Integrated Circuitry For Better Energy Transfer Through Resonant Coupling

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ABSTRACT

In this modern era, electricity has become the life's heart.Even a moment without electricity makes you thinking as though you go dry. The major source of transmission of conventional form of electricity is through wires. The continuous research and development has stepped forward a major quantum leap,which aids transmission of electricity without the medium of wires. This paper describes an authentic idea to annihilate the haphazard usage of wires which implicates lot of confusion in particularly regulating them. When we fantasize a future in which transmitting power wirelessly is feasible in cell phones, household robots, mp3 players, laptop computers and other portable electronics which can charge by their own without getting plugged, pardoning us from that eventual, universal power wire.Bulky batteries of these devices might not be even required to operate.Power can be transmitted efficiently upto 95% in this method through non-radiative means.This mechanism mainly involves the principle of using resonance inductive coupling wherein both the transmitter and the receiver operates at resonant frequency.Power transmission gets more efficacious when both the coils are strongly coupled. The transmitter emits a non-radiative magnetic field resonating at KHz frequencies and the receiving unit load resonates in that field.Compared with prevalent magnetic inductive coupling energy transmission devices, the efficiency of the proposed system is much higher.

KEYWORDS*—non-radiative; resonating inductive coupling; strong coupled;KHZ frequency; efficiency higher*

I. INTRODUCTION

With a large source coil and three receiver coils,wireless transmission of power is being demonstrated in this paper. Lumped capacitors that terminate coil the coils are used to achieve resonance between the coils.Though we are aware of wireless power transmission through radio waves and laser beams,both are not feasible.Thats because radio waves spread in the air and so much of the power gets wasted.In the case of laser,power transmission is possible only when there is line of sight without any obstacles in between.Laser usage for power transmission could also become dangerous during certain circumstances,thus these methods prove to be implausible. Wireless transmission of electricity through resonance magnetic coupling has formidable impacts like immense transmission probity and flat loss and can be transmitted to all over the globe and exclude the need for a faulty, costly, and capital accelerated grid of cables, towers, and substations. The cost of electrical energy used by the customer would be reduced hence getting rid of wires, cables, and transmission towers.

The cleaving up of resonant frequency is observed experimentally and described theoretically for multiple receivers.While taking into the analogy of a single receiver system which is at resonance, more than 50% of the power given by the definite source is delivered to the load but in the case of a multiple receiver system, a means for capturing frequency shifts and continuous retuning of the abided capacitances that end each receiver coil is done so as to widen the performance. In this way,a proficient wireless channel for power transmission can be entrenched and the completeness could be achieved as high as 60%–90% with a distance of about 1cm–3m between the transmitter and the receiver. In other words, this system works with a relative high competency even if there is misalignment due to the operating conditions in a factual situation.

A. Mutual coupling between the coils

In this paper, we describe about two new augmentations:

1) We demonstrate power transfer from a single resonant source coil to multiple resonant receivers, concentrating on the resonant frequency splintering issues that arise in various receiver applications.

2) We show that resonant coupling systems with either single or multiple receivers can be designed using a relatively simple circuit description.The design accurately takes into account mutual coupling between the coils.This description makes it clear that steep Q ringing coupling is the key to the productivity of the system,through an application where the primary coil is inductively coupled to the power source and the receiving coils are anteriorly coupled to the loads.

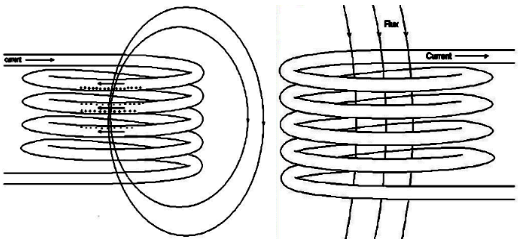

Fig. 1. Mutual coupling between the transmitter and receiver coils

II. RESONANT MAGNETIC COUPLING METHOD

In this method,a circuit model is developed to describe the system with a single receiver, and extended to describe the system with three receivers. With parameter values chosen to obtain good fits, the circuit models yield transfer frequency responses that are in good agreement with experimental measurements over a range of frequencies that span the resonance. An efficient method for wireless power transfer would enable advances in such diverse areas as embedded computing, mobile computing, sensor networks, and microrobotics. The need to minimize energy consumption is often the main design driver in applications where devices need to operate untethered. Energy consumption often restricts or severely limits functionality in such applications. The work described in this paper is motivated by potential application of magnetic resonant coupling as a means for wireless power transfer from a source coil to multiple receivers.Through simple experimental setups and corresponding circuit models, we address issues that are involved in applying the basic mechanism to both a single receiver and multiple receivers with sizes much smaller than the source coil. In the case of wireless electricity transfer systems,the resonant nature of the process ensures that the interaction between the source and device is sufficiently strong and the interaction with non-resonant objects is minimal.

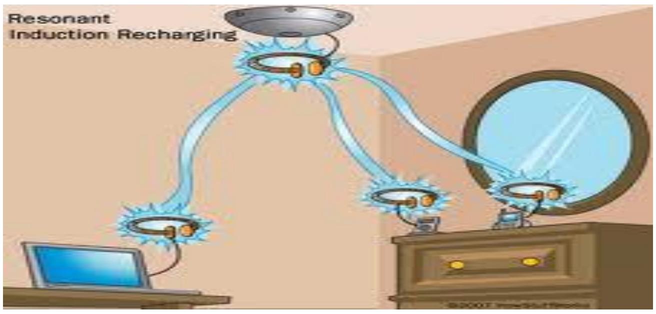

Fig. 2. Inductive recharging through magnetic resonance

A. Comparison with the inductive coupling

Traditional inductive coupling methods have limited transmission distance due to weak coupling between the source and loads. This occurs in the charging of conventional electric toothbrushes. The tooth brush with the receiving coil is placed on the source cradle for getting charged. The efficiency is as low as 1-2%. Using magnetic resonance the transmitting source coil frequency exactly matches the frequency of the receiving coils at resonance. Since the energy transfer is maximum at resonance, magnetic resonance coupling is found to have an efficiency of about 95% .

III. PRINCIPLE OF WORKING OF THE PROPOSED MODEL

A. Resonance

Resonance is a property that exists in many different physical systems. It can be thought of as the natural frequency at which energy can most efficiently be added to an oscillating system. A playground swing is an example of an oscillating system involving potential energy and kinetic energy. The child swings back and forth at a rate that is determined by the length of the swing. The child can make the swing go higher if she properly coordinates her arm and leg action with the motion of the swing. The swing is oscillating at its resonant frequency and the simple movements of the child efficiently transfer energy to the system. Another example of resonance is the way in which a singer can shatter a wine glass by singing a single loud, clear note. In this example, the wine glass is the resonant oscillating system. Sound waves travelling through the air are captured by the glass, and the sound energy is converted to mechanical vibrations of the glass itself. When the singer hits the note that matches the resonant frequency of the glass, the glass absorbs energy, begins vibrating, and can eventually even shatter. The resonant frequency of the glass depends on the size, shape, thickness of the glass, and how much wine is in it.

B. Resonant magnetic coupling

Magnetic coupling occurs when two objects exchange energy through their varying or oscillating magnetic fields. Resonant coupling occurs when the natural frequencies of the two objects are approximately the same.The power sources and capture devices are specially designed magnetic resonators that efficiently transfer power over large distances via the magnetic near-field. The proprietary source and device designs and the electronic systems the control them support efficient energy transfer over distances that are many times the size of the sources/devices themselves.

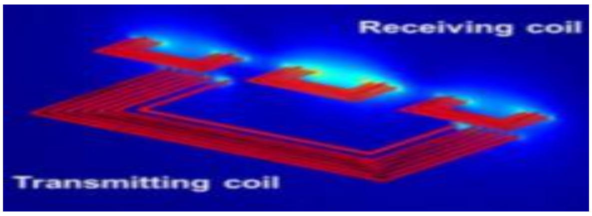

Fig. 3. Resonant magnetic coupling between the coils

IV. THEORY AND DESIGN OF THE PROPOSED MODEL

Wireless Power Transmission using magnetic resonance coupling, is one of the efficient ways to transfer power between points without the use of conventional wire system. Wireless power transmission is very much useful in areas where wire system is unreachable or impossible. This is done using charging a resonant coil from AC and then transmitting the subsequent power to the resistive load.

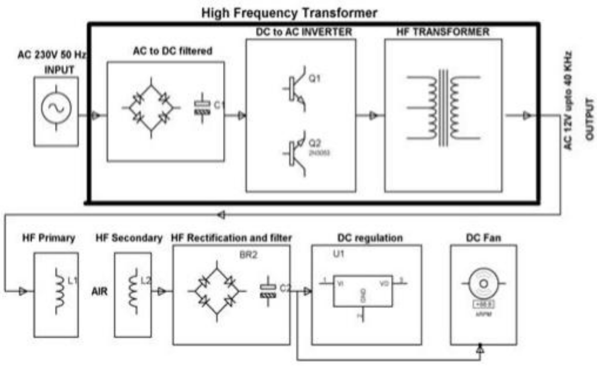

Fig. 4. Block diagram of the proposed model

The transmitter coil in this wireless power transmitter section is given 230v ac supply.This high frequency alternating current, which is linked with the wireless power transmitting coil, would create an alternating magnetic field in the coil due to induction, to transmit energy.In the wireless power receiver section, the receiver coils receives that energy as an induced alternating voltage (due to induction) in its coil and a rectifier in the wireless power receiver section converts that AC voltage to a DC voltage. This dc is converted to ac through an inverter circuit and this gets transmitted to receiver coils where ac is again coverted to dc through rectifier circuit and this dc is supplied to the load circuits.

A. Transmitter section

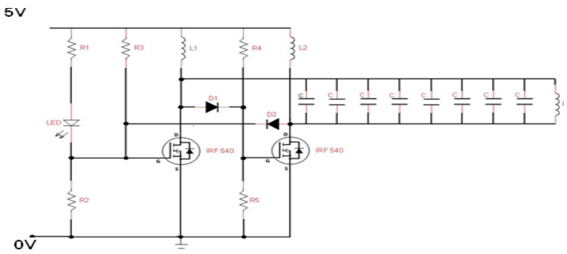

Fig. 5. Circuit diagram of transmitter section

The Transmitter section of wireless charger circuit consists of a transmitter coil, an AC power source and an inverter circuit.

AC power Source: A constant AC voltage is provided by a AC power source, and this AC signal is given as input to the step down transformer circuit. Then ac power is given to an inverter circuit.

Inverter Circuit: The inverter circuit consists of 555 timer and *irfz44n* mosfet circuits for generating and switching frequencies.With this both the transmitter and receiver circuits are made to oscillate at same resonant frequency. This oscillation aids power transfer between the coils in the form of magnetic waves.

B. Receiver section

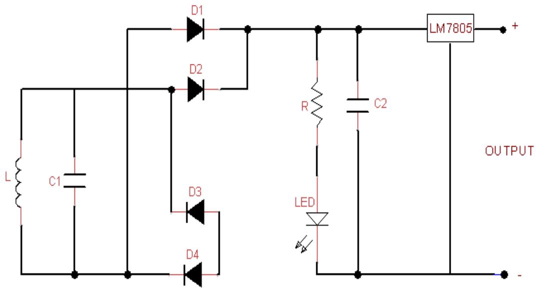

Fig. 6. Circuit diagram of receiver section
Fig. 7.

The receiver section consists of receiver coil, rectifier circuit and a voltage regulator IC. The AC current flowing through the transmitter coil creates a magnetic field. When we place the receiver coil with in a specific distance from this transmitter coil, the magnetic field in the transmitter coil extends to this receiver coil, and it induces an AC voltage and generates a current flow in the receiver coil of the wireless charger.

*Rectifier circuit***:** The ac power from the receiver coil is given to a rectifier circuit and converted to 12v dc.

Voltage regulator ic: : For transmitting power to the receiver devices this 12v power is regulated to 5v using 7805 regulator ic.

C. Parameters for design and hardware implementation

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

$F = ½ \times \pi \times \sqrt{(LC)}$

The equation for finding the inductance of a single layer air core coil is given below.

L = 0.001N(a/2)2/(114a+254l)H

At the transmitter end,

$L = 0.001\ N1\ (a/2)2\ /\ (114a + 254l)$ H

Now we are applying the desired values for the coil,

$L = 0.001\times14\times\ (0.013/2)2\ /\ ((114\times0.013) + (254\times5))$ H

L = 0.1431uh

At the receiver end,

$L = 0.001N2(a/2)2/(114a+254l)$H

$L = 0.001\times7\times\ (0.009/2)2\ /\ /((114\times0.009) + (254\times1.6))$ H

L = 0.1546uh

The capacitance value is chosen to be

C = 1000uf

Frequency of about 40khz is applied to the transmitter coil through 555timer and mosfet irfz44n circuits.

The resonant frequency of both the coils is around 12khz. Frequency matching is established through oscillation of both the coils in their resonant frequencies.This enables wireless electricity transfer to take place between the two coils which charges devices at the receiver end.

D. Hardware prototype model

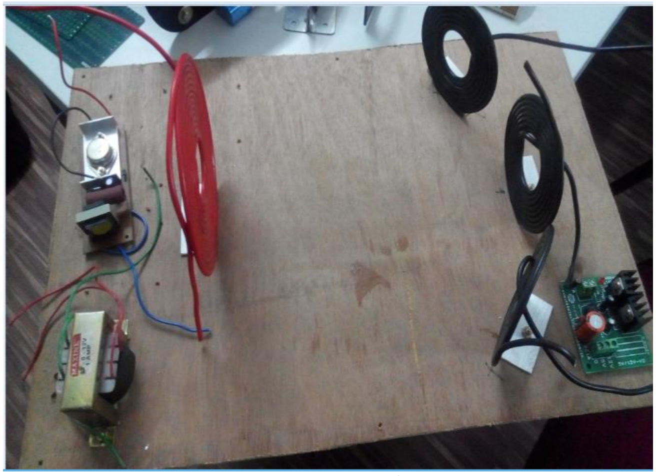

Fig. 8. Hardware prototype model of the proposed system

E. Hardware output results of charging mobile and tablet

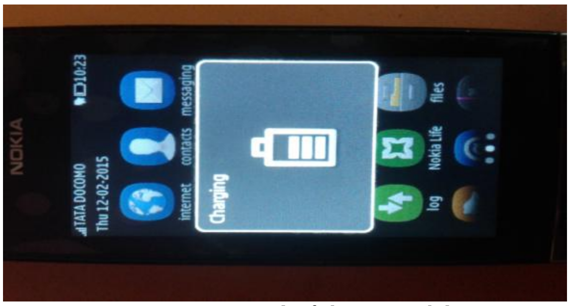

Fig. 9. Output result of charging mobile

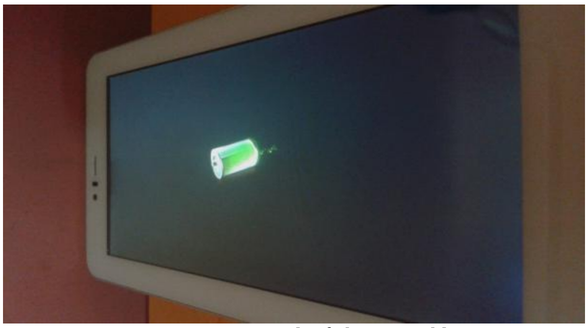

Fig. 10. Output result of charging tablet

F. Simulation results

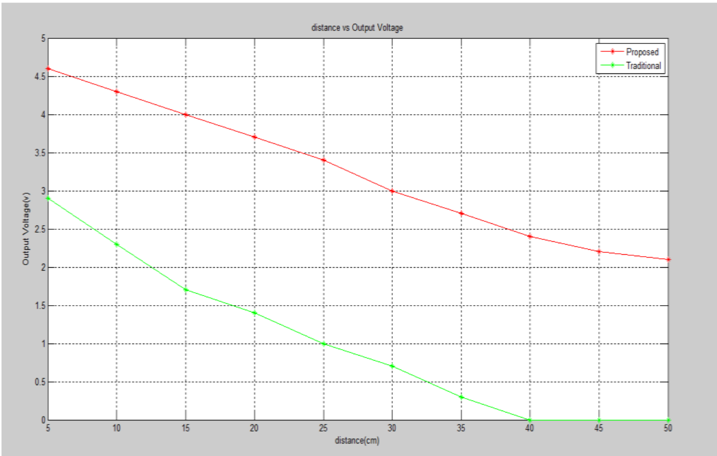

Fig. 11. Variation of distance with output voltage

Based on the empirical modeling four coils(a transmitter and 3 receiver coils)made of copper wire were selected to resonate at a frequency of 40 KHz. The source coil was made of a 14 turn helical coil and the three load helical coils were made of 7 turns each.The source coil is wound around a diameter of 130mm and the load coil around 90mm.The source coil is made of 5m length copper wire and the load of 1.6m copper wire.Distance was varied upto a range of 50cms,which was found to be practically impossible with the existing methods.This large distance of power transmission with a higher efficiency and steady output voltage value was obtained only because of proper frequency matching between the source and the load coils. Various graphs indicating relationships between distance range,frequency,efficiency and output voltage were simulated in MATLAB environment.

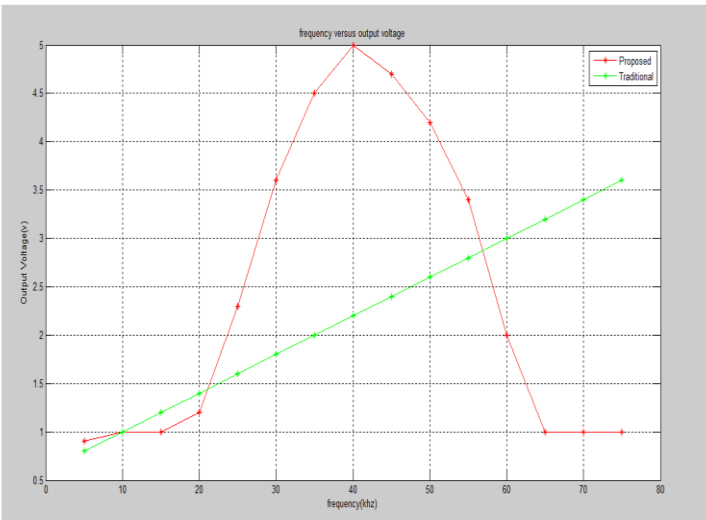

Fig. 12. Variation of frequency versus output voltage

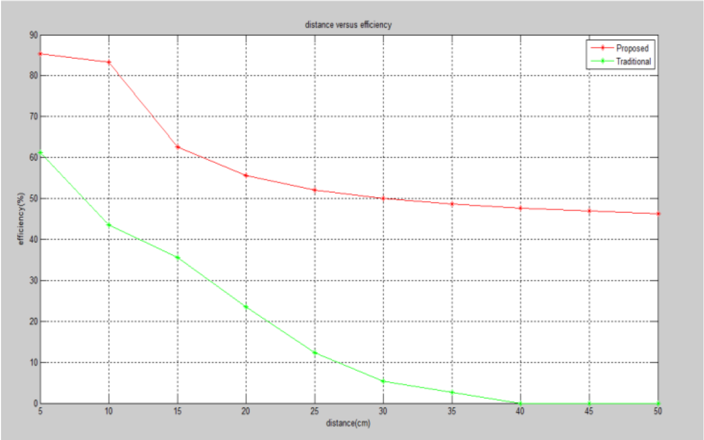

Fig. 13. Variation of distance versus efficiency

V. MERITS OF THE PROPOSED MODEL

Completely eliminates the existing high-power transmission line cables, towers etc..and the cost of transmission and distribution becomes less. It uses resonant magnetic fields to reduce wastage of power and hence efficiency of this method is higher than wired transmission.It aids easy power transmissio to the places where there is no wired transmission as it does not interfere with radio waves.The system can replace the use of power cables and batteries and so the power failure due to short circuit and fault of cables would be completely prevented. Though there is fear of effects due to electromagnetic induction rays,repeted study in this area proves that the radiation level is much lower than that from cellphones or microwave oven and is hence proved to be 100% safe on living tissues.

VI. FEATURES AND APPLICATIONS

Power transfer through magnetic coupling can be used in a wide variety of applications and environments. This technology is reliable,efficient and environment friendly as it is safe,efficient and travels over distance. The technology provides:

Direct Wireless Power— The power needed by the device is provided wirelessly and no batteries are necessary.

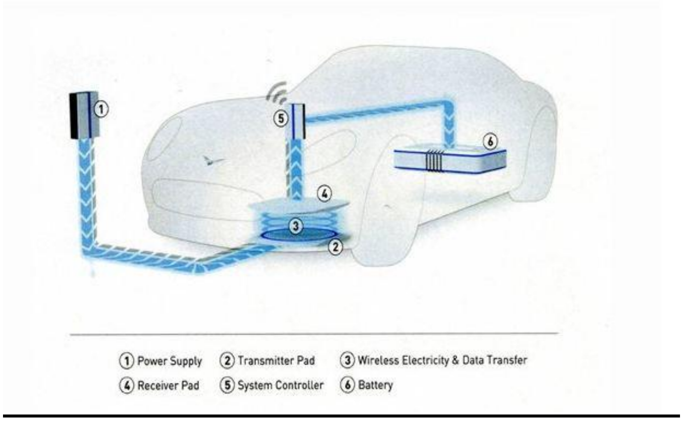

Fig. 14. Direct wireless power transfer without using batteries in a electric car

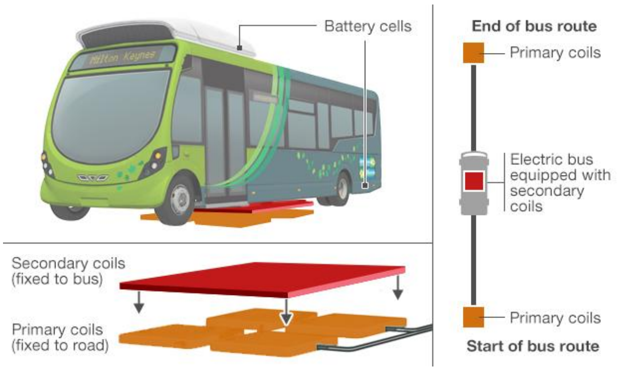

Fig. 15. Direct wireless power transfer without using batteries in a electric bus

Automatic Wireless Charging —A device with rechargeable batteries charges itself automatically when in use or at rest without replacing batteries or using power cords.

Fig. 16. Automatic wireless charging of electronic gadgets without using power chord or battery replacement

VII. CONCLUSION

In this paper, a wireless energy transfer system for power transmission and recharging of electrical devices is studied. In order to showcase its performance, comparable traditional inductive magnetic coupling model is built. Experimental results are reported to demonstrate the effectiveness and characteristics of the proposed method. In summary, the feasibility of this system is demonstrated using practical measurements in order to make meaningful performance comparisons. Wireless electricity transfer will make products more Convenient as there will never be run out of battery power since no manual recharging or changing batteries which inturn reduces use of disposable batteries. It totally eliminates unsightly, unwieldy and costly power cords by reducing product failure rates. It directly uses efficient electric grid power for charging instead of inefficient battery charging and thus it is more environment friendly.

VIII.FUTURE WORK

1. In our future work,we are planning to embed our receiver end circuitry of receiver coil with rectifier and regulator circuits in target devices circuitry during manufacturing so that no external chargers are required to charge the devices.The transmitter end circuitry placed in a circular case when positioned at a distance from the target device,the device will get charged automatically.
2. We are also planning to extend the distance of transmitting power to about 20 metres distance.

IX. ACKNOWLEDGEMENT

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