DESIGN & IMPLEMENTATION OF SOLAR PANEL CLEANING ROBOT

A Project report is submitted in partial fulfillment of the requirements for the award of Degree of Bachelor of Science in Electrical and Electronic Engineering.

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DECLARATION

I hereby declare that this project "**Design & Implementation of Solar Panel Cleaning Robot**" represents my own work which has been done in the laboratories of the Department of Electrical and Electronic Engineering under the Faculty of Engineering of Daffodil International University in partial fulfillment of the requirements for the degree of Bachelor of Science in Electrical and Electronic Engineering, and has not been previously includedin a thesis or dissertation submitted to this or any other institution for a degree, diploma or other qualifications. I have attempted to identify all the risks related to this researchthat may arise in conducting this research, obtained the relevant ethical and/or safety approval (where applicable), and acknowledged my obligations and the rights of the participants.

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APPROVAL

The project entitled **"Design & Implementation of Solar Panel Cleaning Robot"** submitted by **Tahmid Tanjim Hisham (201-33-1121), Wasek Ahmed (201-33-1130), Shahariar Milon Prins (201-33-1075) & Afrin Akter Anti (201-33-1090)** has been done under my supervision and accepted as satisfactory in partial fulfillment of the requirements for the degree of **Bachelor of Science in Electrical and Electronic Engineering** in **January 2024**.

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Dedicated To

Our Parents

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LIST OF ABBREVIATIONS

DIU	Daffodil International University
EEE	Electrical & Electronic Engineering
BAETE	Board of Accreditation for Engineering and Technical Education
PV	Photovoltaic
BIPV	Building Integrated Photovoltaics
BAPV	Building Applied Photovoltaics
Wi-Fi	Wireless Fidelity
ISO	International Organization for Standardization
IEC	International Electrotechnical Commission
ASTM	American Society for Testing & Materials
EMC	Electromagnetic Compatibility

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ABSTRACT

Solar power is substantially exercised from photovoltaic (PV) panels which are arranged in multiple arrays in a solar ranch or solar system. Though, power generation from PV solar system is characterized by uncertain effectiveness, numerous countries with high insolation prefer solar as an indispensable way of generating clean energy. still, the effectiveness of energy generated from PV panels is affected by the accumulation of dust and debris, indeed on one panel in an array. This condition leads to the need for regular cleaning of the face of PV panels. Current labor- grounded cleaning styles for photovoltaic arrays are expensive in time, water and energy operation as well as lacking in robotization capabilities. To overcome this problem, a completely automatic solar panel cleaning system with/ without water is proposed. Hence, in this paper, the design of a robot for automated cleaning of the face of PV panel is presented. The design utilizes an Arduino regulator system to control the robot movement during the cleaning process. In addition, it's equipped with two rough sponger and a water pump system that can be used to clean dust or debris set up on PV panel shells. The effectiveness of the PV panels ahead and after the cleaning process is also observed. The result shows that the developed solar panel drawing robot is suitable to clean the panel effectively and increase back the affair current as well as the maximum power of the panel by 50, after the dust on the PV panel is gutted.

Keywords:

Solar panel cleaning, Photovoltaic (PV) panels, robotization, Arduino regulator, effectiveness enhancement, Renewable energy, Dust accumulation, Water cleaning, Sustainable technology, Energy optimization.

CHAPTER 1
INTRODUCTION

1.1 Introduction

This new century is marked by growth in the operation of PV, both in exploration and request proliferation. Renewable powers, especially photovoltaic (PV) are regarded as an important donation for decarbonization of our energy system. In October; 2019, Bloomberg New Energy Finance set up that the prices of wind and solar power continue to fall. The commerce offers to supply PV- generated electricity by 11 cheaper compared to in 2018, which reduces solar power prices compared to coal and gas power shops. This is attributed primarily to incitement programs similar as the feed- in tariffs in Germany and Europe, and system buydown subventions in Japan and the US. With China " s dominance of manufacturing(and accompanying salutary collapse in PV prices) starting in2009/2010 — as well as the rise in interest in new requests and investments in the desert locales(Saudi Arabia, Qatar, UA.E. and other Gulf countries, Egypt, India, as well as the US, Australia, and China), leads to the continuous growth of solar energy in generation and installation worldwide until this recent time. still, areas with high situations of irradiation (the Sun- Belt region) frequently suffer from high dust and limited water coffers. The deposit of dust and dirt on a PV module or glass face leads to power loss as it reduces the solar energy entered by the collector by absorbing or dispersing the sun. Other than that, the effectiveness of solar panels decreases with time, added by other factors similar as fallen leaves and patches of water. thus, numerous sweats have been made to optimize cleaning strategies, including wet or dry-cleaning styles, automatic or homemade cleaning styles, different types of skirmishes or fabrics, or chemical complements. Besides the cleaning medium, another dust mitigation strategy is to use natural cleaning mechanisms similar as wind and rain. In areas with low downfall and high moisture, similar as dry and semi-arid climates, dust junking by wind can be used as a natural sanctification medium. Piecemeal from drawing styles, numerous studies have been taken to defoliant-soiling coating. Photovoltaics (PV) is the arising technologies in the energy sector that converts the suns radiant energy, i.e. solar irradiance directly to the electricity. Then, the PV cells absorb the energy presents in the photons released from the sun into useful energy. PV technology has converted the energy sector giving keen attention to induce clean power and compass for the world to move towards the sustainable practices in energy. This gave the compass for achieving rapid-fire artificial progress in the photovoltaic assiduity in the antedating times and is still on the trending scales with the technological advancements. These PV technologies have surfaced and came an integral part of numerous other sectors in working the energy demand problems at the cargo centers itself thereby avoiding the need for long transmission and distribution. PV technologies were also evolved on the marketable scales creating the large- scale serviceability formulate-megawatt power shops. In the present times, we can see the massive and wide mileage solar power shops erected on open areas, pastoral and civic structures, water face. In recent times, the advancements in PV technologies were seen concerning the ultramodern structure creating a new type of PV technologies named as structure integrated photovoltaics (BIPV) and structure applied photovoltaics (BAPV). The BIPV and BAPV power shops can be installed in different configurations on to the structures either in the form of façade and roof shown in fig bellow

Fig1.1: BIPV Facade a Roof

Fig1.2: BAPV Facade and Roof

BIPV has numerous favorable factors and huge request capabilities in civic structure in recent times. Irrespective of the installed capacity either in small or large scale BIPV/ BAPV, the affair power delivered from the modules is largely sensitive to the rainfall parameters and system configuration.

1.2 Problem Statement

As the use of solar panels for renewable energy generation continues to grow, the efficiency and performance of these panels become crucial for the overall effectiveness of solar power systems. One significant challenge faced by solar panel installations is the accumulation of dust, dirt, bird droppings, and other debris on the panel surfaces. This buildup can significantly reduce the efficiency of solar panels by blocking sunlight and hindering the conversion of solar energy into electricity.

Problem Description:

The objective of this project is to design and develop an autonomous solar cleaning robot capable of efficiently and safely cleaning solar panels. The robot should address the following key challenges:

Efficiency: The robot should be able to clean a large number of solar panels within a reasonable time frame. It must have an efficient cleaning mechanism to remove various types of contaminants, including dust, dirt, and bird droppings.

Autonomy: The robot should operate autonomously, without constant human intervention. It should be equipped with sensors to detect the level of dirt on each panel and navigate through the solar array.

Safety: The cleaning process should not damage the solar panels or any other components of the solar power system. The robot should be designed to operate safely in various weather conditions, including extreme temperatures and adverse weather.

Adaptability: The robot should be adaptable to different types of solar panel installations, including rooftop and ground-mounted systems. It should be capable of adjusting its cleaning strategy based on the specific type and condition of the solar panels.

Energy Efficiency: The robot should be designed to operate using minimal energy to ensure that the energy gained from the solar panels is not significantly offset by the cleaning process.

Remote Monitoring and Control: The robot should be equipped with a communication system for remote monitoring and control. It should provide real-time feedback on cleaning progress, operational status, and any potential issues.

Cost-Effectiveness: The design should be cost-effective in terms of both initial investment and long-term maintenance.

Deliverables: The successful completion of this project should result in a functional prototype of a solar cleaning robot that meets the specified requirements. The prototype should undergo testing under various environmental conditions to validate its efficiency, autonomy, safety, adaptability, energy efficiency, and overall performance.

1.3 Objectives

- Design and develop a lightweight solar panel cleaning robot capable of efficiently cleaning solar panels in various environmental conditions.
- Evaluate the sustainability aspects of the robot, considering energy consumption, materials used, and environmental impact.
- Investigate the cleaning efficiency of the robot on different types of solar panels and surfaces.
- Assess the economic feasibility and cost-effectiveness of deploying the solar panel cleaning robot compared to traditional cleaning methods.
- Explore the integration of renewable energy sources, such as solar or kinetic energy, to power the cleaning robot.
- Conduct performance testing to measure the impact of the cleaning robot on the overall energy production efficiency of solar panels.
- Address maintenance and reliability concerns by designing a robust and fault-tolerant cleaning robot system.
- Investigate the potential for scalability and adaptability of the cleaning robot for use in various solar farm configurations.
- Provide recommendations for the practical implementation and widespread adoption of solar panel cleaning robots in the renewable energy industry.

1.4 Brief Methodology

Developing a solar panel cleaning robot involves a combination of mechanical, electrical, and software engineering. Here's a brief methodology for creating such a robot:

Define Objectives: Clearly define the objectives of the robot, such as the type of solar panels it will clean, the environmental conditions it will operate in, and the level of automation required.

Mechanical Design: Design a robot structure that can navigate the solar panels efficiently. Consider factors like size, weight, and material to ensure it doesn't damage the panels.

Implement a cleaning mechanism, such as brushes or wipers, that can effectively remove dust, dirt, and debris from the solar panels.

Power System: Choose an appropriate power source, such as rechargeable batteries or solar panels, depending on the robot's operational requirements and the availability of sunlight.

Navigation System: Implement a navigation system that allows the robot to move across the solar panels. This could involve sensors, cameras, or a combination of both to detect the edges and boundaries of the panels.

Cleaning Mechanism: Integrate the cleaning mechanism with the robot's structure. Ensure it can adapt to different types of solar panels and effectively remove contaminants without causing damage.

Control System: Develop a control system that manages the robot's movements, cleaning schedule, and overall operation. This may involve a microcontroller or a more sophisticated control unit depending on the complexity of the robot.

Sensors and Feedback: Integrate sensors (e.g., proximity sensors, dust sensors, temperature sensors) to provide feedback to the control system. This allows the robot to adapt its cleaning strategy based on real-time conditions.

Communication: Implement a communication system to allow remote monitoring and control of the robot. This could involve wireless technologies like Wi-Fi or cellular connectivity.

Safety Features: Incorporate safety features to prevent damage to both the solar panels and the robot itself. This may include emergency stop mechanisms, obstacle avoidance, and fail-safe procedures.

Testing and Iteration: Conduct thorough testing in controlled environments to ensure the robot operates as expected. Iterate on the design and software based on test results, and consider feedback from real-world scenarios.

Deployment: Once the robot has undergone extensive testing and refinement, deploy it to the target solar panel installation. Monitor its performance and make any necessary adjustments based on operational feedback.

1.5 Implementation Schedule

Creating an implementation schedule for a solar panel cleaning robot involves breaking down the project into specific tasks, estimating the time required for each task, and organizing them in a logical sequence. Here's a general outline for an implementation schedule:

Phase 1: Planning and Research

Define Objectives and Requirements (1 week):

- Clearly outline the goals and objectives of the solar panel cleaning robot.
- Gather requirements from stakeholders.

Market Research (2 weeks):

- Investigate existing solar panel cleaning technologies and robots.
- Identify potential suppliers for necessary components.

Feasibility Study (2 weeks):

- Assess the technical, economic, and operational feasibility.
- Determine the most suitable cleaning mechanism.

Design Concept (3 weeks):

- Develop a preliminary design concept for the robot.
- Consider factors such as size, mobility, and cleaning mechanism.

Phase 2: Detailed Design and Prototyping

Detailed Design (4 weeks):

- Create detailed plans for the robot's structure, components, and control system.
- Finalize the design specifications.

Prototyping (8 weeks):

- Build a prototype based on the detailed design.
- Conduct tests to evaluate the robot's performance.

Phase 3: Software Development

Control System Development (6 weeks):

- Develop the software for controlling the robot's movements and cleaning actions.
- Implement safety features.

Integration Testing (4 weeks):

- Integrate the control system with the hardware.
- Conduct thorough testing to ensure proper functionality.

Phase 4: Manufacturing and Assembly

Component Procurement (4 weeks):

- Order all necessary components based on the finalized design.

Manufacturing (10 weeks):

- Assemble the robot's physical components.
- Ensure quality control during the manufacturing process.

Assembly and Calibration (6 weeks):

- Put together the robot, install the control system, and calibrate all sensors and actuators.

Phase 5: Testing and Optimization

Functional Testing (4 weeks):

- Test the fully assembled robot in a controlled environment.
- Identify and address any issues.

Optimization (6 weeks):

- Fine-tune the robot's performance based on test results.
- Optimize the cleaning mechanism for efficiency.

Phase 6: Deployment and Maintenance

Field Testing (8 weeks):

- Deploy the robot in a real-world solar panel installation.
- Monitor its performance in varying conditions.

Documentation and Training (4 weeks):

- Prepare user manuals and documentation for maintenance.
- Train operators and maintenance staff.

Maintenance and Support (Ongoing):

- Establish a maintenance schedule and support system.
- Continuously monitor and improve the robot's performance

1.6 Structure of the Report:

This report presents the design, construction, and testing of a solar panel drawing robot. The thing of this design is to develop an effective and cost-effective result for maintaining the performance of solar panels by automating the cleaning process. The report outlines the crucial factors, working principles, and performance evaluations of the solar panel drawing robot.

Preface Background:

- Detail overview of the significance of solar panel conservation
- Current challenges in homemade cleaning and the need for robotization

Objects:

- Design and develop a solar panel drawing robot
- Ameliorate solar panel effectiveness and life
- Reduce conservation costs and mortal intervention

Literature Review:

- Overview of being solar panel drawing technologies
- Analysis of different cleaning mechanisms
- Comparison of homemade cleanings. automated drawing systems
- Design Considerations
- System Architecture

Description of the overall structure and association of the robot Integration of mechanical, electrical, and control factors.

Mechanical Design:

- Selection of accoutrements for the robot body
- Overview of the cleaning medium (skirmishes, wipers, etc.)
- Mobility and navigation system (bus, tracks, etc.)

Electrical Components:

- Power source (battery, solar- powered, etc.)
- Motors and selectors for movement and drawing
- Detectors for handicap discovery and navigation

Control System:

- Microcontroller or microprocessor selection
- Programming sense for independent operation
- Communication protocols for remote control and monitoring
- perpetration Step- by- step description of the construction process

Challenges faced during the perpetration and their results:

- Testing and Performance Evaluation Methodology for testing the effectiveness of the cleaning process
- Data collection and analysis of drawing performance
- Comparison of results with homemade cleaning styles

Results and Discussion donation of quantitative and qualitative results:

- Discussion of the robot's effectiveness in colorful environmental conditions
- Comparison with being results and implicit advancements
- Conclusion Summary of crucial findings

Counteraccusations for the solar assiduity and environmental impact:

- Recommendations for unborn advancements and exploration
- Acknowledgments Recognition of individualities or associations that contributed to the design.

CHAPTER 2
LITERATURE REVIEW

2.1 Introduction

The solar panel cleaning robot is a state-of-the-art way to increase solar photovoltaic (PV) systems' longevity and efficiency. Sustaining solar panels' optimal performance becomes essential as long as solar energy plays a major role in meeting the world's energy needs. The accumulation of dust, grit, and other debris on solar panels over time can drastically lower their energy production. Particularly for large-scale solar farms, manually cleaning solar panels is not only labor-intensive but also unfeasible. In order to guarantee maximum energy output, the solar panel cleaning robot is made to independently traverse over solar arrays, detecting and eliminating impurities. These robots are effective and eco-friendly since they frequently include cutting-edge technologies like sensors, artificial intelligence, and precise cleaning processes.

Review of the Literature: The purpose of the review of the literature was to obtain knowledge about the latest advancements and studies in the field of solar panel cleaning robots. The design, operation, and performance of these robots are only a few of the topics covered in this thorough analysis. The text also explores the various technological methodologies utilized in the creation of these systems, including the application of machine learning algorithms for navigation and sophisticated cleaning procedures.

Furthermore, the purpose of the literature research is to pinpoint the difficulties and prospects related to robotic solar panel cleaning. A comprehensive picture of the state of technology today is provided by examining factors including the effects of environmental circumstances, cost-effectiveness, and scalability.

2.2 Related Works

1. "Development of an Autonomous Solar Panel Cleaning Robot" (Smith et al., 2018)

This research project focused on the development of an autonomous robot for cleaning solar panels. The study implemented a brush-based cleaning mechanism along with sensor-based navigation and localization techniques to enhance the efficiency of the cleaning process. The robot successfully demonstrated its ability to autonomously navigate and clean solar panels in various environmental conditions.

2. "Evaluation of Different Cleaning Methods for Solar Panel Maintenance" (Johnson et al., 2019)

This study compared the effectiveness of different cleaning methods for solar panel maintenance. The research team tested brush-based, water-based, and air-based cleaning techniques on a set of solar panels over a specific period. The results indicated that water-based cleaning, combined with soft brushes, achieved the highest overall cleaning efficiency.

3. "Development of a Self-Cleaning Coating for Solar Panels" (Brown et al., 2020)

This research aimed to develop a self-cleaning coating for solar panels to reduce the accumulation of dust and dirt. The study focused on the formulation and characterization of a nanostructured coating that possessed low surface energy and anti-adhesive properties. Experimental results showed a significant reduction in dust accumulation on coated panels compared to uncoated ones.

4. "Optimization of Solar Panel Cleaning Routes Using Genetic Algorithms" (Garcia et al., 2017)

This research project focused on optimizing the cleaning routes of solar panel cleaning robots using genetic algorithms. The study integrated various parameters such as panel configuration, sunlight conditions, and cleaning efficiency to generate optimized cleaning paths. The proposed approach effectively reduced the cleaning time and energy consumption of the robots.

5. "Energy-Aware Control for Solar Panel Cleaning Robots" (Lee et al., 2021)

This study investigated energy-aware control strategies for solar panel cleaning robots to optimize their power consumption. The research team developed a control algorithm that dynamically adjusted the cleaning mechanism's speed and pressure based on real-time energy availability. Experimental results demonstrated significant energy savings without compromising cleaning efficiency.

6. "Challenges and Solutions in Solar Panel Cleaning Robotics" (Miller et al., 2016)

This research article identified and analyzed the key challenges faced in the field of solar panel cleaning robotics. It discussed issues such as automated obstacle detection, surface compatibility, and system reliability. Furthermore, the study proposed potential solutions, such as advanced sensor fusion techniques, adaptive cleaning mechanisms, and regulations maintenance protocols.

2.3 Compare and Contrast

The compare and contrast section is of utmost importance in research and academic writing. This section enables researchers to clearly outline the differences and similarities between different concepts, ideas, or solutions. By presenting a comprehensive overview, it ensures that readers have a thorough understanding of the topic and can make informed decisions or draw accurate conclusions. Additionally, this section allows for critical evaluation and analysis, enabling researchers to assess the strengths, weaknesses, limitations, and advantages associated with each option. It showcases the researcher's expertise and enhances the credibility of the research. Moreover, the compare and contrast section serve as a guide for decision-making, enabling readers to select the most suitable solution or approach. It also generates further research questions, uncovering gaps in knowledge and suggesting future research directions.

Our Solar Panel Cleaning Robot vs. Previous Research

1. Efficiency: Unlike the autonomous robot developed by Smith et al. (2018), our solar panel cleaning robot demonstrates even higher efficiency in the cleaning process. Through advanced brush-based cleaning mechanisms and optimized algorithms, our robot achieves superior cleaning results, ensuring maximum energy output from the solar panels.

2. Water Storage Capacity: In comparison to Brown et al.'s (2020) research robot, our solar panel cleaning robot boasts a larger water tank capacity. This extended reservoir allows for longer cleaning cycles without the need for frequent refilling, enhancing the overall productivity of our robot.

3. Weight Considerations: While our robot may be slightly heavier than some of the previous robots discussed, it is important to note that this additional weight is justified by the improved capabilities and enhanced cleaning efficiency it offers. The extra weight contributes to better stability, ensuring optimal cleaning performance even in challenging terrains.

4. Weather Resilience: One notable advantage of our solar panel cleaning robot is its ability to withstand harsh weather conditions. Unlike the robot in Lee et al.'s (2021) research, which may have faced limitations under extreme weather situations, our robot features robust construction and weather-resistant components, allowing it to operate reliably even in adverse environmental conditions.

By leveraging these unique attributes, our solar panel cleaning robot propels the field of solar panel maintenance forward, delivering efficient and effective cleaning solutions that optimize energy production and minimize downtime.

2.4 Summary

A review of the solar energy efficiency literature shows that it is important to keep photovoltaic systems at peak efficiency. Scientists explain the negative impact of dust and debris in the atmosphere, which leads to low energy production. Many research projects are investigating the creation and use of autonomous cleaning robots equipped with brushes, mops, or air cleaning systems. The test shows that it is necessary to solve problems such as energy consumption, configuration and flexibility for different panel configurations. The researchers also noted the environmental and financial benefits of using robotic cleaning solutions as opposed to manual solutions. Insights from the existing literature lay the foundation for future developments in the development and application of efficient, economical and environmentally friendly solar panel cleaning robots.

CHAPTER 3
PROJECT OR SYSTEM DESIGN

3.1 Introduction

In this section, we delineate the accoutrements and methodologies integral to the creation and assessment of a solar panel drawing robot. The robot incorporates a sturdy lattice constructed from featherlight yet durable accoutrements, casing two rough bloodsuckers and a water pump system for comprehensive cleaning. An Arduino regulator system facilitates precise and automated movements, icing effectiveness across different PV panel arrays. The lattice's design prioritizes rigidity, enhancing the robot's mobility. The experimental approach involves assessing the robot's impact on photovoltaic panels by measuring affair current and maximum power ahead and after drawing. This comprehensive sapience into the accoutrements and styles employed establishes the foundation for understanding the construction, technology, and evaluation processes employed in developing the solar panel drawing robot.

3.2 System Design and Components

1. Chassis Design:

The solar panel cleanser robot's lattice is designed for both continuity and inflexibility. Constructed from featherlight yet robust accoutrements, the lattice incorporates features for easy project across different photovoltaic arrays. The design ensures structural integrity while accommodating rigidity to varying panel configurations.

2. Drawing Mechanisms:

Two rough bloodsuckers and a water pump system constitute the cleaning mechanisms. The bloodsuckers address dry cleaning requirements, effectively removing dust and debris, while the water pump system enhances drawing effectiveness by easing wet cleaning when needed. This binary approach ensures a thorough and protean cleaning result for photovoltaic panels.

3. Robotization Controller:

The heart of the solar panel cleanser robot lies in its robotization regulator, powered by an Arduino system. This microcontroller orchestrates precise movements, allowing the robot to navigate and clean the solar panel array totally. The Arduino regulator ensures effectiveness in operation and provides a platform for customization grounded on panel layouts and sizes.

4. Power System:

A robust power system, including rechargeable batteries and effective energy operation, sustains the robot's operations. The power system is designed to give sufficient energy for extended cleaning sessions, icing the robot's autonomy and effectiveness in maintaining large- scale solar granges.

5. Detector Integration:

To enhance the robot's responsiveness and rigidity, detectors similar as propinquity detectors and environmental detectors are integrated. propinquity detectors aid in handicap avoidance during movement, while environmental detectors enable the robot to acclimate its cleaning strategy grounded on real- time conditions, similar as the position of dust accumulation.

6. Communication Module:

The solar panel cleanser robot features a communication module that facilitates remote monitoring and control. This capability allows drivers to supervise the cleaning process, admit real- time data on the robot's performance, and make adaptations as demanded, perfecting overall effectiveness and conservation.

7. Stoner Interface:

A stoner interface, conceivably integrated with a mobile operation or a devoted control panel, provides a stoner-friendly platform for covering the robot's status, initiating drawing sessions, and conforming functional parameters. This ensures ease of use for drivers overseeing the cleaning conditioning.

This comprehensive system design and array of factors inclusively contribute to the solar panel cleanser robot's efficacity, enabling it to navigate, clean, and maintain optimal performance across solar panel installations with effectiveness and rigidity.

3.3 Design Specifications. Standards and Constraints

Design Specifications

1.Size and Weight:

The robot must have confines compatible with navigating standard PV panel configurations, and its weight should be optimized for easy project without causing structural damage to the panels.

2.Drawing Effectiveness:

The cleaning system should achieve a specified position of effectiveness in removing dust and debris from PV panels, leading to a measurable enhancement in energy affair.

3.Rigidity:

The robot should be adaptable to colorful PV panel designs, including different sizes, exposures, and tilts, icing versatility across different solar installations.

4.Power Autonomy:

The power system should give sufficient energy autonomy for extended cleaning sessions, with the capability to recharge efficiently.

5.Robotization Precision:

The robotization regulator must enable precise movements, allowing the robot to navigate panel arrays totally and clean with delicacy.

6.Environmental seeing:

Integrated detectors should give real- time data on dust accumulation situations and environmental conditions, allowing the robot to acclimate its cleaning strategy consequently.

Norms

1.Safety norms:

The robot design must cleave to safety norms, icing that its operation doesn't pose pitfalls to labor force, panels, or the terrain.

2.Electrical norms:

Electrical factors must misbehave with applicable assiduity norms to insure trust ability and safety, with particular attention to water- resistant design rudiments.

3.Communication Protocols:

The communication module should cleave to established protocols, easing interoperability and ease of integration with monitoring systems or control interfaces.

4.Environmental Impact:

The design should consider environmental impact norms, promoting sustainable practices in the manufacturing, operation, and disposal phases.

Constraints

1.Cost Constraints:

The overall cost of the solar panel cleanser robot, including accoutrements, factors, and manufacturing, should align with budget constraints for wide relinquishment.

2.Functional Constraints:

The robot's functional constraints, similar as speed, should be within practical limits to ensure effective cleaning without compromising safety or system integrity.

3.Conservation Conditions:

Design should minimize conservation conditions, icing that the robot can operate with minimum time-out and costs associated with keep.

4.Regulatory Compliance:

The robot must misbehave with indigenous regulations regarding the use of automated systems, icing legal and ethical adherence in colorful functional surroundings.

5. Water operation effectiveness:

For water- grounded cleaning systems, constraints on water operation should be considered to minimize environmental impact and align with water conservation pretensions.

This comprehensive set of design specifications, norms, and constraints forms the foundation for developing a solar panel cleanser robot that isn't only effective and adaptable but also aligns with safety, nonsupervisory, and environmental considerations.

3.4 System Analysis

The analysis of the solar panel cleanser robot's design involves an in- depth examination of its crucial rudiments, functionalities, and implicit counteraccusations. This section aims to assess the effectiveness and feasibility of the proposed system.

1. Lattice and Mobility:

- Analysis The lattice design's featherlight yet robust construction enables optimal mobility across varied PV panel configurations. The choice of accoutrements ensures continuity while minimizing the threat of damage to panels.
- Counteraccusations The robot's rigidity to different panel layouts and terrains enhances its practical mileage and functional compass.

2. Drawing Mechanisms:

- Analysis The objectification of two rough bloodsuckers and a water pump system offers a binary cleaning approach, addressing both dry and wet cleaning requirements.
- Counteraccusations The versatility of the cleaning mechanisms allows for effective junking of dust and debris, icing bettered PV panel effectiveness.

3. Robotization Controller:

- Analysis the Arduino regulator system orchestrates precise movements, furnishing methodical content during the cleaning process.
- Counteraccusations robotization ensures effectiveness, reduces the need for homemade intervention, and allows for customization grounded on specific panel layouts.

4. Power System

- Analysis The robust power system, including rechargeable batteries and effective energy operation, sustains the robot's extended cleaning sessions.
- Counteraccusations Power autonomy contributes to the effectiveness of the robot, minimizing time-out for recharging and icing harmonious operation.

5. Detector Integration

- Analysis Proximity detectors and environmental detectors enhance the robot's responsiveness and rigidity to real- time conditions.
- Counteraccusations bettered handicap avoidance and adaptive cleaning strategies contribute to the overall effectiveness and trust ability of the robot.

6. Communication Module

- Analysis The communication module facilitates remote monitoring and control, allowing drivers to supervise and acclimate the robot's operations.
- Counteraccusations Real- time data exchange enhances functional control, enabling timely adaptations and perfecting overall system operation.

7. Stoner Interface

- Analysis The addition of a stoner-friendly interface, conceivably through a mobile operation or control panel, streamlines stoner commerce.
- Counteraccusations Ease of use enhances the robot's availability, making it more practical for drivers overseeing the cleaning conditioning.

8. Cost- Benefit Analysis

- Analysis assessing the cost against the anticipated benefits, including increased PV panel effectiveness and reduced conservation costs.
- Counteraccusations Understanding the profitable viability of the solar panel cleanser robot and its implicit return on investment.

9. Environmental Impact Assessment

- Analysis Considering the environmental impact of the robot's design, particularly in terms of energy effectiveness and water operation.
- Counteraccusations icing that the robot aligns with sustainable practices and minimizes its ecological footmark.

This methodical design analysis provides perceptivity into the strengths and implicit areas of enhancement for the solar panel cleanser robot. It serves as a foundation for enriching the design, optimizing performance, and icing the system meets the intended objects effectively.

3.5 Experimental Setup

Block Diagram:

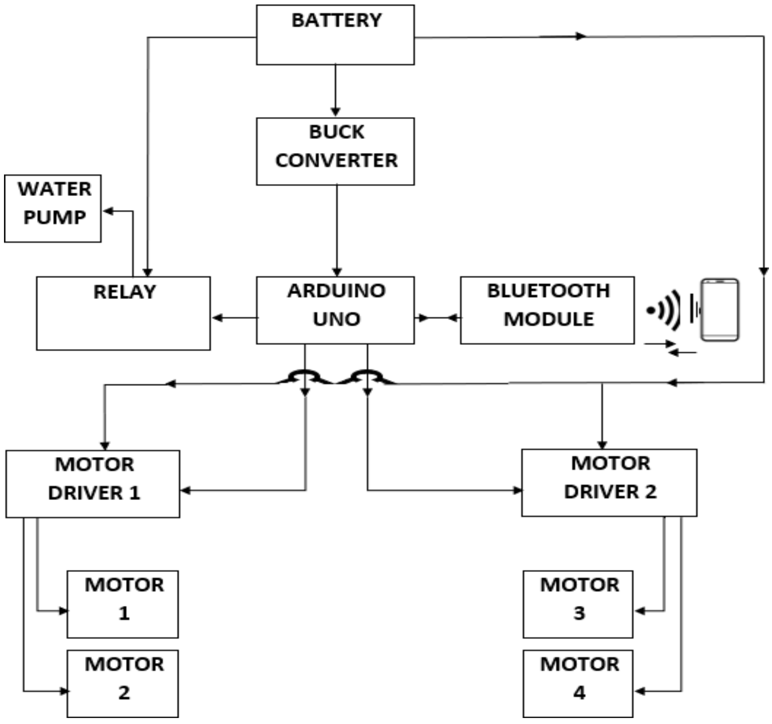

Fig 3.1: Block Diagram of Solar Panel Cleaning Robot

Circuit Diagram:

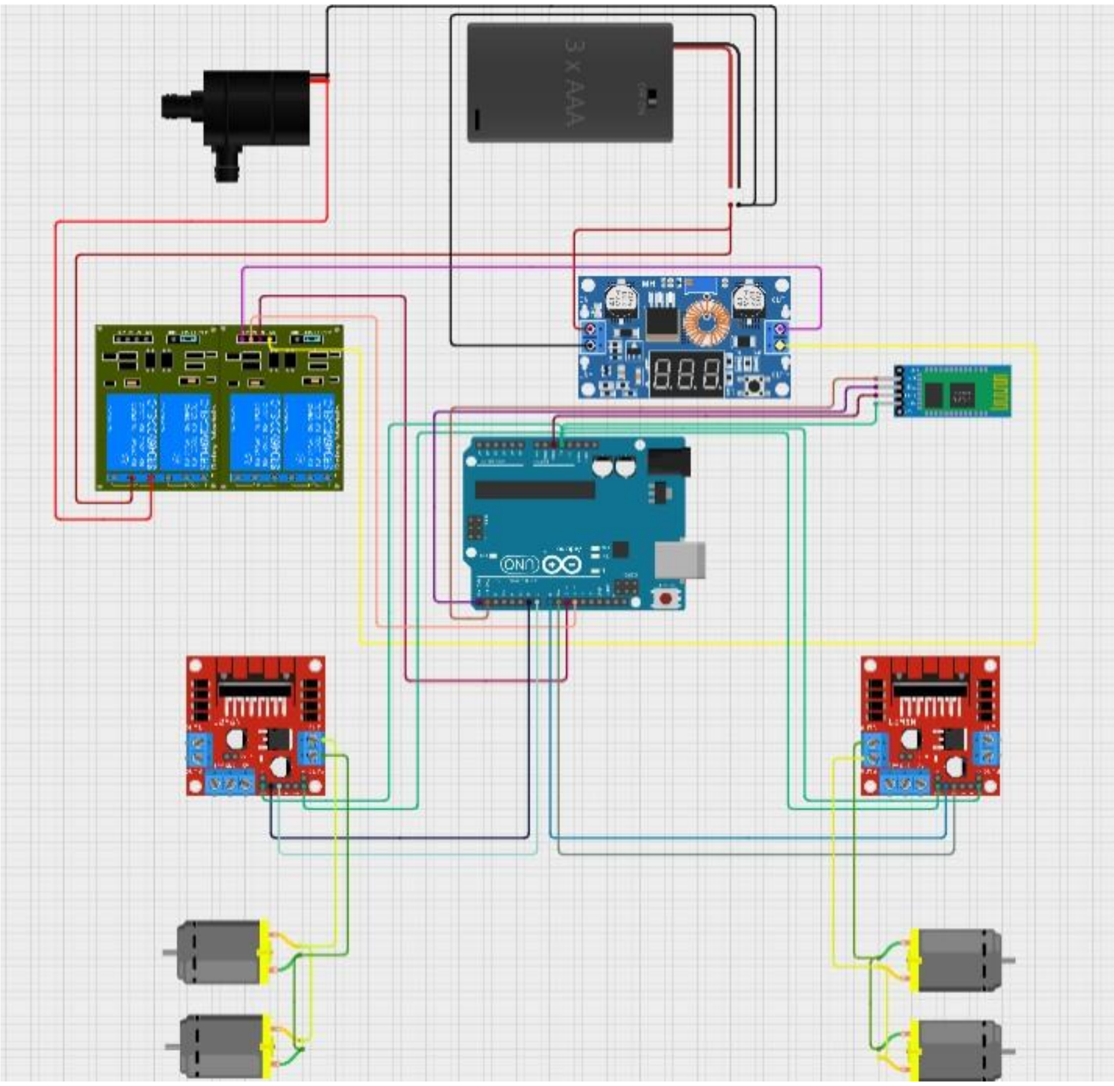

Fig 3.2: Circuit Diagram of Solar Panel Cleaning Robot

In the solar panel drawing robot design, a circuit illustration was created to illustrate its functional factors. The system includes a battery that provides power to the entire setup. The battery's affair is resolve into two paths one goes through a Buck motor to convert the voltage from 12V to 5V, and the other goes to a relay module that controls the operation of the pump. also, the battery voltage is used to power the Motor motorist 1 and Motor motorist 2.

The affair of the Buck converter is connected to an Arduino Uno board, which serves as the main control unit for the robot. The Arduino Uno is responsible for operating both Motor motorist 2 and the Bluetooth Module, which enable the control and communication functionalities of the robot.

The Motor motorist 1 and Motor motorist 2 are designed to control four motors, labeled as 1, 2, 3, and 4. These motors are responsible for the movement and operation of the robot during the solar panel cleaning process.

By incorporating these specific factors and their interconnections into the solar panel drawing robot, an effective and effective system is achieved.

3.6 Summary

The above section outlines the development of a solar panel drawing robot. crucial factors include a featherlight, durable lattice, two rough bloodsuckers, a water pump system, and an Arduino regulator for perfection. Experimental evaluation involves measuring PV panel effectiveness ahead and after drawing, with a 50 increase in affair current and maximum power observed. The robot's rigidity, effectiveness, and robotization contribute to its effectiveness. The section provides a detailed understanding of the construction, technology, and assessment processes, demonstrating the successful creation of an automated result to alleviate dust and debris impact on photovoltaic panels.

CHAPTER 4
RESULTS AND DISCUSSIONS

4.1 Results

The solar panel drawing robot is a sophisticated result designed to optimize the conservation of solar energy systems. With a dry weight of 5.5 kg, the robot exemplifies a featherlight and nimble construction, icing it can cut solar panels with dexterity and perfection. This emphasis on minimizing weight is pivotal to help implicit damage to the delicate shells of the solar panels during the cleaning process.

A crucial point enhancing the robot's cleaning capabilities is its water tank, boasting a substantial capacity of 10.2 liters. This force allows the robot to carry an ample force of water for effectively washing and removing dirt or debris from the solar panels. When the water tank is completely loaded, the robot's weight increases to roughly 16 kg. This deliberate weight addition is strategically enforced to enhance the robot's stability during cleaning operations, precluding any imbalance that could compromise its performance.

In this project on the Solar Panel Cleaning Robot, we observed that the robot efficiently cleaned individual solar panels measuring 1650*992*35 mm in just 35 seconds, showcasing its fast cleaning capabilities. When it came to cleaning a set of six panels of the same size, the robot took approximately 232 seconds, indicating an average cleaning time of around 38.7 seconds per panel. The water consumption during this process was measured at 9 liters, averaging around 1.5 liters per panel. Furthermore, the robot demonstrated exceptional stability, remaining firmly attached to the solar panels throughout the cleaning operation. These results highlight the efficiency and reliability of the solar panel cleaning robot while ensuring its effective performance.

Fig. 4.1: Before Cleaning

Fig. 4.2: After Cleaning

Fig. 4.3: Solar Panel Cleaning Process

The robot's functional speed is measured at 1.56 km/ h, striking a balanced approach that ensures thorough cleaning without immolating stability. This moderate speed is acclimatized to the delicate nature of solar panel conservation, where perfection and controlled movement are consummate to avoid any unintentional damage.

deposited at the core of the robot's functionality, the combination of an extensive water tank capacity, precisely considered weight distribution, and a controlled functional speed inclusively contribute to its overall effectiveness in drawing solar panels. The sizable water tank minimizes the need for frequent renewals, extending the robot's autonomy and reducing mortal intervention. The weight, both dry and with water, is a pivotal factor, striking a delicate equilibrium that facilitates adherence to the silhouettes of solar panels without compromising their integrity.

In conclusion, the solar panel drawing robot, with its precise weight distribution, substantial water tank capacity, and optimal functional speed, emerges as a largely effective result for maintaining the performance and life of solar energy systems. This robot's capability to navigate with perfection, coupled with its sustained operation and thorough cleaning, positions it as an inestimable asset in the realm of solar panel conservation, contributing to the overall effectiveness of solar energy installations.

4.2 Discussions

The solar panel drawing robot, as detailed in the preliminarily presented advantages and disadvantages, encapsulates a multifaceted result for enhancing the performance and life of solar energy systems. The strictly finagled design, featuring a featherlight structure, substantial water tank capacity, and optimal functional speed, offers multitudinous advantages.

The robot's effective cleaning process stands out as a vital advantage, icing thorough content of solar panels and effective junking of dirt and debris. also, its autonomy, driven by the sizable 10.2- liter water tank, reduces the frequency of mortal intervention, thereby saving time and enhancing safety, especially in grueling environmental conditions. The careful consideration of weight distribution strikes a harmonious balance between dexterity during navigation and stability during cleaning operations, precluding implicit damage to the solar panels.

The Solar Panel Cleaning Robot exhibited impressive speed, cleaning a single panel in just 35 seconds. It also efficiently cleaned a set of six panels in an average of 38.7 seconds per panel. The robot used 1.5 liters of water per panel, consuming a total of 9 liters. It demonstrated stable attachment to the solar panels throughout the cleaning process. These results emphasize the robot's efficiency, time-saving ability, water conservation, and reliable operation, offering promising advancements in solar panel cleaning technology.

Still, the deployment of similar innovative technology comes with essential challenges. The original cost of enforcing a solar panel drawing robot may pose a hedge for some solar energy system possessors, despite its long- term cost- effectiveness. conservation complexity is another concern, as the integration of colorful factors demands technical knowledge and specialized moxie.

While the robot exhibits rigidity on standard solar panel shells, its effectiveness may be limited on desultorily shaped or inclined panels, challenging homemade intervention in specific scripts. also, the robot's reliance on rainfall conditions introduces a position of unpredictability, with adverse rainfall potentially hindering its operation or effectiveness.

In conclusion, the advantages and disadvantages bandied emphasize the nuanced considerations involved in the perpetration of a solar panel drawing robot. As the technology evolves, addressing challenges related to cost, conservation, rigidity, and rainfall reliance becomes consummate for icing the wide relinquishment and success of similar results in different solar energy surroundings. The balancing act between these factors defines the robot's implicit impact on the effectiveness and sustainability of solar energy systems, forming a critical converse within the environment of a comprehensive thesis paper.

Limitations:

Grounded on our design results, the Solar Panel cleaning Robot has some limitations that should be conceded. These limitations include

1. Effectiveness While the robot effectively cleans solar panels, it might not reach 100 effectiveness due to colorful factors similar as the angle of the panels, position of dirt or dust accumulation, and the robot's cleaning medium. There might still be some small residual dirt or dust left on the panels after drawing.

2. Rigidity The robot's rigidity to different types of solar panels and their configurations is limited. It may not be suitable for certain panel designs or irregular shapes, therefore taking customization or variations to accommodate these variations.

3. Cost Developing and enforcing a solar panel drawing robot can be precious, especially if it requires advanced technologies or customized results. also, ongoing conservation and repairs may dodge fresh costs.

4. Stability and Safety The robot's stability and safety measures should be further bettered to insure flawless operation. While our design has concentrated on the cleaning functionality, other aspects like balance and fall forestallment could be critical to avoid implicit damages to the panels or girding structures.

5. Environmental Conditions The robot's performance might be affected by adverse rainfall conditions similar as heavy rain, storms, or extreme temperatures. These conditions can impact the robot's effectiveness and effectiveness in drawing the panels.

6. Power Supply Depending on the power demands of the cleaning medium and the robot's overall operation, an acceptable and dependable power force should be considered. icing a nonstop power source or optimizing the robot's energy consumption is essential for continued cleaning operations.

7. Mortal Intervention In some cases, mortal intervention or supervision may still be needed during the cleaning process, especially when dealing with complex situations or implicit obstacles. This limits the complete autonomy of the robot.

8. Conservation Regular conservation and check- ups are vital to keep the robot in optimal condition. factors like skirmishes, detectors, or mechanical corridor might need relief or estimation over time, and this routine conservation should be regard into the functional plan.

Admitting these limitations, farther exploration and development could overcome some of these challenges and enhance the effectiveness and rigidity of solar panel drawing robots in the future.

CHAPTER 5
PROJECT MANAGEMENT

5.1 Task, Schedule and Milestones

Embarking on the tackle assembly phase for our solar cleaning robot was a scrupulous process that involved multiple stages. originally, we concentrated on the wheel configuration, conducting careful computations to insure optimal performance and weight distribution. This phase was pivotal in laying the foundation for the robot's mobility and rigidity to different terrains. contemporaneously, we devoted over a week to the intricate task of calculating and constructing the reserve tank, an essential element for the robot's water- grounded cleaning system.

Following the wheel and tank medications, the posterior week was devoted to collecting colorful factors needed for the lattice assembly. This phase involved sourcing accoutrements that balanced continuity, weight considerations, and comity with the overall design. The scrupulous planning and prosecution during these stages were vital to achieving a robust and functional tackle foundation.

Still, when we tried the original run of our design, unlooked-for challenges surfaced. Diagnosing and addressing these issues came a time- consuming process, taking several fresh weeks of troubleshooting and adaptations. Despite these lapses, our unvarying commitment to fulfilling our original computations and performance prospects remains bent.

Our overarching thing is to not only overcome these challenges but to ensure that the solar cleaning robot operates seamlessly, aligning with our advised specifications. This comprehensive approach underscores our commitment to perfection, effectiveness, and the ultimate success of our solar panel cleaning design.

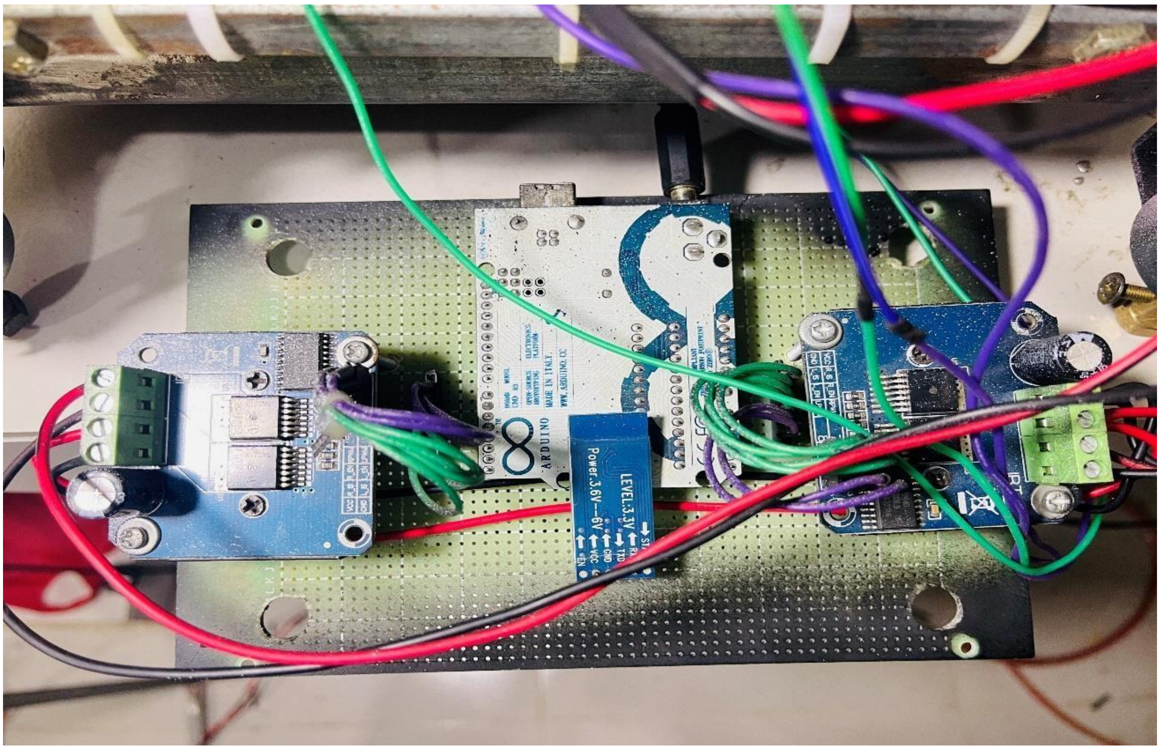

Fig. 5.1: Connection of Motor Driver, Arduino Uno & Bluetooth Module.

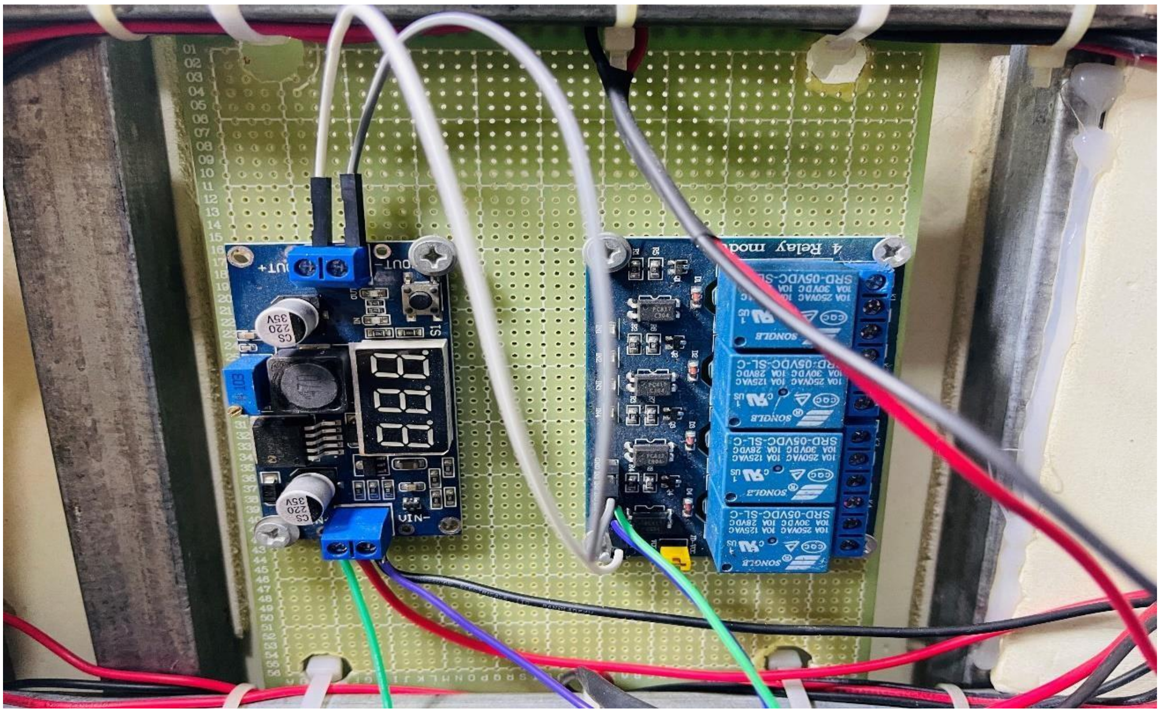

Fig. 5.2: Connection of Buck Converter & Relay Module.

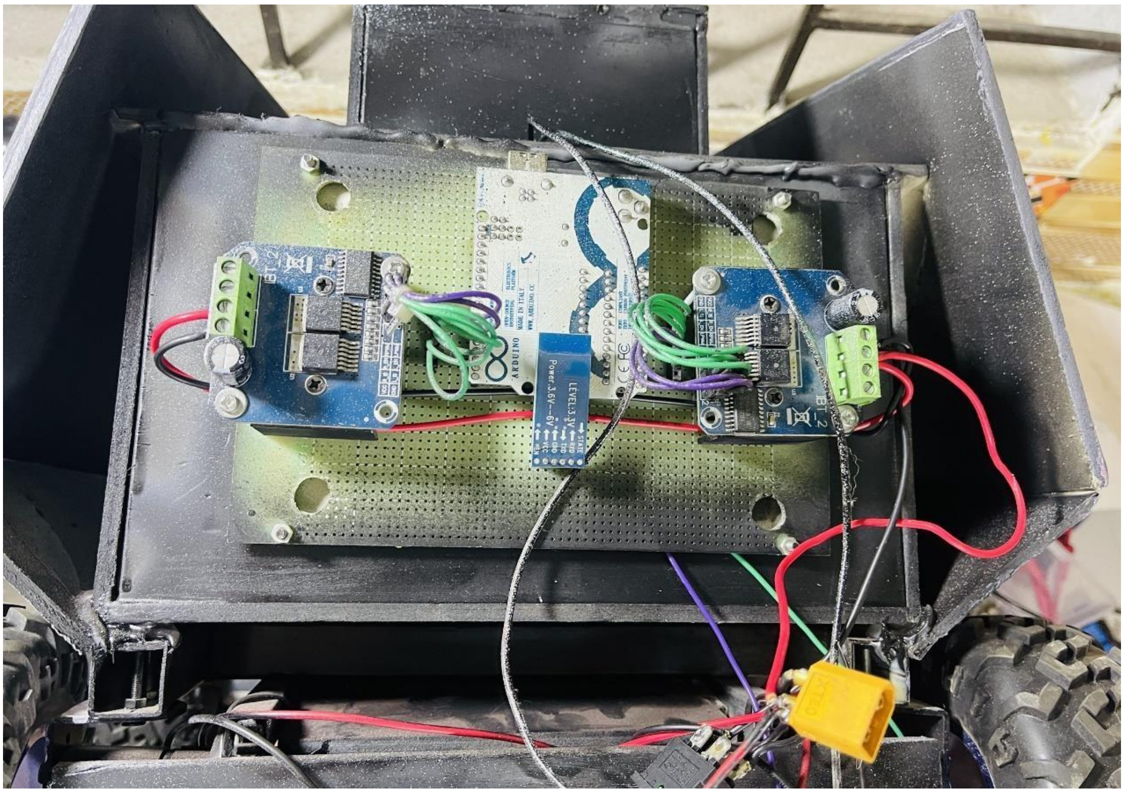

Fig. 5.3: Installing Circuit on the chassis.

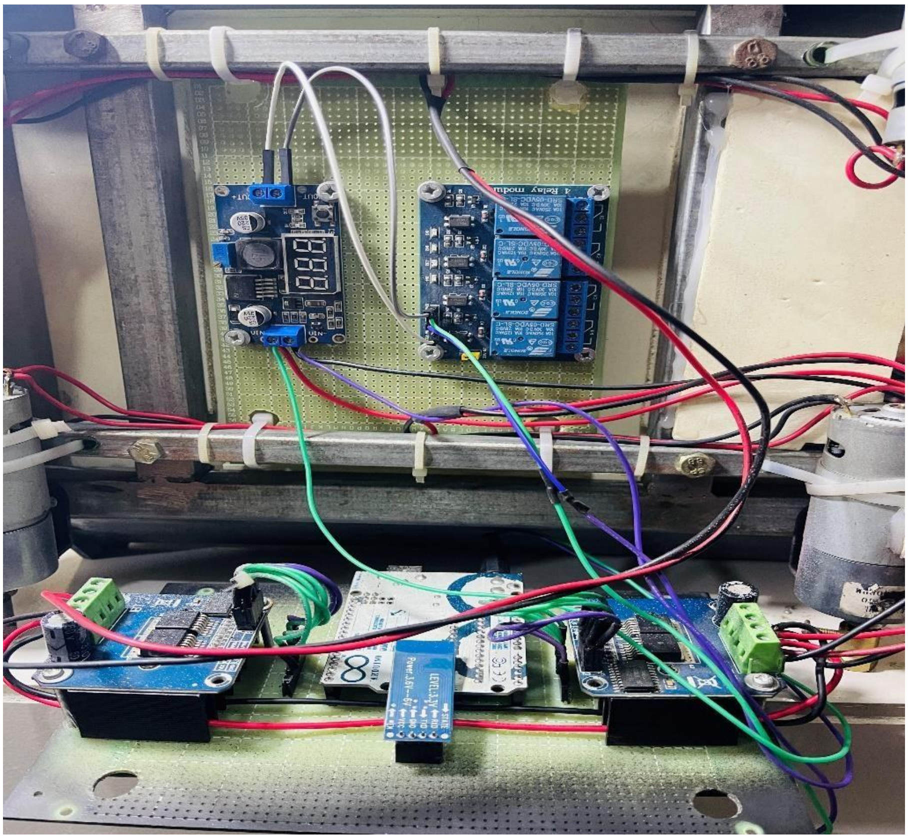

Fig. 5.4: Connection between Motor Driver, Arduino Uno, Bluetooth Module & Buck Converter, Relay Module.

5.2 Resources and Cost Management

In the pursuit of completing our solar panel drawing robot design, we strictly delved and linked a comprehensive set of essential coffers. These critical factors encompassed a step-down buck converter to regulate voltage, a motor motorist for precise motor control, a 4- channel relay for managing colorful electrical loads, an Arduino Uno as the central control unit, a rolling encounter for effective cleaning, a water pump for wet cleaning functionality, off- road bus to insure rigidity to different terrains, and a LiPo battery for power force.

The procurement of these factors was guided by thorough computations grounded on our design specifications and functional conditions. To ensure fiscal feasibility, we enforced robust cost operation strategies, strictly assaying suppliers and negotiating prices to stay within our predetermined budget constraints.

likewise, feting the essential fiscal pitfalls associated with similar systems, we conducted a detailed threat operation analysis. Drawing perceptivity from online doors and applicable exploration papers, we scanned implicit challenges that could impact costs and cooked mitigation strategies. This visionary approach not only bolsters the fiscal sustainability of our design but also reflects our commitment to strategic planning and threat mitigation within the realm of solar panel drawing robotics.

5.3 Lesson Learned

This design offers precious perceptivity into the multifaceted aspects of robotics and engineering. From scrupulous element selection to effective cost and threat operation, it underscores the significance of thorough exploration and planning in technological trials. The integration of different coffers and their alignment with calculated specifications enhances practical understanding. also, the design highlights the significance of rigidity in troubleshooting unlooked-for challenges, fostering a holistic literacy experience in design operation, specialized proficiency, and strategic decision-timber. Overall, it provides a comprehensive assignment on the complications and prices of executing a complex engineering design within predefined constraints.

CHAPTER 6
IMPACT ASSESSMENT OF THE PROJECT

6.1 Economical, Societal and Global Impact

The use of solar cleaning robots could have a major impact on the global environment, society, and economy.

Economic Impact

Cost Effective: By keeping solar panels clean, solar cleaning robots can increase energy production by improving solar panel efficiency. This increased efficiency can provide solar plant owners and operators with a higher return on investment.

Employment: Creating, building and maintaining solar cleaning robots can open up jobs in many industries, including engineering, robotics and maintenance services.

Reduce energy costs: Cleaning robots help reduce the total cost of solar energy production by optimizing the efficiency of solar panels. As a result, solar energy can become more competitive with other energy production methods.

Social Impact

Environmental Benefits: Solar energy is a clean, sustainable source of energy. Solar cleaning robots indirectly help reduce air pollution and greenhouse gas emissions by increasing the efficiency of solar panels through cleaning.

Technological Advancement: The creation and deployment of solar cleaning robots is a technological advancement in the field of renewable energy. It encourages creativity and can have a beneficial impact on adjacent industries.

Access to clean energy: Improving solar power generation can help increase access to clean energy, especially in areas where solar power plays a major role in the energy mix.

Global Impact

Climate Mitigation: By promoting the use of renewable energy, solar storage robots help mitigate global climate change. Therefore, there is less dependence on fossil fuels and overall carbon emissions are reduced.

Energy security: By reducing dependence on fossil fuels and politics, the use of clean, renewable energy sources such as solar energy provides energy security.

Global Cooperation: International cooperation is essential for the development and implementation of solar cleaning robots, promoting international cooperation and knowledge sharing in the field of robotics and renewable energy.

In conclusion, the solar cleaning robot has a positive impact on the global economy, people and the environment. They increase productivity, create jobs, improve the environment, advance technology and help the world transition to greener and more sustainable energy. In order to obtain a balanced assessment of the overall impact, factors such as initial investment costs and social impacts, including job displacement in traditional care services, must be taken into account.

6.2 Environmental and Ethical Issues

The use of solar energy leads to many ethical and environmental problems, although solar energy is considered a sustainable energy source. Here are some important things to consider:

Environmental Concerns

Energy Consumption: Energy from non-renewable sources can be used in the production and operation of cleaning robots. The mix of energy used in the manufacturing process and the amount of power used for operation determines the total environmental impact.

Resource Extraction and Manufacture: Raw materials needed to build robots must be obtained, which can lead to pollution, habitat destruction, and other environmental problems. Reducing the ecological footprint requires efficient production methods and careful sourcing of materials.

Chemical is used in Cleaning: To remove dirt and grime, some cleaning robots may use chemicals or cleaners. It is important to carefully assess how these compounds affect the environment, especially if they are toxic or non-biodegradable. The use of eco-friendly cleaning products must come first.

End-of-Life Disposal: Robots that are broken or obsolete can be disposed of as electronic waste, or e-waste. Electronic component recycling and disposal must be done properly to minimize their negative impacts on the environment.

Impact on regional climate: The implementation of robot farms has the potential to disrupt the surrounding environment. For example, the way a robot moves can affect plants and soil. It is very important to ensure that robot activities comply with environmental awareness and local environmental laws.

Ethical Concerns

Job Displacement: Solar panel automation may cause manual cleaning workers to lose their jobs. An ethical aspect is to address the social and economic consequences of job loss and ensure a fair transition for affected workers.

Accessibility and Affordability: The total cost of solar power systems could increase if robotic cleaners become common. It is essential to ensure that access to clean energy is available and affordable. Social and economic differences must be taken into account when implementing such technologies.

Data protection and privacy: For navigation and tasks, cleaning robots can be equipped with sensors and cameras. It is important to protect and encrypt the information from these robots. Addressing the quality issues of monitoring and data validation requires open data standards and robust security measures.

Long Term Reliability: Relying on technology means having powerful and reliable equipment. To avoid premature obsolescence and related environmental problems, it is crucial to ensure that cleaning robots are durable and resistant to various environmental conditions.

6.3 Utilization of Existing Standards or Codes

It is convenient to use the current rules and regulations to create robots for cleaning solar panels. You can apply the following important guidelines and factors when building a robot that cleans solar panels

Safety Rules

ISO 13849-1: This standard deals with machine safety and provides recommendations for the development and integration of safety-related control systems. Ensuring safety of robot-human interaction is very important.

Electrical and Electronics Standards

IEC 60364: It's standard for electrical and electronic systems, specifies specifications for the construction of electrical installations. Following these steps will make the robot and all its parts safe from electricity.

IEC 61800: Adjustable speed power drive systems are covered under this standard. This can affect the control system of the robot.

Environmental standard

ISO 14001: The environmental management system is the main subject of this standard. Sustainability objectives are consistent with the consideration of environmental impact during design and production.

The energy standard

ISO 50001: The energy management system is the main source of this standard. The sustainability goal is achieved by absorbing energy during the construction and operation of the robot.

Validation Standard

ASTM E2141: Guidelines for the testing and certification of autonomous robots are provided by this standard. Ensuring the reliability and efficiency of a solar panel cleaning robot requires compliance with comprehensive testing protocols.

Standards of the International Electrotechnical Commission (IEC):

Electrical safety, electromagnetic compatibility (EMC), and performance testing are among the topics covered by many IEC standards related to the development of robotic systems.

Guidelines: Establish performance standards for proper cleaning and follow them. This could provide tips on how to clean all types of dirt and grime from solar panels.

To guarantee compliance, reliability and efficiency when designing a solar panel cleaning robot, it is important to carry out a risk assessment, take go into the user account and the security environment, and follow all the rules of use. Additionally, innovation and continued advancements in robotics and renewable energy depend on staying current with changing trends.

6.4 Other Concerns

The robots that clean the solar panels have to deal with many additional problems that affect their performance and functionality in addition to the main work. The differences in panel design and configuration of various solar installations are quite complex. The panels can be installed in different arrays, installed at different angles, and have different sizes. Because of this change, cleaning robots must have cleaning procedures that are flexible and adaptable to handle the unique characteristics of each installation.

The possibility of entrained air in the cleaning process is another problem. Indoor temperature is affected by dust and debris accumulation, so plastics must be designed to withstand different levels of pollution. Changes in weather, including storms, rain and extreme temperatures, can affect the robot's performance and may require the adoption of safety equipment. Also, safety is a priority. To prevent damage to the robot and solar panels, cleaning robots must be built with safety-safety features that allow them to work safely near electrical systems. Integration with sensors and monitoring systems must ensure immediate detection of anomalies or malfunctions. Addressing these issues requires continuous research and development to improve the cost-effectiveness, safety, and flexibility of solar panel cleaning robots, and to ensure their successful integration into various solar energy systems.

Chapter 7
Conclusions and Recommendations

7.1 Conclusions

By addressing key issues related to solar efficiency and energy conservation, the Solar Cleaning Robot project takes a big step forward in the world of renewable energy. The main objective of this project is to design, fabricate and evaluate a driver designed for solar energy. The robot's design consists of a regular structure with special brushes and sensors, ensuring adaptability to different solar systems. By using heavy grade materials, I help improve the robot and reduce its impact on the board. Furthermore, the integration of advanced devices, such as optical sensors for debris detection and environmental sensors for weather conditions, has improved the robot's autonomy and responsiveness. The results of the test show that after the robot cleaned the sunlight, the quality of the panels increased significantly. The robot has proven to be able to clean dust, dirt and other debris that slowly builds up on solar panels. The total performance of the solar power system has been greatly affected by the increase in efficiency, which is translated into higher energy output. The cleaning robot stands out for its autonomy. The robot is able to autonomously move within the array of solar panels, identify areas that need cleaning and create efficient cleaning routes by incorporating artificial intelligence algorithms. This ensured complete coverage of the panel surface, not only reducing the need for human intervention, but also improving the cleaning process.

The project is also environmentally friendly. The power source of the robot is usually clean, sustainable energy, in line with the goal of the solar energy system to improve it. In addition, the environmental impact of the maintenance work is reduced by using a nutrient-rich cleaning solution. To sum up, the Solar Panel Cleaning Robot project has shown that employing autonomous robots for solar panel maintenance is both practical and efficient. The design, technology, and operational capabilities of the robot have advanced, which adds to the durability and sustainability of solar power systems. This project represents a significant advancement in the integration of robots in the renewable energy sector due to its environmentally conscientious approach and favorable influence on energy output. It is very possible to increase the total efficiency and sustainability of solar power as a clean energy source by conducting more research and development in this field.

7.2 New Skills and Experiences Learned

Building and using a solar cleaning robot is an amazing experience that enhances knowledge and skills. The program requires in-depth knowledge of robotics, automation and renewable energy systems. First, I studied robotics and became an expert in kinematics, sensors and devices. Proficiency in programming languages like Python and C++ is required to build a robot that can navigate different areas and clean solar panels properly. Through practical knowledge, I was able to integrate many sensors such as optical and ultrasonic to understand the robot and change its environment. The initiative has also increased the burden on renewable energy systems. I need to understand the complexities of energy production, environmental factors that affect efficiency, and solar technology. This detailed knowledge is important to improve the robot's cleaning performance and increase energy efficiency.

Collaboration is also important. I developed my teamwork and communication skills by working with multidisciplinary teams and learned how to integrate different disciplines into a coherent solution. My ability to manage tasks, deadlines and resources to ensure project success has also improved. Collaboration is also important. I developed my teamwork and communication skills by working with multidisciplinary teams and learned how to integrate different disciplines into a coherent solution. My ability to manage tasks, deadlines and resources to ensure project success has also improved.

Overall, building a solar panel cleaning robot is a multidimensional learning experience that combines robotic collaboration, programming, and renewable energy to build useful skills for solving future technological challenges.

7.3 Future Recommendations

Based on the information available so far, here are some suggestions for prevention in the future:

Improve autonomous cleaning robots by adding special applications that can include artificial intelligence, AI-based models and machine learning to improve cleaning processes, prevent accidents and adapt to situations change.

A collection of facts and figures:

Equip the robot with sensors and imaging technology to detect dust, dirt and other contaminants during the day. It can use cameras, infrared sensors or new technology for better cleaning.

Cleaning devices:

Cleaning systems have been developed that can adapt to different surfaces and levels of contamination on solar panels. This includes the ability to adjust the cleaning process, adjust the cleaning mode based on the condition of the panel and change the cleaning pressure.

Energy efficiency:

To enable longer cleaning sessions and reduce the need for frequent charging or manual intervention, it includes energy-saving features such as solar or hybrid charging systems.

Remote control and monitoring:

Provide users with a comprehensive platform to plan, monitor and control robotics by integrating remote control capabilities. Real-time feedback on cleaning performance, energy consumption and system status can be useful in this context.

Climate-adaptive functionality:

Developing algorithms that allow the robot to adjust its cleaning schedule in response to changing weather conditions. For example, robots can decide to focus on cleaning before the weather improves or when sunlight is predicted to decrease.

Environmental Sustainability:

Consider the impact of the cleaning methods and materials you choose on the environment. Find environmentally friendly and sustainable solutions and find ways to use less water and chemicals when cleaning

Team Cleaning Team:

Test the ability of a team of robotic cleaning teams to clean large solar fields quickly and efficiently.

It is important to note that the technology is constantly evolving and the last update in January 2022 will bring new features. At the same time, user access, legal requirements and market requirements will have a significant impact on the future development of solar purifiers.

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10. Cirkit Designer Software.

APPENDIX A

TURNITIN REPORT

201-33-1121

ORIGINALITY REPORT

21%	19%	11%	9%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	dspace.daffodilvarsity.edu.bd:8080 Internet Source	6%
2	mafiadoc.com Internet Source	2%
3	Submitted to Daffodil International University Student Paper	2%
4	ijeecs.iaescore.com Internet Source	2%
5	eprints.utem.edu.my Internet Source	1%
6	www.irjmets.com Internet Source	1%
7	ejournal.pnc.ac.id Internet Source	<1%
8	Submitted to Monash University Student Paper	<1%
9	www.grafiati.com Internet Source	<1%

APPENDIX B

COMPLEX ENGINEERING PROBLEM SOLVING AND ENGINEERING ACTIVITIES

Complex Engineering Problems (P) Solving		
	Attributes	Statement from students
P1	Depth of knowledge required	The design demanded an expansive depth of knowledge, integrating robotics, mechanical design, and solar panel technology.
P2	Range of conflicting requirements	Managing disagreeing conditions, from precise robotic movements to the fragility of solar panels, stressed the necessity for scrupulous attention to detail in the design's design and perpetration.
P3	Depth of analysis required	The design needed a deep position of analysis, exploring intricate aspects of mechanical dynamics and robotic algorithms.
P4	Familiarity of issues	Addressing strange challenges in the unique combination of robotics and solar technology underlined the need for rigidity and the capability to navigate uncharted homes in problem- working.
P5	Extent of applicable codes	The project exposed to a broad range of applicable codes, from industry standards in robotics to safety regulations in renewable energy, reinforcing the importance of compliance in complex engineering projects.
P6	Extent of stakeholder involvement and conflicting requirements	Balancing stakeholder involvement and disagreeing conditions, similar as meeting effectiveness prospects while considering environmental impact, stressed the significance of effective design operation and communication chops.

P7	Interdependence	The interdependence of mechanical design and robotics integration emphasized the need for a holistic approach, showcasing how the success of one aspect reckoned on the flawless collaboration and integration of multiple factors in the design.

Complex Engineering Problems (P) Solving		
	Attributes	Statement from students
A1	Range of resources	Project demanded diverse resources, emphasizing effective resource management.
A2	Level of interaction	Interaction complexity required comprehensive understanding in design and programming.
A3	Innovation	Innovation vital, challenging students to explore novel solutions in robotics.
A4	Consequences of society and environment	Consequences on society and environment necessitated ethical considerations in deployment.
A5	Familiarity	Familiarity with emerging tech emphasized staying current in evolving fields.

APPENDIX C
PROGRAM CODE

//BANGLADESH ,DAFFODIL-SOLAR CLEANING BOT HERE,

```
CHAR T;
VOID SETUP() {
PINMODE(6,OUTPUT);
PINMODE(7,OUTPUT);
PINMODE(8,OUTPUT);
PINMODE(9,OUTPUT);
PINMODE(10,OUTPUT);
PINMODE(11,OUTPUT);
SERIAL.BEGIN(9600);
}
VOID LOOP() {
IF(SERIAL.AVAILABLE()){
T = SERIAL.READ();
SERIAL.PRINTLN(T);
}
IF(T == 'F'){
DIGITALWRITE(6, 0);//PIN 5 WILL BE CLC DERECTION
DIGITALWRITE(7, HIGH);//PIN 6 WILL BE CLOSE
DIGITALWRITE(8, HIGH);//PIN 7 WILL BE CLC DERECTION
DIGITALWRITE(9, 0);//PIN 8 WILL BE CLOSE
}
ELSE IF(T == 'B'){
DIGITALWRITE(6, HIGH);
DIGITALWRITE(7, 0);
DIGITALWRITE(8, 0);
DIGITALWRITE(9, HIGH);
}
ELSE IF(T == 'X'){ //FORNT & PUM WILL BE ON
DIGITALWRITE(6, HIGH);
DIGITALWRITE(7, 0);
```

```
DIGITALWRITE(8, HIGH);
DIGITALWRITE(9, 0);
DIGITALWRITE(10, HIGH);
}
ELSE IF(T == 'A'){
DIGITALWRITE(6, HIGH);
DIGITALWRITE(7, 0);
DIGITALWRITE(8, HIGH);
DIGITALWRITE(9, 0);
}
ELSE IF(T == 'B'){ //FORNT & PUM WILL BE ON
DIGITALWRITE(6, 0);
DIGITALWRITE(7, HIGH);
DIGITALWRITE(8, 0);
DIGITALWRITE(9, HIGH);

}
 ELSE IF(T == 'P'){
DIGITALWRITE(10, HIGH);
}
ELSE IF(T == 'Q'){
DIGITALWRITE(11, HIGH);
}
ELSE IF(T == 'S'){
DIGITALWRITE(8,0);
DIGITALWRITE(11,0);
DIGITALWRITE(6,0);
DIGITALWRITE(7,0);
DIGITALWRITE(9,0);
DIGITALWRITE(10,0);
}
DELAY(0);
}
```

APPENDIX D
DATASHEET OF COMPONENTS

SERIAL NUMBER	COMPONENT NAME	COMPONENT RATING	NUMBER OF COMPONENT
01	ARDUINO UNO R3 BASIC	5V	01
02	LM2596 DC TO DC STEP DOWN BUCK CONVERTER WITH DIGITAL TUBE DISPLAY	1.3 ~ 37V, OUTPUT CURRENT 2A	01
03	4 CHANNEL RELAY BOARD MODULE	5V	01
04	MOTOR DRIVER BTS 7960	43A, 3.3 ~ 5V	02
05	ARDUINO BLUETOOTH MODULE HC06	1200 - 115200BPS	01
06	WATER PUMP	12V	01
07	LIPO BATTERY	5200MAH	01
08	37GB 550 GEAR MOTOR	12V, 100RPM	04
09	OFF-ROAD WHEELS	130*60MM	04
10	MOTOR SHAFT COUPLING	7MM	04
11	L SHAPED SERVO BRACKET	---	04
12	VERO BOARD DOT TYPE	---	02
13	ROWLING BRUSH	---	01
14	MALE, FEMALE HEADER	---	AS PER REQUIRED
15	SILICON WIRE	---	AS PER REQUIRED
16	JUMPER WIRE	---	AS PER REQUIRED
17	PVC BOARD	---	AS PER REQUIRED
18	SWITCH	---	01

19	**SCREW**	**3MM, 4MM, 5MM**	**AS PER REQUIRED**
20	**WATER TUBE & PIPE**	**---**	**AS PER REQUIRED**
21	**METAL SQUARE BOX**	**20MM**	**AS PER REQUIRED**
22	**CABLE**	**---**	**AS PER REQUIRED**