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Design and Validation of Automatic Brake Failure Detection with Electromagnetic Braking System

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***Abstract*— Brake failure remains a critical safety concern in automotive systems, necessitating advanced detection and emergency response mechanisms. This project presents the design, simulation, and validation of an automatic brake failure detection system integrated with an electromagnetic braking mechanism using MATLAB/Simulink.**

The model monitors braking performance in MATLAB Simulink at an initial speed of 25 km/h and detects failure when the normal braking deceleration drops below the expected level. Once failure is identified, the system activates an electromagnetic braking mechanism to provide auxiliary retardation and reduce stopping distance.

The simulation results show that the proposed system can effectively recognize brake failure, switch to backup braking mode, and improve vehicle control during emergency conditions. This approach offers a simple, reliable, and cost-effective solution for enhancing braking safety in automobiles.

I. INTRODUCTION

Road accidents caused by brake failure constitute a significant portion of vehicle mishaps worldwide, highlighting the urgent need for reliable failsafe braking systems. Traditional hydraulic braking systems, while effective, remain vulnerable to component wear, fluid leaks, and sensor malfunctions that can compromise vehicle safety during critical maneuvers. This project addresses

V. PROPOSED DESIGN (AUTOCAD)

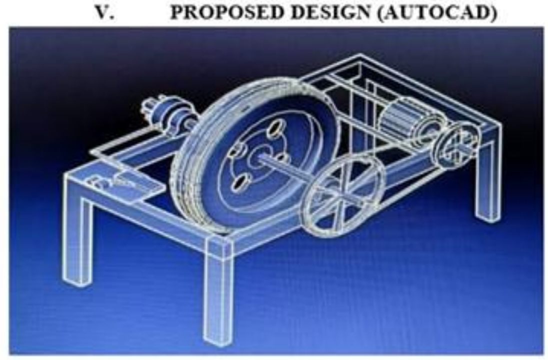

Figure 1 Auto cad Design of Prototype model

these challenges through the innovative integration of automatic brake failure detection with electromagnetic braking technology. The proposed system employs real-time monitoring of key parameters such as wheel speed discrepancies, hydraulic pressure drops, and brake pad positioning to swiftly identify failures before they escalate.

Electromagnetic braking offers distinct advantages over conventional methods, including rapid response times, independence from hydraulic fluid, and consistent performance across temperature extremes. By modeling this hybrid system in MATLAB/Simulink, the project validates the feasibility of seamless transition from primary to backup braking, ensuring enhanced vehicle stability and reduced stopping distances even under fault conditions.

II. PROBLEM STATEMENT

In automobile braking systems, sudden brake failure can lead to loss of vehicle control, longer stopping distance, and serious accidents. There is a need for a reliable brake failure detection and backup braking mechanism that can identify brake malfunction at an early stage and activate an electromagnetic braking system to maintain safe vehicle deceleration. This project aims to design and simulate a brake failure detection system with electromagnetic braking support using MATLAB/Simulink to improve vehicle safety and reduce accident risk.

III. OBJECTIVES

- To Design and Simulate Real Time Break Failure Detection Using MATLAB System.
- To Develop a Model of Brake Failure Detection System.
- To Validate the Performance of the system.

IV. LITERATURE BACKGROUND

Brake failure remains one of the most critical safety concerns in automotive systems because a sudden loss of braking effectiveness can lead to accidents, longer stopping distance, and reduced vehicle control. Recent studies have emphasized the need for fault-tolerant braking strategies that can detect abnormal brake behavior at an early stage and activate an emergency response without driver intervention. In this context, electromagnetic braking has gained attention as a practical auxiliary braking method because it can provide fast retardation, reduce dependence on hydraulic components, and improve safety during failure conditions. Simulation-based research using MATLAB/Simulink has also become important because it allows researchers to model vehicle dynamics, inject fault conditions, and evaluate braking response under controlled scenarios before real implementation. Existing works have shown that such models can effectively represent hard braking, fault detection, and backup braking logic, making them useful for testing control strategies and validating emergency response performance. The literature also indicates that electromagnetic braking systems can reduce mechanical wear, improve reliability, and act as a secondary safety layer when conventional braking is compromised. Therefore, the present project builds on this background by integrating brake failure detection with electromagnetic braking support in MATLAB/Simulink to improve vehicle safety and reduce stopping distance. This approach aligns with the broader trend in automotive research toward intelligent, fault-tolerant, and simulation-validated braking solutions. It is especially relevant for modern vehicles that require dependable emergency braking performance under varying road and operating conditions. Overall, the literature supports the development of a simple, effective, and cost-conscious brake safety system for improved automobile protection.

V. METHODOLOGY

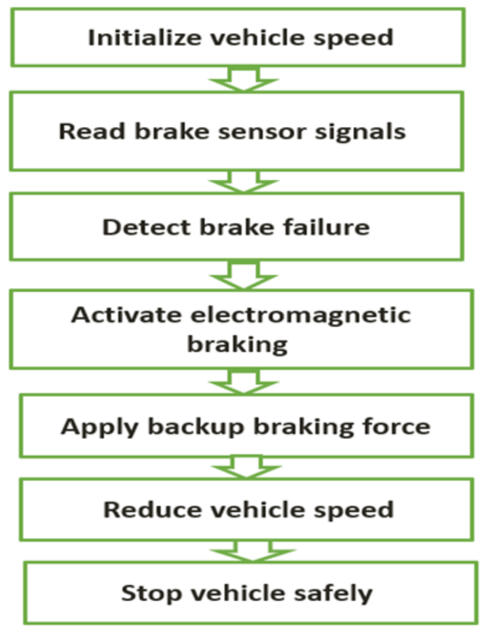

Figure 2 Starting and Ending for process of system of Methodology.

To design and simulate a brake failure detection system with electromagnetic braking backup. First, the working principle of the conventional braking system is studied, and a suitable model is created to represent vehicle speed, braking force, and deceleration under normal conditions. Then, a brake failure condition is introduced in the model to simulate malfunction in the primary braking system. After the failure is detected, the electromagnetic braking system is activated as an alternate braking mechanism to maintain safe deceleration and reduce stopping risk. The complete system is simulated in MATLAB/Simulink at different speed conditions, including the top-speed case, and the outputs are analyzed in terms of speed reduction, braking response, and effectiveness of the backup system.

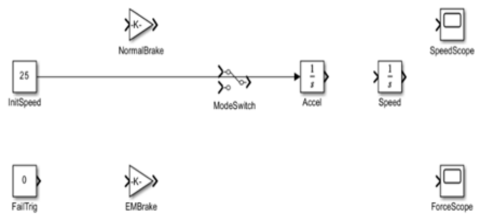

Figure 3 System Model of Simulink

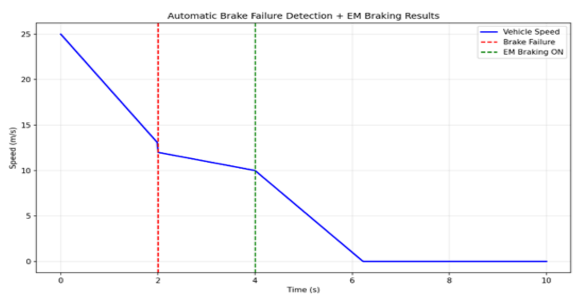

Figure 1 Output analysis of Simulation

VI. RESULT

The simulation results show that the proposed brake failure detection system with electromagnetic braking backup responds effectively under normal and failure conditions. In the initial stage, the vehicle speed decreases according to the braking input, and when the brake failure condition is introduced, the primary braking performance drops as expected. After this, the electromagnetic braking system activates and helps reduce the vehicle speed further, demonstrating its usefulness as a backup safety mechanism. The output graphs clearly show the change in speed and braking response during the different stages of operation.

The main advantage of this project is that it improves vehicle safety by detecting brake failure and providing an alternate braking method through electromagnetic braking. It reduces the risk of accidents by maintaining deceleration even when the primary braking system is not working properly. The project is also useful because it can be simulated and tested in MATLAB/Simulink before actual implementation, which saves time and cost. In addition, the model helps in understanding braking behavior under normal, failure, and emergency conditions, making it valuable for further research and development.

VII. FUTURE SCOPE

The future scope of this project is to extend the simulation model into a real-time hardware-based brake failure detection and electromagnetic braking system. In the next stage, sensors and electronic control units can be integrated to detect brake faults more accurately and activate the backup braking system automatically. The model can also be improved by including real vehicle dynamics, road conditions, load variations, and wheel slip behavior to make the simulation more realistic. Further development may include testing with ABS, regenerative braking, and smart control algorithms to improve safety, efficiency, and response time. This project can also be expanded for use in electric vehicles, autonomous vehicles, and advanced driver-assistance systems, where reliable emergency braking is highly important.

VIII. CONCLUSION

The simulation results show that the proposed brake failure detection system with electromagnetic braking backup responds effectively under normal and failure conditions. In the initial stage, the vehicle speed decreases according to the braking input, and when the brake failure condition is introduced, the primary braking performance drops as expected. After this, the electromagnetic braking system activates and helps reduce the vehicle speed further, demonstrating its usefulness as a backup safety mechanism. The output graphs clearly show the change in speed and braking response during the different stages of operation, confirming that the model behaves as intended.

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