# Wireless Power Transfer For Electric Vehicles: An Arduino-Based Prototype EV With Bluetooth Control

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***Abstract****- Wireless power transfer (WPT) technology has significant potential for electric vehicles (EVs), as it can provide a convenient and safe way to charge EVs without the need for physical cables and plugs. WPT for EVs typically uses magnetic induction or resonant coupling to transfer energy wirelessly from a charging pad on the ground to a receiver coil on the vehicle. The WPT system design consists of a transmitter coil installed under the road and a receiver coil mounted on the base of the EV. It is based on the principle of mutual inductance and uses resonant coupling to transfer power wirelessly.*

***Keywords****-* Wireless PowerTransfer, Electric Vehicle, Mutual Inductance

## I. INTRODUCTION

The usage of fossil fuel-based vehicles or carbon-based vehicles has been a major cause of pollution and Global warming. Hence we are heading toward transitioning from these combustion engines to electric vehicles, which run on batteries and are way friendly for the environment. Although this seems like a great step, it comes with its limitations. The charging of an electric vehicle takes an intolerable duration.The distance an electric vehicle covers on a full charge is also very low when compared to a conventional combustion-engine vehicle on a full tank.

These limitations can be overcome by using Wireless Power Transfer System in EVs by placing coils underneath the roads and beneath the vehicles.

## II. WIRELESS POWER TRANSFER:

Wireless Power Transfer technology, due to its inherent advantages over traditional power transfer methods, has gained significant attention in the last decade and has been proposed for various applications. These applications range from low-power biomedical implants and electric vehicle chargers to railway vehicles, with prototype systems exhibiting 95% or higher efficiencies. Magnetic Wireless Power Transfer systems employ magnetic field coupling to transfer electric power across relatively large air gaps between two or more magnetically coupled coils. Essentially, in Wireless Power Transfer systems, a Transmitter Coil generates a short-range magnetic field, which induces an electric current in a Receiver coil placed nearby, thereby transferring power from one coil to another through induction.

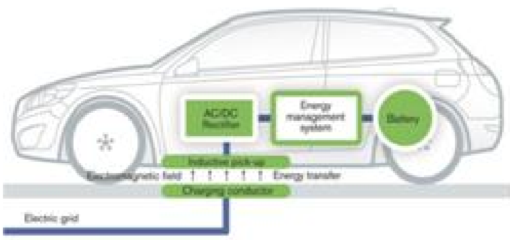


Fig. 1. A basic Wireless Power Transfer system for an electric vehicle.

### A. *Inductive Coupling*

A magnetic field is used to transfer power between wire coils in the inductive coupling, also known as electromagnetic induction or inductive power transfer (IPT). Transformer is created by the pairing of the transmitter and receiver coils. according to Ampere's law, an alternating current (AC) to the transmitter coil (L1) generates an oscillating magnetic field (B). The magnetic field travels through the receiving coil (L2), where, according to Faraday's law of induction, it induces an alternating EMF (voltage), which generates an AC in the receiver.

The induced alternating current can either drive the load directly or it can drive the load after being rectified to direct current (DC) by a receiver's rectifier. Most systems use an electronic oscillator to create a higher-frequency AC that drives the transmitter coil because transmission efficiency increases with frequency. A few systems, like electric toothbrush charging stands, operate at 50/60 Hz, allowing AC mains current to be applied directly to the transmitter coil.

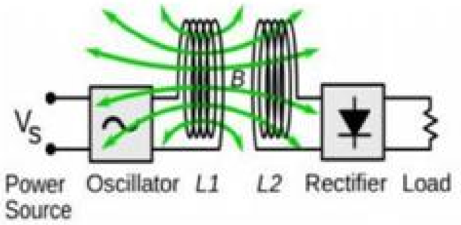


Fig. 2. A basic Wireless Power Transfer system for an electric vehicle.

*B. Resonant Inductive Coupling*

When the "secondary" (load-bearing) side of the loosely linked coil resonates at the same frequency as the “primary” coil, a phenomenon known as resonant inductive coupling, also known as magnetic phase synchronous coupling, occurs. This kind of resonant transformer is frequently employed as a bandpass filter in analog circuits. Moreover, wireless power systems for mobile phones, laptops, and cars use resonant inductive coupling.

This is achieved by using “Resonant Circuits” on both sides of the transformer, which is a capacitance circuit to tune both coils into the same frequency. Resonance can improve efficiency by forming a tuned LC circuit with a capacitively loaded secondary coil and driving it at the secondary side resonant frequency, allowing significant power to be transmitted over a few times the coil diameters at reasonable efficiency.

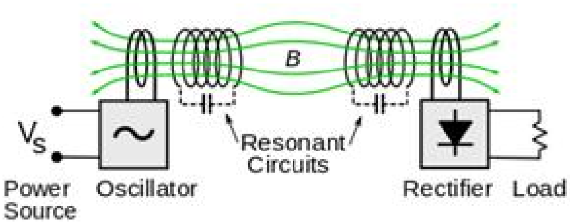


FIG 3 A Visual Representation of Resonant Inductive Coupling.

**III. OBJECTIVES**

Our research aims to achieve the following primary objectives

- To build a prototype EV with a wireless power transfer system.
- To be able to control the EV through an app using a Bluetooth module.
- To avoid obstacles by using an ultrasonic sensor.
- To monitor the voltage received through the coils on both an OLED screen and, remotely through the Blynk App.

**IV. PROPOSED MODEL**

In this proposed model, we implement ARDUINO micro-controller-based Wireless Power Transfer methodology in electric vehicles using non-resonant inductive coupling, as we don’t need resonant circuits for relatively closer coils. The above-proposed model consists of ar ARDUINO microcontroller, Motor driver Circuit, DC Motors, Battery, Inductive Coils, and Vehicle Prototype Module. There will be Two Inductive coils namely Transmitter Coil and Receiver Coil. The Transmitter coil circuitry contains a Power Supply, Transformer, Regulator Circuit, and Transmitter Coil. To achieve Electromagnetic Induction, AC power has to be fed to the Transmitter Coils, So we use Transformer. The power transmitted by the Transmitter Coil is received by the Receiver coil placed under the Electric vehicle.

*A. Transmitter coil Circuitry*

The transmitter coil circuitry consists of all the components that are used to transfer power from beneath the road. It mainly consists of three components.

1) *Power Source:* The power supply or the AC source powers the whole system.
2) *Power Electronics:* These are the AC to DC converters and DC to AC converters to protect the coil from damage due to excess current.

FIG 4 Voltage Regulator

3) *Transmitter Coil:* this is the wounded copper coil that is used to produce magnetic flux.

*B. Receiver Coil Circuitry*

The receiver coil circuitry consists of all the components that are used to receive the power from underneath the car. It consists of the following components.

1) *Receiver Coil:* This is the coil placed underneath the vehicle that receives the magnetic flux and converts it into electric current.

FIG 5 Receiver and Transmitter coil

2) *Rectifier and Regulator Circuit:* These are the components used to rectify and convert the received AC to a pulsating DC. The regulator Circuit helps in maintaining a constant voltage and thus protecting the components from damage.
3) *Battery:* [illegible] batter [illegible] rimary power sourc[illegible] for the electric vehicle prototype. This [illegible] be charged using a wireless power transfer system.
4) *Arduino UNO:* This is a microcontroller board based on ATmega328P. We use this controller to control the EV.

FIG 6 Arduino UNO Microcontroller Board

5) *Bluetooth Module:* A Bluetooth HC-05module that can transfer and receive Bluetooth signals, We use this to receive commands from a mobile app to control the movement of the vehicle.

FIG 7 HC-05 Bluetooth module

6) *Ultrasonic Sensor:* It is a device that can detect objects placed in front of it with the help of ultrasonic waves. We use it to detect obstacles and alert the driver.

FIG 8 Ultrasonic Sensor

7) *Voltage Sensor:* It is a device used to measure voltage. We use it to measure the voltage received at the receiver coil.

FIG 9 REES52 Voltage Sensor Module

8) *Motor Driver:*AMotor Driver IC-L298N device that is used to control the motors of the EV.

FIG 10 Motor Driver IC-L298N

9) *DC Geared Motors:* These are the basic DC motors to rotate the wheels of the electric vehicle.

FIG 11 Geared DC Motors

10) *Buzzer:* It is a basic buzzer, we use it to give alerts when there is an obstacle.

FIG 12 Electromagnetic Buzzer

*C Monitoring Components:*

1) *NodeMCU:* This is a microcontroller based on SOC ESP8266, It is used to upload the received voltage values to the Blynk Cloud for remote monitoring.

FIG 13 NodeMCU ESP8266

2) *I2C LCD:* This is the display screen used to dplay the received voltage values.

FIG 14 I2C Liquid Crystal Display Module

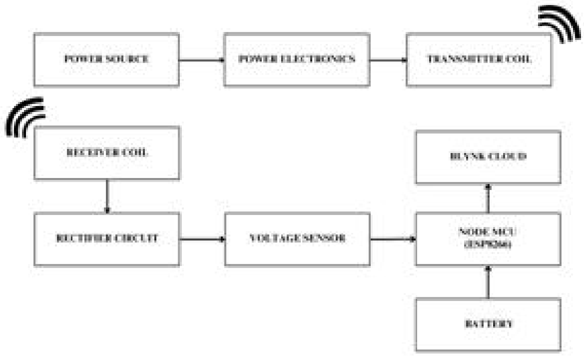


FIG 15 Block Diagram Of Wireless Power Transfer System for electric vehicles

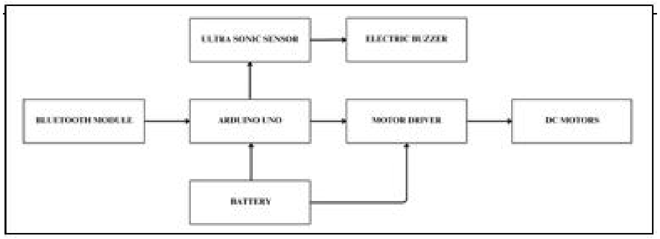


FIG 16 Block Diagram Of electric vehicle

## V. METHODOLOGY

- Design the transmitter and receiver coils using the principle of mutual inductance, taking into account factors such as the distance between the coils.
- Build and test the transmitter and receiver coils to ensure that they are operating efficiently.
- Design and build the EV prototype including the ultrasonic sensor, Bluetooth module, Arduino board, Motor Driver, DC Motors, and Battery Pack.
- Test the car's obstacle avoidance and Bluetooth control functions by writing the appropriate program and ensuring that they are working properly.
- Connect the transmitter to a power source and the receiver to the battery of the EV prototype and display the received voltage using an I2C LCD screen.
- Monitor the received voltageusing the Blynk app.

## VI. PROPOSED OUTPUT

- We use a mobile phone to communicate with Prototype via Bluetooth. The prototype senses Bluetooth signals transmitted from the mobile phone.
- It uses the HC-05 Bluetooth module to sense the command signals from the mobile phone and controls the EV Prototype.
- The proposed system also implements an Arduino micro-controller-based Wireless Power Transfer methodology for charging the electric vehicle.

- The Power received from the transmitter coil to the receiver coil is displayed using a Voltage sensor and an LED Display.
- The power received is also sent to the Blynk cloud for remote monitoring

*A. Advantages*

- Convenience: Wireless power transfer eliminates the need for physically plugging in the vehicle, providing a more convenient charging experience for drivers.
- Safety: Wireless power transfer reduces the risk of electric shock and eliminates the wear and tear on connectors, increasing the overall safety of the charging process.
- Wireless power transfer can be powered by renewable energy sources such as solar or wind power, promoting the use of clean energy and reducing carbon emissions.
- Durability: Because there are no physical connectors or moving parts involved in wireless power transfer, it can be a more durable and reliable charging method. This can result in lower maintenance costs and fewer repairs over the lifetime of the charging system.

B. *Disadvantages:*

- Efficiency: Wireless power transfer is less efficient than wired charging, meaning that more energy is lost during the transfer process. This inefficiency is compounded when the vehicle is in motion, as the power transfer needs to be maintained over a distance, which further reduces efficiency.
- Range: The range of wireless charging is limited, typically to a few centimeters or a few feet. This means that the vehicle needs to be positioned very precisely to receive the charge. This is difficult to achieve when the vehicle is in motion.
- Cost: Wireless power transfer systems can be more expensive to install and maintain than wired charging systems.
- Safety: There are safety concerns associated with wireless charging, particularly when the vehicle is in motion. The electromagnetic fields generated by wireless charging can interfere with other electronic devices.

**VII. RESULTS**

A prototype EV is built with Arduino UNO and we've added multiple features like Bluetooth control, and obstacle avoidance (i.e., the car stops moving if it gets too close to an obstacle and gives off alerts through a buzzer). A remote monitoring system through the Blynk app, which constantly shows the voltage received through the "wireless power transfer system".

*A. Proof of Concept:* Wireless power transmission for electric vehicles in motion is still in the experimental phase and there are several proofs of concept projects that have been developed to demonstrate its feasibility like ElectRoad, KAIST OLEV, Qualcomm Halo, etc. The prototype helps in laying the foundation for better energy distribution for all Electric vehicles. This helps in avoiding long waits during the charging of an EV.

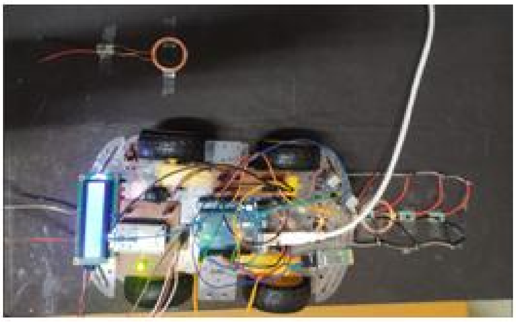

FIG 17 Overall view of the hardware system in the ON condition

*B. The wireless power transfer system:* The wireless power transfer system is responsible for receiving power with the help of transmitter and receiver coils, on the road and underneath the vehicle respectively. When the coils are brought close to each other, it begins to receive power wirelessly.

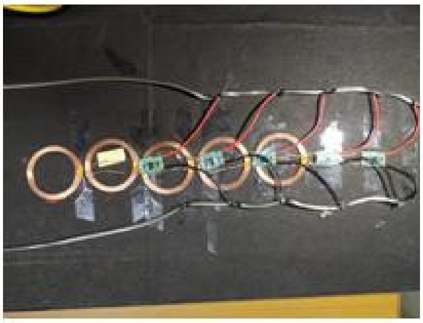

FIG 18 Placement of the coils on the road to transmit power

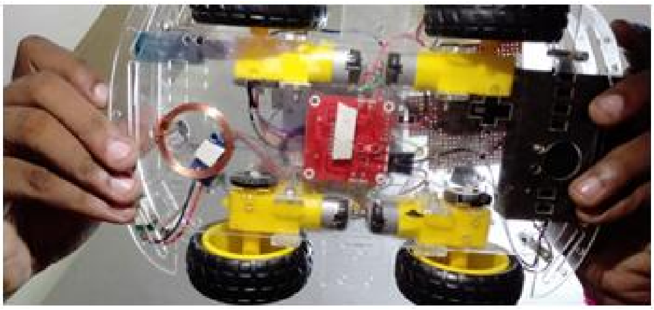

FIG 19 Placement of the coils underneath the car to receive power

The received voltage is measured by a voltage sensor and the values are displayed on an LCD screen.The voltage values received as we change the distance between the coils are as follows.

| Distance between the coils in CM | voltage received through the coil in Volts |
|---|---|
| 0 | 5.33 |
| 0.25 | 5.31 |
| 0.5 | 5.23 |
| 0.75 | 5.1 |
| 1 | 5 |
| 1.25 | 4.7 |
| 1.5 | 4.4 |
| 1.75 | 3.7 |
| 2 | 3 |
| 2.25 | 2.5 |
| 2.5 | 2.3 |

FIG 20 The voltage values received for varying the gap between the coils.

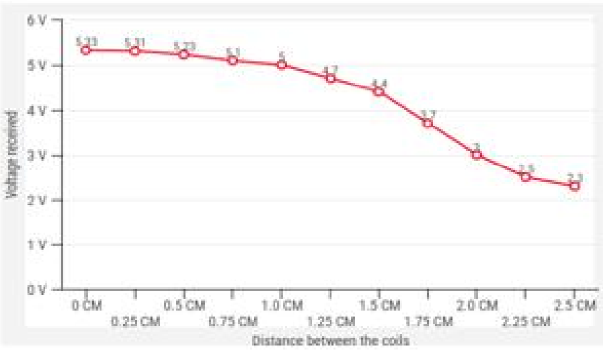


FIG 21 A line chart representation of the voltage values received for varying thegap between the coils.

*C. Vehicle Controls:* The controlling of the EV prototype is done with the help of a Bluetooth controller app. This app sends commands like FORWARD, BACKWARD, STOP, LEFT, and RIGHT, through Bluetooth signals. The prototype receives these signals through the HC05 Bluetooth module. The code in the Arduino is written in such a way that these commands are converted into simple instructions for the Motor Driver to understand. The motor driver in turn drives the DC motors in accordance with the commands. For the FORWARD command, all four wheels rotate clockwise, for the BACKWARD command all the wheels rotate anticlockwise, for the LEFT and RIGHT commands only the left two wheels or the right two wheels rotate.


FIG 22 The control panel of the Bluetooth controller app

*D. Monitoring and alerting system:* The received voltages are displayed on an LCD Screen for quick monitoring. For remote monitoring, we use the NodeMCU to send data to a personal Blynk server through WiFi.This data is displayed on a simple gauge widget.


FIG 2 3 LCD Screen displaying received voltage value


FIG 24Gauge Widget in Blynk app to display voltage received

The obstacle avoidance feature is implemented by an ultrasonic sensor. The EV has a code such that the vehicle stops moving as soon as the ultrasonic sensor senses an obstacle. The ultrasonic sensor senses obstacles in the range of up to 15 centimeters. A sound alert is also given with a buzzer to alert the driver of an obstacle.

## VIII. CONCLUSION

The utilization of Wireless Power Transfer (WPT) for charging the batteries of Electric Vehicles (EVs) has gained significant attention. Numerous prominent car manufacturers have begun to explore the adoption of WPT technology to improve its capabilities. This technology utilizes an economical inductive coupling mechanism between two coils, namely a transmitter coil and a receiver coil. For EV charging purposes, the transmitter coil is situated beneath the road, while the receiver coil is installed in the EV. Typically, resonant-type inductive WPT is employed for medium to high power transfer applications such as EV charging, as it offers superior energy efficiency.

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