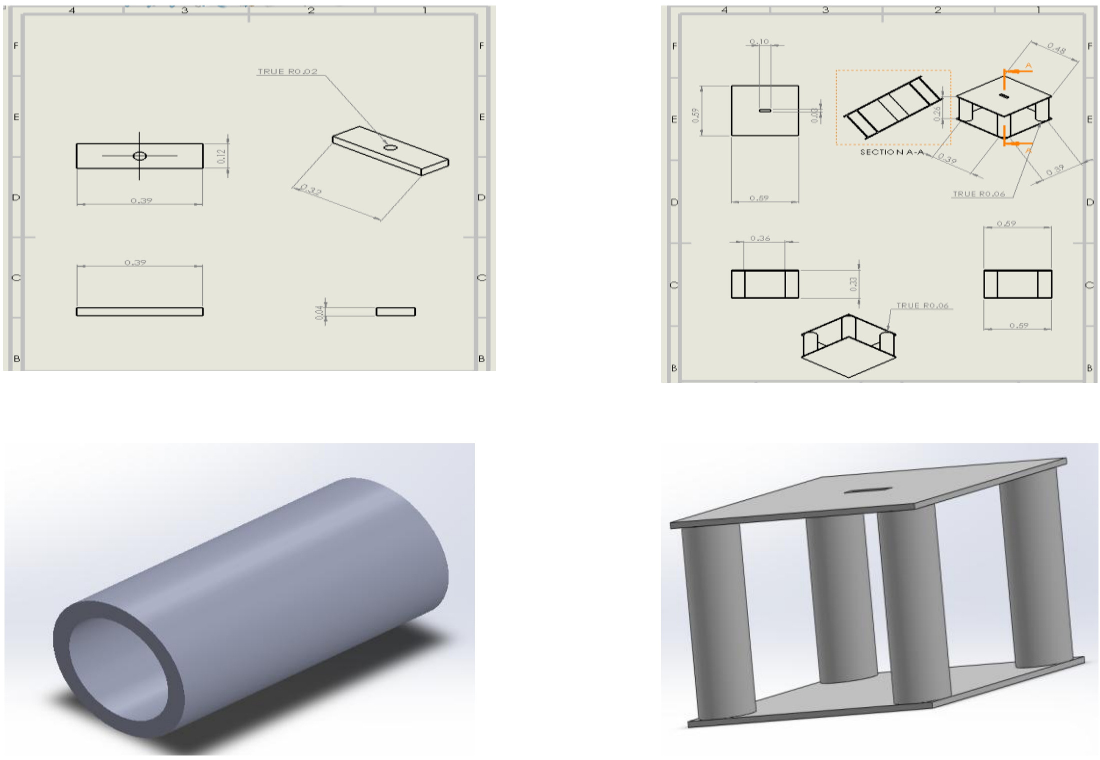
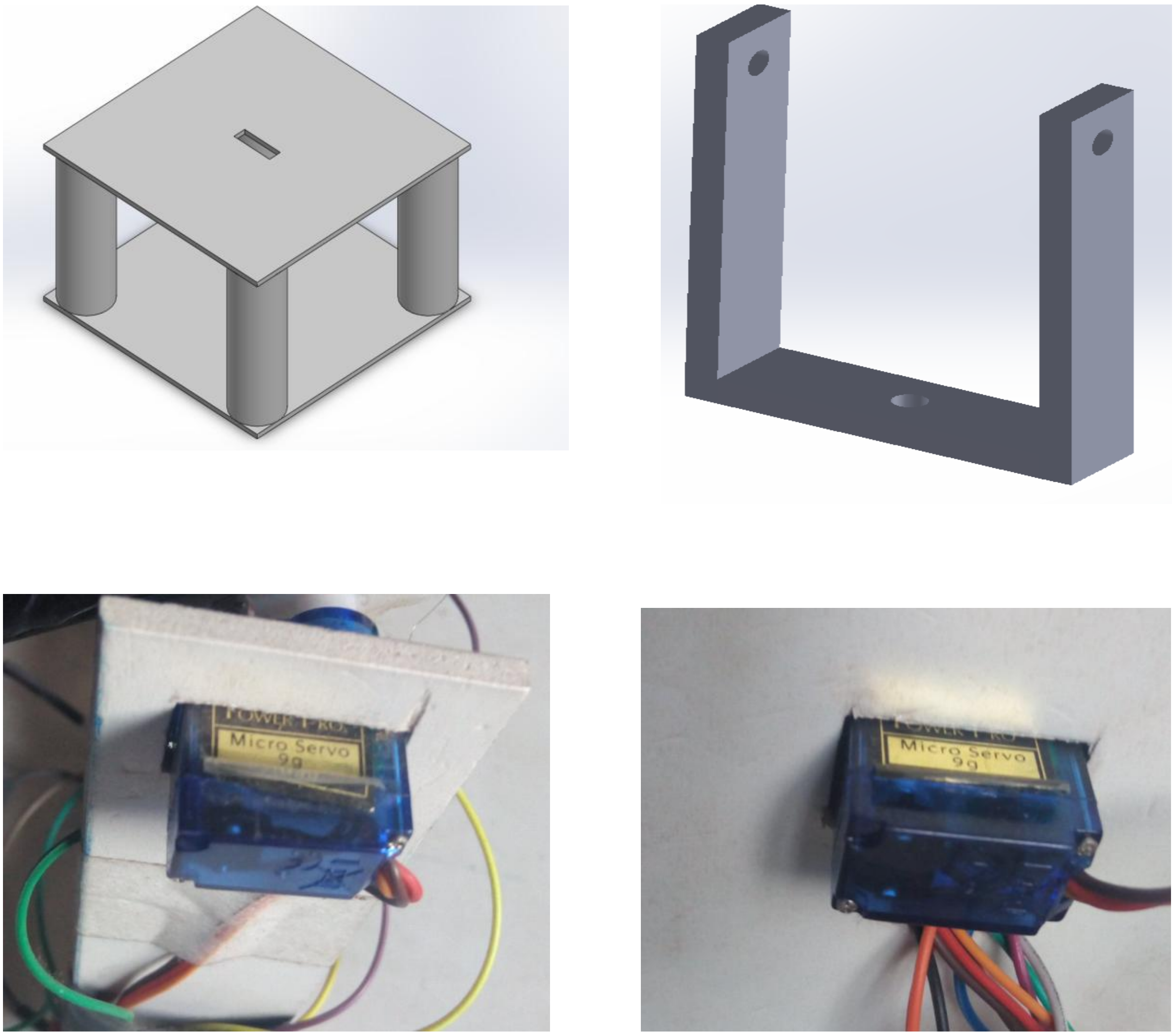


Fig 3.7 : Tubes with top and bottom plaque base setup

Step 2

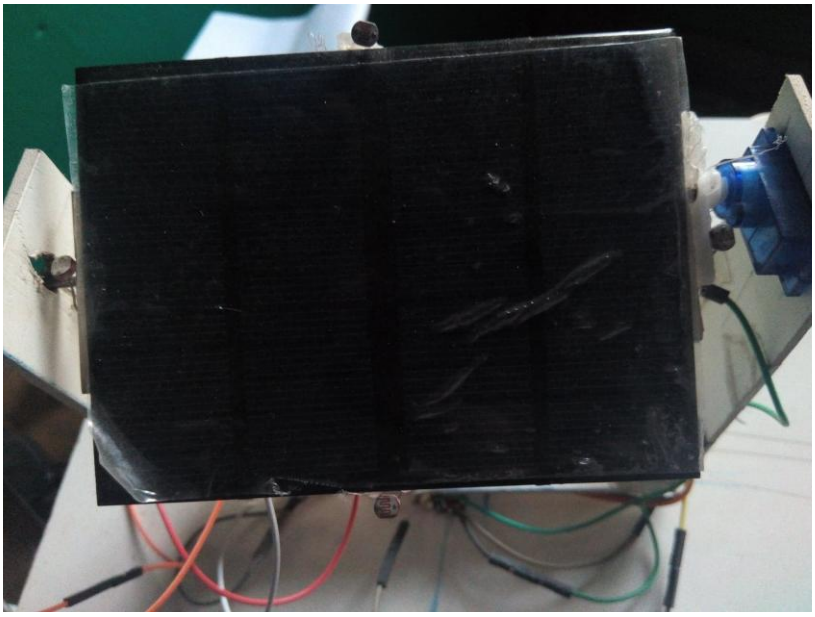
- Hole the plaque to fix the servo motors
- Now connect the servo motors to the perforated holes



3.8 : Plaque hole and servo motors fixation

Step 3

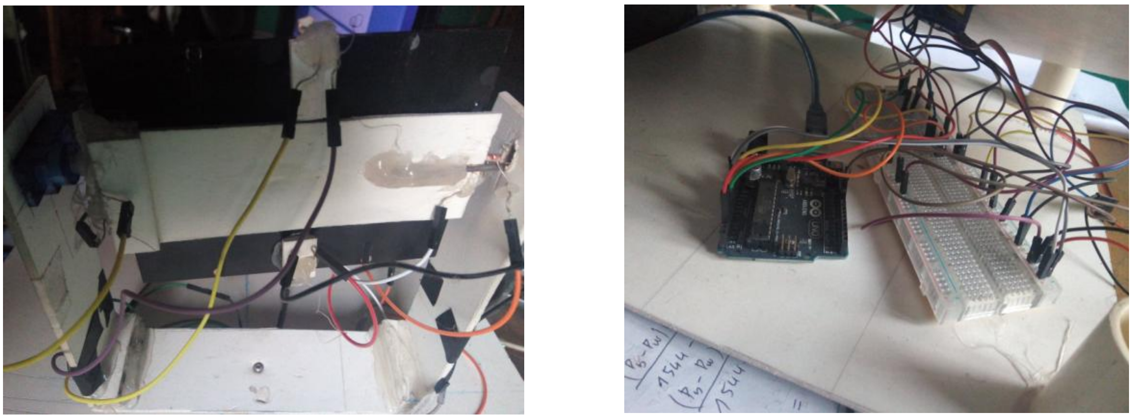
- Stick the solar panel to the plaque
- Stick the four LDRs to the plaque
- Fixe the plaque to the motor



3.9 : LDRs and solar panel fixation

Step 4

- Connect the LDRs with the wires
- Connect the servo motors and the LDRs to the breadboard
- Connect the servo motors and the breadboard to the arduino



3.10 : LDRs and servo motors connection

Step 5

- Upload the code to the arduino Uno

3.5 solar tracker system descriptions

3.5.1 Mechanical structures

After the solar panels and other components were selected, the overall structural design of the solar tracker as seen in Fig 3.7 . The compactness of the proposed solar tracker enables it to be mounted almost everywhere. It consists of the PV panel, the servo motors and Arduino Uno and the vertical pillars with base plates support. The pillars holding panel are aligned to the sides of the panel for better flexibility during the panel rotation and the servo motors are mounted in a such way the tracker system can rotates on a dual-axis freedom of rotation. The sensors are fixed at the sides of the panel to obtain the sun irradiance.

3.5.2 Electrical system

The overall mechanical and electrical subsystems were integrated into the solar tracker system as shown in Fig 3.7. The block diagram of the solar tracker system consists of mostly electrical components. The solar tracker consists of the PV cells, and other subsystems such as the LDR sensors, servo motors and the microcontroller. The LDR sensors sense the sunlight intensity and send the signal to the microcontroller to rotate the PV panel via the servo motor. The servo motor was controlled using the microcontroller. The controller uses the PWM (Pulse Width Modulation) signal to drive the servo motor at a controlled speed correspond to a maximum voltage of 6 V. The PWM wave is a continuous square wave signal that changes between 0 V and 6 V. The duration or width of the pulse determines the angle of the shaft's rotation. The microcontroller target board was used to control the servo motor. It receives the signals from the LDR sensors. The analogue voltage is converted into digital signal for processing.

3.6 complete proposed automatic solar tracker

Fig 3.11: complete propose d automatic solar tracker.

Chapter 4: Result and Discussion

A solar tracker was proposed, designed and constructed. The final design was successful, in that it achieved an overall power collection efficiency increased to a fixed panel for the same panel on the tracking device. the solar energy capture is maximized by a 2-axis tracking system because the solar energy is greatest on cloud-free days when there is ample direct sunshine, and response of a solar module to a ray of light is proportional to the cosine of the angle between a line perpendicular to the module surface and a direct solar ray impinging on the surface. In terms of real value, this means that the overall cost of a system can be reduced significantly, considering that much more power can be supplied by the solar array coupled to a solar tracking device. By extracting more power from the same solar panel, the cost per watt is decreased, thereby rendering solar power much more cost-effective than previously achieved using fixed solar panels. A single axis tracker offers a great power increase over a fixed solar panel, but a two-axis tracker would provide more power still. This could be a subject for further development. Solar tracking is by far the easiest method to increase overall efficiency of a solar power system for use by domestic or commercial users.

Chapter 5: Conclusion

In this project, the sun tracking system is developed based on microcontroller. The Arduino Uno is used in this system with a minimum number of components and the use of DC servo motors enables accurate tracking of the sun. It has been observed that the sun tracking systems can collect maximum energy than a fixed panel system and high efficiency is achieved through this tracker, it can be said that the proposed sun tracking system is a feasible method of maximizing the light energy received from sun. This is an efficient tracking system for solar energy collection. The method implemented in this project is simple, easy to maintain and requires no technical attention for its operation. The software developed for this work is easy to manipulate. The solar module with tracking system can collect maximum energy over a static module. Hence implementation of this technique in building solar systems will greatly improve utility satisfaction.

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