

Wireless Power Transmission to Electric Vehicles using Tesla Coil

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Abstract—The increasing adoption of electric vehicles (EVs) is a major step toward sustainable transportation. However, traditional wired charging systems pose limitations such as inconvenience, high maintenance, physical wear, and lack of mobility. To address these issues, this project presents an advanced Wireless Charging Platform for Electric Vehicles using Tesla Coil-based Wireless Power Transmission (WPT).

The proposed system enables contactless EV charging using resonant inductive coupling. It incorporates ESP32, ultrasonic sensors, relay modules, and mini Tesla coils to automate parking detection and initiate safe wireless charging. The system also integrates IoT through Blynk mobile application for remote monitoring of charging status, voltage, and slot occupancy.

Experimental results demonstrate effective short-range wireless power transmission with stable charging activation, accurate parking detection, and reliable real-time monitoring. The system presents a scalable solution for next-generation EV infrastructure, reducing human intervention and enhancing user convenience. This project contributes toward future smart cities by promoting clean, efficient, and contactless EV charging technology.

Index Terms—Wireless Power Transfer (WPT), Tesla Coil, Electric Vehicles (EV), ESP32, Ultrasonic Sensor, Inductive Charging, Smart Charging System, IoT, Blynk, Arduino.

I. INTRODUCTION

Electric Vehicles (EVs) are rapidly transforming global transportation, offering an eco-friendly alternative to fossil-fuel-based mobility. However, one of the major challenges faced by EV users is the charging process, which typically requires physical plug-in cables. Wired charging suffers from:

- Limited mobility and vehicle positioning
- Connector damage due to frequent use

- User inconvenience and safety hazards
- High installation and maintenance costs

To overcome these challenges, Wireless Power Transmission (WPT) emerges as a promising solution. Wireless charging eliminates the need for physical connectors, enabling safer, cleaner, and more convenient energy transfer.

This project focuses on implementing wireless charging using a Tesla Coil, which operates based on resonant inductive coupling—a technique first conceptualized by Nikola Tesla. The system automatically detects vehicle presence, activates a mini Tesla coil, and transmits power wirelessly to the receiving coil of the EV.

The proposed system combines:

- Sensor-based parking slot detection
- Wireless power transfer using Tesla coil
- ESP32-based automated control
- IoT-enabled monitoring through Blynk

This integrated system demonstrates a smart EV charging model suitable for homes, public charging stations, and future autonomous vehicle infrastructure.

1. HARDWARE COMPONENT

1.1 ESP32

The ESP32 microcontroller is the brain of the system. It handles ultrasonic sensor data, controls relays, processes voltage readings, and communicates with the Blynk cloud for mobile monitoring.

16×2 LCD Display

Displays real-time status of:

- Parking slot occupancy
- Charging ON/OFF status
- Voltage readings

Ultrasonic Sensors (HC-SR04)

Each parking slot has an ultrasonic sensor that detects:

- Vehicle arrival

- Distance threshold (typically <10 cm)
- Proper alignment for safe charging

HARDWARE IMPLEMENTATION

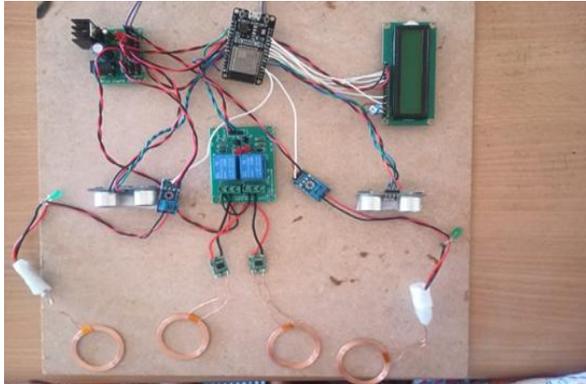


Fig: Circuit representation in absence of power source

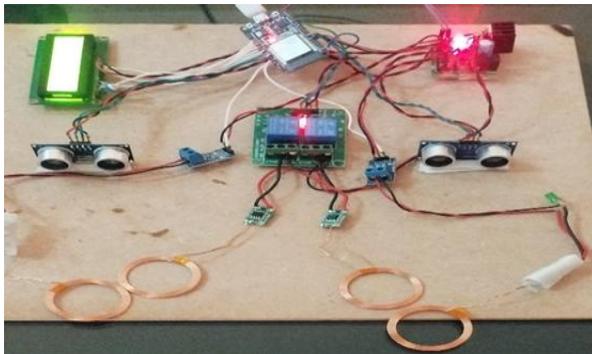


Fig: Circuit representation in presence of power source

Relay Module (5V)

Controls the ON/OFF switching of the mini Tesla coil based on ESP32 commands.

Mini Tesla Coil

Generates a high-frequency electromagnetic field enabling wireless power transfer to the EV.

Jumper Wires

Serve as communication links between ESP32, sensors, relay, display, and power modules.

Power Adapter (12V DC)

Supplies power to the ESP32, sensor modules, display, relay, and Tesla coil.

1.2 Software Components

Arduino IDE

Used to write, compile, and upload code to the ESP32.

Blynk IoT Platform

Provides:

- Remote monitoring of charging status
- Relay ON/OFF control
- Distance and voltage readings
- Real-time notifications

II. LITERATURE SURVEY

A detailed review of recent research on wireless power transfer reveals:

Advancements in WPT (Smith et al., 2024)

Highlighted limitations of inductive systems and advantages of resonant Tesla coil-based charging.

Dynamic Wireless Charging (Johnson & Lee, 2024)

Discussed WPT-enabled roadways that charge EVs while in motion.

EMI & Safety (Patel et al., 2024)

Studied electromagnetic interference challenges and solutions such as optimized frequency selection and shielding.

User Experience (Thompson & Garcia, 2024)

Found that users prefer wireless charging for ease, speed, and convenience.

Efficiency Studies (Nguyen & Kim, 2025)

Reported that Tesla coil systems can achieve >90% wireless transmission efficiency.

Environmental Studies (Martinez & Singh, 2025)

Showed that WPT reduces carbon emissions when powered by clean energy.

These studies reinforce the potential for Tesla coil-based EV charging as a future-ready solution.

III. PROPOSED SYSTEM

3.1 System Overview

The system automates EV wireless charging by:

1. Detecting vehicle presence using ultrasonic sensors
2. Activating the suitable relay
3. Powering the Tesla coil for wireless charging
4. Showing real-time data on LCD
5. Sending live updates to the Blynk app

3.2 Working Principle

Vehicle Detection

Ultrasonic sensors measure distance between the EV and charging pad. If the measured distance <10 cm, the system considers the slot as occupied.

Relay Activation

When the slot is occupied:

- ESP32 triggers the relay
- Relay powers the Tesla coil
- Wireless charging begins

Wireless Charging

Tesla coil transmits energy through an electromagnetic field to the vehicle’s receiver coil.

Real-Time Monitoring

LCD and Blynk display:

- Voltage
- Distance
- Charging status
- Slot occupancy

3.3 Flowchart

The flowchart includes:

- Vehicle approaches
- Alignment detection
- Relay activation
- Tesla coil charging
- Voltage monitoring
- Error handling
- Charging completion

IV. IMPLEMENTATION

Software Flow

- Initialize ESP32, Blynk, LCD
- Read ultrasonic sensor data
- Check manual vs automatic mode
- Control relays accordingly
- Display data on LCD
- Send sensor values to Blynk

V. RESULTS AND DISCUSSIONS

Test Scenarios

The system was tested under multiple voltage and distance conditions:

- Low range
- Medium range
- High range

Each scenario measured:

- Tesla coil output voltage
- Blynk app response
- Sensor precision
- Relay switching accuracy

Observations

- Charging activates only when vehicle is within the threshold
- Blynk app provides accurate real-time updates
- Tesla coil voltage varies with distance, validating wireless power transfer

Case 1: When both the stations are ON

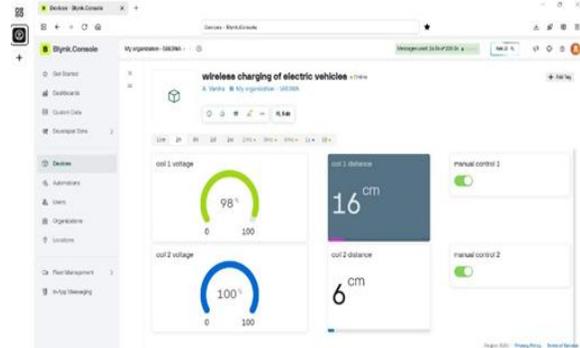


Fig : Blynk app Result when both the Stations are ON

The charging dashboard prominently features manual control, which is an essential functionality for users managing their electric vehicle charging sessions. This option empowers users to have direct oversight over the charging process, allowing them to start, stop, or modify various parameters in real-time. For instance, if a user notices that the voltage percentage being received is low or there's a change in charging efficiency, they can immediately stop the charging session to troubleshoot or switch to a different charging slot. With both charging slots enabled, the manual control feature becomes even more valuable as it gives users the flexibility to prioritize which vehicle should charge first based on its current battery level or specific urgency. If one vehicle is reaching optimal charge levels faster than the other, the user can adjust the settings accordingly to maximize charging efficiency. This level of control not only enhances user convenience but also contributes to better energy management, allowing individuals to make informed decisions based on real-time data. By actively engaging with the charging process, users can ensure that their electric vehicles receive the most efficient and effective charging, ultimately contributing to a

but also converts it into meaningful distance values, which are then displayed on the Serial Monitor. This instant feedback mechanism allows users to observe fluctuations in distance measurements as adjustments are made in real-time, fostering an interactive experience with the system.

Result 1: Low range of Tesla coil and Blynk app output

In this case, the wireless charging system is tested under low-voltage conditions to observe how reduced power transfer affects performance. The coil distance is increased to 10 cm, leading to a noticeable drop in the received voltage and overall charging efficiency.



Fig: Low Range of Tesla Coil output Voltage

In this result, the wireless charging system is tested at a larger coil distance of 10 cm, which is significantly higher than the optimal charging range. As the distance between the transmitter coil and the receiver coil increases, the strength of the magnetic coupling reduces sharply. This weakened coupling leads to a substantial drop in the amount of energy that can be transferred from the transmitter to the receiver. The LCD screen clearly reflects this effect by displaying a very low charging voltage, approximately 2.97 V, which is insufficient for stable and efficient charging. This demonstrates the sensitivity of inductive charging systems to positional variations. The reduced voltage output also indicates a direct decline in charging efficiency. When the coils are positioned farther apart, the electromagnetic field generated by the Tesla coil becomes less effective at inducing current in the receiver coil. As a result, the amount of usable electrical power drastically decreases. This behaviour highlights an important limitation of wireless charging systems: the need for precise alignment and minimal coil separation. Any increase in distance beyond the ideal threshold causes immediate performance

degradation, as seen in the displayed voltage reading. This experiment is essential because it allows users and developers to understand how wireless charging behaves under less-than-ideal conditions. By observing the voltage drop on the LCD, one can identify the operational boundaries of the system and determine the point at which charging becomes ineffective.

The Blynk application provides a remote monitoring interface that allows users to conveniently visualize the charging performance in real time.

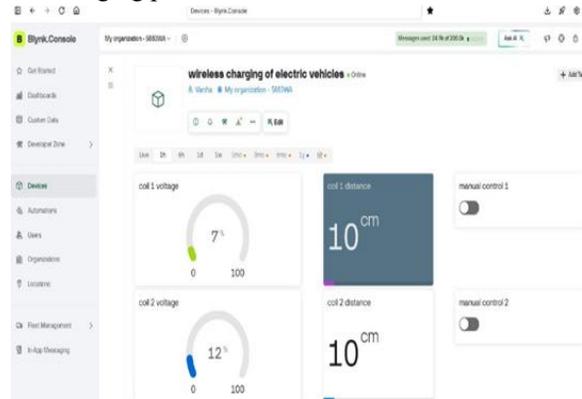


Fig: Low Range of Tesla Coil Blynk app Result

In this test scenario, the Blynk dashboard displays the same low-range charging condition, showing a coil distance of 10 cm along with reduced voltage readings. These values are captured from the sensors connected to the ESP32 microcontroller and are sent to the Blynk cloud, where they are presented in a user-friendly dashboard layout. This enables users to instantly understand how coil separation affects charging efficiency, even without being physically near the hardware setup. The Blynk interface is designed with widgets such as gauges, value displays, and distance indicators that make the data easy to interpret. In this case, the voltage gauges show lower percentages, clearly reflecting the weak power transfer caused by increased coil distance. Additionally, the dashboard includes separate indicators for coil 1 and coil 2 voltages, providing a transparent comparison of performance between the transmitter and receiver sides. By offering such detailed graphical feedback, the Blynk app allows users to make informed decisions, such as repositioning the vehicle or adjusting system parameters to improve efficiency. Another advantage of using the Blynk platform is the

ability to monitor charging behaviour remotely. Even if the user is not near the charging station, they can still observe the system status, voltage output, distance measurement, and any variations that may occur during operation. This feature enhances user convenience and adds a modern layer of IoT-based functionality to the wireless charging project. With real-time data transmission, users receive immediate updates whenever the charging environment changes, such as misalignment or increased separation.

Result 2: Medium range of Tesla coil

In this case, the wireless charging system is tested under a medium voltage range to analyze its effective power transfer performance. With the coils positioned at a moderate distance, the coupling remains sufficiently strong to ensure reliable charging while allowing for more flexibility in device placement.



Fig: Medium Range of Tesla Coil Output Voltage

At the medium range, the wireless charging system is tested with the coils placed at a moderate distance—commonly around 15 cm as seen in the displayed measurements. At this distance, the magnetic coupling between the transmitter and receiver coils remains stable, allowing a more efficient flow of energy compared to long-range operation. The LCD screen in the setup shows a voltage reading of approximately 3.68V, indicating that the power transfer efficiency is significantly better than the low-range condition but still not at its peak. This voltage level demonstrates that the system maintains a strong enough electromagnetic link to support charging without major drops in output. In this mid-range condition, the Tesla coil operates within an optimal balance of distance and performance. Since the coils are neither too close nor too far apart, the electromagnetic field is able to establish a more efficient resonance. This

results in a higher received voltage, reduced transmission losses, and improved charging stability. The voltage displayed on the LCD is a direct reflection of the system's ability to maintain consistent power delivery even as the distance increases slightly from the minimum. Furthermore, medium-range operation provides more flexibility in real-world EV usage. system is capable of sustaining adequate voltage levels necessary for charging.

The Blynk application serves as the monitoring interface for wirelessly transmitted power, offering real-time visualization of system parameters.

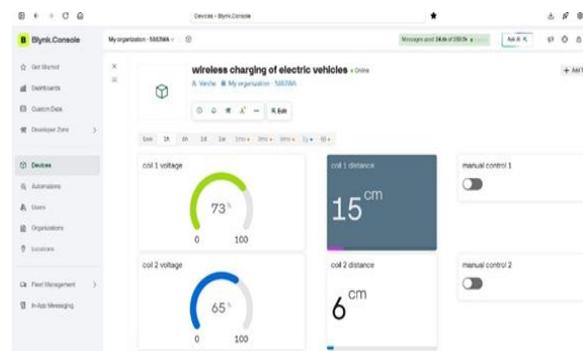


Fig: Medium Range of Tesla Coil Blynk app Result

In the medium-range test, the app shows key indicators such as coil 1 voltage, coil 2 voltage, coil separation distance, and additional control toggles. The coil 1 reading (e.g., 73%) and coil 2 reading (e.g., 65%) reflect that the transmitter and receiver coils are performing at moderate but stable efficiency. The app's clear dashboard design allows users to easily understand how the system behaves when the coil distance is set to 15 cm, reinforcing the concept of medium-range operation. This monitoring capability ensures that the efficiency and stability observed on the physical LCD screen are also captured digitally. The Blynk platform continuously updates values, making it easier to evaluate how distance impacts wireless power transmission. When the coil distance increases to the medium range, the app displays corresponding changes in voltage levels and performance metrics. These analytics help verify whether the system is operating within safe and effective thresholds during wireless charging. Additionally, the Blynk app enhances user interaction and control over the system. Features like manual control switches and real-time graphs help users

identify fluctuations and troubleshoot inefficiencies instantly. Users can monitor coil distance, voltage percentages, and device status remotely, enabling a modern and smart approach to EV wireless charging.

Result 3: High Range of Tesla coil

In this case, the wireless charging system is tested under a higher voltage range to analyze its strongest and most efficient power transfer performance. With the coils placed at a minimal distance, the coupling becomes stronger.



Fig: High Range of Tesla Coil Output Voltage

When the wireless charging system is tested at a high voltage range, the performance of the Tesla coil reaches its maximum efficiency. At this stage, the transmitting and receiving coils are placed at a very small distance, ensuring strong inductive coupling. Because the coils are closer, magnetic field interaction becomes more effective, resulting in higher induced voltage at the receiver coil. This strong coupling leads to minimal energy loss during transmission, allowing the system to achieve optimal power delivery. The LCD display shown in the image indicates a high output voltage reading of approximately 4.88V, which signifies that the system is charging at its strongest and most stable condition. This high voltage output demonstrates that the system can support fast and efficient charging when conditions are ideal. It further confirms the reliability of the wireless power transfer mechanism when coil alignment and distance are maintained at their best. Additionally, this test highlights how sensitive wireless charging systems are to coil distance. Even small reductions in separation can vastly improve performance. The high-range test therefore validates the system's capability to deliver maximum charging efficiency when alignment is precise and environmental conditions support stronger inductive coupling.

The Blynk app interface provides a real-time digital representation of the system's high-range performance. In this case, the app shows that at a coil distance of 5 cm (transmitter) and 6 cm (receiver), the charging efficiency is at its highest.

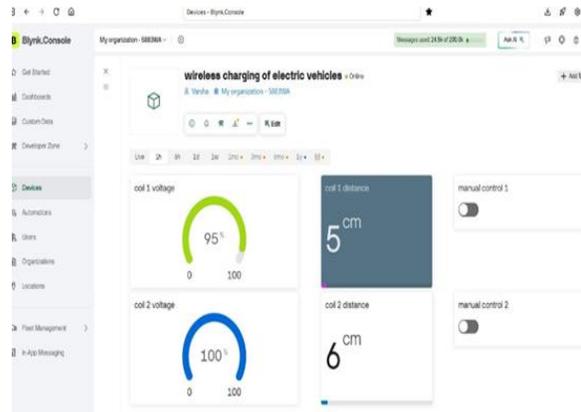


Fig: High Range of Tesla Coil Blynk app Result

The coil-1 voltage indicator shows 95%, and coil-2 voltage displays 100%, confirming that the system is performing at peak energy transfer conditions. These values reflect the strong inductive coupling achieved during the high-range test. The Blynk dashboard plays a crucial role in validating system performance remotely. By visualizing the voltage levels and coil distances, users can confirm that the coils are well-aligned and positioned at an optimal range. This ensures that the charging process remains uninterrupted and efficient. The app eliminates the need for users to be physically present near the hardware setup, offering a more convenient and modern monitoring experience. Furthermore, the app provides additional insights, such as the stability of the charging process and how different distances impact system efficiency. This helps in analysing performance trends and understanding the behaviour of the Tesla coil at varying ranges. With the ability to monitor data continuously, users can identify ideal coil positions for maximum power transfer. The high-range Blynk results ultimately prove that the system achieves excellent efficiency when the coils are positioned close together. The strong readings on the dashboard confirm that the wireless charging system performs at its highest potential under optimal alignment and minimal distance conditions.

VI. ADVANTAGES, DISADVANTAGES & APPLICATIONS

Advantages

- Fully automated charging
- No physical wear
- Safe operation
- Supports smart home integration
- Contactless energy transfer

Disadvantages

- Short-range power transfer
- Lower efficiency than wired systems
- EMI concerns
- Requires precise alignment

Applications

- Home EV charging
- Public charging infrastructure
- Smart parking systems
- Autonomous EV charging

VII. CONCLUSION AND FUTURE SCOPE

This project demonstrates a fully functional, automated wireless EV charging system using Tesla coil-based wireless power transfer. The system effectively combines IoT, automation, and inductive charging to deliver a futuristic charging experience.

Future Scope:

- Long-range WPT using resonant coil optimization
- Dynamic charging roads
- AI-based alignment assistance
- High-power Tesla coil modules
- Solar-integrated charging pads

VIII. ACKNOWLEDGEMENT

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