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International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Advanced Control Strategies for Electric Vehicle Differential Systems

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ABSTRACT

The integration of e-Diff technology in Electric Vehicles (EVs) is a significant advance in automotive engineering. This project aims to modernize traditional mechanical differentials with an efficient electronic alternative for EVs. The objective is to replace bulkier mechanisms in traditional vehicles, addressing limitations, enhancing performance, and reducing noise and maintenance. By seamlessly integrating electronic control systems, the proposed e-Diff aims to overcome challenges posed by mechanical counterparts. Innovative design and precise control algorithms promise improved EV handling, stability, and traction, along with substantially reduced noise for a quieter driving experience. The project's insights stem from an experimental setup utilizing dual speedometers and an indicator light system for real-time feedback. Through meticulous evaluation and comparison, this study highlights e-Diff technology's effectiveness in addressing critical challenges and enhancing EV driving. In conclusion, the Electronic Differential leapfrogs EV performance and dependability, underscoring potential to reshape automotive engineering with a more efficient, quieter, and maintenance-friendly alternative. Findings contribute to electric mobility knowledge and ongoing automotive innovation.

Keywords- Electronic Differential, Electric Vehicles (EVs), Mechanical Differential, Automotive Engineering, Performance Enhancement, Noise Reduction, Traction Control, Experimental Setup, Real-time Monitoring, Innovative Design

1. INTRODUCTION

In automotive mechanics, a differential gear system is vital for power distribution between a pair of driving wheels, allowing them to rotate at different speeds while sharing engine power. This mechanism is essential for navigating corners and uneven terrains. While both wheels rotate uniformly on straight paths, discrepancies emerge during turns, where the outer wheel must cover a greater distance and, if unrestricted, would rotate faster than the inner wheel. Differentials incorporate a gear ratio, often termed the "axle ratio" or "diff ratio," between input and output shafts. For instance, in many vehicles, gearing reduction is achieved by employing a pinion with fewer teeth than the ring gear. Negotiating a turn necessitates the outer wheels to cover more ground due to the larger radius. While this concept is simple when wheels operate independently, complications arise when both drive wheels are linked to the engine, typically via a transmission. While certain vehicles like go-karts rely on wheel slip for turning, most possess differentials to allow varying wheel speeds, thus enhancing cornering performance. Essentially, a differential ensures engine power transmission while permitting differential rotation speeds for the wheels.

Imagine a basic cardboard car with straw axles and bottle cap wheels. When unattached, wheels move effortlessly, allowing easy back-and-forth motion. Turning is unproblematic as each wheel pivots freely. However, securing wheels to the straw axle removes this flexibility. Attempts to turn locked wheels lead to skidding as each wheel must cover a distinct distance while fixed to a single axle. Now, envision a 2-ton vehicle traveling at 60 mph with locked wheels. Rather than simple skidding, the wheels grip the road, subjecting the entire vehicle structure to substantial stress due to powerful forces. The differential's significance in automotive engineering is undeniable. Beyond power distribution and wheel rotation during turns, it showcases intricate gear and axle interplay. This mechanism not only enhances cornering stability but also exemplifies the complexity of automotive design. As technology advances, differentials continue to evolve, underscoring their importance in modern vehicles.

2. PROBLEM STATEMENT

The differential mechanism within an automobile plays a pivotal role in the equitable distribution of power amid the wheels, simultaneously accommodating distinct rotational velocities—particularly evident during manoeuvres. Although this system is meticulously engineered to endure substantial strain and deterioration, it remains susceptible to issues that can manifest over time due to employment, ecological influences, or inherent manufacturing anomalies. This composition delves into prevalent malfunctions that may transpire within an automobile's differential arrangement. The differential assembly resides adjacent to the transmission enclosure in front-wheel drive configurations, whereas in rear-wheel drive setups, it occupies the space between the rear wheels. For vehicles equipped with four-wheel drive capabilities, a pair of differentials are situated at both the front and rear axles.

3. OBJECTIVES

The objectives of this project converge to create a novel transportation solution that optimizes manoeuvrability in tight spaces through zero radius turns while prioritizing animal safety using voice-enhanced detection systems.

1. The advent of the E-differential system represents a groundbreaking leap in automotive technology, offering a revolutionary alternative to the bulkier traditional mechanisms.
2. By embracing the E-differential system, the automotive industry gains a transformative solution that effectively tackles a wide spectrum of challenges that previously seemed insurmountable.
3. The E-differential system, with its advanced engineering, not only replicates the intricate functioning of a mechanical differential but does so with remarkable precision and a notable reduction in noise levels.
4. A compelling advantage of the E-differential system lies in its lower maintenance requirements, setting it apart from its mechanical precursor and contributing to greater longevity and efficiency in vehicle operations.

4. ELECTRONIC DIFFERENTIAL SYSTEM DESIGN

The initial prototype design boasts dimensions of 28x44x55 cm, denoting its length, width and height respectively. A prudent selection led us to opt for a 2.0-inch plastic base tyre, a commonplace choice renowned for its reliability. The framework of the prototype is founded upon square pipes, precisely measuring 25x25mm, ensuring structural robustness.

With a steering angle we can guide the wheel motor, speed of both wheels differentiates.

Fig 1: structure model of project

5. RESULT AND ANALYSIS

Electric differentials, a groundbreaking innovation in the automotive industry, have significantly transformed the dynamics of vehicles, leading to enhanced performance, safety, and efficiency. This project aims to provide a comprehensive overview of electric differentials, including their working principles, benefits, challenges, and real-world applications. Through a detailed analysis of historical developments and technological advancements, this project sheds light on the evolution of electric differentials and their impact on modern vehicles. The automotive industry has witnessed remarkable advancements in technology, and one such innovation that has gained prominence is the electric differential. Traditional mechanical differentials are critical components in vehicles, ensuring smooth power distribution between wheels during cornering or uneven road conditions. Electric differentials, also known as electronic limited-slip differentials (eLSDs) or active differentials, replace mechanical components with electric actuators and sensors, offering greater control over torque distribution. Electric differentials utilize a combination of electric motors, sensors, and control algorithms to optimize torque distribution across the wheels. Unlike traditional differentials that rely on mechanical components, electric differentials can instantaneously vary torque distribution based on factors such as wheel slip, steering angle, vehicle speed, and road conditions. This adaptability improves traction, stability, and overall handling.

6. CONCLUSION

The Electronic Differential System for Electric Vehicles encapsulates our dedication to pushing the boundaries of innovation. By seamlessly blending advanced technology with real-world functionality, we have crafted a solution that not only elevates EV performance but also contributes to the broader goals of energy efficiency and environmental sustainability. As we reflect on this journey of discovery and achievement, we are excited to witness the transformative impact that our innovation will have on the electric vehicle landscape, ushering in a new era of dynamic, efficient, and exhilarating driving experiences.

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