BINDURA UNIVERSITY OF SCIENCE EDUCATION

FACULTY OF SCIENCES AND ENGINEERING

DEPARTMENT OF ENGINEERING AND PHYSICS

DUAL AXIS SOLAR TRACKING SYSTEM

BY

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ABSTRACT

With fossil fuels like oil and gas becoming scarce, there's a growing need for alternative energy sources. Solar energy is a promising option, thanks to the sun's virtually limitless supply of power. However, to make solar energy more commercially viable, we need to improve its efficiency in capturing sunlight. This project focuses on designing a system that tracks the sun's movement and directs sunlight towards solar panels. By doing this, the panels will receive a more consistent and intense source of sunlight, boosting their electricity output.

Developing this system requires further research to improve existing solar tracking technology. This project utilizes Light Dependent Resistors (LDRs) to detect sunlight, a DC gear motor for movement, and an ESP8266 microcontroller as the central processing unit. The microcontroller acts as the brain of the system, receiving sensor data, processing it, and controlling the motor to track the sun. Programming knowledge is crucial, as the program uploaded to the microcontroller dictates the system's operation.

The project focuses on building a working model to test the sun-tracking mechanism. This prototype uses a geared DC motor mounted on a base made of Perspex to move the solar panel throughout the day, simulating sunrise to sunset. Tests are being conducted to refine the design and ensure the system operates efficiently and reliably.

ACKNOWLEDGEMENT

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LIST OF ABBREVIATION

ADC - Analogue-Digital-Converter

FYP - Final Year Project

UTP - Universiti Teknologi Petronas

PIC - Programmable Integrated Circuit

PLC - Programmer Logic Controller

LDR - Light Dependent Resistor

LED - Light Emitting Diode

CHAPTER ONE: INTRODUCTION

1.1 BACKGROUND STUDY

1.1.1 Introduction to Solar Energy

In recent times, renewable energy sources have become crucial in our lives due to the depletion of traditional energy resources like petroleum. New energy sources, including wind, hydropower, and solar energy, have been discovered. Although there are various technologies to generate electricity from natural resources such as petroleum, gas, and diesel, these resources are finite and environmentally harmful. Consequently, research and development on alternative energy sources have intensified. Among these, solar energy has garnered the most attention for being practical, environmentally friendly, and offering an endless, free supply of electricity.

1.1.2 Solar Cell and Solar Panel

Sunlight powers solar panels! These panels are made up of tiny solar cells containing silicon, a common element found in sand. When sunlight hits the silicon, it creates a weak electric current. Metal collectors within the cells capture this current and channel it into wires. These wires connect to a system that manages the electricity. A group of these solar panels working together is called a solar array. They're also known as photovoltaic (PV) modules, because "photovoltaic" refers to generating electricity from light. To work best, solar panels should face the sun and avoid shade.

1.1.3 Types of Solar Collectors

There are three main types of solar collectors: flat-plate, concentrating, and passive [3].

1. Flat-plate Collectors

Flat-plate collectors are the most popular type. They consist of solar panels laid out in a flat arrangement. These panels can be various sizes and their output depends on a few factors like size, direction they face, and how clean they are. Some flat-plate collectors have mechanisms that automatically track the sun to maximize efficiency.

Flat-plate collectors are particularly well-suited for residential hot water heating. They can also be used for generating electricity and come in two modes: stationary (stand-still) and sun-tracking (active).

2. Focusing Collector

Focusing collectors use lenses or mirrors to concentrate sunlight onto a single point, unlike flat-plate collectors which capture spread-out sunlight. This approach can generate much higher temperatures at the focal point. However, focusing collectors also lose some sunlight compared to flat-plate collectors.

Solar furnaces are a prime example of focusing collectors. These powerful devices create extremely high temperatures ideal for research and industrial applications. They can also be used to destroy hazardous waste in a clean and efficient way. By concentrating a powerful beam of light, solar furnaces can break down harmful chemicals like dioxin and PCBs.

3. Passive Collector

Passive collectors stand out from the other two types. Unlike collectors designed to capture sunlight, passive collectors absorb and convert sunlight into heat naturally. Everything has this ability to some degree, but only certain objects, like walls, can effectively trap enough heat for practical use. Sometimes, their natural heat absorption is boosted (like painting them black). Often, a system is added to transfer this heat elsewhere.

A basic example is an incidental heat trap. This involves maximizing sunlight entering through windows and letting it hit a heat-storing material like a stone floor. The area stays cool during the day as the floor absorbs heat, and warm at night as the stored heat is released.

Passive collectors are essentially anything that naturally converts sunlight into heat, including walls. However, their efficiency is generally lower since they weren't specifically designed for this purpose.

Focusing collectors, in contrast, generate very high temperatures, ideal for specific industrial applications. This extreme heat can be a drawback, making them less efficient at very high temperatures. That's why they're used in industries needing intense heat, like hazardous waste detoxification.

Flat-plate collectors are the most common type and often incorporate sun-tracking mechanisms. They come in various configurations and operate at moderate temperatures, making them the most efficient choice for many applications.

1.2 PROBLEM STATEMENT

The growing need for alternative energy sources has driven the increased use of solar power. However, traditional solar panels are typically fixed in place, which limits their efficiency in capturing sunlight throughout the day. To overcome this challenge, active solar tracking systems have been developed. These innovative systems can automatically adjust the position of solar panels to follow the sun's movement from dawn to dusk. By constantly facing the sun, the panels can maximize their exposure to sunlight and generate more electricity.

Studies by Sun Technics GmbH in Hamburg suggest that active solar tracking systems can significantly boost energy output by 23% to 30%. Inspired by this potential, this project aims to design a solar tracker using an ESP8266 microcontroller and a DC gear motor. This system will optimize solar panel performance by automatically adjusting its position to follow the sun's path.

1.3 OBJECTIVES AND SCOPE

The objectives of the Solar Tracking System project are to meet to following requirement:-

i. To study the Solar Tracking System.
ii. To design the Solar Tracking System by using ESP8266 microcontroller.
iii. To fabricate the prototype of Solar Tracking System.

This project holds promise for future commercial applications due to its potential to improve solar energy efficiency. Additionally, it provides a valuable learning experience for the student, offering deeper insights into the system's components, particularly the microcontroller. Through this project, the student can gain practical experience with programming languages, a crucial skill in today's increasingly automated world.

There are several aspects need to be focused on this project. Let divide the project into three components which are:-

1. In-depth exploration: This phase involves a thorough examination of the system and its individual components to gain a comprehensive understanding of their functions and interactions.

2. Circuitry construction: Here, the student focuses on building the electrical circuits that will connect and manage the various inputs and outputs of the system.

3. Programming and control: This stage involves developing the assembly language program that will be uploaded to the microcontroller. This program acts as the brain of the system, dictating its operation and processing information received from the inputs to control the motor and track the sun.

CHAPTER TWO: LITERATURE REVIEW AND THEORY

2.1 HISTORY OF SOLAR TRACKING SYSTEMS

Our fascination with harnessing the sun's power is ancient, stretching back millennia. While today's solar tech fuels buildings and even cars, the roots lie in simply using mirrors and glass to focus heat, like starting fires. Fast forward to the 18th century, and a Swiss scientist builds the first device to capture the sun's heat – a precursor to solar collectors. This early technology even found a practical use – cooking food on an expedition! Around the same time, another inventor was tinkering with heat engines, a technology that would someday be adapted to use the sun's heat to generate electricity directly. These early inventions paved the way for the solar technology we rely on today.

The seeds of modern solar power were sown much earlier than you might think. In the 1800s, scientists were uncovering the basic principles behind it. One key discovery was the photovoltaic effect, where light can directly generate electricity. Another breakthrough was the realization that certain materials, like selenium, could be used to convert sunlight into electricity. Around the same time, inventors were also developing early versions of solar collectors, laying the groundwork for the technology we use today. Even during World War II, there was a surge in interest in using sunlight for heating buildings, demonstrating its potential as a valuable energy source. These early steps paved the way for the widespread adoption of solar technology in the future.

The year 1954 marked a turning point for solar power. Scientists in the US achieved a major breakthrough with the invention of the silicon photovoltaic cell. This was the first solar cell powerful enough to run everyday appliances. These early cells weren't incredibly efficient, but Bell Labs quickly improved the design, doubling its efficiency. This invention sparked a surge in solar power research, making it one of the fastest-growing renewable energy sources globally. Since then, scientists have been continuously developing new types of solar technology and improving how solar panels capture the sun's rays.

2.2 WHAT IS SOLAR TRACKING SYSTEM

Solar trackers are like smart sunbathers for solar panels! By constantly adjusting the panels to face the sun directly, they capture the most sunlight all day long, boosting energy production. These systems use sensors and motors (both electric and mechanical) to achieve this automatic sun-following feat. There are many different tracker options available.

The ultimate solar tracker would mimic a sunflower, perfectly following the sun's movement throughout the day and across the seasons. Since the sun moves slowly, these trackers need to be smooth and avoid jittery adjustments. An ideal system would even reposition itself at night, facing the upcoming sunrise (opposite the previous sunset) to minimize wasted morning energy. Let's explore the different types of solar tracking systems currently on the market.

2.2.1 Electronic Solutions

One popular solar tracker design is pretty simple. It uses a motor powered by the solar panel itself to rotate the panel on a central pivot, following the sun's movement. This keeps things straightforward electrically, but since the panel is often positioned high up to avoid tampering, it can be more vulnerable to wind gusts. Another downside is that as the sun gets lower in the sky and the panel produces less power, the tracker might not have enough juice to keep adjusting smoothly.

A different type of electric solar tracker uses a sensor to constantly measure the angle between the sun and the panel. The goal is to get this angle as close to zero degrees as possible, which means the sunlight hits the panel head-on. Unlike the first design, this tracker's central pivot isn't perfectly flat. One side sits lower than the other, allowing the panel to tilt up or down depending on your location (since the sun's path changes throughout the year). Just like the first design, this tracker gets its power from the solar panel itself.

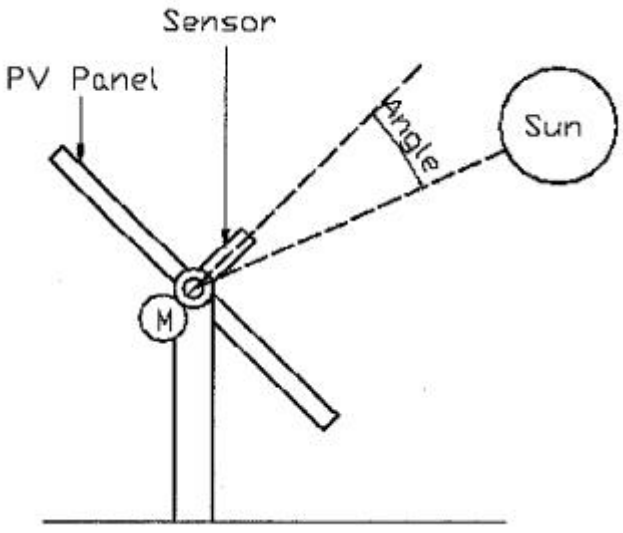


Figure 2-1: An Electric Solar Tracker Including a Sensor that Aims to Minimize the Angle between the Line of the Sun and a Face Perpendicular to the Panel

2.2.2 Passive Solutions

solar panel itself. However, This next solar tracker design ditches electricity altogether! Instead, it uses two identical fluid-filled tubes on either side of the panel. These tubes are partially filled with a liquid, and when sunlight hits them through strategically placed shades, the fluid heats up and even evaporates a bit. This creates an imbalance – one tube gets heavier with more liquid, and this weight difference is what actually moves the solar panel to follow the sun. Damping helps to slow down the movement and prevent jerky adjustments. This design is pretty cheap and doesn't steal any power from the there's a catch: every morning the panel starts facing the wrong direction and has to play catch-up with the rising sun. Despite this drawback, it's a popular choice because of its simplicity and low cost.

Tests have shown that passive trackers have been found to be comparable to electrically based systems in terms of performance, and even though they are less expensive, they have not yet been widely accepted by the consumer. Base on study, the electronic solution will be used in designing the solar tracking system.

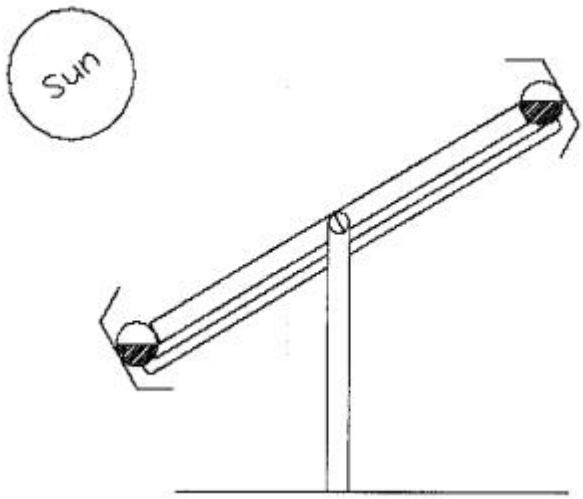


Figure 2.2 Passive Solar tracker using identical cylindrical tubes

2.3 Design Concept of Solar Tracking System

To give the brief view of the design concept, a block diagram for the system has been developed. It consists of all the sub-components of the system which are:-

i. Microcontroller (ESP8266)
ii. Motor Controller
iii. DC Gear Motor
iv. LDR Sensors

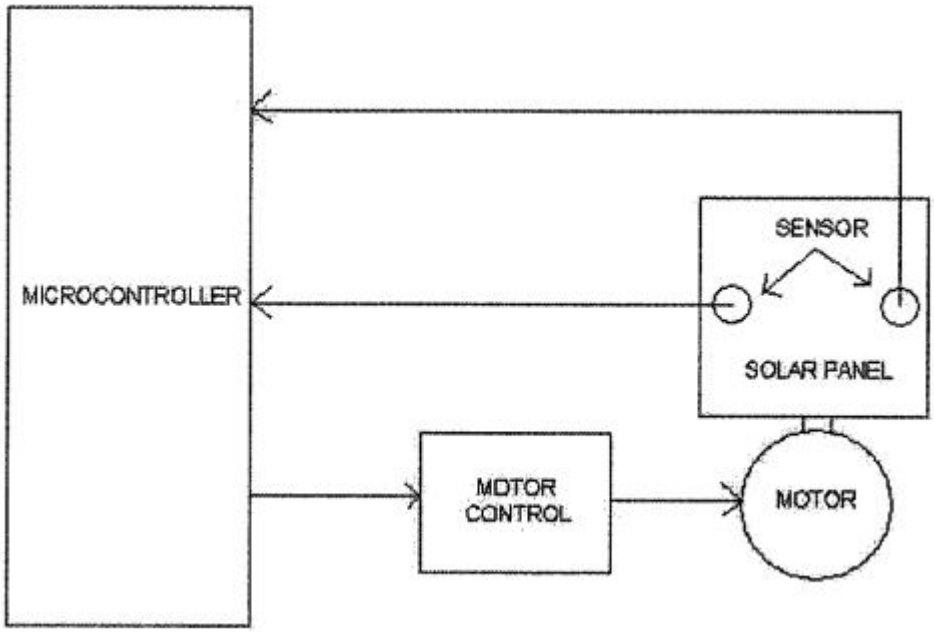


Figure 2.3 The Design Concept of the Solar Tracking System

The core of the system is the microcontroller, which connects all inputs and outputs. A motor controller interfaces between the motor and the microcontroller. The microcontroller sends signals to the motor controller, which then instructs the motor to rotate clockwise or counter clockwise. The solar panel is attached to the motor gear system, with two sensors positioned at each edge of the panel. The microcontroller compares the outputs from both sensors and directs the motor controller accordingly.

2.3.1 Microcontroller (ESP8266W-room)

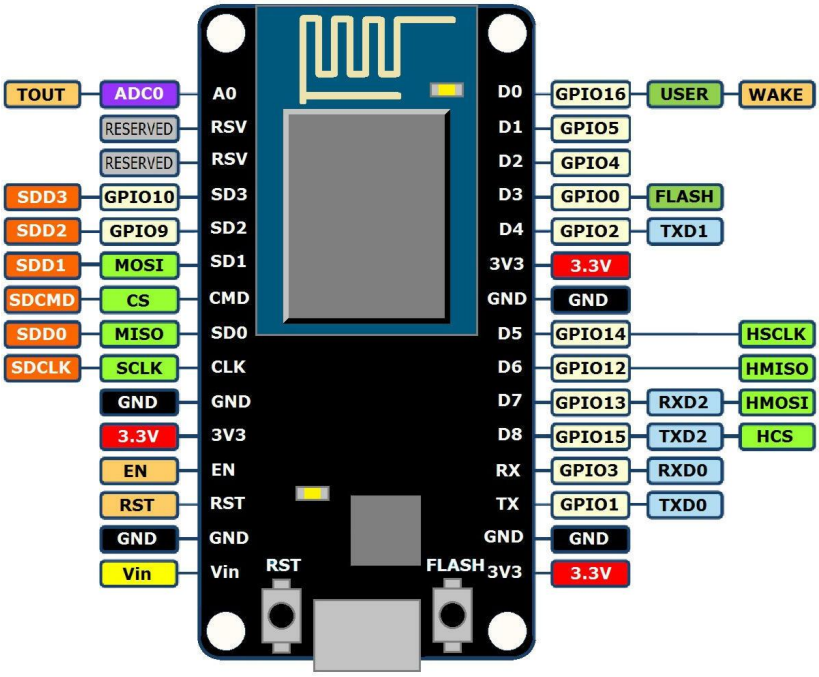


Figure 2.3.1 Structure of ESP8266

The ESP8266 microcontroller is a powerful, versatile microcontroller developed by Espressif Systems. It is widely used in various applications, particularly those involving IoT (Internet of Things) due to its rich set of features. Here are some key aspects of the ESP8266:

1. **Dual-Core Processor**: The ESP8266 features a dual-core Tensilica LX6 processor, providing ample processing power for complex tasks.

2. **Wi-Fi and Bluetooth**: It includes integrated Wi-Fi and Bluetooth (both Classic and BLE), making it ideal for wireless communication applications.

3. **Memory**: The microcontroller comes with a substantial amount of memory, including SRAM and flash storage, to handle a variety of tasks and store data.

4. **Low Power Consumption**: The ESP8266 is designed with power-saving features, making it suitable for battery-operated devices.

5. **Rich Peripheral Set**: It supports numerous peripherals, including GPIOs, ADCs, DACs, UART, SPI, I2C, and PWM, enabling a wide range of applications.

6. **Versatility**: It is used in many applications such as home automation, sensor networks, wearable electronics, and industrial automation.

7. **Development Support**: The ESP8266 has strong development support with various programming environments, including the Arduino IDE, ESP-IDF (Espressif IoT Development Framework), and MicroPython.

2.4 Components and Hardware

To set up the PCW-room's analogue to digital channel, A/D module which has four registers need to be configured, which are [7]:

- A/D Result High Register (ADRESH)
- A/D Result Low Register (ADRESL)
- A/D Control Register O (ADCONO)
- A/D Control Register l (ADCONl)

The details of the above registers will be explained in themethodology section.

2.4.1 Concept of Programming

The ESP8266 actually works on 10-bit digital number. The 10-bit A/D result is loaded onto the register pair ADRESH:ADRESL which is a 16-bitwide register pair. The A/D module gives the programmer a choice whether to left or right justify the 10-bit result in to the 16-bitregister(more details in ESP8266W-room manual). The A/D module has a high reference voltage of 5V and a low reference voltage of OV, therefore, the analog input must be varied within 0-5V. An example to convert the corresponding voltage to a binary number is as shown below: Since the maximum voltage allowed is 5V the corresponding 10-bitbinary number would:-

11 1111 l111$_2$ is equal to l024$_{10}$.

This is the base ration for the next voltage value.

e.g.: Input voltage is 3.75 V

$$3.75V \times \frac{1024_{10}}{5V} \equiv 768_{10}$$

Therefore 768_{10} is equal to 11 0000 0000_2

2.4.2 Motor Controller

H-Bridge circuit is used for rotating the motor clockwise and anti-clockwise. Here is the simple conceptual schematic:

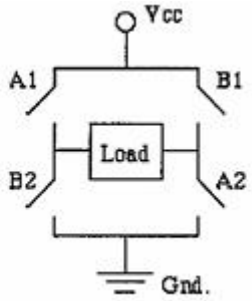


Figure 2.4.2 The Simple Conceptual Schematic of H-bridge Circuit.

A basic H-Bridge has 4 switches, relays, transistors, or other means of completing a circuit to drive a motor. In the above diagram, the switches are labelled Al, A2, B1, and B2. Since each of the four switches can be either open or closed, there are 2 = 16 combinations of switch settings. Many are not useful and in fact, several should be avoided since they short out the supply current (e.g., Al and B2 both closed at the same time). There are four combinations that are useful:

2.4.3 DC Gear Motor

There are several types of electric motors, each with its own unique features and benefits. Basically, most of the electric motors are divided into three categories which are AC, DC, and stepper motor. The difference is in term of the way it generates and moves the magnetic fields. For example, magnetic fields can be generated from permanent magnets or from coils carrying current (electromagnets), and in the latter case, direct connection can deliver current to the coils, through brushes, or by induction. Some motors have permanent magnets on the rotor and coils on the stator, others have permanent magnets on the stator and coils on rotor, and still others have coils and both rotor and stator.

In this project, it was decided to use DC gear motor. DC gear motors operate from a direct current power source. In general, users select brush-type DC motors when low system cost in a priority, and brushless motors to fulfill other requirement (such as maintenance-free operation, high speeds, and explosive environments where sparking could be hazardous). Because varying the voltage and current from the power supply are controlled by speed and torque (twisting force), DC motors work well in complex motion tasks.

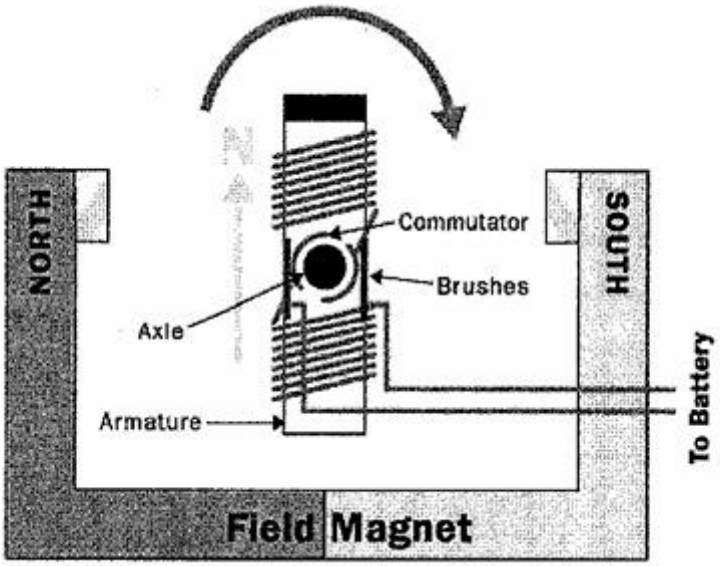


Figure 2.4.3 Parts of an Electric Motor.

Figure 2.4.3 is the overall plan of a simple two-pole DC electric motor. A simple motor has six parts as shown in the figure:-

- Armature or rotor
- Commutator
- Brushes
- Axle
- Field magnet
- DC power supply

Electric motors operate based on the fundamental principle of magnetism, where opposite poles of magnets attract each other and like poles repel. For motion to occur, a motor must accomplish three key tasks: generate magnetic fields in the moving part (rotor or armature), generate a magnetic field in the stationary part (stator), and provide a mechanism to ensure one of these fields remains in motion. This movement causes one field to "chase" the other, resulting in the desired motion.

2.4.4 Light Dependant Resistors (LDR)

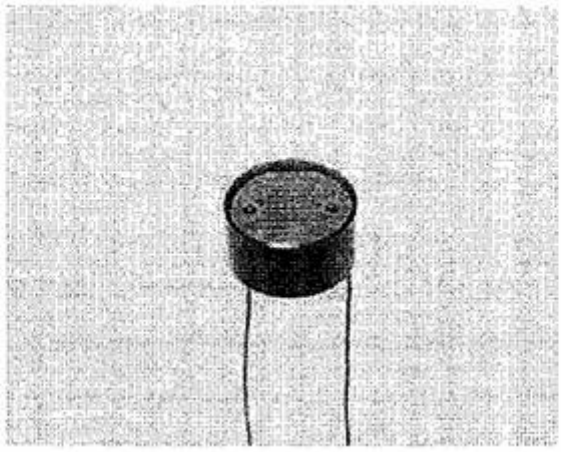


Figure 2.4.4 Example of LDR

An LDR (Light Dependent Resistor) has a resistance that changes based on the amount of visible light it receives. When light hits the brown zigzag lines on the sensor, the device's resistance decreases, a characteristic known as a negative coefficient. However, some LDRs work oppositely, with their resistance increasing as light exposure increases; these have a positive coefficient.

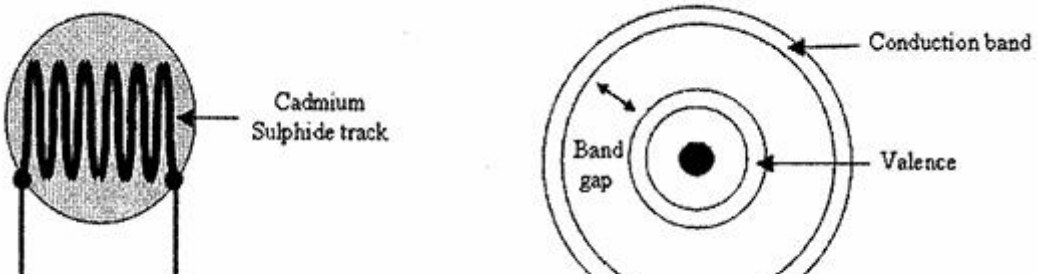


Figure 2.4.5 Structure of a Light Dependent Resistor, Showing Cadmium Sulphide

LDR is made from cadmium sulphide. Cadmium Sulphide is a II-VI semiconductor. (It is so called because Cadmium is in group II and Sulphide is in group VI.) It is light sensitive. When the light shining on it is stronger, the resistance of the LDRis smaller. It is important to note that light has dual properties.

On the one hand, light is electromagnetic wave, on the other hand, it can be seen as photons (energetic particles). When light shines on the LDR, the photons break the bonds in the cadmium sulphide and release electrons for the conduction. If the light is of a stronger

intensity, then more bonds are broken, thus more electrons are freed for the conduction. So LDR's resistance decreases when stronger light shines on it.

CHAPTER THREE: DESIGN AND METHODOLGY

3.1 Procedure Identification

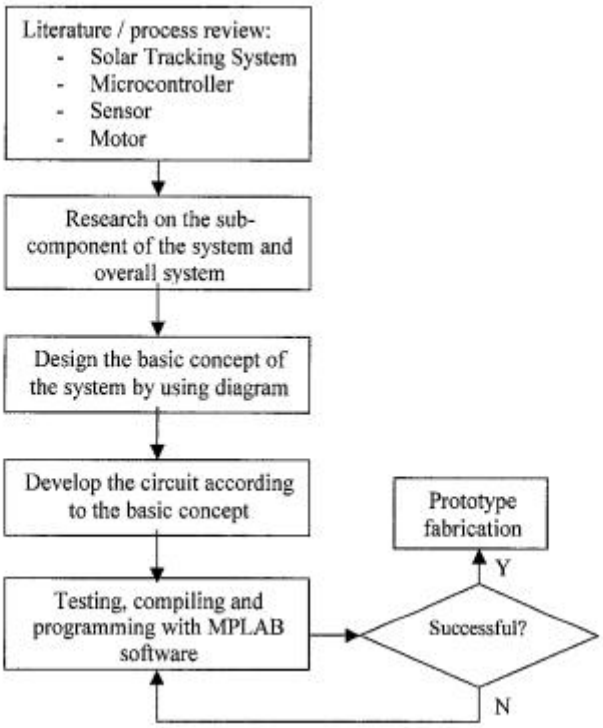
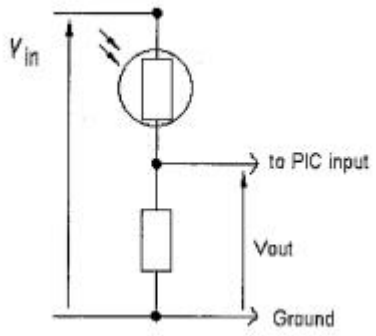


Figure 3.1 Flow Chart for Basic Procedure Identification

In the initial stages of the project a thorough review of the literature was conducted. It is the initial step to show the student understanding towards the project base on the research and study that have been done. Then, the basic concept of the system will be presented including the block diagram. Starting from this point, a further research will be done and the required circuit design will be developed. After that, the source code of the microcontroller programming will be written and downloaded it to the microcontroller. The crucial part is the circuit testing, simulation and analysis of the system. After completing the circuit analysis, the prototype fabrication will be started.

3.2 Hardaware

3.2.1 Sensor's Circuit



The circuit for the LDR sensor is depicted in Figure 3.2. Two identical circuits will be employed, each providing an output to be connected to the ESP8266. Each LDR sensor is housed in a "well" (straw) with a narrow slit that allows sunlight to reach it only when it is directly aligned with the sun. As previously discussed, the microcontroller will compare the output voltages from both sensors after converting them to digital signals. The use of straws enhances the accuracy of the output voltage from each sensor, thus improving the system's overall efficiency.

The LDR circuit operates with a 5 V DC power supply. The output voltage from the lower resistor will be fed to the ESP8266 microcontroller. It is necessary to determine the value of the lower resistor first.

3.2.2 Servo Motor Circuit

3.3 Software

Visual OS v6.42 is used in this project for programming part. Arduino IDE v1.8.2 is the Windows Integrated Development Environment for development systems tools. The program will be written by using this software and then will be downloaded to the controller ESP8266.

3.3.1 Block program of Program Flow

The block diagram of the program's flow illustrates the operations within the ESP8266 microcontroller. Upon receiving outputs from the two LDR sensor circuits, the ESP8266 converts these analog values into digital binary form and stores each value in a separate variable. A subtraction operation is performed on the two binary values, after which the ESP8266 checks the status registers, Z and C. Based on the values in these registers, the ESP8266 sends an output to the motor controller. The motor controller then directs the motor to rotate clockwise, counterclockwise, or to hold its position.

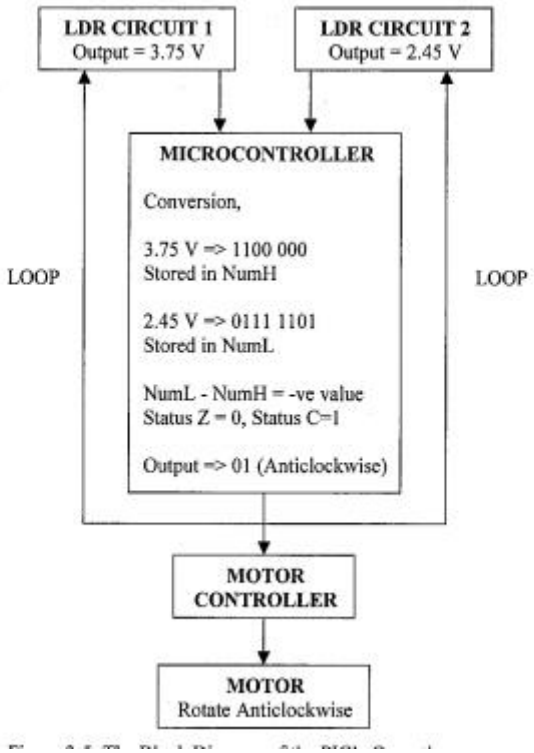


Figure 3.3.1 The Block Diagram of the ESP8266's Operation.

3.3.2 Software

Below is the complete source code written for the purpose of controlling the solar tracking system :-

```
#include <Servo.h>

// 180 degrees horizontal MAX
```

```
Servo horizontal; // horizontal servo
int servoh = 90; // stand horizontal servo
int servohLimitHigh = 180;
int servohLimitLow = 0;

// 65 degrees MAX
Servo vertical; // vertical servo
int servov = 45; // stand vertical servo
int servovLimitHigh = 180;
int servovLimitLow = 0;

void setup() {
  // put your setup code here, to run once:
  horizontal.attach(9);
  vertical.attach(10);
  horizontal.write(90);
  vertical.write(45);

  delay(3000);
}

void loop() {
  // put your main code here, to run repeatedly:
  int dtime = 10;
  int tol = 50;

  int lt = analogRead(0); // top left
  int rt = analogRead(1); // top right
  int ld = analogRead(2); // down left
  int rd = analogRead(3); // down right

  int avt = (lt + rt) / 2; // average value top
  int avd = (ld + rd) / 2; // average value down
  int avl = (lt + ld) / 2; // average value left
  int avr = (rt + rd) / 2; // average value right
```

```
int dvert = avt - avd; // check the difference of up and down
int dhoriz = avl - avr;

if (abs(dvert) > tol) {
  if (avt < avd) {
    servov = servov + 1;
    if (servov > servovLimitHigh) {
      servov = servovLimitHigh;
    }
    vertical.write(servov);
    delay(20);
  } else if (avt > avd) {
    servov = servov - 1;
    if (servov < servovLimitLow) {
      servov = servovLimitLow;
    }
    vertical.write(servov);
    delay(20);
  }
}

if (abs(dhoriz) > tol) {
  if (avl < avr) {
    servoh = servoh + 1;
    if (servoh > servohLimitHigh) {
      servoh = servohLimitHigh;
    }
    horizontal.write(servoh);
    delay(20);
  } else if (avl > avr) {
    servoh = servoh - 1;
    if (servoh < servohLimitLow) {
      servoh = servohLimitLow;
    }
```

```
    horizontal.write(servoh);
    delay(20);
  }
 }
}
```

3.4 Project Development

The development of the Solar Tracking System includes the construction of main controller circuit, LDR sensor circuit, and also the motor controller circuit. Then, all the circuits will be integrated together to fabricate the prototype.

3.4.1 Main Controller Circuit

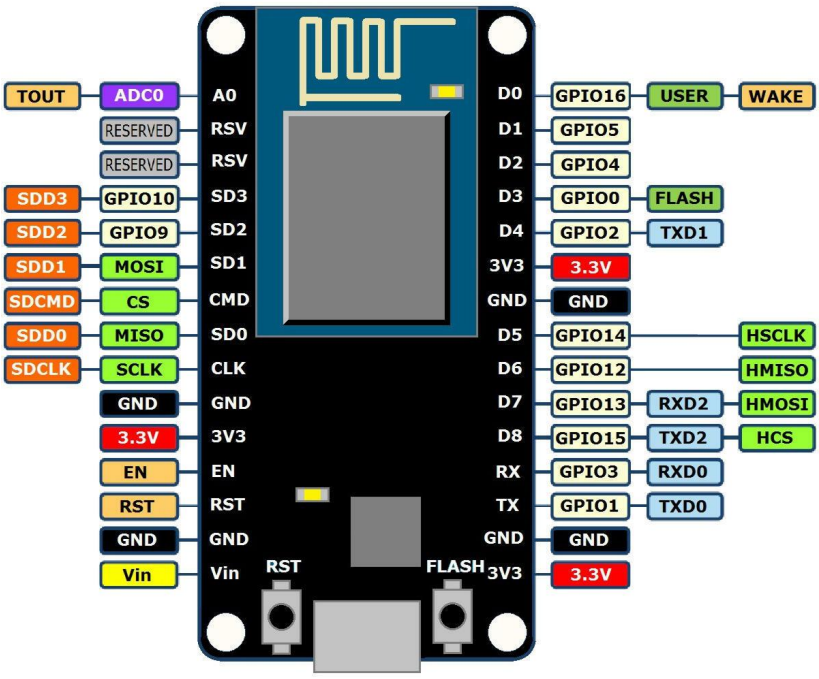


Figure 3.4.1 Circuit of Diagram of ESP8266

After designing the solar tracking circuit in Proteus, it was transferred to a breadboard as shown in Figure 3.4.2. The ESP8266 microcontroller is centrally placed, with four LDRs positioned at the corners to detect sunlight intensity. Two servo motors are connected to digital pins D1 and D2 to adjust the solar panel's position. The LDRs are connected to analog

pins A0 to A3, and a stable 3.3V power supply is used. Common ground is shared among all components. Proper component placement and wiring ensure effective operation, with initial testing and adjustments recommended..

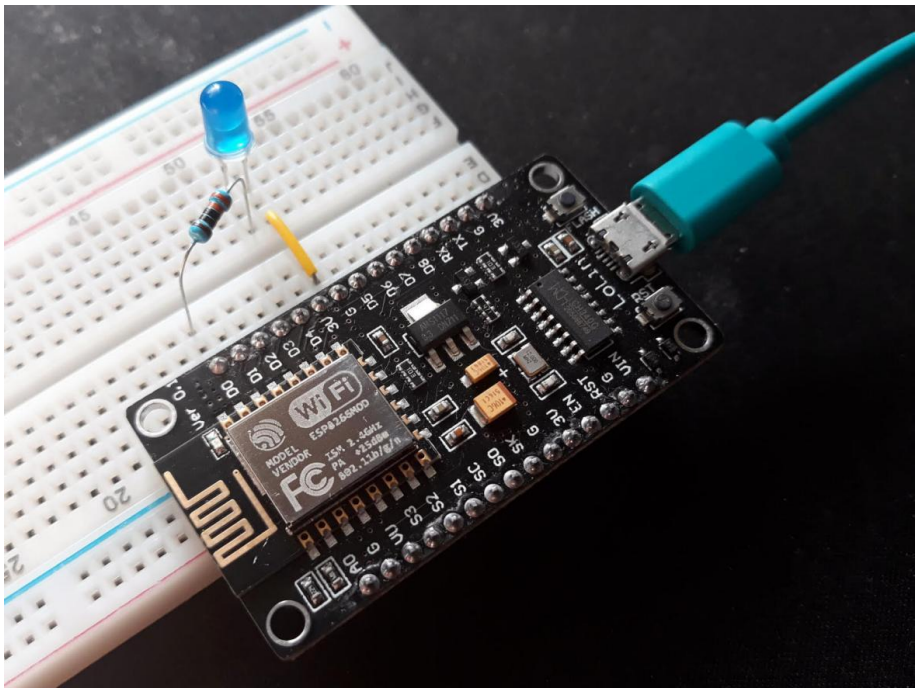


Figure 3.4.2 The Main Controller Circuit on the Breadboard

3.5 LDR Sensor Circuit

Using two light sensors (called LDRs) in this solar tracker design. These sensors are placed at the edge of the solar panel's base, each tucked inside a straw. The straws are important because they help control how much light each sensor receives. By changing the direction of the panel, we can affect how much light gets through the straws and hits the sensors – this difference in light is what the tracker uses to figure out how to adjust the panel's position and keep it facing the sun.

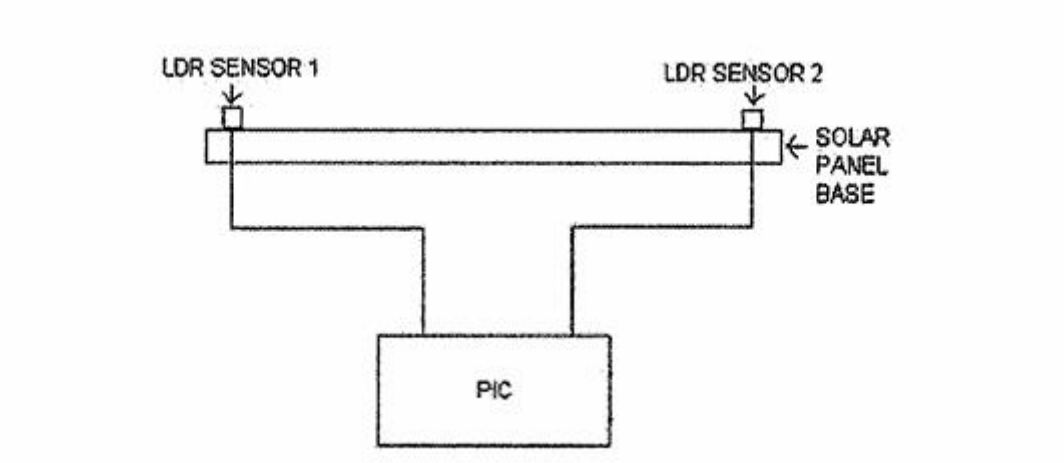
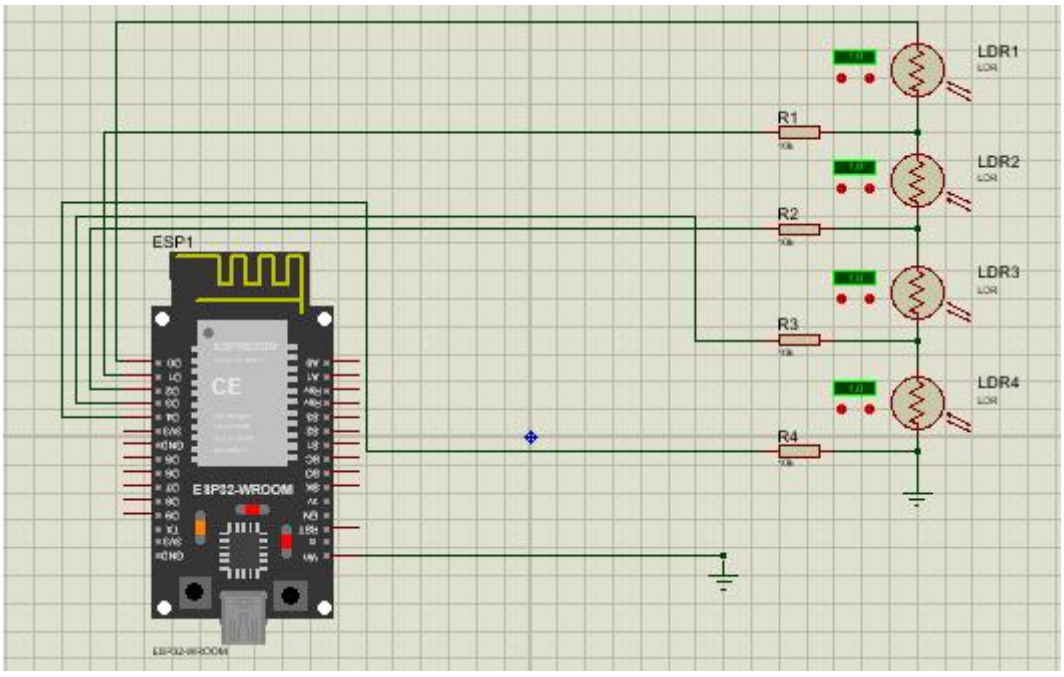


Figure 3.4 Location of LDRs Sensor Circuit

Circuit for LDR on Proteus Simulation:-



The actual circuit of the LDRs on the veroboard, This circuit will be integrated with the main controller circuit is shown below:-

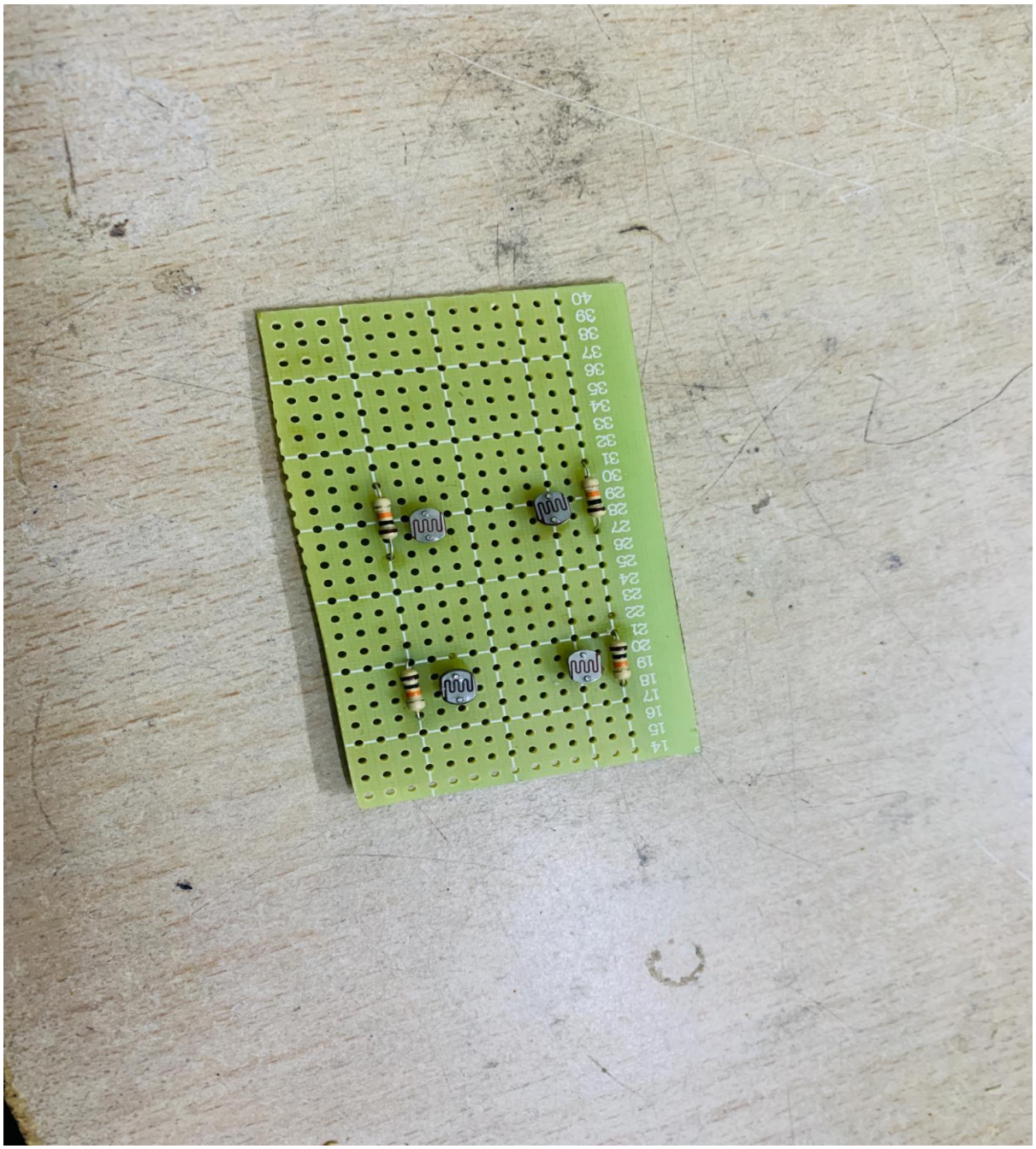
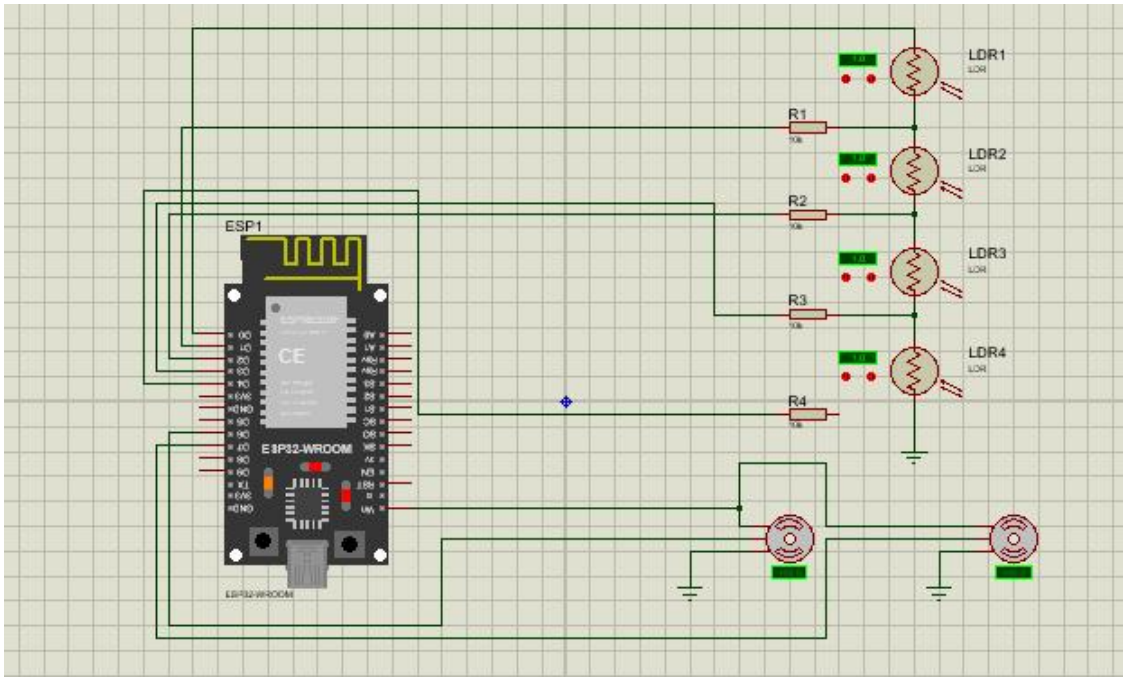


Figure 3.6 LDR set up on veroboard

Full circuit of the Solar Tracker in Proteus Simulation:



CHAPTER FOUR: RESULTS AND DISCUSSION

4.1 LDR CIRCUITS

A test has been done on the LDR sensor. The minimum resistance for that sensor is 10k ohm (during sunshine) and the maximum resistance is 20K ohm (at night). From this value, the value of the bottom resistor will be determined.

$$V_{out} = \frac{R_{bottom}}{R_{bottom} + R_{top}} \times V_{in}$$

To determine the value of the bottom resistor, the student assumes that the maximum output voltage will be 4 V. The input voltage will be set to 5 V.

4V = [R/(R+120ohm)] X5

R/(R+120ohm) = 4/5

R = (4R/5) + 96 ohm

R = 480 ohms

4.2 ANALOGUE TO DIGITAL

An experiment has been conducted on the source code for Analogue to Digital Converter. The result is shown in Table 4.2. The experiment is done by connecting power supply to pin D0. The power source will be varied from 0 V to 4.5 V. The output will be a series of LED connected to D0 to represent the binary value.

4.3 COMPLETE SOURCE CODE

From the previous experimented source codes, the student did a modification by adding a subtraction operation to compare those two digital values and produce an output to motor controller circuit. Below is the table showing the output of the LDR and what is represented by the combination.

NO	LDR	Represent
1	00	Motor in hold position
2	10	Motor rotates clockwise
3	01	Motor rotates anti-clockwise

A couple of simulations have been done by the student to confirm the efficiency of the program. The simulations are conducted by keeping one input to zero value and increasing the other input up to 5 V. The tables show the result of the simulations.

4.4 Prototype Fabrication

Having finalized the design, the next critical step was building the prototype. This stage proved to be the most time-consuming aspect of the project. Perspex served as the primary material for the model's base, providing a sturdy foundation. A steel rod was then incorporated to function as the shaft, supporting the solar panel.

While Figure 4.4 displays a schematic diagram of the prototype, it excludes the motor and gear components.

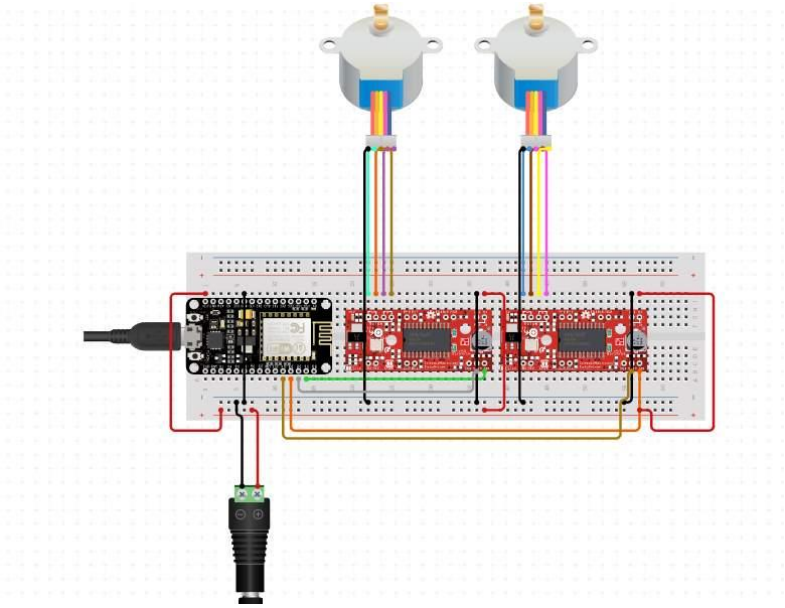


Figure 4.4 Schematic of Dual Axis Prototype

The solar panel base was built as a separate unit before being mounted on the steel rod. It measures 35 centimeters by 18 centimeters and serves as the platform for the solar panels. Two solar panels are securely fastened onto this base. Additionally, LDR sensor circuits are attached to both edges of the solar panel base.

The core of the prototype is a U-shaped base constructed from three pieces of glued Perspex. Before assembly, holes were drilled in the Perspex to accommodate bearings for smooth model movement. Two bearings were then installed in these holes. An additional hole was drilled for attaching the motor.The assembly process involved attaching gears to the steel rod and motor shaft. An 80-tooth gear was secured to the steel rod using glue, while a 12-tooth gear was affixed to the motor shaft. The steel rod was then inserted into the bearings, and the DC motor was screwed onto the base.

The final step involved integrating the electronic components: the microcontroller circuit, motor controller circuit, and LDR sensor circuits were all attached to the prototype. Once the fabrication was complete, testing of the prototype commenced.

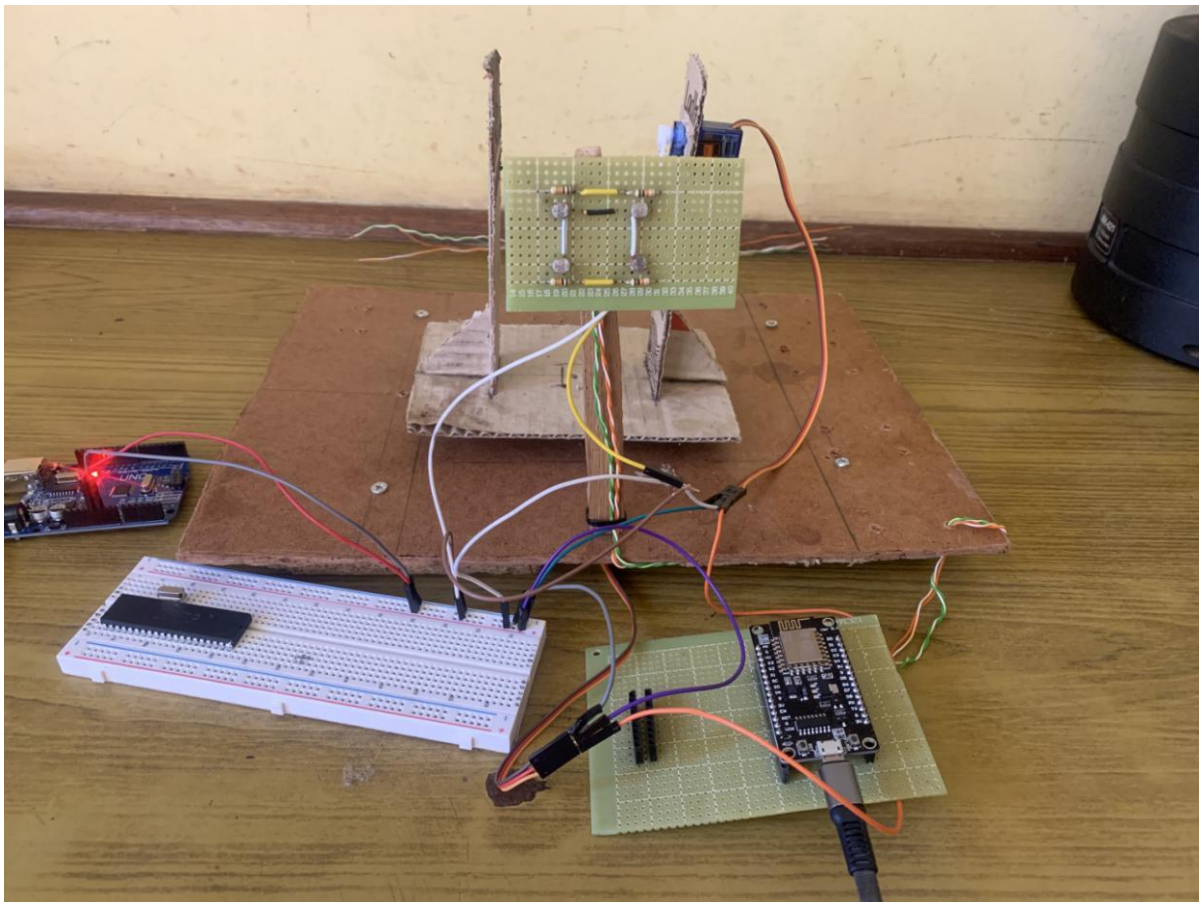


Figure 1 Prototype of Dual Axis Solar Tracker

4.5 Prototype Testing

To assess the performance of the solar tracking system, a series of manual tests were conducted without using the motor. This allowed for individual measurement of the output voltage from each LDR sensor circuit. A spotlight served as a substitute for sunlight, and its angle was randomly adjusted to simulate various light source positions. An LED light served as a visual representation of motor rotation.

The results of these tests are summarized in Table 4.5

LDR Position	Output on Servo Motors
LDR 1> LDR 2	Horizontal Servo Moves Clockwise
LDR 1< LDR 2	Horizontal Servo Moves Anti-Clockwise
LDR 3< LDR 4	Vertical Servo Moves Anti-Clockwise
LDR 3> LDR 4	Vertical Servo Moves Clockwise

CHAPTER FIVE: CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

There are several ways that solar tracker can be implemented. In this project, the student has implemented the 1-axis active solar tracking system. That means the solar tracker can track the position of the sun from the east till the west. The new approached has been introduced which ESP8266 microcontroller, LDR sensors and DC gear motor are used to track the sun.

Basically, this project is concentrating on the microcontroller part which is used to control the movement of the model. In other word, the most important thing is the programming part. Since the student starts the programming part with zero knowledge, a lot of time was spent to develop the source code. So, other improvements cannot be implemented. After completing the Final Year Project, it can be concluded that the design concepts of the project were successfully completed. The fabrication of the prototype according to design was also completed. The micro controller which is used to control the movement of the model was also successfully programmed. The Solar Tracking System project is a very interesting project.

This project will give the student a lot of experiences in problem solving and troubleshooting skills. Most importantly, the student gets the experience on how to conduct an engineering project. Besides, the student gets the information about the solar tracking system, something that he never heard before. The student will also familiarize himself with the programming language (assembly language) which is very important nowadays since the industry moves toward automation

5.2 RECOMMENDATIONS

For the project enhancement, the student would recommend the integration with the computer interface. That means user can monitor the angle of the solar panel base, the output voltage of the solar panel, and even can do some adjustment to the solar tracker angle from the computer interface. There are two most popular medium that can be used to integrate with the computer which are through serial port or parallel port.

All the improvements require the changes to the programming part. It will be more complex and quite challenging. The knowledge in programming language is a requirement in other to enhance the solar tracking system project.

Other techniques for solar tracking system by using PLC controller and fuzzy logic can be implemented. Some of the system combines two techniques in order to get better result.

Most solar trackers they use aluminium or steel bars for the structure construction and it reduces torque and speed of motors hence recommending use of lighter material like plastics and wood.

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