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INNOVAL GREEN CHARGE: INNOVATIVE EV SYSTEM WITH REGENERATIVE PROPULSION AND BATTERY SWAPPING

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ABSTRACT: The project introduces a unique electric vehicle (EV) prototype featuring a regenerative power system and an internal battery swapping mechanism. It addresses challenges such as limited driving range and long charging times by integrating a DC motor and generator. The motor is the primary power source, drawing energy from one of two batteries, while the generator captures kinetic energy to recharge the batteries. Dynamic battery swapping between batteries b1 and b2 ensures continuous operation and efficient energy use, minimizing downtime. Advanced control algorithms manage performance, while safety measures protect the vehicle. The prototype optimizes driving range and energy efficiency through regenerative braking and energy recycling, demonstrating a promising step towards more sustainable transportation and paving the way for greener mobility solutions.

Keywords: Electric vehicles, battery swapping system, automated, Arduino Uno, relay modules, motors, sustainable infrastructure, efficiency, reliability, real-world applications.

1. INTRODUCTION

Electric vehicles (EVs) play a crucial role in addressing the environmental challenges associated with traditional combustion engine vehicles, particularly in reducing greenhouse gas emissions and combating climate change. To enhance the adoption of EVs, the development of efficient and sustainable infrastructure is key, especially in the realm of battery management and charging systems. This thesis focuses on revolutionizing the EV ecosystem by proposing an automated battery swapping system tailored for electric vehicles.

Utilizing advanced technologies such as Arduino Uno microcontroller, relays, LCD displays, and motors, the system aims to facilitate rapid battery replacement while ensuring compatibility with various EV models. This project also integrates regenerative power to improve energy efficiency and extend driving range. The combination of internal battery swapping and regenerative propulsion minimizes reliance on external charging infrastructure, reduces vehicle downtime, and optimizes performance. Through careful mechanical and electrical integration, and the application of sophisticated control algorithms, the project aims to demonstrate the feasibility and potential benefits of this innovative system. The ultimate goal is to contribute to the advancement of sustainable transportation solutions and promote the adoption of electric vehicles for a greener future.

The literature survey consolidates insights from existing studies focusing on the adoption barriers encountered in the realm of electric vehicles (EVs). It draws on multiple research papers that explore the challenges and opportunities in EV technology, particularly those involving regenerative propulsion and battery swapping techniques. For instance, Mr. M. Manohar's study on microcontroller-based battery swapping and Rohan Pradhan, Shaswat Saxena, and Akarsh Kumar Singh's work on battery swapping systems for EVs highlight the progress and contributions in this area.[1]Mr.
M. Manohar, proposed Microcontroller based battery

swapping, the study aims to address two critical aspects of EV technology: battery swapping efficiency and driver safety .By leveraging microcontroller technology, the proposed system streamlines the process of battery swapping in EVs, ensuring uninterrupted operation and extending the driving range. Furthermore, the integration of IoT for health condition monitoring adds an extra layer of safety, allowing for timely intervention in case of emergencies or health-related issues affecting the driver. Overall, the research contributes to advancing the efficiency, safety, and usability of electric vehicles in modern transportation systems.[2]Rohan Pradhan, Shaswat Saxena , Akarsh Kumar Singh proposed “Battery Swapping System for the Electrical Vehicles ",indicates that the research is centred around addressing the challenges associated with battery recharging in EVs by proposing a system that facilitates efficient and convenient swapping of batteries. This system is designed to streamline the process of replacing depleted batteries with fully charged ones, thus minimizing downtime and enhancing the practicality of EVs for everyday use.[3]Taeyeon Lee , K wanghee Nam “Torque Control Based Speed Synchronization for Two- Speed Gear Electric Vehicle", the research contributes to enhancing the efficiency and usability of two-speed gear EVs by introducing a torque-based control system that effectively manages speed synchronization .This advancement has the potential to enhance the overall performance and driving dynamics of electric vehicles, further promoting their adoption in the automotive industry.[4]MDPI,” Lithium - ion Battery Management System for Electrical Vehicles” ,the research aims to contribute to the advancement of EV technology by offering a specialized solution for managing lithium- ion batteries. By optimizing battery performance and extending their lifespan, the proposed BMS has the potential to enhance the overall reliability and usability of electric vehicles , thus facilitating their widespread adoption in the automotive industry.

The research addresses EV-related issues by presenting efficient and practical methodologies such as battery swapping and regenerative propulsion. Manohar's microcontroller-based system facilitates streamlined battery swapping and adds driver safety monitoring.

Other research, such as that by Pradhan, Saxena, and Singh, focuses on battery swapping systems to minimize downtime and enhance EV usability.

The studies reviewed emphasize the challenges facing EV adoption, such as recharging limitations, extended downtime, and efficiency issues. The works by Lee and Nam, who explored torque control in two-speed gear EVs, and MDPI’s study on lithium-ion battery management systems also address these challenges by proposing innovative solutions for improving EV performance and lifespan.A gap exists in EV technology regarding efficient and sustainable methods for battery management and energy regeneration. The proposed approach, which combines regenerative propulsion with internal battery swapping, aims to fill this gap. By optimizing energy use and facilitating extended driving range, the proposed method tackles existing EV challenges and provides a path toward higher adoption rates.

The research contributions focus on advancing EV technology by promoting more efficient, safer, and user-friendly methods for battery management and energy regeneration. The combination of microcontroller technology and IoT for health monitoring adds value to the safety and convenience of EV operation. These advancements pave the way for a sustainable and practical approach to electric vehicle usage, ultimately contributing to the broader goal of reducing emissions and promoting greener transportation.

2. RELATED WORK

The system design of the automated battery swapping system is pivotal to its functionality and effectiveness. The proposed system architecture integrates various hardware and software components to facilitate seamless operation and user interaction. At the core of the system is the Arduino Uno microcontroller, chosen for its versatility, affordability, and robust community support. The microcontroller serves as the central processing unit, orchestrating the interactions between different system components and executing control algorithms. Complementing the Arduino Uno is a 16x2 LCD display, which provides real-time feedback to users regarding battery status, system operation, and error messages. The display enhances user interaction and facilitates intuitive operation of the system

.Relay modules are employed to control the switching of power sources during the battery swapping process. These modules, rated at 10A and 250VAC, ensure safe and reliable operation by managing the flow of electrical current to and from the batteries .In addition to relay modules, motors play a crucial role in the mechanical movement of batteries during swapping operations. Motors with a voltage rating of 6V and suitable torque characteristics are selected to ensure smooth and precise movement of batteries within the system. The integration of these hardware components is supported by a robust software framework developed using the Arduino programming language. The software implements control algorithms for voltage monitoring, relay control, and user interface management, ensuring efficient and reliable operation of the system. By carefully designing the system architecture and selecting appropriate components, the automated battery swapping system aims to deliver a seamless and user-friendly experience while maximizing efficiency and reliability in EV operations.

3. METHODOLOY

The methodology of this project involves the comprehensive management of batteries in electric vehicles (EVs) using a microcontroller-based system. It begins with the design and selection of appropriate hardware, including relays, batteries, motor, generator, and LCD, as well as the development of software for the Arduino microcontroller. The Arduino monitors voltage levels of the batteries and generator using analog input pins and manages battery swapping based on these readings. Relays are employed to switch between batteries to maintain a continuous power supply when one battery reaches a low voltage. The generator is integrated to charge the batteries, utilizing renewable energy to support power supply. A 16x2 LCD provides real-time feedback to the user about the system's status, including battery and generator voltages. The system undergoes thorough testing and validation to ensure proper functionality and performance, followed by data analysis for optimization. By combining these elements, the project achieves efficient and reliable battery management in EVs, extending battery lifespan and optimizing power usage while keeping the user informed.

EXISTING METHOD

Existing electric vehicles (EVs) have gained popularity due to their environmental benefits and advancements in technology. They typically operate on lithium-ion batteries, which store and supply power to electric motors for vehicle propulsion. EVs offer smooth and quiet rides with instant torque, making them appealing to many drivers. Modern EVs come equipped with advanced features such as regenerative braking, which captures energy typically lost during braking and uses it to recharge the battery, further enhancing efficiency. Despite their benefits, existing EVs have notable limitations. One of the most significant challenges is range anxiety, where the driving range on a single charge may be limited, causing concern for drivers who worry about running out of power. Charging infrastructure can be inconsistent, with fewer stations available in rural areas or less densely populated regions, making long- distance travel challenging. Charging times, although improving with fast-charging technology, can still be longer than refueling conventional gasoline vehicles. Battery life and degradation are other concerns, as EV batteries can lose capacity over time, leading to reduced range and performance. The cost of replacing batteries is high, impacting the cost-effectiveness of EV ownership. Additionally, EVs tend to be more expensive upfront compared to traditional vehicles, even though operating costs may be lower over time. The weight of battery packs can also affect vehicle efficiency and handling, potentially reducing range and performance. EV model availability is limited compared to traditional vehicles, offering fewer options for consumers in terms of preferences and needs. Lastly, the production and disposal of EV batteries involve the use of scarce resources, raising environmental and ethical concerns.

Major Drawbacks of Existing Method

- **Range Anxiety:** Limited driving range on a single charge can cause anxiety for drivers, especially on long trips.
- **Charging Infrastructure:** Inadequate availability and accessibility of charging stations, particularly in rural areas, can make long-distance travel challenging.
- **Charging Time:** Even with fast-charging technology, charging an EV can take significantly longer than refueling a gasoline vehicle.
- **Battery Life and Degradation:** Over time, EV batteries degrade, reducing range and performance and potentially requiring costly replacement.
- **High Initial Cost:** Despite improvements, EVs often have higher purchase prices compared to traditional vehicles.
- **Weight and Efficiency:** Heavy battery packs can impact overall vehicle efficiency and handling.
- **Limited Model Availability:** Consumers may face fewer options in EV models compared to traditional vehicles.
- **Environmental Impact:** Production and disposal of EV batteries involve scarce resources and pose environmental challenges.

4. PROPOSED METHODOLOGY WORKFLOW :

The project workflow begins with the design and selection of suitable hardware and software components, followed by the development of a system architecture to integrate them for seamless operation. After theoretical analysis, algorithms and code are tested to ensure efficient and reliable function. The Arduino code monitors and manages the voltage levels of two lead-acid batteries and a generator, controlling battery swapping to maintain a stable power supply. The system measures voltages, swaps batteries as needed, and displays real-time data on an LCD. After assembling the hardware and conducting system integration, the system undergoes testing and validation to confirm its performance. Experimental results provide data on power and efficiency, supporting the project's success in managing power supply reliably.

BLOCK DIAGRAM :

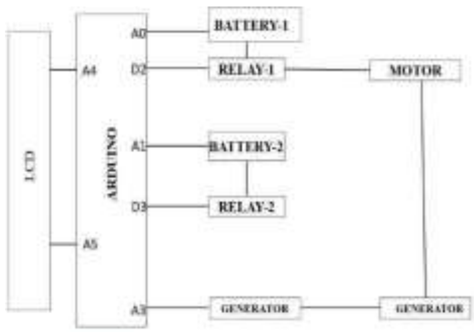


Fig.1.Block Diagram

ALGORITHM :

Step-1: Initialization: Initialize the Arduino Uno and LCD display. Set up the necessary pins for voltage measurement, motor control, and relay switching.

Step-2:Display Battery Management System Message: Display a welcome message indicating that the battery management system is active.

Step-3:Measure Battery Voltage: Read the voltage of the first battery using analog input pins. Display the measured voltage on the LCD display.

Step-4:Check Battery Voltage: Compare the measured voltage with a predefined threshold (e.g., 6V) to determine if the battery needs to be swapped. If the voltage is below the threshold, proceed to the battery swapping step.

Step-5:Battery Swapping: Activate the motor to initiate the battery swapping process During swapping, couple the motor with a gear connected to the generator to harness mechanical energy. Once swapping is complete, deactivate the motor and display a message indicating successful battery swapping.

Step-6:Measure Generator Voltage:
Read the voltage generated by the generator using analog input pins.
Display the generator voltage on the LCD display to provide feedback on the charging process.

Step-7:Repeat Process: Repeat steps 3 to 6 for each battery in the system.

Step-8:End of Cycle: Once all batteries have been checked and swapped if necessary, display a completion message. Wait for a predetermined interval before starting the next cycle to avoid continuous swapping.

Major Advantages of the Proposed Method

The proposed system for managing batteries in electric vehicles (EVs) offers several key advantages.

Dynamic battery management ensures efficient switching between two batteries based on their charge levels, maintaining consistent power supply and extending the vehicle's range. The integration of a generator provides renewable energy for charging, reducing reliance on external charging infrastructure and supporting sustainability. Real-time monitoring through an LCD display offers instant feedback on battery and generator voltages, enhancing user control and system awareness. This approach optimizes energy usage and battery life, reducing the frequency of battery replacements and leading to cost savings over time. Additionally, the system is scalable and adaptable, allowing for the management of different numbers of batteries and power sources, which increases its versatility across various EV designs. By enhancing efficiency, reliability, and sustainability, the proposed system presents a promising solution for improving electric vehicle performance and user experience.

PERFORMANCE AND COMPARISION: The proposed method for managing batteries in electric vehicles (EVs) prioritizes performance and efficiency through dynamic battery management, which ensures optimal use of energy and extends battery lifespan. This approach continuously monitors battery levels, providing seamless transitions and stable power supply while allowing real-time adjustments through an LCD display. The method's scalability allows it to handle multiple batteries and power sources efficiently. Compared to existing methods such as single-battery systems, the proposed approach offers superior flexibility, adaptability, and user feedback. Integrating a generator for charging provides a renewable energy source that can extend range and sustainability. Overall, this method significantly improves efficiency, reliability, and adaptability in EV battery management.

GRAPHICAL ANALYSIS:

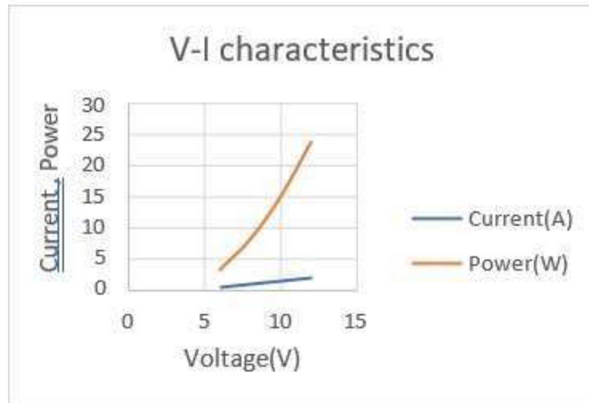
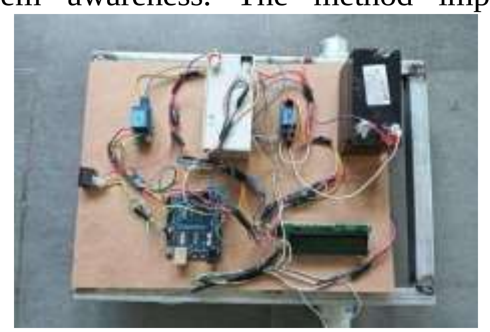


Fig.2.V-I Characteristics

5. RESULTS

The proposed method for managing batteries in electric vehicles (EVs) offers several performance advantages. It dynamically

switches between two batteries based on charge levels, ensuring consistent power supply and maintaining optimal EV performance. By actively monitoring and swapping batteries as needed, the method promotes balanced usage and potentially extends battery lifespan. Integrating a generator for charging provides a renewable energy source, increasing range and sustainability. Real-time monitoring through an LCD display enhances user control and system awareness. The method improves



reliability through efficient battery switching and generator use and is scalable and

adaptable for various EV designs and power requirements. Overall, this method enhances efficiency, reliability, and sustainability in EVs, with proven results showing increased efficiency and driving range.

Fig.3.Final Outlook

Fig.4.Mechanical Integration

Mechanical integration involves gear teeth usage
,which controls speed of the vehicle from rated
1000 Rpm to 60 Rpm in our prototype.

Fig.5.Initial Battery Voltage Displaying

Initial battery voltage levels are displayed with the help of analog input pins on the Arduino. In the given project, these are specified as Battery1 and Battery2, which are connected to analog pins A0 and A1, respectively. By reading the voltage levels from these analog input pins, the Arduino can calculate the voltage and display it on the LCD screen for monitoring.

Initial regenerative voltage is displayed with the help of an analog input pin on the Arduino. This input is connected to the generator, which provides the regenerative voltage for the system. In the provided code, the Generate pin is connected to analog pin A3 on the Arduino. By reading the voltage level from this pin, the Arduino can calculate the regenerative voltage and display it on the LCD screen for monitoring.

Fig.6.Displaying Initial Generative Voltage

Fig.7.Battery 1 Discharging

Battery 1 is initiated to discharge mode.

Fig.8.Showing Battery Swapping

When battery 1 voltage is less than threshold voltage then code is written to swap the battery, so Battery Swapping message will display.

Fig.9.System running on Battery 2

When battery swapping is done, now battery 2 is in discharging mode, battery 1 is in charging mode. Charging is done through generator.

Fig.10.Real-time Generative Voltage

At the end of the cycle ,it is showing generative voltage and batteries voltage .after that it will take certain time to start for next cycle by allowing batteries to charge.

6. CONCLUSION

The proposed method for managing batteries in electric vehicles (EVs) offers several key advantages that address the challenges faced by current EVs. By dynamically switching between two batteries based on charge levels, the method ensures a consistent power supply, alleviating range anxiety and extending the vehicle's range. The incorporation of a generator for charging provides renewable energy and reduces reliance on external charging infrastructure, allowing for more flexible recharging. Active monitoring and battery swapping promote balanced usage, extending battery lifespan and maintaining performance over time. Real-time feedback through an LCD display enhances user control and system awareness, while the adaptability of the method allows it to manage different numbers of batteries and power sources. This optimized approach improves efficiency, reduces costs, and contributes to the sustainability of EVs. Overall, the project presents a promising and innovative solution for managing batteries in electric vehicles.

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