IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

SOLAR POWERED PATH FOLLOWER ROBOT

Pavithra R[1]
Electrical & Electronics Engineering
Dept of EEE, BNMIT
Bengaluru,India

Jayanth G[2]
Electrical & Electronics Engineering
Dept of EEE, BNMIT
Bengaluru,India

Vinod kumar B J[3]
Electrical & Electronics Engineering
Dept of EEE, BNMIT
Bengaluru,India

Ms. Kruthi Jayaram[4]
Electrical & Electronics Engineering
Dept of EEE, BNMIT
Bengaluru,India

***Abstract*— The solar-powered path follower robot is an autonomous robotic system designed to navigate along a predefined path using solar energy as its primary power source. This paper focuses on the design, development, and evaluation of such a robot with the objective of achieving efficient and sustainable autonomous navigation. The paper begins with the integration of solar panels as the main source of energy generation. These panels capture sunlight and convert it into electrical energy, which is then regulated and managed by a solar power system. The system ensures optimal utilization of solar energy and continuous operation of the robot during daylight hours. Energy storage components such as batteries or capacitors are employed to store excess energy, allowing the robot to operate even when sunlight is not available. The path detection and navigation system in-corporates robust sensors and algorithms.**

Keywords: Solar PV panel, sensors, robot

I. INTRODUCTION

Solar-powered path follower robots are autonomous robots designed to navigate and follow a designated path using solar energy as their primary power source. These robots utilize solar panels to capture sunlight and convert it into electrical energy, which powers their onboard systems and allows them to move along the predefined path. The concept of solar-powered path follower robots combines two essential technologies: robotics and solar power. These robots are typically equipped with sensors, motors, and control systems that enable them to detect and track a specific path while adjusting their movements accordingly. They can be used for various applications, such as surveillance, monitoring, agricultural tasks, and even educational purposes. The key component of a solar-powered path follower robot is the solar panel or array of solar panels. These panels are strategically positioned on the robot's body to maximize sunlight absorption. They contain photovoltaic cells that convert solar energy into electrical energy.

The generated electricity is stored in batteries or capacitors, providing power to the robot's systems,

including its motors, sensors, and control circuits. To navigate along the path, the robot typically employs a combination of sensors and control algorithms. Common sensors used in path following robots include line-following sensors, infrared sensors, or even cameras. These sensors detect the path or markers on the ground and send signals to the control system, which adjusts the robot's movements accordingly. For instance, if the robot deviates from the path, the control system can activate the appropriate motors to steer the robot back onto the designated trajectory. Solar-powered path follower robots offer several advantages. First and foremost, they utilize renewable energy from the sun, reducing or eliminating the need for external power sources or frequent battery replacements. They are environmentally friendly, as they produce zero carbon emissions during operation. Moreover, solar-powered robots can operate for extended periods without manual intervention if there is sufficient sunlight available. This makes them ideal for applications in remote or off-grid locations. In summary, solar-powered path follower robots combine the concepts of robotics and solar energy to create autonomous robots capable of navigating along predefined paths. By harnessing the power of the sun, these robots can operate efficiently and sustainably, making them a promising solution for various industries and applications.

The mechanical design of the robot focuses on stability, durability, and integration with the solar panels, batteries, sensors, and control systems. The resulting compact and lightweight structure facilitates effective path-following tasks. Thorough testing and evaluation are conducted to assess the performance, energy efficiency, and accuracy of the solar-powered path follower robot. Results indicate the robot's ability to accurately follow the predefined path, utilize solar energy efficiently, and navigate effectively in diverse environmental conditions. Comparative analysis against existing systems or benchmarks highlights the advantages, limitations, and unique features of the developed robot. This paper contributes to the advancement of sustainable and environmentally friendly robotic systems by showcasing the feasibility and potential applications of solar-powered path follower robots. The findings and insights gained from this paper serve as a foundation for further research and development in this field, enabling the creation of more efficient and reliable autonomous navigation systems powered by renewable[1-4].

II. ANALYSIS OF THE DESIGN

Design and implement a solar-powered line following robot that can navigate a predefined path on the ground. The robot should use solar energy as its primary power source and should be capable of detecting and following a black line on a light-colored surface. The robot should be able to operate both indoors and outdoors, and it should be autonomous, requiring minimal human intervention.

1. Motor control techniques, power management algorithms, and low-power components. The objective is to maximize the robot's operational time using the available solar energy and minimize the need for external power sources or frequent battery replacements.
2. Robust Navigation and Obstacle Avoidance: Implement reliable path detection and navigation algorithms that enable the robot to accurately follow the predefined path while efficiently avoiding obstacles or disturbances along the way. The objective is to ensure safe and smooth navigation even in complex or dynamic environments.
3. Mechanical Design and Integration: Develop a robust mechanical structure for the robot that provides stability, durability, and ease of integration with solar panels, batteries, sensors, and control systems. The objective is to create a compact and lightweight robot that can effectively carry out its path-following tasks. Performance Evaluation and Validation: Conduct thorough testing and evaluation of the solar-powered path follower robot to assess its performance, energy efficiency, and accuracy in path following. The objective is to validate the effectiveness of the developed robot and compare its performance against predefined

A. WORKING PRINCIPLE

Solar Power System: Regulates and manages the solar energy generated by the panels, ensuring proper voltage and current levels. Energy Storage: Stores the generated electrical energy in batteries or capacitors, enabling the robot to operate even when sunlight is not available. Path Detection and Navigation Sensors: Includes various sensors like line-following sensors, infrared sensors, or cameras to detect and interpret the path markers or indicators. Motor Control System:
Controls the speed, direction, and movement of the robot's actuators (motors) based on the input from the path detection and navigation sensors. Control System: Coordinates and integrates the inputs from the path detection sensors and motor control system, ensuring accurate trajectory following and obstacle avoidance. Actuators: Responsible for physical movement and actuation of the robot, typically includes motors and other mechanisms necessary for locomotion[5-6].

B. BLOCK DIAGRAM

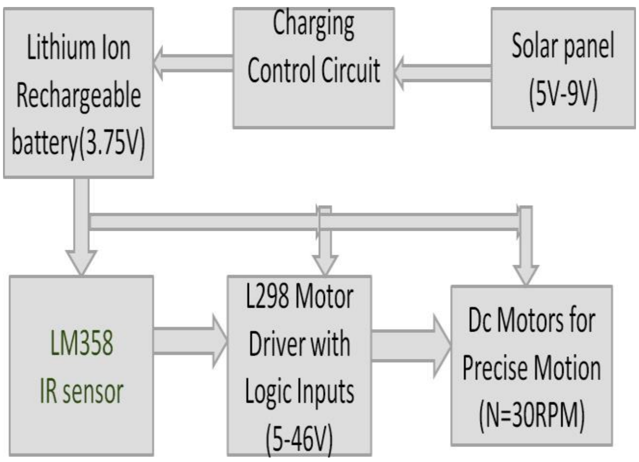


Figure 1. Block Diagram

C. HARDWARE COMPONETS

Solar Panel

Solar panels are made from photovoltaic cells that convert the sun's energy into electricity. Photovoltaic cells are sandwiched between layers of semi-conducting materials such as silicon. Each layer has different electronic properties that energise when hit by photons from sunlight, creating an electric field. This is known as the photoelectric effect – and this creates the current needed to produce electricity. Solar panels generate a direct current of electricity. This is then passed through an inverter to convert it into an alternating current, which can be fed into the National Grid or used by the home or business that the solarpanels are attached to.

Figure 2. Solar Panel

Li-ion Rechargeable Battery 1C (1200 mAh)

This module is a 3S 10A Lithium-Ion BMS module. Here 3S refers to 3 x 3.7 = 11.1V, that is 3 Li- ion Batteries connected in Series.

This is an original 1200mAh 18650 battery. 18650 battery is a Li-ion rechargeable battery with a 1200 mAh Battery Capacity. This is not a standard AA or AAA battery but is very useful for applications that require continuous high current or high current in short bursts like in cameras, DVD players, iPod, etc. A 18650 cell can be charged and discharged up to 1000 cycles without much loss in battery capacity. They are safe to use, environment friendly and have long battery life. It comes with high energy density and provides excellent continuous power sources to your device. It should be used with a protection circuit board that guards the battery against over-charge, over-discharge of the pack, and avoid over-current drawn.

SPECIFICATIONS:

- Voltage: 3.7 Volts
- Capacity: 1200 mAh
- Rechargeable: Yes
- Battery Size: Diameter- 18mm x Length- 67mm
- Charging Method CC-CV
- Brand: Hongli ICR18650

APPLICATIONS:

- Cordless Phones
- Small DRONES
- Tablet PC GPS
- iPod, DVD, MP4 Player, etc
- Mobiles backup power supply/Power bank

Charging Lithium - Ion Battery with Solar Cell

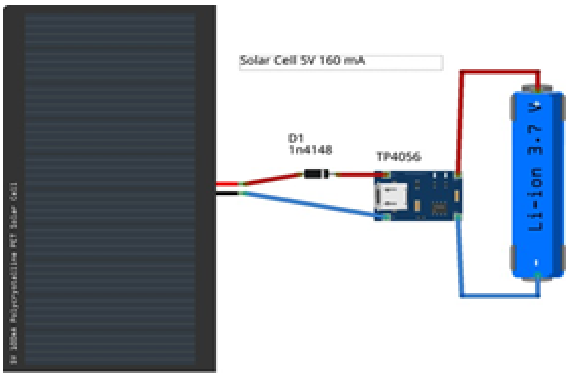


Figure 3. charging solar cell

Charging a lithium-ion battery via solar energy involves utilizing solar panels or photovoltaic cells to capture sunlight and convert it into electrical energy. This electrical energy is then used to charge the lithium-ion battery, providing it with the necessary power for various applications, such as a solar-powered path follower robot. The process of charging a lithium-ion battery with solar energy typically involves the following steps: Solar Panel Integration: Solar panels, consisting of multiple photovoltaic cells, are integrated into the charging system. These solar panels are designed to capture sunlight and convert it into DC (direct current) electrical energy. 2. Solar Energy Conversion: The captured sunlight is converted into electrical energy through the photovoltaic effect.

The photovoltaic cells within the solar panels contain semiconductors that release electrons when exposed to sunlight, creating a flow of electric current.

The process of charging lithium-ion battery with solar energy typically involves the following steps:

Solar Panel Integration: Solar panels, consisting of multiple photovoltaic cells, are integrated into the charging system. These solar panels are designed to capture sunlight and convert it into DC (direct current) electrical energy. 2. Solar Energy Conversion: The captured sunlight is converted into electrical energy through the photovoltaic effect.

Power Regulation and Control: The electrical energy generated by the solar panels is often intermittent and varies depending on factors like solar intensity and environmental conditions. To ensure efficient and safe charging of the lithium-ion battery, a charging controller or power regulation circuit is employed. This controller manages the flow of electrical energy from the solar panels to the battery, maintaining optimal charging conditions.

Battery Charging Parameters: Lithium-ion batteries have specific charging requirements to maximize their performance and lifespan. These parameters typically include a constant current (CC) stage and a constant voltage (CV) stage. During the CC stage, the charging current is maintained at a constant value until a certain battery voltage is reached. Then, the charging switches to the CV stage, where the voltage is held constant while the charging current gradually decreases.

Charging Management: The charging controller or charging management system monitors the battery's charging status, ensuring it remains within safe operating limits. This includes monitoring the battery voltage, current, and temperature. The charging system may incorporate safety features such as overcharge protection, temperature control, and balancing circuits to maintain battery health and prevent damage.

Energy Storage: The lithium-ion battery stores the electrical energy generated by the solar panels during the charging process. This stored energy can be utilized by the solar-powered path follower robot or other devices as needed. By utilizing solar energy for charging, the lithium-ion battery can be recharged using a sustainable and renewable energy source. This reduces reliance on conventional power grids and minimizes the carbon footprint associated with energy generation. Additionally, charging via solar energy enables the deployment of autonomous systems, such as solar-powered path follower robots, in remote or off-grid locations where access to conventional power sources may be limited. It's important to consider factors such as solar panel efficiency, battery capacity, charging time, and system design to optimize the charging process and ensure effective utilization of solar energy for charging lithium-ion batteries.

The photovoltaic cells within the solar panels contain semiconductors that release electrons when exposed to sunlight, creating a flow of electric current.

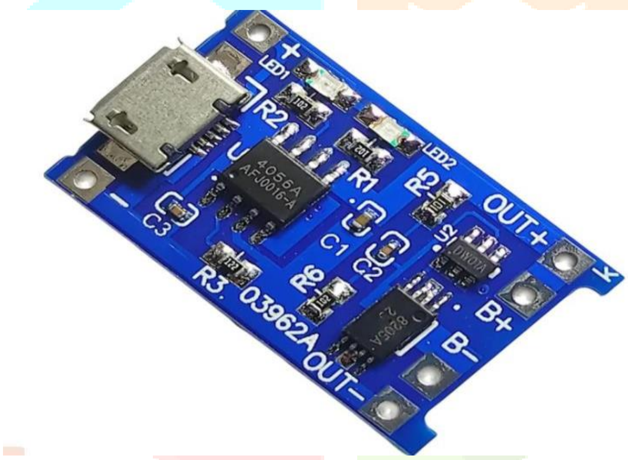


Figure 4. Charging Module

Type	Electric
Battery Type	Lithium Ion
Battery Voltage	3.7-4.2V
Current	1 A
Input Voltage	4-8 V
Voltage (V)	220-240 V
Output Voltage	4.2V
Frequency (Hz)	50/60 Hz
Connector Size	Mini USB
Charging precision	1.5%
Charging method	Linear charging 1%

In line with clients" diverse requirements, we are involved in providing an optimum quality range of TP4056 Battery Charging Module.

Details:
Mini-USB on board connector, you can directly connect to computer USB port for battery charging. If USB is not available you can use an external source voltage at IN+/IN- pads Great for DIY projects
Specifications:

Chip set: TP4056
Working temperature: -10"C~85"C
Charging indicator: Red light charging, blue light fully charged
With Output Terminals, so that you can use it also when battery is charging
With Thermal protection, reduces the charge current according to the temperature

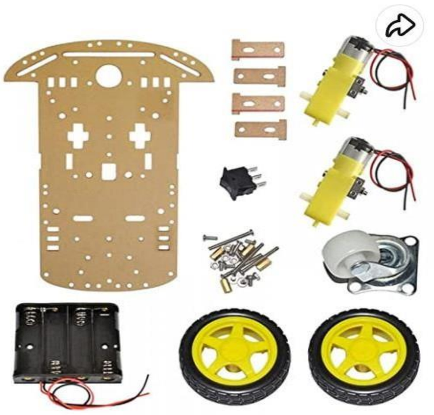


Figure 5. HARDWARE COMPONENTDS

Castrol wheels are been used for flexible motion of robot.

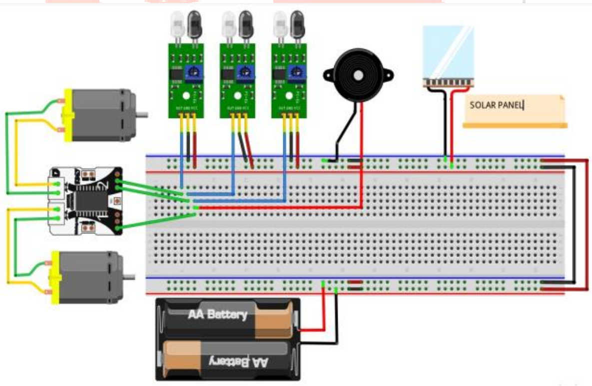
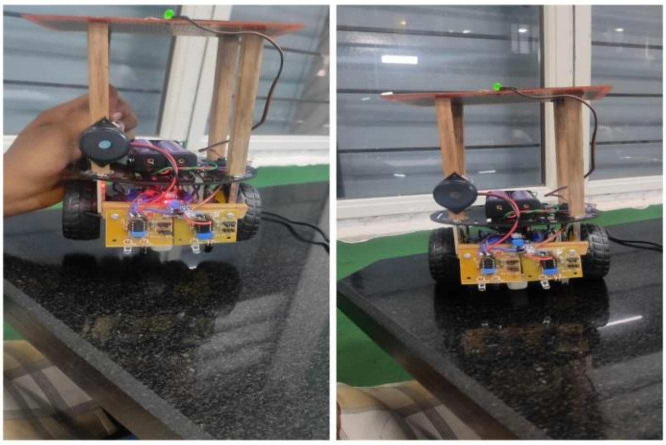


Figure 6. Solar-powered path follower robot model connection.

Solar-powered path follower robots are autonomous robots designed to navigate and follow a designated path using solar energy as their primary power source. These robots utilize solar panels to capture sunlight and convert it into electrical energy, which powers their onboard systems and allows them to move along the predefined path. The concept of solar-powered path follower robots combines two essential technologies: robotics and solar power. These robots are typically equipped with sensors, motors, and control systems that enable them to detect and track a specific path while adjusting their movements accordingly. They can be used for various applications, such as surveillance, monitoring, agricultural tasks, and even educational purposes.

III. RESULTS



.Figure 7. Output Model

APPLICATIONS:

- Line followers can be used to deliver mail within an office building
- It can be used to deliver medications in a hospital.
- The technology has been suggested for running buses and other mass transit systems ,and may end up as part of autonomous cars navigating the freeway.
- The line follower can be used in guidance system for industrial robots moving on shop floor. An example might be in a warehouse where the robots follow 'tracks' to and from the shelves they stock and retrieve from.
- A line follower robot can be used in military as spy kids or in many other applications.

The result section of a solar-powered path follower robot would typically include the findings and outcomes obtained through testing, evaluation, and analysis of the developed robot. Here are some key result that may be included:

Path Following Accuracy: Provide quantitative measures of the robot's ability to follow the designated path accurately. This could include metrics such as percentage of path deviation, mean absolute deviation from the path, or comparison of the robot's trajectory with the desired path.

Energy Efficiency: Present data on the energy consumption and efficiency of the solar-powered robot. This could include measurements of energy generation from the solar panels, energy storage capacity, and the robot's operational time using the available solar energy.

Solar Energy Utilization: Report on the efficiency of solar energy capture and utilization by the robot. This could include metrics such as solar panel efficiency, energy conversion efficiency, and comparisons of energy generated with energy consumed.

Obstacle Avoidance Performance: Evaluate the robot's ability to detect and avoid obstacles along the path. This could include metrics such as successful obstacle detection rate, response time for obstacle avoidance, or analysis of the robot's behavior in complex or dynamic environments.

Robustness to Environmental Factors: Assess the robot's performance under different environmental conditions, such as varying sunlight intensity, shadows, or changes in terrain. Report on the robot's adaptability and reliability in real-world scenarios.

Comparison to Existing Systems: If applicable, provide comparisons of the developed solar-powered path follower robot with existing systems or benchmarks. Highlight the advantages, limitations, and unique features of the developed robot in terms of performance, energy efficiency, or other relevant parameters.

User Experience and Feedback: Include any qualitative feedback or observations from users or testers regarding the usability, reliability, and overall performance of the solar-powered path follower robot.

The results section should present the findings in a clear and organized manner, using appropriate tables, graphs, or figures to illustrate the data collected during testing and evaluation. It is essential to provide sufficient details and explanations to facilitate the interpretation and understanding of the results.

IV. CONCLUSION

In conclusion, the solar-powered path follower robot paper has successfully achieved its objectives of designing, developing, and demonstrating an autonomous robot capable of navigating along a predefined path using solar energy as its primary power source. Throughout the paper, several key findings and outcomes were obtained.

The paper successfully integrated solar panels as the primary source of energy generation, capturing sunlight and converting it into electrical energy. An efficient solar power system was implemented to regulate and manage the solar energy, ensuring optimal utilization and continuous operation of the robot during daylight hours. Energy storage components such as batteries or capacitors were employed to store excess energy and enable the robot to operate even when sunlight is not available.

The path detection and navigation system incorporated robust sensors and algorithms, allowing the robot to accurately follow the designated path. Various path detection techniques, such as line-following sensors, infrared sensors, or cameras, were explored and integrated into the robot's design. The control system effectively coordinated the inputs from the path detection sensors and motor control system, enabling precise trajectory following and efficient obstacle avoidance.

V. REFERENCES

1. Subashka Ramesh, Tarun keshri, Sakshi singh, Aastha sharma, “Solar Powered Obstacle Avoiding Robot”, nternational Journal of Emerging Technologies in Engineering Research (IJETER)Volume 6, Issue 4, April (2018).

2. Zannatun Nayem, Istiaq Ahmed, Liton Kumar Biswas, “Solar Powered Explorer Robotic System Using GSM Technology”, DOI: 10.1109/ICAEEE.2018.8642996, Conference: 2018 International Conference on Advancement in Electrical and Electronic Engineering (ICAEEE).

3. Adam Kaplan, Nathaniel Kingry, Paul Uhing, Ran Dai, “Time-Optimal Path Planning With Power Schedules for a Solar-Powered Ground Robot”, IEEE Transactions on Automation Science and Engineering (Volume: 14, Issue: 2, April 2017), DOI:

10.1109/TASE.2016.2533418.
4. Tarunpreet Kaur, Dilip Kumar, “Design and Development of Solar Powered and Cell Phone Operated Mobile Robot for Border Surveillance”, IJECT Vol. 5, IssuE 3, July - sEpT 2014, ISSN : 2230-7109 (Online) | ISSN : 2230-9543 (Print).
5. Shaik Meeravali, Suthagar S, “Automatic Solar Tracker Robot”, International Journal of Engineering Research & Technology (IJERT)Vol. 1 Issue 6, August – 2012, ISSN: 2278-0181.
6. A.B. Afarulrazi; W. M. Utomo; K.L. Liew; M. Zarafi, “Solar Tracker Robot using microcontroller”, 2011 International Conference on Business, Engineering and Industrial Applications, DOI: 10.1109/ICBEIA.2011.5994256, 22 August 2011.