Coil Wireless Power Transmission for Low-Power Applications

*Course: ETE 300 - Electronic System Design and Project

Soiyod Sifat Mahmud (ID: 2108012)
Department of Electronics and Telecommunication Engineering (ETE)
Chittagong University of Engineering and Technology
Chittagong, Bangladesh
Email: sifatmahmud437@gmail.com.

***Abstract*—Wireless power transmission (WPT) enables electrical energy to be transferred from a power source to an electrical load without physical wires. This project demonstrates a coiled wireless power transmission system using resonant inductive coupling. A primary coil connected to an AC source generates a magnetic field, which induces voltage in a secondary coil. The system was tested to measure voltage transfer efficiency over short distances. Experimental results indicate that proper coil alignment and distance significantly affect power transfer efficiency, demonstrating the feasibility of wireless energy transfer in small-scale applications.**

***Index Terms*—Wireless power transfer, inductive coupling, magnetic field, resonance, efficiency.**

I. Introduction

Wireless Power Transmission (WPT) has emerged as a revolutionary technology in the field of electrical engineering. The fundamental principle relies on the transfer of energy through electromagnetic fields rather than physical conductors. This report explores the implementation of a coil-based system utilizing Faraday's Law of Induction to power small-scale loads wirelessly.

II. System Overview

The wireless power system is comprised of several key components that facilitate the transfer of energy across an air gap.

A. Components

- **Primary Coil (Transmitter):** Connected to an AC voltage source to generate the magnetic flux.
- **Secondary Coil (Receiver):** Intercepts the flux to produce induced voltage.
- **Load:** A resistor or LED used to verify and test power delivery.
- **Coupling Mechanism:** Magnetic induction between the two resonant coils.

B. Working Principle

The system operates on the principle of **Resonant Inductive Coupling**. When an Alternating Current (AC) flows through the primary coil, it generates a time-varying magnetic field. According to Faraday's Law, the secondary coil intercepts this field, resulting in an induced electromotive force (EMF). The efficiency of this transfer is maximized when both coils are tuned to the same resonant frequency and are properly aligned.

III. Methodology and Circuitry

The experimental setup involved winding two identical coils. Both the primary and secondary coils were designed with $N = 20$ turns and a radius of 3 cm. The primary coil was driven by an oscillator circuit to generate an alternating magnetic field.

A. Circuit Diagram

Fig. 1 illustrates the complete circuit diagram of the wireless power transmission system. The transmitter section consists of a DC power supply, oscillator, and primary coil, while the receiver section includes the secondary coil, rectifier, and load.

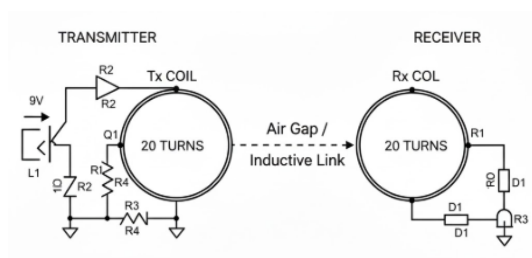

Fig. 1. Circuit diagram of the coil-based wireless power transmission system

IV. Experimental Results and Analysis

The system was tested using an input DC voltage of $9V$ (converted to AC via an oscillator circuit). The induced secondary voltage was measured at various distances to calculate efficiency.

The efficiency η is calculated as:

$$\eta = \left(\frac{V_{secondary}}{V_{primary}} \right) \times 100\%$$

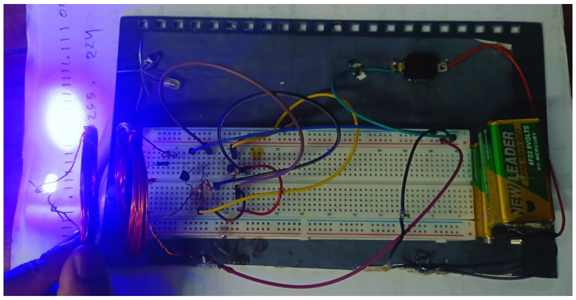

Fig. 2. Variation of induced secondary voltage with distance between coils

TABLE I
VOLTAGE AND EFFICIENCY VS. DISTANCE

Distance (cm)	$V_{secondary}$ **(V)**	**Efficiency (%)**
1	7.0	77.77
2	5.5	61.11
3	4.5	50.00

A. Graphical Representation of Results

Fig. 3 presents the graphical representation of the experimental results obtained from Table I. The graph illustrates the variation of induced secondary voltage with respect to the distance between the transmitter and receiver coils. As the distance increases, the induced voltage decreases due to reduced magnetic coupling between the coils.

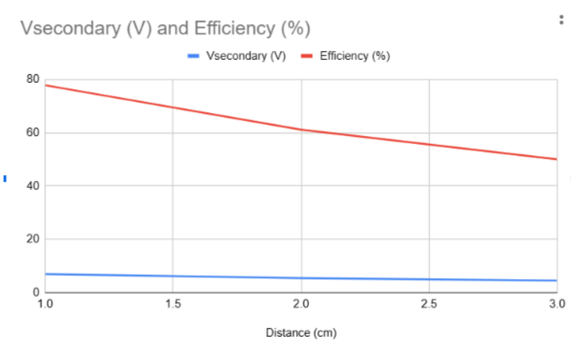

Fig. 3. Induced secondary voltage versus distance between coils

B. Observations

As shown in Table I, the maximum power transfer occurs at the minimal distance of 1 cm. A significant drop in voltage and efficiency was observed as the distance increased or when the coils were misaligned, due to the reduction in the coupling coefficient (k).

V. Conclusion

This project successfully demonstrated a coil-based wireless power transmission system. The results confirm that resonant inductive coupling is highly effective for short-range energy transfer. However, efficiency is extremely sensitive to spatial parameters. Such systems hold great potential for future applications in IoT device charging and low-power medical implants.

References

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