

Improving the Performance of EV by Utilizing Regenerative Braking System

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ABSTRACT

Regenerative braking is an energy-recovery technique used in electric and hybrid electric vehicles to improve overall vehicle efficiency. Unlike conventional friction braking, where the kinetic energy of a moving vehicle is dissipated as heat, regenerative braking converts part of this kinetic energy into electrical energy and stores it in the battery for subsequent use. The proposed system demonstrates the principle of regenerative braking using DC geared motors, wheels, a braking mechanism, a rechargeable battery, LED indicators, and associated electrical components. During normal operation, electrical energy supplied to the motor is converted into mechanical energy to drive the wheels. When braking is applied, the rotating wheels drive the motor in generating mode, converting the available mechanical energy into electrical energy. The recovered energy is indicated through LEDs and supplied to the battery. The developed prototype demonstrates the feasibility of recovering otherwise wasted braking energy and highlights the potential of regenerative braking for increasing energy efficiency, reducing mechanical brake wear, and improving the performance of electric vehicles.

Keywords— Electric Vehicle (EV), Regenerative Braking System (RBS), Energy Recovery, DC Gear Motor, Battery Charging, Energy Efficiency.

INTRODUCTION

Electric vehicles are increasingly being considered as sustainable alternatives to conventional internal combustion engine vehicles due to concerns associated with fossil-fuel consumption, environmental pollution, and energy efficiency. However, improving driving range and optimizing battery-energy utilization remain important challenges in EV development. Regenerative braking provides an effective approach to addressing these issues by recovering a portion of the kinetic energy that would otherwise be dissipated during braking.

In a conventional braking system, friction between braking components converts the vehicle's kinetic energy into heat, which is ultimately lost to the environment.

In regenerative braking, the electric traction motor operates as a generator during deceleration and converts mechanical energy from the rotating wheels into electrical energy. The recovered electrical energy can subsequently be stored in the vehicle battery and reused for propulsion or auxiliary applications. This improves overall energy utilization while reducing dependence on friction braking.

Regenerative braking is particularly beneficial under urban stop-and-go driving conditions, where frequent acceleration and braking provide repeated opportunities for energy recovery. In addition to improving energy efficiency and vehicle range, the system can reduce mechanical brake wear and associated maintenance requirements. Therefore, the present work focuses on demonstrating a regenerative braking arrangement using a prototype EV system.

LITERATURE SURVEY

Regenerative braking systems have been widely investigated as an effective technique for improving the energy efficiency and performance of electric and hybrid vehicles. Rahane and Varpe [1] discussed the design and fabrication of a regenerative braking system in which the kinetic energy normally dissipated during braking is recovered and converted into useful electrical energy. Prakash *et al.* [2] investigated regenerative braking using PMSM motors with vector-control techniques for hybrid electric vehicle applications, emphasizing effective motor control during energy recovery. Sheladia *et al.* [3] reviewed different regenerative braking methodologies for electric vehicles and highlighted their potential for reducing energy losses, improving vehicle efficiency, and decreasing dependence on conventional friction braking. These studies establish regenerative braking as an important approach for recovering otherwise wasted braking energy.

Ehsani *et al.* [4] presented the fundamental concepts and technologies associated with electric, hybrid-electric, and fuel-cell vehicles, including energy management and regenerative braking. Li and Gao [5] investigated energy management and control strategies based on regenerative braking and motor optimization, demonstrating the importance of coordinated control for improving electric-vehicle performance. Chau and Wong [6] provided an overview of power-management strategies in hybrid electric vehicles and emphasized effective management of energy flow between the propulsion system and energy-storage components. Collectively, the literature indicates that regenerative braking can enhance energy utilization, extend vehicle driving range, and reduce mechanical brake wear by converting kinetic energy during deceleration into electrical energy that can be stored and reused.

PROBLEM STATEMENT

Electric vehicles require efficient utilization of the limited electrical energy available from onboard batteries. During conventional braking, a considerable amount of kinetic energy is dissipated as heat and cannot be reused. Existing regenerative systems may also experience limitations associated with energy-recovery efficiency, system design, control, and integration. Therefore, an effective method is required to recover braking energy and reuse it to improve EV performance and energy efficiency.

OBJECTIVES

1. To recover the kinetic energy produced during vehicle braking and convert it into useful electrical energy for storage in the battery.
2. To improve the energy efficiency and operating performance of an electric vehicle while reducing energy losses and dependence on conventional friction braking.

PROPOSED SYSTEM

The proposed system demonstrates regenerative braking through an electromechanical prototype consisting primarily of DC gear motors, wheels, brakes, a battery, adapter, charging cable, and LED indicators. During the driving condition, electrical energy supplied to the DC gear motor is converted into mechanical rotational energy and transmitted to the wheels. When braking is applied, the rotational energy available at the wheels is transferred back to the DC gear motor, enabling it to operate as a generator.

In generating mode, kinetic energy from the rotating system is converted into electrical energy. The generated electrical output is indicated using LEDs and supplied to the battery for storage. The stored energy can subsequently be utilized for electrical loads, including the charging arrangement demonstrated in the prototype. Thus, the proposed system illustrates the fundamental principle of recovering otherwise wasted braking energy and reusing it to enhance energy utilization.

BLOCK DIAGRAM

Fig. 1 shows the block diagram of the regenerative braking system, where rotational energy from the wheels is converted into electrical energy using a generator motor during braking. The generated energy is used for battery charging and, after voltage regulation, can also be utilized for mobile charging.

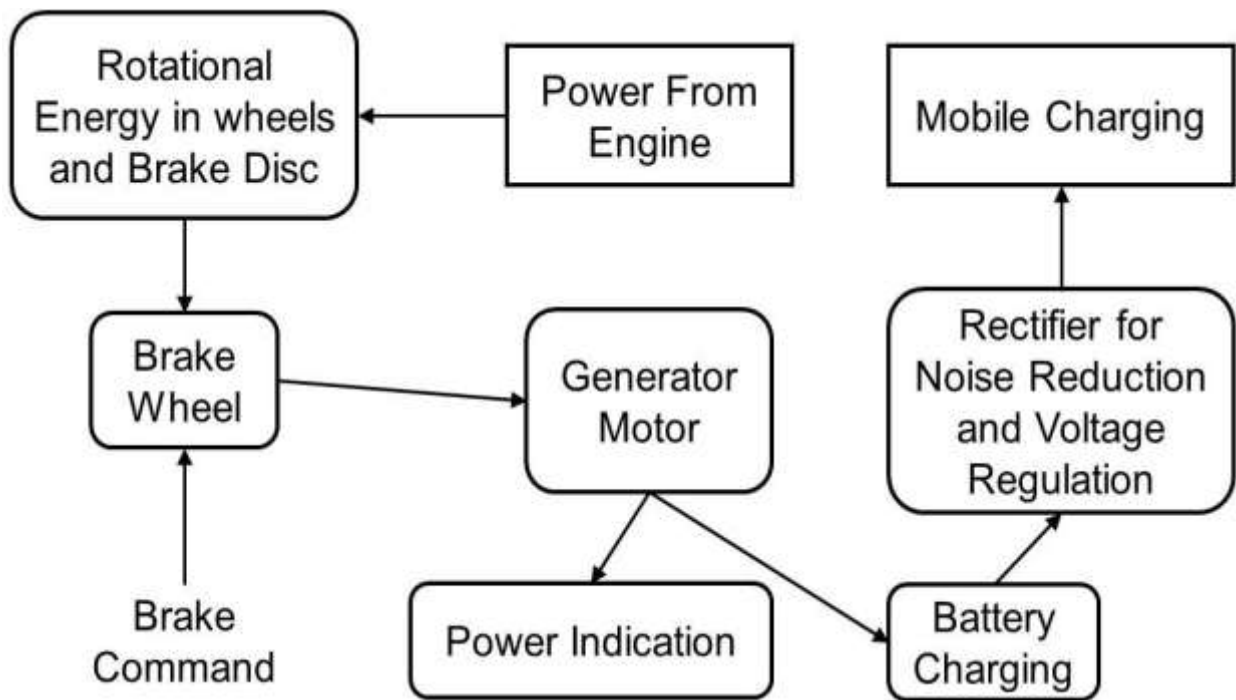


Fig 1 improving the performance of Ev by utilization of regenerative braking system.

CIRCUIT DIAGRAM

Fig. 2 shows the circuit diagram of the regenerative braking system, illustrating the electrical connection between the motor, battery, switching device, diodes, resistances, and inductances. During regenerative braking, the generated electrical energy is directed through the circuit to the battery for energy recovery and charging.

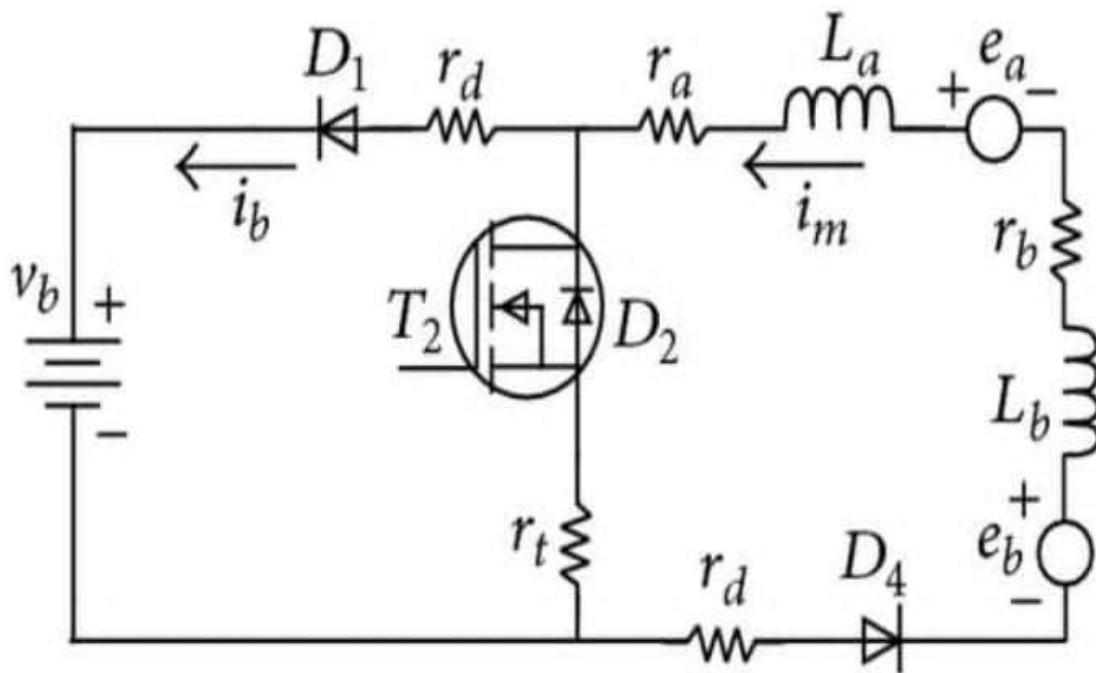


Fig 2 Circuit Diagram

METHODOLOGY

The methodology is based on two principal operating modes: **motoring mode** and **generating mode**. During motoring operation, a 12-V, 1-A adapter supplies electrical energy to the 500-rpm DC gear motors. The motors convert the supplied electrical energy into mechanical energy and rotate the shaft and wheels. When braking is applied, the speed of the wheels decreases and their rotational motion is transferred through the braking arrangement to the DC gear motor.

During generating operation, the DC gear motor functions as a generator and converts available kinetic energy into electrical energy. The generated output is indicated through the LEDs and is supplied to the battery. The methodology requires sufficient wheel momentum for regeneration and provision for storing or immediately utilizing the recovered electrical energy. The design also recognizes the need for conventional friction braking as a backup or emergency braking mechanism.

RESULTS AND DISCUSSION

Fig. 3 shows the developed experimental setup of the regenerative braking system, which demonstrates the recovery of electrical energy during braking. The kinetic energy that would normally be dissipated as heat is converted into electrical energy and stored in the battery, thereby improving energy utilization and potentially extending the operating range of the electric vehicle.

The system also reduces dependence on conventional friction braking because the electric motor contributes to vehicle deceleration while operating in generating mode. Consequently, mechanical brake wear can be reduced, potentially lowering maintenance requirements. The recovered braking energy also reduces overall energy losses and can contribute to smoother deceleration and improved vehicle operation, particularly under frequent braking conditions.



Fig 3 Experimental Setup

CONCLUSION

The developed regenerative braking system demonstrates an effective approach for recovering kinetic energy that would normally be dissipated during conventional braking. By operating the DC motor as a generator during braking, a portion of the available mechanical energy can be converted into electrical energy and stored in the battery. This principle contributes to improved energy efficiency, reduced energy wastage, lower mechanical brake wear, and potentially increased operating range of electric vehicles.

Although regenerative braking introduces additional system complexity and depends strongly on the characteristics of the motor and energy-storage system, its advantages make it an important technology for sustainable transportation. Future improvements in battery technology, control algorithms, energy-storage systems, and power-electronic converters can further enhance the efficiency and practical applicability of regenerative braking systems.

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