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# Circuit-Model Based Analysis of Wireless Energy Transfer System Using Inductive Coupling

[1] Nausheen Bilal, [2] Aisha Jilani, [3] Hamna Hamid, [4] Ayesha Inayat, [5] Sana Naeem, [6] Nimra
[1] Asstt Prof., Department of Electrical Engineering, Lahore College for Women University, Pakistan
[2] Lab Engr, Department of Electrical Engineering, Lahore College for Women University, Pakistan
[3, 4, 5, 6] Department of Electrical Engineering, Lahore College for Women University, Pakistan

[2] ai_jilani@yahoo.com

## ABSTRACT

Wireless charging through inductive coupling is one of the new emerging technologies that will bring tremendous change in human's life. Due to shortage of time there is increase in the demand of the wirelessly charged products. Wireless power transfer is one of the simplest and inexpensive ways of charging as it eliminate the use of conventional copper cables and current carrying wires. In our research work, a technique is devised for a wireless power transfer through inductive phenomena, and a feasible design is modeled accordingly. The technique used in our paper is the inductive coupling as it the easiest method of wireless power transfer because of high efficiency and large amount of the energy transferred. In our paper we will show results of experiment we have done to check wireless working of our different applications by glowing LEDs , running a fan, charging a mobile, detecting a smoke and sensing a gas.Wireless power transfer is not much effected by placing hurdles likes books, hands and plastic between transceiver and receiver. This research work focuses on the study of wireless power transfer for the purpose of transferring cut and dried amount of energy at maximum efficiency.

**Keywords:** *Inductive coupling, efficiency, transmitting coil, receiving coil, Wireless Power Transfer*

## 1. INTRODUCTION

Wireless power transfer has shown tremendous progress in its effectual transferring technique due to its fast speed and reliable work. To achieve the goal of transferring power wirelessly researches have been made since 19th century. Since long the idea of wireless transmission is implemented in the telecommunication sector using different transmission methods [1]. Few examples of wireless transmission are radio waves, cellular broadcast, Wi-Fi etc. [2]. Research work [3] has investigated the concept of charging the devices wirelessly making one's life quite easier and simpler rather than using wired charger that makes the devices bulky and complicated. A lot of efforts have been made for contactless charging due to the growing increase in the demand of wireless devices e.g. mobile electronics, powered radio way electric vehicles, biomedical implantable devices [4]. As discussed in [5], so far an efficient way of transferring power wirelessly is through inductive coupling between transmitter and receiver which are just few millimeter apart from each other. Some other methods that are not much efficient are power harvesting, optical beam transmission, acoustic coupling. In research work [1] technology of transmitting power wirelessly via inductive coupling over past decade has been considered as most effective and reliable way to transmit power across air gap using weak magnetic coupling. It offers typically high efficiency 80-90% with high robustness and reliability.

The main circuitry of that system is relying on Primary side and Secondary side. The power developed in the primary side copper tube is inductively coupled to the copper tube on the secondary side across an air gap. Then the power induced in the secondary coil is shifted to loads across it. Distance and voltage are related inversely with each other as it provides power along path of few millimeters. More space between primary and secondary side voltage start decreasing with increasing space [6]. This research work mainly concentrates on the innovatory idea of transmitting power without using wires through inductive coupling and behavior of different loads.

## 2. BACKGROUND

The idea of wireless power transmission has been introduced since the beginning of the 20th century and this idea was presented by Nikola Tesla [8]. Tesla presented the idea of the electrostatic induction and accomplished the experiment by the use of the Tesla coil to create the changing and very high potential differences between two pieces of metal. There are two plates of the metal between these pieces creating an alternating electric field thus releasing energy to be captured by a receiver. After doing this he thought that this concept would be very useful in the room where the lights could easily be moved without the help of the wire. He also presented the concept that by building two huge Tesla coils, one on each side of the Atlantic Ocean, a field could be created around the complete world. From that time till now many studies have been made for the motivation of the transfer of the energy through the wireless power transfer but due to the lack of the transmitting cables for the wireless power transmission there are the limitations in their outcomes.

Since Tesla's research and experiments, scientists are trying to find out many other ways to transmit the power to very long distances with safety and more efficiency. The most promising technology that has been developed is known as resonant inductive coupling. By the use of this technology, very strong magnetic link is created between the transmitting coil and the receiving coil thus causing the coils to resonate at the same frequency. One very important benefit of this technology

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is high efficiency of 80% at the distance of the 2 to 3 coil radii from the source coil.

## 3. METHODOLOGY

The three main parts of wireless power transfer are transmitter, inductive coils and receiver. The DC power source consists of a simple step down transformer and a rectifier circuit. A prototype oscillator circuit is used as modified Royer Oscillator. Transmitting and receiving coils are constructed with copper tube. A rectifier is an electrical device that converts alternating current (AC), which periodically reverses direction, to direct current (DC), which flows in only one direction. The process is known as rectification .A voltage regulator is an electrical regulator designed to automatically maintain a persistent voltage level. Figure 1 shows the flow chart of our project in which we are showing how after different processes the energy is being transferred to the load.

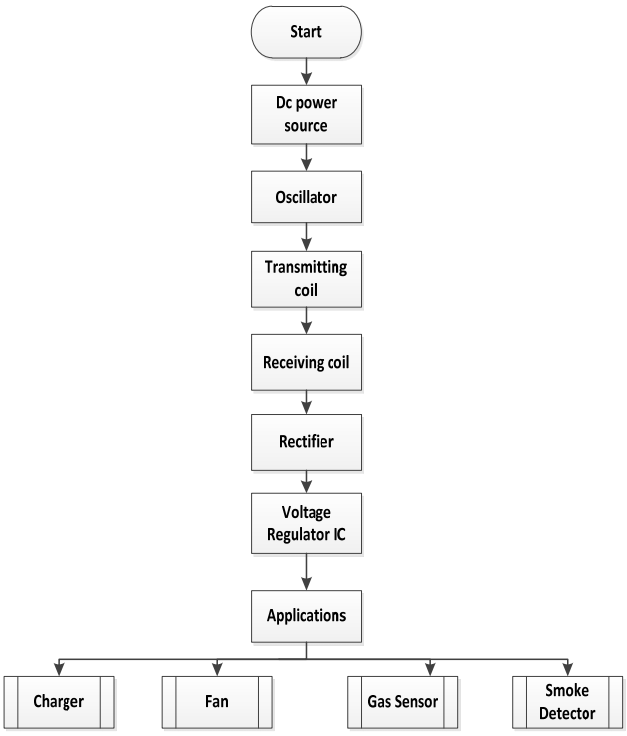


**Fig 1:** Flow Chart of Research Work

The appliances which we operated through wireless power transfer are Fan, Charger, Gas sensor and Smoke detector.

### 3.1 Simulation

In this research work, we have used Proteus software which combines advanced schematic capture, mixed mode SPICE simulation, PCB layout and auto routing to make a complete electronics design system. Proteus simulation of wireless power transfer is shown in Figure 2.

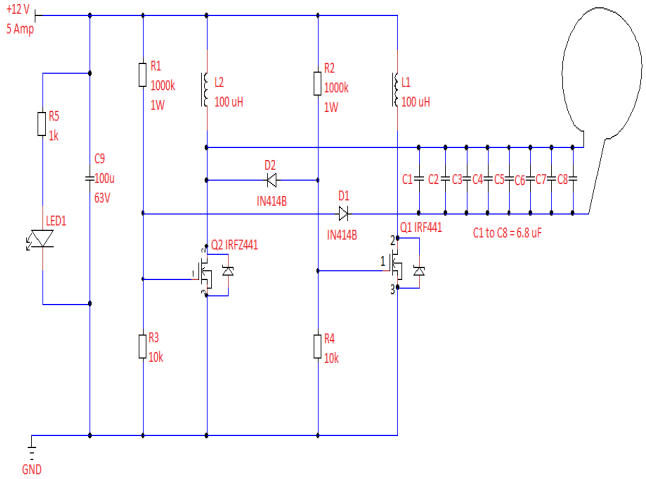


**Fig 2:** Simulation of Wireless Power Transfer using Proteus Software

### 3.2 Basis Of Wireless Power Transfer Using Inductive Coupling

Practical analysis has been done to check the performance of wireless power transfer. In our research work, we will check working of our different applications by glowing LEDs , running a fan, charging a mobile, detecting a smoke and sensing a gas. Input of the transitter will be provided by separate AC source. Output voltage will develop at receiving side through inductive coupling. Experimental structure of different applications are shown in Fig 3.

**Fig 3:** Experimental setup up and collect data

### 3.3 Results by Placing Hurdles between Transmitter and Receiver

We have done experiments by placing different obstacles between transmitter and receiver to check the effect of these materials on our output. The wireless transfer is not much affected by shielding materials such as the presence of books, hands and types of plastic.

#### 3.3.1 By Placing Hand Between Transmitter and Receiver

Experiment has been done for checking the working of project by placing hand between transmitter and receiver inducting coil. This is shown in Fig. 4.

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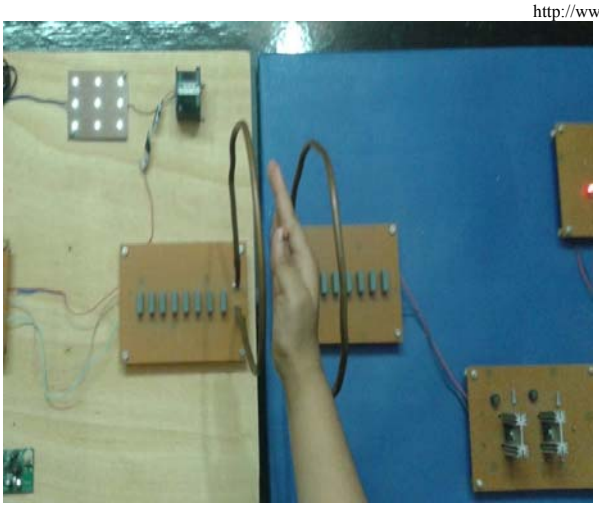

**Fig 4:** Experiment using obstacle hand

### 3.3.2 By Placing Solid Object between Transmitting and Receiving Coil

Experiment has been done for checking the working of project by placing a solid object like book in between transmitter and receiver inducting coil. This is shown in Fig. 5.

**Fig 5:** Experiment using book as obstacle

## 4. OUTCOMES

We conducted experiments on LEDs at receiving end and check how output voltages reduces as we increase the distance between transmitting coil and the receiving coil. At the end when distance become almost 1 foot then output voltage reduces to zero and LED stops glowing. Similarly the graph of efficiency also falls down as we take receiving coil away from transmitting coil. The Table 1 shows the comparison between distance, voltage and efficiency. Fig. 6 & Fig.7 shows the results that have been created according to Table 1.

**Table 1:** Comparison between Distance, Voltage & Efficiency

| Distance (in) | Voltage (V) | Efficiency (%) |
|---|---|---|
| 1 | 11.8 | 95.5 |
| 2 | 11.7 | 94.35 |
| 3 | 10.9 | 87.94 |
| 4 | 8.3 | 66.93 |
| 5 | 6.4 | 51.61 |
| 6 | 4.1 | 33.07 |
| 7 | 4 | 32.28 |
| 8 | 2.25 | 18.14 |
| 9 | 0.08 | 0.63 |
| 10 | 0.04 | 0.32 |
| 11 | 0.01 | 0.08 |

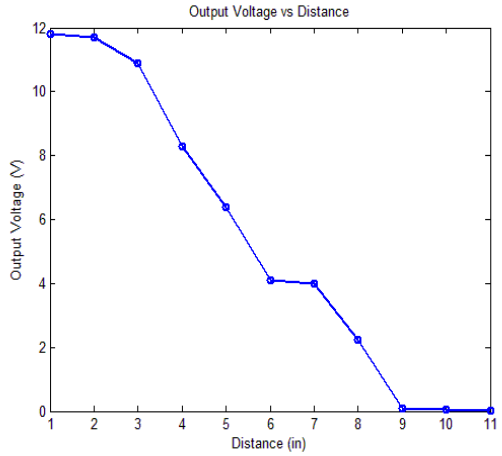


**Fig 6:** Graph between Voltage and Distance

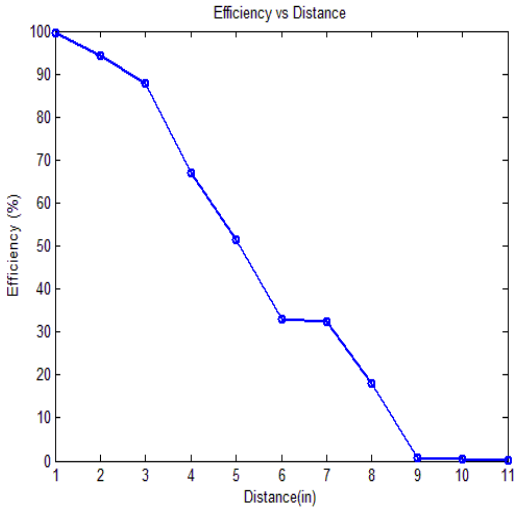


**Fig 7:** Graph between Efficiency and Distance

## 5. CONCLUSION

The main purpose of our research work was to design a device that provides wireless transfer of power at medium distance through inductive coupling. This concept is an Emerging Technology, and in coming years the distance of power transfer can be enhanced as the research across the world is still going on. Wireless power transfer can make a remarkable change in the field of the electrical engineering which eliminates the use of conventional copper cables and current carrying wires. This will lead to no more messy wires and with widespread enough use it could even eliminate costly

batteries. This is of a great use in various fields like wireless sensors, where critical environmental conditions make it troublesome to run wiring. Without wires, power transmission is often a more suitable, greener alternative to conventional plug-in charging.

In [7], the charging of mobile via inductive coupling is done where the distance was restricted to 5cm but in our research work, we have increased the distance to almost 10 inches by changing the number of turns of coils and by increasing the size of coils. Wireless technology will be a key enabler for future smart applications. However, there are still many researches to be made in order to achieve a successful implementation of this technology.

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