Project Report on

Automated Solar Panel Cleaning System

Submitted in partial fulfillment of the requirements for the degree of

Bachelor of Engineering In Electronics and Computer Science

BY

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University of
Mumbai
(2022-23)

This work is dedicated to my family.

I am very thankful for their constant motivation and unwavering support.

Internal Approval Sheet

CERTIFICATE

This is to certify that the project entitled **"Automated Solar Panel Cleaning System"** is a bonafide work of **Zeeshan Khan (Roll no: 8810), Tanisha John (Roll no: 8824), Omkar Patil (Roll no: 8826)** submitted to the University of Mumbai in partial fulfillment of the requirement for the award of the degree of Bachelor in **Electronics and Computer Science.**

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(Dr. Surendra Singh Rathod)

Principal

Approval Sheet

Project Report Approval

This project report entitled by **Automated Solar Panel Cleaning System** by **Zeeshan Khan, Tanisha John and Omkar Patil** is approved for the degree of Bachelor of Engineering in Electronics and Computer Science.

Examiner 1. ___________________________

Examiner 2. ___________________________

Date:

Place:

Declaration

We declare that this written submission represents our ideas in our own words and where others' ideas or words have been included, we have adequately cited and referenced the original sources. We also declare that we have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in my submission. We understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

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Date:

Abstract

Solar energy is the most abundant renewable energy source, but its efficiency is reduced by soiling caused by weather. An automated solar panel cleaning system is designed to solve this problem, using a sprinkler system and nylon brushes rotating with motors. An App can monitor power generated, time and date, and camera feed. Automation is more convenient and cost-effective than manual cleaning, especially if the client has a large PV plant. Solar PV is a renewable energy source that has been leading the global market for several years.

However, its efficiency varies due to factors such as lower irradiance, higher AM, and higher temperature. Cleaning solar PV panels has been a challenge in order to achieve maximum efficiency. This abstract theorizes how constraints such as dust and humidity affect the output of solar PV panels and the automated technologies involved in solar PV panel cleaning systems. It also discusses the problems that have emerged in the PV cleaning system around the world and how we can solve them.

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Acknowledgments

We have great pleasure in presenting the report on **"Automated Solar Panel Cleaning System"**. I humbly take this opportunity to express my sincere thanks towards the guide **Dr. Deepak Bhoir**, C.R.C.E, Bandra (W), Mumbai, for providing the relentless support, technical guidelines, and the suggestions regarding the line of this work. We enjoyed discussing the work progress with him during our visits or online meetings and sir was kind and patient enough to not just hear out all our doubts and queries but also provide us with suitable suggestions to solve our problems.

We thank **Dr. Sapna Prabhu**, Head of Electronics and Computer Science Department, **Principal Dr. Surendra Singh Rathod** and the management of C.R.C.E., Mumbai for the much-needed encouragement and providing necessary infrastructure for pursuing the project. We never returned empty handed when we asked for help of any and all kinds from our respected faculty.

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Contents

List of Figures

List of Tables

Chapter 1

Introduction

1. Comparison between Wet Cleaning and Dry Cleaning of Solar Panel

Wet Cleaning and Dry Cleaning are two major bifurcations of the Solar Panel Cleaning System with resource constraints.

Robotic cleaning, also known as dry cleaning, is a method of cleaning solar modules without the use of water. Air pressure and dry brushes are used by solar panel cleaning robots to remove dirt from the surface of solar modules. In general, dry-cleaning systems are less effective than wet cleaning systems. This is because the water used in wet cleaning acts as a medium for dust particles to escape.

There are numerous other advantages and disadvantages to solar panel robotic cleaning.

Advantages of Dry Cleaning:

Solar panel cleaning robots/systems can be a great way to save water, which is one of the most valuable commodities in today's world. Large solar power plants necessitate highly trained labour as well as significant capital investment. Robotic systems, on the other hand, have a fixed initial cost and require little maintenance. You can clean your modules every day with robotic cleaning systems, which is extremely difficult with manual cleaning. Because modules are cleaned daily, the overall energy production of dry-cleaning is higher when compared to manual cleaning.

Disadvantages of Dry Cleaning:

Dry cleaning is less effective than water cleaning. This is due to the fact that fluids such as water act as a better medium for dust particles to transport away from the modules.
The initial investment in these robotic systems is quite large. As a result, it is not the best option for a residential system. These robotic cleaners are powered by electricity. This electricity is an additional cost. Because robotic technology is relatively new, much R&D (Research and Development) is still required in this sector. These machines still require advanced technologies such as artificial intelligence.

Cleaning mechanisms	Advantages	Disadvantages
Air-blowing treatment	• Very basic and simple automated system • Low initial cost • Very low maintenance • Low energy consumption • Free of water consumption • No risk of surface damage • Applicable to all collector types	• Inefficient with highly adhesive dirt • Partial restoration of IDS efficiency • Risk of resettlement of blown dust
Water-jetting treatment	• Significant restoration of IDS efficiency • No movable parts in the system • Low maintenance • Low water consumption if high pressure is used • No risk of surface damage • Applicable to all collector types	• Inefficient with highly adhesive dirt if low pressure is used • Risk of dribble or splash on building windows • Usage of water

Figure 1.1 Advantages Vs Disadvantages of Dry and Wet Solar Panel Cleaning System

1.2 Motivation:

Dust accumulation on even one panel reduces energy generation efficiency. As a result, the surface of the panel should be kept as clean as possible. Human-based cleaning methods for solar panels are currently expensive in terms of time, water, and energy consumption. Because there has been no automation in cleaning solar panels, there is a need for developing automatic cleaning machines that can clean and move easily on the glass surface of the panels. The robot produced a favourable result and demonstrated the viability of such a system by enabling robotic cleaning, thereby assisting the solar panel in maintaining its efficiency. Therefore, we chose to go ahead with this project topic.

1.3 Objectives:

To study and compare the conventional cleaning methods for Solar Panels. To study the modified cleaning methods for Solar Panels and compare them with the conventional ones. To come up with an efficient Automated Cleaning System for Solar Panels.

1.4 Applications of Solar Panel Cleaning Systems:

- The Automated Solar Panel Cleaning System developed significantly reduces the number of workers required to clean the arrays.
- Further development could be done to make the system smaller, lighter, and easier to assemble in larger quantities, as well as to make it more user-friendly.
- The next step will be to expand the robot's functionality by adding auto inspection, communication, and self-diagnostic capabilities.
- Because the cleaning head is in direct contact with each individual panel, the installation of a thermal camera module will allow for inspection of the panels. Cold spots just beneath the glass surface indicate an un-cleaned section of panel and will prompt the cleaner to make another pass if necessary.
- Instead of using individual batteries, solar panel energy can be used. Wireless cameras can also be connected for flawless wireless operation. The applications for such systems come with a world of opportunity when put to right use.

Chapter 2

Literature Review - Both Conventional and Modified Solar Panel Cleaning methods

Solar energy is the most abundant renewable energy source. The efficiency of the system is reduced by constant soiling caused by weather factors. It is therefore essential to clean the panels regularly and properly.

We solve this problem with our automated solar panel cleaning system. Panels are cleaned using a sprinkler system and nylon brushes rotating with motors. It is a sensor less system that uses power generated to schedule the system to switch on. It can be retrofitted directly onto a solar panel that moves on it using motors.

The solar panels are monitored with a camera mounted to the system, which helps detect objects and faults.

Solar panels attract atmospheric dust, which could also accumulate over time and compromise the panel's efficiency, resulting in significantly reduced energy capacity. With the assistance of this project, we hope to recommend the utilization of automatic solar panel cleaners in order to preserve panel efficiency and achieve maximum power output.

Automation is more convenient and cost-effective than manual cleaning, especially if the client has a large PV plant.

The global energy demand is expected to rise by more than 50% by 2030. Carbon dioxide emitting energy source use has declined substantially over the last three years. Various techniques are being developed to ensure maximum use of renewable energy. Many governments around the world have pledged to implement renewable energy sources to meet energy demand in the heating, transportation, and power sectors. In 2016, an estimated 9.8 million people were employed in the renewable energy sector, a 1.1% increase over 2015. The majority of jobs are related to solar PV and biofuels.

Solar PV, one of the renewable energies, has been leading the global market for several years.

Solar PV energy is derived from solar radiation; however, for monocrystalline solar PV panels under STC, only 15-18% of solar radiation is used to generate electricity. This efficiency varies due to several factors such as lower irradiance, higher AM, and higher temperature; however, solar radiation is not captured due to the accumulation of foreign particles such as dust, bird excrement, snow, and many others. Cleaning solar PV panels has been a challenge in the renewable energy sector in order to achieve maximum efficiency.

Various cleaning systems have been designed to compensate for the loss of efficiency, and studies have been conducted to demonstrate the effectiveness of the cleaning system.

This abstract theorises how constraints such as dust and humidity affect the output of solar PV panels and the automated technologies involved in solar PV panel cleaning systems that help in maximising output by minimising the effect the constraints have on solar panels and presents the constraints that directly and indirectly influence the efficiency of solar panel generation and their impacts, as well as different existing techniques for improving the efficiency. It also discusses the problems that have emerged in the PV cleaning system around the world and how we can solve them.

In this section, many different cleaning methods that have been developed over the past decade, will be discussed.

1. Automated Cleaning of Solar Panels:

The dust particles that accumulate on the solar panels prevent solar energy from reaching the solar cells, reducing overall power generation. If the module is not cleaned for a month, its power output can be reduced by up to 50%. An automatic cleaning system that removes dust from the solar panel is being developed in order to clean the dust on a regular basis.

The problem is discussed in this report, as well as the method for dust removal. A robot cleaning device that travels the entire length of the panel is developed. The robot control system is implemented. [1]

Following the invention of the solar cell, solar technology advanced to the skies by incorporating solar panels that use solar energy to generate electrical energy.

Renewable energy is used in all industries, and they use a large number of solar panels in the form of an array.

On the other hand, it has begun to play a significant role in household usage. The issue with solar panel implementation is their maintenance.

To maintain the efficiency of solar panels, various cleaning methods are used.

2. Dry Cleaning of Solar Panel

Robotic cleaning, also known as dry cleaning, is a method of cleaning solar modules without the use of water. Air pressure and dry brushes are used by solar panel cleaning robots to remove dirt from the surface of solar modules. [2]
In general, dry-cleaning systems are less effective than wet cleaning systems. This is since the water used in wet cleaning acts as a medium for dust particles to escape.
However, water is not abundant everywhere, and the lack of water makes cleaning the modules difficult. Furthermore, it appears to be difficult to perform daily wet cleaning of PV modules (as it requires a huge amount of water, manpower & capital expenditure).
Dry cleaning can be a great alternative in this case.
You can, however, take work from a robotic system every day.
There are numerous other advantages and disadvantages to solar panel robotic cleaning.

3. Wet Cleaning of Solar Panel

It automatically washes and rinses the solar panels. It attaches nozzles to the solar panels. It comprises a reservoir for soap concentrate. There is also a sediment filter that contains water softener media. It also has an anti-siphon valve to prevent backwashing into the system. System consists of a controller which automatically provides wash and rinse cycles, the controller programming can be changed as per seasonal requirements. [3]

4. Solar Brush

Solar Brush is a robotic solar panel cleaning system. The 'solar brush' robot walks over the solar PV panel. It can operate at an inclination of 350 degrees. It is rechargeable and wireless. It has a cleaning brush that swipes the dust away. The solar brush weighs only 2.5 kg. In addition, manufacturers have been attempting to enter the market with drone-based cleaning.

5. PLC Based Cleaning System

This is an example of a cleaning system that improves the output power performance of a PV system that has been hampered by the effects of shadowing and shading. The PLC, which controls and powers both the mechanical and electrical components of the design, is the main component of this system. The system was successful in removing dust and bird droppings from the PV panels, resulting in a higher output and thus a more efficient and reliable system for offshore applications.

6. Electrostatic Charge Systems

Electrostatic cleaning techniques are used in places where water is scarce, such as deserts, dry areas like Saudi Arabia, or even places where there is no water, such as Mars. The electrostatic charge concept has been used to provide a standing wave-type electric curtain by lifting and transporting charged particles of insulating materials. In this case, we have a standing wave with a definite direction and amplitude oscillating at the imposed frequency at any point. Along the field line, a single charged particle oscillates. The current context of solar cleaning necessitates a variety of prospects to be considered in order to maximize the performance of the panels.

6.1. Historical Development of Electrostatic Charge System

Large solar parks are frequently found in deserts. There is plenty of room here, and the sunlight required to generate solar power is available all year. But there's another issue: dust. Due to dust accumulation on the solar modules, their performance can be reduced by nearly 30% in a month. Furthermore, as dust storms become more common as a result of climate change, the efficiency of solar panels can rapidly decline unless they are cleaned several times per month. A common cleaning method is to blast the panels with high-pressure water. Only pure, demineralised water can be used to avoid recontaminating or damaging the glass of the panels. The cost of transporting water to often remote desert regions accounts for approximately 10% of total operating and maintenance costs. It is estimated that up to 10 billion gallons of potable water would be used each year just to clean solar panels, which is enough water to meet the annual needs of approximately 2 million people in developing countries.

The inefficiency of current cleaning methods prompted Kripa Varanasi, a mechanical engineering professor at the Massachusetts Institute of Technology (MIT), and his PhD student Sreedath Panat to develop a touchless cleaning system that can automatically and without water remove dust from solar panels. To remove dust particles from the surface of the solar cells, the system employs electrostatic repulsion. Although dust is not electrically conductive, the researchers discovered that the particles can be charged by an electrode that runs directly over the surface of the solar panel. The panel is then covered with a transparent film that has been charged in the opposite direction. As a result, the panel's glass surface repels the irritating dust particles.

According to the researchers, the system, which uses a small amount of solar energy, could be used in conjunction with a separate cleaning robot or retrofitted to the panels.

While the MIT engineers are working to scale up their new system, other researchers are developing a coating technology for solar panels inspired by the self-cleaning properties of the lotus leaf. German researchers at Ben Gurion University, for example, attempted to create a hydrophobic coating for silicon-based solar cells to prevent dust from collecting on the surface

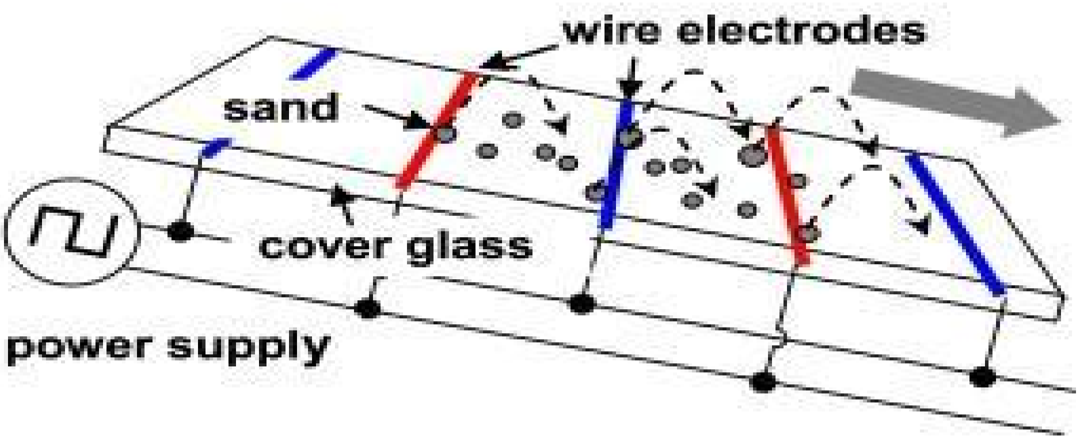

Figure 6.1 Hydrophobic coating for Silicon Based Solar Panel

Chapter 3

Problem Statement

3.1 Drawbacks of Dry Cleaning of Solar Panels

Cleaning dirty panels with commercial detergents can be time consuming, expensive, hazardous to the environment, and even corrode the frame of the solar panel. Solar panels should ideally be cleaned every few weeks to maintain peak efficiency, which is especially difficult with large solar panel arrays. There is a need for an automated cleaning solution for this problem that can service large ground-based solar arrays of up to 22,000 panels (20,000 Square meters). Dry cleaning is less effective than water cleaning. This is due to the fact that fluids such as water act as a better medium for dust particles to transport away from the modules. The initial investment in these robotic systems is quite large. As a result, it is not the best option for a residential system.

3.2 Solution To Above Problem

3.2.1 Proposed Solution:

We propose to modify the original Dry Cleaning of Solar Panels such that there will be more effective and efficient cleaning of the panels and they will consequently become more durable.

The system we make is lightweight because most of its components are made of aluminium and its modular and hence can be retrofitted at any solar panels site. When the costs of manual and automatic cleaning are compared, the cost of automatic cleaning is shown to be more economical and significantly less cumbersome, especially in systems with many solar panels. Frequent and routine cleaning ensures that the solar panels always operate consistently and with high transmittance.

This project investigates the impact of dust, dirt, pollen, sea salt, and bird droppings on the efficiency of PV systems. The effect of dust on the efficiency and performance of solar panels is significant. The peak power generation can be reduced by up to 30%. Power was reduced due to dust accumulation on the panels, which can be improved by using a robotic cleaning method. It has increased the solar panels' power generation capacity.

This process has several advantages, including ease of maintenance, low cost, and low power consumption. Finally, using this cleaning system can help to overcome the reduction in peak power generation.

3.2.2 Implemented Solution:

The most plentiful renewable energy source is solar energy. The system's efficiency is compromised by constant soiling induced by weather variables. As a result, it is critical to clean the panels on a frequent and thorough basis.

This issue is solved by our automated solar panel cleaning technology. A sprinkler system and nylon brushes rotated by motors are used to clean the panels. It is a sensor-free system that leverages the power generated to turn on the system. It can be retrofitted directly onto a solar panel powered by motors.

A camera mounted to the system monitors the solar panels and detects objects and malfunctions.

Solar panels absorb atmospheric dust, which can accumulate over time and reduce the efficiency of the panel, resulting in drastically reduced energy capacity. We hope to promote the use of automatic solar panel cleaners with the help of this project in order to preserve panel efficiency and achieve maximum power output.

If the client has a large PV plant, automation is more convenient and cost-effective than hand cleaning.

By 2030, worldwide energy demand is predicted to increase by more than 50%. The utilisation of carbon-emitting energy sources has decreased significantly over the last three years.

Several approaches are being developed to maximise the usage of renewable energy.

Many governments throughout the world have committed to implementing renewable energy sources in order to meet energy demand in the heating, transportation, and electricity sectors.

The renewable energy sector employed an estimated 9.8 million people in 2016, a 1.1% increase over 2015. The majority of jobs are in the solar PV and bio industries.

For some years, solar PV, one of the renewable energies, has led the global industry.

Solar PV energy is obtained from solar radiation; however, only 15-18% of solar radiation is utilised to generate electricity in monocrystalline solar PV panels under STC.

This efficiency changes owing to a variety of conditions such as lower irradiance, higher AM, and higher temperature; nevertheless, solar radiation is not collected due to the deposition of foreign particles such as dust, bird excrement, snow, and other contaminants. In order to attain optimal efficiency, cleaning solar PV panels has been a challenge in the renewable energy business.

Various cleaning procedures have been developed to compensate for the loss of efficiency, and studies have been carried out to demonstrate the cleaning system's effectiveness.

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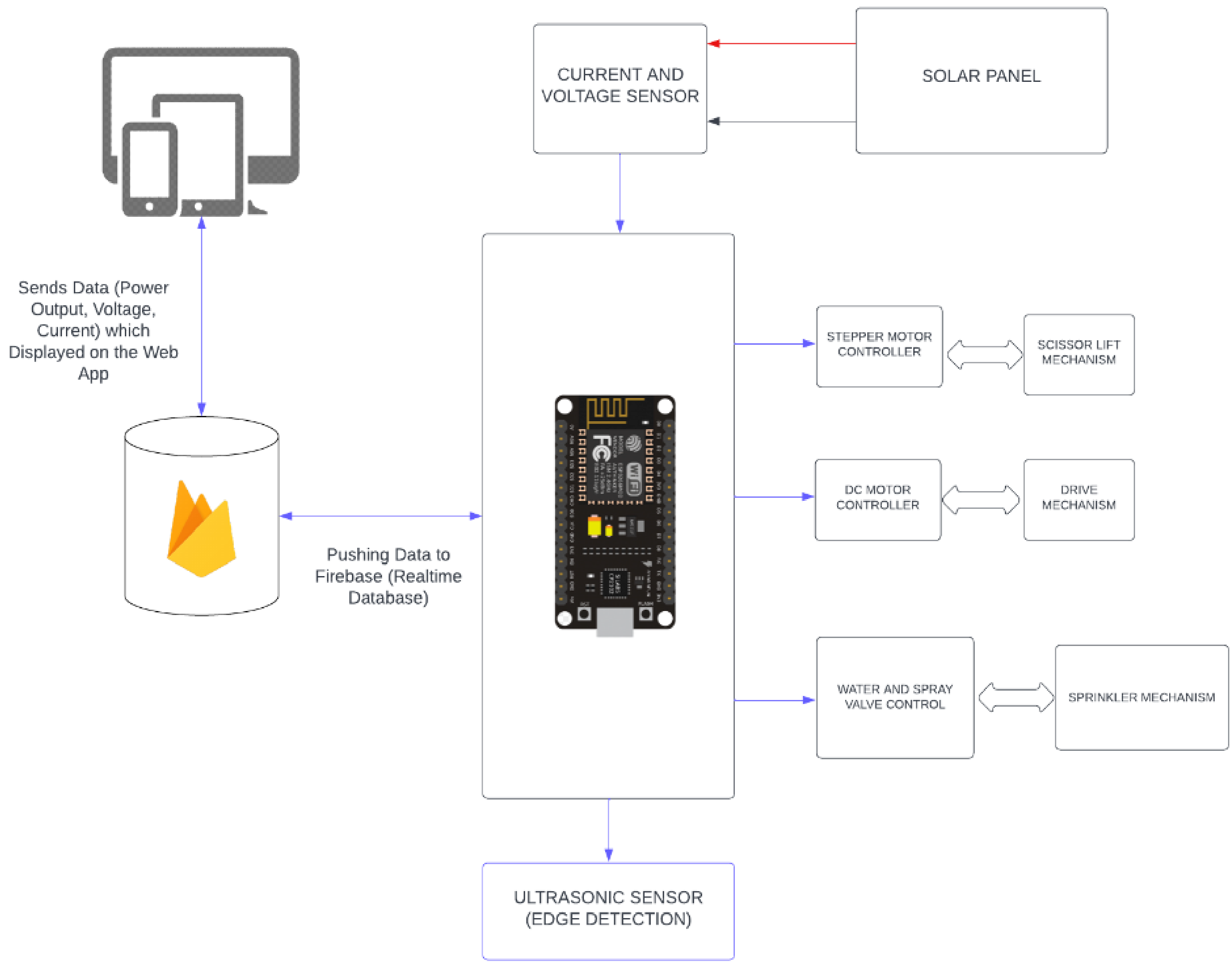
Chapter 4

Project Description

Mechanical, electrical, and internet of things subsystems make up our automated solar panel cleaning system. The system uses the wet cleaning technique because it was created for coastal areas. The output voltage of the solar panel is sensed to automatically turn on and off the system. The system has a distinctive design, is constructed of modular components, and can be adapted into any solar cell layout. The system is built such that it does not drive on the panels, extending their lifespan and preventing microcracks. The Microcontroller used is ESP-WROOM-32 2.4GHz Dual-Mode WiFi + Bluetooth Dual Cores Microcontroller, ESP32 ESP-32S Development Board. The entire system uses the least amount of PCB space thanks to the ESP32's integration of filters, management modules, power amplifiers, low-noise amplifiers, RF baluns, and antenna switches. With TSMC's ultra-low power consumption 40nm technology, the 2.4 GHz Wi-Fi plus Bluetooth dual-mode chip offers the best power dissipation and RF performance, is safe and dependable, and is simple to adapt to a wide range of applications. With IOT, the system reports data like the solar panel's power output, voltage, and current and stores it in a real-time database (Firebase). In order to determine whether the sensors and actuators are functioning properly or not, a web app is utilized to see the power generated and the voltage output of the solar cells. In the event of a malfunction, the Web App features an override feature that can be used to halt and reset the system.

4.1.1 Block Diagram



4.1.2 Hardware Requirements

- Espressif ESP-32:
  In this project Esp-32 is used for connectivity from the microcontroller to ThingSpeak for monitoring the data as well as analysing the data at the same time and displaying it on the OLED Display.
- DC Geared Motor:
  The motors are mounted along with wheels for the drivetrain of the Solar Panel Cleaning System which would help in maneuvering the bot along the solar panel.
- NEMA-17 Stepper Motor:
  Stepper Motor is coupled along with the lead Screw mechanism which is used for the horizontal motion of the brushes which will increase the stroke of the brushes.
- L298N Motor Driver:
  The DC Geared Motor are powered with the help of a L298N motor driver.
- Stepper Driver(A4988):
  The NEMA stepper motor is controlled using this stepper driver.
- Buck Converter:
  Since there is a 12V LiPO Battery which would be bringing down the voltage from 12V to 5V. The voltage is brought down since it is integrated with the ultrasonic sensor (HC-SR04) and the dual channel relay.
- HC-SR04
  The HC-SR04 sensor is an ultrasonic sensor used to determine the distance between the solar panel and the bot. The approximate distance between the ultrasonic sensor and the solar panel is considered as 10cms.
- Lead Screw Mechanism:
  The Lead screw mechanism is used for the horizontal motion of the scissor lift. It increases the range of motion of the brushes.
- Liner Guide and Rail (in meters)::
  The linear guide and rails provide stability during the motion of the bot across the solar panel.
- 6061 Aluminum Sections:
  The Aluminium Sections are used for the fabrication of the chassis.
- Aluminum Sheets:
  The aluminium sheets are used for the mounting of the DC Geared Motor which are used for the drive of the bot.

- Relay (Single Channel):

  The device is connected between the COM (common) terminal and either the NC (normally closed) or NO (normally open) terminal, depending on whether the device should remain normally on or off. Between the remaining two pins (coil1 and coil2) is a coil that acts as an electromagnet. The sprinklers are switched ON and OFF using these Relays.

- Oled Display :
  The Oled Display is used to show the voltage readings against time.
- Miscellaneous Electrical Components:
  Buzzer alarm, Wires, connectors, etc.

4.1.3 Software Requirements

- IOT implemented with the help of ThingSpeak.

4.2 Module Description

4.2.1 Modules

- **Mechanical Subsystem**: The mechanical subsystem deals with the water source and cleaning mechanism. To reduce the space occupation, the mechanical subsystem is integrated within the area of the solar panel. The water is reserved in a small tank that is placed on the system body itself. A pump is used to drain the water to the sprinklers. Sprinklers are used in our system to ensure spreading water all over the solar panel the sprinklers are attached to the scissor lift cleaning system. The system consists of railing mounted on the stand -linear guides, a drive system, stepper-motor as linear guide. The linear guide attached to the scissor lift mechanism moves the sprinklers back and forth cleaning the solar panel.

- **Electrical Subsystem:** The electrical subsystem works on monitoring the current and voltage output of the solar panel. The INA219 Module having solar panel voltage as input works on I2C protocol connected to ESP32-WROOM board the voltage are mapped from(0-3.3V) and are displayed on an oled display too. The Micro-controller we are using is ESP-WROOM-32 2.4GHz Dual-Mode WIFI + Bluetooth Dual Cores Microcontroller, ESP32 ESP-32S Development Board. The entire system uses the least amount of PCB space thanks to the ESP32's integration of filters, management modules, power amplifiers, low-noise amplifiers, RF baluns, and antenna switches. With TSMC's ultra-low power consumption 40nm technology, the 2.4 GHz Wi-Fi plus Bluetooth dual-mode chip offers the best power dissipation and RF performance, is safe and dependable, and is simple to adapt to a wide range of applications. The Movement of the motor is controlled using a L298N Motor Driver. H-bridge is used to allow the motor to move in both directions based on the signal provided by the ESP32 Micro controller. A lead screw mechanism attached to stepper motor is used for the scissor lift cleaning mechanism which sprinklers attached to it (the water coming out of the sprinklers is controlled by a solenoid valve which is controlled using a relay switch). The stepper motor is controlled using A4988 Stepper Driver (Bipolar Stepper Motor NEMA 17)

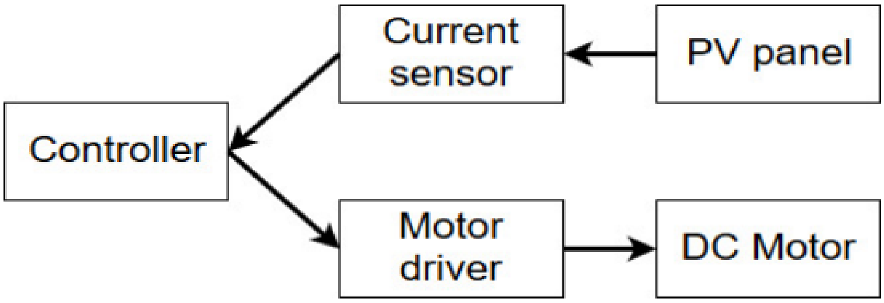


Figure 4.2.1 No 1 Simplified Block Diagram

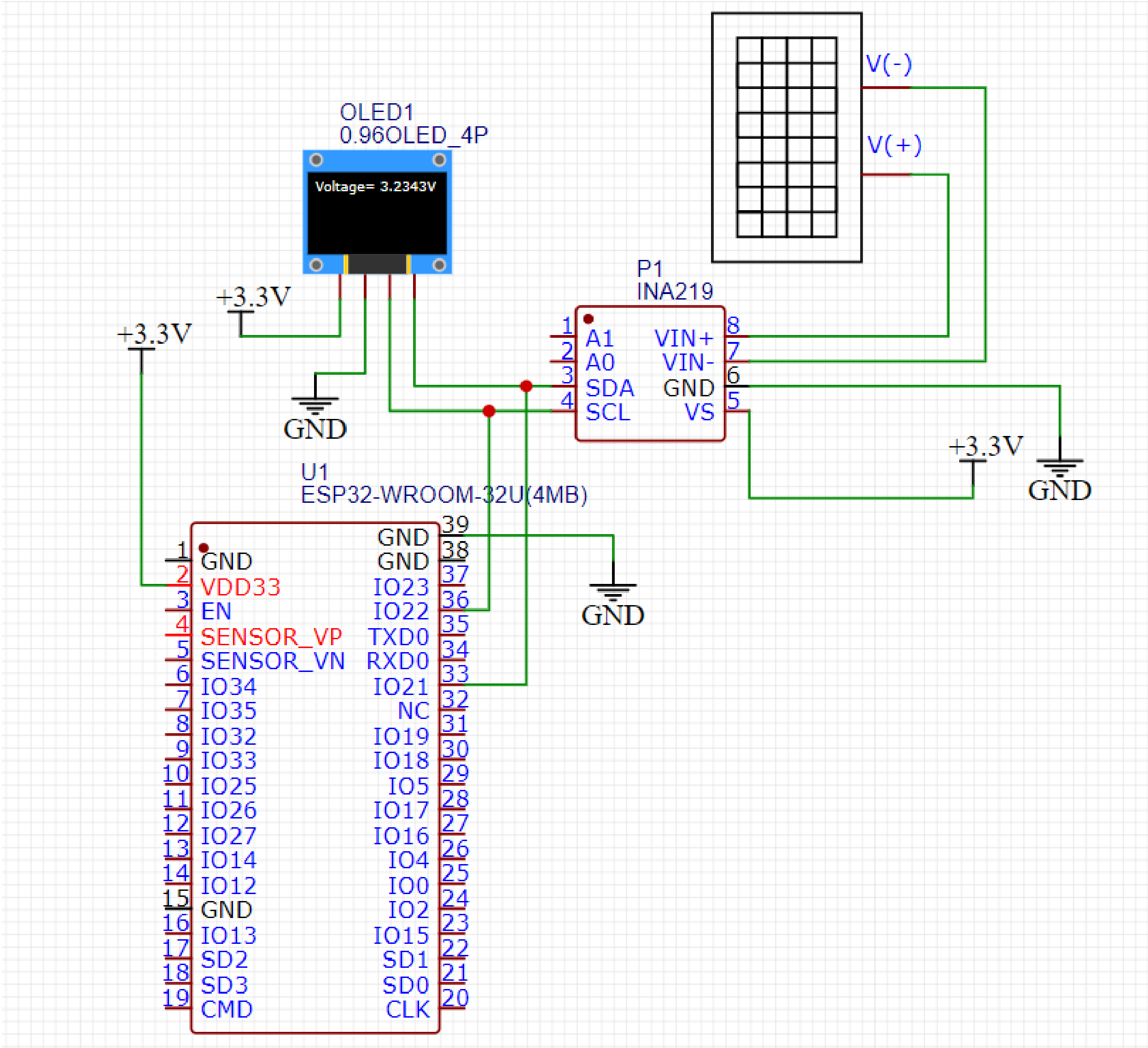


Figure 4.2.1 No 2 Voltage and Current Sensing Circuit

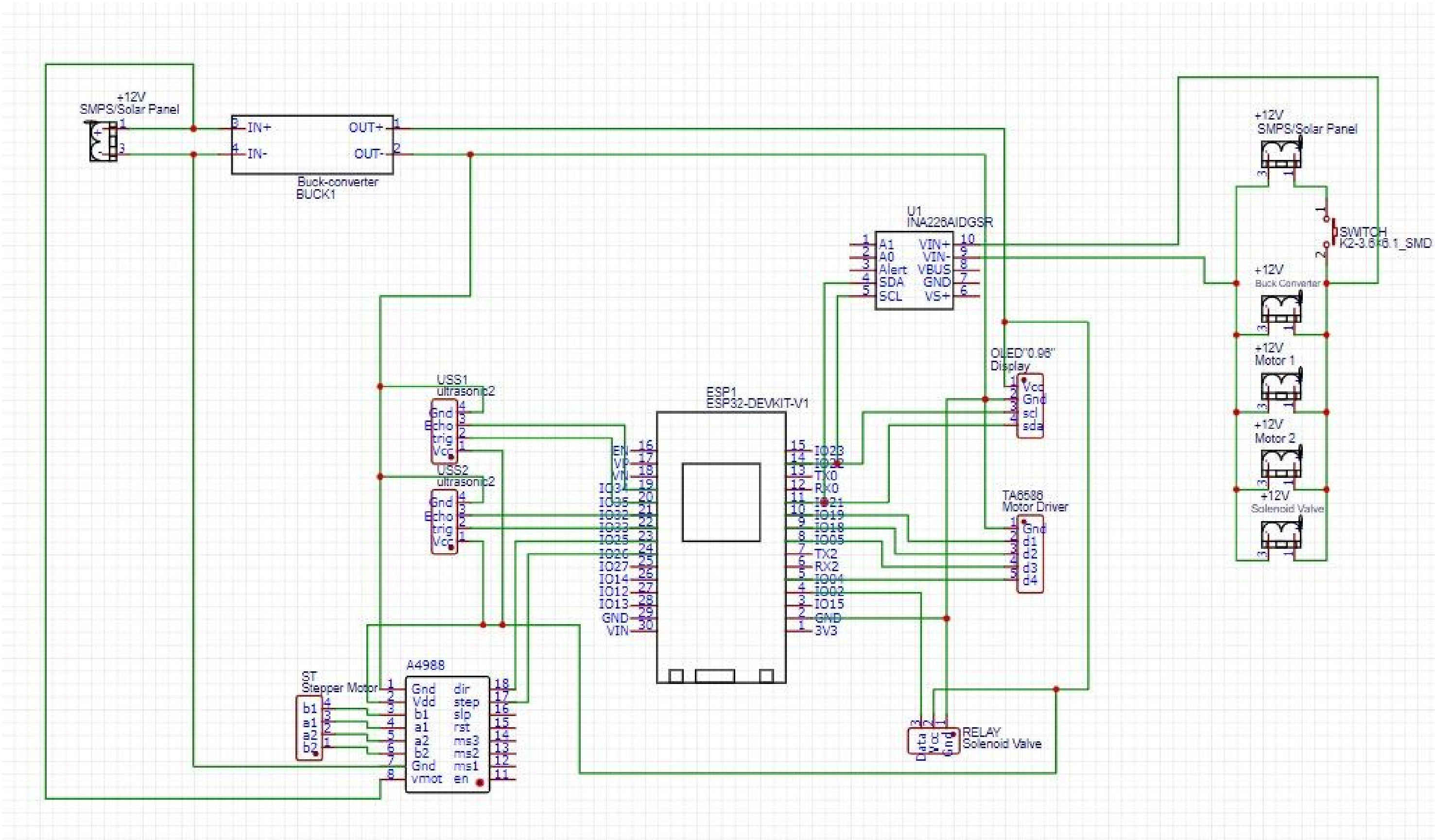


Figure 4.2.1 No 3 Circuit Diagram of the Automated Solar Panel Cleaning System

- **Proposed Algorithm:**

The creation of an effective algorithm is crucial for starting the cleaning mechanism. In order to guarantee the solar panel's regular operation (normal power production), cleaning is crucial. However, to avoid wasting water and power, the cleaning mechanism shouldn't be utilized vigorously. The suggested method should also only be able to operate on local information and have a modest level of complexity.

The algorithm considers the output of power from both the solar panel and the season. The production of power will be two daily measurements are made. Essentially, a power threshold output is predetermined, and the starting point for the cleaning mechanism when the output power falls beneath this limit. However, Other elements besides dust may have an impact on power output, including clouds. the algorithm starts the cleaning mechanism as a result. after seeing the power loss for a while, which varies according to the season, as this will have an impact the presence of clouds and their duration.

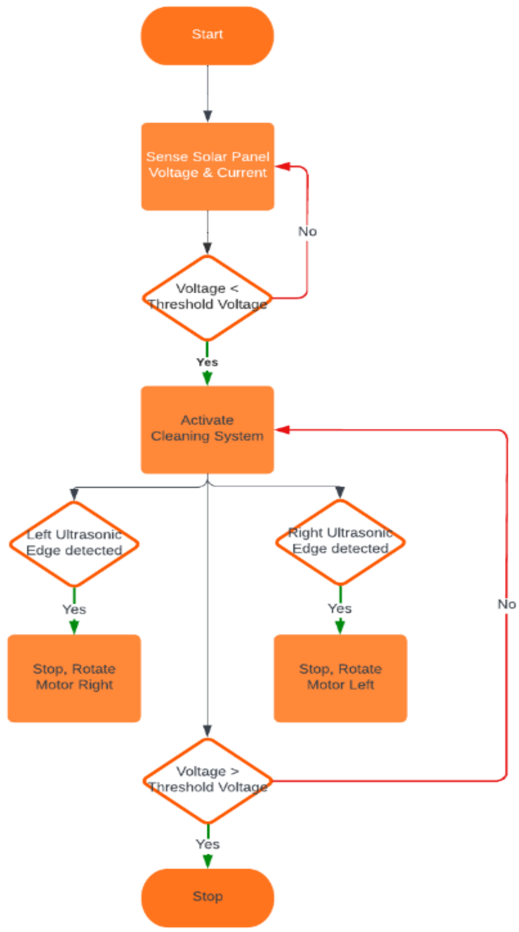


Figure 4.2.1 No 4 Algorithm for the Cleaning of the System

- **Internet of Things (IOT):**

  We implement IOT Level 2 where Googles Realtime Database (Firebase) is used as the cloud database to which the Node delivers the data, we utilize HTTP data protocol and WIFI, and the Board will be programmed in C/C++ using the Arduino IDE. The Web app is used at the client end to monitor data like the power produced by the solar panels, voltage output, sensors, and actuators functionality. The Web App has an override option that can be used to stop and restart the system in the event of a fault. Django, HTML, CSS, and JavaScript (FRONT END) will be used to create the web application (Python Backend Framework).

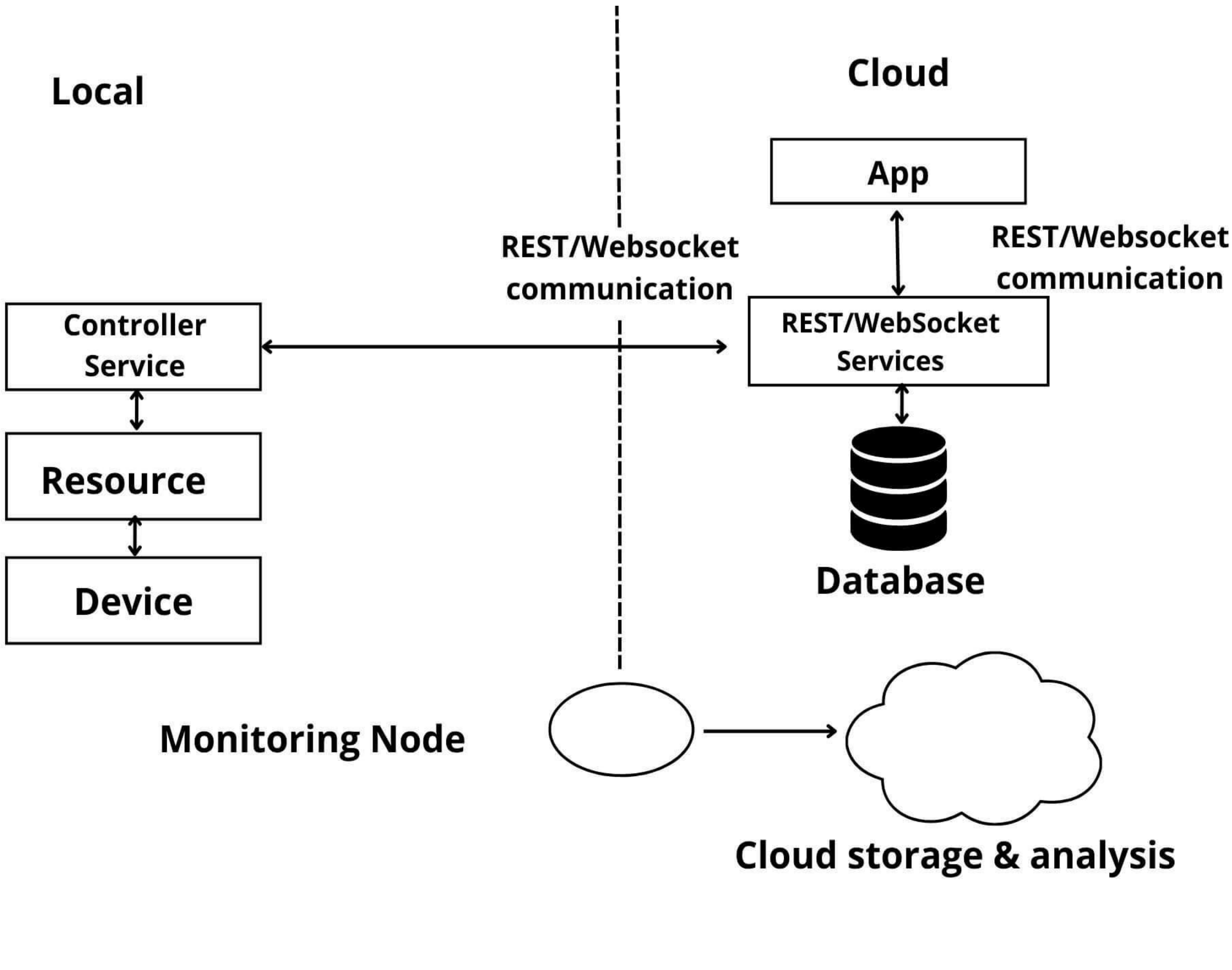


Figure 4.2.1 No 5 IOT Deployment Level Diagram

Chapter 5

Implementation Details

5.1 Methodology

The mechanical subsystem of the Automated Solar Cleaning System is incorporated within the region of the solar panel to reduce the weight of the system and increase space efficiency. The system may be customized to fit any solar cell configuration, has a unique design, and is made up of modular components. Since the Espressif ESP-32 has Bluetooth and WIFI built-in, making it ideal for IOT applications, it serves as the system's brain. We implement IOT Level 2 where Googles Realtime Database (Firebase) is used as the cloud database to which the Node delivers the data, we utilize HTTP data protocol and WIFI, and the Board will be programmed in C/C++ using the Arduino IDE. The Web app is used at the client end to monitor data like the power produced by the solar panels, voltage output, sensors, and actuators functionality. The Web App has an override option that can be used to stop and restart the system in the event of a fault. Django, HTML, CSS, and JavaScript (FRONT END) will be used to create the web application (Python Backend Framework).

TABLE I. COMPONENTS FOR THE PROPOSED SYSTEM

Components
Espressif ESP-32
DC Geared Motor
NEMA-17 Stepper Motor
L298N Motor Driver
Stepper Driver(A4988)
Buck Converter
HC-SR04
Lead Screw Mechanism
Liner Guide
Rail (in meters)
6061 Aluminum Sections
Aluminum Sheets
Relay (Single Channel)
Oled Display

5.2 ADVANTAGES

After implementation of the project we conclude that the implemented project has the following Advantages over the researched project systems studied and analysed during the research stage.

- Production costs are modest, and no heavy machinery is required.
- Reduces the need for human effort.
- It is not necessary to use manual assistance.
- The working principle is simple.
- Self-cleaning system that may be mounted to solar panels and operated without the need for human intervention.
- It is simple to build, inexpensive, and requires little upkeep.
- Increase your efficiency.
- Solar plates were not damaged as a result of the dry and wet cleaning.

5.3 Implementation Pictures

Figure 5.3 No 1 Robotic Structure of Cleaning System made with solidworks

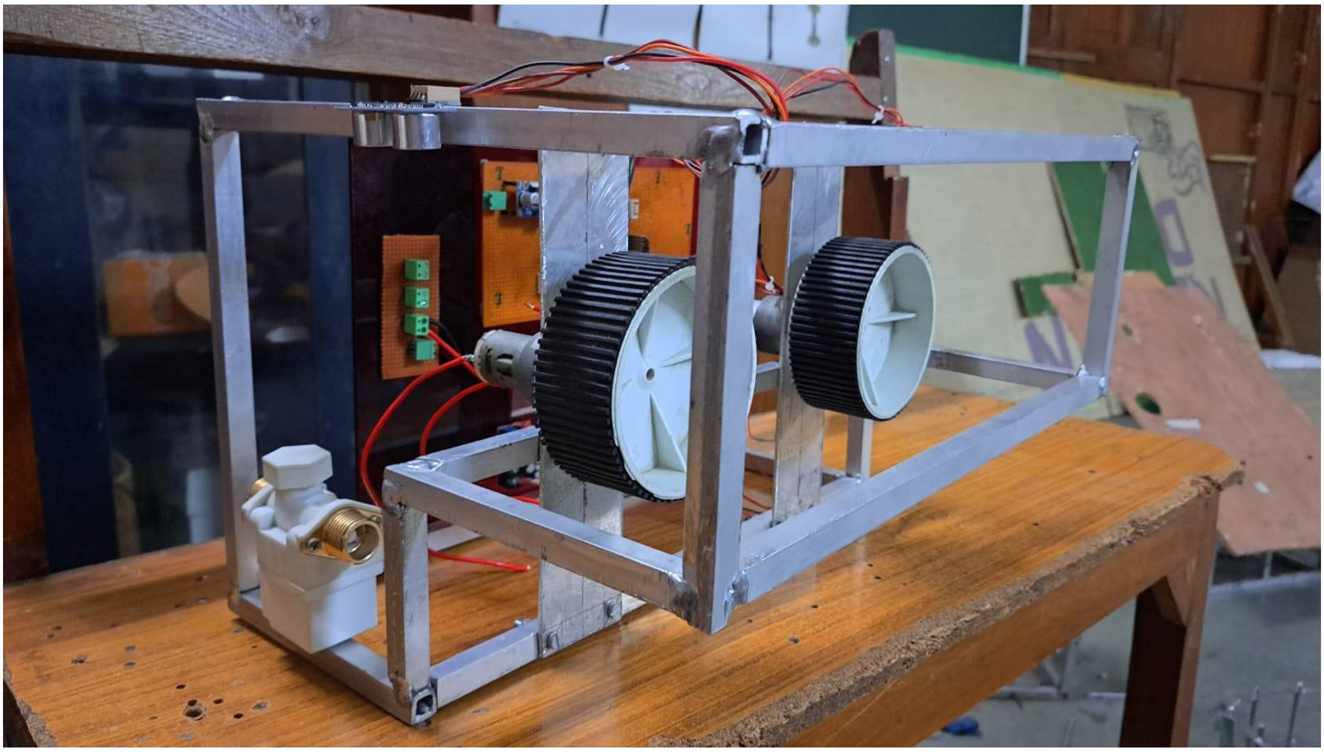


Figure 5.3 No 2 Robotic Structure of Cleaning System

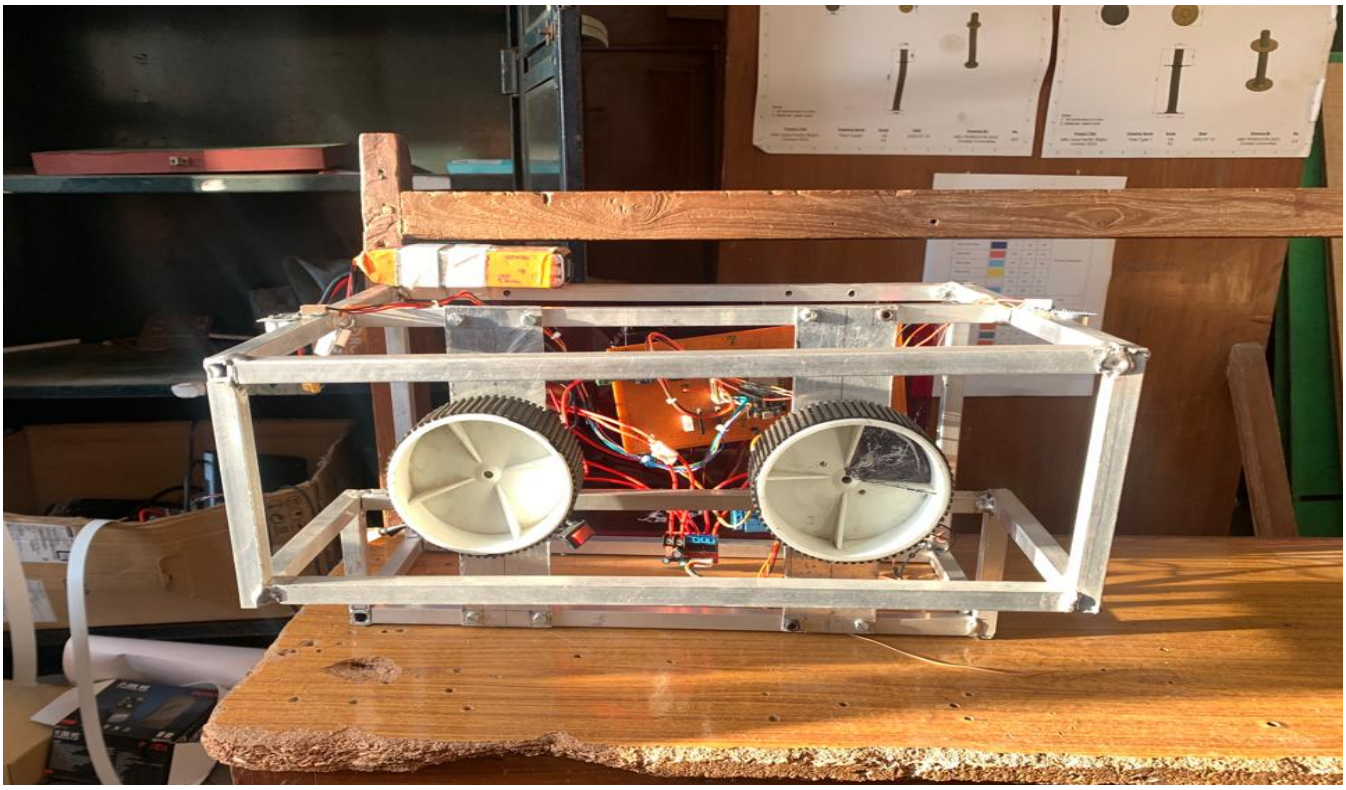


Figure 5.3 No 3 Robotic Structure of Cleaning System

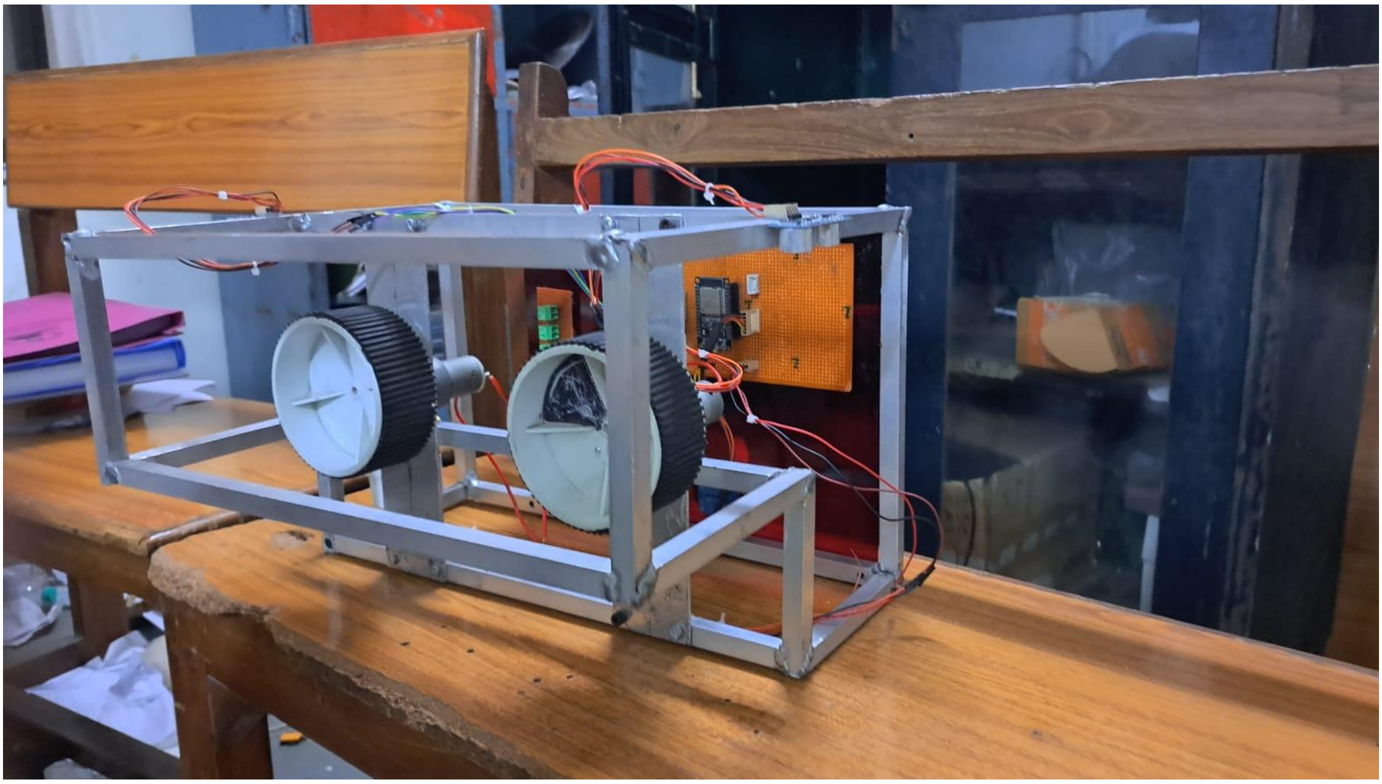


Figure 5.3 No 4 Robotic Structure of Cleaning System

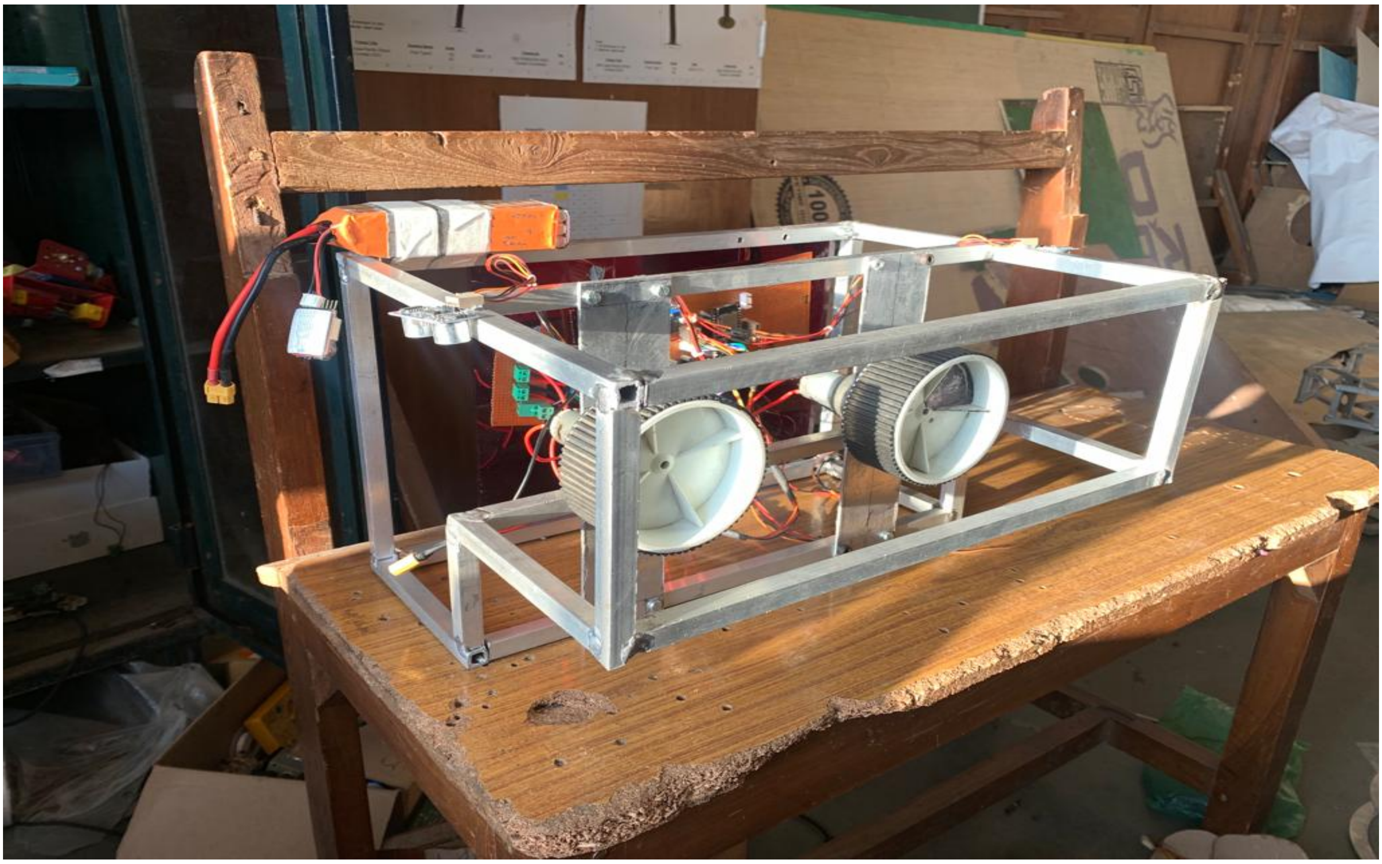


Fig 5.3 No 5 Robotic Structure of Cleaning System.

5.4 Output on ThingSpeak

Fig 5.4 No 1 Voltage output on Thingspeak

Appendix

Code For ThingSpeak

```
#include "WiFi.h"
#include "NewPing.h"
#include "ThingSpeak.h"

const char* ssid = "Robokhan";
const char* password = "onlyfans007";

WiFiClient  client;

unsigned long myChannelNumber = 1;
const char * myWriteAPIKey = "RKVA9ZUFWUG9C8N9";

unsigned long lastTime = 0;
unsigned long timerDelay = 30000;

#define d0  19
#define d1  18
#define d2  5
#define d3  4

#define trig_pin_right 34
#define echo_pin_right 35
#define trig_pin_left 33
#define echo_pin_left 32

NewPing sonarRight(trig_pin_right,echo_pin_right);
NewPing sonarLeft(trig_pin_left,echo_pin_left);

#define relay_pin 2
```

```
#define v_sensor_in 13
float vout = 0.0;
float vin = 0.0;
float R1 = 30000.0;
float R2 = 7500.0;
float value =  0.0l;

float threshold_voltage = 10.0;

void setup() {
Serial.begin(115200);
WiFi.mode(WIFI_STA);
ThingSpeak.begin(client);
pinMode(d0, OUTPUT);
pinMode(d1, OUTPUT);
pinMode(d2, OUTPUT);
pinMode(d3, OUTPUT);
digitalWrite(d0, LOW);
digitalWrite(d1, LOW);
digitalWrite(d2, LOW);
digitalWrite(d3, LOW);

pinMode(relay_pin,OUTPUT);
digitalWrite(relay_pin,LOW);
pinMode(v_sensor_in,INPUT);
}
void loop() {
if ((millis() - lastTime) > timerDelay) {

   // Connect or reconnect to WiFi
   if(WiFi.status() != WL_CONNECTED){
     Serial.print("Attempting to connect");
```

```
    while(WiFi.status() != WL_CONNECTED){
      WiFi.begin(ssid, password);
      delay(5000);
    }
    Serial.println("\nConnected.");
  }
 value = analogRead(v_sensor_in);
 vout = (value * 5.0)/1024.0;
 vin = vout / (R2/(R1+R2));
 Serial.print("Solar Panel Voltage:");
 Serial.println(vin);
int x = ThingSpeak.writeField(myChannelNumber, 1, vin, myWriteAPIKey);
if(x == 200){
 Serial.println("Channel update successful.");
}
else{
 Serial.println("Problem
 updating channel. HTTP error code " + String(x));
}
 if(vin < threshold_voltage){

   digitalWrite(relay_pin,HIGH);

   int distanceRight = sonarRight.ping_cm();
   int distanceLeft = sonarLeft.ping_cm();

   if (distanceRight < 10){
     digitalWrite(d0, HIGH);
     digitalWrite(d1, LOW);
     digitalWrite(d2, HIGH);
     digitalWrite(d2, LOW);
   }
   else if(distanceLeft < 10){
```

```
        digitalWrite(d0, HIGH);
        digitalWrite(d1, LOW);
        digitalWrite(d2, HIGH);
        digitalWrite(d3, LOW);
    }
    else {
      digitalWrite(d0, LOW);
      digitalWrite(d1, LOW);
      digitalWrite(d2, LOW);
      digitalWrite(d3, LOW);
    }

  }
  lastTime = millis();
}
delay(10);
}
```

Chapter 6

Conclusion And Future Enhancements

6.0.1 Conclusion

A sensor-free system that activates and deactivates the system based solely on the power produced by the solar panel has been devised. It can be installed retroactively right onto solar panels in solar power plants, buildings for commercial use, and houses. The electrical subsystem sleeps, which aids in power conservation and reduces power consumption. The client will keep an eye on the cleaning system over the web. With the help of this project, we hope to improve solar panel efficiency by removing waste, debris, and dust. We also assist personnel who manually clean the panels while putting their health and lives in danger.

This automated cleaning system primarily focuses on small systems, but by making some minor tweaks to the system, it can be useful for big arrays. Our solution is suitable for solar street lights as well as solar roof top installations. This work can also be done using the rack and pinion mechanism. The linear actuator system operates very smoothly and may attain the desired parameters.

6.0.2 Future Enhancements

The technique will eventually be used to implement electrostatic cleaning, which MIT engineers are currently researching. Making the system fully sensor-free and autonomous by analysing the pattern of system activation using machine learning algorithms and data analytical tools. The system can employ a better microcontroller with a more potent processor. To reuse the water used during cleaning, a water filtration plant might be created.

The goal of the Solar Panel Cleaning System project was to provide a better option for preserving solar efficiency. The major goal was to create a machine that could clean a solar panel using a good control system. This project is a prototype that has been built to expand on a new and growing market.The project crew encountered numerous roadblocks along the way.

The control system design requires knowing Raspberry Pi setups, Python scripting, and its interaction with electrical components. It was new to use soldering boards to implement the intended circuit, hardware wire, relays, and machinery. Having said that, the project completed the desired design with the planned control and mechanism. To control the speed and direction of the DC motors, relays and drivers were used.

References

[1] A. P. C. W. B . Heinzelman and H. Balakrishnan, “An application-specific protocol architecture for wireless microsensor networks,” IEEE Transactions on Wireless Communications, vol. 1, pp. 660–670, 2002.

[2] A. C. W. R. Heinzelman and H. Balakrishnan, “Energy-efficient communication protocol for wireless microsensor networks,” in Proc. The Hawaii International Conference on System Sciences, Hawaii, 2002, pp. 3005–3014.

[3] D. E. B. Krishnamachari and S. Wicker, “Modeling data-centric routing in wireless sensor networks,” Wireless Communications, vol. 1, pp. 660–670, 2002.

[4] V. Godbole, “Performance analysis of antnet-la protocol for ad-hoc networks based on disaster area mobility model,” Radio Electronics Society, Vietnam (REV) Journal of Electronics and Communications, vol. 3, no. 1-2, pp. 28–39, 2013.

[5] J. S. Baras and H. Mehta, “A probabilistic emergent routing algorithm for mobile ad hoc networks,” 2003.

[6] D. E. Goldberg, Genetic Algorithm in a Search Optimization and Machine Learning. Ad- dison Wesley, Boston, 1989.

[7] G. D. Caro and M. Dorigo, “Mobile agents for adaptive routing,” in proc. The Thirty-First Hawaii International Conference on System Sciences, august 1998, pp. 74–83.

[8] V. Godbole, “Performance analysis of bio-inspired routing protocols based on random way- point mobility model,” Defence S & T Technical Bulletin, vol. 2, pp. 114–134.

[9] P. Lalbakhsh, B. Zaeri, and M. N. Fesharaki, “Applying nonlinear learning scheme on antnet routing algorithm,” in Proc. Annual Meeting of the North American Fuzzy Information Processing Society (NAFIPS), 2010, pp. 1–6.

[10] D. E. Knuth and D. Bibby, The texbook. Addison-Wesley Reading, MA, USA, 1986, vol. 1993.

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