Design of wireless transmission of power - A new era of development

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Abstract

Wireless Transmission of Power explores the advancements and potential of wireless power transmission, heralding a new era in technological development. The traditional reliance on wired connections for power transfer has limited mobility and posed challenges in various applications. However, wireless power transmission offers a paradigm shift by enabling efficient energy transfer over significant distances without physical connections. The design aspects of wireless power transmission systems are explored in detail, covering factors such as power efficiency, system scalability, safety, and regulatory compliance. The use of advanced technologies, such as resonant coils, metamaterials, and beamforming, is examined, showcasing their role in optimizing power transfer efficiency and minimizing energy losses. This paper mainly deals with the idea of wireless power transfer (WPT) throughinductive coupling. The development of a wireless mobile charger employs MATLAB simulation software and the concept of wireless power transfer (WPT).

Keywords: Wireless power transfer (WPT), Inductive coupling, MAT- LAB

1 Introduction

Nowadays, Wireless Power Transfer (WPT) has attracted a lot of interest. The problem of having too many wires in a small place gave rise to the concept of wireless power transfer (WPT) [3]. The primary purpose of wireless power transfer (WPT) is to eliminate the limitations of a power cord and enable continuous charging of electrical equipment. The use of inductive coupling is a highly popular technique for converting energy among the numerous methods of power transfer. Wireless charging and powering of electronic gadgets, medical equipment, mobile chargers, electric car chargers, etc. are some uses for wireless power transfer. Inductive coupling is the safest and most wireless way to transfer energy, even though some wireless power transfer techniques may have limitations.

Despite Michael Faraday being the inventor of the idea of transferring energy wirelessly, many engineers and physicists credit Nicola Tesla with the invention of wireless power transfer.[2] At his lab in Colorado, USA, Nicola Tesla started working on wireless power transfer in 1891.[1]

Inductive coupling, a Wireless Power Transfer (WPT) idea, will be the main topic of this essay. It will be used to develop a wireless mobile charger that solves the problem of having too many cables in a small area.

2 Literature Survey

Salamn et al. claim that the functioning of wireless power transfer is based on the inductive coupling within coils theory. In this procedure, one copper coil is installed at the sending end and the other at the receiving end. The transmission coil is connected to the power source (230V, 50Hz), while the receiving coil is connected to the device or appliance. When the power is turned on, the transmitting coil converts the supplied input power into magnetic flux that oscillates at a predetermined frequency. the magnetic flux that is present near the coil that transmits and results in emf in the receiver's receiving coil. The induced emf may be used to power the receiving coil. By using this induced emf, electric and electronic

equipment can be powered.[5]
Pande et al. proposed the concept of delivering power wirelessly, or as magnetic waves, from one location to another in order to minimise transmission and distribution losses. The idea of wireless power transfer was born out of the drawbacks of using many cables, where connected wires may be an annoyance or a hazard. Efficiency is the most crucial factor in wireless power transfer. The most well-known abstraction of Wireless Power Transfer (WPT) is Resonance Inductive Coupling (RIC), which includes inductive coupling and resonance.
Resonant inductive charging, which may charge many devices simultaneously provided they have the same resonant frequency, is the idea behind this.[3]

Powade et al. claim that Wireless Power Transmission (WPT) has attracted a wide range of subjects in different industries and has also developed into a very active study area due to its potential to integrate cutting-edge technology into our everyday life. It will soon be necessary to adopt wireless power transmission since this technology makes it feasible to send electrical energy without the use of connecting cables across an air gap from a power source to an electrical load.[4]

3.0 Methodology

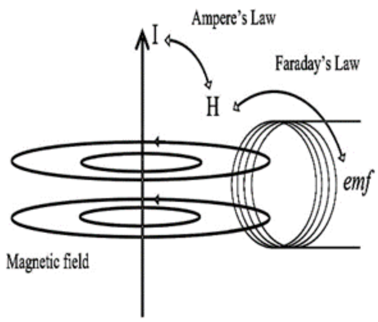


Figure 1 Wireless Power Transfer

The idea of electromagnetic induction serves as the foundation for wireless power transfer (WPT). Michael Faraday made the initial discovery of electromagnetic induction in 1831. Nicola Tesla created the Wireless Power Transmission (WPT) for the first time in 1891.

Electromagnetic Induction

An electric conductor experiences an electromotive force (emf) as a result of electromagnetic induction when a magnetic field is changing. In addition, according to Faraday's experiment, a static magnetic field does not result in a current flow, whereas a time-varying field results in an induced voltage that results in a current flow in a closed circuit.

Resonant Inductive Coupling

When the load-bearing side of a loosely coupled coil resonates, it is known as Resonant Inductive Coupling (RIC), and this occurrence causes the coupling to become stronger. Resonant inductive coupling (RIC) is a component of wireless charging systems for mobile devices, cell phones, and automobiles.

3.1 Block Diagram of wireless mobile phone charger

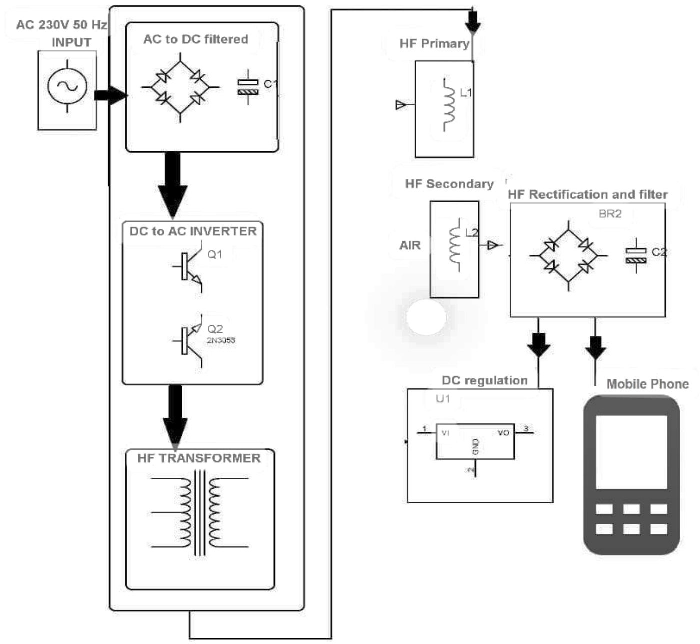


Figure 2 Block diagram

Two portions make up the majority of the block diagram. A high frequency transformer, a DC to AC inverter, an AC to DC rectifier, a transmitter coil, and a 220v AC supply are all components of the transmitter circuit. A voltage regulator, a load, a receiver coil, and an AC to DC rectifier are all components of the receiving circuit.

Rectifiers and Filter Stage: - Four diodes are used in a full wave rectification system to rectify the AC input, turning the AC power into pulsing DC. Due to the pulsing DC output, a filter made of capacitors is used to smooth the rectified output.

HF Inverter Stage: - After that, four MOSFETs are used to convert the filtered DC back to AC at a very high frequency.

HF Primary and Secondary Coil Stage: - The transmitter coil and receiver coil are the two coils that make up this state. When high frequency AC is introduced to the transmitter side, a magnetic flux is created that, with the aid of inductive coupling, induces AC in the receiving coil.

Inductive Coupling: - The electromagnetism principle underlies inductive or magnetic coupling. A magnetic field is created in a wire when it is close to a magnetic field. Inductive coupling is the process of transferring energy between wires using magnetic fields. If a portion of the magnetic flux produced by one circuit interacts with the second circuit, then the two circuits are magnetically coupled and energy can transfer from one circuit to the other.

HF Rectification and Filter Stage: - Full bridge rectifier is used to first rectify the AC output from the secondary side before converting it to pulsing DC. Due to the pulsing DC output, a capacitor-based filter is used to smooth the rectified output.

4.0 Result and Discussion

4.1 DESIGN CLCULATION

Assuming, O/P Voltage, V_O = 12V AC
Resonance frequency = 85K HZI/P Voltage, V_{in} = 220V AC Quality Factor, Q = 4

- RMS value of O/P Voltage, $V_{O\,RMS} = (2\sqrt{2}\ V_0) / \pi = (2\sqrt{2} * 12) / \pi = 10.8V$
- The Load resistance, $R_L = (8/\pi^2) *(V_0^2/ P_0) = (8/\pi^2) *\{(12)^2 / 10\} = 11.843\Omega$
- The RMS value of I/P Voltage, $V_{i\,RMS} = (2\sqrt{2}\ V_{in}) / P_O = (2\sqrt{2} * 220) / 10 = 62.22V$
- The O/P Current is, $I_{O\,RMS} = V_{O\,RMS}/ R_L = 10.8/11.67 = 0.925$ Amp
- The I/P Current is, $I_{in\,RMS} = P_O/ V_{i\,RMS} = 10/62.22 = 0.16$ Amp

- The Mutual Inductance,

  $M = I_{O\,RMS} * \{R_L/ (I_{in\,RMS} * W_0)\} = 0.925 * 11.67/ 0.16*2*\pi *85000 = 1.263*10^{-4}$ H
- Coefficient of Coupling, $K = (1/Q) * \sqrt{\{1-(1/4Q^2)\}} = (1/4) * \sqrt{\{1-(1/4*4^2)\}} = 0.248$
- Secondary side Inductance, $LS = Q * (R_L / \omega_0) = 4*\{11.67 / (2\pi*85000)\}$

$= 8.74*10^{-5}$ H

- The Primary Side Inductance, $L_P = M^2 / (L_S * K^{2)}$

$= (1.263*10^{-4})^2 / (8.75*10^{-5}*0.248)^2$

$= 2.967*10^{-3}$ H

- The Secondary Side Capacitance, $C_S = 1/L_S\omega_o^2 = 1/\{8.74*10^{-5}*(2\pi*85000)^2\}$

=4.011*10-8 F

- The Primary Side Capacitance, $C_P = 1/ Lp\omega_0^2 = 1/\{2.967*10^{-3}*(2\pi*85000)^2\}$

  $=1.181*10^{-9}$ F

4.2 SIMULATION OF CIRCUIT DIAGRAM

The simulation of circuit diagram is done with the help of MATLAB software.

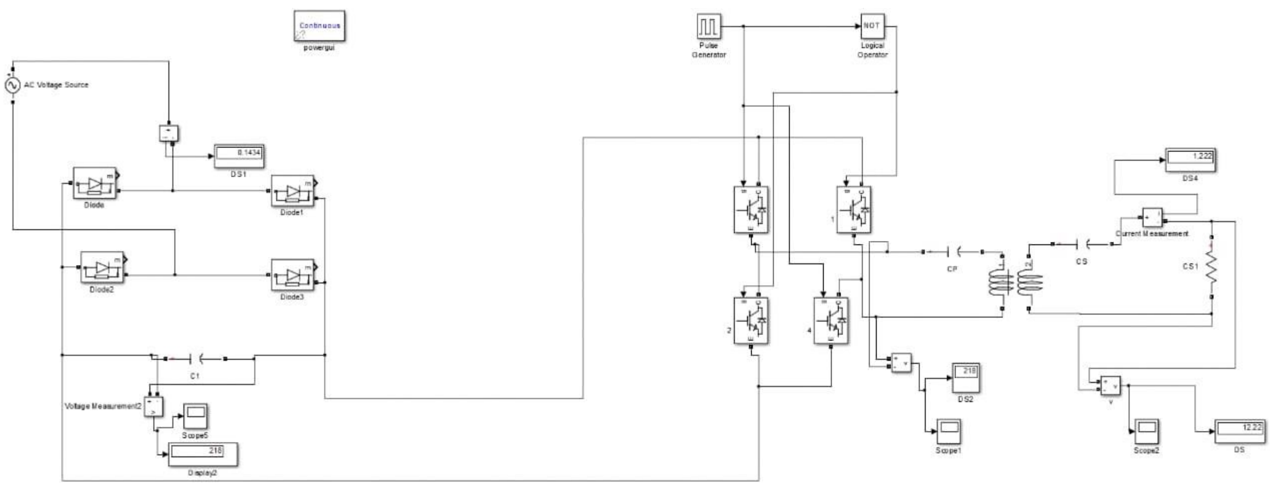
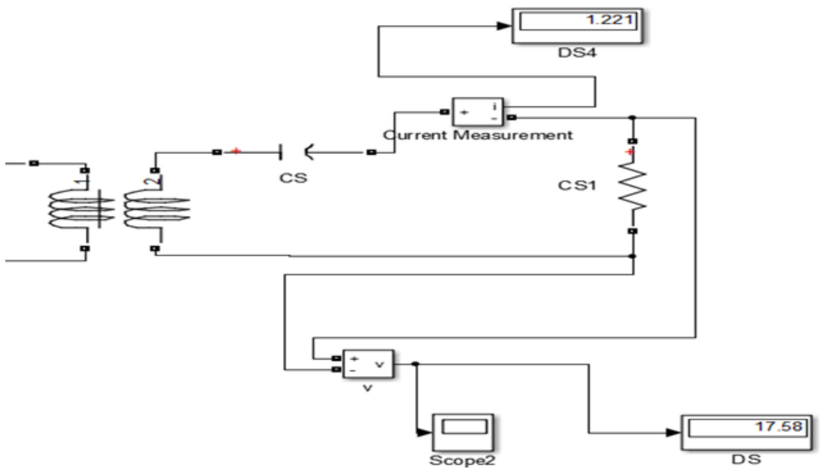


Figure 3 MATLAB Simulation of Transmitting Side



4.3 Output Waveform

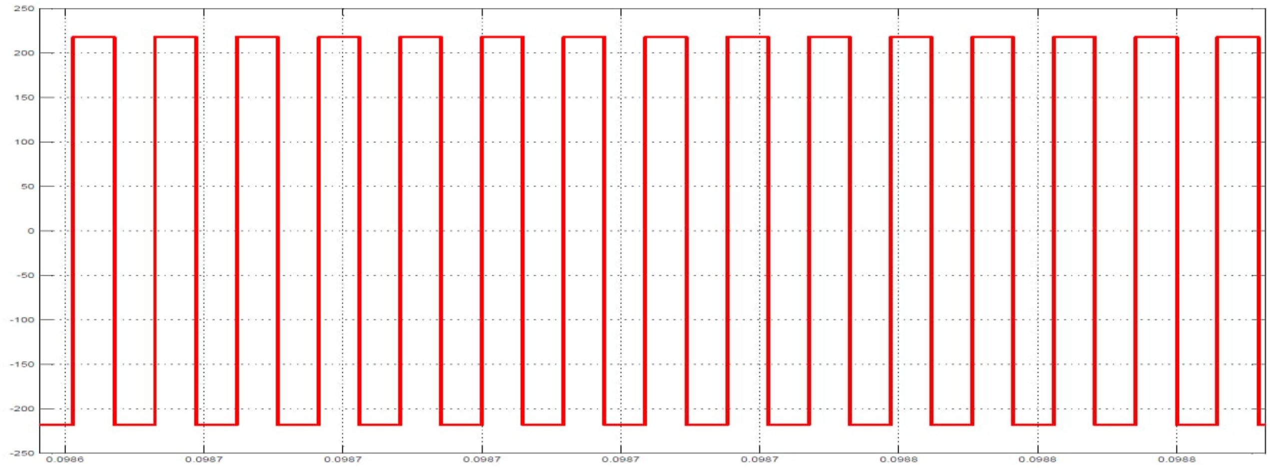


Figure 5: Input Graph between voltage and time

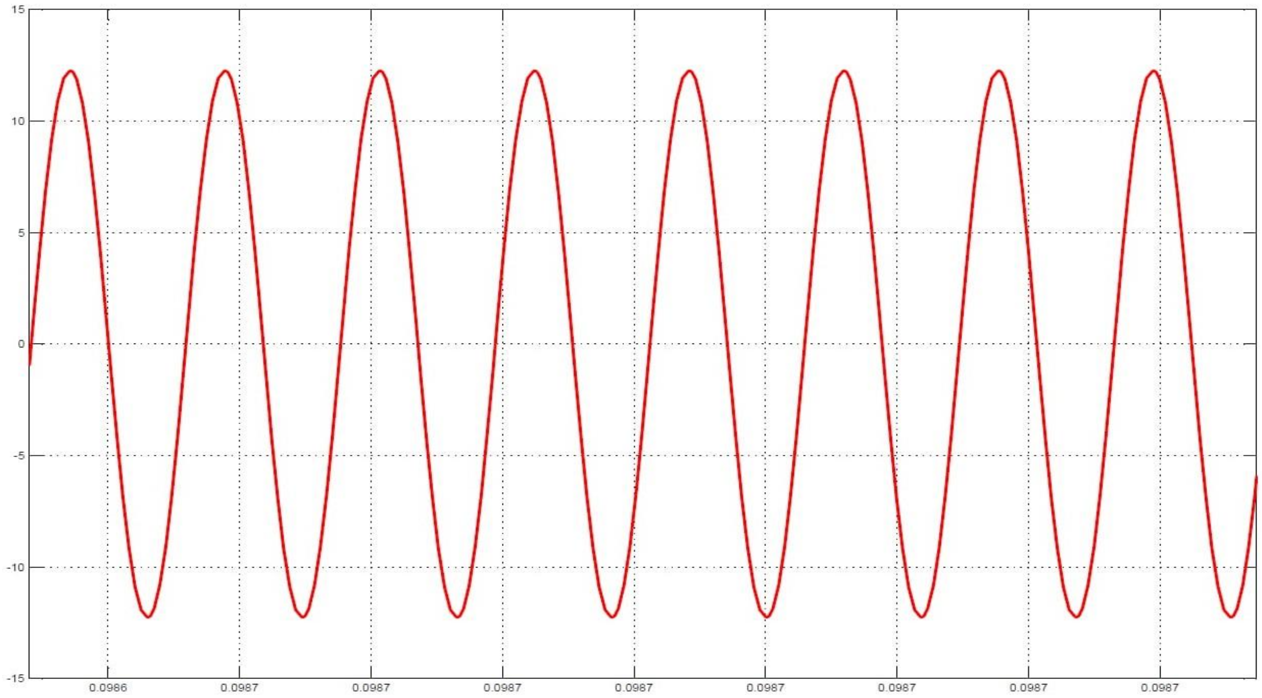


Figure 6: Output Graph with respect to voltage and time

The input graph is between voltage and time which shows the input voltageapplied i.e., 220V. The output graph is obtained after the final stage of rectification and filter. It gives the output of 12V which is the required output voltage for our wireless mobile charger. The graph is obtained with respect to time.

Voltage applied to the Bridge Rectifier	220V AC
Output of Bridge Rectifier that applied to MOSFET	217.8V DC
Transmitting side Voltage	217.8V AC
Receiving side voltage	12V AC

5.0 Conclusion

One of the most exciting emerging technologies is wireless power transfer (WPT). In this paper, a software model for a wireless mobile charger is created utilising a simulation system in MATLAB. Insightful technology known as wireless power transmission (WPT) has the potential to have a significant impact in the near future. There is no need for physical connections, wires, or cables while using wireless power transmission. Users can commence charging by just placing their devices on a charging pad or within the range of a power transmitter, which is more practical and hassle-free.

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