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Four Wheel Steering with Zero Radius Turning Vehicle

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Abstract: *Conventional two-wheel steering vehicles face limitations in maneuverability, especially in congested urban environments and during parking. This work presents the design and development of a Four Wheel Steering (4WS) vehicle with Zero Radius Turning capability to overcome these limitations. The proposed system integrates multiple steering modes—two-wheel steering, four-wheel steering, and zero-degree turning radius—within a single vehicle using a mechanically actuated arrangement. Dual rack-and-pinion steering columns, interconnected through a steering shaft and knuckle joints, along with a modified bevel gear differential, enable effective rear-wheel steering and counter-rotation during zero-radius turns. Experimental results show a significant reduction in turning radius from 235 cm to 178 cm, along with improved maneuverability and stability. The system offers a practical and cost-effective solution for vehicles operating in tight spaces.*

Keywords: Four Wheel Steering (4WS), Zero Radius Turning, Vehicle Maneuverability, Steering Mechanism, Modified Differential, Turning Radius Reduction, Rack and Pinion Steering

I. INTRODUCTION

The steering system is one of the most critical subsystems of a vehicle, directly influencing maneuverability, stability, and driving safety. Conventional vehicles predominantly use two-wheel steering systems, where only the front wheels are steered while the rear wheels follow passively. Although this configuration is simple and reliable, it results in a relatively large turning radius and limited maneuverability, especially in congested urban environments, narrow roads, and confined parking spaces.

With the rapid growth of vehicle population and urban infrastructure constraints, there is an increasing demand for advanced steering mechanisms that can improve low-speed handling and reduce driver effort. Four Wheel Steering (4WS) systems have emerged as a promising solution by enabling controlled steering of the rear wheels in coordination with the front wheels. Such systems enhance cornering performance, reduce turning radius, and improve vehicle stability under varying operating conditions.

An extension of the four-wheel steering concept is the zero-radius turning mechanism, which allows a vehicle to rotate about its own axis by enabling counter-rotation of wheels. This feature is particularly useful for applications requiring extreme maneuverability, such as urban transport, industrial vehicles, and agricultural machinery. However, many existing solutions rely on complex electronic or steer-by-wire systems, increasing cost and maintenance requirements. In this work, a mechanically actuated four-wheel steering system with zero-radius turning capability is designed, fabricated, and experimentally evaluated. The proposed approach integrates multiple steering modes within a single vehicle using a simple and cost-effective mechanical arrangement, aiming to enhance maneuverability while maintaining feasibility for practical applications.

II. PROBLEM STATEMENT

Weed Increasing traffic density and reduced road space in urban environments make it difficult for conventional two-wheel steering vehicles to maneuver efficiently, particularly during low-speed cornering, parking, and navigation in

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narrow areas. Traditional steering systems result in a large turning radius, poor maneuverability, and increased driver effort. Although advanced steering technologies exist, they are often complex and costly, limiting their practical adoption. Hence, there is a need for a simple, cost-effective steering mechanism that can significantly reduce vehicle turning radius, improve handling, and provide enhanced maneuverability, including the capability of zero-radius turning, without relying on complex electronic control systems..

III. METHODOLOGY

A four-wheel steering (4WS) project with zero-radius turning focuses on developing a system in which all wheels can steer independently, enabling the vehicle to rotate about its own center for full 360° maneuverability. This capability makes the design ideal for tight spaces, narrow pathways, and precise parking applications. The project methodology generally involves: Concept and Design (selecting suitable steering linkages such as planetary mechanisms or actuators, creating chassis models using FEA, and choosing appropriate DC motors or linear actuators); Fabrication (constructing the frame, integrating motors, actuators, and gear systems, and establishing the control architecture); Implementation (programming the controller to achieve independent wheel steering and synchronized motion); and Testing (evaluating zero-turn functionality, measuring reduction in turning radius, and assessing structural performance and operational efficiency

Fabrication Process and Design


Fig 1: Rack and pinion for steering.


Fig 2: Knuckle joint

Fig 3: Electric Motor


Fig4: Final assembly image

Fig1: We used the rack & pinion steering gear box which is normally used in maruti 800 in the front.
Fig2: A knuckle joint is a mechanical joint used to connect two rods which are under a tensile load, when there is a requirement of small amount of flexibility.
Fig3: 12V blower motor for a Mitsubishi vehicle, likely designed for Right-Hand Drive (RHD) models.
Fig3: The entire system was visually inspected and tested under no-load conditions before road evaluation.

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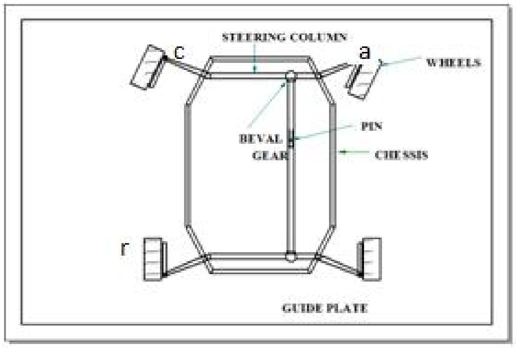
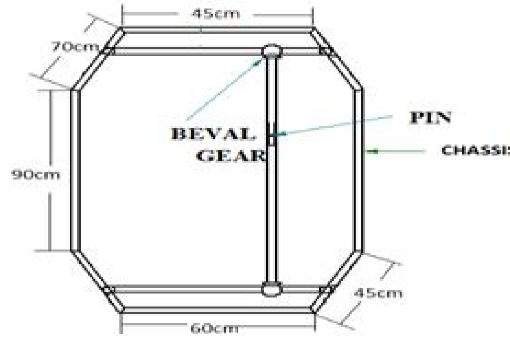
CAD Designs





IV. RESULTS AND DISCUSSION

The experimental evaluation of the four wheel steering system with zero-radius turning capability demonstrates a significant improvement in vehicle maneuverability compared to conventional two-wheel steering. The turning radius was reduced from 235 cm in the conventional mode to 178 cm in four-wheel steering mode, confirming effective rear-wheel coordination. In zero-radius turning mode, the vehicle was able to rotate almost about its own axis, enabling operation in extremely confined spaces. Improved cornering stability and smoother steering response were observed during low-speed maneuvers, reducing driver effort and enhancing control. These results validate the theoretical advantages of four-wheel steering and highlight the effectiveness of the mechanically actuated design as a practical and cost- efficient alternative to complex electronically controlled steering systems.

V. CONCLUSION

This project successfully demonstrates the design, fabrication, and testing of a four wheel steering system with zero-radius turning capability. The proposed mechanically actuated system effectively overcomes the limitations of conventional two- wheel steering by significantly reducing the turning radius and improving vehicle maneuverability and low-speed handling. Experimental results confirm enhanced cornering stability, smoother steering response, and ease of operation in confined spaces. By integrating multiple steering modes within a single, simple, and cost-effective mechanism, the study establishes the practical feasibility of four-wheel steering with zero-radius turning. The developed system shows strong potential for application in urban vehicles, industrial transport, and agricultural machinery, with further scope for integration of advanced control technologies.

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