



International Journal of Innovative Research in Science Engineering and Technology (IJIRSET)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)



Impact Factor: 8.699

Volume 14, Issue 4, April 2025

Self Power Generation in Electric Vehicles using Driving Wheel

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ABSTRACT: The design and development of electric cars with DC motors that can charge themselves is aided by this research. Another name for these cars is self-power producing vehicles. It is composed of Two batteries, a charging unit and a DC motor with four gears. The vehicle's driving wheel was connected to the DC motor and took in torque from the wheel's displacement. The torque is transformed by the charging unit into electrical and electrochemical energy that is stored in the battery. The motor is set up to convert the battery's electrical energy into torque, which the driving wheel will use to move the car. The self-charging electric vehicle model's hardware prototype was created, and it showed off the drive system's functionality. The suggested model is easier to drive and more environmentally efficient. Lithium ion batteries, low cost systems, a variety of motor options and self-charging systems are the foundation of the future of electric vehicle technology.

KEYWORDS: Charging circuit, Batteries, DC motor, electric vehicle, voltage regulator and dynamo etc.

I. INTRODUCTION

The transportation industry, carbon emissions, repair costs, and driving patterns are all changing as a result of electric vehicles. Due to fuel optimization, hydrogen production, storage, and technical constraints, electric vehicles (EVs) are more fuel-efficient than gasoline-powered vehicles. Fossil fuels are used in the traditional transportation sector, which has a disastrous effect on the environment due to its high emissions of greenhouse gases and air pollution. The electric driving technology eliminates the barrier of conventional transportation sectors, produces extremely low carbon emissions, and is environmentally benign. Over the past few decades, electric vehicles (EVs) have become increasingly popular and advanced significantly. Global plug-in vehicle deliveries in 2019 reached 2264400 units, which is 9% higher than for 2018. This is a significant departure from the growth rates of the previous five years, which were between 45% and 70% near about. The automobile industry continued to work on innovation and recent advancement of EV technologies and its associated components, such as motors, energy storage systems, and power conversion technologies. Around 5.2 million chargers for light-duty EVs were in use at the end of 2018, with nearly 540000 of those being public charging stations.

Aspects including vehicle range, pricing, battery pack replacement cost, battery pack life, and rapid and simple recharging will be the main focus of EV technology advancement [1]. Among the many benefits of battery-powered vehicles are their low carbon gas emissions, energy crisis, high energy efficiency, and ability to combat global warming. EVs' drawbacks include their high initial cost, limited driving range, lengthy charging time, commercial availability, and decreased passenger capacity [2–3]. One of the finest and most widely accepted ways to improve the quality of the air is through the use of electric vehicles (EVs). When compared to Si material-incorporated devices, EVs leverage the appealing characteristics of SiC and GaN material-based power semiconductor devices, which include better efficiency, breakdown voltage, and specific on-resistance [4]. The state of the art and current developments in electric vehicles from 2002 to 2012 have been illustrated in this paper [5]. The development of batteries and electric machines is covered in this article, along with an explanation of the idea of battery charging and EV self-power generation.

Electrical safety and prevention in EV electric charging are explained in the literature [6]. This article's primary goals are to examine degradation, protection shortcomings, cyberattack threats, and supply and demand imbalances. Power systems that use smart charging systems may find that charging safety is a significant factor.

The development and application of self-driving cars in the transportation industry has been spurred by artificial intelligence (AI) technology. Perception, decision-making, localization, and its mapping form the foundation of AI applications [7]. The primary limitations of AI applications are complexity, ambiguity, sensor problems that impact the AI approach's input, model tuning concerns, and hardware-solving issues. The lightweight electric car, which uses a bidirectional DC-DC converter, is primarily utilized in urban settings [8]. Plug-in electric vehicle based agent technique is used for the real time observation of power system models and embedded system approach [9]. In addition to reviewing two battery aging techniques—the depth of discharge and the charging process—this tool illustrates the optimization methodology. The quick charging strategy incorporates the different connected issues such as power flow, short circuit, utility upgrade software package and protection of electric vehicles [10]. Rapid charging technology, which has recently advanced, is utilized in automobiles and installed in commercial and residential areas. The current method is linked to a number of limitations, such as flicker, harmonics, and voltage sags, which could destroy the apparatus. The demand for electric vehicles and its sustainable growth are rising as a result of fast charging methods. The charging time consumption of electric vehicles was one of the limitations; this is eliminated by employing the self-charging approach. This article advances the development of electric vehicles that can charge themselves.

II. LITERATURE SURVEY

The concept of self-power generation in electric vehicles (EVs) using the driving wheel is an emerging approach aimed at enhancing energy efficiency and reducing dependency on external charging infrastructure. Several research works and technical studies have been conducted in this field, exploring various methods such as regenerative braking, in-wheel generators, and kinetic energy recovery systems. Below is a survey of notable literature in this area.

1.Regenerative Braking Systems : Regenerative braking is a widely adopted technique in modern EVs to recover kinetic energy during deceleration. According to C. Mi et al. (2011), regenerative braking can recover up to 10–30% of the energy otherwise lost in frictional braking, thereby improving the vehicle's overall efficiency. This system utilizes the motor as a generator to convert kinetic energy into electrical energy and store it in the battery.

2.In-Wheel Generator Mechanism: R&D efforts have been made to incorporate in-wheel generators that produce electricity as the wheel rotates. A study by S. Tiwari et al. (2018) discussed the feasibility of using miniature alternators integrated into the wheel hub to continuously generate power while the vehicle is in motion. This approach supports auxiliary charging and can contribute marginally to range extension.

3. Kinetic Energy Recovery Systems (KERS) : Originally developed for Formula 1 racing, KERS technologies are now being evaluated for integration into consumer EVs. The system captures braking energy and stores it either electrically or mechanically. The review by P. Singh and R. Kumar (2020) elaborated on the electromechanical variants of KERS suitable for small-scale EVs, showing potential for compact and efficient energy recycling.

4. Piezoelectric Energy Harvesting : Some research has explored the use of piezoelectric materials embedded in tires or suspension systems to generate electricity from road vibrations and pressure changes. A study by L. Zhang et al. (2017) proposed a piezoelectric transducer-based energy harvesting system which showed promising results under laboratory testing but requires further development for road use.

5. Integration Challenges and Battery Management : Although energy harvesting from the wheels is promising, integrating such systems with the vehicle's battery management system (BMS) remains a significant challenge. Y. Chen and D. Cao (2019) highlighted the importance of synchronizing energy inputs with the BMS to prevent overcharging, overheating, and to ensure optimal power flow.

6. Economic and Environmental Implications : A lifecycle analysis by A. Verma and N. Shah (2021) indicated that even marginal improvements in self-power generation can significantly reduce carbon emissions and dependence on grid power when scaled across large fleets of EVs.

III. METHODOLOGY

A four-gear DC motor, a driving wheel, a charging device, and two parallel batteries make up the suggested electric vehicle type. A self-generating electric vehicle's block diagram is displayed in Fig. 1. To give the wheels traction power, the electric motor transforms the battery's energy into mechanical energy. High starting torque, a broad speed range, low noise, controllability, lack of maintenance, and affordability are all necessary for the motor. Figure 2 illustrates how the suggested system works. The shaft in this suggested drive system is attached to the motor, and the battery is connected to the shaft. The motors are connected to dynamo and dynamo generated AC power which convert the DC using a rectifier and are associated with the battery. The electric charging circuits are used for battery charging and also protect the battery from overcharge. In this charging circuit LM317 is used as a variable voltage regulator to adjust the charging voltage of the battery and two LEDs are associated with the battery which one indicate the battery charging status and second for the battery full charging indication. When LED glows in red color means battery is fully charged and glows of green color means battery charging going-on. One battery is used for the drives of the vehicles and another is charged using driving wheels.

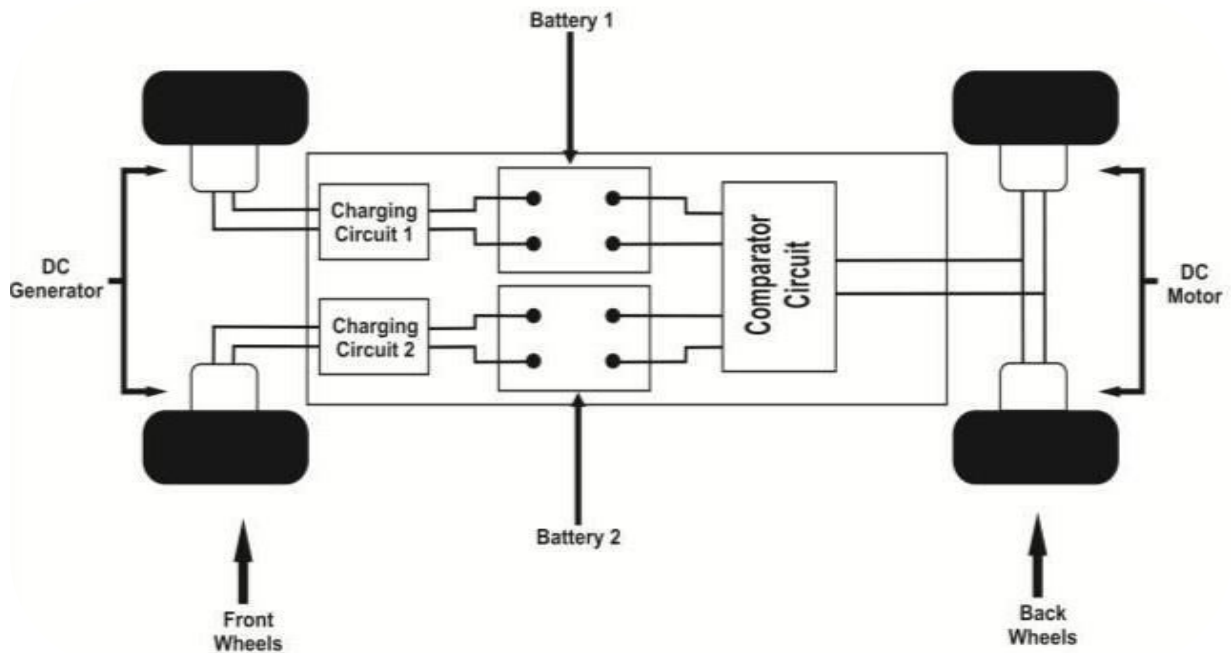


Fig. 1 Block diagram of proposed Self generating Electric Vehicle

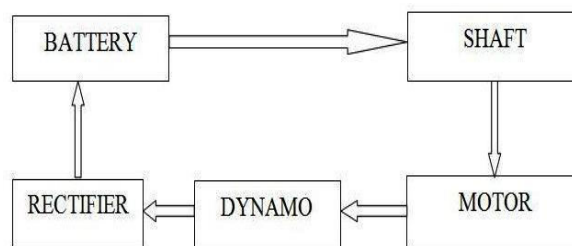


FIG. 2 WORKING OPERATION OF THE PROPOSED SYSTEM

IV. EXPERIMENTAL RESULTS

The development and innovation of batteries is one of the most noticeable and disruptive aspects of electric vehicles. Numerous aspects, including power density, weight, volume, cycle life, cost, range, safety, material recycling, nominal voltage, nominal energy, specific energy and power, and maintenance, influence the choice of energy storage battery. Lithium-ion technology is the foundation of EV batteries of the future, and its advantages include a high energy density and twice the energy per unit volume of other battery compositions. Sodium sulfur (NAS), flow batteries, Li-on batteries, and lead-acid batteries are among the different battery materials utilized in the market. There are three different approaches for battery management: system design, appropriate product, optimum battery sizing, and minimum lifetime costs. The paper [11] describes the performance analysis of the battery system using various test beds. The lifetime prediction of Li-on batteries is discussed in this article using various processes such as physical and chemical, weighting of the Ah, and event oriented concept from mechanical engineers [12–13]. It also incorporates the operating strategy, operating conditions, stress factors, and effect of aging processes. The advantages of Li-on batteries include high operating voltage, a flat discharge voltage curve, low self-charging rate, and high energy density in volume and weight. The articles [14] focused on the development of electric vehicles beyond energy storage and illustrate the modern power network issue and its applications; the performance of the lead-acid battery behavior is illustrated using various approaches such as sphere model and discharge process [15]. The battery-based vehicle has no exhaust emission and is used for charging only; the comparative study of the lithium-ion and lead acid batteries for electric vehicles is mentioned in Table 1. Battery charging and discharging are very important for optimization and computing potential impact of electric vehicles, and the bidirectional power flow is crucial in terms of economic feasibility.

TABLE I. COMPARATIVE STUDY OF LITHIUM-ION AND LEAD ACID BATTERIES

| Parameters | Lithium-ion | Lead acid |
|---------------------------------|--------------------|--------------------|
| Capacity | 15 KWh+ | 1.5-15 KWh |
| Efficiency | 95% | 80-85% |
| Depth of discharge | 85% | 50% |
| Lifespan | 10-14 Years | 3-10 Years |
| Price | Rs. 30000-50000 | Rs. 25000-35000 |
| Specific Energy | High | Low |
| Weight and size (same capacity) | Lower | Higher |
| Cycle life | 5000 | 300-500 |
| Charging time | Faster (1-3 Hours) | Slower (4-8 Hours) |
| Safety required | Less | More |

A charging circuit, two DC motors, two dynamo wheels, and two batteries make up the suggested hardware prototype model. A DC motor is a 12V geared motor that has a 2 mm encoder shaft and a 0.25 inch motor output shaft. The ENC 300 quadrature, which enables motor position control, is connected to this shaft encoder. The motor controller is utilized for temperature and overcurrent protection and has a 12V, 2A rating. The lists of hardware components and their features are included in Table 2. Figure 3 depicts the hardware configuration, and Figure 4 displays the printed representation of the charging circuit. The 230 V power source is linked to the center tapped transformer's primary winding, while the secondary generates the required step-down voltage of 15-0-15V. It is coupled to the diodes IN4001 D2 and 1N4001 D1 at its output. The output of the rectifier equipped with a 470 μ F capacitor will eliminate the AC ripple content in the DC output voltage, while the uncontrolled rectifier will produce pulsating DC output. The LM 317 has a maximum output current of 1.5A and is utilized as a variable voltage regulator between 1.2 V and 37 V. The

IN4001 D5 diodes and resistor R5 are used in the configuration of this voltage regulator. When the primary power source is unable to generate electricity, the D5 diode's goal is to prevent the battery from deep-discharging. The LED begins to flash green when the battery is fully charged. The green LED is shielded from high voltages by the resistor R3. Because this battery pulls all of the necessary currents for charging, the zener diode 1N4728A D6 will not conduct if the battery voltage is less than 12V. The battery is cut off from drawing current when the voltage reaches 13.5V, and the transistor BD139 Q1 grounds the regulator's output. Consequently, the complete charge is indicated by the red LED.

The performance of electric vehicle simulation results using MATLAB/Simulink were displayed in Fig. 5. The battery state of charge (SoC) is a key parameter to monitor and control the electrical vehicles and to secure the power responses due to changes in operating conditions. The battery SOC ranges from 70% to 69%, at which point the battery will draw the maximum current. If the SOC is 100%, the cell is fully charged, and if it is 0%, the cell is completely discharged.

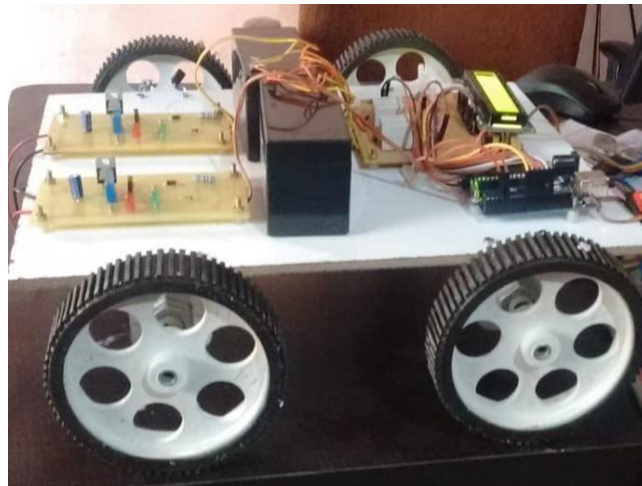


Fig. 3 Hardware setup of prototype self charging electric vehicles

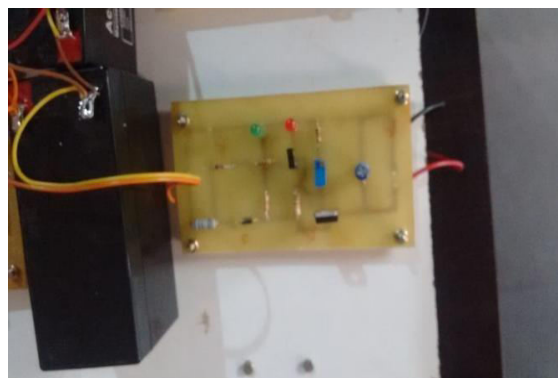


Fig. 4 View of printed charging circuit

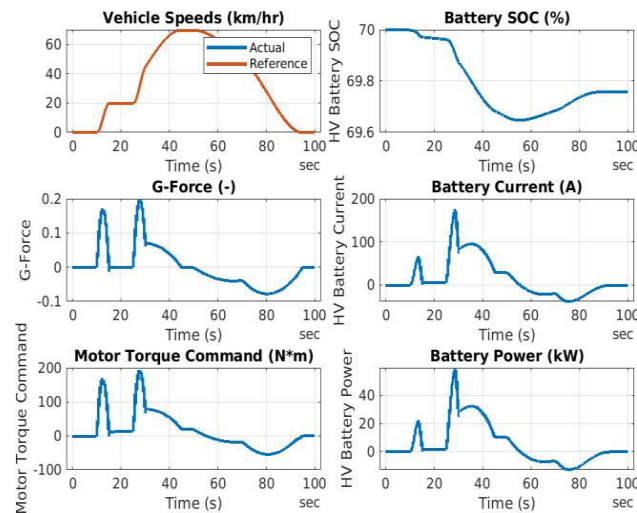


Fig. 5 Simulation results of electric vehicles

V. CONCLUSION

The development of environmentally friendly electric cars that can charge themselves without an external power source is aided by this paper. The vehicle's driving wheel is connected to the DC motor and receives torque from the driving wheel's displacement in the suggested drives model, which is an amiable drive system. The DC motor is powered by the second battery after the charging circuit unit transforms the torque into electrical energy and stores electrochemical energy in the first battery. The motor is set up to convert the battery's electrical energy into torque, which the driving wheel will use to move the car. Aspects including vehicle range, pricing, battery pack replacement cost, battery pack life, and rapid and simple recharging will be the main focus of EV technology advancement.

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