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# DYNAMIC WIRELESS POWER TRANSFER SYSTEM FOR ELECTRIC VEHICLES WITH IoT MONITORING

## *Smart, Contactless And Efficient EV Charging Solution*

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***Abstract :*** The emergence of electric vehicles (EVs) has highlighted the significance of creating effective and user-friendly charging systems to fulfill the escalating need for environmentally friendly transportation. However, the scalability of the infrastructure and consumer convenience are limited by traditional fixed charging infrastructure. To solve these issues, a unique Dynamic Wireless Charging System (DWCS) is presented in this work. The suggested method makes use of cutting-edge wireless power transfer technologies to allow electric vehicle charging while driving.
The system's dynamic charging characteristics enable it to adjust to the location and speed of the vehicle, resulting in smooth and uninterrupted charging while it is moving. By improving the accessibility and flexibility of EV charging, this strategy lessens range anxiety and promotes the wider use of electric vehicles. The study highlights the DWCS's potential to completely transform the infrastructure for electric car charging in the future by going over its essential elements, guiding principles, and possible uses. To develop an innovative wireless charging system capable of dynamically transferring power to electric vehicles (EVs) in motion, integrated with real-time IoT based monitoring for enhanced efficiency and diagnostics.
This project proposes the design and implementation of an IoT-enabled inductive charging station for electric vehicles (EVs), integrating wireless power transfer (WPT) with real-time system monitoring and control. The system employs resonant inductive coupling to enable efficient, contactless energy transfer between a primary coil embedded in the charging pad and a secondary coil mounted on the vehicle. Key system parameters—including coil alignment, power transfer efficiency, and thermal behavior—are continuously monitored using embedded sensors and microcontrollers (e.g., ESP32 or Arduino-based platforms).
IoT connectivity is achieved through Wi-Fi or MQTT protocols, allowing transmission of real-time data to a cloud-based platform for analytics, remote diagnostics, and user notifications. A custom web or mobile dashboard provides visualizations of charging metrics such as voltage, current, power delivered, state-of-charge (SoC), and estimated time to full charge. The system also features automated access control, energy usage logging, and fault detection mechanisms, enhancing reliability and security.
By combining inductive charging technology with IoT-based monitoring, the solution supports smart energy management, reduces dependency on manual operations, and advances the development of scalable, intelligent EV infrastructure

## I. Introduction

As electric vehicles gain popularity, efficient and convenient charging solutions are essential. This project presents a dynamic wireless power transfer system that eliminates the need for stationary charging docks by enabling continuous charging on the move. The system integrates IoT technology to provide live monitoring of power transmission and environmental parameters. The transition to sustainable energy systems has accelerated the global shift toward electric vehicles (EVs) as a means to reduce greenhouse gas emissions, mitigate fossil fuel dependence, and improve urban air quality.
However, the success of EV adoption is intrinsically linked to the availability of robust, scalable, and intelligent charging infrastructure. Conventional plug-in charging stations, while widely used, pose several limitations, including user inconvenience, mechanical wear, exposure to environmental conditions, and potential safety hazards due to human error.
In response to these challenges, inductive charging—a form of wireless power transfer (WPT)—is gaining momentum as a promising alternative. Utilizing the principle of resonant inductive coupling, energy is transferred contactlessly from a transmitter

coil located in the charging pad to a receiver coil embedded in the vehicle. This method offers a safer, cleaner, and more user-friendly charging experience, particularly in urban environments and autonomous vehicle applications where manual intervention is impractical.
To further enhance the performance, intelligence, and adaptability of inductive charging systems, the integration of Internet of Things (IoT) technology becomes essential. Through the deployment of embedded microcontrollers, sensors, and wireless communication protocols (e.g., MQTT, Wi-Fi), the charging system can monitor critical parameters such as coil alignment, power transfer efficiency, voltage, current, temperature, and state of charge (SoC) in real time. These data streams can be transmitted to a cloud-based platform or edge-computing system for analytics, visualization, and remote control via web or mobile applications.

## II. Problem Statement

The rapid growth of Electric Vehicles (EVs) is an important step toward reducing greenhouse gas emissions and dependence on fossil fuels. However, the current EV charging infrastructure mainly relies on plug-in stationary charging systems, which require vehicles to stop for extended periods of time. This results in several challenges such as long charging durations, limited charging station availability, and increased range anxiety among EV users.
Traditional wired charging systems also require significant user interaction, physical connectors, and regular maintenance. In addition, the growing number of EVs places increasing pressure on existing charging infrastructure, leading to congestion at charging stations and inefficient energy management.

To address these limitations, Dynamic Wireless Power Transfer (DWPT) has emerged as a promising solution. DWPT enables EVs to receive power wirelessly while moving over specially equipped roadways using **Inductive Power Transfer technology. Although this approach eliminates the need for frequent stops and improves driving convenience, several technical challenges remain. These include maintaining high power transfer efficiency during vehicle motion, coil misalignment between the transmitter and receiver, and ensuring safe and reliable operation under varying environmental conditions.

Another major challenge in wireless charging systems is the lack of real-time monitoring and intelligent system management. Without proper monitoring, it becomes difficult to track system performance, detect faults, or optimize power delivery. Integrating Internet of Things (IoT) technology can help address this issue by enabling continuous monitoring of key parameters such as voltage, current, temperature, power transfer efficiency, and system status.
However, existing wireless charging solutions often lack a comprehensive framework that combines dynamic wireless power transfer with IoT-based monitoring and control systems. This limits the ability to achieve efficient energy management, predictive maintenance, and reliable operation of EV charging infrastructure.

Therefore, there is a need to design and develop a dynamic wireless power transfer system integrated with IoT monitoring that can enable efficient power transfer to electric vehicles during motion while providing real-time system monitoring, improved operational efficiency, and enhanced reliability of the charging infrastructure.

## III. Research Area & Discussion

### *A. Research Areas*

The development of a Dynamic Wireless Power Transfer system with IoT monitoring for electric vehicles involves several interdisciplinary research domains. These areas combine concepts from power electronics, wireless energy transmission, embedded systems, communication technologies, and intelligent monitoring systems.

#### 1. Electric Vehicle Charging Infrastructure

One of the primary research areas involves the improvement of charging infrastructure for Electric Vehicles (EVs). Conventional charging stations require vehicles to stop for long durations to recharge their batteries. Research in this field focuses on developing efficient charging technologies that minimize downtime and improve user convenience.
Dynamic wireless charging infrastructure embeds transmitter coils within the roadway, allowing vehicles equipped with receiver coils to charge while in motion. This concept significantly reduces the need for large battery capacities and frequent charging stops, thereby improving the overall efficiency of EV transportation systems.

#### 2. Wireless Power Transfer Technology

Another critical research domain is Wireless Power Transfer (WPT) technology. WPT allows electrical energy to be transferred without physical connections using electromagnetic fields.
The most commonly used technique for EV wireless charging is Inductive Power Transfer, where power is transmitted between two coils through magnetic coupling. The transmitter coil, installed in the road surface, generates a magnetic field that induces current in the receiver coil installed underneath the vehicle.
Research in this area focuses on:

- Improving power transfer efficiency
- Reducing energy losses
- Designing optimized coil structures
- Maintaining stable energy transfer despite vehicle movement and misalignment These improvements are necessary for achieving reliable dynamic charging performance.

### 3. Internet of Things (IoT) Integration

The integration of Internet of Things (IoT) technologies is another major research area. IoT enables real-time communication between charging infrastructure, vehicles, and monitoring platforms.

IoT devices such as microcontrollers and sensors can monitor parameters like:

- Voltage levels
- Current flow
- Temperature conditions
- Charging status
- System faults

This data is transmitted to cloud-based platforms where it can be analyzed for system optimization and predictive maintenance.

IoT integration enhances system reliability and allows operators to monitor the performance of wireless charging infrastructure remotely.

### 4. Power Electronics and Energy Conversion

Power electronics play a significant role in the wireless power transfer system. High-frequency inverters convert the supplied electrical power into a form suitable for wireless transmission.

Key research topics include:

- High-frequency inverter design
- Rectifier circuits for receiver modules
- DC–DC converters for battery charging
- Efficiency optimization in power conversion stages

Efficient power conversion is essential to minimize power loss and ensure that sufficient energy reaches the EV battery during motion.

### 5. Smart Transportation and Intelligent Energy Management

Dynamic wireless charging systems also contribute to the development of smart transportation networks. Research in this field focuses on integrating EV charging with intelligent traffic systems, renewable energy sources, and smart grid technologies.

## *B. Discussion*

The implementation of a dynamic wireless power transfer system integrated with IoT monitoring presents a promising solution to several limitations associated with traditional EV charging systems.

One of the most significant advantages of this technology is the ability to charge vehicles while they are in motion. This capability greatly reduces the dependence on stationary charging stations and minimizes waiting times for vehicle charging. As a result, EV users experience increased convenience and reduced range anxiety.

Wireless charging through inductive coupling provides a safer and more reliable method of energy transfer compared to conventional plug-in systems. Since there are no exposed connectors, the risk of electrical hazards, mechanical wear, and environmental damage is significantly reduced.

The integration of IoT monitoring further enhances the efficiency and reliability of the system. Real-time monitoring allows operators to track system performance continuously and identify potential faults before they lead to system failures. Parameters such as voltage fluctuations, overheating, and abnormal current levels can be detected early, enabling predictive maintenance and improved operational safety.

However, several technical challenges must still be addressed for widespread implementation. Maintaining high power transfer efficiency during vehicle movement is one of the primary concerns. Misalignment between the transmitter and receiver coils can reduce power transfer efficiency, leading to energy losses.

Another challenge involves the high infrastructure cost associated with installing transmitter coils beneath roadways. Large-scale deployment requires significant investment in infrastructure development and standardization of wireless charging technologies.

Despite these challenges, ongoing research and technological advancements are steadily improving the feasibility of dynamic wireless charging systems. Improvements in coil design, power electronics, and intelligent monitoring systems are expected to increase efficiency and reduce implementation costs.

Overall, the combination of wireless power transfer technology with IoT-based monitoring represents a significant step toward building a reliable and sustainable EV charging infrastructure for future smart transportation systems.

# IV. Materials And Methods

### 1. ESP32 Microcontroller

The ESP32 microcontroller acts as the main control unit of the system. It is responsible for processing sensor data, controlling system operations, and enabling wireless communication through Wi-Fi or Bluetooth.

In the proposed system, the ESP32 collects data from sensors such as temperature and humidity sensors and proximity sensors. It also controls components like relays and motors based on the system logic. Additionally, it enables IoT-based monitoring, allowing system data to be transmitted to a cloud platform or monitoring application.

Key features include:

- Built-in Wi-Fi and Bluetooth connectivity
- Low power consumption
- High processing capability
- Multiple GPIO pins for sensor and actuator integration

### 2. DHT 11

The DHT11 sensor is used to measure temperature and humidity conditions around the system. Monitoring environmental conditions helps ensure that the wireless charging system operates safely and efficiently.

Excessive heat can affect electronic components such as coils, batteries, and inverters. The DHT11 sensor provides realtime environmental data that can be transmitted through the IoT system for monitoring and analysis.

### 3. BO Motors

BO motors are small DC geared motors used to drive the wheels of the robotic vehicle prototype. These motors convert electrical energy from the battery into mechanical motion, allowing the vehicle model to move along the test track where wireless charging occurs.

### 4. Robot Wheels

Robot wheels are attached to the BO motors to allow smooth movement of the vehicle chassis. They enable the model EV to travel over the wireless charging track where the transmitting coils are placed. Proper wheel alignment ensures stable movement, which is important for maintaining alignment between transmitting and receiving coils for efficient wireless power transfer.

### 5. Chassis

The chassis serves as the structural framework of the prototype vehicle. It holds and supports all hardware components such as motors, battery, receiver coil, sensors, and microcontroller modules.

A stable chassis ensures proper positioning of the receiver coil underneath the vehicle, which is essential for maintaining effective inductive coupling with the transmitter coil embedded in the road model.

### 6. Zero PCB (Printed Circuit Board)

A zero PCB or prototype board is used to mount and connect electronic components without designing a custom printed circuit board. It provides a convenient platform for soldering and organizing components like sensors, resistors, microcontrollers, and relays.

This allows the system to maintain reliable electrical connections and simplifies circuit development during the prototyping stage.

### 7. Proximity Sensor

The proximity sensor is used to detect the presence of the vehicle near the charging area. When the vehicle approaches the transmitter coil region, the sensor sends a signal to the ESP32 controller.

This signal can be used to activate the wireless power transfer system automatically, ensuring that energy is transmitted only when a vehicle is present. This improves energy efficiency and prevents unnecessary power consumption.

### 8. Relay

A relay is an electrically controlled switch used to control high-power circuits using low-power signals from the microcontroller. In this system, the relay allows the ESP32 microcontroller to switch the wireless power transmission system on or off based on sensor input or control logic. It also provides electrical isolation between low-voltage control circuits and high-power charging circuits.

### 9. Lithium Battery

The lithium battery serves as the primary energy storage unit for the vehicle prototype. It powers components such as the ESP32 controller, motors, and other electronic modules. The wireless charging receiver transfers power to recharge this battery.

### 10. Jumper Wires

Jumper wires are used for making electrical connections between various components in the circuit. They provide flexible connections between sensors, microcontrollers, relays, and other modules during the prototyping phase. They help simplify circuit assembly and allow quick modifications during system testing.

### 11. Wireless Transmitting Coil + Inverter

The transmitting coil is placed beneath the road surface or charging track. It generates an alternating magnetic field when high-frequency AC current flows through it. The inverter converts DC power into high-frequency AC power required for wireless transmission. This alternating current produces a magnetic field around the transmitting coil. This magnetic field is responsible for transferring energy wirelessly to the receiver coil installed in the vehicle.

### 12. Receiver Coil + Rectifier

The receiver coil is installed underneath the vehicle chassis. When the vehicle moves over the transmitting coil, the magnetic field induces voltage in the receiver coil. The rectifier circuit converts the induced AC voltage into DC voltage, which can then be used to charge the lithium battery. This process forms the core mechanism of wireless energy transfer using electromagnetic induction.

### 13. Solar Panel

A solar panel is used as a renewable energy source to supply electrical energy to the system. It converts sunlight into electrical energy using photovoltaic cells. The generated electricity can be used to power the wireless charging system or charge thebattery used in the infrastructure. Using solar energy helps reduce reliance on conventional power sources and supports sustainable energy solutions.

### 14. Mini Wind Turbine

The mini wind turbine is another renewable energy component used in the system. It converts kinetic energy from wind into electrical energy. This additional renewable energy source helps demonstrate how EV charging infrastructure can be integrated with green energy technologies such as wind and solar power.Combining these renewable sources can improve system sustainability and reduce environmental impact.

### 15. Solar Charge Controller

A solar charge controller is an essential electronic device in off-grid solar systems that regulates the voltage and current flowing from solar panels to the battery bank. It prevents batteries from overcharging, prevents reverse current at night, and manages power to loads, thereby maximizing battery life and efficiency

## V. System Architecture

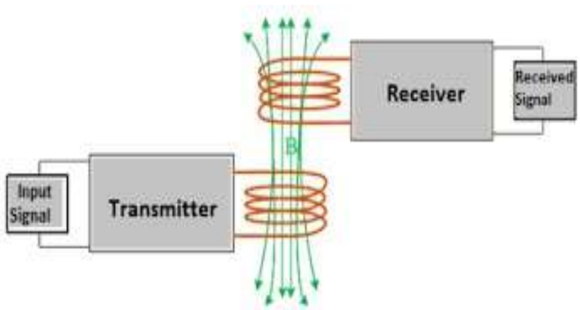


*Figure 5.1 Wireless Architecture*

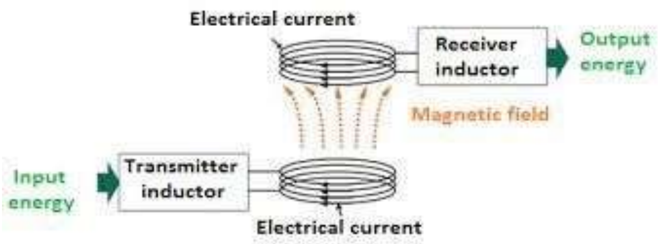


*Figure 5.2 Wireless Architecture*

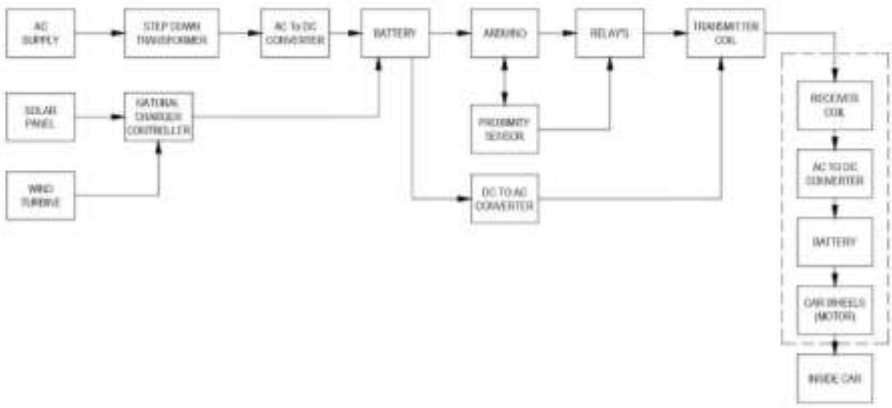


Figure 5.3 - Block Diagram

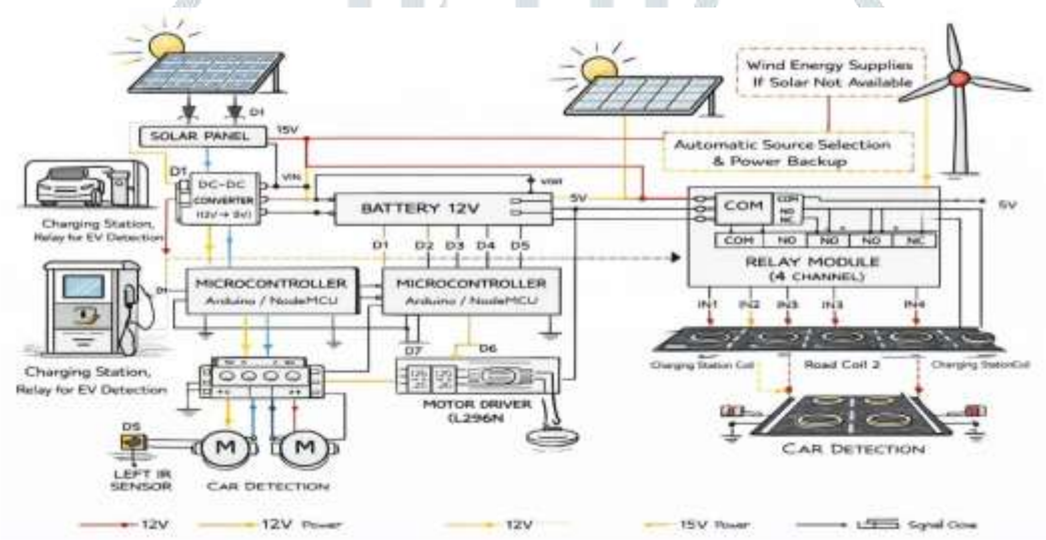


*Figure 5.4- Circuit Diagram*

*Figure 5.5 - Module Testing*


*Figure 5.6- Solar Charge Controller Testing*

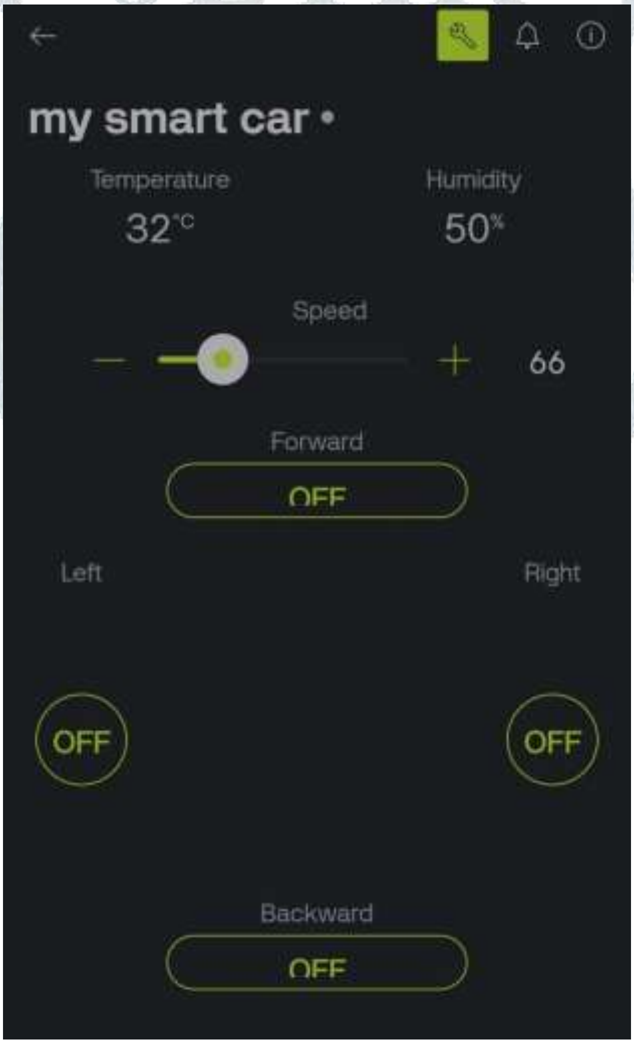


*Figure 5.7 – Temperature & Humidity Testing*

## VI. Applications

a. Smart City EV Charging Infrastructure
**b.** Public Transportation Systems
c. Industrial and Logistic App.
d. Integration With Renewable Resources
e. Sustainable transportation and eco-friendly energy systems
f. Research And Development platform For Wireless Power Trasnsfer Technologies

## VII. Advantages of Development of Wireless Charging For EVs:

### 1. Improved Convenience for EV Users

One of the major advantages of wireless charging is the convenience it offers to EV users. Traditional charging systems require drivers to manually connect charging cables to their vehicles. This process can be inconvenient, especially in adverse weather conditions or in crowded charging stations.
Wireless charging eliminates the need for cables and connectors. The vehicle can automatically charge when it is parked over a charging pad or while moving over a wireless charging lane. This improves the overall user experience and simplifies the charging process.

### 2. Charging While Driving

One of the major advantages of wireless charging is the convenience it offers to EV users. Traditional charging systems require drivers to manually connect charging cables to their vehicles. This process can be inconvenient, especially in adverse weather conditions or in crowded charging stations. Wireless charging eliminates the need for cables and connectors. The vehicle can automatically charge when it is parked over a charging pad or while moving over a wireless charging lane. This improves the overall user experience and simplifies the charging process.

### 3. Reduced Wear And Maintenance

In conventional charging systems, physical connectors are frequently used to connect and disconnect the charging cable. Over time, these connectors may wear out due to repeated usage, environmental exposure, or mechanical damage. Wireless charging systems eliminate physical contact between the power source and the vehicle. As a result, there is less mechanical wear and lower maintenance requirements for charging infrastructure.

### 4. Enhanced Safety

Wireless charging systems provide improved safety compared to wired charging systems. Since there are no exposed electrical contacts or cables, the risk of electrical shock, short circuits, and accidental damage is reduced. Additionally, modern wireless charging systems are designed with advanced protection mechanisms that prevent power transfer when foreign objects are detected between the transmitter and receiver coils.

### 5. Better Integration with Smart Infrastructure

Wireless EV charging systems can easily be integrated with smart technologies such as Internet of Things (IoT) and smart grids.
IoT-enabled monitoring systems can track parameters such as:

- Charging efficiency
- Battery status
- Temperature levels
- Energy consumption

This data can be used for real-time monitoring, system optimization, and predictive maintenance of the charging infrastructure.

### 6. Reduced Charging Infrastructure Congestion

With wireless charging systems embedded in parking areas or roadways, vehicles can charge automatically without occupying dedicated charging stations for long periods.This helps reduce congestion at charging stations and improves the availability of charging facilities in urban areas.

### 7. Support for Renewable Energy Integration

Wireless charging systems can be integrated with renewable energy sources such as **Solar Energy and **Wind Energy. Renewable energy can be used to power the wireless charging infrastructure, reducing dependence on conventional electricity sources**.**

### 8. Improved Urban Infrastructure

## VIII. Conclusion

We have discussed and reviewed charging of electric vehicles using wireless power transmission. Wireless charging is considered a better alternative to traditional wired charging systems as it is user and environment friendly. Furthermore, it eliminates the need for wires and mechanical connectors, and therefore, avoids the associated Wireless charging systems for electric vehicles hassles and hazards. Wireless charging systems also reduce the range anxiety and enhance the system efficiency.

The wireless power transmission, in general, takes place using either microwave, laser or mutual coupling. However, only mutual coupling-based techniques are generally used for wireless charging. The mutual coupling-based techniques, inductive and capacitive power transfer, are employed for contactless power transfer and charging of electric devices.

Both these techniques are discussed, compared and contrasted, and it is concluded that the inductive power transfer has advantages and is the prime method for wireless charging of electric vehicles. For this purpose, static, semi or quasi dynamic or completely dynamic methods of wireless charging can be employed.

These modes of wireless charging of electric vehicles are explained in this article. In addition, important aspects of a wireless charging system, such as, charging pad, compensation topologies, system misalignment, communication and control are reviewed and discussed. As various parameters of a charging system are determined by the batteries, a brief overview of battery types and models is also provided.

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