Advance Wireless Power Transfer System

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***Abstract*—Every human being in the modern era needs a mechanism that transfers power extremely efficiently. One of those systems that has seen a lot of activity in recent years is wireless power transfer. Wireless power systems deliver electricity without the need for cables and boost efficiency by lowering power loss. Various techniques for wireless power transfer are covered in this study. Furthermore, a qualitative comparison of the approaches is covered, focusing on factors such as separation distance, power transmitting capacity, cost, efficiency, and safety. In addition, we talk about the latest advancements in wireless power transfer technologies, including PMA, A4WP, and Qi. Additionally, WPT has several applications, including those in solar power satellites (SPS), medical science, and other fields.**

***Index Terms*—Wireless power transfer, induction coupling, resonance coupling.**

I. Introduction

THE transfer of electrical power in a reliable and efficient way is always challenging for the designers and engineers. Currently, wires and underground cables are used to transport all electrical power from the generating units to the distribution station. Losses resulting from the material's resistance are a significant problem in these kinds of systems. In general, 26% of power is lost during transmission and distribution.

The use of portable devices, such as electric vehicles and mobile robots, has increased in modern technology. Mobility is the main concern of these equipment; that is, they are not connected to the main source of power.

The primary source of motivation for researchers is each of these issues. Wireless power transfer was first conceptualized by Nikola Tesla [1]. However, a lack of finance and technological advancements has left this technology from the Tesla era underdeveloped. However, study has been ongoing for the past few years, and new developments have been noted in the sector.

Wireless Electricity Transfer or WET is a process to supply power through an air gap without using any wires or physical links. In this wireless system, the transmitter device generates a time-varying or high-frequency electromagnetic field, which transmits power to the receiver device without any physical connection. The receiver device extracts power from the magnetic field and supplies it to electrical load. Therefore, to convert the electricity to an electromagnetic field, two coils are used as transmitter coil and receiver coil. The transmitter coil is powered by alternating current and creates a magnetic field, which is further converted into a usable voltage across the receiver coil.

Wireless power transfer can be achieved by several methods. Here we discussed a basic low powered wireless transmitter circuit to glow an LED.

II. Literature Review

- Following extensive research in the field of electromagnetics by numerous trailblazers, Michael Faraday developed the electromagnetic induction law, which serves as the foundation for wireless power transfer.
- In 1891, Nikola Tesla was the first pioneer who started working on wireless power transfer system in his "experimental station" at Colorado, by using Tesla coil [1].
- Tesla wanted to develop a wireless power system that is capable of transmitting power over long distances. He proposed many such systems.
- Nikola Tesla used a resonant circuit that was grounded on one end to successfully light a tiny incandescent lamp. The current that is induced in the coil lights the bulb.
- Tesla also created the Wardenclyffe Tower to demonstrate wireless electrical power transfer and to facilitate transatlantic radio telephone service [2].
- In order to facilitate wireless power charging and powering of portable devices with a capacity of up to 5W and a separation distance of 4cm, the Wireless Power Consortium was founded in 2008 to link all manufacturers of Qi inductive power standards.
- Energy harvesting also called power harvesting which is the conversion of ambient energy from the environment to electric power which is mainly used to power mini watts wireless electronic devices. The ambient energy is produced from stray electric or magnetic field or radio waves.

III. Working Principle

A. Working Process

This type of WPT is simply based on inductive coupling between two coils. This is a type of near-field technique measuring with appliance near the source. It is generally based on the principle of mutual induction, where two coils are placed vicinity to each other and there is no physical connection between these two coils. The simplest example is a transformer where the transfer of energy takes place due to electromagnetic coupling.

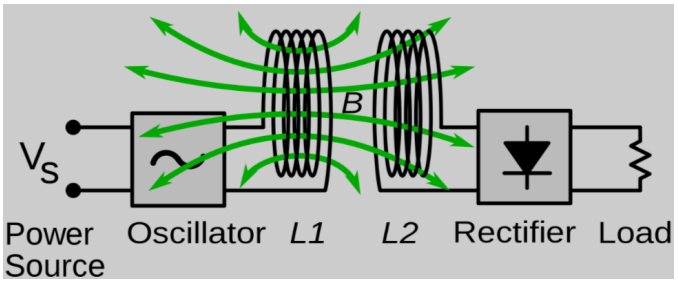

Fig. 1. Inductive Coupling

The circuit consists of two parts- Transmitter and Receiver. In transmitter section, the transistor is generating high-frequency AC current across the coil and the coil is generating a magnetic field around it [3]. As the coil is center tapped, the two sides of the coil start to charge up. One side of the coil is connected to the resistor and another side is connected to the collector terminal of NPN transistor. During the charging condition, the base resistor starts to conduct which eventually turns on the transistor. The transistor then discharges the inductor as the emitter is connected with the ground. This charging and discharging of the inductor produce a very high frequency oscillation signal which is further transmitted as a magnetic field.

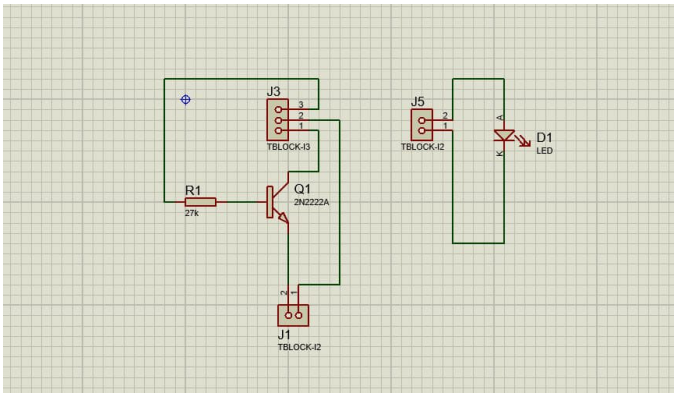

Fig. 2. Circuit Schematic Diagram

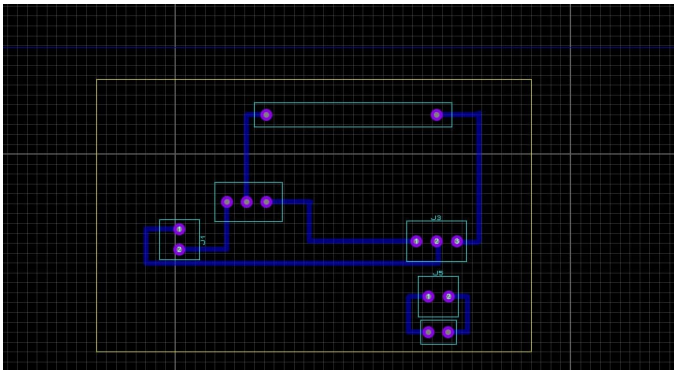

Fig. 3. 2D Visualization

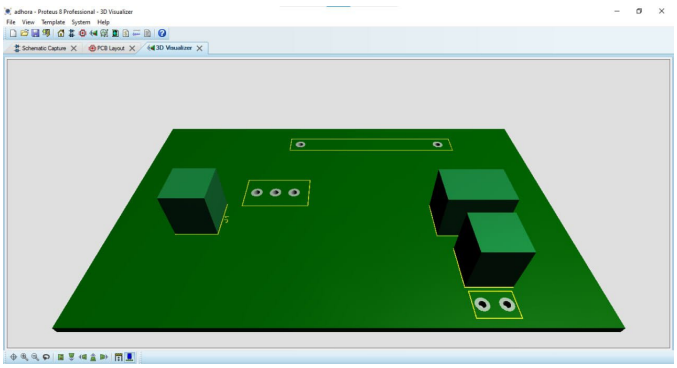

Fig. 4. PCB layout (front)

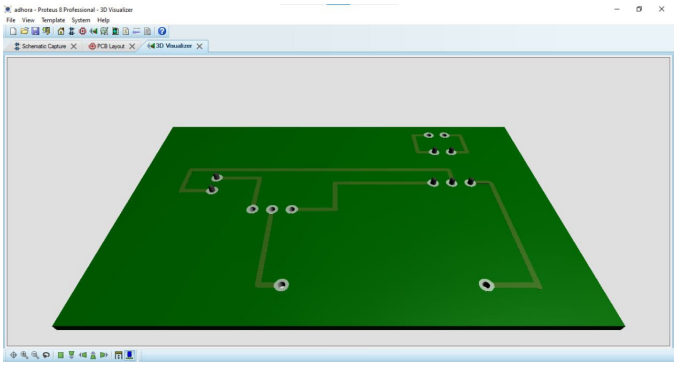

Fig. 5. PCB layout (back)

On the receiver side, that magnetic field is transferred into the other coil, and by the Faraday's law of induction, the receiver coil starts producing EMF voltage which is further used to light up the LED.

Fig. 6. PCB Implementation

B. LIMITATION of THE CIRCUIT

This small circuit can work properly but it has a huge limitation. This circuit is not suitable to deliver high power and has input voltage restriction. The efficiency is also very poor.

The range can be very less up to few cm and the separation distance is very less than the coil diameter. To overcome this limitation, a push-pull topologies using transistors or MOSFETs can be constructed [3]. However, for better to improve the transmission distance, wind up the coil properly and increase the no. of turns in the coil.

IV. HARDWARE IMPLEMENTATION

A. TRANSISTOR

A transistor is a semiconductor device that is used to power and amplify electrical impulses. It is among the fundamental components of contemporary electronics. It has at least three terminals for connecting to an electronic circuit and is made of semiconductor material. The current flowing through a different pair of transistor terminals is controlled by a voltage or current applied to one pair of terminals. A transistor can magnify a signal because the regulated (output) power can be greater than the controlling (input) power. While many more transistors in small form are found incorporated in integrated circuits, some are packaged individually. Transistors are regarded by many as one of the greatest innovations of the 20th century because they are the essential active components in almost all modern electronics.

B. LED

A light-emitting diode (LED) is a semiconductor light source that emits light when current flows through it. Electrons in the semiconductor recombine with electron holes, releasing energy in the form of photons. The color of the light (corresponding to the energy of the photons) is determined by the energy required for electrons to cross the band gap of the semiconductor. White light is obtained by using multiple semiconductors or a layer of light emitting phosphor on the semiconductor device.

C. Resistors

A resistor is a passive two-terminal electrical component that implement electrical resistance as a circuit flow, adjust signal levels, to divide voltages, bias active elements, and terminate transmission lines, among other uses. High power resistors that can dissipate many watts of electrical power as heat, may be used as parts of motor controls, in power distribution systems, or as test loads for generators. Fixed resistors have resistances that only change slightly with temperature, time or operating voltage. Variable resistors can be used to adjust circuit elements (such as a volume control or a lamp dimmer) or as sensing devices for heat, light, humidity, force, or chemical activity. Resistors are common elements of electrical networks and electronic circuits and are ubiquitous in electronic equipment. Practical resistors as discrete components can be composed of various compounds and forms. Resistors are also implemented within integrated circuits.

D. PCB

A printed circuit board (PCB) mechanically supports and electrically connects electrical or electronic components using conductive tracks, pads and other features etched from one or more sheet layers of copper laminated onto and/or between sheet layers of a nonconductive substrate. Components are generally soldered onto the PCB to both electrically connect and mechanically fasten them to it. Printed circuit boards are used in all but the simplest electronic products. They are also used in some electrical products, such as passive switch boxes. methods, as components are mounted and wired in one operation. Large numbers of PCBs can be fabricated at the same time, and the layout only has to be done once. PCBs can also be made manually in small quantities, with reduced benefits.

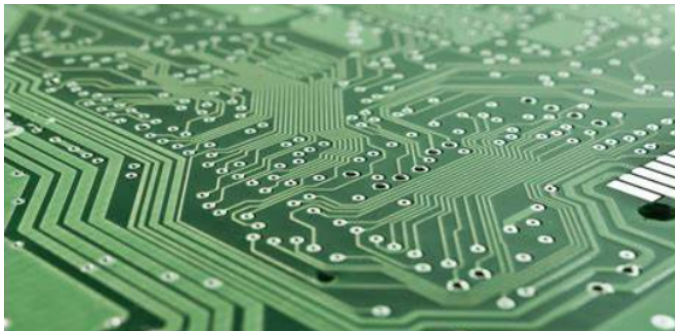

Fig. 7. PCB board

V. METHODOLOGY

In this, power is transferred between coils of wire by a magnetic field.The transmitter and receiver coil together form a transformer where current through the transmitter coil(Tx) creates an oscillating magnetic field [4].The magnetic field passes through the receiving coil(Rx) induced voltage which creates current in the receiver and it drives the current to the LED(load) and then the LED gets lights up.

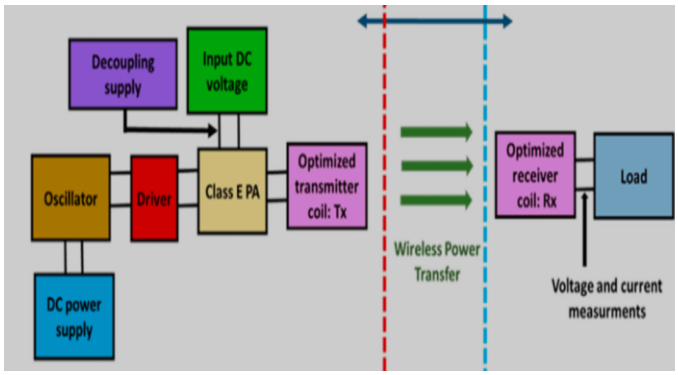

Fig. 8. Block Diagram

VI. ADVANTAGES AND DISADVANTAGES

A. ADVANTAGES

- Human comfort is enhanced by the lack of chording or wiring issues, which facilitates easier mobility.

- Large-scale heating and power outages are not an issue.
- Because there are no cables used, the total cost of the system is reduced.
- A reduction in power loss results in an increase in overall efficiency.
- Because there is no exposure to the environmentally friendly atmosphere, it does not offer rusting.
- It offers ranges of power levels and separation distance between coils.

B. DISADVANTAGES

- WPT methods use the electromagnetic radiation for power transfer and the main effect of electromagnetic wave is its biological impact which harms human beings and animals.
- Biological impact of inductive coupling and resonance coupling is far less than compared to the microwave power transmission technique.
- There is also a limitation of separation distance and power capacity.
- Initial cost is very high for implementing WPT system.

VII. APPLICATIONS OF WPT

A. CHARGING DEVICES

By substituting wired charging options, WPT can eliminate the conventional charging system in areas with current power requirements. Wireless power transfer offers a universal cordless power solution for all portable gadgets, which eliminates the need for each portable consumer good to have its own charging method. Numerous gadgets like as smartwatches and smartphones that have integrated wireless power solutions are already on the market. The ability to create fully waterproof products is another advantage of WPT for designers [3]. The device can be designed to be water resistant because wireless charging eliminates the need for a power connector. Additionally, it efficiently provides a large range of charging options.

B. ELECTRICAL VEHICLES

The most important application of WPT system is solar power satellite that uses the microwave for energy transferring. Satellites are generally equipped with solar power transmitter and receiver antenna. Solar panel converted the generated electricity into high power microwave beams and directed toward the ground station receiver antenna. The major problem with this system is it biological effect of microwave radiation on human and animals, if they are distracted from their path. The receiving zone of SPS is much larger for getting a small amount of power. For achieving 750MW power with power intensity of 1mw/cm2, we have to take an area with 10KM diameter so that radiation level is in safe zone.

C. MEDICAL DEVICES

The most important application of WPT is in medical science. As we know medical device uses a very small amount of power. Some medical devices are LAVAD heart assist pumps, pacemakers and infusion pumps. These devices one implemented in human body. Now for the replacement of battery, there is a need of surgery after a particular period. With using the WPT technology, the power can sufficiency supplied to medical devices without harming human body.

VIII. CONCLUSIONS

After discussing many elements of wireless power transmission systems, it is clear that it is a crucial research field for electrical engineers with significant future potential in power generation and transmission. Our analysis shows that magnetic resonance coupling is the most efficient method in all respects. WPT provides comfort, convenience, safety, dependability, cheap cost, and high efficiency simultaneously, making it one of the top research fields in electrical engineering.

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