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# Wireless Charging of EV Systems by using Mutual Inductance

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**ABSTRACT:** This paper describes the emerging technology of wireless power transfer (WPT), which uses mutual induction to transmit power from a source to an electrical load without the use of connectors. With the growing number of electric vehicles on the road, wireless charging is becoming a popular solution to issues that electric vehicle drivers encounter, such as charging time and the requirement for specialized equipment. With transfer lengths ranging from a few meters to a few hundred meters and efficiency exceeding 90%, WPT is a viable technology for electric car charging applications in both stationary and dynamic charging circumstances. The study delves into the research and development of wireless charging systems for electric vehicles based on resonance coupling, explaining the required components and covering health and safety concerns related to the technology. Furthermore, the article investigates and compares emerging concept- based wireless charging systems, such as "vehicle-to-grid (V2G)" and "in-wheel" wireless charging systems (WCS), to existing technologies.

**KEYWORDS**: Electric vehicles, Electromagnetic compatibility, Wireless electric vehicle charging system.

## I. INTRODUCTION

The world is dealing with a serious problem of pollution created by internal combustion engines used in automobiles. This has resulted in a decrease in the use of fossil fuels and a greater demand for cleaner, greener energy with zero emissions. The automobile industry has been continually inventing to enhance fuel efficiency and lower pollution, which has resulted in the creation of hybrid cars. Electric cars, on the other hand, hold the key to a sustainable future, but they have certain downsides, such as high costs, restricted range, and lengthy charging periods.

Wireless charging methods for electric vehicles are being developed to overcome these difficulties. Wireless charging systems eliminate the need for cable charging stations by providing a flexible and simple method of charging electric automobiles. These systems are suitable for use in homes, parking lots, and garages. To accomplish efficient power transmission in these systems, resonant coupling methods have been employed, with coil design playing a significant role. Because of its great efficiency and ease of maintenance, the resonant inductive wireless charging technique has attracted more attention than other wireless power transmission methods.

In the future, self-sufficient electric vehicles will require an automated charging system that does not require human involvement. This necessitates a completely automatable, quick, safe, cost-effective, and dependable charging infrastructure that supports a successful business model and rapid adoption of electric transportation systems. Wireless charging solutions have the benefits of flexibility, simplicity, safety, and the opportunity to become fully automated. This article provides an overview of the current state of resonant inductive wireless power transfer charging technology and its prospects in the wireless EV industry. It also illustrates the current state and problems of wireless charging systems, offering insights that mightaid in the study and development of WPT systems.

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## II. WIRELESS POWER TRANSFER

Wireless power transmission is a new technique that goes beyond simply charging electronics wirelessly. It represents a major shift in our understanding of energy and our relationship with technology. We are constructing a dynamic energy system that can adapt to society's changing demands by removing the need for physical connections and cables. This technology represents an important step towards a more sustainable future in which energy is no longer a finite resource but rather a fluid network that can be harnessed and shared. Wireless power transmission has the potential to lessen our reliance on fossil fuels while also combating climate change by making electricity available to everyone, regardless of location, money, or access to infrastructure. The method works by using the magnetic field formed by a transmission coil, which is not the same as a standard transformer. Resonant magnetic induction is the solution for transferring electricity over many feet of outdoor space. Despite the existence of hurdles like efficiency, safety, and scalability, ongoing innovation and development can bring us to a cleaner and more sustainable future. Wireless power transfer represents our ability to co-create and share energy to improve the world for ourselves and future generations.

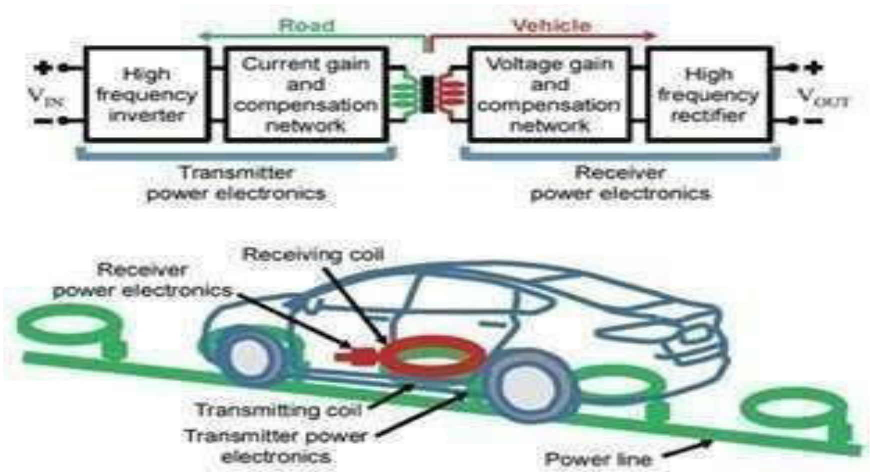


**Fig-1:** Model of WPT

### 1. TYPES OF WPT

Wireless power transmission is a paradigm change towards a new connection with energy and technology, not only for the ease of charging electronics without cables. This technology allows energy to be transmitted via an electromagnetic field formed by a transmission coil, resulting in a dynamic energy system that can adapt to society's changing demands. Unlike typical transformers, wireless power transfer technology transmits electricity across many feet via resonant inductive coupling. This breakthrough offers a glimpse of a sustainable energy future in which energy is a common resource that benefits everyone.

Wireless power transfer technology has transformed the way we charge our electronic gadgets. Magnetic induction, magnetic resonance, radio frequency, and laser power transfer are the four types of wireless power transmission methods. Each has advantages and downsides, and they are best suited for specific use scenarios. Magnetic induction and magnetic resonance are widely used to charge smartphones and electric cars, although RF and laser power transmission are still in the experimental stage. Inductive and capacitive technologies are used in close-field WPT structures, with inductive WPT systems being favored for medium- range transfers such as electric car charging. These technologies, which vary from medical implants to distant sensors, have the potential to alter a wide range of sectors and will likely play a big part in creating our future.

### 2. MUTUAL INDUCTANCE POWER TRANSFER

Mutual inductance power transfer is a type of wireless power transfer that uses two coils, a transmitter coil, and a receiver coil, to transfer energy wirelessly. This method works by generating a magnetic field in the transmitter coil, which induces a current in the receiver coil, allowing for the transfer of power. The amount of power transferred is dependent on various factors, such as the number of turns in each coil, the distance between the coils, and the frequency of the alternating current used.

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The power transfer can be calculated using the following formula:

$P = (1/2\pi) \times (\omega MI)^2 \times (d^2/4)$

Where P is the power transferred, is the angular frequency, M is the mutual inductance, I is the current in the receiver coil, and d is thedistance between the transmitter and receiver coils.

Mutual inductance power transfer has several applications, including wireless charging of electric vehicles, medical implants, and consumer electronics. However, it has limitations, such as the distance between the coils and the loss of power due to the heating of the coils. Despite its limitations, mutual inductance power transfer is a promising technology for a future where wireless charging will become increasingly important.

## 1. ADVANTAGES:

Mutual inductance power transfer offers several advantages over other forms of wireless power transfer. One of the main benefits is its efficiency, with typical efficiencies of 70-80% reported for wireless charging systems. This is due to the ability of mutual inductance to transfer energy over short distances without significant loss.
Another advantage is that mutual inductance is a relatively simple and low-cost technology, requiring only a few components such as coils and capacitors. This makes it an attractive option for a wide range of applications, including electric vehicle charging, consumerelectronics, and medical devices.
Mutual inductance power transfer is also safe and reliable, with no risk of electric shock or other hazards. Additionally, mutual inductance systems can be designed to be compatible with existing infrastructure, such as wireless charging pads for smartphones.
Overall, the advantages of mutual inductance power transfer make it a promising technology for a variety of applications, and ongoing research and development efforts are expected to further improve its performance and broaden its adoption.

## 3. Diagrams Related to the project

### 1. Power Transmitting Module

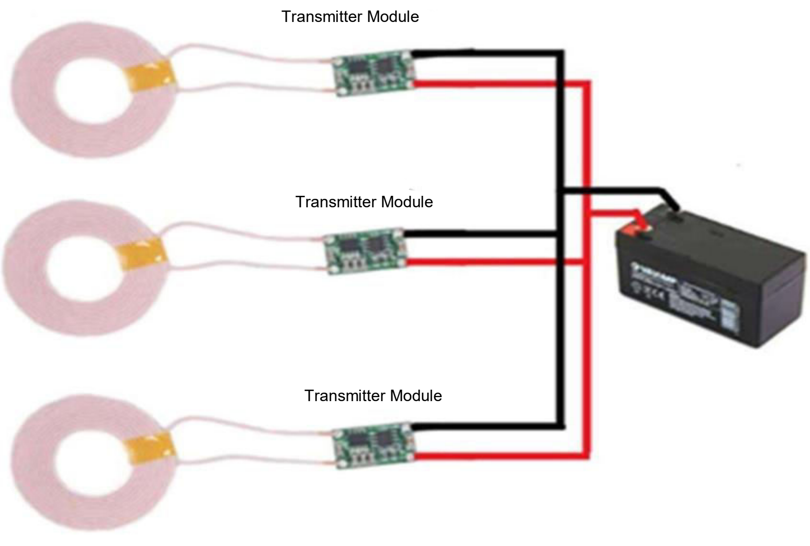


**Fig-2**: Power Transmission System

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**4. Power Receiving Module**

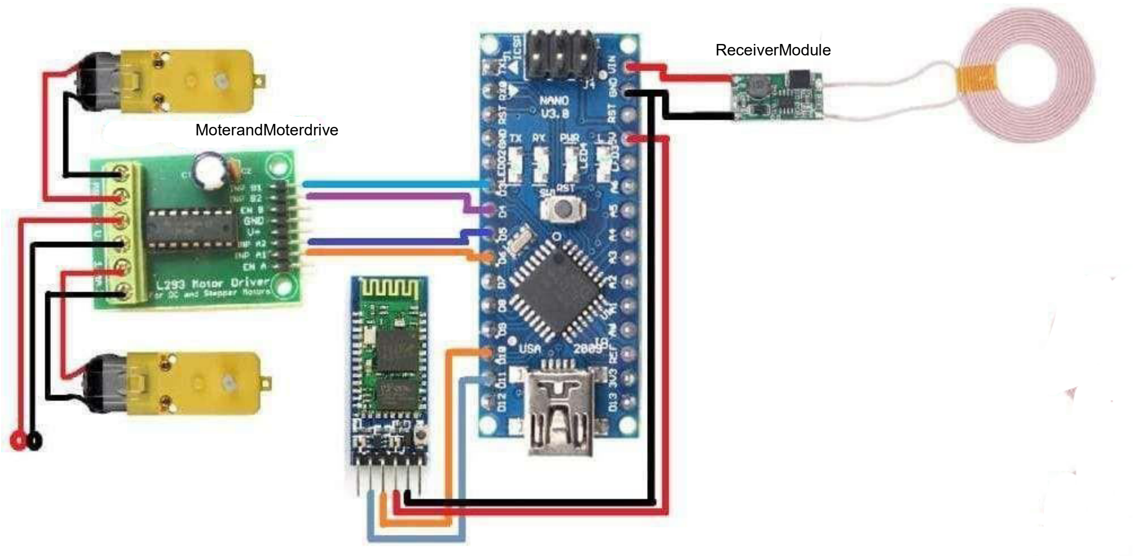
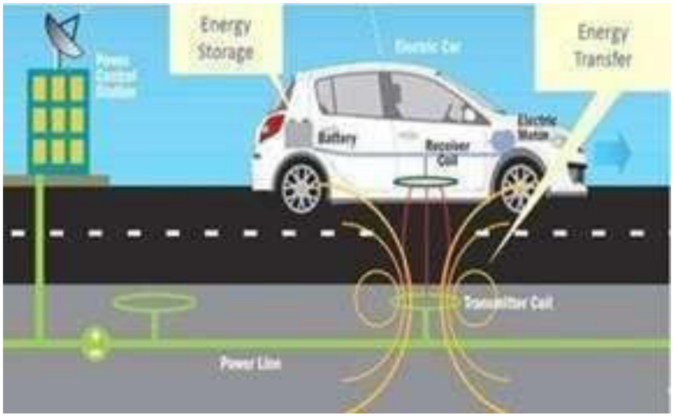



**Fig -3:** Power Receiving System

## IV. PROPOSED SYSTEM




**Working of the proposed system:-**

In the wireless charging system designed for electric vehicles using mutual induction, the transmitter and receiver play essential roles in enabling efficient power transfer. The transmitter comprises an induction coil integrated into the charging station, while the receiver incorporates an induction coil installed within the electric vehicle.

When the AC supply is provided to the charging station, it undergoes voltage reduction through a transformer, followed by rectification to convert it into a usable form. Through mutual induction, power is then transferred from the transmitter coil tothe receiver coil, eliminating the need for physical connections. The receiver coil is connected to a control circuit that regulates the frequency and Q factor to optimize power transmission efficiency. This control circuit manages the supply of power from the charging coil to the vehicle's battery, controlling its activation and deactivation as necessary to ensure effective charging while preventing overcharging.

To facilitate these operations, the control circuit incorporates several components such as a voltage sensor, an LCD display, a transistor, a freewheeling diode, ceramic capacitors, a crystal oscillator, and a microcontroller. These components collectively monitor the battery status, control the relay, display relevant information, release stored voltage, and generate pulses for the microcontroller's operation.

By employing mutual induction, this wireless charging system provides an efficient and convenient solution for electric vehicle charging. It eliminates the need for physical connections, offering seamless charging without the inconvenience of handling cables. Embracing the principles of mutual induction promotes a greener and more sustainable future by facilitating the widespread adoption of electric vehicles and reducing dependence on conventional fossil fuel-based transportation.

**Working of the proposed system (with respect to the prototype):-**

In the wireless charging system for electric vehicles using mutual induction, the work involves the coupling of induction coils between the charging station and the electric vehicle. The charging station model consists of an AC supply that is fed to a transformer to step down the voltage. The rectifier circuit then converts the voltage into a usable form. The power is transmitted to the control circuit for storage in a battery with a voltage of 4 volts and a current of 1.5 amperes.

The control circuit is responsible for regulating the frequency and Q factor to achieve maximum transmission efficiency between the transmitter and receiver. The receiver is connected to the control circuit and then to the battery. The control circuit controls the supply from the charging coil to the battery, turning it on and off. When the battery reaches its full capacity, the control circuit disconnects the coil connection through a relay.

To monitor the battery voltage, a voltage sensor is used, and the information is displayed on a 16 by-2 LCD display. A transistor is employed to control the relay, acting as a switch. A freewheeling diode is incorporated to release the stored voltage from the relay coil. The system also includes ceramic capacitors, a crystal oscillator, and a microcontroller for generating pulses for its operation. A digital budget is used to indicate the battery status and a 10-ohm variable resistor controls the brightness of the LCD display. Finally, a power switch is used to turn on the vehicle using the fully charged battery.

By utilizing the principles of mutual induction, this wireless charge increase enables efficient and convenient charging of electric vehicles without the need for physical connections. The control circuit ensures optimal power transfer and safeguards the battery from overcharging. This model demonstrates the potential of mutual induction in revolutionizing the electric vehicle charging infrastructure for a greener and more sustainable future.

**Working of the microcontroller in the prototype proposed system:-**

In the wireless charging system for electric vehicles using mutual induction, an Arduino Nano microcontroller unit is employed as a key component of the control circuit. The Arduino Nano is a compact, multifunctional microcontroller board with customizable capabilities that acts as the system's brain.

The Arduino Nano, which has been programmed with precise algorithms and instructions, guarantees that the wireless charging system operates efficiently. It controls the frequency and Q factor to optimize power transmission between the transmitter and receiver coils. It also keeps track of the charging progress and protects the battery by preventing overcharging.

The tiny size and low power consumption of the Arduino Nano make it a perfect candidate for this wireless charging system. Its adaptability enables modification and connection with other system components, allowing for smooth communication and control.

Overall, the Arduino Nano microcontroller unit improves the system's intelligence and usefulness. It allows for precise control, effective power management, and real-time monitoring, all of which contribute to the charging processes' overall performance and dependability.

The Arduino Nano is in charge of regulating and directing the charging process in general. It accepts sensor inputs, such as the voltage sensor, and analyses the data to determine the battery's status. The microcontroller unit then takes the relevant steps, such as activating or disabling the charging coil connection, based on this information.

## V. SAFETY CONCERN

One of the safety concerns associated with wireless charging of electric vehicles using mutual induction is the exposure to high-frequency magnetic fields. During the wireless charging process, there is a magnetic field generated between the transmitting and receiving coils. The large air gap between these coils can result in a high leakage flux. The frequency and amplitude of this leakage magnetic field must be carefully controlled to ensure compliance with safety regulations.

To ensure safety, it is important to define a designated safe area for wirelessly charging electric vehicles. The magnetic flux density should be within acceptable limits when individuals are in normal positions, such as standing near the vehicle or sitting inside it. Safety guidelines need to be followed to minimize any potential health risks associated with exposure to magnetic fields.

Fortunately, vehicles are typically made of metal, which provides a good level of shielding. This helps in reducing the exposure to magnetic fields, providing an additional layer of protection for individuals using or being near wirelessly charging electric vehicles. It is essential to regularly assess and comply with safety regulations and guidelines to mitigate any potential risks associated with magnetic field exposure during the wireless charging of electric vehicles. Proper monitoring and adherence to safety standards will contribute to the overall safety and acceptance of wireless charging technology in the electric vehicle industry.

## VI. CONCLUSION

This paper has presented a design for wireless charging of electric vehicles using mutual induction. Wireless charging offers numerous advantages over wired charging, enabling mass market penetration of electric vehicles and addressing environmental concerns. However, further research is needed in topology, control systems, inverter design, and human safety to ensure optimal implementation. With ongoing advancements, wireless charging holds promise for a greener and more sustainable transportation landscape. By embracing wireless charging technology, we can move closer to a future with cleaner transportation systems, reduced emissions, and decreased reliance on finite fossil fuel resources.

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