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Energy Generation from Vehicle Suspension

Gunasekaran K
BE ECE (Final Year), Jeppiaar Engineering College, Chennai

Abstract: ***With the rapid increase in the number of vehicles worldwide, a significant amount of mechanical energy is continuously dissipated in vehicle suspension systems due to road irregularities such as bumps, potholes, and uneven surfaces. This energy is normally wasted in the form of heat. This paper presents a practical approach for harvesting energy from vehicle suspension systems and converting it into useful electrical energy. The proposed system uses a mechanical rack and pinion mechanism coupled with a DC generator to convert vertical oscillatory motion of the suspension into rotational motion. The generated electrical energy can be stored in a battery and utilized for low-power applications such as vehicle lighting, sensors, or charging electronic devices. The proposed method is economical, environmentally friendly, and suitable for real-time implementation. Experimental analysis indicates that the system can generate usable power without affecting ride comfort significantly.***

Keywords: Energy harvesting, Vehicle suspension, Rack and pinion mechanism, DC generator, Renewable energy.

I. INTRODUCTION

The growing demand for energy and the depletion of conventional energy sources have motivated researchers to explore alternative and renewable energy technologies. Energy harvesting from ambient sources such as solar, wind, vibration, and mechanical motion has gained significant attention. Vehicles experience continuous vibrations and vertical movements due to road surface variations. The suspension system, designed to absorb these shocks and provide passenger comfort, dissipates a large amount of mechanical energy. This wasted energy can be effectively captured and converted into electrical energy using suitable mechanical and electrical components. Energy generation from vehicle suspension systems provides a promising solution to enhance energy efficiency and reduce dependency on fossil fuels. This paper focuses on the design and working of an energy harvesting system using a rack and pinion mechanism integrated with a DC generator.

II. SYSTEM OVERVIEW

The proposed system consists of a rack and pinion mechanism connected to the vehicle suspension. When the vehicle moves over uneven roads, the vertical movement of the suspension causes linear motion of the rack. This linear motion is converted into rotational motion by the pinion gear, which drives a DC generator.

A. Rack and Pinion Mechanism

The rack and pinion mechanism converts linear motion into rotary motion efficiently. The rack is mounted along the suspension, and the pinion is coupled to the generator shaft. As the suspension moves up and down, the rack slides, causing the pinion to rotate.

B. DC Generator

A DC generator is used to convert mechanical rotational energy into electrical energy. The generated voltage depends on the speed of rotation, which varies with road conditions and vehicle speed.

C. Energy Storage Unit

The electrical energy generated is stored in a rechargeable battery. A rectifier and voltage regulator are used to ensure stable charging and protect the battery from overvoltage.

III. WORKING PRINCIPLE

The working principle of the system is based on mechanical-to-electrical energy conversion. When the vehicle passes over road irregularities, the suspension undergoes vertical displacement. This movement drives the rack linearly, which rotates the pinion gear. The rotating pinion shaft is coupled to a DC generator, producing electrical energy. The generated power is conditioned and stored in a battery for later use.

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IV. ADVANTAGES

The proposed system offers several advantages:

1) Utilizes waste mechanical energy
2) Environmentally friendly and renewable
3) Simple and cost-effective design
4) Can be implemented in different vehicle types
5) Reduces load on conventional power sources

V. APPLICATIONS

The energy generated from the vehicle suspension can be used in various applications such as:

1) Charging vehicle batteries
2) Powering vehicle lighting systems
3) Supplying energy to sensors and control units
4) Charging mobile devices and low-power electronics

VI. EXPERIMENTAL RESULTS AND DISCUSSION

A prototype model of the proposed system was developed and tested under different loading and vibration conditions. The experimental results show that a measurable amount of electrical energy can be generated without affecting the suspension performance significantly. The output voltage increases with an increase in suspension displacement and vehicle speed. Although the power generated is limited, it is sufficient for low-power applications.

VII. FUTURE SCOPE

Future improvements can be made by integrating advanced generators, supercapacitors, and power electronics to improve efficiency. The system can also be combined with regenerative braking and smart energy management systems for enhanced performance.

VIII. CONCLUSION

This paper presented a method for generating electrical energy from vehicle suspension systems using a rack and pinion mechanism. The proposed system effectively converts mechanical vibration energy into usable electrical energy. It offers a sustainable and practical solution for energy harvesting in vehicles. With further optimization, the system can contribute significantly to green energy initiatives in the automotive sector.

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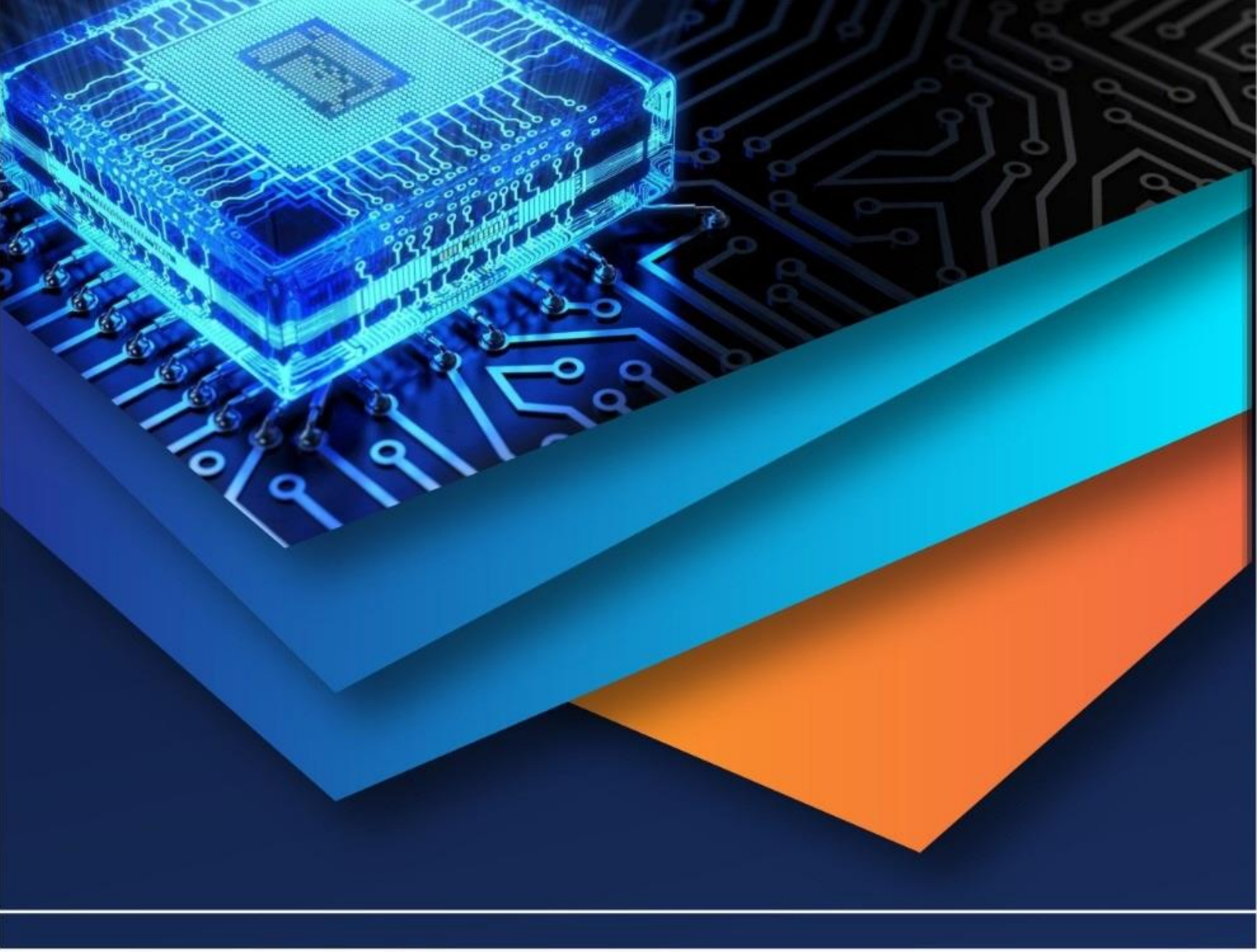

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