ABSTRACT

The Integration of a solar tracking system with a solar-powered car enhances energy efficiency and mobility. The system utilizes Light-Dependent Resistors (LDRs) and a servo motor to track the sun's position and adjust the azimuth location of the solar panels accordingly. By incorporating Arduino technology, the system offers flexibility for customization and integration with other systems. The integration of a solar car adds mobility to the tracking mechanism, creating a sustainable mode of transportation powered by renewable energy. The project involves hardware integration, testing, and optimization to ensure efficiency. This innovative solution contributes to improving solar energy harvesting efficiency, making it suitable for small-scale solar power applications while offering opportunities for learning and innovation in renewable energy and vehicle design.

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LIST OF SYMBOLS

mAh Milliampere-hours

mm Millimeters

Ω Ohms

V Volts

W Watts

LIST OF ABBREVIATIONS

AGMVC	Adaptive Generalized Maximum Versoria Criterion
BO	Battery Operated
BMS	Battery Management System
BLDC	Brushless Direct Current
DC	Direct Current
EV	Electric Vehicle
GND	Ground
IDE	Integrated Development Environment
LDR	Light Dependent Resistor
MCU	Microcontroller Unit
MPPT	Maximum Power Point Tracking
PV	Photovoltaic
PWM	Pulse Width Modulation
USB	Universal Serial Bus

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION TO SOLAR TRACKING SYSTEM

The utilization of solar energy has garnered significant attention as a sustainable and renewable alternative to traditional fossil fuels. However, the efficiency of solar panels can be greatly enhanced by maximizing their exposure to sunlight throughout the day. This is where solar tracking systems come into play, offering a sophisticated solution to dynamically align solar panels with the sun's position. A Solar Tracking System is a technological marvel that incorporates various sensors, actuators, and control algorithms to optimize the orientation of solar panels in response to the sun's movement. At its core, this system aims to achieve one primary objective: to capture as much sunlight as possible by ensuring that solar panels are always perpendicular to the sun's rays.

The fundamental principle behind solar tracking systems lies in their ability to track the apparent motion of the sun across the sky. Unlike fixed solar panels that remain stationary throughout the day, solar tracking systems continuously adjust the position of solar panels to maximize sunlight exposure. This dynamic tracking capability allows solar panels to capture sunlight more efficiently, thereby increasing energy production.

Key components of a solar tracking system typically include Light-Dependent Resistors (LDRs), which measure sunlight intensity, and servo motors, which adjust the azimuth position of solar panels based on sensor readings. These components work in tandem with sophisticated tracking algorithms, which analyze sensor data and determine the optimal orientation of solar panels relative to the sun.xi

The integration of Arduino technology further enhances the capabilities of solar tracking systems, offering flexibility for customization and integration with other systems. Arduino microcontrollers serve as the brain of the system, enabling real-time data processing and precise control of servo motors. Solar tracking systems come in various configurations, including single-axis and dual-axis systems, depending on the degree of freedom for panel movement. Single-axis systems track the sun's movement along one axis (typically the east-west axis), while dual-axis systems also account for changes in solar elevation. Solar tracking systems represent a cutting-edge solution for maximizing solar energy harvesting efficiency. By continuously adjusting the orientation of solar panels to align with the sun's position, these systems offer a promising avenue for increasing renewable energy generation and advancing sustainability efforts on a global scale.

1.2. ROLE OF SOLAR ENERGY IN RESOURCES MANAGEMENT

Solar energy is a cornerstone of modern resource management practices, offering a renewable and sustainable alternative to traditional fossil fuels. It plays a multifaceted role in optimizing energy production, reducing environmental impact, enhancing energy security, promoting sustainable development, and fostering economic growth. By harnessing sunlight efficiently, solar technologies contribute to a more sustainable and resilient energy future.

At the forefront of resource management, solar energy optimizes energy production by maximizing the capture of solar radiation. Through advanced solar panel technologies and tracking systems, such as the Solar Tracking System i.e., solar installations dynamically adjust their orientation to follow the sun's path across the sky. This meticulous tracking ensures that solar panels maintain an optimal angle relative to the sun, thereby maximizing energy yield throughout the day.

In addition to enhancing energy production, solar energy minimizes environmental impact by reducing reliance on finite fossil fuel resources. Unlike coal, oil, and natural gas, which emit greenhouse gasses and contribute to climate change, solar power generation produces no harmful emissions during operation. This clean and renewable energy source mitigates environmental degradation, preserves natural resources, and helps combat climate change, making it a vital component of sustainable resource management strategies. Furthermore, solar energy enhances energy security by diversifying the energy mix and reducing dependency on volatile or geopolitically sensitive energy sources. By decentralizing energy production and empowering communities to generate their own electricity, solar technologies promote energy independence and resilience. This diversification mitigates the risks associated with supply disruptions and price fluctuations in global energy markets, ensuring a more stable and secure energy future.

In terms of sustainable development, solar energy promotes equitable access to clean and reliable energy sources, particularly in underserved or remote areas where traditional energy infrastructure may be lacking. Solar projects empower communities to meet their energy needs sustainably, without relying on centralized power grids or expensive diesel generators. This decentralized approach to energy production fosters economic development, improves quality of life, and reduces energy poverty, contributing to a more equitable and sustainable future for all.

CHAPTER 2

LITERATURE SURVEY

[1] The paper titled **"Increasing the Solar Reliability Factor of a Dual-Axis Solar Tracker Using an Improved Online Built-In Self-Test Architecture," in *IEEE Access*, vol. 12, pp. 37715-37730, 2024 by S. L. Jurj and R. Rotar** presents an innovative approach to enhance the reliability of dual-axis solar trackers through an improved online built-in self-test architecture. By integrating features like bit-flip mechanisms and extended Hamming codes, it enables real-time detection and correction of circuit faults, thereby bolstering the overall reliability factor of solar tracking systems. However, the implementation of such advanced testing architectures may introduce complexities and potentially increase system costs. Furthermore, the effectiveness of these methods could vary depending on environmental conditions and operational parameters, necessitating thorough validation in real-world scenarios**.**

[2] The paper title **"A Novel Method for Maximum Power Point Tracking of the Grid-Connected Three-Phase Solar Systems Based on the PV Current Prediction" in *Chinese Journal of Electronics*, vol. 32, no. 2, pp. 353-364, March 2023 by S. Bairami, D. Mirabbasi and M. Salimi** introduces a novel method for maximum power point tracking (MPPT) in grid-connected three-phase solar systems, employing predictive control of PV current. By utilizing a predictive model of PV current, the proposed method optimizes MPPT through adaptive perturbation and observation techniques. This approach aims to minimize voltage and current ripple, enhancing system stability and performance. Simulation results demonstrate improvements over traditional MPPT techniques, showing reduced total harmonic distortion in inverter voltage and current. However, the complexity of implementing predictive control algorithms and the need for accurate parameter tuning may pose challenges in practical applications

[3] The paper titled **"A Comprehensive Review on Electric Vehicle: Battery Management System, Charging Station, Traction Motors", in *IEEE Access*, vol. 11, pp. 20994-21019, 2023 by C. Dhanamjayulu, T. Girijaprasanna, D. Mohanraj,S. M. Muyeen,S. Raju and S. Thangavel** provides a comprehensive review of Electric Vehicles (EVs), focusing on Battery Management Systems (BMS), power converters, motors, charging stations, and cyber security. It highlights the advantages of EVs, such as lower environmental impact, reduced maintenance costs, and cheaper refueling. However, it also acknowledges challenges like high initial costs, limited range, and the need for more charging infrastructure. Overall, the paper underscores the pivotal role of EV technology in mitigating greenhouse gas emissions and fostering sustainable transportation solutions.

[4] The research titled **"Grid Tied Solar PV System with Power Quality Enhancement Using Adaptive Generalized Maximum Versoria Criterion", in**

***CSEE Journal of Power and Energy Systems*, vol. 9, no. 2, pp. 722-732, March 2023 by M. Badoni, R. Kumar ,A. Singh, A. K. Singh and H. Saxena** introduces a novel heuristic methodology for the optimal selection of control strategies in dual-axis solar tracking systems, aimed at reducing tracking error and energy consumption simultaneously. By characterizing system constraints and pre-selecting controllers based on conventional and non-conventional options, the approach facilitates the identification of feasible solutions. The methodology involves a multistage process, including constraint definition, controller pre-selection, heuristic selection, and comparative analysis. While offering the advantage of improved system performance, particularly in low-power photovoltaic applications, the approach may necessitate sophisticated tuning processes for certain controllers, potentially adding complexity to implementation.

[5] The paper titled **"Optimal Selection of the Control Strategy for Dual-Axis Solar Tracking Systems," in *IEEE Access*, vol. 11, pp. 56561-56573, 2023 by D. A.Flores-Hernánde,J.M.González-Lira,F. A.Ortiz-Martínez,S.I.Palomino-Resendiz, and I.V. Paramo-Ortega**, proposed adaptive generalized maximum Versoria criterion (AGMVC) control technique introduces significant advancements in grid-tied solar PV systems with power quality enhancement. By effectively extracting fundamental Constituents from non-sinusoidal load currents, it addresses multiple power quality issues like harmonics, reactive power demand, and load unbalancing.

Moreover, the AGMVC control technique exhibits superior performance metrics, including lower steady-state mean square error and reduced computational complexity compared to traditional controllers. However, despite these benefits, challenges such as the need for sophisticated hardware and potentially higher implementation costs may impede its widespread adoption in practical scenarios.

CHAPTER 3

EXISTING SYSTEM

Existing solar tracking and conversion systems typically employ various methods to optimize energy generation and efficiency. One common approach involves fixed solar panels that are statically positioned to capture sunlight throughout the day. While simple and cost-effective, this setup lacks adaptability and may not fully utilize the available solar energy, especially during periods of changing sun angles.

To address these limitations, some systems utilize single-axis solar tracking mechanisms, which adjust the tilt angle of solar panels to track the sun's apparent motion across the sky. This method enhances energy capture by ensuring panels are optimally aligned with the sun throughout the day. However, single-axis tracking systems are limited in their ability to account for changes in both solar elevation and azimuth angle.

More sophisticated solar tracking systems incorporate dual-axis tracking, enabling panels to adjust both tilt and azimuth angles to accurately follow the sun's position in the sky. By dynamically optimizing panel orientation, dual-axis trackers significantly increase energy output compared to fixed or single-axis systems. However, they tend to be more complex and expensive to implement, requiring precise control algorithms and mechanical components.

Another emerging approach is integrated solar tracking and conversion systems, which combine solar tracking mechanisms with advanced power conversion technologies. These systems not only track the sun's position but also optimize energy conversion efficiency by employing maximum power point tracking (MPPT) algorithms. By continuously adjusting panel orientation and operating conditions, integrated systems can maximize energy harvest under varying environmental conditions.

Moreover, integrated systems often incorporate grid-tied functionality, allowing them to seamlessly integrate with the existing electrical grid. This enables surplus energy generated by solar panels to be fed back into the grid, promoting energy self-sufficiency and potentially offsetting electricity costs for consumers. Additionally, grid-tied integration facilitates the implementation of power quality enhancement features, such as harmonic filtering and reactive power compensation, further enhancing the system's overall performance and reliability. Furthermore, the concept of integrated solar tracking and conversion systems can extend beyond stationary applications to include mobile platforms like solar-powered vehicles. By integrating solar tracking mechanisms and efficient power conversion systems, solar cars can harness sunlight to generate electricity, reducing reliance on fossil fuels and mitigating environmental impact.

CHAPTER 4

PROPOSED METHOD

4.1 SYSTEM SPECIFICATION

4.1.1 HARDWARE REQUIREMENTS

Table 4.1 : Requirement Specification

COMPONENT	QUANTITY	SPECIFICATION
Arduino	1	UNO
Solar Panels	1	70mm x 70mm 6V 100 mAh
LDR	2	5 mm
Resistors	2	10K O (Ω) 1/2w (0.50 watt) ±5% Tolerance
BO Motors	2	150RPM Dual Shaft BO Motor
Bread board	1	840 pin
Battery	2	9V Rechargeable Battery
Jumper Wires	Atleast 20 pcs	Male to Male

4.1.2 SOFTWARE REQUIREMENTS

- Arduino IDE
- Arduino Libraries

4.2 PROPOSED SYSTEM

The integrated Solar Tracking and conversion system combines solar energy harvesting with propulsion, maximizing efficiency and extending range. By optimizing solar panel orientation and converting sunlight into usable power, this project offers a sustainable and eco-friendly solution. The proposed method follows a sequential flow approach as given in Figure 4.1.

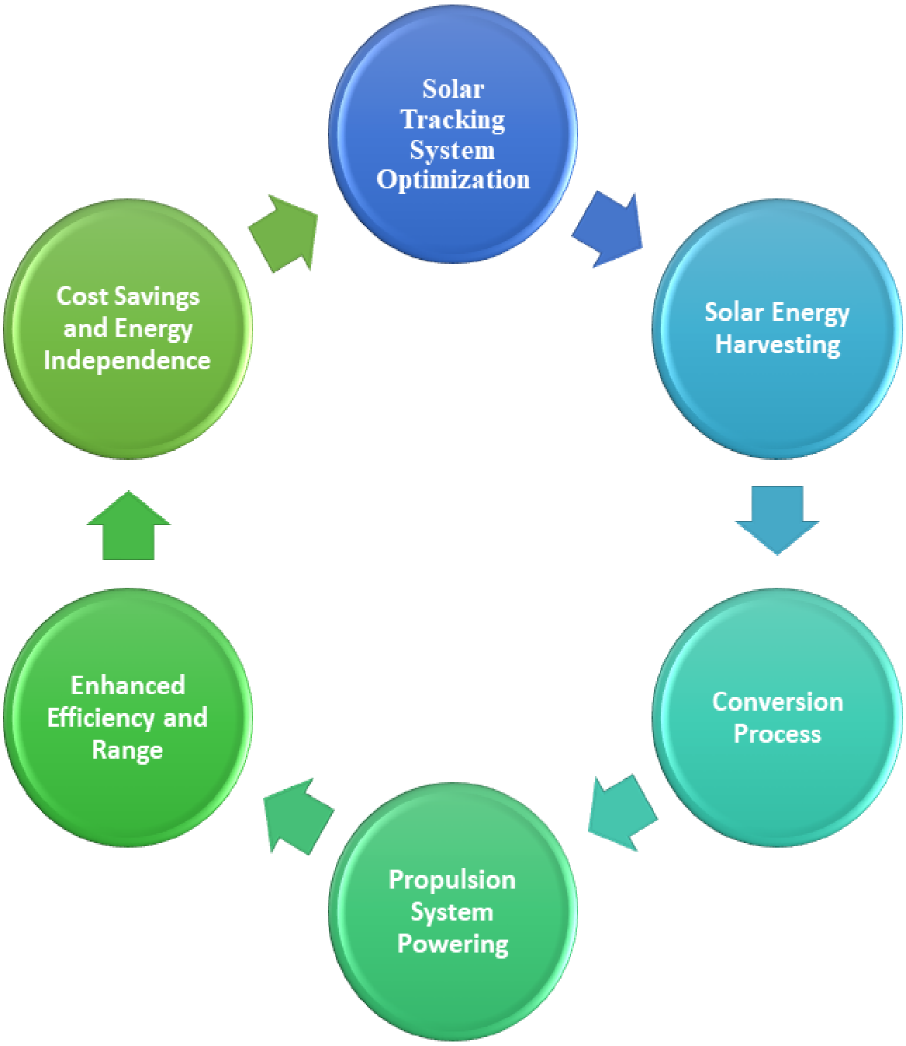


Figure 4.1 Proposed System Architecture

Solar Tracking System Optimization:

- Light-Dependent Resistors (LDRs) continuously measure sunlight intensity.
- Data is processed by the tracking algorithm to determine optimal solar panel orientation.
- Servo motor adjusts solar panels' azimuth position to align with the sun's trajectory.

Solar Energy Harvesting:

- Solar panels capture sunlight and convert it into direct current (DC) electricity.
- The Solar Tracking System ensures panels are positioned optimally for maximum energy capture.

Conversion Process:

- DC electricity from solar panels is fed into a charge controller.
- Charge controller regulates electricity flow to the batteries, preventing overcharging.
- Excess energy is stored in battery storage for later use.

Propulsion System Powering:

- Electricity from batteries powers the vehicle's propulsion system.
- The integration of solar tracking technology optimizes energy production, extending the vehicle's range.

Enhanced Efficiency and Range:

- Continuous optimization of solar panel orientation maximizes energy production.

- Solar-powered car can travel longer distances without external charging, increasing efficiency and range.

<u>Environmental Sustainability:</u>

- Zero emissions during operation reduce carbon footprint and environmental impact.
- Reliance on clean, renewable solar energy aligns with sustainability goals and mitigates climate change.

<u>Cost Savings and Energy Independence:</u>

- Reduced dependence on fossil fuels and grid-based electricity lowers fuel costs and utility bills.
- Energy independence provides flexibility and resilience, particularly in remote areas.

4.3 SYSTEM ARCHITECTURE

The work flow of the Integrated Solar Tracking and Conversion System is given in as follows and shown in Figure 4.2.

<u>Components Overview and Setup:</u>

The solar tracking system consists of an Arduino UNO microcontroller, LDRs, a servo motor, a solar panel, 10K resistors (x2), and a BO motor with wheels. These components are assembled and interconnected to facilitate solar tracking functionality. The Arduino UNO serves as the central control unit, while the LDRs detect sunlight intensity changes. The servo motor adjusts the solar panel's tilt angle, and the BO motor provides mobility to the system. Proper setup ensures seamless interaction between components for effective solar tracking.

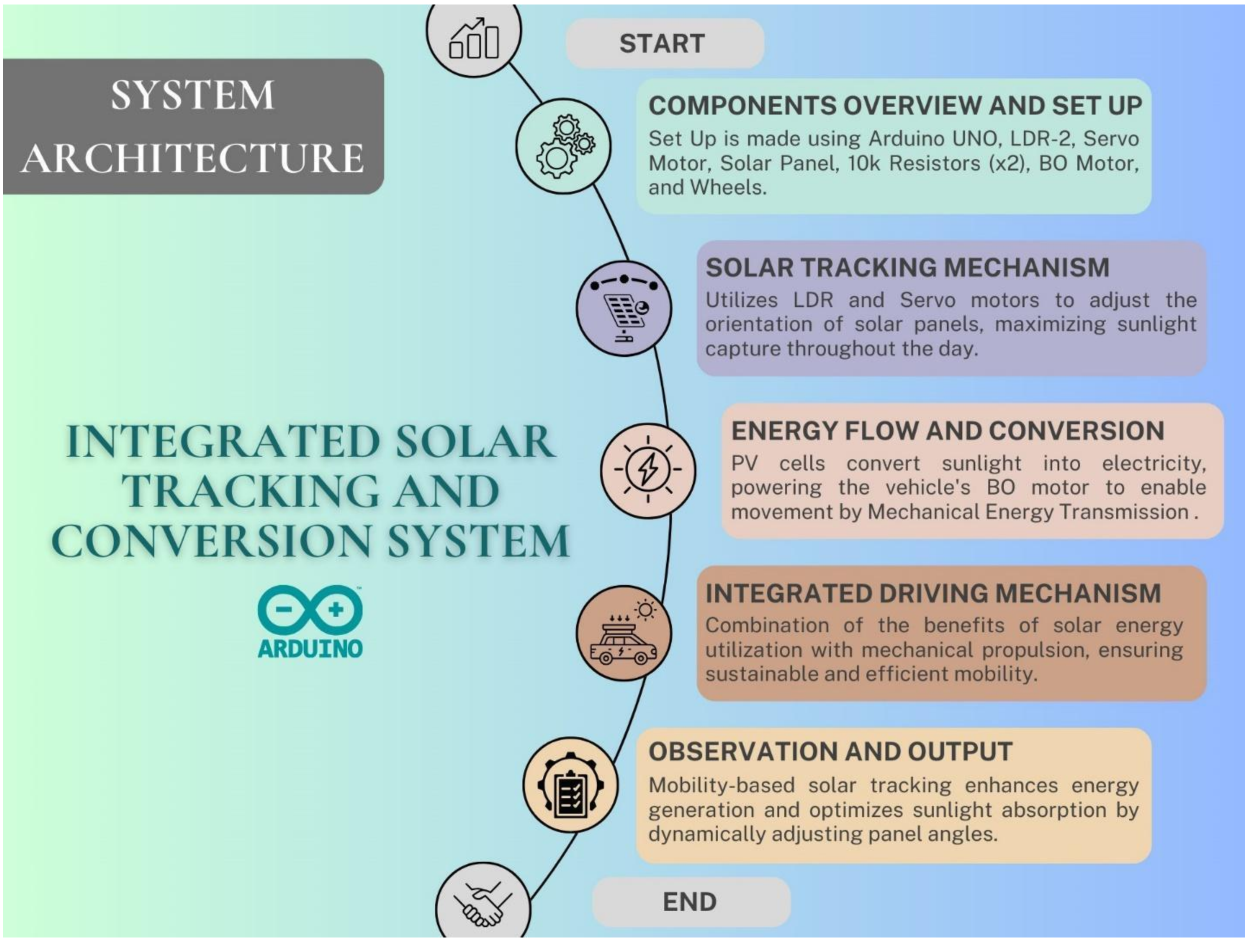


Figure 4.2 System Architecture

Solar Tracking Mechanism:

Sunlight intensity changes are detected by the LDRs and relayed to the Arduino UNO, which calculates the optimal tilt angle for the solar panel. The servo motor then adjusts the panel's orientation based on this input, ensuring it remains aligned with the sun's position. This dynamic tracking mechanism allows continuous adjustment of the panel's orientation throughout the day, optimizing energy capture. Real-time monitoring and adjustment ensure efficient solar tracking and maximum energy absorption.

Energy Flow and Conversion:

Sunlight captured by the solar panel is converted into electrical energy, powering both the servo motor for panel adjustment and the Arduino controller for system control. Additionally, surplus energy generated by the solar panel can be stored in batteries for later use, ensuring continuous operation even during periods of low sunlight intensity. Moreover, the system is designed to utilize the energy directly from the tracked sunlight intensity, maximizing energy utilization efficiency.

Integrated Driving Mechanism:

PV cells convert sunlight into electricity, powering the vehicle's BO motor to enable movement by Mechanical Energy Transmission. This motor drives the wheels of the vehicle, propelling it forward. The mechanical energy transmission mechanism ensures smooth and reliable movement, allowing the vehicle to operate solely on solar power. Combination of the benefits of solar energy utilization with mechanical propulsion, ensuring sustainable and efficient mobility. By harnessing the power of the sun, the vehicle reduces its reliance on traditional fossil fuels, minimizing environmental impact and promoting cleaner mobility.

Observation and Output:

Continuous monitoring of sunlight intensity changes allows real-time adjustment of the solar panel orientation for maximum energy capture. Increased energy output compared to fixed panels confirms the effectiveness of the solar tracking mechanism. The system's performance is observed and analyzed to optimize energy capture and utilization. This setup showcases the practical application of mobility-based solar tracking for enhanced solar energy utilization, contributing to sustainable energy solutions.

4.4 THE SOLAR TRACKING SYSTEM

A solar tracking system is an advanced technology designed to optimize the efficiency of solar panels by adjusting their orientation to follow the path of the sun throughout the day. Comprising light sensors, a microcontroller unit (MCU) such as Arduino, and servo motors, this system continuously monitors sunlight intensity and calculates the ideal tilt angle for the solar panels in real-time.

Light sensors, often Light Dependent Resistors (LDRs) or photodiodes, are strategically positioned to detect changes in sunlight intensity. They provide data on the sun's position relative to the solar panels, allowing the microcontroller to determine the optimal orientation for maximum sunlight exposure. Using sophisticated algorithms, the MCU processes this data and controls the servo motors to adjust the panels accordingly.

The primary advantage of a solar tracking system lies in its ability to significantly increase energy output compared to fixed solar panels. By continuously optimizing panel orientation to face the sun directly, the system captures a higher percentage of available sunlight throughout the day. This dynamic alignment leads to greater energy production, making solar tracking systems particularly beneficial for applications where maximizing energy generation is essential.

Solar tracking systems play a crucial role in advancing the adoption of solar energy. By maximizing energy capture and output, they contribute to greater overall efficiency and shorter payback periods for solar installations. As renewable energy becomes increasingly important in addressing climate change and transitioning to a more sustainable energy future, solar tracking systems represent a significant technological innovation in the renewable energy sector.

Furthermore, solar tracking systems are increasingly being integrated with smart grid technologies. This integration allows for better energy management and distribution, ensuring that the energy generated is used most efficiently.

4.4.1 CIRCUIT CONNECTION OF SOLAR TRACKING SYSTEM

The Circuit Connection of Solar Tracking System is given as Block Diagram in Figure 4.3 followed by steps involved to ensure proper connection.

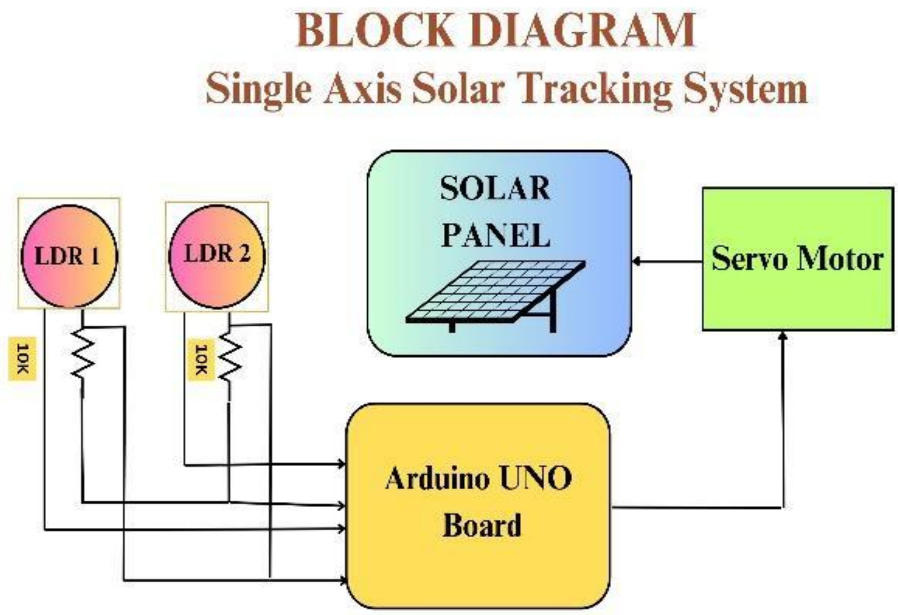


Figure 4.3 Circuit Connection of Solar Tracking System

Arduino UNO Connections:

- Connect the 5V pin of Arduino to the positive rail of the breadboard.
- Connect the GND pin of Arduino to the negative rail of the breadboard.
- Solar Panel Connection:
- Connect the positive terminal of the solar panel to the positive rail of the breadboard.
- Connect the negative terminal of the solar panel to the GND rail of the breadboard.

LDR Connections:

- Connect one leg of each LDR to an analog pin of the Arduino (e.g., A0 and A1).
- Connect the other leg of each LDR to the positive rail of the breadboard.

Resistor Connections:

- Connect one leg of each 10K resistor to the same row as the corresponding LDR.
- Connect the other leg of each resistor to the negative rail of the breadboard.

Servo Motor Connection:

- Connect the control wire of the servo motor to a PWM pin of the Arduino (e.g., pin 9).
- Connect the power wire of the servo motor to the 5V pin of the Arduino.
- Connect the ground wire of the servo motor to the GND pin of the Arduino.

BO Motor Connections:

- Connect the positive terminal of each BO motor to a digital pin of the Arduino (e.g., pins 2 and 3).
- Connect the negative terminal of each BO motor to the GND pin of the Arduino.

<u>Breadboard and Jumper Wires:</u>

- Use the breadboard to facilitate connections between components.
- Use male-to-male jumper wires to connect components to the breadboard.

4.4.2 WORKING OF SOLAR TRACKING SYSTEM

The working principle of a solar tracking system involves orienting solar panels or collectors towards the sun to maximize their exposure and energy generation throughout the day. Light sensors, such as light-dependent resistors (LDRs) or photodiodes, detect the sun's position relative to the panels.

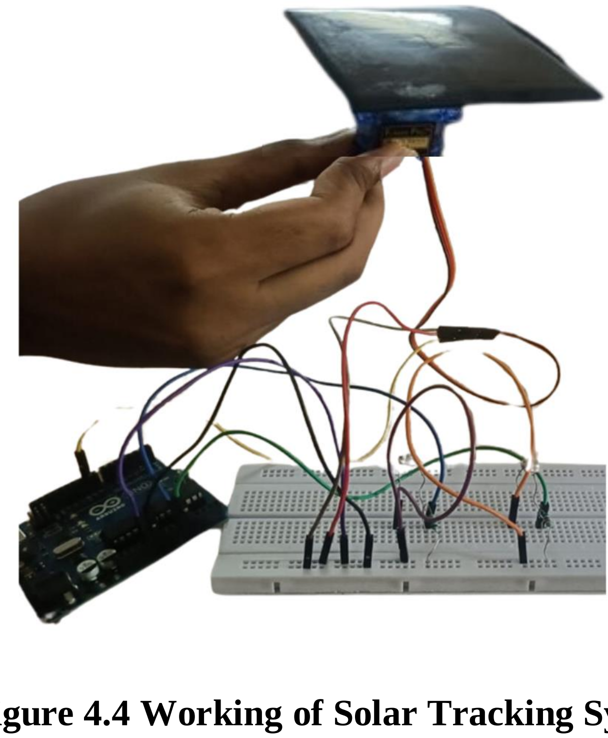


Figure 4.4 Working of Solar Tracking System

This information is then processed by a microcontroller, such as an Arduino, which controls the movement of actuators, typically servo motors, to adjust the orientation of the solar panels accordingly. By continuously tracking the sun's position, the system ensures that the panels are optimally aligned to receive maximum sunlight, thus increasing energy output. This automated adjustment significantly enhances the efficiency of solar energy capture compared to fixed installations, particularly in locations with varying sun angles throughout the day as shown in Figure 4.4.

Sunlight Detection: Light sensors, such as Light Dependent Resistors (LDRs) or photovoltaic cells, measure the intensity of sunlight.

Data Processing: The sensor data is collected and processed by a microcontroller, such as Arduino. The microcontroller analyzes the data to determine the position of the sun relative to the solar panels.

Calculation: Using algorithms based on the sun's position, time of day, and geographical location, the microcontroller calculates the optimal angle at which the solar panels should be oriented to receive maximum sunlight.

Orientation Adjustment: The microcontroller sends control signals to actuators, typically servo motors, attached to the solar panel mounts. These actuators adjust the orientation of the solar panels, tilting them to align with the calculated optimal angle.

Continuous Monitoring: Throughout the day, the microcontroller continues to monitor sunlight intensity and adjust the orientation of the solar panels in real-time to track the sun's movement across the sky.

Energy Harvesting: By continuously optimizing the orientation of the solar panels, the system maximizes the amount of sunlight absorbed by the panels, increasing energy harvesting efficiency.

Compile and Upload Code: Once the code is written, compile it within the Arduino IDE to check for any syntax errors or bugs. Once successfully compiled, upload the code to the Arduino UNO board using a USB cable.

Test and Calibration: After uploading the code, test the solar tracking system to ensure it functions as expected. This may involve placing the system in different lighting conditions to verify its ability to accurately track the sun. Fine-tune any parameters or calibration settings as needed to optimize performance.

4.5 ANGLE OF ROTATION OF SOLAR PANEL

In a single-axis solar tracking system, solar panels pivot around an east-west axis to track the sun's trajectory across the sky. Light sensors, such as Light Dependent Resistors (LDRs), detect sunlight intensity changes and relay data to a controller, like an Arduino. Using this information, the controller calculates the optimal tilt angle for the panels to maximize solar energy absorption. Servo motors or linear actuators adjust panel orientation accordingly. This process is facilitated by coding in Arduino IDE as shown in Figure 4.6, where algorithms interpret sensor data, compute optimal angles, and control servo motors to adjust panel orientation in real-time, ensuring efficient solar tracking throughout the day.

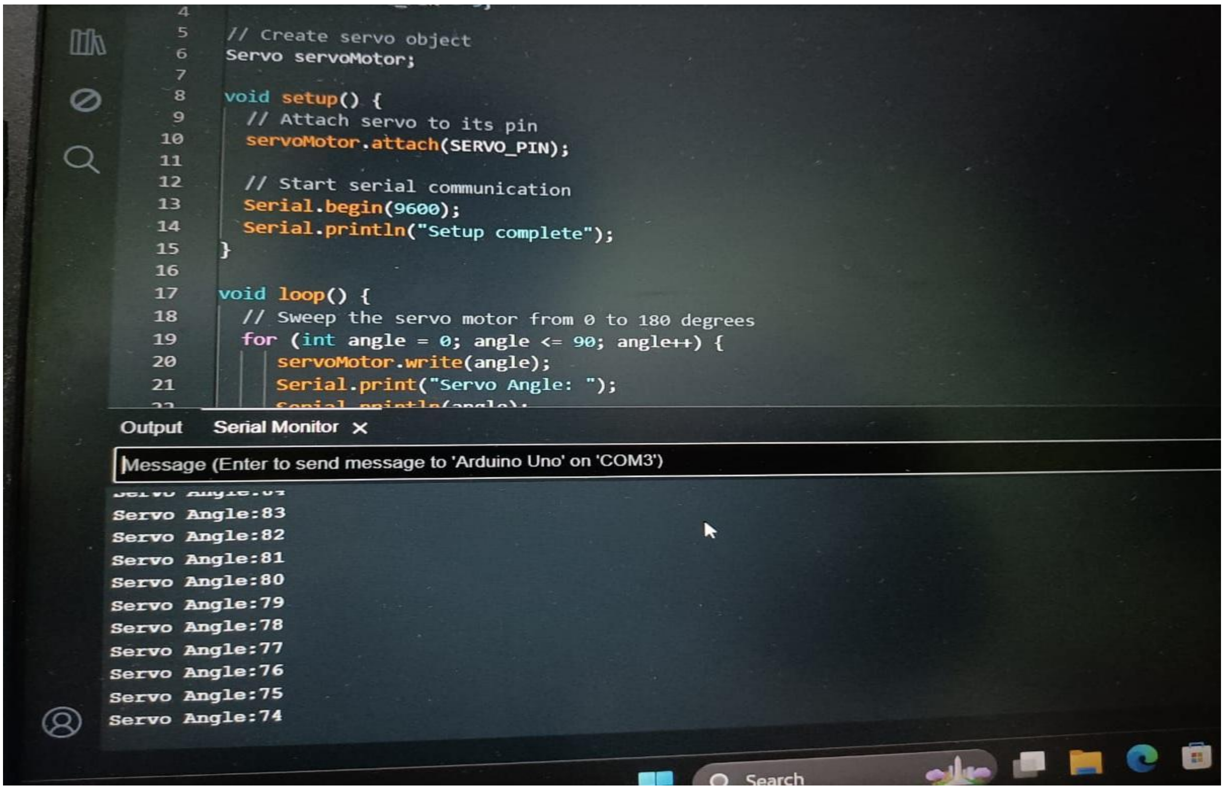


Figure 4.5 Angle of Rotation of Solar Panel

4.6 OBSERVATION OF SUNLIGHT INTENSITY

In the observation of sunlight intensity, two Light Dependent Resistors (LDRs) are strategically placed to capture variations in light intensity. These LDRs serve as sensors to detect changes in sunlight levels throughout the day. Connected to an Arduino microcontroller, the LDRs provide input data that reflects the intensity of sunlight falling on them. By comparing the readings from both LDRs, the Arduino can determine the direction of the sunlight and calculate the optimal orientation for solar panels. This information is crucial for ensuring accurate solar tracking and maximizing energy absorption. In the Arduino code, the output from the LDRs is processed and displayed as shown in Figure 4.6, allowing users to monitor sunlight intensity levels in real-time and verify the system's performance.

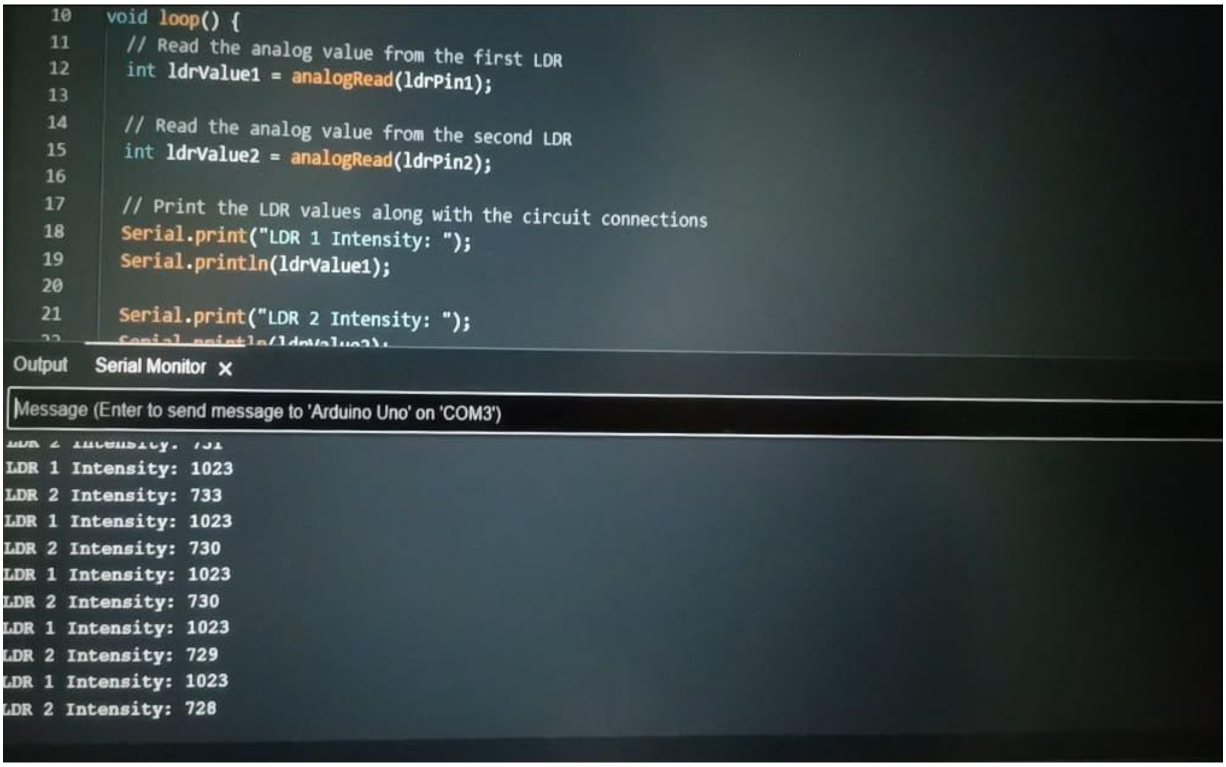


Figure 4.6: Observation of Sunlight Intensity

4.7 THE SOLAR POWERED CAR

The cutting-edge idea of a solar-powered car represents the innovative conversion of solar energy into a versatile and practical application. Unlike traditional gasoline-powered vehicles, solar-powered cars harness energy directly from sunlight, offering a sustainable and environmentally friendly mode of transportation. At the heart of this concept are photovoltaic cells integrated into the car's roof or body, which efficiently convert sunlight into electricity. This electricity powers an electric motor, propelling the vehicle forward without relying on fossil fuels.

By seamlessly integrating solar panels into the car's design, maximum exposure to sunlight is achieved, ensuring optimal energy capture. This innovative approach not only reduces the vehicle's carbon footprint but also offers significant long-term benefits, such as zero emissions and reduced dependence on finite fossil fuel resources. While solar-powered cars may currently have limitations in terms of range and speed compared to conventional vehicles, ongoing advancements in technology are rapidly addressing these challenges.

As solar cell efficiency improves and battery technology advances, solar-powered cars hold the promise of becoming more practical and mainstream in the future. With continued research and development, these vehicles have the potential to revolutionize transportation, offering clean, sustainable mobility solutions that contribute to a greener planet. The concept of solar-powered cars exemplifies the convergence of renewable energy and automotive innovation, paving the way for a brighter and more sustainable future.

4.7.1 WORKING OF INTEGRATED SOLAR POWERED CAR

The working of a solar-powered car revolves around the efficient utilization of solar energy to drive its propulsion system. Here's how it operates

1. Sunlight Detection with LDRs

The Light-Dependent Resistors (LDRs) serve as sensors to detect changes in sunlight intensity as the sun moves throughout the day. These variations are crucial for tracking the sun's movement and optimizing energy capture.

2. Orientation Adjustment with Servo Motor

Utilizing inputs from the LDRs, the Arduino UNO calculates the optimal orientation angle for the Solar Panel. The Servo Motor then adjusts the Solar Panel's position accordingly to maximize sunlight exposure, ensuring efficient energy conversion.

3. Solar Panel Operation

The Solar Panel, acting as the primary energy source, converts sunlight into electrical energy (DC) through the photovoltaic effect. This energy forms the backbone of the car's power system, providing the necessary electricity to drive its components.

4. Motor Control and Propulsion

Controlling the speed and direction of the vehicle, the Arduino UNO regulates the BO Motor based on the inputs from the LDRs. The motor converts electrical energy into mechanical energy, propelling the car forward or backward, depending on the desired direction.

5. Continuous Monitoring and Adjustment

Throughout its operation, the system continuously monitors sunlight intensity using the LDRs. By adjusting the orientation of the Solar Panel, the car ensures maximum energy capture, enabling it to operate efficiently under varying sunlight conditions.

4.8 INTEGRATION AND CONVERSION SYSTEM

The integration and conversion system encompass the mechanisms and technologies that facilitate the seamless integration of solar energy harvesting and propulsion systems. This innovative concept combines the efficiency of solar tracking technology with the mobility of a solar-powered vehicle, offering numerous benefits and advantages. At the core of the integration and conversion system is the Solar Tracking System itself, which optimizes solar panel efficiency by dynamically adjusting their orientation to follow the sun's path. This technology ensures that the solar panels continuously receive maximum sunlight exposure, thereby maximizing energy production. By integrating this system into a solar-powered car, the vehicle can harness solar energy more efficiently, extending its range and reducing its reliance on conventional energy sources. The conversion aspect of the system involves transforming solar energy into usable electrical power to drive the vehicle's propulsion system. Solar panels on the car's surface capture sunlight and convert it into direct current (DC) electricity. This electricity is then fed into a conversion system, which typically consists of a charge controller and a battery storage system. The charge controller regulates the flow of electricity from the solar panels to the batteries, ensuring optimal charging rates and preventing overcharging or damage to the batteries. The battery storage system stores the excess energy generated by the solar panels for later use, providing a reliable power source for the vehicle's propulsion system.

One of the primary advantages of integrating a solar tracking system into a solar-powered car is the significant increase in energy efficiency and range. By continuously optimizing solar panel orientation to capture maximum sunlight, the system maximizes energy production, allowing the vehicle to travel longer distances without requiring external charging. This extended range makes the solar-powered car more practical and versatile, particularly for long-distance travel or off-grid applications.

Additionally, the integration of solar tracking technology enhances the environmental sustainability of the solar-powered car. By relying on clean, renewable solar energy for propulsion, the vehicle produces zero emissions during operation, reducing its carbon footprint and environmental impact. This eco-friendly approach aligns with sustainable transportation initiatives and contributes to efforts to combat climate change. Furthermore, the integration and conversion system offers the potential for cost savings and energy independence. By generating its own electricity from sunlight, the solar-powered car reduces dependence on fossil fuels and grid-based electricity, lowering fuel costs and utility bills. This energy independence provides greater flexibility and resilience, particularly in remote or off-grid locations where access to traditional energy sources may be limited or unreliable.

The integration and conversion system in a solar tracking solar-powered car project offer numerous benefits and advantages, including increased energy efficiency, extended range, environmental sustainability, cost savings, and energy independence. By harnessing the power of the sun for propulsion, these innovative vehicles represent a promising solution for sustainable transportation and energy management in the 21st century. Significance and application involved in efficient integration and conversion system are as follows

Efficiency Enhancement: Strategies employed to optimize energy conversion and utilization efficiency are meticulously detailed. These encompass energy management algorithms aimed at maximizing energy harvesting and minimizing wastage. Additionally, the report discusses the incorporation of lightweight materials, aerodynamic designs, and energy-efficient components to bolster the overall performance of the integrated system.

Synergy and Coordination: An exploration of the symbiotic relationship between the solar tracking system and the solar car underscores their collective functionality enhancement. The report elucidates how real-time data from the solar tracking system informs operational and navigation decisions, ensuring optimal sunlight exposure for charging and operation of the mini solar car.

Practical Applications: The report extrapolates potential real-world applications and benefits of the integrated solar tracking system with the solar car. It articulates advantages such as reduced environmental impact, energy independence, and enhanced mobility in remote or off-grid locations.

CHAPTER 5

RESULTS AND DISCUSSION

SIMULATED OUTPUT OF SOLAR TRACKING SYSTEM

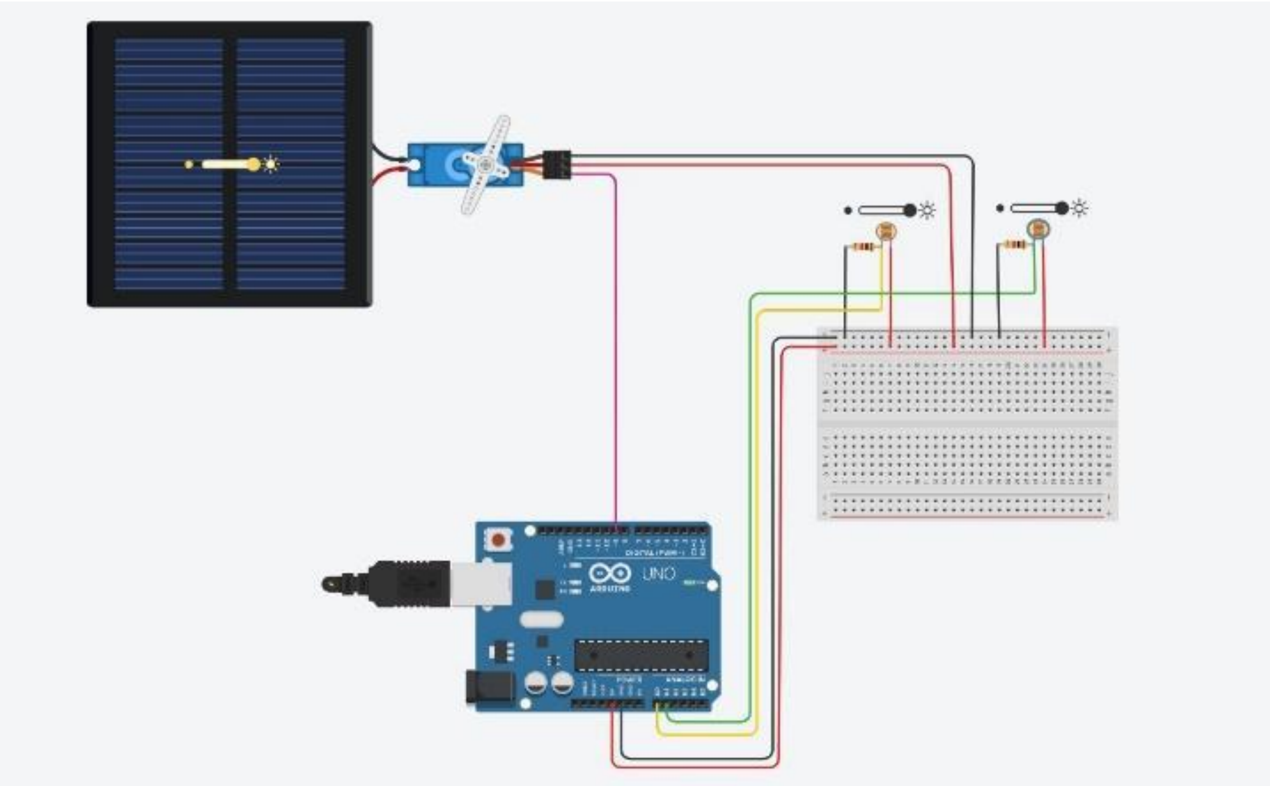


Figure 5.1 Simulated Output of Solar Tracking System

The simulated output of a solar tracking system as shown in Figure 5.1, typically involves visualizing the movement of solar panels in response to changing sunlight conditions throughout the day. Using simulation like Tinkercad, the system can demonstrate how the solar panels adjust their orientation to maximize sunlight exposure and energy capture. In the integrated solar car, the output of the solar tracking system is visualized through the dynamic movement of the solar panels mounted on the vehicle. As the car moves, the solar panels adjust their orientation in real-time to optimize sunlight capture. This functionality ensures that the car maximizes its energy efficiency and extends its range by continuously tracking the sun's position.

OUTPUT OF INTEGRATED SOLAR TRACKING AND CONVERSION SYSTEM TO A SOLAR POWERED CAR

The output of integrating a solar tracking and conversion system into a solar-powered car yields a holistic solution for sustainable transportation. By seamlessly merging solar tracking technology with the propulsion system of the vehicle, the car as shown in Figure 5.2,becomes self-sufficient in harnessing renewable solar energy for its operation. The integrated system ensures optimal alignment of the solar panels with the sun's position throughout the day, maximizing energy capture and efficiency. This leads to extended range and reduced dependency on non-renewable energy sources, contributing to lower operating costs and environmental impact. Moreover, the integration facilitates autonomous operation, allowing the vehicle to adapt to varying sunlight conditions seamlessly.

The results of integrating a solar tracking and conversion system into a solar-powered car demonstrate enhanced energy efficiency, extended range, and reduced environmental impact. Future developments could focus on refining the system's tracking accuracy, optimizing energy storage capabilities, exploring alternative propulsion methods, enhancing user interface and control systems, and integrating with smart grid technologies for grid interaction and energy management. These advancements aim to further improve the sustainability, reliability, and practicality of solar-powered transportation solutions, paving the way for widespread adoption and a greener automotive industry.

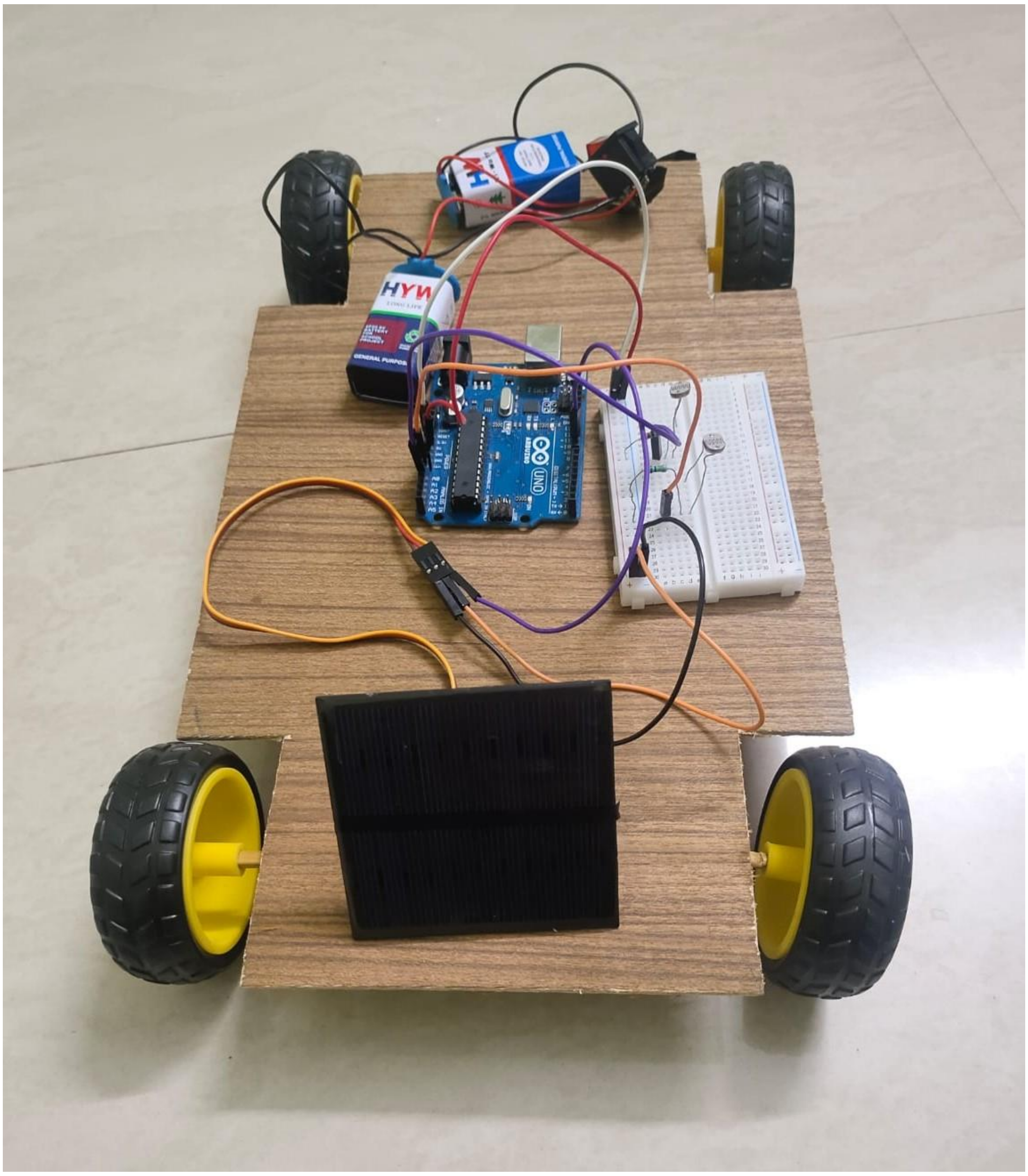


Figure 5.2 Output of integrated solar tracking and conversion system to a solar powered car

CHAPTER 6
CONCLUSION AND FUTURE SCOPE

The project has delved into the intricate realm of solar tracking systems and their integration into solar-powered cars, advocating for sustainable energy solutions. Beginning with an abstract exploration of solar tracking mechanisms and their significance in resource management, the journey traversed through system specifications, architecture, and methodological implementations. The proposed method outlined the intricacies of the solar tracking system, the operation of solar panels, and the integration with a solar-powered car, highlighting the potential of renewable energy sources for mobility. Through rigorous testing and discussion, the project underscored the efficacy of these systems in enhancing energy efficiency and reducing environmental impact.

The project shows significant success in integrating a solar-powered car with a solar tracking system, establishing a seamless connection between them. Through our programming efforts, we've achieved the capability for the solar panel to dynamically adjust its angle to optimize sunlight capture. Additionally, we've implemented functionality to monitor sunlight intensity, enabling intelligent adjustments throughout the day. This integration represents a substantial advancement in sustainable transportation. It empowers solar-powered vehicles to effectively utilize advanced solar tracking technology, enhancing efficiency and environmental friendliness.

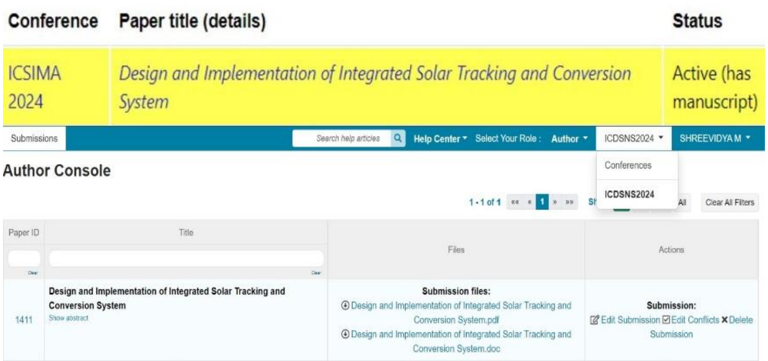
Future developments could focus on refining the system's tracking accuracy, optimizing energy storage capabilities, exploring alternative propulsion methods, enhancing user interface and control systems, and integrating with smart grid technologies for grid interaction and energy management. Exploring alternative propulsion methods, such as electric motors or hydrogen fuel cells, offers versatility and efficiency improvements, catering to diverse transportation needs. Enhancements in user interface and control systems make solar-powered vehicles more accessible and user-friendly, promoting wider adoption among consumers. Integrating with smart grid technologies enables dynamic energy management and grid interaction, facilitating efficient energy utilization and grid stabilization. These advancements collectively contribute to reducing greenhouse gas emissions, mitigating environmental impact, and fostering a greener automotive industry. These advancements aim to further improve the sustainability, reliability, and practicality of solar-powered transportation solutions, paving the way for widespread adoption and a greener automotive industry. This not only contribute to reducing greenhouse gas emissions and mitigating environmental impact but also pave the way for a greener and more sustainable automotive industry.

APPENDIX I

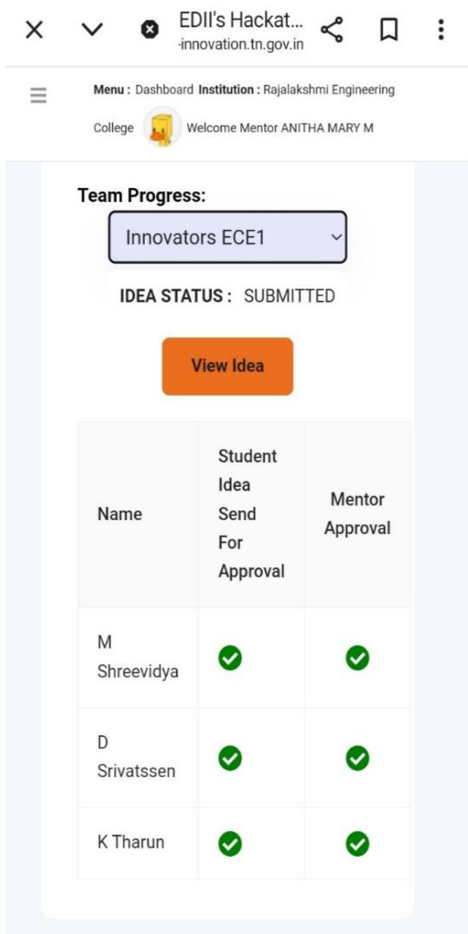
LIST OF PUBLICATIONS

1. Applied paper titled "Design and Implementation of Integrated Solar Tracking and Conversion System" in *2024 IEEE 10th International Conference on Smart Instrumentation, Measurement and Applications (ICSIMA)*".
2. Applied paper titled "Design and Implementation of Integrated Solar Tracking and Conversion System" in *2024 IEEE International Conference on Data Science and Network Security (ICDSNS)*".
3. Submitted an idea titled "Integrated Solar Tracking and Conversion System in EDII- TN's HACKATHON 2023-2024.

INTERNATIONAL CONFERENCE
Paper Submission (2)



EDII-TN's HACKATHON
Idea Submission



4. Submitted an idea titled " Integrated Solar Tracking and Conversion System" in AICTE "The Invertors Challenge 2024".

AICTE "The Inventors Challenge 2024" – Idea Submission Authorization Letter

RAJALAKSHMI ENGINEERING COLLEGE
An AUTONOMOUS Institution
Affiliated to ANNA UNIVERSITY, Chennai

Authorization letter for participation in "The Inventors Challenge 2024"

To whom so ever it may concern

Subject: Authorization of Participants for "The Inventors Challenge 2024" jointly organized by All India Council for Technical Education (AICTE), Arm Education and ST Microelectronics.

I hereby certify/authorize that the below listed faculty and students are enrolled in our institution

RAJALAKSHMI ENGINEERING COLLEGE

Name of the Faculty	Designation	E-mail	Department
Ms. M. Anitha Mary	M.Tech., Assistant Professor (SS)	anithamary.m@rajalakshmi.edu.in	Department of ECE

Students' Name	Degree	Current Year/Semester	E-mail	Department
1. K THARUN	B.E., ECE	2024/VI	210801224@rajalakshmi.edu.in	Electronics and Communication Engineering
2. D SRIVATSSEN	B.E., ECE	2024/VI	210801213@rajalakshmi.edu.in	Electronics and Communication Engineering
3. M.SHREEVIDYA	B.E., ECE	2024/VI	210801194@rajalakshmi.edu.in	Electronics and Communication Engineering

Name of the idea: **INTEGRATED SOLAR TRACKING AND CONVERSION SYSTEM**

Abstract of the Idea: The integration of a solar car with a solar tracking system enhances energy efficiency and mobility. The system utilizes Light-Dependent Resistors (LDRs) and a servo motor to track the sun's movement and adjust the solar panels' azimuth position accordingly. By incorporating Arduino technology, the system offers flexibility for customization and integration with other systems. The integration of a solar car adds mobility to the tracking mechanism, creating a sustainable mode of transportation powered by renewable energy. The project involves hardware integration, software development, testing, and optimization to ensure safety, efficiency, and compliance with regulations. This innovative solution contributes to improving solar energy harvesting efficiency, making it suitable for small-scale solar power applications while offering opportunities for learning and innovation in renewable energy and vehicle design.

AN AUTONOMOUS INSTITUTION

Institute Seal HOD Name: Dr. L. BHAGYALAKSHMI, M.E.,Ph.D.,

HOD Signature :

Date : 30.4.24

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Rajalakshmi Institutions

APPENDIX II

CERTIFICATE FOR PRESENTATION

RAJALAKSHMI ENGINEERING COLLEGE
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Affiliated to ANNA UNIVERSITY, Chennai

IEEE ComSoc
IEEE Communications Society

INSTITUTION'S INNOVATION COUNCIL
(Ministry of HRD Initiative)

AICTE IDEALab

CERTIFICATE OF APPRECIATION

This is to certify that ~~Mr.~~ / Ms. SHREEVIDYA.M of III Year ECE Department , has successfully presented a project in

"DESIGN-A-THON '24"

an Interdepartmental Two week project contest organized by Department of Electronics and Communication Engineering in association with Designers Consortium of Rajalakshmi Engineering College, Chennai on 16.03.2024.

Dr.R.Gayathri
Chief Coordinator
Design A Thon'24

Dr.M.Palanivelan
Convenor
Designers Consortium

Dr.S.N.Murugesan
Principal
Rajalakshmi Engineering College

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IEEE ComSoc
IEEE Communications Society

INSTITUTION'S INNOVATION COUNCIL
(Ministry of HRD Initiative)

AICTE IDEALab

CERTIFICATE OF APPRECIATION

This is to certify that Mr. / ~~Ms.~~ SRIVATSSEN.D of III Year ECE Department , has successfully presented a project in

"DESIGN-A-THON '24"

an Interdepartmental Two week project contest organized by Department of Electronics and Communication Engineering in association with Designers Consortium of Rajalakshmi Engineering College, Chennai on 16.03.2024.

Dr.R.Gayathri
Chief Coordinator
Design A Thon'24

Dr.M.Palanivelan
Convenor
Designers Consortium

Dr.S.N.Murugesan
Principal
Rajalakshmi Engineering College

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IEEE ComSoc
IEEE Communications Society

INSTITUTION'S INNOVATION COUNCIL

IDEALab

CERTIFICATE OF APPRECIATION

This is to certify that Mr. / ~~Ms.~~ THARUN · K of III Year ECE Department , has successfully presented a project in

"DESIGN-A-THON '24"

an Interdepartmental Two week project contest organized by Department of Electronics and Communication Engineering in association with Designers Consortium of Rajalakshmi Engineering College, Chennai on 16.03.2024.

Dr.R.Gayathri
Chief Coordinator
Design A Thon'24

Dr.M.Palanivelan
Convenor
Designers Consortium

Dr.S.N.Murugesan
Principal
Rajalakshmi Engineering College

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RAJALAKSHMI ENGINEERING COLLEGE

DEPARTMENT OF ECE

PROGRAM OUTCOMES (POs)

Engineering Graduates will be able to:

PO1 Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2 Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3 Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4 Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5 Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO6 The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7 Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8 Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO9 Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10 Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11 Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12 Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PROGRAM SPECIFIC OUTCOMES (PSOs)

PSO1: An ability to carry out research in different areas of Electronics and Communication Engineering fields resulting in journal publications and product development.

PSO2: To design and formulate solutions for industrial requirements using Electronics and Communication engineering

PSO3: To understand and develop solutions required in multidisciplinary engineering fields.

COURSE OUTCOMES (COs)

CO1	Upskill in emerging technologies and apply to real industry-level use cases
CO2	Understand agile development process
CO3	Develop career readiness competencies, Team Skills / Leadership qualities
CO4	Develop Time management, Project management skills and Communication Skills
CO5	Use Critical Thinking for Innovative Problem Solving and develop entrepreneurship skills