

Witricity: Designed to Change the World

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Abstract: Electricity is an integral part of every human being and power transmission by wires is a necessity to fulfill the need of electricity. 'What if we can come out of this tangled wire-theory?' - With this view, Nikola Tesla introduced the concept of wireless power transfer in early 20th century. Wireless Power Transfer (WPT) is not only reliable and efficient but it is also eco-friendly and cost effective. A lot of concepts for WPT are already discussed by researchers, scientists and inventors. In addition to the available works and principles, this paper explains the basic concept, design and implementation of wireless electricity with magnetic induction technique and determining its practical result carried out with the same.

Keywords: Wireless power transmission, magnetic induction, electrical power, WPT, non radiative.

1. INTRODUCTION

Electricity has become an integral part of our life these days. It is the most important source of energy. We use electricity as a powerful source of energy in houses, factories, offices, schools etc.

But generally, whenever we think about electricity, we think about wires which carry electric current. Electricity system with wires is shown in Fig 1.

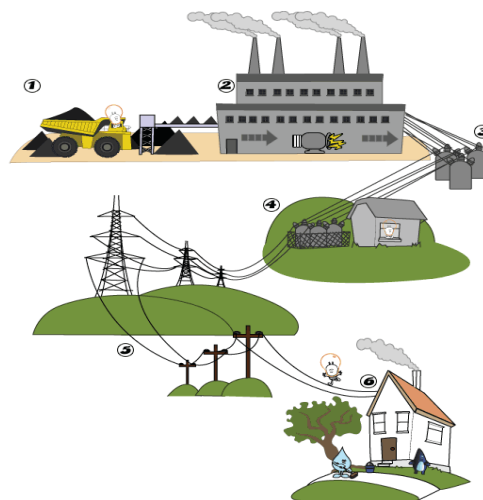


Fig1. Electricity System with wires

No one has ever thought about if there is any way incurring electricity without wires until, the term Witricity came in to the light. Wires are basically the carrier medium through which the physical connection has been made up between source and receiver and the flow of electricity takes place. But in most of cases some amount of power is wasted and the overall performance of the system is degraded. The problem is so emerging that it doesn't only tainted the performance but it is expensive, inefficient and unreliable. Also it has more chances of getting a shock due to structural issues.

It was Nicola Tesla whose dream has finally been become reality after his experiment with the copper coil. Tesla was an American electrical engineer and scientist who introduced the primary idea about Witricity. The motive behind the proposal is the massive distribution of free electricity. He proposed a method of wireless power transmission without using any physical medium now known as Witricity. During early 20th century he started experimenting with Radio Frequency Resonant Transformers which generates Alternate Current [1]. In the beginning, he was able to transmit the power for short distances and came to a conclusion that he can increase the distance by using inductive and capacitive coupling. But it was failed due to its 'near -field effect' and the diffusion of the wireless power. However, Tesla was passionate about developing a wireless mass power distribution system that could transmit power into factories and houses directly [2]. So, he began building up of a grand high-voltage coil facility, the Wardencllyffe Tower at Shoreham, New York and proposed it as an archetype transmitter for a 'World Wireless System' that can transmit power worldwide, but by 1904 he ran out of the research funds and the facility was never completed and at that time a practical and cost efficient method of wireless power distribution could not be developed [3]. A snapshot of Nikola Tesla, his experiment and Wardencllyffe tower is shown in Fig 2.

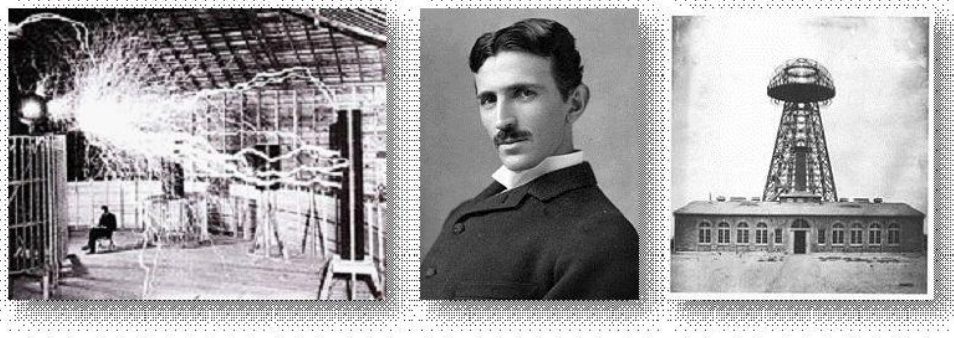


Fig2. Nikola Tesla, his experiment & Wardencllyffe Tower

However, whatever seemed Tesla's fascinating dream that time, rejuvenated by a researcher team from Massachusetts Institute of Technology (MIT) headed by Mr. Marin Soljagic [4]. They have proposed the term 'Witricity' for the first time by using Tesla's concept into practice and powered a 60W light-bulb wirelessly at a distance of 7 feet with an overall efficiency of 40%. Later on this method has become popular and well known to everyone in this field.

1.1. Witricity: The Basic Idea

Then term Witricity was coined by the MIT Researcher team, was working on a project for transmitting power wirelessly [5]. The term Witricity is defined as the capability to supply electrical energy to distant appliances without wires using oscillating magnetic fields.

The research begins with the idea of charging mobile phone wirelessly. It was Prof. Soljagic who always stuck up with the mobile battery dead. And there is always a need to charge with wires and not only that but there are a lot more technical gadgets to charge again and again. So, he wants to develop a facility which can took care of the charging battery at its own. And that is how the idea has been generated [6].



Fig3. Charging with wires

According to the basic concept, two objects having same magnetic resonance system and of same resonating frequency have been coupled to exchange energy and squandering comparatively less energy to the unconnected off-resonant objects.

1.2. Why it is Required?

Nicola Tesla had a dream to provide free electricity to masses without having trouble of any bills or surcharges. This was the basic need then. But now, in the world of globalization, the needs of individuals and commercial entities have been increased. And with the rapid development in electronic science blows a revolution in the society. Now, everyone needs to run their electronic devices with the help of energy [7]. So we are using chemical energy sources i.e. battery, which is cost ineffectual and time taking process. With the help of wireless power, one energy source can pass energy to many receivers simultaneously with an efficient manner.

2. BASIC TECHNIQUES AND IDEAS FOR WITRICITY

According to the literature review and previous work available, here are some basic techniques applied to Witricity [8].

2.1. Electromagnetic Radiation

In this method, the radiative energy has been released by some electromagnetic processes and the transmitted power is dissolute in all directions. So the amount of power needed cannot be received by the receiver [9]. It can be used to transmit information in long distance range.

2.2. Optical Technique

In this method, the energy is transmitted in the form of light for wireless power transmission and uses lasers. It has the directional electromagnetic waves and the energy can be transmitted to large areas [10]. This method is successful only for a static receiver. The way from transmitter to receiver should be clear for standard function.

2.3. Microwaves

This technique is radiative in nature. The energy can be transmitted using microwave frequencies in wireless power transmission [11]. The distance range for this method is high but it is not at all eco-friendly or safe to human beings because the microwave frequencies on a higher power levels can harm people.

2.4. Electrodynamics Induction

Electrodynamics induction method is completely eco-friendly, non-radiative and safe method of wireless power transmission. In this method, two same frequency resonance objects exchange energy. There is possibility of higher range because it has much freedom of placement of transmitter and the receiver. The researcher team from MIT used the same method to coin the term Witricity in 2007 [12].

2.5. Magnetic Induction

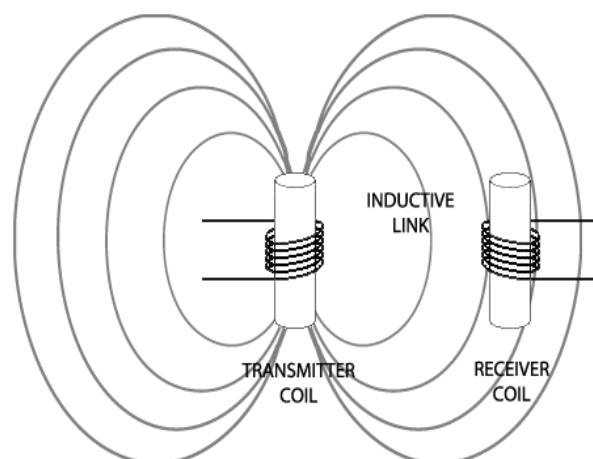


Fig4. Magnetic Induction [14]

This technique is cost effective and reliable method of wireless power transmission which is non radiative in nature. It follows the law of mutual induction [13-16]. In this method, a coil carrying current is generating a magnetic field. A second conducting coil, when brought close to the first, it captures some portion of that oscillating magnetic field, which in return, induces an electric current in the second coil. The current generated in the second inductive coil can be used to supply energy to different devices [17-20].

This paper is an addition to wireless power transmission using this magnetic induction technique.

3. EXPERIMENTAL DESIGN AND IMPLEMENTATION TECHNIQUE

Magnetic induction is a cost effective, trustworthy, proficient, protected, and eco-friendly method for wireless power transmission.

As this method is non-radiative in nature, the electrical energy can be transmitted from one place to another without using wires.

The basic concept behind electromagnetic approach of WPT is magnetic induction between two coil say transmitting and receiving coil. When transmitter coil is energized then it generates energy and when receiver coil receives this energy, a potential difference is developed across its terminals. The potential difference developed in receivers is directly related to distance between transmitter and receiver coil. The basic principle of an inductively coupled power transfer system is shown in Figure 1. It consists of a transmitter coil L_1 and a receiver coil L_2 . Both coils form a system of magnetically coupled inductors. An alternating current in the transmitter coil generates a magnetic field which induces a voltage in the receiver coil. This voltage can be used to power a mobile device or charge a battery.

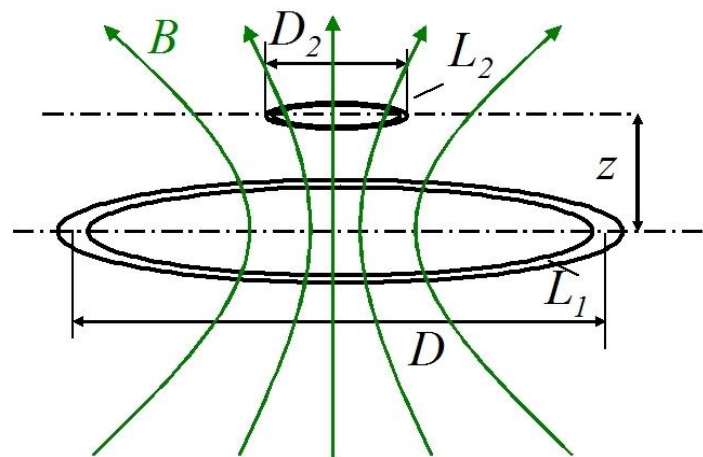


Fig5. Typical arrangement of an inductively coupled power transfer system [15]

The block diagram using magnetic induction is shown in Fig. 6

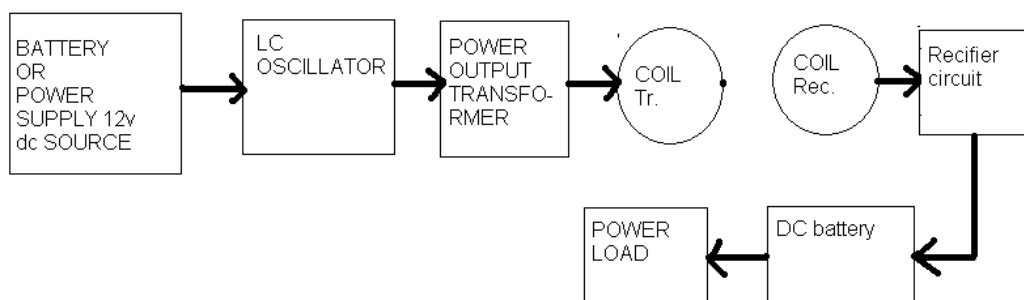


Fig6. Block Diagram of WPT using Magnetic Induction

This system contains two sections, the transmitter section and the receiver section. Where the transmitter coil converts the DC power to high frequency AC signal and receiver coil receives the power and converts it into DC signal.

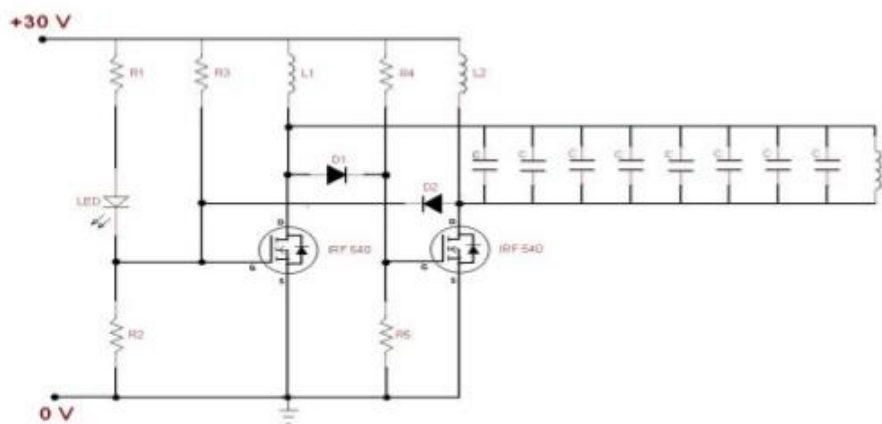


Fig7. Transmitter section

Description of Transmitter section- it contains following parts-

DC power Source has a step down transformer that step downs the supply voltage to a desired level, and a rectifier circuit convert that AC voltage to DC signal. A modified **Oscillator circuit** is used in this design. With this circuit one can easily achieve a high oscillating current for the transmitter coil. Two N channel enhancement power **MOSFET** are used. It also has a transmitter coil L (inductor) and the resistors R1, R2, R3 and R4 (works as a biasing network for Q1 & Q2).

The operating frequency of the oscillator is determined by the resonance formula given below,

$$F = \frac{1}{2} \times \pi \times \sqrt{LC}$$

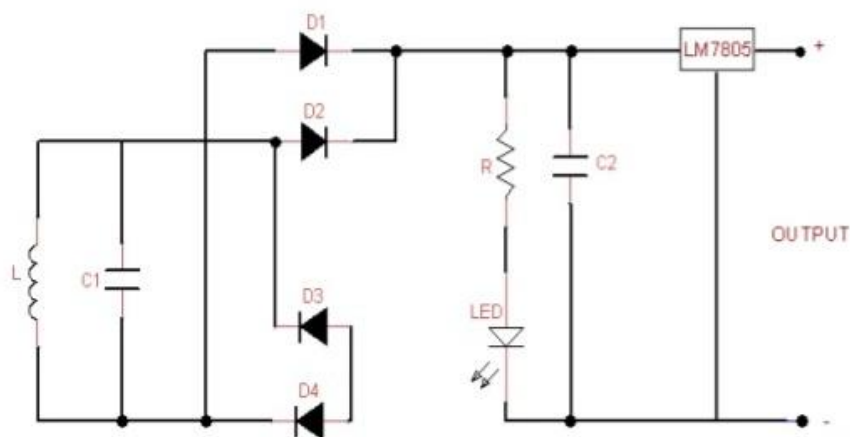


Fig8. Receiver section

Description of receiver section- It consists of a receiver coil, rectifier circuit and a voltage regulator IC. The rectifier circuit in the receiver section converts this AC voltage in to DC. Voltage control IC helps to provide a constant limited regulated output voltage to the load for charging. Here the voltage regulator IC is of LM 7805. The IC gives a regulated 5V as its output.

The impedance matching of transmission coil is made by 250 turns of 23 no. wire at 6 inch diameter former. The resultant inductance gives maximum output with the output of transformer. The other coil at receiver end is also with the same specifications as of transmitting coil.

4. RESULTS AND DISCUSSIONS

Here we clearly found that this coil will get ac voltage of around 2.5 to 6 volts depends upon the distance between two coils. The output of secondary coil is further rectified and connected to the rechargeable battery of 4.5-6 Volts. Any DC load can be directly connected to this. One may use any 6 volts 20Watt output inverter with this to show power LOAD at output. We can use a CFL or tube light for this.



Fig9. Mobile charging with WPT by magnetic induction technique [16]

4.1. Advantages of the Design

High transmission integrity and low loss

Low maintenance cost

Environment friendly

Need for battery is eliminated

Unaffected by weather, time and season

Effective use for devices that consume mid range power

Every coin has two sides and every discovery has pros and cons. The major disadvantage of this method is a biological impact on wireless power transmission. One common criticism of the Tesla wireless power system is regarding its possible biological effects. While calculating the circulating reactive power, it was found that the frequency is very small and such a frequency is very biologically compatible.

5. CONCLUSION

The transmission of power without wires is not a theory, it is now a reality. The electrical power can be economically transmitted without wires. Many researchers have worked and established in numerous observations, experiments and measurements, qualitative and quantitative. Nikola Tesla is the father of this invention. Wireless transmission of electricity have tremendous merits like high transmission integrity and Low Loss (90 – 97 % efficient) and can be transmitted to anywhere in the globe and eliminate the need for an inefficient, costly, and capital intensive grid of cables, towers, and substations. The system would reduce the cost of electrical energy used by the consumer and get rid of the landscape of wires, cables, and transmission towers. It has negligible demerits like reactive power which was found insignificant and biologically compatible. It has a tremendous economic impact to human society. Many countries will benefit from this service.



Fig10. Witricity in future

In future, a significant research can be carried out in the area of wireless power. Reduced size wireless power transmission systems with better efficiency over large distances can be developed. Efficient wireless power transmission systems can be designed in future to transmit tens and thousands of KW power over hundreds of miles with maximum efficiency and performance.

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