

Design and Implement of Solar Powered Tricycle with Automatic Ultrasonic Mechanical Braking System

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Abstract— The present project focuses on the design and implementation of a solar powered tricycle integrated with an autonomous ultrasonic braking system, aimed at providing a sustainable, safe, and cost-effective mobility solution. With the increasing demand for eco-friendly transportation and enhanced rider safety, the integration of renewable energy with intelligent control systems has become essential.

The system utilizes two 20W photovoltaic solar panels connected in series a 24V battery as the primary power source, supported by solar panels for charging. These panels charge a 24V battery, which powers a 250W BLDC hub motor for propulsion. An Arduino UNO microcontroller acts as the central control unit and processes real-time data from an ultrasonic sensor (HC-SR04) to detect obstacles.

When an object is detected within a threshold distance of 30–40 cm, the system automatically cuts off motor power using a relay and activates a braking mechanism through a motor-driven cable system. This ensures immediate stopping of the vehicle without manual intervention, thereby enhancing rider safety.

The developed prototype demonstrates efficient solar energy utilization, reliable obstacle detection, and effective braking performance. The system reduces dependency on fossil fuels while maintaining low operational cost and high efficiency. Overall, the project provides a practical and innovative solution for sustainable and safe transportation.

Keywords- Solar Powered Tricycle, Renewable Energy, Photovoltaic (PV) System, Sustainable Transportation, BLDC Hub Motor, Arduino UNO, Ultrasonic Sensor (HC-SR04), Autonomous Braking System, Obstacle Detection.

1. INTRODUCTION

Rapid urbanization and increasing environmental concerns have created a strong demand for sustainable and efficient transportation systems. Conventional vehicles rely heavily on fossil fuels, resulting in environmental pollution, increased carbon emissions, and high operational costs. Although electric

vehicles offer a cleaner alternative, they still depend on grid electricity, which may not always be sustainable or accessible.

The present project focuses on the design and implementation of a solar powered tricycle integrated with an autonomous ultrasonic braking system. The system utilizes renewable solar energy, reducing dependency on conventional fuels. Two 20W solar panels connected in series are used to charge a 24V battery, which powers a 250W BLDC hub motor for propulsion. The system operates using a battery as the main power source, while solar panels are used to charge the battery.

An Arduino UNO microcontroller is used as the central control unit, which processes real-time data from an ultrasonic sensor (HC-SR04) mounted at the front of the tricycle. The sensor continuously detects obstacles in the path of the vehicle. When an object is detected within a threshold distance of 30–40 cm, the system automatically cuts off motor power and activates a braking mechanism using a motor-driven cable system.

This project combines renewable energy utilization with intelligent safety features, making it suitable for real-world applications, especially for elderly and physically challenged users. The motivation behind this project arises from the increasing need for eco-friendly, safe, and cost-effective transportation solutions. Conventional vehicles contribute significantly to environmental pollution and are becoming increasingly expensive to operate due to rising fuel costs. Solar charging reduces dependency on external grid charging.

Additionally, many existing mobility solutions lack advanced safety features. Physically challenged and elderly users often face difficulties due to delayed reaction times, increasing the risk of accidents. Traditional braking systems depend entirely on manual operation, which may not be sufficient in emergency situations.

The integration of solar energy with an automatic braking system provides a solution that addresses both sustainability and safety. This motivated the development of a system that not only reduces environmental impact but also enhances rider protection through intelligent automation.

2. LITERATURE REVIEW

The literature survey focuses on existing research related to solar powered tricycles and automatic braking systems. The review highlights key developments in renewable energy-based mobility solutions and intelligent safety systems using sensors and microcontrollers. The selected papers provide a strong foundation for integrating solar energy with automated braking mechanisms. Paper 1: Design and Fabrication of Solar Tricycle for Physically Challenged Persons (2017)

Author: V. Prabhakaran, This study presents the design of a solar powered tricycle specifically developed for physically challenged individuals. The system uses solar panels for energy generation and a BLDC motor for efficient propulsion. A lightweight chassis design is adopted to improve mobility and reduce energy consumption. The study highlights the environmental benefits of solar energy and demonstrates that such systems are cost-effective compared to conventional fuel-based vehicles.

Paper 2: Advanced Automatic Braking System (2017)

Author: Nilima G. Maraskolhe, This research introduces an ultrasonic sensor-based automatic braking system using an Arduino microcontroller. The system detects obstacles using ultrasonic waves and automatically activates braking when an object is within a critical distance. The proposed system is low-cost, easy to implement, and significantly improves vehicle safety by reducing human dependency.

Paper 3: Design and Development of Solar Powered Hybrid Tricycle (2018)

Author: Prashant Kadi, This paper discusses a hybrid solar powered tricycle system incorporating photovoltaic panels and a charge controller for efficient energy management. The system achieves a maximum speed of around 15 km/h and demonstrates improved energy efficiency. The study emphasizes the importance of renewable energy integration for sustainable mobility solutions.

Paper 4: Smart Braking System for Electric Vehicle (2021)

Author: Ashish Katkar, This research focuses on the development of an intelligent braking system for electric vehicles. The system uses real-time obstacle detection techniques and automated braking responses to improve safety. It highlights the effectiveness of sensor-based systems in reducing accidents and enhancing vehicle control.

3. SYSTEM CONFIGURATION

The block diagram of the solar powered tricycle represents the overall system architecture, showing the interaction between electrical, mechanical, and control components. It provides a clear understanding of how energy flows from the solar panel to the motor and how the control system ensures safety through automatic braking.

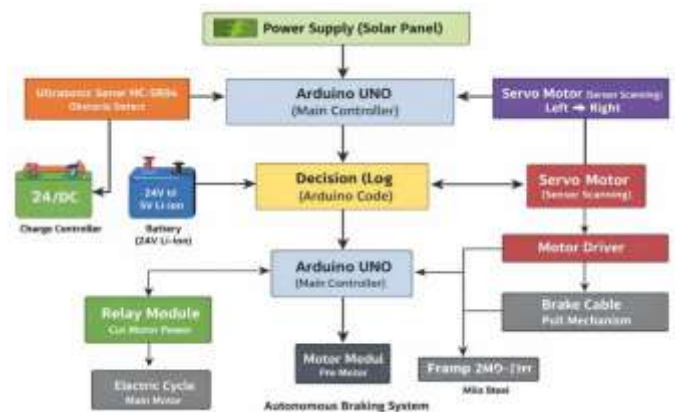


Fig. 1: Block diagram of Solar Powered Tricycle

1. Solar Panel Unit:

The solar panel unit serves as the primary source of energy for the system. It consists of two 20W photovoltaic solar panels connected in series to obtain the required voltage output. These panels convert solar energy into electrical energy using the photovoltaic effect. The generated electricity is used to charge the battery and power the system, making the tricycle eco-friendly and reducing dependence on conventional energy sources.

2. Charge Controller:

The charge controller is responsible for regulating the voltage and current coming from the solar panels before it reaches the battery. It protects the battery from overcharging and deep discharge, which can damage the battery and reduce its lifespan. By maintaining optimal charging conditions, the charge controller ensures safe, reliable, and efficient battery operation.

3. Battery Unit:

The battery unit is a 24V rechargeable battery system that stores the electrical energy generated by the solar panels. It acts as an energy storage device, supplying power to all components of the system, including the motor, controller, and sensors. The battery ensures uninterrupted operation even when sunlight is not available, such as during nighttime or cloudy conditions.

4. Motor Controller (ESC):

The motor controller, also known as the Electronic Speed Controller (ESC), controls the speed and direction of the BLDC motor. It receives input signals from the throttle and control signals from the Arduino. Based on these inputs, it regulates the power supplied to the motor, enabling smooth acceleration, deceleration, and efficient motor performance.

5. BLDC Hub Motor:

The BLDC hub motor is the main driving component of the tricycle and is rated at 250W. It converts electrical energy into mechanical energy to rotate the wheel and move the vehicle. BLDC motors are highly efficient, require less maintenance, and have a longer lifespan, making them ideal for electric vehicle applications.

6. Arduino UNO (Control Unit):

The Arduino UNO acts as the brain of the system. It processes the data received from the ultrasonic sensor and executes control decisions based on programmed logic. It controls the relay

module and the braking mechanism, ensuring that the system responds quickly and accurately to obstacles, thereby enhancing safety.

7. Ultrasonic Sensor (HC-SR04):

The ultrasonic sensor is used for obstacle detection. It works by transmitting ultrasonic waves and measuring the time taken for the waves to reflect back after hitting an object. This helps in calculating the distance between the vehicle and the obstacle. The sensor continuously sends real-time data to the Arduino for monitoring and decision-making.

8. Servo Motor / Brake Motor:

The servo motor or brake motor is used to apply the braking mechanism automatically. When the Arduino detects an obstacle within a certain distance, it activates the servo motor, which pulls the brake cable mechanically. This ensures immediate braking action and helps prevent accidents.

9. Relay Module:

The relay module acts as a switching device that cuts off the power supply to the motor during emergency braking. When activated by the Arduino, it disconnects the motor from the power source, ensuring that the vehicle stops instantly and safely.

10. User Control (Throttle & Switches):

The user control system includes the throttle and switches, which allow the rider to manually operate the tricycle. The throttle controls the speed of the motor, while the switches are used to turn the system on or off. This provides a simple and effective interface for the user to control the vehicle.

4.SYSTEM CALCULATION

1.Power Requirement:

Assume:

Load = 20 kg

Speed = 10 km/h = 2.78 m/s

Rolling Resistance Force:

$$F = 0.005 \times 20 \times 9.81$$

$$F \approx 0.98 \text{ N}$$

2. Battery Calculation:

Battery = 24V, 10Ah

Energy:

$$E = V \times Ah$$

$$E = 24 \times 10$$

$$E = 240 \text{ WH}$$

3.Solar Panel Calculation:

Panels:

$$2 \times 20W = 40W$$

Charging time:

$$\begin{aligned} \text{Solar Power} &= 2 \times 20W \\ &= 40W \end{aligned}$$

$$\text{Battery Energy} = 24V \times 10Ah$$

$$= 240 \text{ WH}$$

$$\text{Charging Time} = 240/40$$

$$= 6 \text{ hours}$$

5.EXPERIMENTAL RESULTS OF PROJECT

The experimental setup of the solar powered tricycle was developed to evaluate the performance of the system under real-time conditions. The setup includes the integration of mechanical, electrical, and control components.

The system consists of two 20W solar panels connected in series, a 24V battery, a 250W BLDC hub motor, a motor controller, and an Arduino UNO microcontroller. The ultrasonic sensor (HC-SR04) is mounted at the front of the tricycle on a servo motor to enable scanning of the surroundings.

The braking mechanism is connected to a DC motor, which pulls the brake cable when activated. A relay module is used to cut off the motor power during braking conditions.



Fig. 2: Final Working Prototype

Sr. No.	Distance (cm)	System Response	Motor Status	Brake Status
1	> 60 cm	Normal Operation	ON	OFF
2	40–60 cm	Warning Zone	ON	OFF
3	30–40 cm	Brake Activation	OFF	ON
4	< 10 cm	Emergency Stop	OFF	ON

Table.1: Obstacle Detection and Braking Performance

6. CONCLUSION

The present project successfully demonstrates the design and implementation of a battery-powered tricycle integrated with a solar charging system and an autonomous ultrasonic braking mechanism. The system effectively combines renewable energy utilization with intelligent control to provide a safe, efficient, and cost-effective mobility solution.

The tricycle operates primarily on a 24V battery, which serves as the main power source for propulsion through a 250W BLDC hub motor. The integration of two 20W solar panels enables continuous charging of the battery, thereby extending the operating time and reducing dependency on external power sources.

The ultrasonic sensor-based braking system, controlled by an Arduino UNO microcontroller, accurately detects obstacles in real time and activates the braking mechanism when the distance falls below the predefined threshold of 30–40 cm. The relay module successfully cuts off motor power, and the braking actuator ensures immediate stopping of the vehicle, enhancing rider safety.

The experimental results confirm that the system performs reliably under real-time conditions, with fast response time and efficient operation. The project achieves its objective of developing a sustainable and safe transportation system, particularly beneficial for elderly and physically challenged users. Overall, the system demonstrates a practical approach toward integrating renewable energy and intelligent safety features in personal mobility solutions.

7. REFERENCE

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