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FABRICATION OF REGENERATIVE AND AUTOMATIC BRAKING SYSTEM USING ULTRASONIC SENSOR

Mayank Gupta[1], Maitrei Tiwari[1], Kundan Yadav[1], Kartikey Pandey[1], Dr. Suvandan Saraswat[1]

[1]*Department of Mechanical Engineering, JSS Academy of Technical Education, Noida*

Abstract

This study explores the integration of regenerative braking with an automatic braking system using ultrasonic sensors in electric and hybrid vehicles. The suggested system employs ultrasonic sensors to identify obstacles and automatically activate the braking system to avoid potential collisions. Together with the automatic braking system, the regenerative braking system is utilized to transform the vehicle's kinetic energy into electrical energy during braking. This energy is subsequently collected and stored in the battery, where it can be employed to power the electric motor, which increases the vehicle's efficiency and reduces its dependence on traditional fuel sources. Upon evaluation of the proposed system using a simulation model, it was observed that the system could capture a considerable quantity of energy during braking. This led to an increase in the vehicle's range, thereby improving its overall performance. Moreover, the automatic braking system using ultrasonic sensors demonstrated high accuracy and response time, making it an effective safety feature. Overall, the integration of regenerative braking with an automatic braking system using ultrasonic sensors has the potential to improve the energy efficiency and safety of electric and hybrid vehicles. Future research could focus on developing a real-world prototype and evaluating its performance under various driving conditions.

Keywords: Regenerative Braking, Automatic braking, Ultrasonic sensor, Energy, Arduino, Motor**.**

1. Introduction

The number of automobile users has been increasing steadily over the years, as more people around the world are able to afford personal transportation. The increasing number of automobile users has raised concerns about both the environment and road safety. The widespread use of automobiles has led to increased carbon emissions, air pollution, and other environmental issues, while the rise in accidents has led to serious injuries and fatalities. To address these concerns, governments and industry organizations are taking steps to promote more sustainable and safe transportation solutions. For example, as a means of reducing carbon emissions and enhancing air quality, a number of nations are advocating for the adoption of electric and hybrid vehicles. Similarly, the development of autonomous vehicles has the potential to significantly reduce the number of accidents by eliminating driver error.

Regenerative braking is a technology implemented in hybrid and electric vehicles, which enables the vehicle to recover energy that would have otherwise been wasted during braking. This recovered energy is then employed to recharge the battery of the vehicle. During normal braking, a vehicle's kinetic energy is converted into heat and dissipated into the environment through the brakes. In contrast, regenerative braking systems operate by using the electric motor in a reverse mode, functioning as a generator to transform the kinetic energy of the vehicle in motion into electrical energy. The generated electricity is then used to recharge the battery, which can then power the electric motor to accelerate the vehicle again.

The traditional braking system, which typically uses hydraulic pressure to apply brake pads to the wheels, is used to provide additional stopping power when needed or when the RBS is unable to capture enough energy to halt the vehicle completely. The combination of regenerative and traditional braking system provides a highly effective and efficient braking solution for hybrid and electric vehicles. The RBS helps to reduce wear and tear on the traditional braking system, while also providing energy savings and reducing carbon emissions. At the same time, the traditional braking system provides the additional stopping power needed to ensure safe and effective braking in all driving conditions.

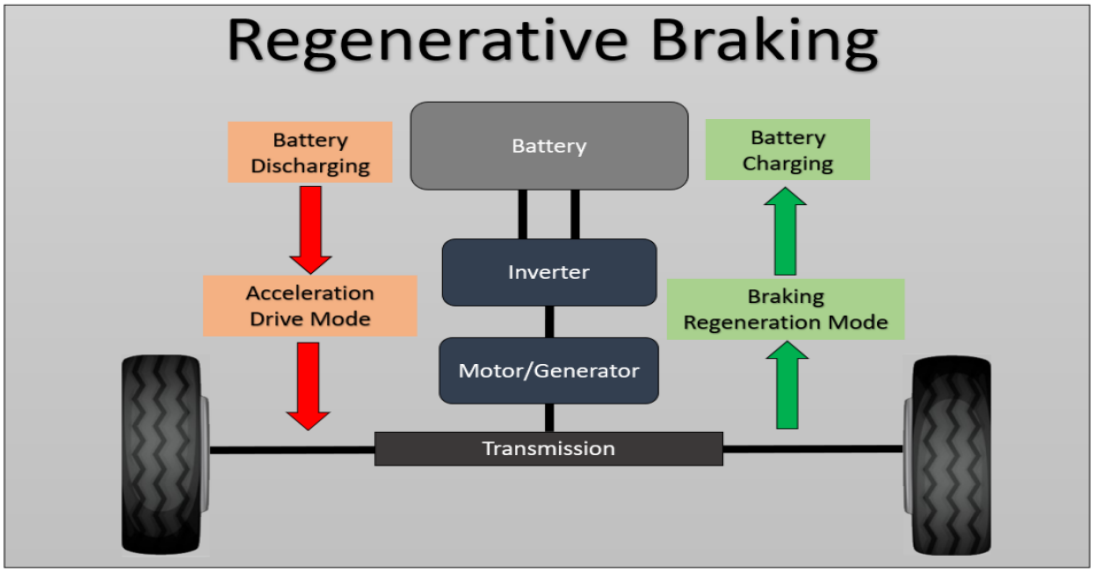

Fig. 1- Regenerative Braking

Regenerative braking is often integrated with automatic braking systems in modern vehicles. An automatic braking system uses sensors and control systems to automatically apply the brakes when it detects an impending collision. When used in conjunction with a regenerative braking system, this capability enables the vehicle to capture and store more kinetic energy, since the automatic braking system can detect and respond to braking situations more quickly than a human driver.

Regenerative braking with automatic braking systems is becoming increasingly common in electric and hybrid vehicles and is an important technology for increasing the efficiency and range of these vehicles. Since regenerative braking retrieves energy that would have been otherwise dissipated during braking, it can assist in lessening the dependence of the vehicle on conventional fuel sources and diminish its general carbon footprint.

By combining these two technologies with ultrasonic sensors, the system can detect obstacles or other vehicles in the vehicle's path and automatically apply the brakes to prevent a collision. The

ultrasonic sensors use sound waves to detect objects in front of the vehicle, and the system can apply the brakes automatically to bring the vehicle to a stop.

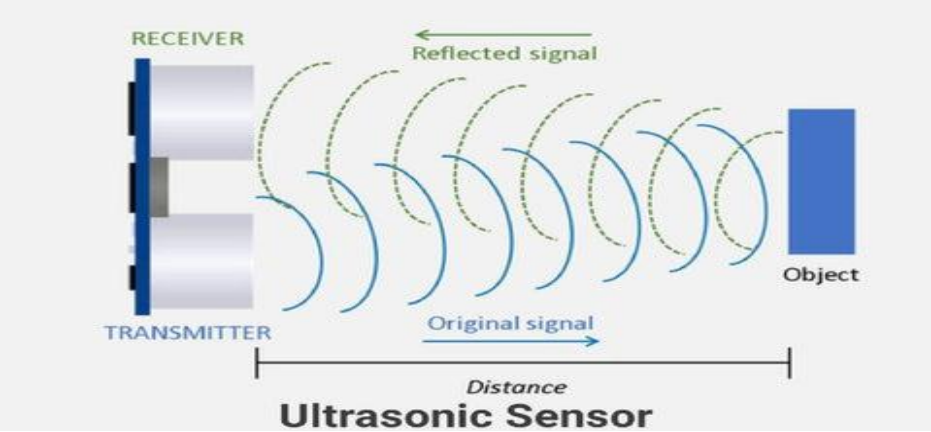

Fig. 2- Working of Ultrasonic Sensor

GENERATING ELECTRICAL ENERGY FROM KINETIC ENERGY THROUGH MOTOR CONVERSION:

The process of converting kinetic energy to electrical energy using a motor in RBS can be broken down into a few simple steps:

1. When the driver applies the brakes, the electric motor switches to generator mode, using the kinetic energy of the moving vehicle to turn the rotor.
2. As the rotor turns, it generates an electric current that is sent to the inverter, which converts the current from AC to DC.
3. Direct current is then sent to the battery, where it is stored for later use or used to power an electric motor.
4. As the vehicle comes to a stop, the traditional friction-based braking system may also be used to provide additional stopping power, if necessary.

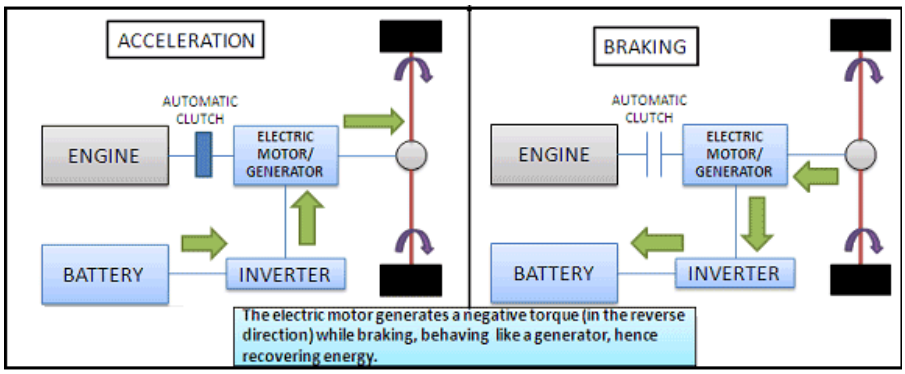

Fig. 3- BRAKING CIRCUIT OF RBS

2. Literature Review

Regenerative braking and automatic braking systems are two of the most important technologies in the automotive industry. These technologies help to increase the efficiency of vehicles, reduce energy consumption and reduce emissions. Ultrasonic sensors have been widely used in automotive applications due to their accuracy and reliability. This literature review will focus on

the research that has been conducted on the topic of regenerative and automatic braking system using ultrasonic sensors.

A. "Design and Fabrication of Intelligent Mechatronic Braking System" (Rajyalakshmi et al., 2018)

In their study, Rajyalakshmi et al. introduced an innovative "intelligent mechatronic braking system" in their research, which uses ultrasonic sensors to improve the safety of a vehicle and regulate its speed. An ultrasonic wave transmitter and receiver are employed in the suggested system, strategically placed at the front side of the vehicle, to emit and detect waves within a specified distance. A microcontroller is employed to regulate the vehicle's speed by processing the received signal information and activating the braking mechanism, thus ensuring the safety of both the driver and passengers. The proposed system is designed to ensure that the vehicle maintains a safe distance from any obstacle present in its path.

B. "Regenerative Braking Systems (RBS)" (P. Bhandari et al., 2017)

In their study, Pratik Bhandari and Shubham Dubey emphasized that regenerative braking has a remarkable capacity to transform a considerable amount of energy into electrical power, which can then be preserved for later use. In the case of automobiles, the frequent braking events result in higher energy losses, providing a greater opportunity for savings. Despite the fact that regenerative braking presently transforms only a portion of the total kinetic energy into mechanical or electrical energy, continued research in this area has the potential to play a crucial role in preserving non-renewable sources of energy in the future.

C. "Fabrication of Regenerative Braking System" (C. Jagadeesh Vikram et al., 2018)

In the paper by C. Jagadeesh Vikram et al, titled 'Fabrication of Regenerative Braking System', The authors address the implementation of the regenerative braking in accordance with specific measures. The research underscores the significance of tailoring future enhancements to meet the study's requirements. It was found that the adoption of the regenerative braking system is crucial in achieving optimal braking performance within the automotive transportation sector.

D. "Design & Development of Regenerative Braking System at Rear Axle" (Warake et al., 2018)

In their paper, Warake K., et al., elaborate on the primary objective of implementing the Regenerative Braking System (RBS) in vehicles, which is to recuperate the energy that is typically lost during braking. The RBS is specifically designed to recover a portion of the battery charge that would otherwise be lost as heat through friction brakes, instead of dissipating it into the environment. However, it is not intended to function as the primary braking system of the vehicle. Research has demonstrated that the RBS can recover a minimum of 11% of battery energy that would otherwise be wasted as heat through friction brakes. Implementing RBS in actual vehicles can increase the distance travelled between two consecutive charging requirements by 10 to 15%.

E. "Automatic Braking System Using Ultrasonic Sensor" (J.V.Sai Ram et al, 2017)

The paper entitled "Automatic Braking System Using Ultrasonic Sensor" by Sai Ram J.V., delves into the use of various sensors in the braking system to reduce the number of deaths caused by road accidents. Automotive safety could be headed towards a bright future with the development of the Automatic Braking System (ABS). Through this paper, the authors have emphasized the importance of incorporating advanced safety systems in vehicles to ensure road safety.

3. Principle of Operation

The principle of operation of a regenerative and automatic braking using ultrasonic sensors can be broken down into several steps:

1. Detects the distance of an obstacle or vehicle ahead: This is achieved using an ultrasonic sensor, which emits the sound waves and calculates the time taken for the wave to reflect back to the sensor. Based on this time measurement, the distance between the obstacle and the sensor can be measured.
2. If the distance is less than 30 cm, the system will send a signal to motor driver to stop the vehicle. The motor driver will then apply the brakes to bring the vehicle to a full stop.
3. If the ultrasonic sensor detects an obstacle or vehicle that is between 30 cm and 90 cm, the system will send a signal to the motor driver to apply the brakes to slow down the vehicle while simultaneously generating electrical energy through regenerative braking.
4. If the ultrasonic sensor detects an obstacle or vehicle that is more than 90 cm away, the system will allow the vehicle to continue moving without any intervention.

During operation, the system uses an Arduino Uno microcontroller to control the operation of the motor driver and relay module, which are responsible for applying the brakes and generating/regulating the electrical energy produced during regenerative braking. The battery provides the necessary power to operate the system, while the DC motors are used to power the wheels of the vehicle. In addition, the system may also include other components such as LEDs, electric wires, square bar, drag board, brake wheel, and wheel to facilitate the overall operation and functionality of the system.

4. Components used in the system

BATTERY: The battery is a crucial component of the system as it provides the electrical energy needed to power the various components. A 12V, 2.5 ampere battery is a common choice for small electric vehicles and can provide enough power to operate the system effectively.

ARDUINO UNO: The Arduino Uno (fig. 4) is a microcontroller board that acts as the brain of the system. It can be programmed to receive signals from the ultrasonic sensor and the motor driver and control the operation of the motor and the relay module. The Arduino Uno can also be used to implement the fuzzy logic controller for the intelligent regenerative braking system.

Fig. 4- Arduino Uno

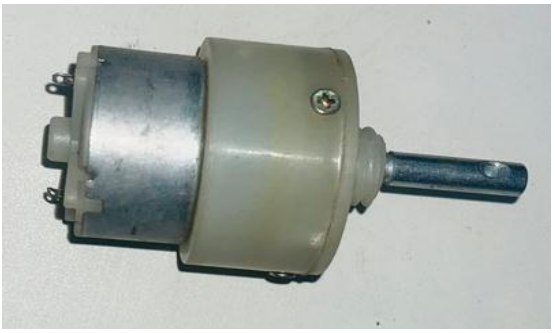

Fig. 5- D.C. Motors / Alternator

DIRECT CURRENT MOTORS: D.C. motors function by transforming electrical energy into mechanical energy. In a regenerative and automatic braking system, D.C. motors can be used to power the wheels of the vehicle and provide the mechanical power needed to move the vehicle. They can also be used in the alternator to generate electrical energy during the braking process.

ALTERNATOR: The alternator (fig. 5) is a component that is used to convert mechanical energy into electrical energy. In the regenerative braking system, the alternator is employed to capture the energy produced during the braking process and convert it into electrical energy, which can then be stored in the battery for later use. The alternator is an important component of the system as it plays a crucial role in optimizing the energy efficiency of the vehicle.

ULTRASONIC SENSOR: An ultrasonic sensor (fig. 6) is a type of sensor that emits high-frequency sound waves and calculates the time it takes for the waves to reflect back to the sensor. This sensor is employed to gauge the proximity between the vehicle and any potential obstacles in its path. The ultrasonic sensor provides input to the Arduino Uno, which then adjusts the regenerative braking force to maximize the energy efficiency of the vehicle.

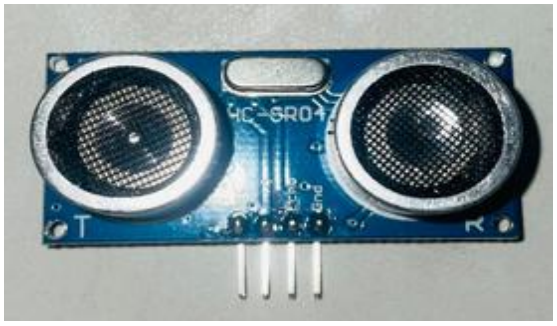

Fig. 6- Ultrasonic Sensor

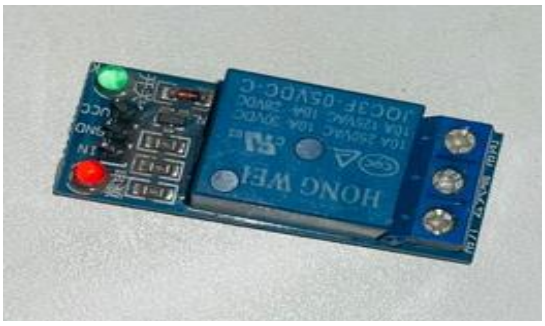

Fig. 7- Relay Module

RELAY MODULE: The relay module (fig. 7) is a device that is used to switch high-voltage or high-current circuits using a low-voltage signal. The relay module is commonly utilized in automatic braking systems to control the flow of power to the motor and activate the brakes once the ultrasonic sensor detects an obstacle in the vehicle's path. The relay module receives a signal from the Arduino Uno to activate the braking system.

MOTOR DRIVER: The motor driver is a circuit that controls the speed and direction of the motor. It receives signals from the Arduino Uno and regulates the power sent to the motor. A motor driver is essential for the operation of the system as it ensures that the motor operates efficiently and reliably.

LEDS: Light Emitting Diodes (LEDs) are tiny electronic devices that produce light by passing an electrical current through them. In the context of a regenerative and automatic braking system, LEDs can function as indicators to display the current status of the system. For example, an LED can be used to indicate when the regenerative braking system is activated or when an obstacle is detected by the ultrasonic sensor.

ELECTRIC WIRES: Electric wires are an essential component of any electrical system as they are used to connect the various components together. In a regenerative and automatic braking system, electric wires are used to connect the battery, Arduino Uno, motor driver, ultrasonic sensor, and relay module together. High-quality wires should be used to ensure that the system operates reliably and safely.

BRAKE WHEEL: The brake wheel is a component of the vehicle's wheel assembly that slows down or stops the vehicle's motion. In a regenerative and automatic braking system, the brake wheel can be used in conjunction with the regenerative braking system to further slow down the vehicle and recover energy.

WHEEL: Wheels are circular components that rotate on an axle and support the weight of a vehicle. In a regenerative and automatic braking system, wheels are essential components as they provide the necessary traction to move the vehicle and can be used in conjunction with the braking system to slow down the vehicle.

FINAL FABRICATED MODEL:

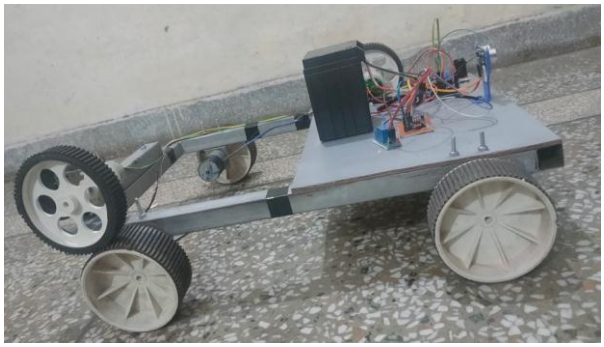

Fig. 8- Side View

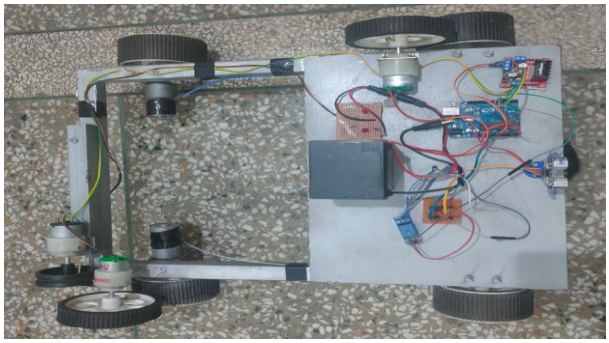

Fig. 9- Top View

5. Advantages

- Enhancing Energy Efficiency: Best for Optimal Resource Utilization.
- Advancing Safety Standards: Best Practices and Innovations for a Safer Environment.
- Minimizing Brake Wear and Tear: Effective Techniques for Prolonging Vehicle Longevity.
- Combatting Emissions: Sustainable Solutions for Reducing Environmental Impact.
- Elevating the Driving Experience: Innovative Features and Technologies for a Smooth Ride.

6. Limitations

- The performance is limited in certain driving conditions, such as high speeds and adverse weather.
- The integration can elevate complexity and maintenance costs, potentially impacting system reliability.
- Limited range of application as it may not be universally applicable, as heavy-duty trucks and off-road vehicles necessitate distinct braking mechanisms.
- The effectiveness hinges on driver acceptance and behavior, as some drivers may find the system disruptive and opt to disable or ignore it, ultimately diminishing its efficacy.
- The efficacy can be hindered by limited battery capacity, as the recovered kinetic energy may exceed the battery's storage capability.

7. Result & Discussions

The operation of a regenerative and automatic braking system that incorporates an ultrasonic sensor includes the activation of the Arduino board when the power supply is turned on. Initially, the relay switch is in the OFF state, and the motor connected to the battery remains in the stationary position. As the motor is activated by the Arduino board, the vehicle starts moving forward. The ultrasonic sensor installed in the vehicle detects obstacles in its path from a distance of 150 cm. When an obstacle is detected between 90 and 30 cm, the sensor sends a signal to the motor driver, which slows down the vehicle. When an obstacle approaches the vehicle and reaches a distance of 30 cm, the ultrasonic sensor sends a signal to the relay switch. This activates the switch, which disconnects the power supply to the motor, ultimately causing the vehicle to stop completely.

Following successful testing, the model was operated under various loading conditions, and the resulting data was recorded and tabulated for analysis.

Table 1: Result Table

Sr. No.	RPM before brakes pressed	RPM after brakes pressed	Output Voltage (in V)
1.	100	93	9.34
2.	125	114	10.86
3.	150	135	11.79
4.	175	152	12.81
5.	200	176	13.59
6.	250	231	13.88
7.	300	282	14.59

According to the tabulated results, the efficiency of the regenerative braking system employing DC motors was discovered to rise with the motor's angular velocity. This increase in efficiency can be attributed to the fact that higher motor speeds result in a greater amount of recoverable energy. At higher speeds, the losses were primarily due to mechanical factors such as friction and air resistance, rather than electrical losses. By focusing on achieving higher motor speeds, it may be possible to significantly improve the efficiency and effectiveness of these systems in recovering energy and reducing waste.

8. Conclusion

In conclusion, regenerative and automatic braking systems using ultrasonic sensors have the potential to significantly improve the efficiency and safety of the vehicle's braking system. By capturing and storing kinetic energy that would typically be dissipated during braking, the regenerative braking system has the potential to increase the vehicle's overall energy efficiency, thereby reducing fuel consumption or extending the range of electric vehicles. The automatic braking system can detect obstacles in front of the vehicle and apply the brakes automatically to avoid a collision, which can help prevent accidents and improve the safety of the vehicle. Furthermore, these systems can provide a more comfortable and convenient driving experience for the driver, reducing the need for sudden and harsh braking maneuvers. The integration of these systems with other advanced safety features can provide a more comprehensive safety system for the vehicle.

However, it is important to note that these systems have some limitations, such as the need for proper maintenance and the dependence on the quality of the ultrasonic sensor. Further research and development can help optimize these systems for different driving conditions and enhance their overall performance, making them an important part of the future of automotive safety and sustainability.

Acknowledgement

We would like to express our sincere gratitude to our mentor and co-author, Associate Prof. Dr. Suvandan Saraswat, for his invaluable guidance, suggestions, and support from the initial level until the completion of this project. His vast knowledge and expertise have been a great source of inspiration for us. We would also like to extend our thanks to the Head of the Department of Mechanical Engineering, Prof. Dr. Mamatha T.G. at JSSATE, Noida, for providing us with the necessary resources and infrastructure to conduct this project.

References

[1] Rajyalakshmi, M., Kumar, B. K., Vaibhav, A. K., Khan, M. A., & Sai, B. V. V. S. (2018). Design and Fabrication of Intelligent Mechatronic Braking System. International Journal of Science Technology & Engineering.

[2] Bhandari, P. N., Dubey, S., Kandu, S., & Deshbhratar, R. (2017). Regenerative braking systems (RBS). International Journal of Scientific Research in Science and Technology.

[3] Vikram, C. J., Kumar, D. M., & Chandra, P. N. (2018). Fabrication of Regenerative Braking System. International Journal of Pure and Applied Mathematics.

[4] Warake, K., Bhahulikar, S. R., & Satpute, N. V. (2018). Design & Development of Regenerative Braking System at Rear Axle. International Journal of Advanced Mechanical Engineering.

[5] Ram, J., Manikanta, K. M. S. V., Pavanth, G., Jagadeep, B., & Kumar, B. R. (2017). Automatic braking system using ultrasonic sensor. International Journal of Innovative Science and Research Technology.

[6] RBS. Retrieved from https://cecas.clemson.edu/cvel/auto/systems/regenerative_braking.html

[7] Robocraze. What is an Ultrasonic Sensor? Retrieved from https://robocraze.com/blogs/post/what-is-ultrasonic-sensor