

# Design And Fabrication of Regenerative Braking System with Power Monitoring

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**Abstract-** The project represents an innovative approach to enhancing energy efficiency in vehicles. Through enormous amount of heat energy is unwantedly disappear in to atmosphere at the time of brakes are applied while vehicle is in running, it will be useful if we store this energy somehow which is otherwise getting wasted out and reuse it while we started to accelerate. In this perspective, here we propose a regenerative braking system with power a monitor. This system allows a vehicle to generate energy each time brakes are applied as well as track the amount of power generated. When brakes are applied strongly more heat energy will be generated. Also, a circuitry is used to track the generated voltage every time while applying force on the brake pedal.

This method is based on the principle of converting the kinetic energy created by mechanical energy of the motor into electrical energy and the converted electrical energy is stored in battery for later use. This system furnishes benefits across fuel saving. In consequence this system allows for charging of vehicle battery each time brakes are applied, thus providing a regenerative braking system. It moves us another step ahead towards a pollution free transportation system.

**Key Words:** Regenerative braking, Brakes, Kinetic energy, Motor, Generator, Power monitor.

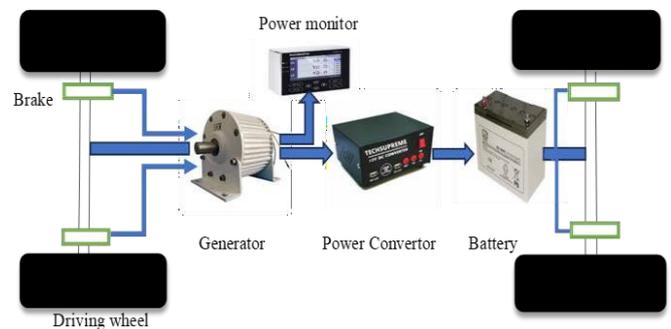
## 1. INTRODUCTION

In the pursuit of escalating environmental concerns and the imperative to reduce carbon emissions, the automotive industry is witnessing a paradigm shift towards sustainable and energy-efficient technologies. One such innovation that has garnered significant attention is the Regenerative Braking System (RBS), a groundbreaking approach to harnessing and optimizing energy within vehicular systems.

The research article is going to enlighten on the design and fabrication of a regenerative braking system which comes under one of the core mechanisms in the discipline of

mechanical engineering. Regenerative Braking is an energy recovery mechanism that slows down a moving vehicle or object by converting its kinetic energy or potential energy into an electrical energy that can be either used immediately or stored until needed.

The traditional friction-based braking systems employed in vehicles dissipate kinetic energy in the form of heat, leading to significant energy wastage and reduced fuel efficiency. Regenerative braking, on the other hand, represents a pioneering solution to this challenge by capturing and converting the kinetic energy during deceleration into electrical energy, which can be stored or redirected for various applications within the vehicle's powertrain.



**Figure 1:** Regenerative braking system with power monitoring

The integration of a power monitoring system with regenerative braking holds immense promise in providing valuable insights into energy exhausting patterns, efficiency fluctuations, and system health. By closely monitoring and analyzing the power flow during braking events, researchers and engineers can refine regenerative braking algorithms, maximize energy recapture, and ensure seamless integration with the vehicle's power grid.

In the following sections of this paper, we will delve into the technical aspects of regenerative braking systems, explore the various methodologies of power monitoring, and present

empirical evidence from real-world applications. Through a comprehensive analysis, this research aims to contribute valuable insights to the ongoing discourse surrounding sustainable transportation and the pivotal role of regenerative braking systems with advanced power monitoring in shaping the future of automotive engineering.

## 2. LITERATURE REVIEW

The integration of regenerative braking systems in vehicles has gained significant attention due to their potential to improve energy efficiency and reduce environmental impact. Power monitoring is a crucial aspect of these systems, providing insights into their performance and optimizing energy recovery.

As per the studies of Pavan Kalyan Pandranki (2023), The “regenerative braking system” has been widely used in recent times in electric and hybrid vehicles. However, the proportion of conventional fuel-based vehicles all over the world is significantly high compared to EVs. It also enhances the lifespan of braking pads by reducing the frequency of friction between rotators and brake pads. According to the consideration of Siva Maran Venkatesan (2022), Regenerative braking is a small, yet very important, step toward our eventual independence from fossil fuels. These kinds of brakes allow batteries to be used for longer periods without the need to be plugged into an external charger. These types of brakes also extend the driving range of fully electric vehicles. All vehicles in motion can benefit from utilizing regeneration to recapture energy that would otherwise be lost. The studies of Yadav et al. (2022), concluded a “regenerative braking system” reduces fuel consumption by approximately 33% by converting kinetic energy into electric and mechanical energy.

Bing Yang Cao (2021), mentioned that the advantages of regenerative braking energy recovery are that it not only improves energy recovery efficiency, but also reduces mechanical wear and tear in mechanical and hydraulic braking, achieving more precise braking control. Yang Y (2020), designed a dual-motor regenerative braking force distribution strategy based on the optimal braking energy recovery. Kulkarni (et al. 2020), has been recognized that the RBS increase the driving range up to 11-22% based on the RBS parameters and “drive cycle settings” such as energy consumption. Arun Kumar (2020), reveals that this system had minimal loss in transmission there by leading to better efficiency and better conversion ratio as compared to any other earlier braking system using motor-generator set up.

As per the studies of Jagandeep Kaur (2017), The energy lost during the braking is conserved by the regenerative braking system. These systems can work at the high-temperature

ranges and are highly efficient when compared to the conventional brakes. Regenerative brakes are more effective at higher momentum. As per the narration of Pratik Bhandari (2017), Bhandari concludes that, Regenerative braking is necessarily limited when the batteries are fully charged. Because the additional charge from regenerative braking would cause the voltage of a full battery to rise above a safe level, our motor controller will limit regenerative braking torque in this case. Tribhuvan Singh and Shahzad Ali (2016), stated that the life of primary dynamo or the main dynamo and further our modification at this small scale can give us a maximum of 9V voltage which can charge all the equipment's. There are some more advantages too of using this modification in regenerative braking system, after using this modification fuel consumption of the vehicle can also be decreased up to a certain value which will ultimately save the money.

## 3. METHODOLOGY

Research methodology defines the approach of conducting the entire research on the specific topic by collecting and analyzing adequate relevant data in the most convenient way without facing any significant hazards. Thus, different tools and methods related to conducting research are going to be evaluated in the below section:

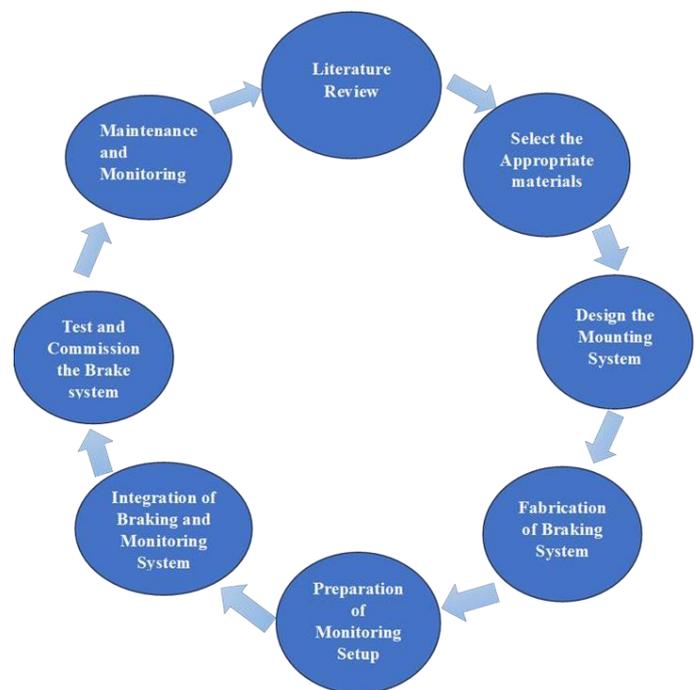


Fig 2: Methodology of Regenerative Braking System

### 3.1 Components Used in Carrying Out Performance Testing:

- MS Square Tube and Bar (1 inch).
- Wheel.

- 100 rpm motor (2 in quantity).
- 1000 rpm Starter Motor.
- Dynamo (Brake Gear).
- Atmega328p Arduino.
- LCD display.
- Wires.
- Adhesives.

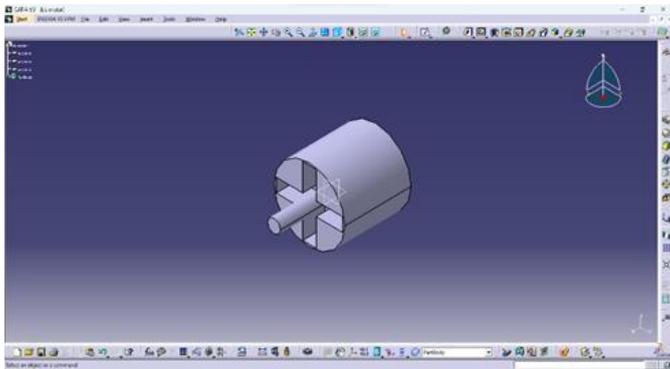


Fig 3: Motor

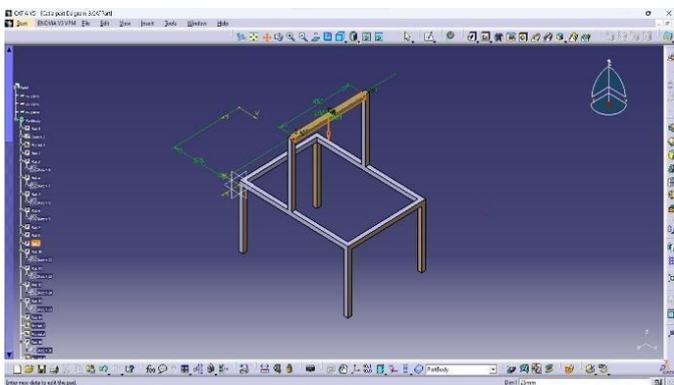


Fig 4: Supporting Frame

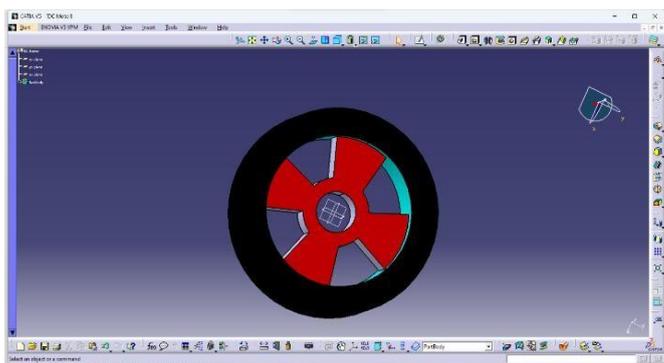


Fig 5: Wheel

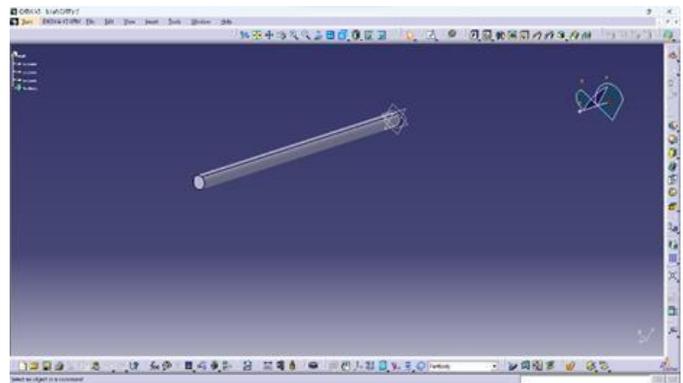


Fig 6: Shaft

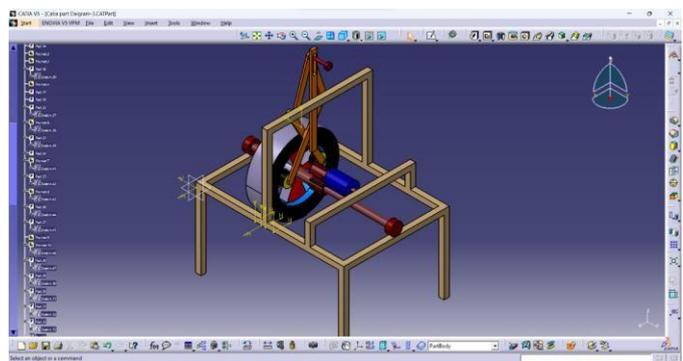


Fig 7: Catia Model of Actual setup

## 4. PROCEDURE

### 4.1 For setting up the Braking System:

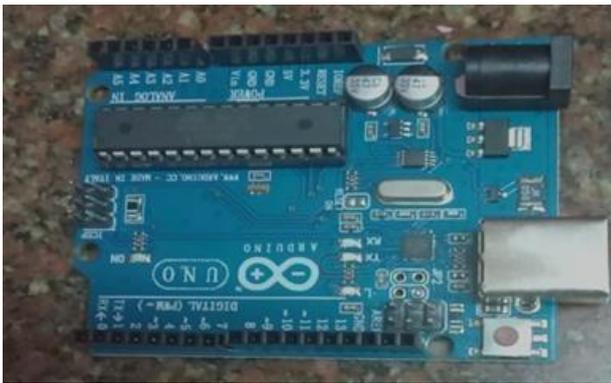
The procedure for setting up the “regenerative braking system” goes through the following steps mentioned in the below in a sequential order.

1. Initially mark the Ms. Square Tube to the required specifications. Place the Ms. Square on the Table, then cut the material with accurate dimensions. After marking the material should be welded according to the joints of the supporting frame.
2. Take the wheel shaft and couple them using simple nuts and bolts and mount this wheel onto the stand. Use mechanical bushes as a medium between the wheel shaft and the rods to reduce the friction between the shaft and rod and to ensure a smooth rotation of the wheel at high speeds.
3. Take Ms. Flat and mark it to the required dimensions. Using a Radial drilling machine drill a hole of specified Dia for cross link mechanism, which is applied as Brakes.
4. Make a slot vertically on Ms. flat for providing up and down movements of cross link mechanism and attach the motors (Dynamo).

- Using a Lathe machine drill into the shaft with a drill of the same diameter as the motor and then couple the motor to the shaft.

**4.2 For setting up the Monitoring System:**

- Dynamo attached at the end of the cross link, whenever brakes are applied dynamo attachment moves towards the inner surface of rotating wheel.
- Attach the wires of this motor to the Arduino screen to get the generated output energy.
- The IR module will continuously measure the rpm and send it to Arduino and in the same way, the voltage module will measure the voltage after the application of the brakes.



**Fig 8:** Atmega328p Arduino

- The coding of Arduino is done in such a way, that it will take the readings of voltage and rpm simultaneously.
- LCD display connected to Arduino to show the real time information of power generation during brakes are applied.

The regenerative system recovers some of the waste energy and puts it to work again. The system captures and converts this waste energy into electricity. The electricity thus regenerated; charges the battery of an electric or hybrid vehicle. In the regenerative braking system, the motor; which drives an electric vehicle, also performs the function of braking. The system consists of an electric motor with dual function. It works as a motor, in one direction, and as a generator, in the opposite direction. When it runs as a motor, it converts electrical energy into mechanical energy and drives the wheels. However, while braking; it runs in the opposite direction and becomes an electric generator. Applying the brakes of an electric or hybrid vehicle causes the electric motor to run in reverse direction i.e. in generator mode, thereby, slowing down the wheels (Kulkarni et al. 2020).



**Fig 9:** Actual photo of the setup

**5. RESULTS AND DISCUSSION**

The Regenerative Braking System is developed as the supplementary and advanced braking system, which is mainly used along with “conventional braking systems” to enhance the efficiency of braking in stopping cars and restoring the kinetic and concerning braking energy in the form of electric energy. Regenerative braking recaptures up to 70% of the kinetic energy that would otherwise be lost during braking.

By conducting the performance test on the “Regenerative Braking System” invented the following Data as results.

Sl. No	Voltage (v)	Speed (rpm)	Time taken to full stop from maximum speed to zero (sec)
01.	5.4	450	5
02.	6	500	6
03.	8	680	8.5
04	10.5	800	10
05	11	1000	12

**Table 1:** Results (Voltage and Speed)

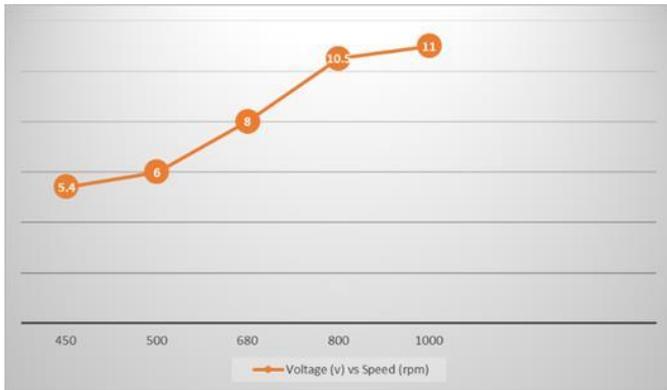


Chart 1: Graph of Voltage versus Speed

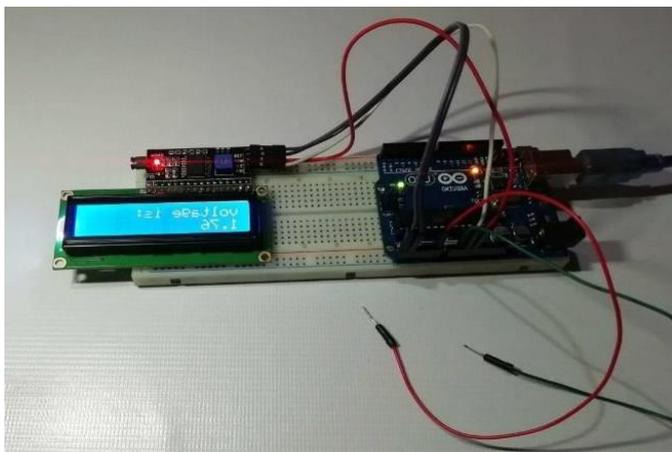


Fig 10: Model of Power Monitoring

- From Table 1, it can be observed that as the voltage increases there is a gradual increase in speed (rpm) of the wheel.
- Chart 1 shows the variation between voltage and the rpm, which is depicted by an almost linearly increasing graph.
- From the above observations, it can be concluded that the maximum power generated is 11V, which is capable of glowing 5 LEDs.
- Average Output voltage (v) = 8.18 V
- Average Speed (rpm) = 686 rpm
- Average Time taken to full stop from maximum speed to zero is 8.3 sec.

Fig 10 indicates actual model of power monitoring using Atmega328p Arduino. It shows Voltage on LCD display.

## 6. CONCLUSIONS

The integration of regenerative braking systems with power monitoring not only promotes energy efficiency but also contributes to the development of more sustainable and environmentally friendly transportation solutions. As technology continues to advance, ongoing research and

innovation in this field will likely lead to further improvements, making regenerative braking an integral component of future energy-conscious systems.

We conclude that as soon as brakes are applied, the LCD display shows the real time information about power generation, it allows drivers to customize their driving experience. This may include adjusting regenerative braking levels, setting preferences for energy recovery, and receiving feedback on driving habits. On the other hand, if we increase the rpm of the wheel, the voltage generated is also increased. Hence, we can with the backing of scientific studies say that the voltage generated is directly proportional to Rpm.

## 7. FUTURE SCOPE

The use of more efficient ceramic composite brake materials could lead to effective Braking system, which stops the moving vehicle quickly. Future research and development on ceramic composite materials will likely lead to further improvements, making regenerative braking systems a key component of future mobility solutions. The use of Integrated monitoring techniques to this system for providing real time feedback, it is superior to invent well organized techniques.

However, the extensive use of the RBS in high-speed vehicles, especially in petrol and diesel engine vehicles, is still a lack of conviction and hence, future research and further improvement are required.

## 8. REFERENCES

- (1) Pavan Kalyan Pandranki (2023). Design Analysis of Regenerative Braking System. International Journal for Multidisciplinary Research (IJFMR),05(04).
- (2) Siva Maran Venkatesan (2022). Regenerative braking power system. Manufacturing Technology Today, Vol. 20(11-12).
- (3) Hamada, A.T. and Orhan, M.F., (2022). An overview of regenerative braking systems. Journal of Energy Storage, 52, p.105033.
- (4) Yadav, D., Kumar, R., Kulshrestha, U., Jain, A. and Rani, S., 2022. Enhancement of fuel efficiency in heavy duty vehicles through integrated module of TEG, piezoelectric and regenerative braking solutions. Materials Today: Proceedings, 63, pp.1-5.
- (5) Sathishkumar, A., Soundararajan, R., Vel, T.M., Arjith, M.B.S. and Sakthivel, G., 2022. Review on regenerative braking system. E-Mobility: A New Era in Automotive Technology, pp.149-163.
- (6) Rohan S Kulkarni (2020). Design, Analysis & Performance Testing of Regenerative Braking

System. International Research Journal of Engineering and Technology (IRJET),07(08).

- (7) Popiołek, K., Detka, T., Zebrowski, K. and Małek, K., 2019. Analysis of regenerative braking strategies. system, 1, pp.4-84.
- (8) Mathur, K., Choudhary, L.K., Natu, A.M., Srinivas, K. and Rastogi, V., 2019. Conceptualization and Modeling of a Flywheel-Based Regenerative Braking System for a Commercial Electric Bus. SAE International Journal of Commercial Vehicles, 12(02-12-04-0018), pp.223-239.
- (9) Nagaraja, M., and Bruno, D. (2018). Performance testing of a Regenerative braking system. International Journal of Engineering Research &Technology (IJERT), 06(04).
- (10) Jagandeep Kaur, Shruti Karkra (2017). Regenerative Braking. International Journal on Recent and Innovation Trends in Computing and Communication (IJRITCC), 05(5).
- (11) LOI WEI CHEONG, "A development and use of a regenerative braking model for a parallel hybrid electric vehicle," SAE Technical Paper Series, 2013.



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**BIOGRAPHIES**



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