GENERATION AND UTILIZATION OF ELECTRICAL ENERGY

J-COMPONENT PROJECT FINAL REPORT

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WIRELESS POWER TRANSMISSION FOR EV CHARGING

SLOT: C2

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Abstract:

Wireless Power Transfer (WPT) technology can transfer electrical energy from a transmitter to a receiver wirelessly. Due to its many advantages, WPT technology is a more adequate and suitable solution for many industrial applications compared to the power transfer by wires. Using WPT technology will reduce the annoyance of wires, improve the power transfer mechanisms. Recently, the WPT gain enormous attention to charging the on-board batteries of the Electric Vehicle (EV). Several well-known car manufacturing companies start efforts to adopt WPT technology and enhance its features. Therefore, WPT can be achieved through the affordable inductive coupling between two coils named a transmitter and a receiver coil. In EV charging applications, transmitter coils are located underneath the road, and receiver coils are installed in the EV. The inductive WPT of resonant type is generally applied to medium-high power transfer applications like EV charging because it achieves better energy efficiency. In this chapter, various WPT technologies are discussed and tested in EV wireless charging applications. Furthermore, extensive information is given to developing an advanced WPT technology that can transfer maximum power by achieving maximum efficiency.

Introduction:

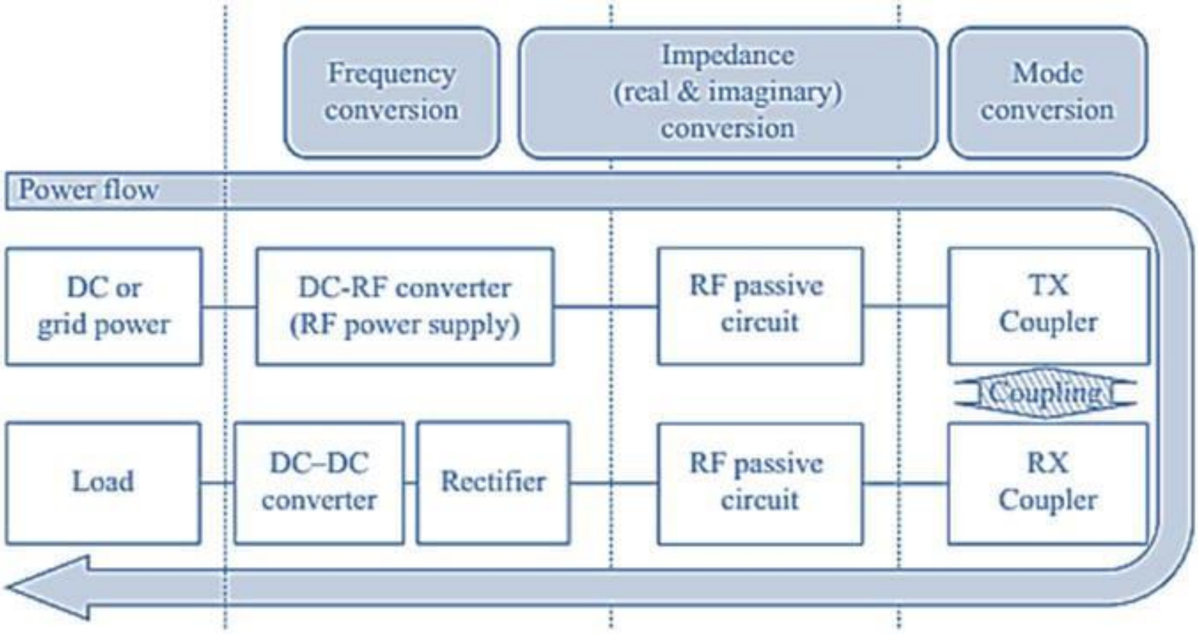
A Wireless Power Transfer (WPT) is one of the promising technologies used to transfer electric energy from a transmitter to a receiver wirelessly. WPT is an attractive solution for many industrial applications due to its enormous benefits over wired connections. The advantages include the no hassle of carrying wires, easy charging, and smoot of power transmission even in unfavourable environmental circumstances.

The idea of wireless power transfer (WPT) was first introduced at the end of the 19th century by Nicola Tesla. He manufactured a wireless lighting bulb that was used to receive electrical charge wireless . Tesla used two metal plates that were closely placed to each other. A high-frequency Alternative Current (AC) potentials were passed between these two plates, and the bulb powered ON. However, some of the issues appeared while using WPT technology. One of the main issues is that the minimum power density and low transfer efficiencies affect when the distances increase. As a result, the performance of WPT technology becomes very slow. Therefore, the WPT technology is improved and used “strong coupled” coils when the distance increases more than 2 m while charging wirelessly . The two important WPT technologies are Inductive Power Transfer (IPT) and Capacitive Power Transfer (CPT). CPT is only applicable to low power applications with very short air gaps between 10–4 and 10–3 m, whereas IPT can be used for large air gaps around several meters, and its output power is much higher than CPT.

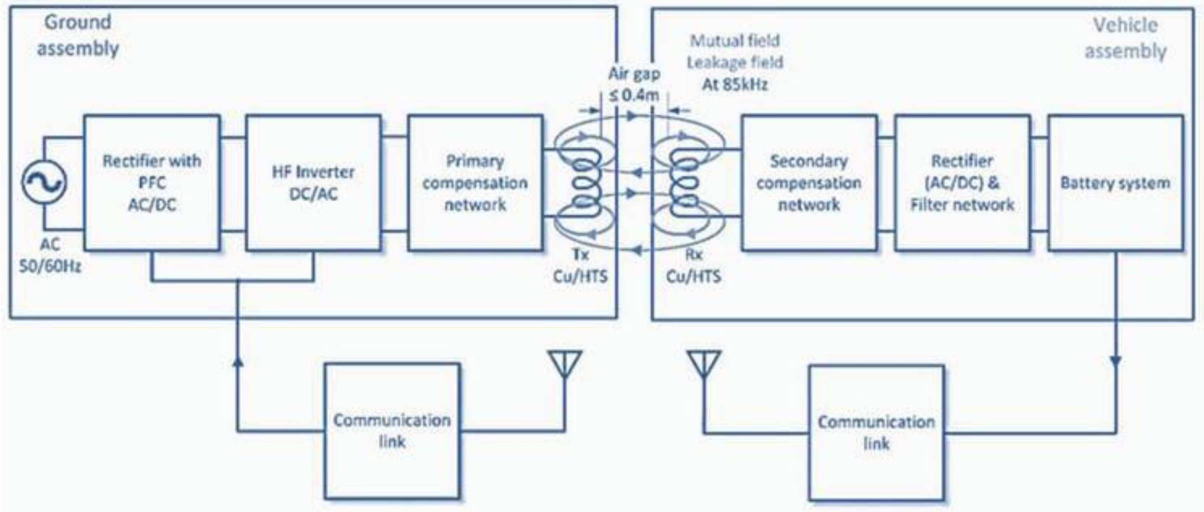
Methodology:

When AC or DC electrical energy is transformed to high-frequency electrical energy by using a high-frequency inverter, the wireless feeding device (Tx.) releases electrical energy through a transmission device into space. Then, the receiving system (Rx.) converts the electrical power into DC in the recipient electrical apparatus. In addition, the efficiency of the electrical power transmission, medical and environmental influence of electromagnetic waves, and improvement the facile high speed charging, safe security, and energy storage density are essential limits should be considered when WPT is designed for EVs.

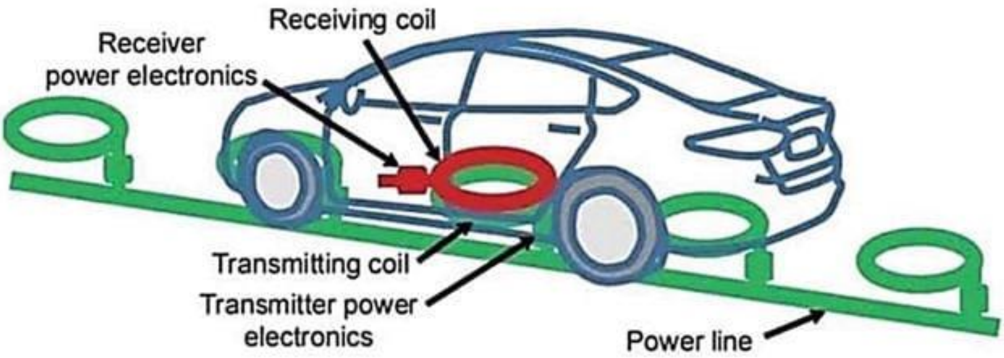
Power flow in WPT system:



The block diagram of the Power flow in WPT system. RF inverter converts the frequency of the power. Typically, RF inverter also converts the voltage of the power. Considering that the power is P = VI and the impedance is Z = V/I, the RF inverter also converts the impedance of the power. The rectifier in Rx side also changes the frequency of the power.



(a)



(b)

depicts the base components of a WPT system for EV charging. It consists of two prime sub-systems, one of which is existing underneath the road surface and the second is found into the vehicle underbody . The first subsystem includes the source of energy, rectifier and high frequency inverter, primary compensation network and the primary/transmitter coil (Tx). The built subsystem in EVs, has the secondary/receiving coil (Rx) and secondary compensation network composes a resonance circuit that supplies into a high frequency rectifier, filter and the battery. The sub-systems are separated by an air gap. The distance between the two systems depends on the type of vehicle, ground clearance and road conditions such as pavement thickness. Usually the air gap is smaller than 0.4 m. Additionally, both sub-systems share information via a communication link.

Circuit Diagram:

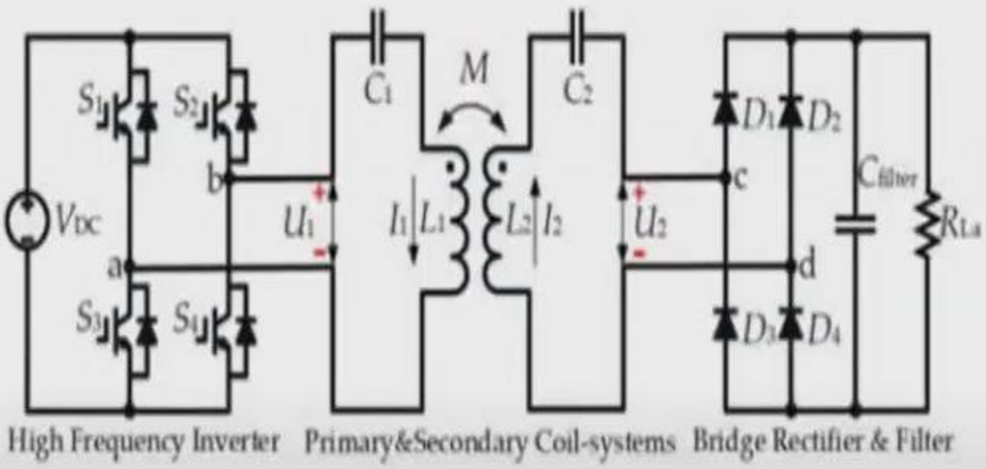
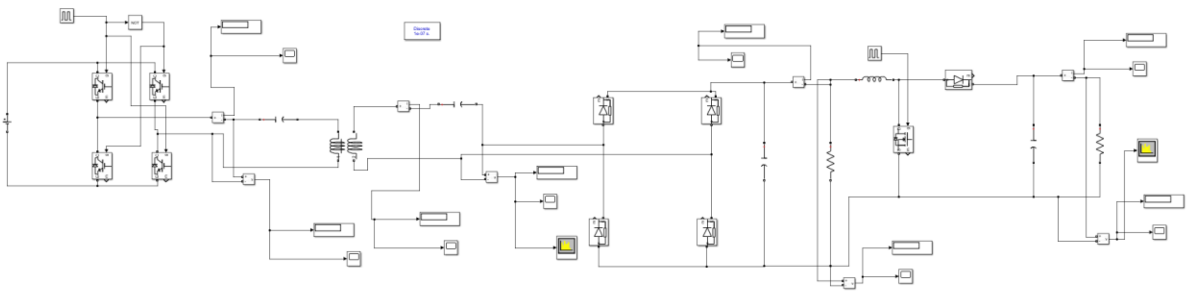


fig.1 Two coils SS compensated WPT system

Simulation circuit:



Model Specifications:

Power output level	3.6kw,11.7kw
Output voltage	135v,450V
Resonant frequency	85KHz
Supply voltage	240 V

Materials Required:

S. No.	Name of the apparatus	Quantity
1.	IGBT Diode	4
2.	Diode	5
3.	MOSFET	1
4.	Capacitor	3
5.	Resistor	2
6.	Inductor	1
7.	Copper coils	2
8.	Pulse Generator	2
9.	Ammeter	4
10.	Voltmeter	4
11.	Dc supply(240V)	1

Model Calculation:

Model Calculation Used

$$R_o = \frac{V_o^2}{P_o} = \frac{400 \times 400}{7700} = 20.77\Omega$$

$$R_L = \left(\frac{8}{\pi^2}\right) \times \frac{V_o^2}{P_o} = \frac{8}{\pi^2} \times \frac{400\times400}{7700} = 16.84\Omega$$

$$V_{sRMS} = \frac{2\sqrt{2}\, V_o}{\pi} \Rightarrow \frac{2\sqrt{2}\times 400}{\pi} \Rightarrow 360.12V$$

$$L_s = Q_s \times \frac{R_L}{\omega_o} = 4 \times \frac{16.84}{2\times\pi\times 85000} = 1.261\times 10^{-4}\, h$$

$$I_{SRMS} = \frac{V_{SRMS}}{R_L} = \frac{360.12}{16.84} = 21.38A$$

$$I_{PRMS} = \frac{P_o}{V_{PRMS}} = \frac{7700}{240} = 32A$$

Mutual Impedance.

$$M = I_{sRMS} \times \frac{R_L}{I_{PRMS}\times\omega_o} \Rightarrow 21.38 \times \frac{16.84}{32\times 2\times\pi\times 85000} = 2.106\times 10^{-5}\, h$$

$$K_c = \left(\frac{1}{Q_i}\right) \times \sqrt{1-\left(\frac{1}{4\times Q_s^2}\right)}$$

(Quality F.)

$$\Rightarrow \frac{1}{4}\sqrt{1-\frac{1}{4\times 4^2}}$$

$$\Rightarrow 0.248$$

$$L_p = \frac{M^2}{L_s \times K_c^2} = \frac{2.106 \times 10^{-5} \times 2.106 \times 10^{-5}}{1.261 \times 10^{-4} \times (0.2)^2}$$

$$\Rightarrow 8.793 \times 10^{-5} \, H$$

$$C_p = \frac{1}{L_p \omega_0^2} = \frac{1}{8.793 \times 10^{-5} \times (2\pi \times 85000)^2}$$

$$= 3.98 \times 10^{-8} \, F$$

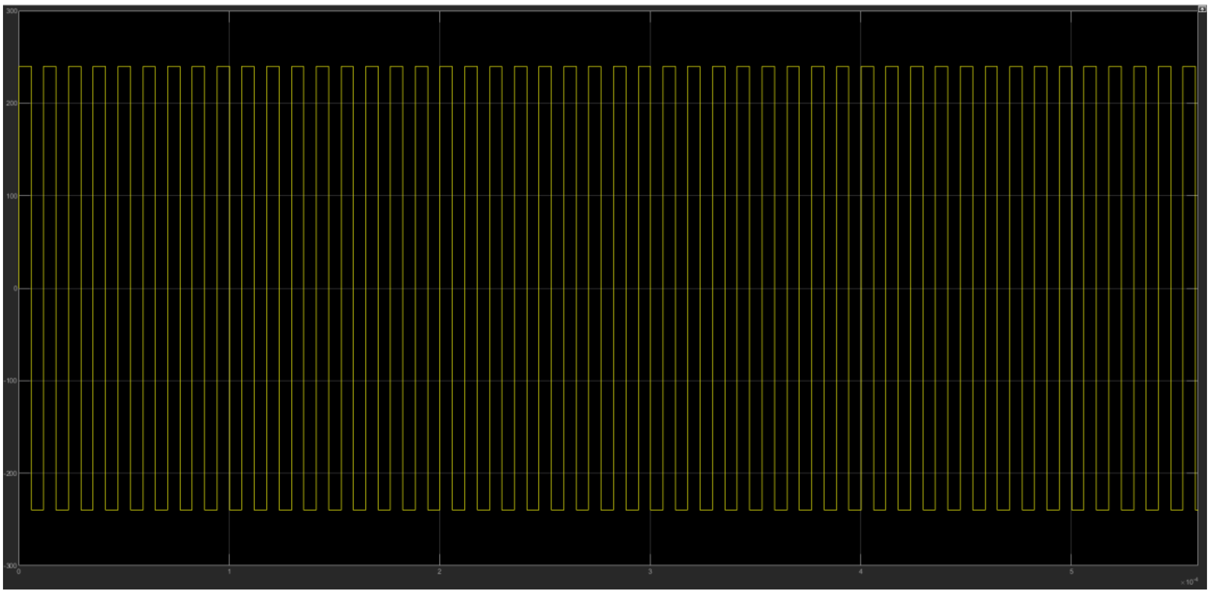
$$C_s = \frac{1}{L_s \omega_0^2} = \frac{1}{1.261 \times 10^{-4} \times 2\pi \times 85000}$$

$$\Rightarrow 2.78 \times 10^{-8} \, F$$

Outputs:

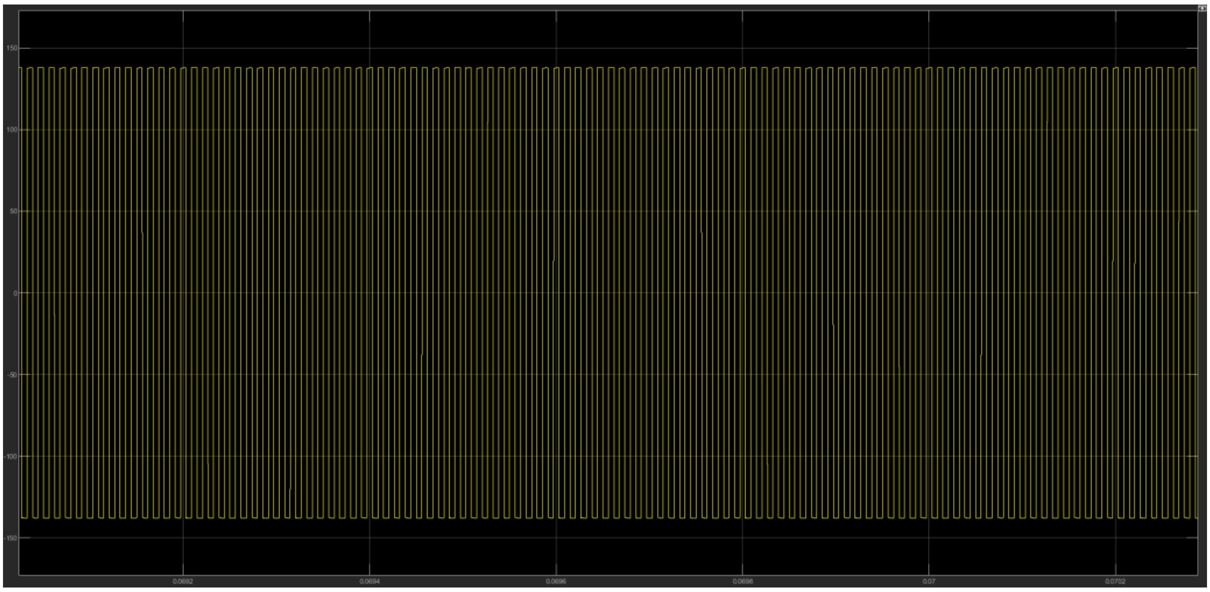
Input Voltage Graph Before Transmission

V=240V



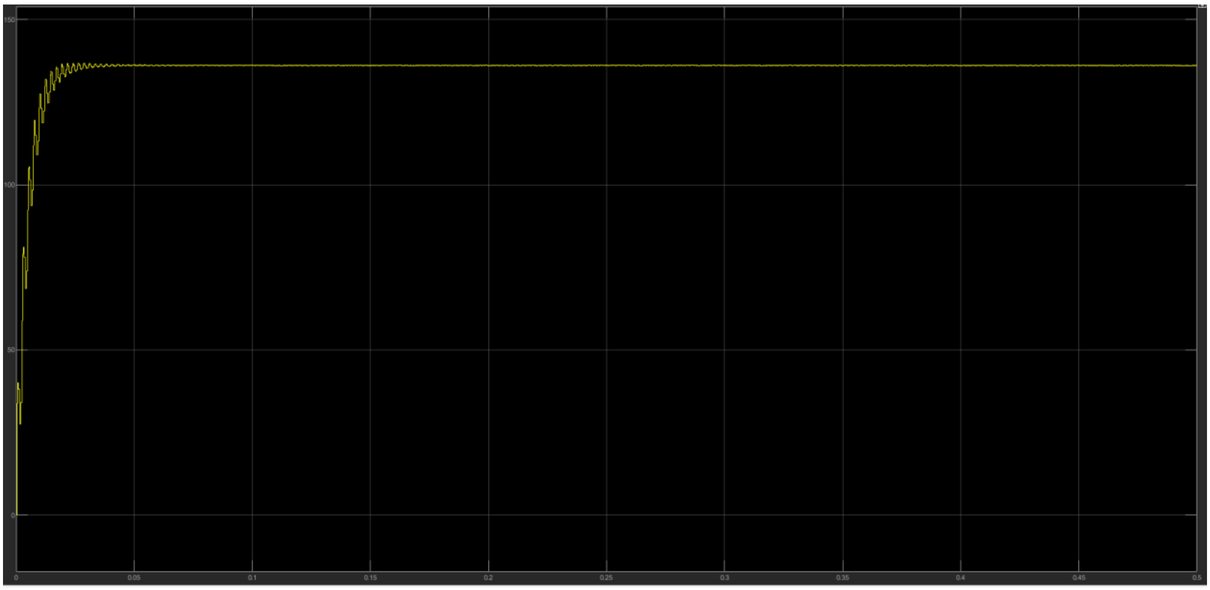
Voltage After Mutual Inductance

V= 130v



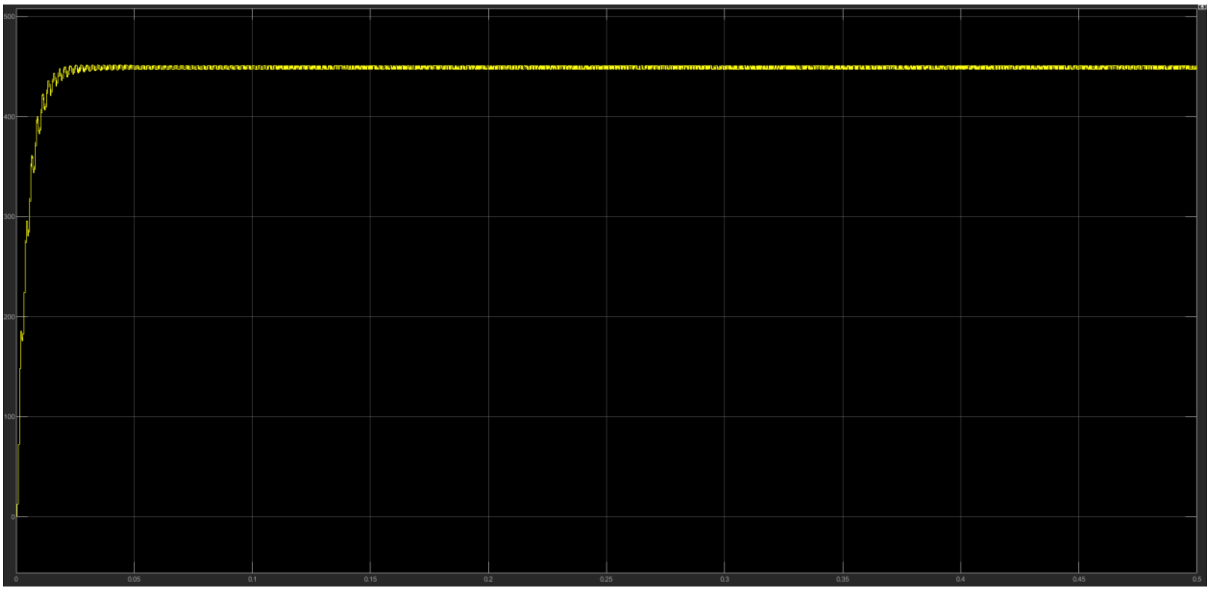
Voltage After Conversion from AC to DC

V=136 V



Voltage After Boost Conversion

V=450V



Conclusion:

In this chapter, several WPT technologies are presented and explained the importance of WPT. In recent years, WPT technology gains enormous attention due to its advantages. WPT systems are classified as microwave, evanescent wave, magnetic resonance, electrical resonance, or electromagnetic induction methods. Moreover, the prospective EV wireless charging applications are also highlighted, and different coupling techniques are discussed in this chapter. Inductive coupling, magnetic resonance coupling, and microwave are the main EV wireless charging techniques. The chapter also provided detailed information on the manufacturing and configuring the magnetic resonance coupling based wireless charging system. This chapter deals with the basic overview of the present and future scenarios of EVs. After discussing the scenarios, various concerns regarding battery types and charging methodologies are discussed as well.

References:

- https://www.researchgate.net/publication/224244866_Smart_electric_vehicle_charging_system
- https://iopscience.iop.org/article/10.1088/1742-6596/1074/1/012140/meta
- https://www.researchgate.net/publication/267512972_Wireless_Power_Transmission_Trends
- https://en.wikipedia.org/wiki/Wireless_power_transfer