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# Vehicle to Vehicle Charging System

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**Abstract:** *Wireless power transfer (WPT) technology has gained significant attention as an advanced solution to overcome the limitations associated with conventional plug-in electric vehicle (EV) charging systems. Traditional wired charging methods suffer from issues such as physical cable dependency, safety risks, limited accessibility, and increased charging time. To address these challenges, this paper presents the design and implementation of a bidirectional wireless EV charging system based on inductive coupling principles. The proposed system enables efficient and contactless energy transfer between two batteries, making it suitable for vehicle-to-vehicle (V2V) charging applications, where one EV can act as an energy source for another EV.*

*The system architecture consists of an Arduino Uno microcontroller, which acts as the central control unit for monitoring and managing the charging process. An INA219 current sensor is integrated into the system to provide accurate real-time measurements of voltage and current, ensuring effective energy management and system protection. A relay module is used to control the ON/OFF switching of the charging circuit, allowing bidirectional energy flow based on system conditions. Furthermore, wireless transmitter and receiver modules are incorporated to enable remote communication and control between the charging units. A buck converter (LM2596) is employed to regulate and stabilize the voltage levels for safe and efficient operation. Additionally, an LCD display is used to present real-time system parameters such as voltage and current to the user.*

*The working principle of the system is based on electromagnetic induction, where the transmitter coil generates a magnetic field, and the receiver coil captures this field to induce voltage, which is then rectified and used to charge the battery. The system is designed to operate with high efficiency under short-distance conditions, and it minimizes power losses through proper circuit design and component selection. Experimental results demonstrate that the proposed system achieves stable wireless power transfer with reliable monitoring and control features.*

*This approach significantly reduces the dependency on fixed charging infrastructure, enhances user convenience, and improves overall system safety by eliminating direct electrical contacts. Moreover, the bidirectional capability of the system supports flexible energy sharing between EVs, which is highly beneficial in emergency situations where charging stations are not available. The proposed system is cost-effective, scalable, and suitable for future advancements in smart EV charging technologies, including integration with IoT-based monitoring systems and smart grid applications.*

**Keywords:** Wireless Power Transfer (WPT), Electric Vehicle (EV), Bidirectional Charging, Vehicle-to-Vehicle (V2V), Inductive Coupling, Arduino Uno, INA219 Sensor, Relay Module, Buck Converter, Wireless Communication, Energy Transfer, Contactless Charging

## I. INTRODUCTION

The rapid growth in global energy demand and increasing environmental concerns have accelerated the development and adoption of electric vehicles (EVs) as a sustainable alternative to conventional internal combustion engine vehicles. EVs offer significant advantages such as reduced greenhouse gas emissions, improved energy efficiency, and lower

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operational costs. However, one of the major challenges associated with EVs is the availability of efficient, reliable, and user-friendly charging infrastructure. Conventional plug-in charging systems, although widely used, suffer from several limitations including dependency on physical cables, risk of electric shock, wear and tear of connectors, and inconvenience to users.

Wireless power transfer (WPT) technology has emerged as a promising solution to overcome the drawbacks of wired charging systems. WPT enables the transfer of electrical energy from a power source to a load without the need for physical connections. This technology is primarily based on electromagnetic induction or resonant inductive coupling, where energy is transmitted through a magnetic field between two coils, namely the transmitter coil and the receiver coil. In the context of EVs, wireless charging systems can significantly enhance user convenience by eliminating the need for manual plug-in operations and reducing maintenance requirements.

Wireless EV charging systems can be broadly classified into three categories: static charging, quasi-dynamic charging, and dynamic charging. Static wireless charging is performed when the vehicle is stationary, such as in parking areas or garages. Quasi-dynamic charging allows charging during short stops, such as at traffic signals. Dynamic wireless charging, on the other hand, enables charging while the vehicle is in motion, thereby extending the driving range and reducing the need for large battery capacities. Among these, dynamic and quasi-dynamic charging systems are gaining attention due to their potential to revolutionize EV infrastructure.

Another innovative concept in wireless EV charging is vehicle-to-vehicle (V2V) charging, where one EV can transfer energy to another EV wirelessly. This concept is particularly useful in emergency situations where a vehicle runs out of charge and no charging station is available nearby. V2V charging enhances flexibility and reduces dependency on fixed charging infrastructure. It also supports efficient energy utilization by enabling energy sharing between vehicles.

Despite the advantages of wireless charging, several technical challenges still exist, including power transfer efficiency, alignment of transmitter and receiver coils, energy losses, and system cost. Efficient control and monitoring of the charging process are essential to ensure safe and reliable operation. Microcontroller-based systems, such as those using Arduino platforms, provide a cost-effective solution for implementing control strategies in wireless charging systems. Additionally, sensors such as the INA219 can be used to measure voltage and current parameters in real time, enabling better system monitoring and protection.

In this paper, a bidirectional wireless EV charging system is proposed and implemented using inductive power transfer principles. The system is designed to enable energy transfer between two batteries without physical connections, supporting V2V charging functionality. An Arduino Uno microcontroller is used as the central control unit, while a relay module controls the switching operation of the charging circuit. A wireless communication module is integrated to facilitate remote control, and an LCD display provides real-time system information. A buck converter is used to regulate voltage levels, ensuring stable and efficient operation.

The proposed system aims to provide a simple, cost-effective, and efficient solution for wireless EV charging applications. By combining wireless power transfer with bidirectional energy flow and real-time monitoring, the system enhances flexibility, safety, and user convenience. The implementation of such systems can play a significant role in the development of future smart EV charging infrastructure and contribute to the widespread adoption of electric vehicles.

## II. PROBLEM STATEMENT

The increasing adoption of electric vehicles (EVs) has created a significant demand for efficient and accessible charging infrastructure. However, conventional plug-in charging systems face several limitations that restrict the widespread usability and convenience of EVs. These systems require physical cable connections between the charging station and the vehicle, which leads to issues such as wear and tear of connectors, risk of electric shock, and inconvenience to users, especially in adverse environmental conditions. Additionally, the availability of charging stations is limited, resulting in long waiting times and range anxiety among EV users.

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Another major challenge is the dependency on fixed charging infrastructure. In situations where a vehicle runs out of charge in remote or less-developed areas, accessing a charging station becomes difficult. This creates a need for a more flexible and portable charging solution. Furthermore, wired charging systems lack the capability of efficient energy sharing between vehicles, which could otherwise help in emergency scenarios.

Wireless power transfer (WPT) technology provides a potential solution to these challenges by enabling contactless energy transfer. However, existing wireless charging systems still face issues such as low efficiency, limited transfer distance, alignment sensitivity between coils, and lack of proper monitoring and control mechanisms. Moreover, most current systems are unidirectional, restricting energy flow only from the grid to the vehicle, without supporting bidirectional or vehicle-to-vehicle (V2V) charging.

Therefore, there is a need to design and develop a wireless EV charging system that is efficient, safe, cost-effective, and capable of bidirectional energy transfer. The system should also include real-time monitoring and control features to ensure reliable operation. Addressing these challenges will help in reducing dependency on fixed charging stations, improving user convenience, and enhancing the overall performance of EV charging infrastructure.

## III. LITERATURE SURVEY

The development of wireless charging technology for electric vehicles (EVs) has gained significant attention in recent years due to the increasing demand for efficient, safe, and user-friendly charging systems. Researchers have proposed various techniques based on wireless power transfer (WPT), inductive coupling, and vehicle-to-vehicle (V2V) charging to overcome the limitations of conventional plug-in charging systems.

In recent studies, wireless EV charging systems based on inductive power transfer have been widely explored. These systems utilize electromagnetic induction between a transmitter coil and a receiver coil to transfer energy without physical contact. A study presented in  explains the basic structure and operation of wireless EV charging systems, highlighting both static and dynamic charging methods. Static charging is performed when the vehicle is stationary, whereas dynamic charging allows charging while the vehicle is in motion. The study also emphasizes that wireless charging improves user convenience and reduces dependency on physical connectors. However, it also identifies challenges such as energy losses and system efficiency.

Another important advancement in EV charging technology is vehicle-to-vehicle (V2V) charging. A research work discussed in  proposes a wireless V2V charging system where one electric vehicle can transfer energy to another without the need for a fixed charging station. This concept addresses the issue of limited charging infrastructure and provides a flexible solution in emergency situations. The study also discusses the importance of coil alignment and mutual inductance in achieving efficient power transfer. However, the system requires precise design and control to maintain efficiency under different operating conditions.

Further research presented in  focuses on the design and comparison of different V2V charging systems. The paper highlights key parameters such as power capacity, cost, and efficiency of wireless charging systems. It also discusses the impact of coil design and compensation circuits on system performance. The results indicate that proper coil design and alignment significantly improve power transfer efficiency. Additionally, the study compares various compensation techniques and concludes that advanced circuit designs can enhance system stability and  efficiency.

Another study in  presents a wireless V2V charging system using high-frequency inverter circuits and resonant inductive coupling. The system demonstrates the transfer of electrical energy between two vehicles using transmitter and receiver coils. The research shows that matching the resonant frequency of both coils is essential for efficient energy transfer. It also highlights that wireless charging systems can be used in real-time applications but require optimization to reduce charging time and improve efficiency.

From the above studies, it is observed that wireless EV charging systems provide significant advantages over traditional wired systems, such as improved safety, convenience, and flexibility. However, challenges such as low efficiency, alignment issues, and high implementation costs still exist. Most existing systems focus on unidirectional charging, where energy flows only from the grid to the vehicle. There is limited work on bidirectional charging systems that support both charging and discharging operations between vehicles.

Therefore, there is a need to develop a cost-effective and efficient wireless charging system that supports bidirectional energy transfer with proper monitoring and control. The proposed system in this paper addresses these challenges by implementing a wireless V2V charging system using Arduino-based control, real-time monitoring using sensors, and improved circuit design for stable operation.

## IV. PROJECT DISCRIPTION

The proposed project focuses on the design and implementation of a bidirectional wireless electric vehicle (EV) charging system using inductive power transfer technology. The primary objective of this system is to enable efficient and contactless energy transfer between two batteries, thereby supporting vehicle-to-vehicle (V2V) charging applications. The system eliminates the need for physical connections such as cables and connectors, improving safety, flexibility, and user convenience.

The overall system is developed using a combination of hardware and software components. At the core of the system, an Arduino Uno microcontroller is used as the central control unit to manage the entire operation. The Arduino continuously monitors system parameters and controls the charging and discharging process based on predefined conditions. The system is designed to operate in two modes: charging mode and discharging mode, allowing bidirectional flow of energy between two battery units.

In the charging mode, electrical energy is transferred wirelessly from the transmitter side to the receiver side. The transmitter section consists of a power source, a switching circuit, and a transmitter coil. The switching circuit generates a high-frequency alternating current, which is supplied to the transmitter coil. This alternating current creates a varying magnetic field around the coil. On the receiver side, a receiver coil is placed within the magnetic field generated by the transmitter coil. Due to electromagnetic induction, an alternating voltage is induced in the receiver coil. This induced AC voltage is then converted into DC using a rectifier circuit and filtered to provide a stable output, which is used to charge the battery.

In the discharging mode, the stored energy in the battery can be supplied to an external load or transferred to another battery. The relay module plays a crucial role in controlling the switching between charging and discharging operations. The Arduino microcontroller sends control signals to the relay module to activate or deactivate the charging circuit based on system conditions. This enables safe and controlled bidirectional energy flow, which is essential for V2V charging applications.

To ensure proper monitoring of system performance, an INA219 current sensor is integrated into the circuit. This sensor measures both voltage and current in real time and sends the data to the Arduino. The measured parameters are displayed on an LCD screen, providing the user with real-time information about the system status. This feature enhances system reliability and allows for better control and protection against faults such as overcharging or deep discharge.

A buck converter (LM2596) is used in the system to regulate the voltage levels and ensure a stable power supply to the components. Voltage regulation is essential for maintaining the efficiency and safety of the system, as fluctuations in voltage can affect the performance of the battery and other electronic components. Additionally, wireless communication modules are incorporated to enable remote operation and control of the system, further enhancing its flexibility and usability.

The proposed system is compact, cost-effective, and suitable for small-scale implementation. It demonstrates the feasibility of wireless bidirectional charging using simple components and provides a foundation for further research and development in this field. The system can be extended for real-world applications such as dynamic charging roads, smart charging stations, and integration with IoT-based monitoring systems.

Overall, this project provides an efficient solution to the challenges associated with conventional EV charging systems. By enabling wireless and bidirectional energy transfer, the system reduces dependency on fixed charging infrastructure

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and enhances the practicality of electric vehicles. The implementation of such systems can contribute significantly to the advancement of sustainable transportation technologies and support the future development of smart energy systems.

## V. OBJECTIVE OF PROJECT

1.The main objective of this project is to develop an efficient and reliable bidirectional wireless Vehicle-to-Vehicle (V2V) charging system for electric vehicles. The system aims to enable energy transfer between two batteries without using physical connections, thereby improving convenience and flexibility.

2.Another objective is to design a system that ensures safe and controlled power transfer by monitoring battery parameters such as voltage, current, and State of Charge (SoC). This helps in preventing overcharging, deep discharging, and battery damage.

3.The project also focuses on improving energy efficiency and reducing power losses during the charging process by using suitable power electronic components like a DC-DC converter and relay control.

3.In addition, the system aims to incorporate real-time monitoring and intelligent control using a microcontroller (Arduino UNO), which can make decisions based on battery conditions.

4.Finally, the objective is to develop a simple, cost-effective, and practical solution that can support future electric vehicle charging systems, especially in situations where charging infrastructure is limited or unavailable.

## VI. SYSTEM ARCHITECTURE

The proposed system architecture of the wireless electric vehicle (EV) charging system consists of multiple hardware components integrated to achieve efficient wireless power transfer and bidirectional energy flow. The system is divided into major sections: power supply unit, control unit, sensing unit, wireless power transfer unit, switching unit, and display unit.

The power supply is provided by a rechargeable battery, which acts as the energy source in the system. The energy is transferred wirelessly from the transmitter coil to the receiver coil based on the principle of electromagnetic induction. The Arduino Uno microcontroller acts as the central control unit, which monitors system parameters and controls the overall operation. A current and voltage sensor is used for real-time monitoring, while a relay module controls the charging and discharging process. A buck converter is used to regulate the voltage, and an LCD display is used to show system parameters.

The overall architecture ensures proper coordination between all components to achieve safe, efficient, and reliable wireless charging.

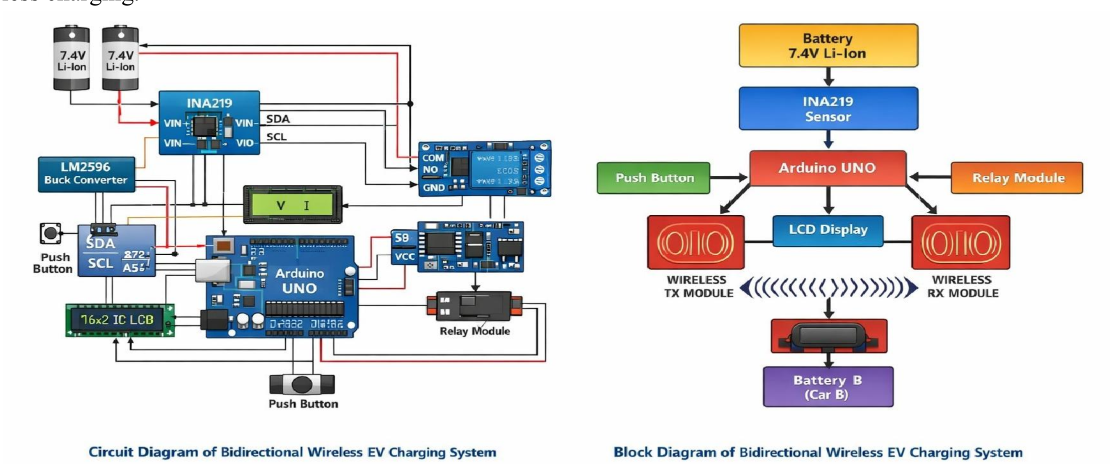


**Fig.1 Arduino Uno (Control Unit)**

The Arduino Uno is the main controller of the system based on the ATmega328 microcontroller. It is responsible for controlling and monitoring all operations of the system. It reads data from the sensor, processes it, and controls the relay module for switching between charging and discharging modes. It also sends data to the LCD display for user monitoring.

**2. Battery (Power Source)**

The battery is used as the primary energy source in the system. A 7.4V Li-ion battery is used to store electrical energy. During charging mode, the battery gets charged through the wireless power transfer system, and during discharging mode, it supplies power to the load or another battery.

**3. Wireless Transmitter and Receiver Coils**

The transmitter coil generates a magnetic field when alternating current flows through it. The receiver coil captures this magnetic field and converts it into electrical energy. This process is based on electromagnetic induction. Proper alignment of coils is necessary for efficient power transfer.

**4. INA219 Current Sensor (Sensing Unit)**

The INA219 sensor is used to measure voltage and current in the circuit. It provides real-time data to the Arduino using I2C communication. This helps in monitoring system performance and protecting the system from overcurrent and overvoltage conditions.

**5. Relay Module (Switching Unit)**

The relay module acts as an electrically operated switch. It is controlled by the Arduino to turn ON or OFF the charging circuit. It plays an important role in enabling bidirectional charging by controlling the direction of power flow.

**6. Buck Converter (LM2596) (Voltage Regulation)**

The buck converter is used to step down and regulate the voltage to a required level. It ensures a stable voltage supply to the battery and other components. This improves system efficiency and prevents damage due to voltage fluctuations.

**7. LCD Display (Display Unit)**

The LCD display is used to show real-time parameters such as voltage and current. It helps the user to monitor system performance easily. It is interfaced with Arduino using I2C communication.

**8. Wireless Communication Module**

The wireless module is used to enable remote control and communication between transmitter and receiver units. It enhances system flexibility and allows control of charging operations without physical interaction.

## VII. CONCLUSION

In this paper, a bidirectional wireless electric vehicle (EV) charging system based on inductive power transfer has been successfully designed and implemented. The proposed system enables efficient and contactless energy transfer between two batteries, eliminating the need for conventional wired connections. By integrating wireless power transfer technology with an Arduino-based control system, the project demonstrates a simple, cost-effective, and practical solution for modern EV charging challenges.

The system supports both charging and discharging operations, allowing bidirectional energy flow, which is essential for vehicle-to-vehicle (V2V) charging applications. The use of components such as the INA219 sensor enables real-time monitoring of voltage and current, improving system reliability and safety. The relay module ensures controlled switching between different operating modes, while the buck converter provides stable voltage regulation for efficient operation. Additionally, the LCD display enhances user interaction by providing real-time system information.

Experimental results indicate that the system is capable of transferring power wirelessly with stable performance under short-distance conditions. Although the efficiency of wireless power transfer is slightly lower compared to conventional wired systems, the advantages in terms of safety, flexibility, and ease of use make it a promising alternative. The system also reduces dependency on fixed charging infrastructure and provides a useful solution in emergency situations where charging stations are not available.

Overall, the proposed wireless EV charging system demonstrates the feasibility of bidirectional energy transfer using simple and low-cost components. The project contributes to the development of advanced EV charging technologies and supports the future growth of smart and sustainable transportation systems. Further improvements in efficiency, coil design, and long-distance power transfer can enhance the performance of the system and make it suitable for large-scale real-world applications.

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