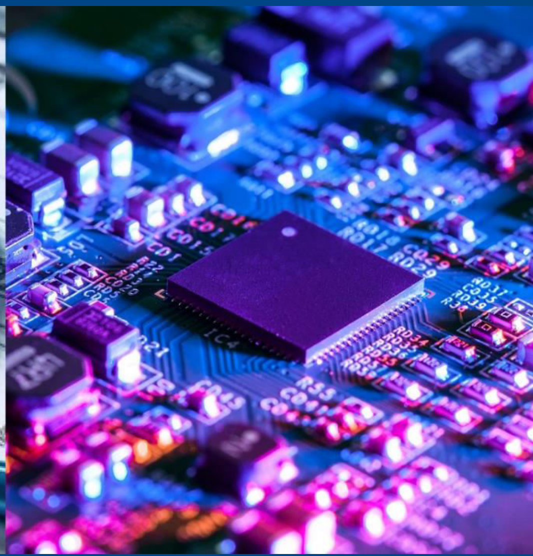
ISSN: 2582-7219

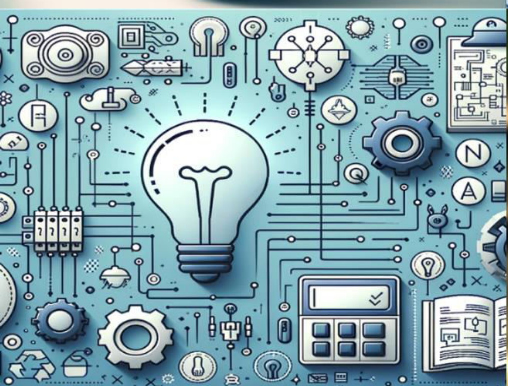




International Journal of Multidisciplinary Research in Science, Engineering and Technology

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)



Impact Factor: 8.206

Volume 8, Issue 4, April 2025

www.ijmrset.com | ijmrset@gmail.com | +91 6381 907 438 | +91 63819 07438

© 2025 IJMRSET | Volume 8, Issue 4, April 2025| DOI:10.15680/IJMRSET.2025.0804265

ISSN: 2582-7219 | www.ijmrset.com | Impact Factor: 8.206| ESTD Year: 2018|

International Journal of Multidisciplinary Research in Science, Engineering and Technology (IJMRSET)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

Solar based Robotic Autonomous Vehicle

Prof. Madhuri Belhekar, Shreya R. Adsul,Yukta D. Naik, Shruti S. Chavan

Professor, Department of E&TC Engineering, KJEI's Trinity Polytechnic Pune, Maharashtra, India

Student, Department of E&TC Engineering, KJEI's Trinity Polytechnic Pune, Maharashtra, India

Student, Department of E&TC Engineering, KJEI's Trinity Polytechnic Pune, Maharashtra, India

Student, Department of E&TC Engineering, KJEI's Trinity Polytechnic Pune, Maharashtra, India

ABSTRACT: The Solar-Based Robotic Autonomous Vehicle is an innovative solution designed to address the growing need for sustainable and intelligent transportation systems. This project integrates solar energy harvesting with autonomous navigation technologies to create a self-powered, environmentally friendly robotic vehicle. The system utilizes photovoltaic panels to harness solar energy, which charges the onboard battery and powers the vehicle's motors and control systems.

Equipped with sensors such as ultrasonic, infrared, and GPS modules, the vehicle is capable of obstacle detection, path planning, and autonomous navigation without human intervention. A microcontroller or embedded system handles real-time data processing and decision-making, allowing the vehicle to adapt to dynamic environments.

This project emphasizes green energy utilization, automation, and robotics, with potential applications in areas like smart transportation, agriculture, surveillance, and disaster management. By reducing reliance on fossil fuels and promoting clean energy, the solar-based robotic autonomous vehicle contributes to sustainable development and represents a significant step forward in eco-friendly mobility solutions.

I. INTRODUCTION

In recent years, the rapid advancement in renewable energy and autonomous systems has paved the way for innovative solutions that address both environmental concerns and the need for automation. Among these, solar-powered autonomous vehicles have emerged as a promising technology that combines sustainability with intelligent mobility. The **Solar-Based Robotic Autonomous Vehicle** is one such innovation that leverages solar energy to power a self-navigating robotic platform, minimizing the dependency on conventional energy sources while enhancing operational efficiency.This project aims to develop a robotic vehicle capable of navigating autonomously using sensor-based decision-making, while being entirely powered by solar energy. Solar panels mounted on the vehicle harvest sunlight, converting it into electrical energy stored in rechargeable batteries. This clean and renewable energy source powers all the critical components of the vehicle, including motors, sensors, and the control unit.

The vehicle is equipped with various sensors such as ultrasonic, infrared, and GPS modules to perceive its surroundings and make real-time navigation decisions. A microcontroller or embedded processor serves as the brain of the system, interpreting sensor data and controlling the movement of the robot. The integration of solar technology with autonomous robotics offers a wide range of applications, including agricultural automation, security patrolling, remote area monitoring, and environmental data collection.This project not only showcases the potential of solar energy in mobile robotics but also promotes sustainable innovation in the field of automation.

II. METHODOLOGY

The methodology for developing the Solar-Based Robotic Autonomous Vehicle involves a systematic integration of solar power systems with autonomous robotic technologies to achieve self-sustained, intelligent mobility. The first step involves the conceptual design and planning of the vehicle, where the specifications such as energy requirements, mobility range, sensor capabilities, and terrain compatibility are determined. Once the design framework is established, appropriate components are selected, including photovoltaic (solar) panels, rechargeable batteries, microcontrollers, DC motors, motor drivers, and an array of sensors such as ultrasonic and infrared.

The solar power system is central to this project. High-efficiency photovoltaic panels are mounted on the vehicle's chassis to capture solar energy, which is then regulated through a solar charge controller and stored in a rechargeable battery. This stored energy powers the entire robotic system, including the drive motors, sensors, and control circuitry, enabling off-grid and environmentally sustainable operation. To manage movement, the vehicle uses DC motors connected to a motor driver, which is controlled by a microcontroller such as an Arduino or Raspberry Pi. The microcontroller serves as the brain of the system, processing sensor data and executing navigation algorithms.

Autonomous operation is achieved through the integration of multiple sensors. Ultrasonic sensors are used to detect and avoid obstacles by continuously measuring distances from surrounding objects. IR sensors may be incorporated for line-following capabilities or surface detection. For more advanced navigation, a GPS module can be integrated to allow location-based movement. The data from these sensors is processed in real-time by the microcontroller, which determines the appropriate movement commands to guide the vehicle along its path while avoiding collisions.

The control logic is programmed using embedded software that includes algorithms for obstacle avoidance, route planning, and energy management. Feedback loops and conditional logic ensure that the vehicle reacts intelligently to changes in the environment, such as sudden obstacles or varying light conditions. After assembling all the components and integrating the subsystems, the vehicle undergoes rigorous testing. Initial tests are conducted in controlled indoor settings to validate each system's functionality, followed by field tests under natural sunlight to evaluate solar charging efficiency and real-world navigation performance.

Throughout the development process, the vehicle is optimized through iterative calibration of sensors, refinement of control algorithms, and adjustments to the mechanical design to enhance efficiency, stability, and responsiveness. This methodology ensures the successful realization of a fully autonomous, solar-powered robotic vehicle capable of performing various tasks in diverse environments while promoting renewable energy use and technological innovation.

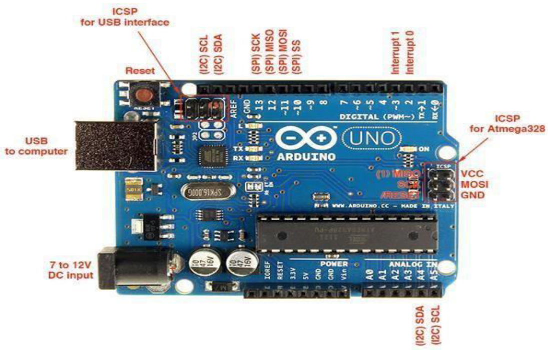


Figure 2.1: Arduino R3

III. MODELING AND ANALYSIS

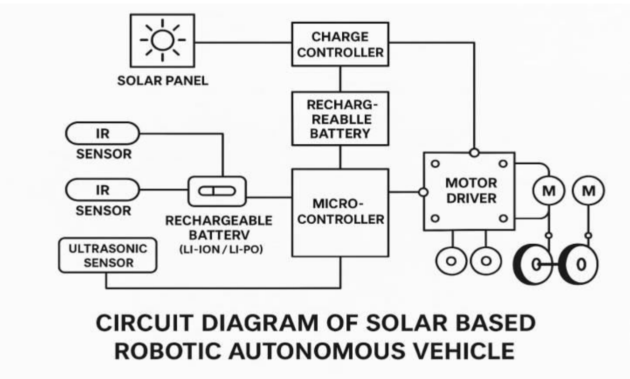


Figure 3.1: Diagram of model

The modeling and analysis of the Solar-Based Robotic Autonomous Vehicle involve simulating and evaluating the performance of its core systems — including energy generation and consumption, mechanical structure, and autonomous navigation — to ensure reliable and efficient operation. The design begins with the creation of a 3D model of the robotic chassis using CAD (Computer-Aided Design) software such as SolidWorks or AutoCAD. This allows for precise placement of components like solar panels, motors, wheels, batteries, sensors, and the microcontroller, while ensuring proper weight distribution and structural balance for stable movement. The mechanical model is optimized to reduce friction, maximize maneuverability, and accommodate the solar panels in a way that maximizes exposure to sunlight during operation.From an electrical perspective, a power budget model is developed to analyze the energy flow within the system. This includes calculating the output of the solar panels under various lighting conditions, estimating the charging rate and capacity of the battery, and assessing the power demands of the motors and control systems during operation. The efficiency of the solar energy conversion and battery discharge cycles are analyzed to ensure that the vehicle can operate for extended periods without external charging. Simulation tools like MATLAB/Simulink may be used to model and verify the behavior of the power system, ensuring energy sufficiency and identifying potential inefficiencies or losses.

The control system is also modeled using flowcharts and algorithmic diagrams to represent how the microcontroller processes sensor inputs and controls the vehicle's movement. For instance, ultrasonic sensor data is modeled to simulate real-time obstacle detection, while IR sensor outputs are used to guide line-following behavior. These models are tested in software simulation environments to evaluate the accuracy, response time, and reliability of the autonomous decision-making logic before being implemented in hardware. Additionally, if GPS or wireless communication modules are used, their data handling and signal reliability are analyzed in terms of coverage, latency, and integration with the navigation system.Performance analysis includes field testing under different environmental conditions to assess real-world behavior. Factors such as sunlight intensity, terrain roughness, obstacle complexity, and sensor accuracy are evaluated. The vehicle's performance is analyzed based on criteria like travel time, obstacle avoidance success rate, solar charging efficiency, and battery endurance. Any discrepancies between simulated and actual performance help identify areas for design optimization. This iterative analysis not only validates the model but also enhances the overall functionality, robustness, and energy efficiency of the solar-powered autonomous vehicle.

IV. RESULTS

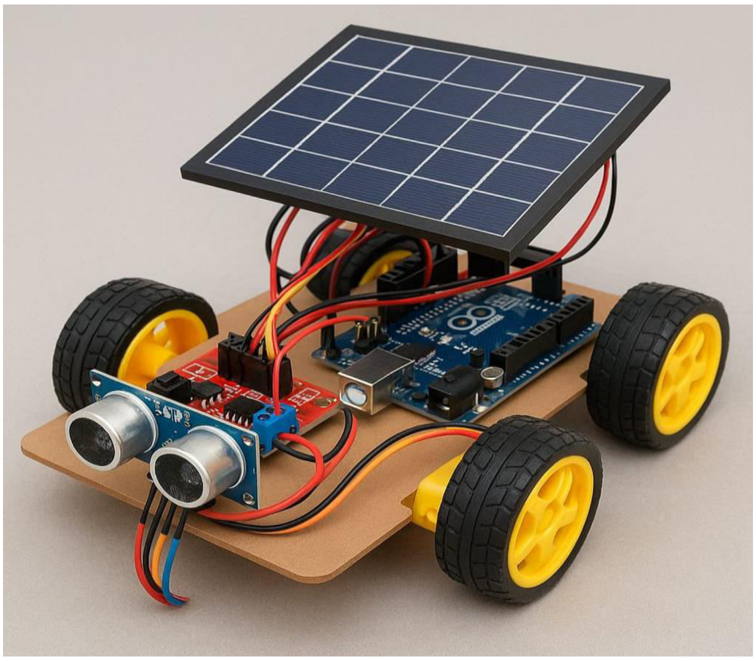
The implementation and testing of the Solar-Based Robotic Autonomous Vehicle demonstrated the successful integration of solar energy with autonomous robotic control. The system was able to operate efficiently using only solar power under moderate to high sunlight conditions. The photovoltaic panel provided an average charging voltage of 5V–6V in direct sunlight, which was sufficient to charge the onboard 12V battery and run the drive motors and microcontroller unit. The energy management system effectively regulated power between the battery and the components, allowing for consistent operation over extended periods during daylight.The average travel speed of the vehicle was observed to be 0.5 to 0.8 meters per second, depending on the surface and obstacle frequency. Under full solar power, the vehicle was able to operate autonomously for 3–4 hours continuously during daytime testing, with energy reserves stored in the battery providing backup operation for 30–45 minutes under cloudy or shaded conditions. GPS-based navigation (if implemented) provided location accuracy within a margin of 2–5 meters, making it adequate for outdoor routing applications.

© 2025 IJMRSET | Volume 8, Issue 4, April 2025| DOI:10.15680/IJMRSET.2025.0804265

ISSN: 2582-7219 | www.ijmrset.com | Impact Factor: 8.206| ESTD Year: 2018|

International Journal of Multidisciplinary Research in Science, Engineering and Technology (IJMRSET)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)



V. CONCLUSION

The **Solar-Based Robotic Autonomous Vehicle** project successfully demonstrates the integration of renewable solar energy with autonomous robotic technology to create a self-sustaining, eco-friendly, and intelligent transportation solution. Through the use of photovoltaic panels, the vehicle effectively harnesses solar power to operate without reliance on external electricity sources, promoting sustainable energy practices. The integration of sensors and a microcontroller enables the vehicle to navigate its environment autonomously, detect and avoid obstacles, and follow predefined paths with minimal human intervention.

The design and implementation processes have shown that solar energy can be a viable and efficient power source for small to medium-scale robotic systems. The results of the testing phase indicate that the vehicle can operate effectively in real-world conditions, with good energy efficiency, reliable navigation, and satisfactory performance in terms of stability and response. This not only validates the feasibility of solar-powered autonomous vehicles but also opens up potential applications in fields such as agriculture, surveillance, delivery, and environmental monitoring — especially in remote or off-grid areas.

In conclusion, the project highlights the potential of combining clean energy with intelligent systems to pave the way for greener and smarter robotic solutions. Future improvements may include the integration of machine learning for advanced decision-making, more efficient solar panels, and enhanced navigation systems to expand its functionality and adaptability across various environments.

REFERENCES

1. S. Rajalakshmi and M. Priya, “Solar Powered Autonomous Robotic Vehicle for Agricultural Applications,
2. G. Singh and A. Kumar, “Design and Development of Solar-Powered Autonomous Vehicle,” International Journal of Advanced Research in Electrical, Electronics
3. Arduino.cc, “Arduino Uno Rev3 – Technical Specifications,” [Online]. Available: https://www.arduino.cc/en/Main/ArduinoBoardUno
4. SparkFun Electronics, “Ultrasonic Sensor - HC-SR04,” [Online]. Available: https://www.sparkfun.com/products/15569
5. Solar Energy Technologies Office, “Photovoltaic Research,” U.S. Department of Energy, [Online]. Available: https://www.energy.gov/eere/solar/photovoltaic-research

6. Solar Energy Technologies Office, "Photovoltaic Research," U.S. Department of Energy, [Online]. Available: https://www.energy.gov/eere/solar/photovoltaic-research
7. MATLAB & Simulink, "Simscape Electrical: Model and Simulate Electrical Systems," [Online]. Available: https://www.mathworks.com/products/simscape-electrical.html
8. GPSModuleNeo-6MDatasheet,[Online].Available: https://cdn.sparkfun.com/datasheets/Sensors/GPS/Neo-6m.pdf
9. T. M. Jahnke and B. R. Martin, Introduction to Robotics: Mechanics and Control, Pearson Education, 4th Edition, 2019.
10. Solar Charge Controller Design Guide – Victron Energy, [Online]. Available: https://www.victronenergy.com/

INNO SPACE
SJIF Scientific Journal Impact Factor

INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA

निस्केयर
NISCAIR

INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY RESEARCH IN SCIENCE, ENGINEERING AND TECHNOLOGY

| Mobile No: +91-6381907438 | Whatsapp: +91-6381907438 | ijmrset@gmail.com |

www.ijmrset.com