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Energy Efficient Electric Vehicles Using Regenerative Braking System

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ABSTRACT: A regenerative braking system (RBS) is a pivotal technology in modern automotive engineering, offering significant advantages in energy efficiency and sustainability. This abstract provides an overview of regenerative braking systems, their working principles, benefits, challenges, and future prospects within the automotive industry.

Regenerative braking is a method of harnessing kinetic energy produced during deceleration or braking of a vehicle and converting it into electrical energy for storage or immediate reuse. Unlike conventional braking systems, which dissipate kinetic energy as heat through friction, regenerative braking systems capture this energy through electromechanical means, typically using electric motors or generators

KEYWORDS: Regenerative Braking, Battery Charging, Energy Efficiency, Kinetic Energy Recovery and Energy Recapture.

I.INTRODUCTION

The advent of regenerative braking systems (RBS) marks a pivotal moment in the evolution of automotive engineering, offering a transformative solution to improve energy efficiency, reduce emissions, and enhance vehicle performance. This introduction provides an overview of regenerative braking technology, its historical development, working principles, applications, benefits, and challenges. The concept of regenerative braking dates back to the early 20th century, with early experiments conducted by engineers seeking to harness the energy of decelerating vehicles. One of the earliest examples is the electric tram system developed by the Siemens company in Germany in the late 19th century, which utilized regenerative braking to recover energy during braking events. However, it was not until the latter half of the 20th century that regenerative braking technology began to gain traction in the automotive industry.

In the 1960s and 1970s, amid growing concerns about fuel consumption and environmental pollution, researchers and engineers began exploring ways to improve the energy efficiency of vehicles. This led to the development of early hybrid vehicles equipped with regenerative braking systems, such as the General Motors Electron air and the Toyota Prius concept car. These pioneering efforts laid the groundwork for the widespread adoption of regenerative braking technology in modern automotive applications. The ESP32 microcontroller is a powerful and versatile device popular in the realm of IoT (Internet of Things) and embedded systems.

II. SYSTEM MODEL AND ASSUMPTIONS

The electric vehicle (EV) with regenerative braking can be modelled as a system with several key components Converts electrical energy from the battery to mechanical energy for driving the wheels. Stores electrical energy to power the motor. Converts kinetic energy from the vehicle's motion back into electrical energy during braking. This energy is then stored in the battery. Represents the physical properties of the vehicle, including mass, drag coefficient,and rolling resistance. These factors affect the energy consumption during driving. * Manages the power flow between the battery, motor, and regenerative braking system. It optimizes the use of regenerative braking to capture kinetic energy and reduce reliance on the battery during deceleration.

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Perfect conversion efficiency This is an idealistic scenario where there are no energy losses during conversion processes.

In reality, there will be some energy losses due to heat generation in the motor and other components.

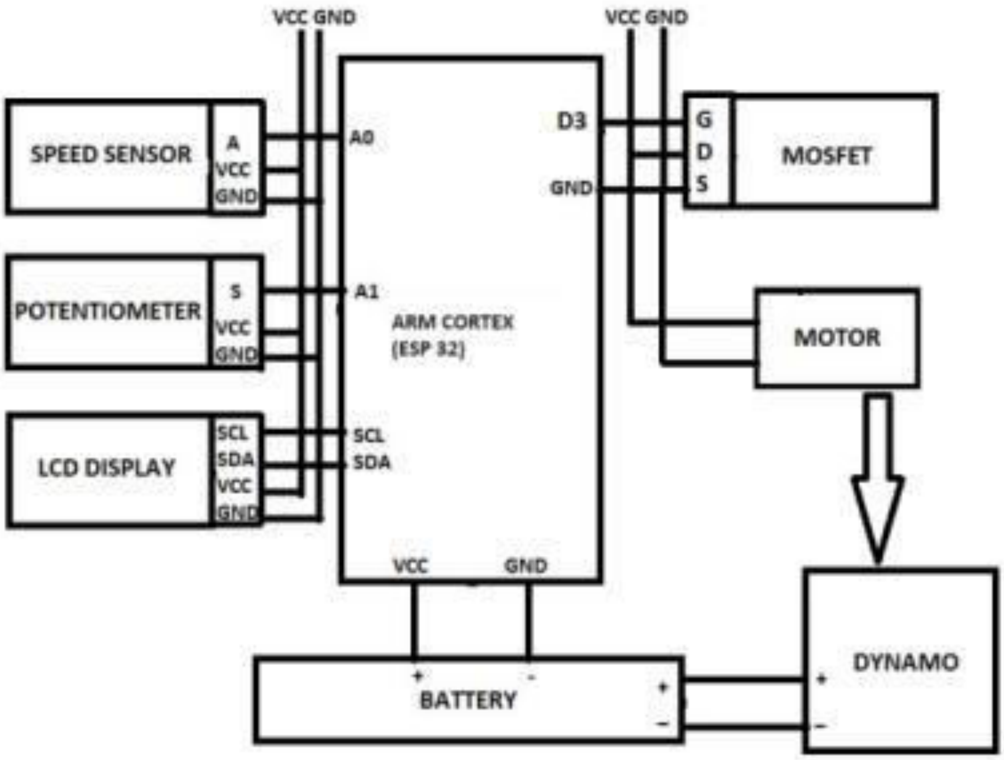

Fig. 1 System Model

Predictable driving cycle the model assumes a pre-defined driving profile that includes acceleration, constant speed, and deceleration phases. This allows for calculating the potential energy recovery through regenerative braking. Flat terrain the model may not account for significant changes in elevation, which can impact energy consumption. Constant battery capacity battery degradation over time is not considered. The model can be expanded to include different control algorithms for the regenerative braking system. This can optimize the amount of energy recovered based on factors like vehicle speed and remaining battery capacity.

Real-world driving behaviour can deviate from the assumed driving cycle. The model can be further enhanced to incorporate driver aggressiveness (frequent braking and acceleration) impacting energy efficiency. By analysing this system model and addressing the assumptions, engineers can design and evaluate energy-efficient electric vehicles that maximize the benefits of regenerative braking. This model focuses on the relationship between motor torque, motor speed, and vehicle speed during regenerative braking. It's useful for understanding the power conversion and braking force generated. provides a more detailed picture of the RBS's operation and helps optimize energy recovery and system design. The model can be further enhanced by incorporating the regenerative braking control strategy. This would involve equations or algorithms that determine the desired motor torque for optimal regeneration based on factors like driver input, vehicle speed, and battery state. These models can be implemented in simulation software to analyse RBS performance under various driving conditions and design scenarios. The torque-speed model is a good starting point for understanding the basic principles, while the electro-mechanical model offers a more in-depth view for optimizing system design and control strategies.

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III.METHODOLOGY

Electric motors are reversible. In driving mode, the motor uses electricity from the battery to rotate the wheels. During regenerative braking, the motor operates in reverse. The vehicle's kinetic energy from motion is used to rotate the motor shaft, which acts as a generator. This generator function converts kinetic energy into electrical energy that's fed back to the battery, extending the vehicle's range. The heart of RBS, it functions as both motor and generator. This system, including inverters and DC-DC converters, controls the flow of power between the battery, motor, and regenerative braking system. This unit monitors vehicle speed, calculates torque, and manages the regeneration process. It ensures optimal energy recovery while maintaining safe braking distances.

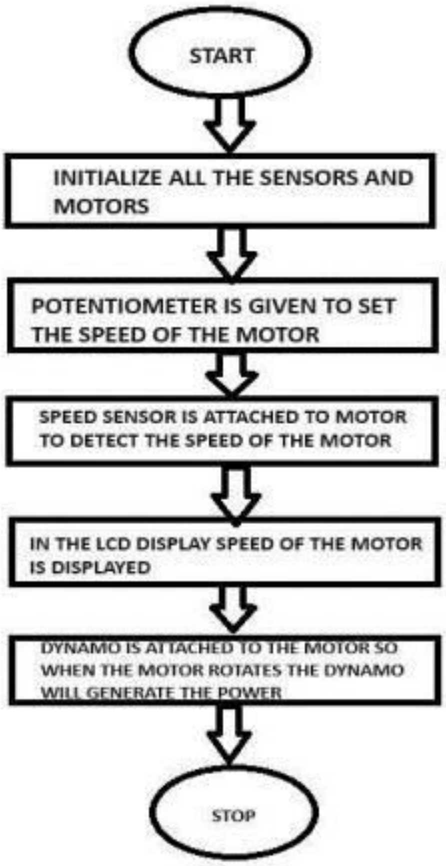

Fig. 2 Flow Chart

The driver presses the brake pedal. The braking controller detects pedal input and initiates regenerative braking. The controller signals the inverter to reverse the current direction in the motor windings. The motor acts as a generator, resisting the rotation of the wheels and converting kinetic energy into electrical energy. The power electronics system manages the regenerated electricity. It might involve voltage adjustments by the DC-DC converter for compatibility with the battery. The BMS ensures safe charging conditions and directs the recovered energy back to the battery, extending the driving range. Regenerative braking can't capture all the vehicle's kinetic energy. In some situations, regenerative braking might not provide sufficient deceleration. Traditional friction brakes are used in conjunction with RBS to ensure overall stopping power. Manufacturers are developing algorithms to optimize regenerative braking based on factors like vehicle speed, road conditions, and driver behaviour. Regenerative braking is a cornerstone technology for EVs, enhancing efficiency and ranger. This can improve energy recovery and driver experience.

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IV.SURVEY DESCRIPTION

The influence of the regenerative braking on the overall energy consumption of a converted vehicle, Naili Hud, Sunarto Kaleg, Redo Kurnia, Alexander Christianto Budiman his shows a decrease in electrical energy consumption by about 6.16%, which indicates an enhancement in mileage or vehicles efficiency, vehicle into electric vehicle has been carried out by testing in the real-world environment. The 12.4-km road in Bandung, Indonesia, is designated as a vehicle test route. Some variables are set, and the same value is approximated throughout the testing. Test date and time, numbers of datum, duration of each test, total battery charge/discharge power, and vehicle mileage was recorded and used to calculate the electricity consumption data for each run. The reliability of the data is confirmed by means of confidence intervals. The calculation of confidence intervals is used as an indication of the level of confidence that the average value taken could represent the average population.

Regenerative braking of electric vehicles Valentin Tote proposed the purpose to inform in a concise way the essence of regenerative braking and different methods, utilized to accumulated recuperated energy. This paper presented key points of information and the essence of regenerative braking in a more concise way. Topics such as electric vehicles which are significantly broad and modern always pick at one's interest. Worldwide efforts are spent in research and development. Regenerative braking as a beneficial way of deceleration of an EV by itself is also very exciting and broad topic. It can increase the vehicle's range between 8 to 25% [1, 10, 11].

V.FUTURE SCOPE AND DISCUSSION

energy-efficient electric vehicles (EVs) utilizing regenerative braking systems is promising and multifaceted. Firstly, ongoing advancements in regenerative braking technology are expected to improve system efficiency, allowing for even greater energy recovery and extended driving ranges. EV adoption continues to rise globally, the integration of regenerative braking systems will become standard practice across various vehicle models, further enhancing their appeal and practicality.

The application of regenerative braking principles may extend beyond traditional passenger vehicles to encompass other modes of transportation, such as buses, trucks, and even bicycles, amplifying the impact on energy conservation and emissions reduction. Research into novel materials and designs for regenerative braking components holds potential for cost reduction and performance enhancement, making EVs more accessible and competitive in the automotive market.

VI.CONCLUSION

In conclusion, the integration of regenerative braking systems in electric vehicles (EVs) marks a significant stride towards enhancing energy efficiency and sustainability in transportation. Through the harnessing of kinetic energy otherwise dissipated as heat during braking, these systems effectively convert it into electrical energy, which is then stored for future use. This process not only extends the range of EVs but also reduces the demand on traditional energy sources, consequently lowering greenhouse gas emissions and mitigating environmental impact. Moreover, the adoption of regenerative braking technology promotes the optimization of energy resources, contributing to the overall efficiency of the vehicle. By supplementing the power needs of the vehicle, it lessens dependency on external charging sources and enhances the autonomy of EVs, making them more practical and appealing to consumers. Embracing this technology paves the way for a more sustainable transportation ecosystem, ultimately reshaping the way we move and interact with our environment.

VII.RESULT

An energy-efficient electric vehicle incorporating a regenerative braking system presents a promising solution for improving overall efficiency and extending driving range. Regenerative braking technology allows the vehicle to recover kinetic energy during braking or deceleration, converting it back into electrical energy to recharge the battery pack. By harnessing this otherwise wasted energy, electric vehicles equipped with regenerative braking systems can significantly reduce energy consumption and increase overall efficiency. This not only enhances the vehicle's environmental friendliness but also contributes to lower operating costs for drivers. regenerative braking systems can enhance the driving experience by providing smoother deceleration and reducing wear on traditional friction braking components. Overall, the integration of regenerative braking technology represents a key advancement in the

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development of more sustainable and efficient electric vehicles, further promoting their adoption and acceptance in the automotive market.

	output
Battery storage	8v
Total Efficiency	15%

Speed (km/hr)	Volts (v)
10-50	0-2
50-100	2-3
100-150	3-4
150-200	4-6
200-250	6-8

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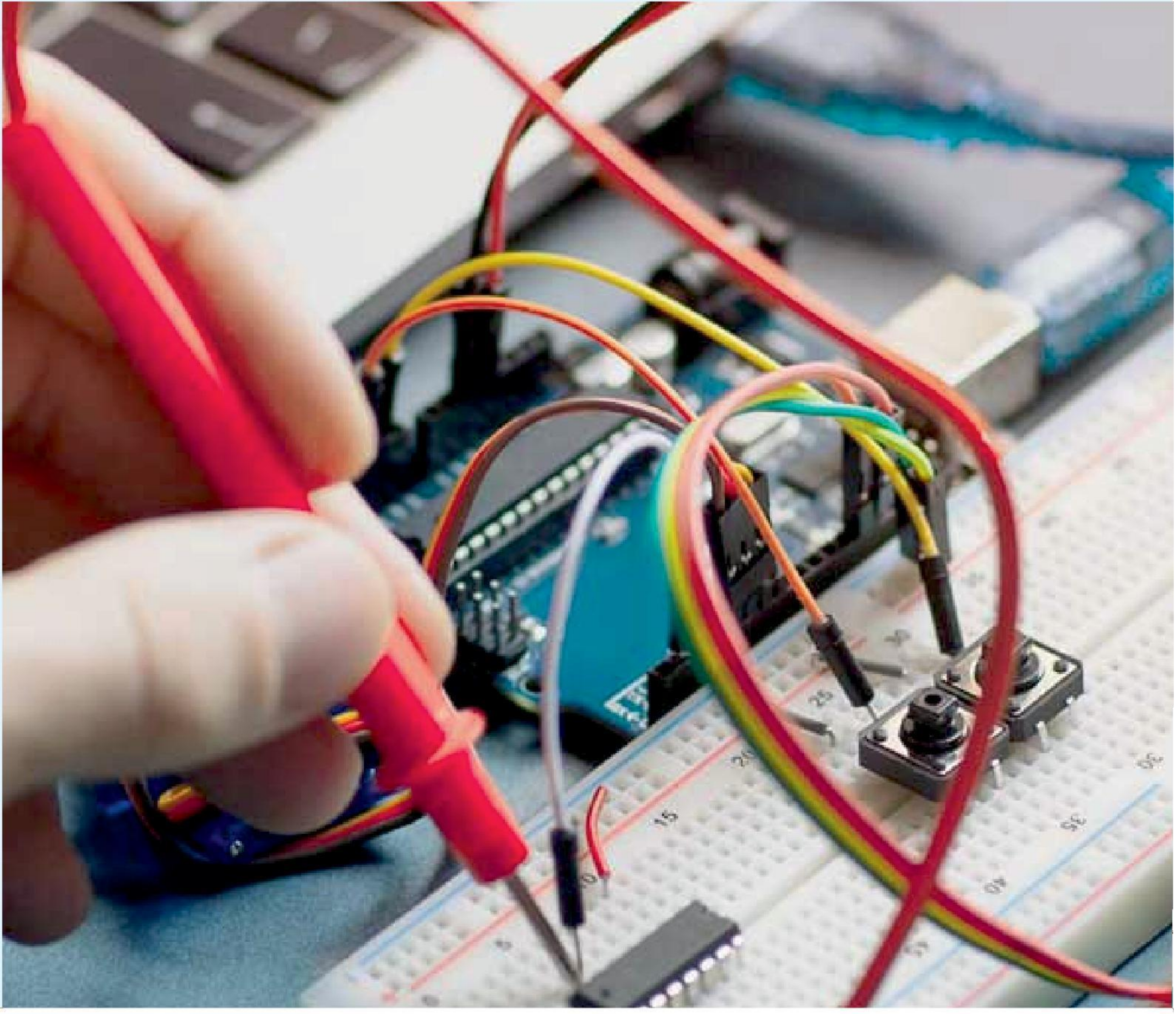

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