



WIRELESS POWER TRANSFER FOR ELECTRIC VEHICLES (EV) CHARGING IN MATLAB

S. Muralikrishna¹, Mr.M.Rama Krishna²

Department of Electronics and Communication Engineering,

Andhra Loyola Institute of Engineering and Technology (ALIET) Vijayawada, Andhra Pradesh, 520008, India^{1,2}

Abstract: The technology for Electric vehicles (EVs) has become the one with the quickest rate of growth in the transportation sector. This is necessary to lessen environmental pollution, carbon dioxide emissions, and fossil fuel depletion. The primary problem with EVs, which use batteries as their primary energy source, is how they charge their batteries. The inductively coupled power transfer methodology, which is thought to be the most sophisticated and well-liked way of charging EVs, is the foundation of the model we provide in this study. The suggested system employs the series-series (SS) wireless power transmission topology, and a thorough discussion of the system's parameters is provided. The performance of the suggested system is briefly examined along with a theoretical study utilizing three simulated models on the MATLAB/SIMULINK platform. Additionally, the simulation findings of inductively coupled wireless power transmission are validated for various types of charging stations.

Keywords: Electric vehicles (EV), Series-Series topology (SS), Inductive coupling Simulink, Single-phase Wireless Power Transfer (WPT), Three-phase WPT.

I. INTRODUCTION

The depletion of fossil fuels and the need to reduce environmental pollution have led to an increase in the popularity of electric vehicles, or EVs, in recent years. When it comes to electric vehicles (EVs), which run mostly on batteries, the main issue is with battery charging. Wireless power transfer is the most innovative and popular method of charging electric vehicles (EVs) (WPT). In this study, we present a model based on the inductively coupled power transfer method. The Wireless Power Transfer (WPT) technology allows electrical energy to be transferred without the need for physical wires or conductors. Using wires and plugs is the conventional way of charging electric vehicles (EVs), which can be hazardous and inconvenient at times. Electric vehicles may be efficiently and safely charged without the use of wires or plugs thanks to WPT technology.

II. LITERATURE SURVEY

Because wireless power transmission (WPT) has the ability to bring high technology into our daily lives, it has drawn interest from a wide variety of subjects in a number of sectors and grown into a very active study area. In order to illustrate the current state of wireless power transmission technology, as well as emerging trends, we conducted a pilot research that is presented in this paper. Additionally, we outline a wide range of wireless transmission applications. [1].

Even though it's widely acknowledged that electric cars (EVs) are more environmentally friendly than petrol or diesel cars, some people are adamantly opposed to the switch, mostly due to expense. But there are other variables as well. An insufficient number of efficient charging stations and range anxiety are acknowledged as serious deterrents to buying, per a McKinsey analysis. These two elements may soon become even more important as EV prices continue to drop, the research claims. [2].

The autonomy of an electric vehicle using four distinct battery types—lithium ion (Li-Ion), molten salt (Na-NiCl₂), nickel metal hydride (Ni-MH), and lithium sulphur (Li-S)—that have the same ability to store electric energy is presented in this study. This scientific effort is innovative in that it uses a computer simulation to assess the autonomy of an electric vehicle and the efficiency of four different battery types in real time throughout a driving cycle. MATLAB/Simulink has been used to simulate five circuits. Every circuit has a transmitter and a receiver section and is based on inductive coupling. This paper suggests straightforward circuits for wireless power transfer that are simple to develop.



We have discussed the idea of wireless transmission, which is the transfer of electricity without the use of wires or other kinds of electrical conductors. Here, we have introduced a concept that minimizes transmission, allocation, and other forms of losses by using microwaves to convey electrical energy. Microwave Power Transmission is the term for this kind of method (MPT). [3]

Wireless chargers for electric vehicles Electric vehicles (EVs) may be able to be charged using WEVCS without requiring a permanent charging cable. This paper describes the current status of wireless power transfer technologies for electric vehicles. It also includes wireless transformer component parts. This has been studied using a variety of ferrite forms. WEVCS are associated with health, security, and welfare issues that have been investigated in connection with the establishment of current international standards.

III. SYSTEM DESIGN

The transmitting, receiving, and resonant circuits makeup the proposed WPT system for electric vehicles (EVs). In contrast to the receiving coil, which is connected to the EV's battery, the transmitting coil is connected to a power source. A successful power transfer occurs when the resonant circuit matches the resonance frequencies of the transmitting and receiving coils. The circuit design is simulated using MATLAB/Simulink. The simulation model includes the transmitting coil, receiving coil, resonant circuit, and load resistor. The load resistor represents the EV's battery, which the WPT system charges [3]. Fig.2. shows the block diagram of wireless power transmission.

3.1 Background On Wireless Power Transfer

The technique known as Wireless Power Transfer (WPT) makes it possible to move electrical energy without the use of physical wires or conductors. Though the idea behind WPT has been around for more than a century, technological developments in the last few years have made it a workable option for a number of applications, such as industrial automation, consumer electronics, medical implants, and electric car charging. The basic principle of WPT is the use of an electromagnetic field to transfer power between two or more coils or resonant circuits, which are typically referred to as the transmitter and the receiver. The transmitter generates an alternating current that is fed to a coil, which then generates a magnetic field [4]. This magnetic field may cause a current to flow through a nearby coil or resonant circuit, which might be utilized to power an appliance or replenish a battery.

WPT has many advantages over traditional wired power transfer, including greater convenience, improved safety, and reduced maintenance costs. Wireless Power Transfer (WPT) provides wireless charging for electric vehicles, reducing the necessity of physical connectors and wires. It also reduces the risk of electric shock and reduces wear and tear on physical connectors [6]. WPT also offers the potential for dynamic charging, allowing vehicles to charge while in motion, Which could significantly extend the range of electric vehicles.

MATLAB/Simulink is a powerful platform for designing and simulating WPT systems, allowing researchers and engineers to model and optimize system performance, including efficiency, power transfer, and safety [7].

3.2 Power Transfer Efficiency Optimization

By changing the parameters of the transmitting and receiving coil lengths, the coupling coefficient, and the resonant frequency [8], the power transfer efficiency of the WPT system is maximized. The following formula is used to determine the power transfer efficiency:

$P \text{ transfer efficiency} = P \text{ received} / P \text{ transmitted}$

Where P received is the power received by the EV's battery and P transmitted is the power transmitted by the transmitting coil [9]. The simulation results demonstrate that the coupling coefficient, resonance frequency, and coil lengths can all be modified to achieve the highest possible power transfer efficiency [10]. A technology called wireless power transfer makes it possible to charge electronics without the use of wires or cords. Power is transferred from a transmitter to a receiver utilizing electromagnetic fields in this system. The following techniques can be applied to boost wireless power transfer's power transfer effectiveness:

3.3 Resonant Frequency Calculation

The WPT system's resonant frequency is determined using the following equation:

$$\text{frequency resonant} = 1 / (2 * \pi * \text{sqrt}(L * C)).$$

where L is the inductance of the coils, C is the capacitance of the resonant circuit, and f resonant is the resonant frequency. The values of L and C are chosen based on the desired resonant frequency. The resonant frequency is calculated using MATLAB/Simulink, and the values of L and C are adjusted until the resonant frequency matches the desired frequency [13].

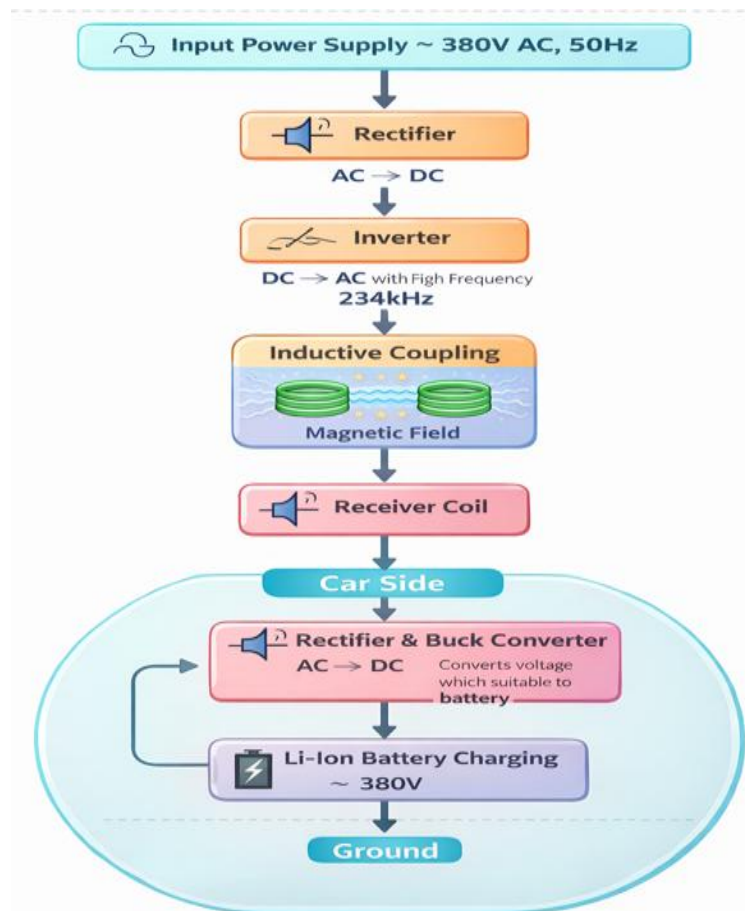


Fig.1.Flow Chart of the Wireless Power Transmission

- Resonant Coupling: Power transmission efficiency can be greatly increased by using resonant coupling between the transmitter and the receiver. Resonant coupling can be achieved by matching the resonant frequencies of the transmitter and receiver.
- Magnetic Coupling: Using magnetic coupling instead of electrical coupling can also improve the power transfer efficiency [15]. Magnetic coupling works by using a magnetic field to transfer power between the transmitter and the receiver.
- Distance and Alignment: Both the coil alignment and the distance between the transmitter and receiver can have a substantial effect on the power transfer efficiency. Placing the coils nearby and aligning them properly can improve efficiency. Capacitive Coupling: using capacitive coupling can also improve the power transfer efficiency. Capacitive coupling works by using electric fields to transfer power between the transmitter and the receiver. Fig.1. shows the Flow Chart of the Wireless Power Transmission [16].

IV. FUTURE SCOPE

- Explore ways to enhance the efficiency of wireless power transfer mechanisms. This could involve improving the design of the charging system, refining the power electronics, or employing advanced materials for better energy transmission.
- Investigate the integration of wireless charging systems with smart grids. This could involve developing communication protocols that enable the EV to communicate with the power grid for optimal charging times and load balancing.
- Work towards standardizing wireless charging technologies to ensure interoperability among different vehicle models and charging infrastructure. This could involve collaboration with industry stakeholders and standardization bodies.
- Investigate safety aspects associated with wireless power transfer for EVs. Ensure compliance with regulatory standards and work on developing fail-safe mechanisms to prevent accidents or hazards during the charging process.



- Explore the integration of emerging technologies such as artificial intelligence and machine learning to optimize charging processes. This could involve predictive algorithms for charging behavior dynamic power management, and adaptive control systems.

V. CIRCUIT DIAGRAM OF WIRELESS POWER TRANSFER FOR ELECTRIC VEHICLES

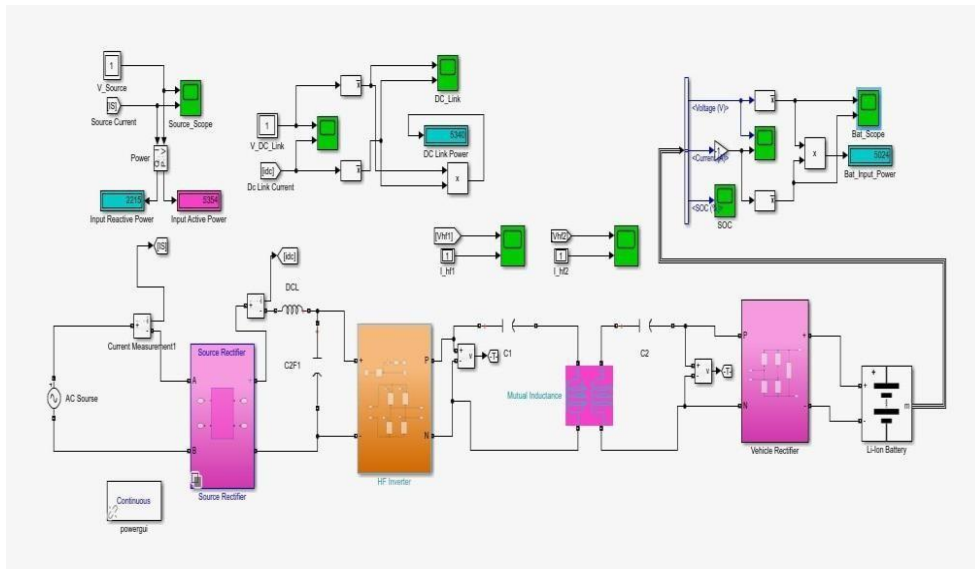


Fig.2. Block Diagram of Wireless Power Transmission

5.1 Input Power Supply

Electric vehicles (EVs) may be charged quickly and easily without the use of cables thanks to the wireless power transfer (WPT) technology or Plugs. MATLAB/Simulink is a popular tool for designing and simulating WPT systems shown in Fig.2. Input power supply 330, Current 50 Amps, Frequency: 50Hz. Fig.3. shows the Wireless Power Transmission of Input voltage and current.

5.2 Rectifier in Base Pad

A rectifier's function is to change alternating current (AC) into direct current (DC). Typically, a diode or a set of diodes is used to restrict the flow of electricity in one direction. Rectifiers are utilized in a variety of Electronic devices and power supplies to convert AC power to DC power.

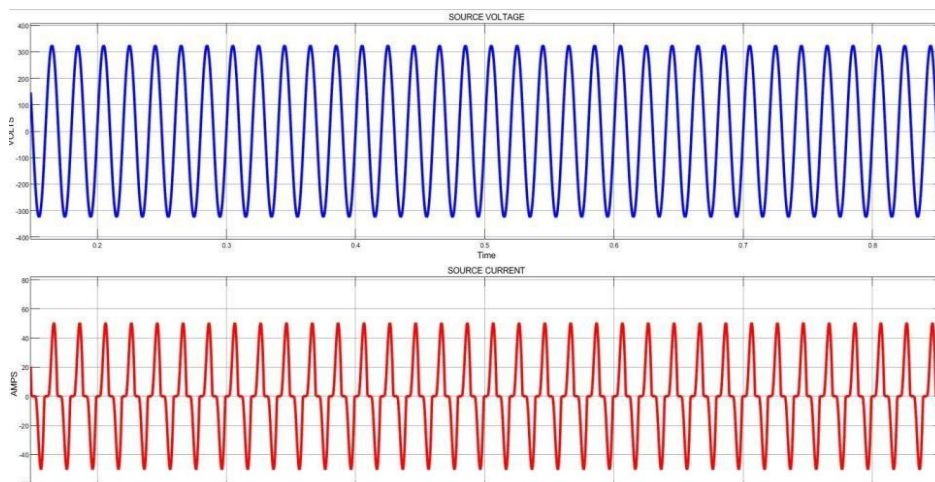


Fig.3. Wireless Power Transmission of Input voltage and current.

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5.3 Inverter

An inverter's function is to change direct current (DC) into alternating current (AC). A uses inverters to convert a wide range of applications where AC power is required, such as in homes and businesses, as well as in industrial and automotive applications.

5.4 Coils

Wireless power transmission (WPT) technology depends heavily on coils. A technique called wireless power transfer (WPT) is used without using cables, electrical energy can be transferred between a transmitter and a receiver using magnetic fields. Coils are utilized in WPT because they enable the generation of a magnetic field, which is essential for the transmission of energy.

5.5 Rectifier In Vehicle PAD

Direct current (DC) is produced from alternating current (AC) via a rectifier. Using a diode or a network of diodes, current is often allowed to flow in only one way in order to achieve this. Rectifiers are utilized in a variety of electronic components and power sources to convert AC power to DC power [11,12].

5.6 Buck Converter

An input of high voltage and low current is transformed into an output of high voltage and low current using a buck converter. output, with high efficiency. In power electronics applications including voltage regulators, power supply, and battery charging circuits, buck converters, a particular kind of DC-DC converter, are frequently employed.

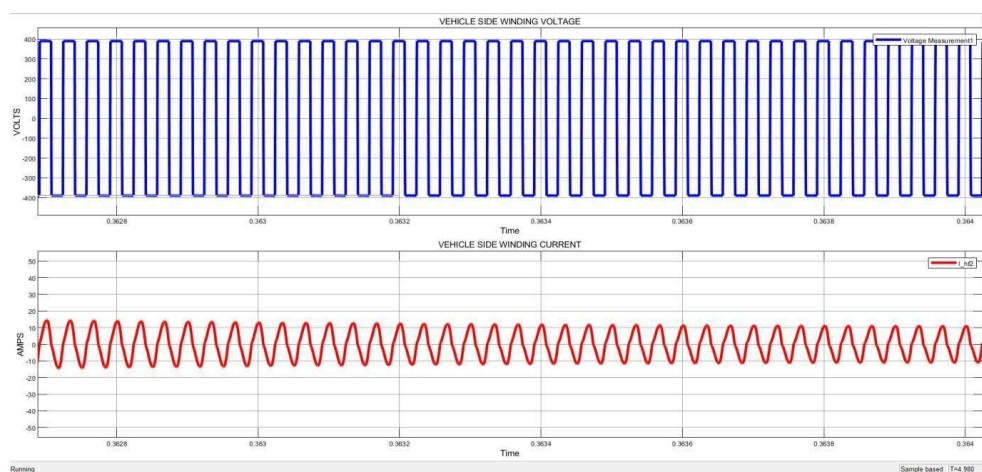


Fig.4. Wireless Power Transmission Vehicle Side Output.

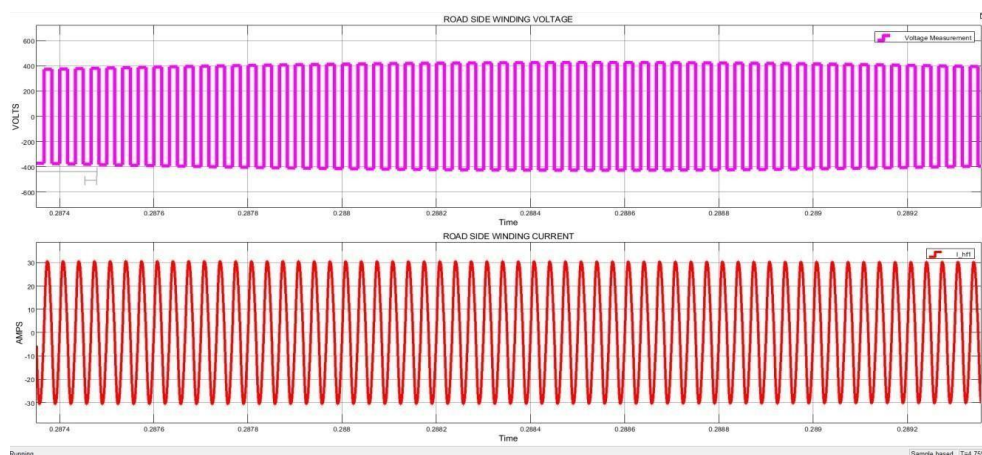


Fig.5. Wireless Power Transmission Road Side Output.



5.7 Car Battery

Batteries play a critical role in cars as they are used to power the electrical systems of the vehicle, including the starter motor, lights, audio system, and other electronic components [13]. In addition, batteries are used to power the onboard computers that control the engine, transmission, and other systems in the car. Fig.4., Fig.5. shows the wireless power transmission for vehicle and road side output. Because internal combustion engines need an electrical power source to function, batteries are necessary in automobiles. The starting motor, which cranks the engine over to start it, receives this power from the battery. As soon as the, When the engine is operating, the alternator takes over and powers the vehicle's electrical systems while simultaneously recharging the battery. Fig.6. shows input voltage to the car.

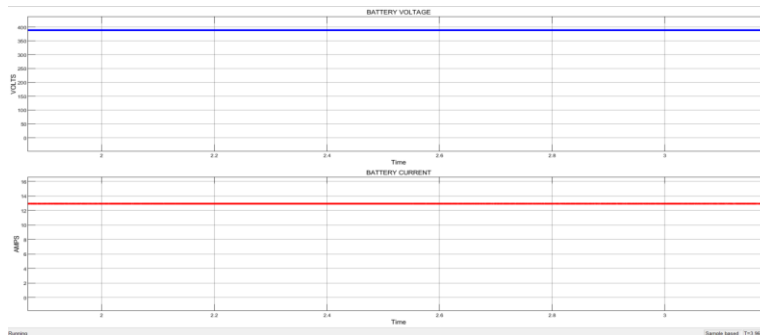


Fig.6. Input Voltage to the Car.

Table 1. Parameters Involved in Circuit Diagram of Wireless Power Transmission

S.No	Parameter	Ranges
1	Input voltage	330V
2	Input current	50 AMPS
3	Frequency	50 Hz
4	Output voltage	380 V
5	Output current	13 AMPS
6	Efficiency	90 to 93%
7	Size of transmitting coil	120m x 1.5m
8	Size of receiving coil	1m x 1m
9	Mutual inductance	46 uH

VI. ADVANTAGES AND DISADVANTAGES OF WIRELESS POWER TRANSFERRING

6.1 Some of the advantages are as follows

- One common illustration involves non-particulate radiation, such as radio waves. Although this form of radiation excels in transmitting information wirelessly For the transfer of power, it is not practical. It's completely impractical to use it for power transmission given our current state of knowledge [16] [17]. Radiation spreads in all directions , therefore a tremendous amount of electricity would be squandered in space.
- The former high-tension power transmission line cables, towers, and substations involving the generating plant would be replaced by a wireless power transmission system. and customers and makes it possible for electrical generating facilities to be connected globally.
- There is more flexibility for both the transmitters and the receivers. The WPT system may even choose to use portable transmitters and receivers.
- Power could be delivered to locations without enough cable transmission capabilities. Since Wireless Power Transmission reduces transmission by a minimal amount, this method is far more efficient than cable transmission.
- With the WPT running, power can be purchased via the receiver. Power theft won't be conceivable in any way, and power failure due to shorts and cable faults isn't something that may happen during transmission [20].

6.2 Some of the disadvantages are as follows

- For the practical deployment of wireless power transmission, high capital costs.
- The interference of microwaves with the current wireless communication system is a possible drawback as well



[22].

- When taken in high amounts, microwave radiation has negative health effects on people.

VII. CONCLUSION

Present is the idea of wireless power transmission. We've talked about how modern technology is being used to improve human lives in the modern world. When it comes to discussions of the subject of upcoming standards, three new wireless power technology standards that are already in competition with one another are also on the table. Which of these three wireless charging protocols will triumph in the competition determined by their most recent outstanding applications? The comparative table demonstrates that while Qi and PMA are also developing swiftly, Technology-wise, A4WP standards, which have a strong magnetic field and a long charging distance, must stay ahead of other standards. Only if wireless power keeps becoming better will

we be able to use more of the robotics and wireless power charging applications that are now being researched [15].

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