

Energy Recovery Using Regenerative Braking Technology

Mr. Balamurugan A¹ Harsha B² Ashwini G R³ Priyanka B N⁴ Sushmitha G V⁵

¹Assistant Professor ^{2,3,4,5}Student

^{1,2,3,4,5}Department of Electrical & Electronics Engineering

^{1,2,3,4,5}Rajeev Institute of Technology, Hassan, India

Abstract — When a vehicle is decelerating, its kinetic energy is momentarily saved and then repurposed as kinetic energy by the regenerative braking system. To recover energy that is frequently wasted in today's world due to the energy crisis and the ensuing resource depletion, certain technology is required. In other words, the regenerative braking system is one of those practical innovations. One step toward lowering the usage of fossil fuels is regenerative braking. When braking, a significant quantity of energy is wasted as heat. Instead of wasting this energy, a regenerative braking system seeks to use it. Through this method, the electric traction motor recovers energy lost during braking by using the momentum of the vehicle. This is in contrast to the traditional braking system, which uses dynamic brakes or converts extra kinetic energy into undesirable heat that is squandered as a result of brake friction.

Keywords: Regenerative Braking, Electric Vehicle (EV), Energy Recovery, Conventional Braking System, Power Recovery, Battery

I. INTRODUCTION

Fossil fuels have been widely utilized in recent years to meet energy demands, but their supply is running out annually. Furthermore, the ecology is seriously harmed by the harmful fumes produced after using fossil fuels. Electric vehicles have been around for a few decades, but due to significant constraints, they have not been expanded to meet the demands of IC engines. As a result, countries and industry are concentrating on creating efficient electric vehicles[1]. Among the drawbacks include low power consumption, component instability, and a shortage of charging outlets. Through the use of wheel rotation and modified motor connections, regenerative braking uses the wheel's inertia to rotate the generator, which charges the battery. In the end, it is kept in battery cells and used again[2].

The only method to charge the battery without a mechanical connection is to use onboard regenerative braking, which not only increases EV fuel efficiency but can also be modified for the ICV to help reduce vehicle emissions by reducing wasted energy and increasing driving range [3]. Brakes are just as crucial to a car as the engine. The momentum is absorbed to re-accelerate each time the brakes are engaged. As so, it will eventually lead to energy waste. A regenerative brake is an energy recovery device that slows down a car by changing its kinetic energy into a different form that can be used right away or stored for later. For later use, the energy produced during braking is thus stored in a battery or bank of capacitors. In a revolving flywheel or by compressing air, energy can also be stored [4].

"Performance Improvement of Regenerative braking system" Authors: Tushar L. Patil, Rohit S. Yadav, Abhishek D, et al. Improving the Regenerative Braking System's Performance The authors include Rohit S. Yadav, Abhishek D., Tushar L. Patil, and others. This review paper

presents methods for improving the regenerative braking system's efficiency. Reducing the vehicle's weight enhances performance, and employing a super capacitor speeds up the regenerative braking system's energy conversion rate. Additionally, making the car smaller tends to boost the system's efficiency. [1]. "Design and Fabrication of Regenerative Braking System" Authors: Eswaran, S. Ajith, V Karthikeyan, P Kavin, S Loganandh. In order to save some of the energy lost when braking, this study looks at how well the vehicles' regenerative braking system works. It is also more efficient than a traditional braking system and may be used in a wide temperature range. To create a better system that gathers more energy and stops more quickly, regenerative braking systems need more research. By recovering energy that would have been wasted during braking, these technologies can help all moving vehicles. Any nation's economy might see significant savings with the adoption of more effective processes.[2].

"Design & Development of Regenerative Braking System at Rear Axle" Authors: Ketan Warake, Dr. S. R. Bhahulikar, Dr. N. V. Satpute. The regenerative braking system in cars, according to this review paper, meets the goal of preserving some of the energy wasted when braking. A portion of the battery charge lost during vehicle braking can be recovered by the regenerative braking system. By using a friction brake, the energy is transformed into heat and released into the atmosphere. The generator's rotor rotates with this energy, transforming the wheels' mechanical energy into a useful battery charge. Since it is unable to bring the vehicle to a stop, the regenerative braking system cannot be utilized as the primary braking system. The regenerative braking system can recover at least 11% of the battery energy that would otherwise be used to heat the friction brakes, according to experiments. This regenerative braking might therefore improve the distance traveled between two consecutive charging requirements by 10% to 15%. [3]. "Regenerative Braking Control Strategy for Electric Vehicles Based on Optimization of Switched Reluctance Generator Drive System" Authors: Zhu Y, Wu H, & Zhang J. The optimization method presented in this review paper enhances the SRG's performance. Key factors including torque, speed, and energy efficiency are analyzed, and techniques are suggested to optimize the system for improved energy recovery. Optimizing the SRG system's performance is part of the authors' innovative regenerative brake control approach. While maintaining smooth and effective operation, this tactic seeks to optimize energy recovery during braking. This study also emphasizes the possibility of more economical and environmentally friendly power train systems, which are crucial for the development of electric vehicles in the future. [4].

II. METHODOLOGY

Utilizing the motor's mechanical energy, regenerative braking transforms kinetic energy into electrical energy that is then delivered back into the battery. Using the same principle as an alternator, the regenerative braking system

should be able to convert a significant portion of its kinetic energy to charge the battery.

- 1) For regenerative braking, the motor serves as a generator in addition to a motor for propulsion. It is the fundamental element responsible for transforming motion-related mechanical energy into electrical energy and vice versa.

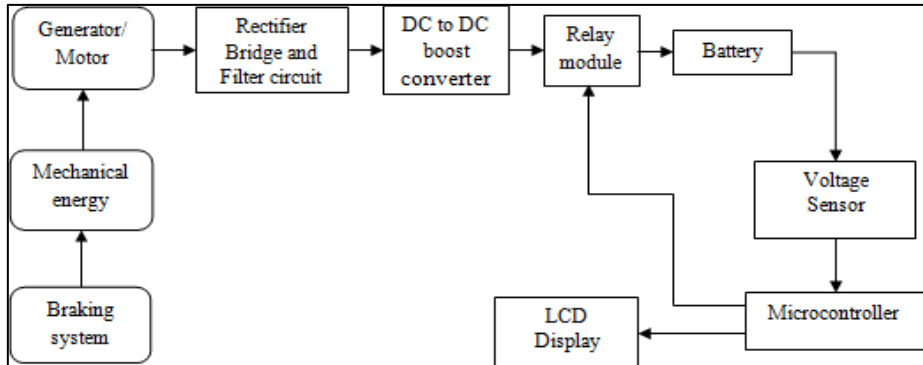


Fig. 1: Block Diagram of regenerative braking technology

- 2) Usually, braking generates alternating current (AC) electricity. Conversion to DC is required in order to charge the battery, which stores DC (direct current). It is the rectifier bridge that converts AC to DC. In order to eliminate ripples and produce a cleaner DC output, the filter circuit smoothes out the rectified DC current, ripples and providing a cleaner DC output.
- 3) To effectively charge the battery, the voltage must be stepped up, which is ensured by the DC-to-DC boost

converter. The charging process is optimized by regulating the voltage.

- 4) When regenerative braking occurs, the electrical energy produced is stored in the battery. Afterward, the motor can be powered by this stored energy.
- 5) The voltage of the battery is measured by the voltage sensor.

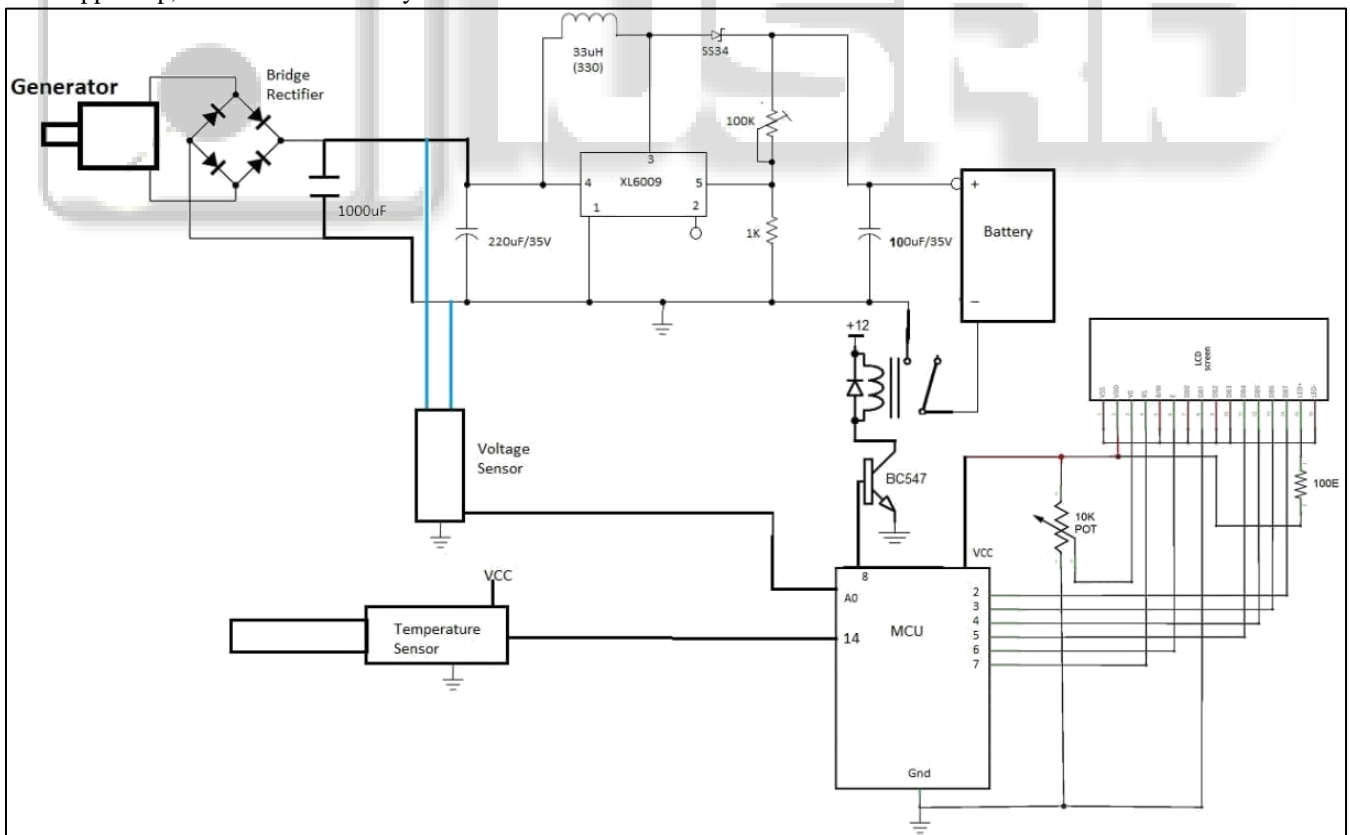


Fig. 2: Circuit Diagram of regenerative braking Technology

Utilizing the motor's mechanical energy, regenerative braking transforms kinetic energy into electrical energy that is then delivered back into the battery. Using the

same principle as an alternator, the regenerative braking system should be able to convert a significant portion of its kinetic energy to charge the battery.

A mechanical force will rotate the generator component once the operator applies the brake.

- 1) The filter circuit and rectifier will receive this power. This circuit will produce a pure DC output from the generated power. The DC-to-DC converter will receive this power in order to increase the voltage.
- 2) This power will then be stored in the battery bank. A microcontroller and a voltage and temperature sensor are being interfaced in order to record the voltage and temperature.
- 3) The user may see the battery's temperature and the voltage produced by the device on the LCD display.

Function	Quadrant	Speed	Torque	Power output
Forward motoring	i	+	+	+
Forward braking	ii	+	-	-
Reverse motoring	iii	-	-	+
Reverse braking	iv	-	+	-

Table 1: Four quadrant operation and its relationship.

The table illustrates how a motor operates in its four quadrants and how speed, torque, and power output are related to each. Any drives or DC motor operating in four quadrants indicates that the machine is operating in four different areas. This includes reverse braking, forward motoring, forward braking, and forward motoring. Braking and motoring are the two modes of operation for a motor. When in driving mode, the device functions as a motor, transforming electrical energy into mechanical energy to propel itself forward. The machine acts as a generator when in braking mode, transforming mechanical energy into electrical energy to counteract motion.

III. RESULTS AND DISCUSSION

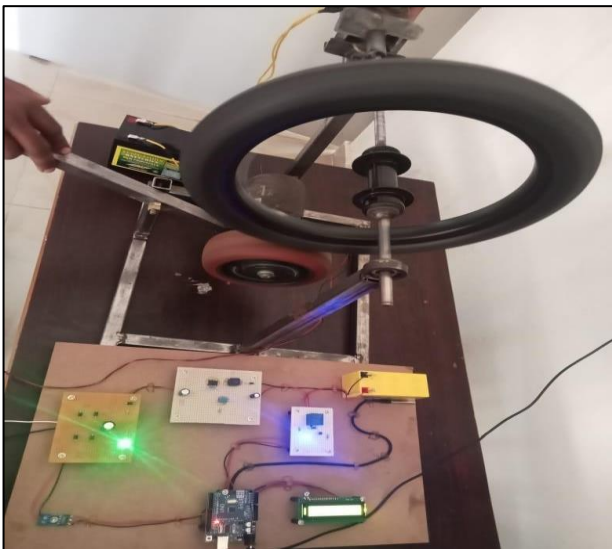


Fig. 3: The Model of Regenerative braking technology
Regenerative braking technology's operational model is depicted in the above graphic. This project is being carried out for a braking system-based power generation system. A mechanical force will rotate the generator component once

the operator applies the brake. The circuits for the rectifier and filter will receive this power. This circuit will produce a pure DC output from the generated power. The DC to DC converter will receive this power in order to increase the voltage. The battery receives this voltage and uses it to store the electrical energy that would otherwise be wasted while applying braking. The system's generated voltage and temperature will be detected using temperature and voltage sensors. The relay trips the circuit if the temperature rises above the predetermined threshold. The temperature and the generated voltage will both be visible on the LCD display. As a result, energy loss is decreased and efficiency is raised.



Fig. 4: Measurement of the Voltage and Temperature Before Brake Applied.



Fig. 5: Measurement of the Voltage and Temperature After Brake Applied.

The accompanying figure displays the energy generated during energy regeneration as the output of the regenerative braking system. The user may see the system-generated voltage and battery temperature on the LCD display.

IV. CONCLUSION

Vehicles with regenerative braking systems are able to save some of the energy that is lost when braking. The purpose of the regenerative braking system is to partially recover the battery charge that is lost when the vehicle is braking. Friction brakes transform the energy into heat, which is then released into the surroundings. This energy is used to turn the generator's rotor, which transforms the wheels' mechanical energy into a useable battery charge. Since the regenerative

braking system is unable to stop the car, it cannot be employed as the primary braking system. Regenerative braking is a rather easy technique that isn't as complicated or costly as other approaches.

V. FUTURE SCOPE

Regenerative braking systems appear to be promising and widespread in a number of fields, including energy storage, heavy vehicles, hybrid cars, and electric vehicles. Improved energy recovery rates, more effective regenerative braking systems, and integration with other cutting-edge automotive technology are all anticipated outcomes of ongoing research and development. It has great potential for a number of industries, especially when it comes to sustainability and the shift to greener, more energy-efficient solutions.

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