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[ijerst.editor@gmail.com](mailto:ijerst.editor@gmail.com)  
[editor@ijerst.com](mailto:editor@ijerst.com)

**Research Paper**

# DESIGN AND ANALYSIS OF WIRELESS POWER TRANSFER SYSTEM FOR ELECTRICAL VEHICLE

Dr. Karimulla Peerla Shaik  
Dept. of EEE  
MRCET, Dulapalli  
Secunderabad, Telangana, India  
[Karim.02214@gmail.com](mailto:Karim.02214@gmail.com)

Ms. S. Roshini  
Dept. of EEE  
MRCET, Dulapalli  
Secunderabad, Telangana, India  
[roshinisamalla@gmail.com](mailto:roshinisamalla@gmail.com)

Ms. K. Sohitha  
Dept. of EEE  
MRCET, Dulapalli  
Secunderabad, Telangana, India  
[sohithareddy.katam@gmail.com](mailto:sohithareddy.katam@gmail.com)

Mr. G. Varshith  
Dept. of EEE  
MRCET, Dulapalli  
Secunderabad, Telangana, India  
[varshithladdu30@gmail.com](mailto:varshithladdu30@gmail.com)

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**Abstract**—This project utilizes MATLAB to construct and analyze a Wireless Power Transfer (WPT) system for electric cars. The goal is to create a dependable and effective WPT system that would enable EV charging conveniently without requiring physical hookups. The project entails building a comprehensive simulation model of the WPT system, which includes the power electronics, resonant circuits, and transmitter and receiver coils. The system's performance under various operating situations is simulated using MATLAB/Simulink. To maximize power transmission efficiency, important factors such as coil spacing, alignment, and load conditions are examined. Simulations and actual testing are used to verify the viability and efficacy of the developed system.

**KEYWORDS** : Wireless power transfer ,Electric Vehicles, MATLAB, Simulation, Resonant circuits.

## I. INTRODUCTION

This project's main objective is to construct and analyze a wireless This project utilizes MATLAB to construct and analyze a Wireless Power Transfer (WPT) system for electric cars. The goal is to create a dependable and effective WPT system that will enable EVs to be conveniently charged without the need for physical hookups. The transmitter and receiver coils, resonant circuits, and power electronics are all included in the comprehensive simulation model of the WPT system. The system's performance under various operating situations is simulated using MATLAB/Simulink. To maximize power transmission efficiency, important factors such as coil spacing, alignment, and load conditions are examined. Simulations and experimental testing are used to validate the developed system, ensuring its feasibility and efficacy. The results are intended to promote more environmentally friendly and user-friendly charging infrastructure while advancing WPT technology for EVs. Without the need of physical connections or cables, wireless power transfer transfers electrical energy from a power source to an electrical device using electromagnetic fields. Wireless Power Transfer (WPT) for electric cars (EVs) is a significant improvement in energy transfer technology, transforming the way electric vehicles are charged. WPT is based on the fundamentals of electromagnetic induction, which states that a changing magnetic field is produced by an alternating current passing through a transmitter coil. A receiver coil inside the EV then experiences a current due to this magnetic field. By doing away with bulky physical connections like cables and plugs, this technique improves the charging process's efficiency and ease..WPT is often divided into two modes:

static charging and dynamic charging. When a car is placed over a charging pad—which is usually found in parking lots, houses, or public charging stations—static charging takes place.

The efficiency of Wireless Power Transfer (WPT) systems for electric vehicles (EVs) is evaluated using many essential criteria that determine energy transfer efficacy. The coupling coefficient, which measures how well the magnetic fields of the transmitter and reception coils interact, is important; a higher coupling coefficient often leads in greater efficiency, which is controlled by the coil distance and alignment. Furthermore, in order to maximize efficiency, both coils must be tuned to resonate at the same frequency because variances might result in energy losses. The coils' capacity to store and transmit energy is indicated by their quality factor (Q factor); greater Q factors correspond to less resistive losses. The efficiency of power electronics, such as inverters and rectifiers, has an influence on overall performance since it reduces energy losses during AC-DC conversion. Efficiency can be impacted by load conditions, for example the vehicle's battery's state of charge (SoC), so designs that maximize performance in a range of situations are required. Environmental variables like temperature and electromagnetic interference further complicate efficiency calculations, making effective heat management and shielding crucial. Engineers can learn a lot about these parameters by using simulations and real-world testing. This will improve the efficiency and dependability of WPT systems and encourage the wider use of electric vehicles. Finally, cost analysis and application appropriateness assessments are required to determine the WPT system's economic feasibility and scalability. Alignment tolerance must be taken into account since reliable systems

should be able to tolerate some misalignment without suffering appreciable efficiency losses.

When an alternating current runs through the transmitter coil of a Wireless Power Transfer (WPT) system for electric vehicles (EVs), it creates an alternating magnetic field. Wireless energy transmission is made possible by the coupling of this magnetic field with the vehicle's reception coil. Because the coil is made to resonate at a certain frequency, losses are reduced and energy transfer efficiency is increased. The alignment and separation of the transmitter and reception coils affect how their magnetic fields interact. In the end, this effective energy transmission makes it possible to charge the EV's battery without the need for physical connections.

### 1.1 Objectives of the project

The goal of the "Design and Analysis of Wireless Power Transfer (WPT) System for Electric Vehicles (EVs)" project is to create a method for charging electric vehicles efficiently and without touch. Designing a WPT system with an inductive or resonant coupling and improving power transfer efficiency by taking alignment, distance, and coil design into account is the main goal. Improving charging speed is a major objective as it will allow the system to supply high power quickly, making it suitable for usage in charging stations. Prioritizing safety means making sure the system conforms with safety regulations to guard against dangerous electromagnetic interference and guarantee user security. The study will use simulations to assess the system's performance, examining its behavior under various scenarios such as load changes and environmental variables. Another important factor is cost-effectiveness, which aims to provide a solution that is inexpensive for broad use. Scalability for further developments and integration with current EV infrastructure are also crucial goals. Finally, an evaluation of wireless power transfer's environmental effect in comparison to conventional cable charging will be conducted. The project's overall goal is to increase EV charging's practicality, efficiency, and convenience while also advancing the development of cutting-edge infrastructure for EVs.

## II. METHODOLOGY

### Wireless power transfer System

The technique for the "Design and Analysis of Wireless Power Transfer System for Electric Vehicles" takes a systematic approach, beginning with the design of the system, which includes the transmitter and receiver coils and employs inductive or resonant coupling to ensure efficient power transmission. To maximize energy conversion and reduce losses, the system's components—such as power electronics, resonant circuits, and control systems—will be carefully chosen. Software tools like COMSOL or MATLAB will then be used to model and simulate the design, enabling the examination of electromagnetic fields, power transfer efficiency, and system behavior under various situations.

Following modeling, a system prototype will be built and put through real-world testing to assess factors including safety standard.

The system's performance will be extensively tested, taking into account measures such as charging speed, efficiency, and stability. The design will be improved for cost-effectiveness, safety, and efficiency based on the testing findings. Finally, taking into account elements like user convenience, environmental effect, and the practical viability of widespread adoption, the wireless system will be contrasted with conventional cable charging techniques. This all-encompassing strategy guarantees the creation of a reliable and effective wireless power transfer system for electric cars.

### Implementing Mutual Inductance

Mutual inductance is implemented in a Wireless Power Transfer (WPT) system for electric vehicles (EVs) by magnetically connecting the transmitter and reception coils. The efficiency of energy transmission is influenced by the mutual inductance ( $M$ ), which measures the interaction between these coils. In order to maximize this, the coils are positioned closely together and have suitable shapes, which improves their coupling coefficient. According to Faraday's law of electromagnetic induction, when the transmitter coil is operating, the alternating current in it generates a magnetic field that causes a voltage to be induced in the reception coil. The system may optimize mutual inductance and enhance power transfer efficiency and overall performance by fine-tuning coil alignment and spacing. Block of Mutual Inductance:

Use MATLAB's mutual inductance block to simulate the connection between the primary and secondary coils. Modify Coupling Coefficient: To model various transmitter-receiver coupling scenarios, set the mutual inductance value.

### Parameter Configuration

Parameter setting in a Wireless Power Transfer (WPT) system for electric vehicles (EVs) entails determining the best values for critical components to improve efficiency and performance. To optimize energy transmission, the operating frequency must coincide with the resonance frequencies of both coils. The required inductance and mutual inductance are achieved by adjusting the transmitter and reception coils' size and number of turns. In order to reduce losses at the working frequency and generate a resonant circuit, capacitor values are selected. In order to increase the coupling coefficient and, eventually, the total power transfer efficiency, the coils' alignment and distance from one another are also changed. Values of Inductance and Capacitance:

Set the values for  $L_1$ ,  $L_2$ ,  $C_1$ , and  $C_2$  to produce resonance at the appropriate operating frequency (e.g., 100 kHz). For

optimal power transfer, load resistance needs to match the WPT system's output, and the efficiency and intensity of the magnetic field are influenced by the transmitter and receiver coil designs. For dependable operation, proper alignment tolerance is essential, and sophisticated control systems handle changing power requirements. Furthermore, user safety and system dependability are guaranteed by efficient cooling systems and compliance with safety regulations. Wireless power transfer (WPT) for electric vehicles (EVs) has potential for substantial advancements in uptake and efficiency.

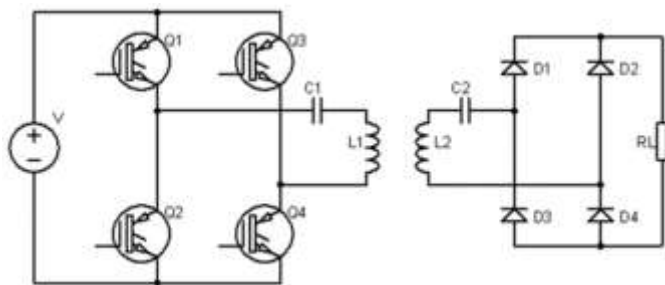


Fig.3.1: Implementation of WPT For EVs

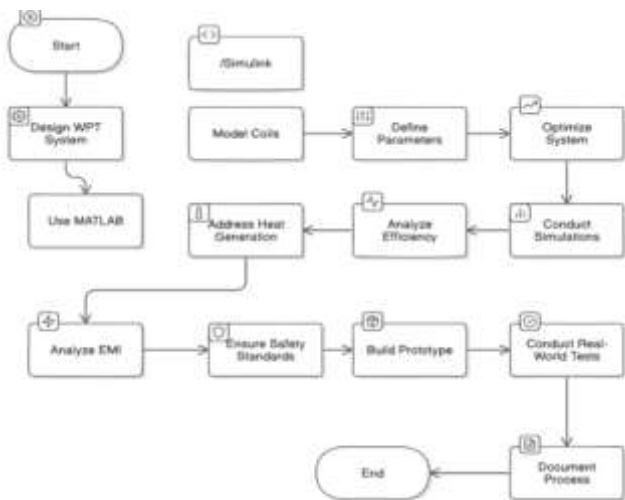


fig.2.1 : Flow chart for WPT system

### III. SIMULATION AND ANALYSIS

Simulation and analysis in a Wireless Power Transfer (WPT) system for electric cars (EVs) need the use of software tools such as MATLAB/Simulink to simulate the system components and dynamics. Engineers may examine the energy transfer efficiency in a variety of scenarios by building intricate models of the transmitter and reception coils and related electronics. In order to find the best configurations, simulations enable the analysis of variables including coil alignment, distance, and resonant frequency. Graphs and performance metrics may be used to illustrate the outcomes, giving information on the efficiency and behavior of the system. In the end, this procedure helps to improve the design prior to actual prototype, which lowers development expenses and time.

To understand energy transfer efficiency and system performance, engineers must analyze voltage waveforms in Wireless Power Transfer (WPT) systems for electric vehicles (EVs). Figure 2 illustrates the implementation of WPT for EVs. When the transmitter coil creates an alternating magnetic field, the receiver coil induces a corresponding voltage. The ideal voltage waveform at the receiver should be a clean sine wave, indicating effective energy transfer; deviations from this ideal, such as distortion, spikes, or harmonics, can suggest issues like misalignment, improper tuning, or inefficiencies in the coupling between coils. Engineers can capture and analyze these waveforms using oscilloscopes or simulation software, concentrating on important parameters like peak voltage, RMS voltage, and total harmonic distortion (THD). The phase connection between voltage and current waveforms is also evaluated in order to compute the power factor, which influences total system efficiency. Real-time identification of possible issues is facilitated by voltage waveform analysis, which directs modifications to maximize system performance and design. In the end, this study is crucial for guaranteeing dependable and effective electric car charging, opening the door for WPT deployments to be successful. In order to provide convenience and lessen component wear, Wireless Power transmit (WPT) for Electric Vehicles (EVs) uses electromagnetic fields to transmit energy between a charging pad and a vehicle without the need for physical connectors. In addition to using dynamic charging methods to increase EV range, recent studies highlight improvements in efficiency, alignment tolerance, and safety.

The subject of wireless power transmission has grown greatly in recent years because to advances in simulation speed and capacity of magnetic fields, as well as power electronics. Electric cars are being investigated as a potential substitute for internal combustion engine-powered vehicles that run on oil in the transportation sector of the future, particularly from the standpoint of alternative energy and CO2 reduction. However, because of their large weight, cumbersome volume, and short driving range, electric vehicles need a number of significant problems to be fixed. This article presents OLEV, a new on-road dynamic wireless charging method for electric vehicles. Electric car charging technology may be divided into three categories: slow or quick, fixed or dynamic, and conductive or wireless. Fast charging with a power capability of up to 100 kW and a wireless dynamic charging idea are discussed.

Additionally, this study describes the design idea, system architecture, and development method of optimizing the magnetic flux field for improved power transfer efficiency. In light of the unique technology's development idea, current state, and practical viability.

transmitter and receiver are some of the variables that affect a WPT system's efficiency.

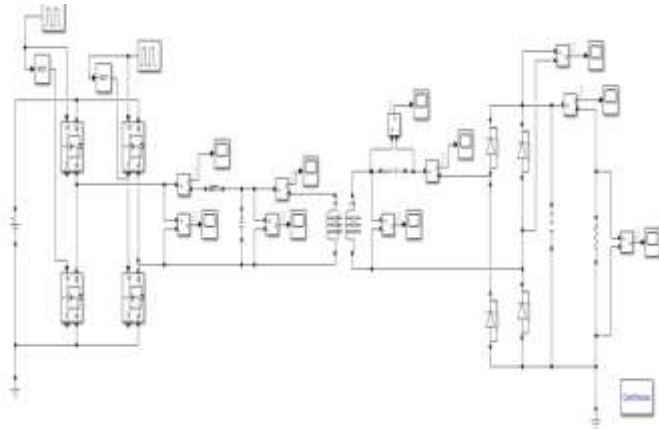


Fig.3.2: Simulink diagram of Wireless Power Transfer System For Electrical Vehicle

For electric vehicles (EVs), wireless power transfer (WPT) represents a revolutionary development in car charging technology. By leveraging inductive coupling, WPT offers efficient power transfer without the need for physical connectors, boosting convenience and user experience. This method removes the inconvenience of plugging in by enabling charging in a variety of locations, including parking lots and roads. One big advantage of WPT is the possibility for dynamic charging, which would allow vehicles to charge while in motion, considerably increasing driving range and lowering range anxiety. WPT also reduces connection wear and tear, which lowers maintenance costs and increases dependability.

WPT systems now achieve over 90% efficiency because to developments in coil design and power electronics. Even when the distances between coils vary, these enhancements guarantee efficient energy transmission. Furthermore, improved safety protocols aid in electromagnetic field management, addressing issues for both pedestrians and automobiles.

Notwithstanding its benefits, WPT has drawbacks, including the requirement for manufacturer uniformity and hefty upfront infrastructure expenses. To increase these systems' efficacy and affordability, especially for high-power applications, ongoing research is crucial.

**Efficiency and Power Losses**

The design and analysis of a Wireless Power Transfer (WPT) system for electric cars must take into account efficiency and power losses. The capacity of the system to move energy from the transmitter to the receiver with the least amount of energy loss is referred to as efficiency. Coil alignment, coupling strength, operating frequency, and the distance between the

**IV. SIMULINK RESULTS**

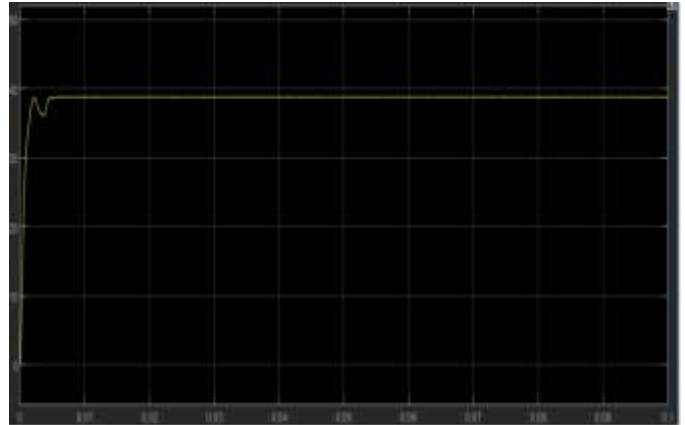


Fig.4.1.: Voltage Waveform across load

The output waveform, which can be sinusoidal or changed, has a substantial impact on the system's efficiency; good designs strive for above 90% efficiency to minimize energy loss. All things considered, the output voltage of the inverter is essential to guaranteeing that electric cars get the energy they require for charging while nevertheless operating at their best. Figure 5 above displays the voltage waveform across the load. The output is further affected by the input power to the transmitter coil; in order to satisfy the EV charging needs, the receiver side often experiences induced voltages of several hundred volts. WPT systems can provide effective and efficient power transfer for electric cars by fine-tuning these characteristics.

In wireless power transfer (WPT) systems for electric vehicles (EVs), the inverter output voltage is critical for effective power conversion and transmission.

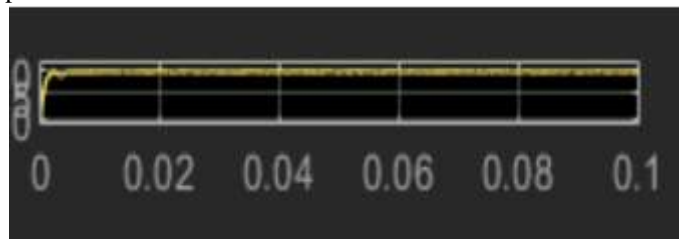


Fig.4.2: Inductive Current Waveform

The inverter output voltage of wireless power transfer (WPT) systems for electric cars (EVs) normally ranges between 300 and 400 volts, depending on the vehicle's charging requirements. From 85 kHz to 200 kHz, the inverter effectively transforms DC power into AC for transmission.

Power transmission is optimized by advanced control systems that dynamically modify the voltage and frequency, and total efficiency is impacted by the output waveform, whether it is sinusoidal or changed. In order to reduce energy loss during charging, effective designs strive for above 90% efficiency.

## V. CONCLUSION

WPT, or wireless power transfer, is a revolutionary development in vehicle charging technology for electric cars (EVs). WPT improves user experience and convenience by utilizing inductive coupling to facilitate effective power transmission without the necessity of physical connections. This method removes the inconvenience of plugging in by enabling charging in a variety of locations, including parking lots and roads. The possibility of dynamic charging, which would enable cars to charge while driving and greatly increase driving ranges while lowering range anxiety, is a key advantage of WPT. WPT also reduces connection wear and tear, which lowers maintenance costs and increases dependability. Thanks to developments in power electronics and coil design, WPT systems are now operating at above 90% efficiency. These enhancements allow efficient energy transmission even at different coil lengths. Additionally, improved safety protocols aid in controlling electromagnetic fields, resolving issues for both cars and pedestrians.

## FUTURE SCOPE

The future of design and analysis of Wireless Power Transfer (WPT) systems for electric vehicles (EVs) appears bright, with the potential for significant improvements in efficiency, speed, and integration. To enable quicker and more dependable charging, research might concentrate on increasing power transfer efficiency over greater distances and at higher power levels. Furthermore, dynamic wireless charging, which charges EVs while they are moving and does away with charging downtime, has the potential to completely transform the market. Sustainability may be further improved by combining WPT with renewable energy sources like solar power. In order to reduce energy losses and increase system dependability, developments in power electronics and materials science—such as superconducting coils—will be essential. Future work will also focus on defining universal standards for WPT systems to ensure interoperability with

diverse EV models and charging infrastructure. WPT systems are probably going to be a crucial component of an international, effective, and eco-friendly network of electric car charging stations as these technologies develop.

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