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Wireless Power Transmission

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Abstract: This paper contains the information about the project named “Wireless Power Transmission”. It is the system for transmitting the electrical power from a transmitting source to load wirelessly using coils. In this project two coils are used, one on the transmitter side called as primary coil and another at the receiver side called as secondary coil. This project is not similar to the wireless signal transmission which is used in cell phones. In this method of transmission, power from electrical source is transmitted in the form of magnetic flux. In this project, the AC power is supplied to the transmitting circuit which converts the AC Power into magnetic flux using primary coil. When secondary coil interacts with this flux, an E.M.F. will be induced in the secondary coil. In this way, electrical power will be transmitted without using wires.

Keywords: Electrical power Transmission, Coils, Magnetic Rays, Flux, E.M.F.

I. INTRODUCTION

Wireless Power Transmission is a method for the transmission of electrical power from a transmitting source to a receiver (electrical load), such as an electrical power grid or a consuming device, without using manmade conductors like co-axial cable, twisted pair cable or copper wires. It is useful to power electrical devices in case where connecting wires are not possible. This project is not same like the transmission of signal using electromagnetic is used in radio operating devices likes FM radio, cell phones, routers etc. In this mode of transmission, power is transmitted in the form of magnetic flux. Electromagnetic waves causes harm to humans as well as other living beings, while magnetic rays do not cause harm to any living organism.

A. The conventional wired method:
Conventionally copper wires are used to supply electricity (AC Power) to residential buildings, schools and commercial buildings. Electrical stations produces AC power that is transmitted over a large geographical area using overhead wires which is then routed to electrical meter rooms and then finally distributed to individual homes and offices via transmission lines (copper wires) and step-down transformers. Most of our electrical devices have AC power wires/cords. If wired method is used, the totality of chords (wired connections) will increase which will just make a network of useless wires. This will make a complicated design.

II. NEED OF WIRELESS POWER TRANSMISSION

- One of the major drawbacks in wired power system is the losses taking place during the transmission and distribution of electrical power. The approximated amount of power loss during distribution and transmission is 26%. The main reason for this power loss is the resistance of wires that are used for grid [1].
- We can improve the efficiency of power distribution and transmission to a little extent by using underground cables and high strength overhead conductors (composite overhead conductors) that employ high temperature super conductor. However, the transmission efficiency is still less (inefficient).
- As per the World Resources Institution (WRI), the percentage power loss during transmission and distribution in India because of electricity grid is around 27%.According to some Indian Government Agencies the percentage power loss is 30%-40% and more than 40%. This attributes to theft and technical losses.
- Power transmission using wired way doesn’t provide portability for the devices or instruments consuming power [1].
- Wireless Power Transfer (WPT) allows us to use air as a medium for the transmission of electricity without using any kind of current carrying conductors. It can deliver electricity or power from an AC source to compatible devices or batteries without using wire or any kind of physical connectors. It can also used to charge mobile cell phones, tablets, electric cars or bikes, drones, and transportation equipment’s. It might also allow us to transmit the power gathered by arrays of solar panels wirelessly. Wireless transmission of power is emerging as a trend to transmit power and charge various devices without any wired medium.

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III.LITERATURE SURVEY

The idea of transmitting power wirelessly is not new. In fact it is widely popular since 19th century, when this technique was implemented conduction based wireless power transmission system instead of using a resonance based magnetic field to transmit electrical power without wires. As the method was radiative, large amount of electrical power was getting wasted [2]. Nikola Tesla was successful to light an electric bulb without using wires at his Colorado Springs Lab by using electro-dynamic induction (resonant inductive coupling).

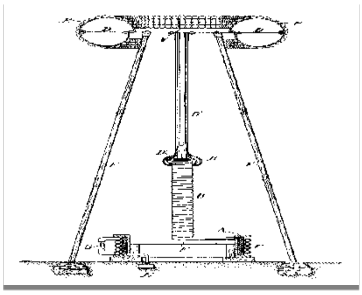

Fig. 1 An image depicting Nikola Tesla's patent for an "apparatus for transmitting electrical power", 1907[6].

Three electric bulbs were lit by a power source kept 60 feet (18metres) away from the bulbs, and the complete demonstration was properly documented. Tesla had planned to transmit power without using wires i.e. wirelessly across the Atlantic Ocean with his Long Island based Warden clyffe Tower. This never happened due to several problems, including timing and funding [6].

Wireless power transmission technique makes use of time-varying magnetic, electric, or electro-magnetic fields. This technique can be used to power electrical and electronic devices where wires cannot be used or at the places where wired interconnection is impossible or inefficient.

• In 1826, Andre-Marie Ampere developed ampere's circuital law that shows that the electric current flowing through a conductor will produces a magnetic field [1, 4].

• In 1831, Michael Faraday developed Faraday's law of induction, describing the E.M.F. gets induced in a conductor when it comes in contact with a time varying magnetic field [1, 4].

• In 1862, James Clerk Maxwell done some modifications in these laws along with some other observations, experiments as well as equations of electricity, magnetism and optics into a consistent theory, deriving equations called as Maxwell's equations [1,4].

These laws together form the base for wireless power transmission [1].

A. Radiative or Far-Field technique:

In radiative or far-field techniques, electro-magnetic radiation, like laser beams power or microwaves is used to transmit power wirelessly. These techniques are capable transfer energy over a longer distance but the transmitted signal must be directed toward the receiver. Familiar applications related to this type of technique are wireless powered drone aircraft and solar power satellites [3].

B. Near-field (non radiative) technique:

The near field components of magnetic and electric fields are approximately same as quasi-static oscillating dipole fields for large relative distance. These fields reduce with the cube of distance: (Drange/Dcoil). As the power is proportional to the square of the strength of the field the transferred power reduces/decreases as (Drange / Dcoil) −6 or 60 dB per decade. Therefore, in order to transfer power over a short range/distance only capacitive and inductive coupling can be used within a few times the diameter of the antenna device Dcoil, Dissimilar the radiative type systems in which maximum radiation occurs when the dipole antennas are oriented transverse with respect to the direction of propagation, with dipole fields the maximum coupling occurs when the dipoles are oriented longitudinally. In near field techniques, inductive coupling is used to transfer the power between two coils of wire, or by electric fields using capacitive coupling between metal electrodes. Inductive coupling is the most widely used technique for wireless transmission of power. Its applications include charging portable devices like phones and electric toothbrushes, RFID tags, and chargers for cell phones. [3]

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Merits and Demerits of methodologies discussed in some papers

- **One-Dimensional Array of Free Access Mat for 2.45GHz -**The efficiency is measured as 38%. We need to adjust the frequency of the device at 2.45GHz for ISM band usage and better efficiency. The method used here provides good efficiency but according to us it is expensive to produce.
- **Relaxation Oscillator at the transmitting end and two coils as transmitter and receiver-**This method allows distance of 0.18 cm between the two coils, it is possible to transmit enough power to power a 40 W light bulb. Distance achieved in this project is not meeting the need of our project.
- **The design of transmitting and receiving antenna at 915MHz -** Theoretically the circuit can charge a AA battery of 1.2volts, 200mAh with a total coverable distance of 1.5m. The output voltage is relatively very low, the distance as per the proposal is good but practical output is yet to be defined by the author.
- **Resonant Inductive Coupling-** This method can provide efficiency up to 80% at a distance of 10 cm between Transmitter and receiver. The project implemented by author provides good efficiency for wireless transmission of power i.e. Resonant Inductive Coupling.

IV. PROPOSED SYSTEM

The problems discussed as well as the efficiency of wireless power transmission using conduction based technique can be increased by using resonant inductive coupling technique. As we can see in fig. 1 the system uses the inductive coupling method to transfer the electrical power by magnetic flux between any two resonant circuits i.e. tuned circuits, one at the transmitter and another at receiver. Each resonant circuit consists of a coil. The coil is made of enamelled copper connected to a capacitor, or a self-resonant coil or other resonator with internal capacitance. Both the coils are tuned such that they resonate at the same frequency; this frequency is called as resonant frequency. Tuning both the coils at same resonant frequency results in increased coupling efficiency, similar to the vibrating tuning fork induces vibration into any fork at a particular distance if they are tuned at the same frequency (pitch) [3].

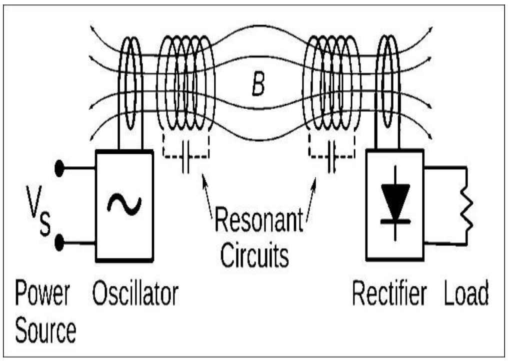

Fig. 2 Resonant Inductive Coupling

The basic idea behind the resonant inductive technique for coupling is that at high Q factor the resonant circuits tends to exchange energy at a higher rate compared to what they lose due to damping internally. This is why the resonance technique can be used to transfer maximum amount of power to a greater distance, using the weaker magnetic flux (field).Therefore Resonant inductive coupling can be used to achieve greater efficiency up to the ranges of 4 to 10 times the diameter of coil (Dcoil). [3]

Another important advantage is that resonant circuits strongly interact with one another resulting in a negligible amount of power absorbed by the nearby stray objects.

Is it possible to transmit power through the materials other than air?

Yes, it is possible to wirelessly transmit power through almost all non metallic materials, including solids like plastics, wood, glass, textiles, brick, liquids and gases.

When an electrically conductive or metallic material is kept within close vicinity of a magnetic field, the metallic object will absorbs the power from the magnetic field produced by the transmitter, which heats the material. This in turn, affects the system efficiency because of the power being lost due to absorption. Induction based cooking is based on this technique in which the less efficient power transfer from the cook top results in heat to enable cooking. [5]

How efficiency is calculated for wireless power transmission?

The percentile amount of power received as compared to transmitted power is called as efficiency receiver i.e. while transferring power from a source to a receiver if 70% power is received as that of transmitted power that means 30 % power is lost during transmission from the socket to the receiving system.

To calculate the efficiency theoretically we can use the formula:
Efficiency=Dc output power /dc input power. [5]

V. ADVANTAGES

- Transmission of electricity is possible at the places where the wired connections cannot be established.
- High efficiency than wired power transmission.
- Power transmission is possible in many directions simultaneously.
- Harmless to living beings
- E-waste can be reduced as need of wires decreases
- Portability since no wire is used between transmitting source and receiving load.

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VI. APPLICATIONS

- To act as a charging source for portable devices like laptops, mobiles, etc.
- To power electronics and electrical devices or appliances.
- This technique can be used to transmit power from one part of the country to another.
- To act as a source for electric vehicles like cars, buses, motor cycles, etc.

VII. BLOCK DIAGRAM AND WORKING

Wireless power transmission work on the principle of inductive coupling between the coils. In this technique two copper coils are arranged one at transmitting end and another at the receiving end, the transmitting coil is connected to the power source (230volts, 50Hz AC) while the receiving coil is connected to the appliance/device at the receiving end. When the power is turned on, the transmitting coil converts the supplied input power to magnetic flux, which oscillates at specific frequency. This magnetic flux gets induced into the coil at the receiver in the proximity to the transmitting coil, which in turn induces E.M.F. in the receiving coil. This induced E.M.F. can be used to supply power to electrical and electronic devices.

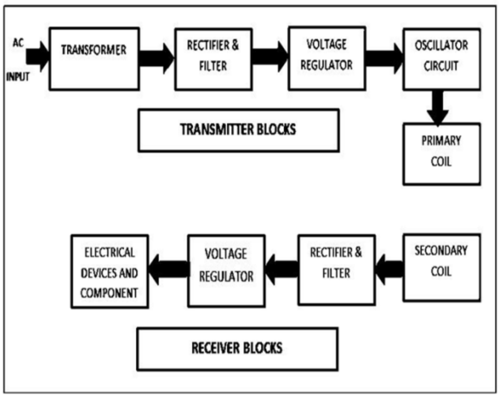

Fig. 3 Block Diagram

As shown in the block diagram in fig. 2, 230 volts, 50Hz AC power is supplied to the input of step down transformer at primary circuit which then gives output to rectifier which gives pulsating DC and finally it is supplied to the oscillator circuit after purifying it using filter and regulating it using the voltage regulator. The oscillator used here is an astable

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multivibrator designed using IC555.This oscillator is used to generate oscillations in primary coil. Secondary coil at a distance resonates at the frequency similar to as that of the primary coil due to which the power transfer takes place. Signal received at the receiving end is rectified and smoothened using rectifier and filter. Desired DC voltage can be produced by using differed voltage regulator or a single variable voltage regulator.

A. FIGURES REPRESENTING BLOCK DIAGRAM

Fig. 4 Transmitter Circuit

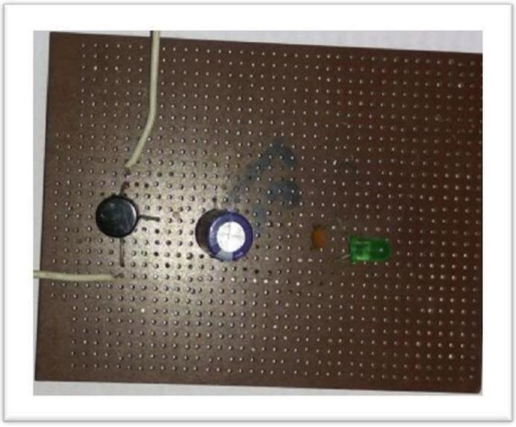

Fig. 5 Receiver Circuit

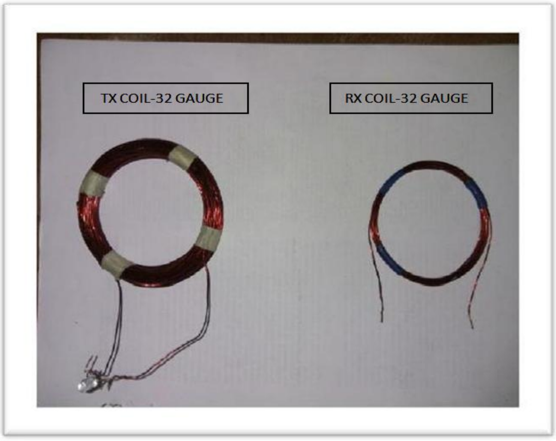

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Fig. 6 Coils Set 1 (Transmitting and receiving coil)

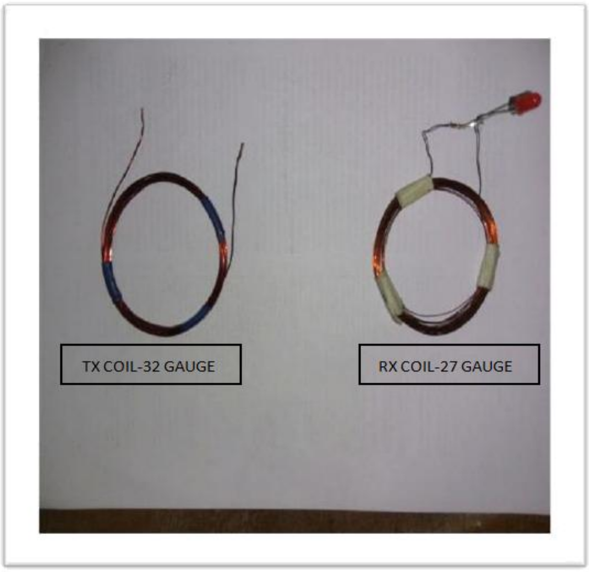

Fig. 7 Coils Set 2 Transmitting and receiving coil

VIII. OBSERVATIONS

The magnetic flux should satisfy certain conditions like it should be time varying, if not; power transmission doesn't takes place.

- There is a loss of power during transmission if there is any strong Ferro-magnetic substance within the field created by the magnetic flux from transmitting coil.
- Possibility of "energy theft". Someone can be using your power.
- As distance increases, efficiency decreases.

IX. RESULTS

Different circuits and coils of different dimensions were designed and tested during this project and with that we concluded that as Magnetic wires are used here to design the coil which is the major component here, it can give us maximum efficiency and its efficiency depend on various factors :

- AGW of the magnetic wire.
- Diameter of the coil.
- Number of turns of the wire.
- Input oscillation frequency
- Distance between the primary and secondary coil.
- Type of material
- Coils (Primary and Secondary) Resonant frequency.

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X. OUTPUT

Gauge of the copper wire		No. of turns of copper wire		Diameter of the coil (in cm)	Distance Between T_x and R_x (in cm)	Output (in volts)
T_x	R_x	T_x	R_x			
32	32	50	15	7	10	5.3
32	32	50	15	7	7	2.7
32	27	15	15	7	2	2
32	27	15	15	7	4	1.5

XI. CONCLUSION

After completion of this project it is concluded that, Faraday's law of electromagnetic induction is the major factor here followed by Ampere's law as well as the Maxwell's equations which helped us getting the desired conditions to get the output with maximum efficiency and one can successfully transfer the power wirelessly by using inductive coupling with 80-90% efficiency.

XII. FUTURE SCOPE

- The circuit can be made more compact by using SMT-Surface Mount Technique for designing primary and secondary coils
- The coils can be designed on micro-strip line or strap lines.

- Wireless power transmission is possible from electrical source to the receiving load (device or appliance), so it can also be used in transferring power from one device to another for example between mobile to mobile just like wireless sharing of data.

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