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Smart Regenerative Breaking System with Auto Braking System

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Abstract: *The Smart Regenerative Braking System with Automatic Braking Feature aims to improve vehicle efficiency and safety by recovering the kinetic energy normally lost during braking and converting it into usable electrical energy. The system uses a dynamo-based regenerative mechanism to store the generated energy in a battery, reducing overall power consumption. In addition, a proximity-sensor-based automatic braking feature is integrated to detect obstacles and apply brakes without driver intervention, preventing potential accidents.*

Keywords*:* Regenerative breaking, Energy recovery, Automatic breaking, Obstacle detection

I. INTRODUCTION

As the demand for energy-efficient and sustainable transportation increases, regenerative braking systems have become an essential technology in modern vehicles. Conventional braking systems rely on friction, which converts kinetic energy into heat and leads to significant energy loss. Regenerative braking addresses this issue by capturing the vehicle's kinetic energy during braking and converting it into electrical energy that can be stored and reused, thereby improving overall efficiency and reducing energy consumption.

This project presents a Smart Regenerative Braking System with an Automatic Braking Feature, implemented on a rotating wheel. A dynamo is used to convert the recovered kinetic energy into electrical energy, which can be stored in a battery or used to power internal components. In addition to energy recovery, the system incorporates an automatic braking mechanism that detects obstacles and applies brakes without driver intervention, enhancing vehicle safety. By combining energy efficiency with accident prevention, this project highlights the practical application of regenerative braking technology and supports the development of sustainable and safer transportation systems.

II. PROBLEM STATEMENT

Conventional braking systems waste a large amount of kinetic energy as heat during braking, leading to reduced energy efficiency, increased fuel consumption, and higher emissions. In addition, road accidents remain a major safety concern, primarily caused by human errors such as over speeding and lack of attention. To overcome these limitations, there is a need for an advanced braking system that improves energy utilization while enhancing vehicle safety. Hence, this project focuses on developing a Smart Regenerative Braking System with an Automatic Braking Feature to recover energy during braking and reduce accidents by automatically responding to obstacles.

III. LITERATURE REVIEW

Sayed Nashik et al. (2016) designed, fabricated, and tested a regenerative braking test rig using a BLDC motor, demonstrating effective energy recovery during braking and validating its application in electric vehicle systems.

Tushar L. Patil et al. (2016) focused on improving the performance of regenerative braking systems and emphasized that optimized braking strategies significantly enhance energy efficiency and overall system performance.

Jagadeesh Vikram, D. Mohan Kumar, and P. Naveen Chandra (2018) fabricated a regenerative braking system and highlighted its role in minimizing energy losses and improving vehicle efficiency.

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Eswaran et al. (2018) designed and fabricated a regenerative braking system, concluding that such systems contribute to better energy utilization and reduced dependence on conventional braking mechanisms.

Ketan Warake, S. R. Bhahulikar, and N. V. Satpute (2018) developed a regenerative braking system for the rear axle and demonstrated that rear-axle energy recovery improves braking efficiency and vehicle stability.

Siddharth K. Sheladia et al. (2018) reviewed various regenerative braking methodologies used in electric vehicles and discussed their advantages, limitations, and impact on energy conservation.

Khushboo Rahim and Mohd. Tanveer (2018) presented a comprehensive review of regenerative braking systems, emphasizing their significance in enhancing vehicle efficiency and reducing energy wastage.

IV. METHODOLOGY

A. Design Concept

The design concept focuses on developing a Smart Regenerative Braking System integrated with an automatic braking feature to improve energy efficiency and vehicle safety. A contact-based regenerative braking mechanism is employed, where a dynamo mounted on a separate shaft is mechanically engaged during braking to convert kinetic energy into electrical energy. Proximity sensors are incorporated to detect obstacles and activate automatic braking when required. A microcontroller is used as the central controller to ensure smooth coordination between regenerative energy recovery and automatic braking operations.

B. Material Selection

The materials are selected based on strength, durability, availability, and cost-effectiveness. A mild steel frame is used for structural support due to its high strength and ease of fabrication. The dynamo is chosen for efficient electrical energy generation during braking. A 12 V rechargeable battery is selected for energy storage. Proximity sensors, a microcontroller, LEDs, and connecting wires are chosen for reliable sensing, control, and indication. Bearings and shafts are selected to ensure smooth mechanical operation and reduced friction.

V. WORKING

Step 1: Energy Generation during Braking

When the vehicle is in motion, kinetic energy is produced due to wheel rotation. On applying the brake, the brake lever engages a roller mechanism connected to a 12 V dynamo mounted on a separate shaft. The contact between the rotating rollers causes the dynamo to rotate, converting kinetic energy into electrical energy.

Step 2: Energy Storage and Indication

The electrical energy generated by the dynamo is transferred to a 12 V battery for storage and later use. LED indicators and a multimeter provide real-time information about the system operation and the voltage generated during regenerative braking.

Step 3: Automatic Braking for Safety

Proximity sensors continuously detect obstacles in front of the vehicle. When an obstacle is detected within a predefined distance, the microcontroller activates the automatic braking system, applying the brakes to reduce speed and prevent collisions. The microcontroller ensures smooth coordination between regenerative braking and automatic braking functions.

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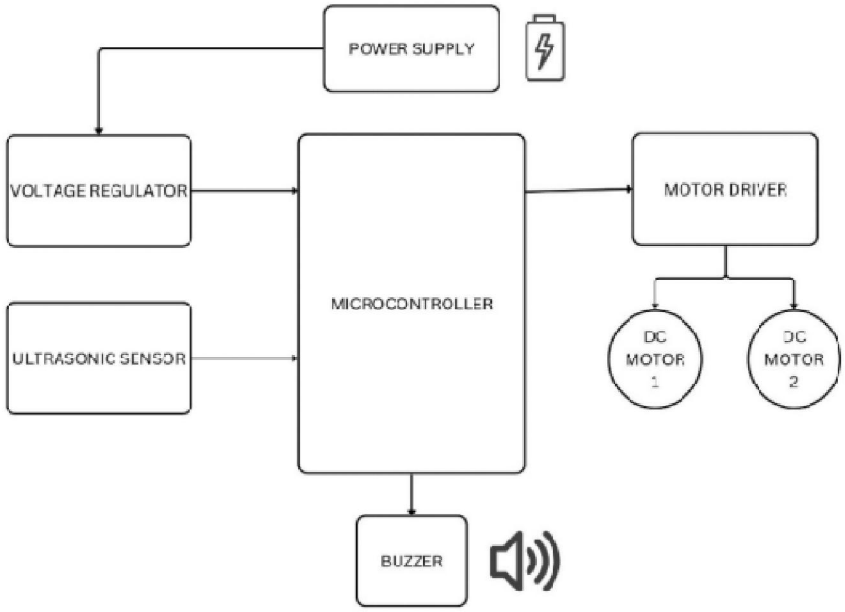
VI. BLOCK DIAGRAM



COMPONENTS USED

- 12V dynamo
- 12V dc motor
- Ultrasonic sensors
- Brake lever mechanism
- Led indicators
- Multimeter
- Microcontroller
- Dc motor
- Wiring and connectors
- Frame/chassis for assembly

VII. COMPONENTS DESCRIPTION

Step 1: Vehicle Motion and Energy Generation When the vehicle is in motion, the rotation of the wheels generates kinetic energy, which is available for recovery during braking.

Step 2: Brake Lever Activation When the rider applies the brake lever, the mechanical braking system is activated along with the regenerative braking mechanism.

Step 3: Engagement of Regenerative Mechanism The brake lever engages a roller mechanism mounted on a separate shaft. This roller comes into contact with the rotating shaft connected to the wheel.

Step 4: Dynamo Operation As contact occurs, the 12V dynamo attached to the shaft begins to rotate. The rotational motion converts kinetic energy into Direct Current (DC) electrical energy.

Step 5: Energy Storage The generated DC electricity is supplied to a 12V battery, where it is stored for future use such as powering vehicle accessories.

Step 6: Obstacle Detection Ultrasonic sensors continuously monitor the surroundings of the vehicle to detect obstacles within a predefined safety distance.

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Step 7: Automatic Braking ActivationWhen an obstacle is detected, the microcontroller processes the sensor signal and automatically activates the braking system to slow down or stop the vehicle.
Step 8: Control and IndicationThe microcontroller coordinates regenerative braking and automatic braking operations. LED indicators display system status, and a multimeter shows the voltage generated by the dynamo in real time.

VIII. ADVANTAGES

• Energy Recovery: Captures and converts kinetic energy during braking into electrical energy, improving overall energy efficiency.
• Reduced Fuel Consumption: By utilizing stored energy, the project can decrease reliance on fuel, contributing to lower operational costs.
• Enhanced Vehicle Safety: The automatic braking feature reduces the risk of collisions by providing timely responses to obstacles.
• Sustainability: Promotes environmentally friendly transportation solutions by minimizing energy wastage and reducing emissions.
• Dual Braking System: Combines regenerative and traditional braking systems, ensuring reliability and safety even if one system fails.
• User-Friendly Interface: Real-time feedback through LED indicators and multimeters keeps users informed about system performance.

IX. LIMITATIONS

The amount of energy recovered during braking is limited and is less effective at low vehicle speeds. Since the system uses a contact-based mechanism, mechanical wear may occur over prolonged use. The ultrasonic sensors used for obstacle detection have a limited range and their performance can be affected by environmental conditions. The effectiveness of automatic braking depends on sensor accuracy and controller response time. Additionally, the stored energy is not sufficient for vehicle propulsion and is mainly suitable for powering auxiliary components, making the system more appropriate for prototype and low-speed applications.

X. FUTURE SCOPE

Advanced Regenerative Braking Mechanism: Replacing the contact-based regenerative braking system with a motor-based or non-contact regenerative system would reduce mechanical wear, improve energy recovery efficiency, and enhance system reliability.
Improved Energy Storage System: Upgrading the existing 12V battery to high-capacity lithium-ion batteries or supercapacitors would increase energy storage efficiency, reduce weight, and support faster charging during regenerative braking.
Enhanced Obstacle Detection System: Integrating advanced sensors such as LiDAR, radar, or camera-based systems would improve obstacle detection accuracy, range, and reliability under varying environmental conditions.
Integration with ADAS Technologies :Incorporating the system with Advanced Driver Assistance Systems (ADAS) can enable features such as adaptive braking, collision avoidance, and intelligent speed control.
Scalability for Electric Vehicles: The proposed system can be scaled and optimized for use in electric and hybrid vehicles, allowing higher energy recovery and improved overall vehicle efficiency.

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