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IMPLEMENTATION OF AI-INTEGRATED ELECTRIC VEHICLE SAFETY SYSTEM WITH INDUCTIVE CHARGING TECHNOLOGY USING WIRELESS POWER TRANSFER AND INTELLIGENT SENSORS

Guided by,

Mrs.Nithya J ME.,
Assistant Professor,
Anjalai Ammal Mahalingam Engineering College,(Anna University),
Thiruvarur-India,
nithyasuresh2403@gmail.com

Presented by,

Afreena Nasreen S,
ECE,
Anjalai Ammal Mahalingam Engineering College,(Anna University),
Thiruvarur-India,
afreenanasreen0904@gmail.com

Aiswaryaa M,
ECE,
Anjalai Ammal Mahalingam Engineering College,(Anna University),
Thiruvarur-India,
aiswaryaa031104@gmail.com

Asha K.K,
ECE,
Anjalai Ammal Mahalingam Engineering College,(Anna University),
Thiruvarur-India
ashakkumar2004@gmail.com

Niranjani S,
ECE,
Anjalai Ammal Mahalingam Engineering College,(Anna University),
Thiruvarur-India,

Abstract

This paper presents an integrated safety and power management system for electric vehicles (EVs), utilizing a wireless inductive charging technique combined with critical rider and vehicle safety features. The system architecture is divided into Sender and Receiver modules. The Sender module includes a microcontroller-controlled primary coil that transmits high-frequency alternating current wirelessly after converting DC from the battery through a chopper and converter circuit. The Receiver module employs a PIC microcontroller and a secondary coil to receive and rectify the induced current, which is then regulated and managed by a battery management unit to charge the EV battery. Additionally, the receiver incorporates multiple safety mechanisms, including fire detection with automatic water pump activation, alcohol sensing to disable the motor, helmet and seat belt detection for vehicle operation control, and an alarm system. This integrated approach enhances rider safety, promotes responsible vehicle use, and improves charging efficiency, offering a practical and intelligent solution for safer and more sustainable electric mobility.

Keywords— *Electric vehicle (EV), wireless inductive charging, safety management, PIC microcontroller, battery management unit (BMU), fire detection, alcohol sensor, helmet detection.*

I. Introduction

The rapid adoption of electric vehicles (EVs), encompassing both two-wheelers and four-wheelers, has intensified the need for enhanced safety mechanisms and efficient energy management solutions. Urbanization and environmental concerns have accelerated the shift toward sustainable transportation, with electric scooters, bikes, and cars gaining prominence due to their low maintenance, reduced emissions, and operational economy. Despite these advantages, challenges persist in rider safety, battery charging efficiency, and intelligent system integration, limiting overall reliability—particularly in densely populated areas.

A critical concern across both vehicle categories is the lack of advanced safety features. Accidents frequently result from human negligence, including helmet or seat belt noncompliance and driving under the influence of alcohol. Additionally, battery-related hazards such as overheating, overcharging, and short circuits pose fire risks. Conventional wired charging methods further introduce issues of mechanical wear, loose connections, and electrical hazards. These limitations necessitate a smart, integrated system that enhances safety while improving charging reliability.

This paper presents an integrated safety and power management system combining wireless inductive charging with intelligent safety features applicable to both two- wheelers and four-wheelers. The proposed system employs contactless energy transfer, eliminating physical connectors and reducing electrical risks. It comprises two primary modules:the Sender Side and the Receiver Side. The Sender Side uses a microcontroller-based power control unit, chopper, and high-frequency converter to convert DC to high-frequency AC, which is transmitted via a primary coil. The Receiver Side captures energy through a secondary coil via electromagnetic induction; the received AC is rectified,filtered, and regulated by a battery management system (BMS) to ensure safe and efficient charging.

Beyond power transfer, the system integrates multiple safety mechanisms. A fire detection unit activates a water pump and alarm upon sensing abnormal heat or flame. An alcohol sensor disables the motor if alcohol consumption is detected, while helmet (for two-wheelers) and seat belt (for four-wheelers) detection switches prevent vehicle startup unless compliance is satisfied. These features collectively ensure rider safety, regulatory adherence, and system reliability. By synergizing wireless power delivery with intelligent safety controls, the proposed solution offers a practical framework for safer, smarter, and more sustainable electric mobility.The remainder of this paper is organized as follows: Section II describes the system architecture and hardware implementation. Section III presents the operational workflow and safety logic. Section IV discusses experimental results and performance evaluation. Section V concludes the paper with a summary and future scope.

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II. LITERATURE REVIEW

A. Wireless Power Transfer in Electric Vehicles

Electric vehicles require efficient and safe charging methods to improve usability and reduce maintenance problems. Conventional charging systems rely on physical cables that suffer from connector degradation and safety risks. Recent studies by Zhang *et al.* (2025) demonstrated that wireless power transfer using inductive coupling enables efficient contactless energy transmission between transmitter and receiver coils. High-frequency magnetic resonance improves charging efficiency and operational safety while eliminating mechanical wear associated with wired charging systems . Hence, inductive wireless charging is considered a promising solution for future electric vehicle infrastructure.

B Battery Management System for Electric Vehicles

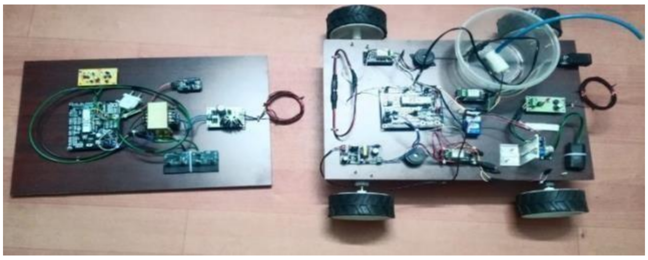
The battery system plays a vital role in electric vehicle performance and safety. Improper charging conditions may lead to overheating, overcharging, and reduced battery lifespan. Kumar and Singh (2024) proposed an intelligent Battery Management System capable of monitoring voltage, temperature, and state of charge in real time. Their study highlighted that advanced BMS protection algorithms significantly improve battery reliability and energy utilization efficiency. Therefore, integrating an intelligent battery management system is essential for safe EV operation.

.C. AI-Based Vehicle Safety Monitoring System

Modern transportation systems increasingly adopt Artificial Intelligence to enhance vehicle safety. Patel *et al.* (2025) developed an AI-based vehicle monitoring framework that continuously analyzes sensor data to detect unsafe driving behavior and abnormal vehicle conditions. The system automatically generates alerts and initiates protection mechanisms, thereby reducing accident risks caused by human error. Intelligent monitoring systems improve decision-making capability and enable smart vehicle automation.

D. Alcohol Detection for Safe Vehicle Operation

Drunk driving remains a major cause of road accidents worldwide. Ahmed *et al.* (2024) introduced an alcohol detection system using gas sensing technology integrated with vehicle control mechanisms. The system prevents vehicle ignition when alcohol concentration exceeds permissible limits, ensuring responsible vehicle usage and enhanced public safety. Such systems play an important role in accident prevention.



E. Helmet or Seatbelt Detection System

Safety compliance monitoring is essential for reducing accident injuries. Lee *et al.* (2024) proposed a smart helmet and seatbelt detection system using IoT sensors and wireless communication techniques. The system verifies safety equipment usage before vehicle startup and restricts operation under unsafe conditions. Automated safety enforcement significantly improves rider protection and compliance levels

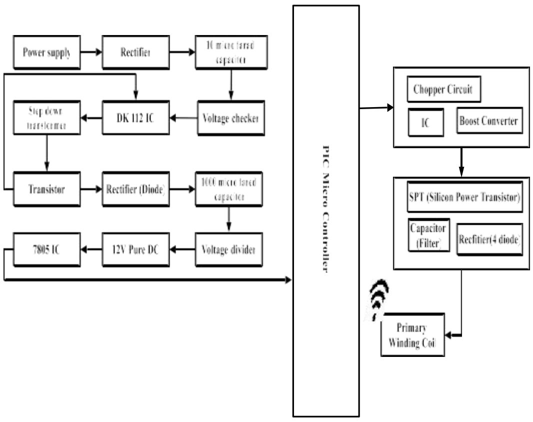


Fig.1 Wireless Transmitting System

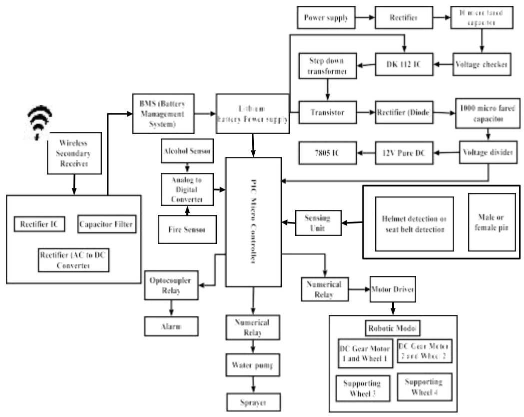


Fig.2 Wireless Receiving Unit

III. EXISTING METHODOLOGY

Current electric vehicles predominantly employ wired charging systems that rely on physical connectors, leading to mechanical wear, increased maintenance, and reduced long- term reliability. Safety provisions remain elementary: most EVs lack integrated intelligent monitoring for real-time battery and vehicle condition tracking. Critical safety mechanisms such as automatic fire detection and suppression, alcohol detection for drunk-driving prevention, and rider safety features (e.g., helmet or seatbelt enforcement) are either absent or operate as isolated subsystems without centralized coordination. This fragmented approach limits the ability to respond effectively to emergencies and compromises overall vehicle safety and system reliability.

IV. PROPOSED METHODOLOGY

The proposed system integrates artificial intelligence with smart sensors to enable real-time monitoring of battery parameters, temperature, energy consumption, and driving behavior, facilitating predictive hazard prevention through driver alerts or automated corrective actions. safety interlocks incorporate helmet detection for two-wheelers and seat belt detection for four-wheelers; the vehicle motor is disabled unless these conditions are satisfied. an intelligent battery management unit optimizes charge-discharge cycles to extend battery life and improve energy efficiency.

Fig.3 Intelligent EV Battery Vehicle

Additionally, vehicle-to-everything (v2x) communication enhances road safety through cooperative interaction with surrounding infrastructure. this unified architecture delivers enhanced safety, reduced maintenance costs, and extended operational life for electric two-wheelers and four-wheelers.

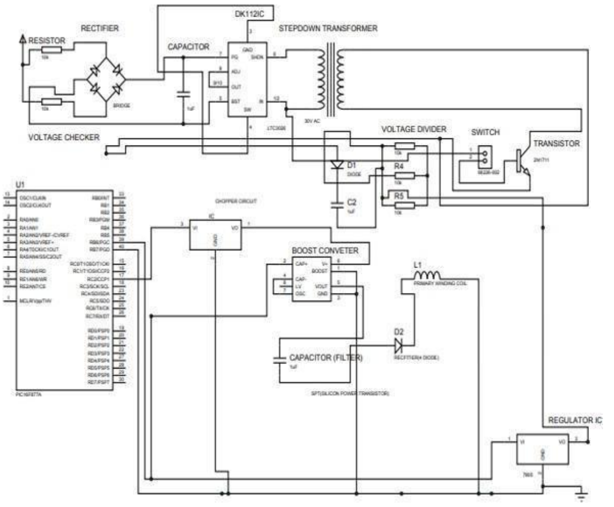


Fig.4 Circuit diagram for Wireless Transmitting Unit

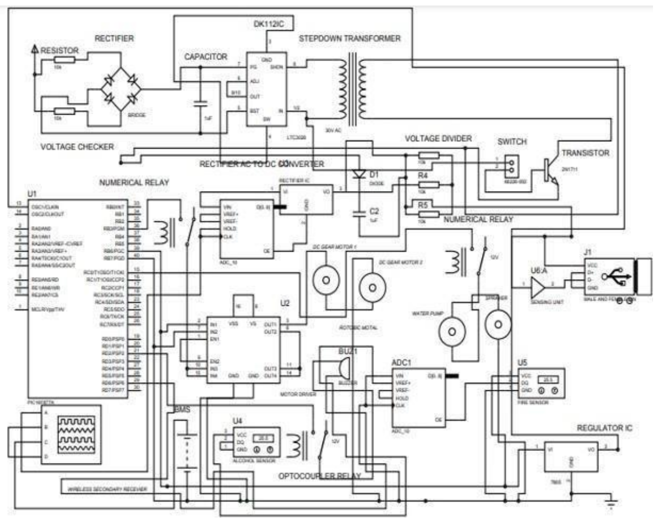


Fig.5 Circuit diagram for Wireless Receiving Unit

V. CONCLUSION

This paper has presented an integrated wireless inductive charging system incorporating advanced safety mechanisms for electric vehicles (EVs), encompassing both two-wheelers and four-wheelers. The proposed architecture eliminates physical charging connections, thereby mitigating mechanical wear and enhancing user convenience alongside safe energy transfer. Intelligent safety subsystems—including fire detection with automatic suppression, alcohol sensing, helmet detection, and seatbelt monitoring—collectively minimize accident risks and enforce responsible vehicle operation. Furthermore, the integration of embedded systems with AI- based monitoring facilitates real-time data analytics, predictive maintenance, and optimized battery management, contributing to improved battery longevity and energy efficiency. The coordinated operation of the sender and receiver modules ensures stable power transmission, while integrated sensor networks enable rapid, autonomous responses to hazardous conditions. The proposed system

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