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Wireless Power Transmisson using Resonant Inductive Coupling

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***Abstract*: In this paper we have discussed about wireless transmission of Power using Resonant Inductive Coupling. It is the system for transferring the electrical power from the source to the receiving load wirelessly i.e. without any physical current carrying wires/cables. There are two coils used, one at the sending end and another at the receiving end. This project is useful in transferring power where physical connection is not possible. Furthermore this technique can also be used in number of applications, like to charge a mobile device, laptop battery, iPod, and to light CFL bulbs wirelessly. And also this kind of charging provides minimal risk of electrical shock as it uses magnetic fields for delivering power from one end to another end.**
Keyword: Coil, magnetic field, E.M.F, microcontroller, PWM

I. INTRODUCTION

The wireless power transmission using Resonant Inductive Coupling technology is in the lead of electronic development. The main function of wireless power transfer is to allow electrical devices to be continuously charged and lose the constraint of a power cord. Although the idea is only a theory and not widely implemented yet, extensive research dating back to the 1850's has led to the conclusion that wireless transmission of power is possible. This technique of delivering power is different from those used for cell phones. In cell phones microwaves are used which consist of magnetic as well as electric field whereas in this technique magnetic waves are used. Micro-waves are harmful to human beings as well as other living organisms, while magnetic rays are not harmful to any living organism. Here two objects having same resonating frequency and in magnetic resonance tend to exchange energy, while dissipating relatively little energy to the extraneous off-resonant objects.

II. NEED OF WIRELESS POWER TRANSMISSION

A. One of the major issues in power system is the losses that occur during the transmission and distribution of electrical power. As the demand increases day by day, the power generation increases and the power loss is also increased.

B. The major amount of power loss occurs during transmission and distribution. The percentage of loss of power during the transmission and distribution is approximated as 26 %. The main reason for power loss during transmission and distribution is the resistance of wires used for grid. [1]

C. efficiency of power transmission can be improved to certain level by using high strength composite overhead conductors and underground cables that use high temperature super conductor. But, the transmission is still inefficient.

D. According to World Resources Institution (WRI), India's electricity grid has the highest transmission and distribution losses in the world a whopping 27%. Numbers published by various Indian government agencies put that number at 30%-40% and greater than 40%. This is attributed to technical losses (grid's inefficiencies) and theft. Power transmission using wires is not possible to every places and it doesn't provide portability for the devices or instruments consuming power. [1]

E. The efficiency of power transmission can be increased by transmitting the power wirelessly. The concept of wireless electricity is not new. In fact it dates back to the 19th century, when Nikola Tesla used conduction based systems instead of resonance magnetic fields to transfer wireless power. As the method was radiative, most of the power was getting wasted.[2]

III.LITERATURE SURVEY

Wireless Power Transmission (WPT) technologies use time-varying electric, magnetic, or electromagnetic fields. Wireless transmission is useful to power electrical devices where interconnecting wires are inconvenient, hazardous, or are not possible. Wireless power techniques mainly fall into two categories, non-radiative and radiative. In near field or non-radiative techniques, power is transferred by magnetic fields using inductive coupling between coils of wire, or by electric fields using capacitive coupling between metal electrodes. Inductive coupling is the most widely used wireless technology; its applications include charging handheld devices like phones and electric toothbrushes, etc. [3]

In 1826, Andre-Marie Ampere developed ampere's circuital law showing that electric current produces a magnetic field. [1, 4] 1831, Michael Faraday developed Faraday's law of induction, describing the electromagnetic force induced in a conductor by a time-varying magnetic flux. [1, 4]

In 1862, James Clerk Maxwell synthesized these and other observations, experiments and equations of electricity, magnetism and optics into a consistent theory, deriving Maxwell's equations. [1, 4]

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A. Far-field or Radiative Technique

Microwaves or laser beams. These techniques can transport energy longer distances but must be aimed at the receiver. Proposed applications for this type are solar power satellites, and wireless powered drone aircraft. [3]

B. Near-field or Nonradiative Technique

At large relative distance, the near-field components of electric and magnetic fields are approximately quasi-static oscillating dipole fields. These fields decrease with the cube of distance: (Drange/Dant) since power is proportional to the square of the field strength, the power transferred decreases as (Drange/Dant) −6 or 60 dB per decade. In other words, if far apart, doubling the distance between the two antennas causes the power received to decrease by a factor of 26 = 64. As a result, inductive and capacitive coupling can only be used for short-range power transfer, within a few times the diameter of the antenna device Dant, Unlike in a radiative system where the maximum radiation occurs when the dipole antennas are oriented transverse to the direction of propagation, with dipole fields the maximum coupling occurs when the dipoles are oriented longitudinally. [3]

IV. PROPOSED SYSTEM

The above discussed problem can be solved by choosing an alternative option for power transmission which could provide much higher efficiency; low transmission cost and avoids power theft. Wireless Power Transmission is one of the promising technologies and may be the righteous alternative for efficient power transmission. Using Wireless Power Transmission maximum efficiency for the power transmission can be achieved.

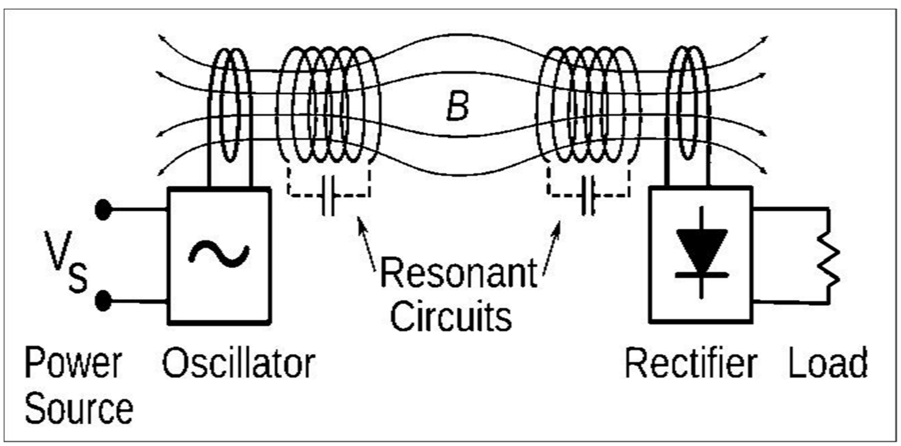

Fig.1 Resonant Inductive Coupling

The power losses taking place during transmission and distribution by using conductors can be overcome to an extent as well as the efficiency of wireless power transmission using conduction based technique can be increased by using Resonant inductive coupling technique (electrodynamics coupling, strongly coupled magnetic resonance) as we can see in fig. 1 is a form of inductive coupling in which power is transferred by magnetic fields between two resonant circuits (tuned circuits), one in the transmitter and one in the receiver. Each resonant circuit consists of a coil of wire connected to a capacitor, or a self-resonant coil or other resonator with internal capacitance. The two are tuned to resonate at the same resonant frequency. The resonance between the coils can greatly increase coupling and power transfer, analogously to the way a vibrating tuning fork can induce sympathetic vibration in a distant fork tuned to the same pitch. [3]

The concept behind resonant inductive coupling is that high Q factor resonators exchange energy at a much higher rate than they lose energy due to internal damping. Therefore, by using resonance, the same amount of power can be transferred at greater distances, using the much weaker magnetic fields out in the peripheral regions ("tails") of the near fields (these are sometimes called evanescent fields. Resonant inductive coupling can achieve high efficiency at ranges of 4 to 10 times the coil diameter (Dant). This is called "mid-range" transfer, in contrast to the "short range" of non-resonant inductive transfer, which can achieve similar efficiencies only when the coils are adjacent. Another advantage is that resonant circuits interact with each other so much more strongly than they do with non-resonant objects that power losses due to absorption in stray nearby objects are negligible. [3]

V. ADVANTAGES

A. Electricity can be transmitted at the places where wired transmission is not possible.
B. High efficiency than wired power transmission.
C. power can be delivered in any direction.
D. Not harmful to other living beings
E. No need for meter rooms and electrical closets.
F. Reduction of e-waste by eliminating the need for power cords
G. Portability since no wire is used between transmitter and receiver.

VI. BLOCK DIAGRAM AND WORKING

Thw proposed system is based on Resonant Inductive Coupling which produces magnetic flux (field) which then couples the two coils/tubes. This method is attractive because it allows fairly large amounts of power to be transmitted without need for high voltages. The basic idea is again to have two high-Q resonant circuit, which are now coupled magnetically and are preferred to have as low characteristic impedance as possible. The only question that remained was how to feed RF power at an appropriate frequency into the transmitting tank circuit – and some sort of a self-resonant oscillator looked like a good choice.

The Projects is based on Pre Programmed PIC MCU 12F683(PWM generator). Use a microcontroller to generate a PWM signal which is then filtered to produce bias voltage. The duty cycle is slowly increased until the system starts to oscillate, and the current is monitored by an ADC to detect any problems.

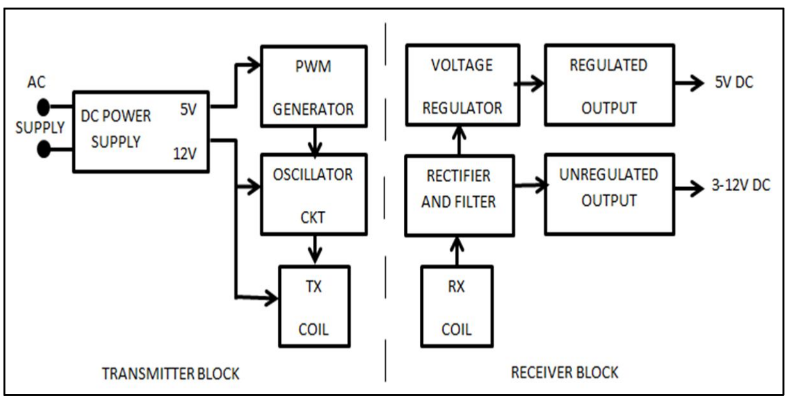

Fig.2 Block Diagram

Wireless power transmission requires MOSFET Based RF Power Amplifier. For MOSFET Overload Protection, Requires Current Sensing and Auto shut down. It is done By MCU. Current through a circuit can be measured by introducing a 0.1 ohm resistor and measuring the voltage across it. And current is calculated. The voltage across 0.1 ohm resistor is also feedback to the analog pin via 100K ohm resistor. 5.1V Zener Diode is added in parallel to these analog input pins to protect PIC from over voltages.

Two MOSFETs need to generate square waveforms (PWM) which come from the current within the two inductors when powering at DC voltage. The capacitor allows the cross-coupled FET's to pull the opposing FET's gate voltage down to shut it off. The resistors bias BOTH the FETs in the ON state, which is an unstable condition- they cannot both be ON because this would turn them both OFF. It becomes bi-stable, the resonance of the LC tank sets the pace. When the resonant cycle reaches a point where the drain voltage of the OFF state FET begins to drop, it sucks the bias voltage of the opposite FET away through the capacitor, turning it off.

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The power supply circuit is based on 3 terminal voltage regulators, which provide the required regulated +5V and unregulated +12V. +5V output powers the micro controller and other logic circuitry. The unregulated voltage of approximately 12V is required for MOSFET Amplifier Circuits.
Transmitted power is received by the receiving Coil. Received Power is AC; it is fed to bridge rectifier the output of which is then filtered using electrolytic capacitor and fed to voltage regulator. +5V output powers is used for Mobile Charging or other low voltage circuitry. The unregulated voltage of approximately 6 ~ 12V is available which can be used to operate Lamp, 12V DC Fan, etc.

VII. OBSERVATIONS

A. The magnetic flux should satisfy certain conditions like it should be time varying, if not; no power transmission takes place.
B. There is a loss of power transmission if there is a strong Ferro-magnetic substance within the field created by the magnetic flux from transmitting coil
C. Possibility of "energy theft". Someone can be using your powe
D. As distance increases, efficiency decreases

VIII. RESULTS

Different circuits, coils and copper tubes of different dimensions were designed and tested for this project and with that we concluded that as Copper Tubes 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 :

A. Thickness of the magnetic coil/tube
B. Diameter of the coil/copper tube
C. Number of turns of wire in case of magnetic coil
D. Input oscillation frequency
E. Resonant frequency of the coil's or copper tube in this case (Primary and Secondary)

Output Achieved in this project: 20 volts at a distance of 0.5cm and 6.5 volts at a distance of 16 cm,

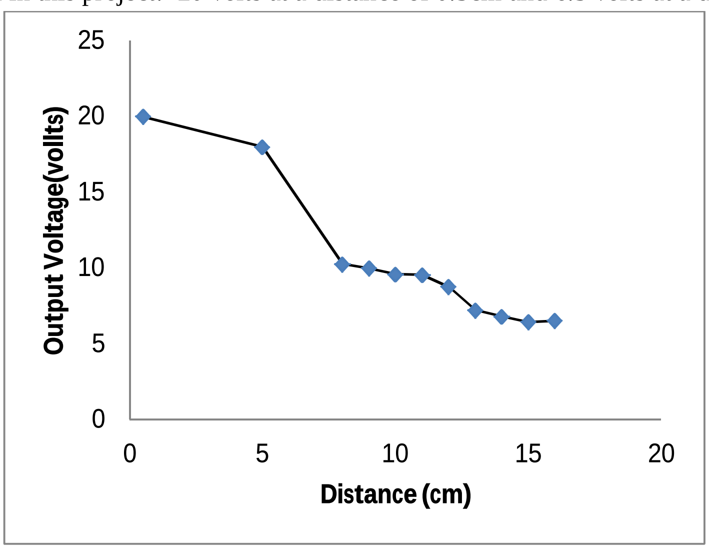

Fig.3 line graph showing relation between distance and output voltage

For maximum efficiency the resonant frequency of both the coils should be approximately same .Using this technique any electrical device can be powered or charged wirelessly with maximum efficiency economically

IX. CONCLUSIONS

Different circuits, copper tubes and coils of different dimensions were designed and tested for this project and with that we concluded that the coils designed using hallow copper tube of length 43cm ,diameter 0.5 cm and coil diameter of 12.5cm provides maximum efficiency.

X. ACKNOWLEDGMENT

Any accomplishment requires the effort of many people and this work is no different and it would be incomplete without mentioning the name of the persons who have helped to make it possible. We take this opportunity to express our gratitude in few words to all those who have helped us in completion of the report.

We convey our sincere thanks to Mrs. Rutvi Thakar and Dr. Madhuri Mavinkurve for guiding us and encouraging us to work on this project and helping us whenever we needed their support and also Mr. Shailendra Shastri for always helping and guiding us whenever we needed.

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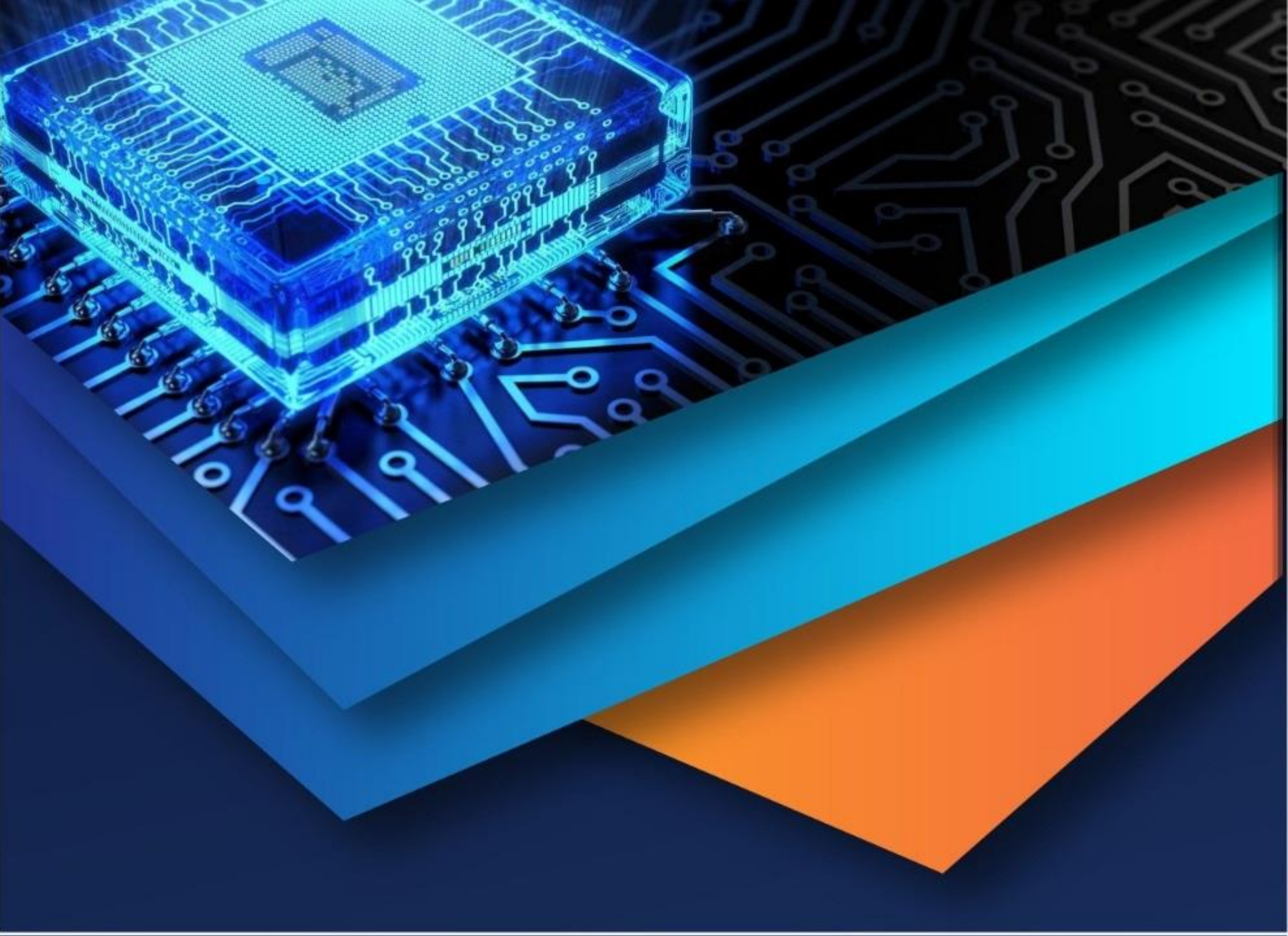

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