

Efficient Wireless Electric Power Transmission Using Magnetic Resonance Coupling

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Abstract— This paper presents how one can effectively transfer electric power wirelessly using magnetic resonance coupling, this paper also shows the results obtained from effective wireless electric power transmission, these results are obtained by transmitting magnetic waves at specific resonance frequency between two coils. This paper also provides some ways to improve wireless power transmission efficiency. In the end this paper gives a lot of practical applications where results of this project can efficiently use.

Index Terms— MRC (Intro), Hardware Description, Hardware Circuitry, Statistics, Enhancement, Applications, Conclusion, Acknowledgement.

I. INTRODUCTION

In 2006, the researchers at the Massachusetts Institute of Technology applied the near field behavior well known in electromagnetic theory to a wireless power transfer concept based on coupled resonators. In a short theoretical analysis they demonstrate that by sending electromagnetic waves around in a highly angular waveguide, evanescent waves are produced which carry no energy [3]. If a proper resonant waveguide is brought near the transmitter, the evanescent waves can allow the energy to tunnel (specifically evanescent wave coupling, the electromagnetic equivalent of tunneling) to the power drawing waveguide, where they can be rectified into DC power. Since the electromagnetic waves would tunnel, they would not propagate through the air to be absorbed or dissipated [1], and would not disrupt electronic devices or cause physical injury like microwave or radio wave transmission might. Researchers anticipate up to 5 meters of range for the initial device, and are currently working on a functional prototype.

"Resonant inductive coupling" has key implications in solving the two main problems associated with non-resonant inductive coupling and electromagnetic radiation, one of which is caused by the other; distance and efficiency [2]. Electromagnetic induction works on the principle of a primary coil generating a predominantly

Magnetic field and a secondary coil being within that field so a current is induced within its coils. This causes

The relatively short range due to the amount of power required to produce an electromagnetic field. Over greater distances the non-resonant induction method is inefficient and wastes much of the transmitted energy just to increase range [4]. This is where the resonance comes in and helps efficiency dramatically by "tunneling" the magnetic field to a receiver coil that resonates at the same frequency. Unlike the multiple-layer secondary of a non-resonant transformer, such receiving coils are single layer solenoids with closely spaced capacitor plates on each end, which in combination allow the coil to be tuned to the transmitter frequency thereby eliminating the wide energy wasting "wave problem" and allowing the energy used to focus in on a specific frequency increasing the range.

II. HARDWARE DESCRIPTION

A. Rectifier

In hardware circuitry a full bridge diode rectifier is used to convert low voltage AC signal coming from center tapped transformer to DC signal. This full bridge rectifier has power diodes.

B. Oscillator

To provide high frequency oscillations to switching circuit an IC oscillator is used. Switching circuit can be a part of oscillator. Switching circuit contains BJT, S, FET, S OR IGBT, S. Due to high current & voltage rating and high speed of switching IGBT, S are preferred.

C. LC circuit

By designing inductor and capacitor values, resonance frequency is calculated by using resonance frequency formula.

$$f_0 = \frac{1}{2\pi\sqrt{LC}}$$

D. Frequency Converter

At receiver side high frequency signal is converted into low frequency AC signal using AC capacitor.

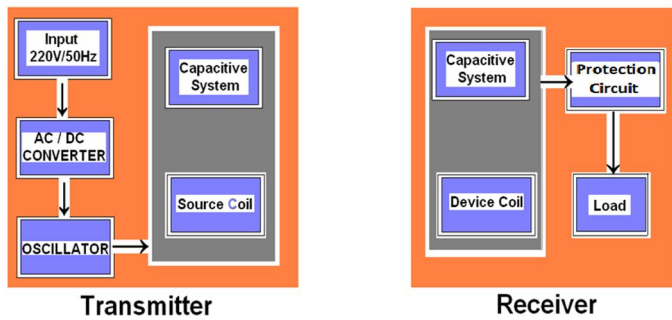


Fig 1. Flow Diagram of hardware

III. HARDWARE CIRCUITRY

In transmitter circuit the oscillator IC SG3525 is used to create pulses of frequency within a range of 0 to 1000 KHz. In this project the frequency is set at 640 KHz by using RC filter attached with SG3525. This oscillator is then attached to a pair of push pull BJT amplifier which is used to create appropriate threshold at the gate of a pair of IGBT arrays [5]. These IGBT, S are used to produced high power pulses and in the end the output of IGBT, S are attached to a LC circuit containing a trio of inductive coils. As shown in Fig. 2

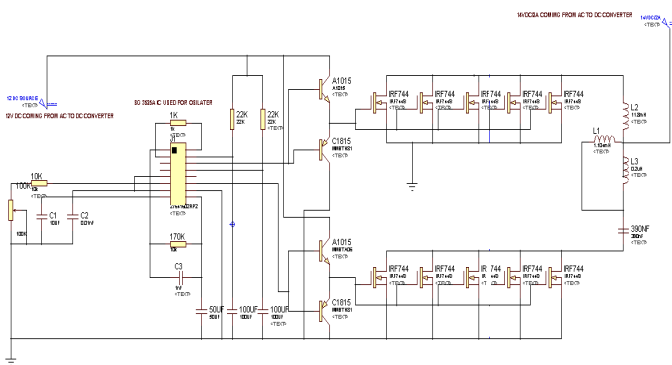


Fig 2. Transmitter Circuit

At receiver side a trio of LC circuits used, two of them are used to provide power to load and one of them is used to provide power to a protection circuit containing a comparator arrangement using LM741. As load driving LC circuits contain appropriate power to drive load then comparator senses this power and then power is transferred to load. As shown in Fig 3.

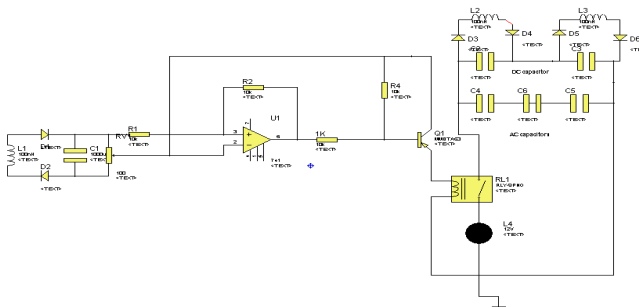


Fig 3. Receiver Circuit

IV. STATISTICS

According to statistics gathered from experimental results, maximum 80% efficiency achieved at 10 cm distance between transmitter and receiver. As shown in Fig 4.

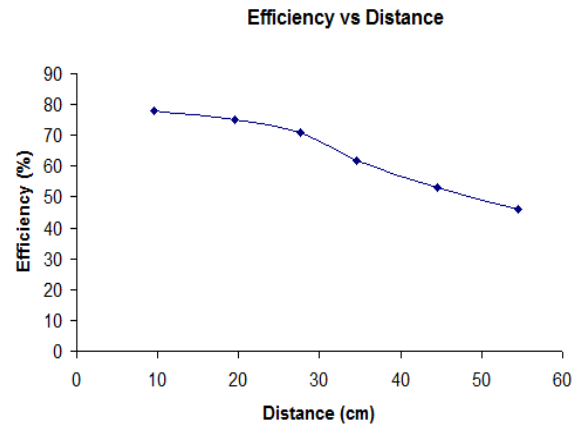


Fig 4 Graph between Efficiency vs. Distance

While the resonant frequency at which maximum (80%) efficiency achieved was 640 KHz (approx.). As shown Fig 5.

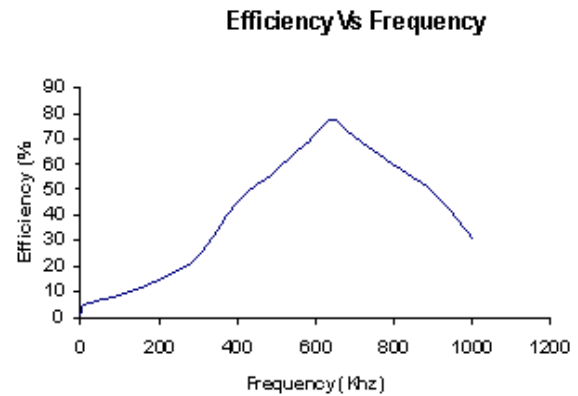


Fig 5. Graph between Efficiency vs. Frequency.

V. ENHANCEMENTS

Following enhancements can be made in this project:

A. Coils Structures

By using different types of structures of coils some more enhanced results can be obtained. Different structures of coils can be:

- Circular
- Rectangular
- Square
- Triangular
- Spherical
- Etc...

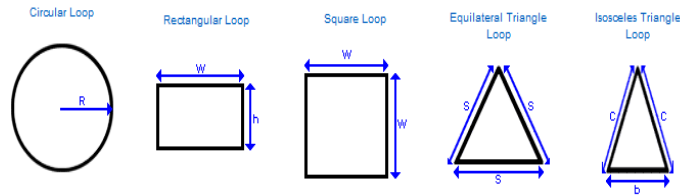


Fig. 6 Different Structures of coil

B. Using different type of material

By using different types of material in wires one can achieve more exact results. Every wire has to be chosen either by its gauge size or by its relative permeability [8].

C. Varying Resonant frequency

By choosing different values of resonant frequency, efficiency of system can be enhanced. The only thing which has main concern during variation in frequency is the saturation of coils which must be avoided [7].

D. Portability

By reducing the size of receiver, the factor of portability can be achieved. If this system becomes portable then it can be tremendously in daily electronics or electrical equipments.

E. High Power Rating Components

By using high power rating components, the efficiency of whole system can be increased. The only thing which should be kept in mind, the coil wiring must be according to that power rating.

VI. APPLICATIONS

This project can be used in following applications:

- Mobile devices wireless charging
- Laptops, Cellular Phones, Music players
- Household devices
- Implanted medical devices
- More efficient factories

- Wireless energizing of pacemaker
- Constant energy to factory robots
- Electric railway systems

VII. CONCLUSION

This paper describes how electric power can efficiently transmit wirelessly by using magnetic resonance coupling. The paper also provide a detailed designing and working of how one can implement a high power and high frequency oscillation circuit which generate highly resonant magnetic waves that not only transmit over a large distance but can easily pass through air with high efficiency. The biological hazards of these resonant magnetic waves are also very minute.

The outcomes of this paper would be very beneficial in various sectors like Bio-medical Engineering, Embedded Systems, Computer Systems, Telecommunication, Automation, Material, Metallurgy and Mechanical Engineering.

VIII. ACKNOWLEDGMENTS

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