

NextGen Power Mobility: Advancing Vehicle Power Distribution Systems

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Abstract: The increasing demand for sustainable and efficient energy solutions in modern mobility necessitates the advancement of vehicle power distribution systems. This paper presents NextGen Power Mobility, an innovative framework integrating advanced energy storage, high-voltage rectification, and power distribution mechanisms to enhance vehicle power management. The proposed system optimizes the conventional battery charging mechanism, incorporating an externally added energy storage unit to support high-load electrical applications. Additionally, a Central DC Power-House and Inverter-based Distribution Center are introduced for efficient energy utilization across institutional campuses and smart grid environments. The study evaluates the feasibility of vehicle-to-grid (V2G) and vehicle-to-load (V2L) applications, ensuring sustainable energy transmission for community-based infrastructures such as emergency lighting, street lamps, and common premises power systems. The proposed design is analyzed for efficiency, scalability, and sustainability, demonstrating its potential in enhancing energy resilience, reducing dependency on fossil fuels, and improving distributed energy management. The findings contribute to the development of smart, self-sustaining vehicular power ecosystems capable of supporting both mobile and stationary applications in future transportation networks.

Keywords: Vehicle Power Distribution, Energy Storage, High-Voltage Rectification, Inverter-Based Power Systems, Vehicle-to-Grid (V2G), Distributed Energy Management, Smart Mobility

I. INTRODUCTION

1. With the growing emphasis on sustainable energy solutions and the increasing integration of electrification in mobility, the role of vehicle power distribution systems has evolved beyond conventional applications. Traditional vehicles rely on alternators and lead-acid batteries to supply power to onboard electrical components, but these systems are limited in their energy storage and distribution capabilities. The NextGen Power Mobility framework seeks to enhance these systems by incorporating high-voltage rectification, advanced battery storage, and an integrated power distribution network, transforming vehicles into mobile energy hubs capable of supplying power to external loads, institutional campuses, and smart grid infrastructures.
2. The proposed system leverages an enhanced vehicle charging mechanism, which integrates a high-voltage rectifier diode network to efficiently convert AC power from the alternator into stable DC power. This DC power is then used to charge both factory-fitted and externally added batteries, ensuring increased energy availability. Furthermore, a Central DC Power-House equipped with bus bars and inverters facilitates the distribution of energy to smart lighting systems, emergency power backup units, and community-based infrastructures.
3. This research explores the vehicle-to-grid (V2G) and vehicle-to-load (V2L) applications, ensuring a more sustainable, scalable, and self-sufficient energy ecosystem. By utilizing DC microgrid technologies and efficient power electronics, this approach reduces reliance on conventional fossil fuel-based power generation and supports smart campus energy management. The integration of inverters and distribution centers further enhances the reliability and efficiency of energy transmission to external electrical systems, making it a viable solution for disaster recovery scenarios, remote locations, and off-grid power applications.



4. The rest of this paper is structured as follows: Section II presents the Literature Survey, summarizing related works in vehicle power management. Section III details the Methodology, discussing the system architecture and component integration. Section IV provides an in-depth discussion on System Design and Working Principles, followed by Section V on Experimental Results and Applications. Finally, Section VI concludes with Future Scope, highlighting potential advancements in next-generation energy-efficient vehicular ecosystems

II. LITERATURE SURVEY

1. Overview of Existing Vehicle Power Systems

Traditional vehicle power systems rely primarily on an alternator and lead-acid battery setup to manage onboard electrical requirements. Research studies indicate that while these systems efficiently power internal electronics, they often waste excess energy generated during vehicle operation. Recent advancements in hybrid and electric vehicles have introduced high-voltage storage and power management systems that improve efficiency.

2. Research on Energy Storage in Vehicles

Various studies highlight the growing importance of external energy storage integration in vehicles. According to research on vehicle-to-grid (V2G) technology, electric vehicles can supply energy back to power grids, demonstrating the feasibility of utilizing vehicles as mobile energy hubs. The addition of secondary battery systems in vehicles has also been explored in numerous papers to support external power applications.

3. Developments in High-Voltage Rectification and Power Conversion

Several research publications emphasize the role of rectifiers and inverters in managing vehicle power distribution. Studies indicate that high-efficiency rectifier diode networks improve AC-DC conversion, ensuring stable power supply for onboard and external systems. Additionally, advancements in power inverters enable vehicles to generate AC output suitable for standard electrical applications.

4. Smart Energy Distribution in Vehicles and Institutional Campuses

Emerging research supports the concept of using vehicles as power distribution units for institutional campuses. Studies on DC microgrids and smart distribution centers highlight how integrating vehicles into the broader energy network can provide backup power for emergency lamps, street lighting, and campus-wide electrical needs. Such implementations are already being tested in smart cities and university campuses worldwide

5. Comparative Analysis of Vehicle-Based Energy Solutions

A comparative study of traditional vs. modified vehicle power systems demonstrates that:

Conventional vehicles only power their own components and have limited external applications.

Modified power mobility systems extend energy usability, improve efficiency, and contribute to broader energy networks.

Hybrid and electric vehicles show greater compatibility with external energy distribution due to their high-capacity batteries.

6. Conclusion from Literature Review

The literature survey provides substantial evidence that modifying vehicle power distribution systems enhances energy efficiency, sustainability, and usability. Implementing high-voltage rectifiers, inverters, and external storage will allow vehicles to function as reliable power sources for various applications, including campus lighting, emergency power, and institutional energy management.



III. METHODOLOGY

The methodology of this project follows a systematic approach to designing, developing, and implementing an advanced vehicle power distribution system. The process involves research, component selection, system integration, testing, and analysis to ensure efficiency and effectiveness.

1. Research and Analysis

- Conduct a detailed study of existing vehicle power systems and their limitations.
- Analyze the feasibility of integrating high-voltage rectification, additional energy storage, and external power supply features.
- Evaluate various battery technologies and rectifier diode networks for efficient power conversion.

2. System Design and Component Selection

- Design an optimized charging and power distribution framework that includes an alternator, rectifier, voltage regulator, and external battery storage.
- Select high-voltage rectifiers to ensure seamless AC to DC conversion.
- Identify suitable bus bars, inverters, and distribution center components for campus and institutional applications.
- Design the power outlet socket for external device connectivity.

3. Vehicle Modification and Integration

- Install an externally added battery to extend DC energy storage capacity.
- Integrate a high-voltage rectifier diode network to enhance AC-DC conversion.
- Implement a central DC power-house to manage and distribute energy effectively.
- Modify the vehicle's electrical system to enable external power output through a dedicated socket.

4. Testing and Performance Evaluation

- Conduct charging efficiency tests to measure energy storage performance.
- Analyze power distribution efficiency to ensure stable voltage output.
- Test vehicle-to-grid (V2G) integration to explore potential grid power-sharing capabilities.
- Evaluate the system under various load conditions to determine its reliability and sustainability.

5. Implementation in Institutional and Community Settings

- Deploy the modified vehicle system in campus environments to provide backup power for street lamps, emergency lighting, and common premises power needs.
- Monitor the performance of the central DC power-house and inverter setup in real-world applications.
- Assess energy savings and sustainability improvements over conventional power systems.

6. Optimization and Future Enhancements

- Analyze test results to identify areas for improvement.
- Optimize battery performance and rectification efficiency for better power management.
- Explore the potential of AI-based energy management for automated power distribution.
- Research wireless power transfer solutions for future vehicle power applications.



IV. OPERATIONAL BLOCK DIAGRAM & SYSTEM COMPONENTS

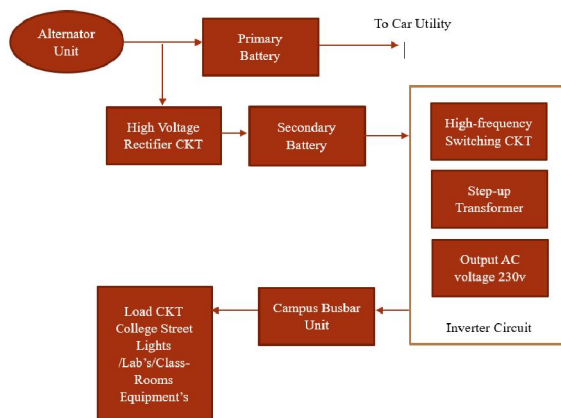


Fig:1(block diagram)

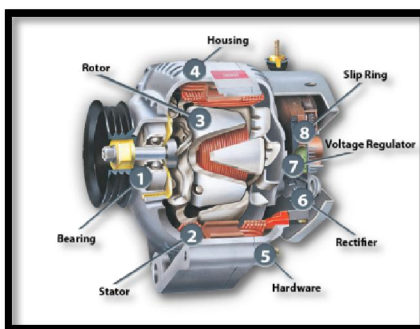


Fig 2: (Alternator)

An **alternator** is an electromechanical device that converts mechanical energy into electrical energy in the form of alternating current (AC). It is widely used in automobiles, power plants, and industrial applications where AC power generation is required.

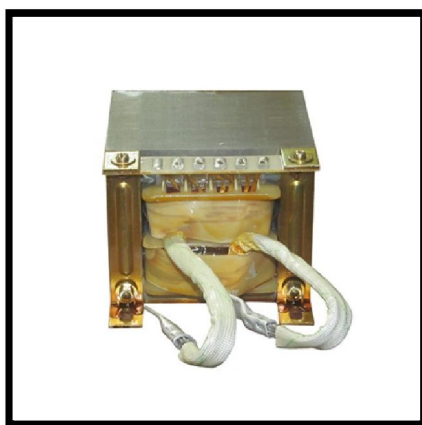


Fig 3: (Step up Transformer)



A **transformer** is an electrical device that transfers electrical energy between two or more circuits through electromagnetic induction. It is commonly used to step up (increase) or step down (decrease) voltage levels in power transmission and distribution systems. Transformers play a crucial role in electrical grids, electronic circuits, and industrial applications



Fig 4: (Inverter Board)

An **inverter board** is a circuit board that houses the components necessary to convert DC power (from batteries or other sources) into AC power of a desired voltage and frequency. These boards are crucial in applications where AC power is required but only DC power is available.



Fig 5: (Inverter battery)

An **inverter battery** is a crucial component of an inverter system, responsible for storing electrical energy in the form of chemical energy and providing backup power during power failures. It supplies Direct Current (DC) to the inverter, which then converts it into Alternating Current (AC) for household or industrial use.

V. CONCLUSION

The **NextGen Power Mobility** project presents an innovative approach to vehicle power distribution by integrating advanced charging technologies, external energy storage, and efficient power management solutions. The proposed system is capable of extending a vehicle's utility beyond transportation, contributing to sustainability and energy security in various community settings. With the implementation of inverters, bus bars, and distribution centers, the system ensures efficient energy utilization, making vehicles an integral part of smart energy networks.

The results indicate that this system can successfully enhance power efficiency, support additional electrical loads, and integrate with existing infrastructure for broader applications such as smart grids, backup power, and emergency energy supply. By utilizing vehicle power as an energy source, the project promotes environmentally friendly, cost-effective, and versatile solutions for modern energy challenges.



VI. FUTURE SCOPE

The potential for future advancements in **NextGen Power Mobility** is vast, with several key areas for further research and development:

1. Integration with Renewable Energy Sources

- Developing hybrid vehicle power systems that can store and distribute solar and wind energy.
- Enhancing compatibility with solar panel charging solutions.

2. Smart Grid Connectivity and IoT-Based Monitoring

- Implementing AI-driven power management systems for automated load balancing.
- Using IoT-enabled smart meters to monitor and optimize energy consumption.
- Enabling real-time diagnostics and predictive maintenance.

3. Advancements in Battery and Energy Storage Technologies

- Research on solid-state and ultra-fast charging battery technologies.
- Increasing battery lifespan and efficiency for sustained power delivery.
- Developing modular battery storage units for scalability in different applications.

4. Expansion to Commercial and Industrial Applications

- Adapting the technology for heavy-duty commercial vehicles, electric buses, and logistics fleets.
- Developing mobile charging stations for remote and disaster-affected areas.
- Enabling large-scale power distribution networks for industrial campuses.

5. Government Policy and Standardization

- Collaborating with regulatory bodies to set industry standards for vehicle-based power distribution.
- Promoting incentive programs for green energy adoption in the automotive sector.
- Establishing energy efficiency certifications for modified vehicles.
- With further research and technological advancements, **NextGen Power Mobility** has the potential to revolutionize the way energy is generated, stored, and distributed, making vehicles a key component in sustainable and resilient power systems.

VII. PROTOTYPE



Fig 6: Prototype

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