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Wireless Power Transfer by Engrafting Resonance to High Voltage Pulses

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ABSTRACT

This paper is about transmitting electricity wirelessly using high voltage high frequency signals. The device uses concepts of tesla coil, mutual induction and resonance to procreate electricity in the receiver coil placed at a distance. The main aim in designing this device is to allow automatic recharge of mobiles when the power gets drained. This is device can also be used for internal pacemaker charging without the need of surgery. To achieve this, mutual induction and resonance concepts were employed Mutual induction is achieved through high voltage pulses that can be achieved as a novel attempt. From this experimental setup the maximum distance of transmission achieved is 55cm.

Key words: Mutual induction, resonance, high voltage, spark gap, coil

INTRODUCTION

This paper explicates an experimental setup which deals with transferring power wirelessly by using the concepts of high voltage and low frequency. It is called as 'witricity' which means wireless power transmission. The delineate was initially designed by Sir Nikola Tesla in 1900 [1]. In 1904 Nikola Tesla contrived a large scale project of transmission of electricity wirelessly entire the city it wasn't successful due to the lack of funding. To avoid surgery for the recharge internal pacemakers and to auto recharge laptops, mobiles and other devices wireless transmission of electricity can be engaged [2]. In 2004 MIT university researchers designed a prototype which could transmit electricity for 2 meters to flare a 60watt blub. But this design was bulky and requires high expenditure. Designers across the world have designed similar projects which aren't portable [3].

In this design a central transmitter is employed which is portable enough to place it on a table. The total diameter of this design is 55cms.This has the capability to drive smaller appliances like lights, mobiles etc. The receiver size is variable depending on the device used by the receiver. Maximum distance can be achieved when the receiver and transmitter are identical.

DESIGN DESCRIPTION

The design was inspired from the tesla coil design of Nikola Tesla as illustrated in [4], where the secondary coil is removed and the primary coil is used as the transmitter. A circular cardboard structure is taken to wound the coil around it and the power supply and driver circuit are placed at centre which would function as transmitter section. The main blocks present in the experimental setup are Power supply, Oscillator, Fly back transformer, Clamper circuit, Capacitor bank, Transmitter coil, Receiver coil as illustrated in Fig.1.

The block diagram in Fig.2 illustrates the transmitter section.

Power Supply

A 4V 200ma power supply is employed for this project. This supply was constructed using a 12-0-12, 1A transformer. A bridge rectifier was used to convert the AC supply to DC. A capacitor filter was engaged along with a LM317 IC to regulate the voltage to 4V.

Oscillator and its Step up

The oscillator was constructed using a D882 power transistor. Using the joule ringer concept the high voltage inverter was designed. The design consists of transistor along with the fly back transformer. This fly back transformer has three coils in total. Two primary coils and one secondary coil are present in the transformer, the primary coils has feedback coils with 3 turns and the main coil with 7 turns, both using 36 gauge copper wire. The secondary coil consists of 450 turns of wire with lesser thickness. This oscillator produces ac signal and the transformer steps up the voltage to few hundred volts at very low current (approx few micro amps).

Clamper

The output of the fly back transformer is connected to the clamper circuit to multiply the voltage. The capacitors used in this clamper circuit are 0.1uf high voltage capacitors rated at 1KV and the diodes used are 1n4007. Four stages of clamper are used to obtain a quadrupled voltage at output, which is close to 2KV.

Capacitor Bank

The output obtained from the fly back transformer is about 450v but with very less current of about few micro amps. This current cannot drive a big coil, therefore succeeding the clamper circuit a HV capacitor is used which is about 0.22uf rated at 2KV. This capacitor stores a charge of 2KV.

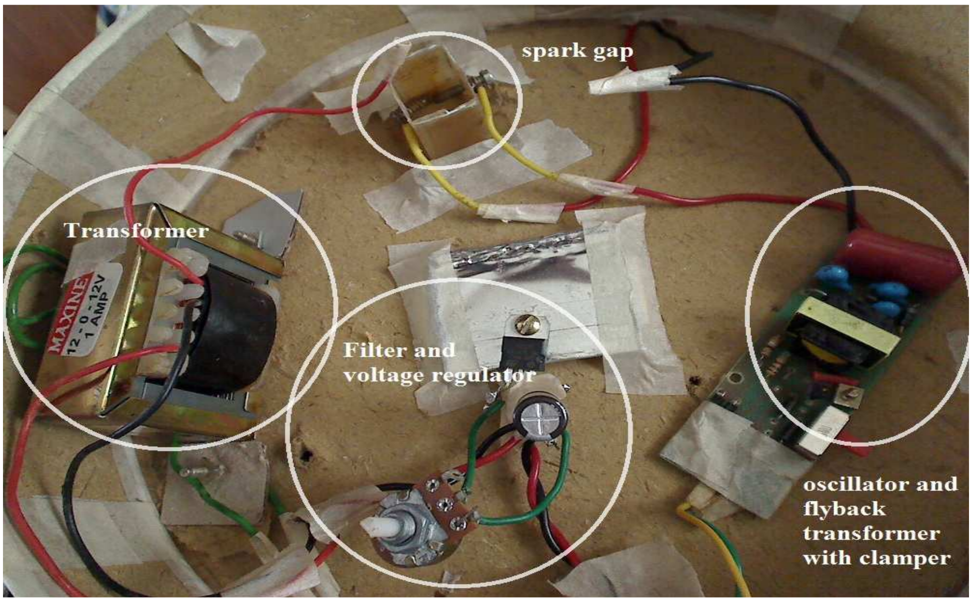


Fig.1 Transmitter driver circuit fitted in the coil

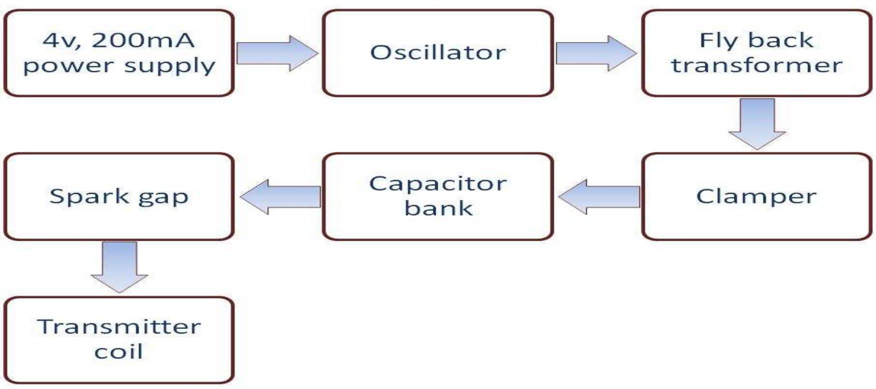


Fig.2 Block diagram of transmitter section

Spark Gap

The output of capacitor bank is connected to the transmitter coil through a spark gap. One of the terminals of capacitor is connected to one terminal of the coil and, the second terminal of the capacitor is connected to spark gap. In the same manner second terminal of coil is also connected to the spark gap. The spark gap provides a 2-4mm gap between the two terminals such that only when the capacitor is completely charged then only the charge is transferred from the capacitor to the coil. The spark gap is constructed by fitting two screws to a plastic structure (non conducting structure) with a small gap between the two ends of the screws. Two wires are connected to the two screws. The spark gap during off state and on state are illustrated in Fig.3 and Fig.4

Fig.3 Off state

Fig.4 On state showing spark

Transmitter Coil

The coil is 22.5cm in diameter with 60 turns of 22 gauges enamelled copper wire wound with hand around a non metallic structure as shown in Fig.5. It has an inductance of about 0.038mh. The coil is connected to the spark gap and the capacitor. When the HV capacitor is completely charged to 2000v the air between the spark gap acts as dielectric and the charge in the capacitor is transferred to the coil. The coils of transmitter and receiver can be circular or square shaped. The coverage area also varies with the shape of the coil along with number of turns and diameter. Circular coil was found to be more efficient than square coil. The circular transmitter and receiver coils are shown in Fig.5. The receiver section is illustrated in the following block diagram of Fig. 6

Fig.5 Transmitter and receiver coils

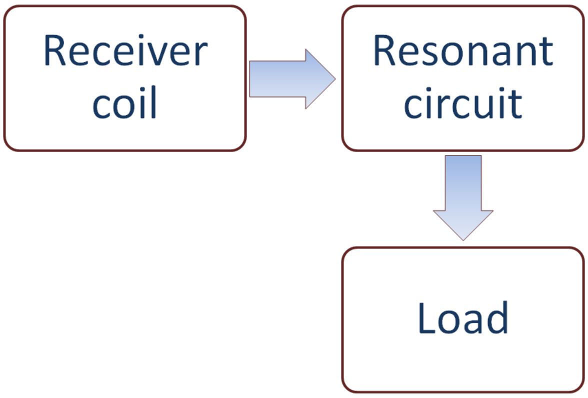


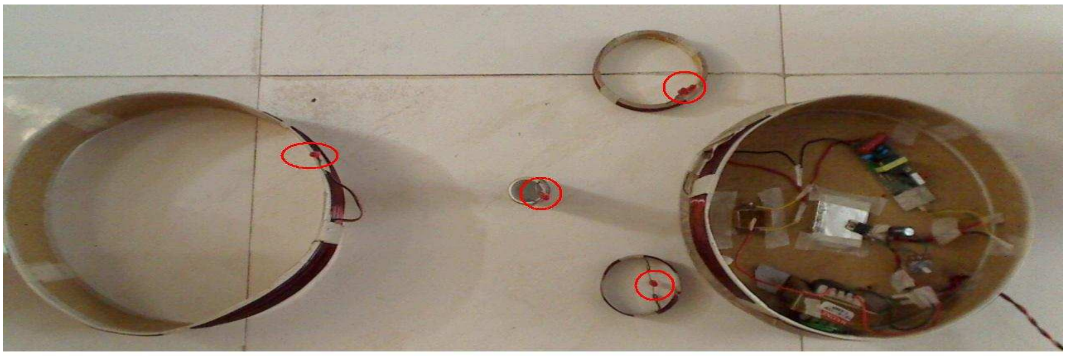
Fig.6 Block diagram of receiver section

Receiver Coil

The receiver coil is also built with same dimensions to obtain maximum transmission distance. Smaller coils can also be designed to operate at lower distances. The operation of the receiver varies with distance from the transmitter, size of the coil, number of turns, thickness of the wire used. Fig. 7 shows the receivers when the power is switched off and Fig. 8 shows the receivers when the power is switched on and the leds are glowing.

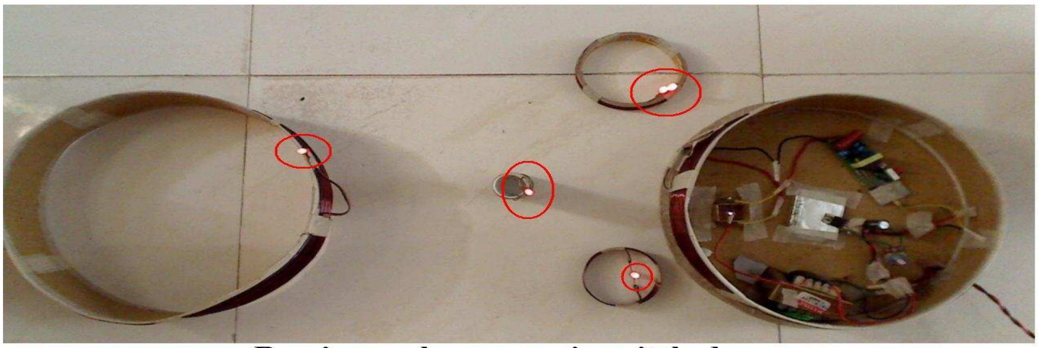
Resonant Circuit

The resonant circuit consists of a capacitor in parallel with the receiver coil such that it forms a tuned LC circuit. The resonant circuit is used for coupling transmitter coil with the receiver coil so that maximum power transfer takes place at long distances.



Receivers when power is switched off

Fig.7 Receivers during off state



Receivers when power is switched on

Fig. 8 Receivers during on state

SETTING RESONANT FREQUENCY OF RECEIVER COIL

The voltage in the coil does not have a fixed frequency; it varies with respect to the spark gap and the charging time of the capacitor bank. This frequency is the resonant frequency of the circuit. Initially the value of Capacitor in the receiver circuit should be chosen using trial and error method and the resonant frequency F can be calculated using Equation 1.

$$F = 1/2\pi\sqrt{(LC)} \tag{1}$$

F is obtained in HZ.

The frequency can be directly measured using CRO (cathode ray oscilloscope). Once the frequency is known the capacitor value for other receivers can be calculated using other formula.

RESULTS ANALYSIS

Through experimentation with various coils it we found that circular coils with large diameter and more number of turns were more advantageous to use as they produce larger transmission range. The following results are shown graphically in Fig. 9.

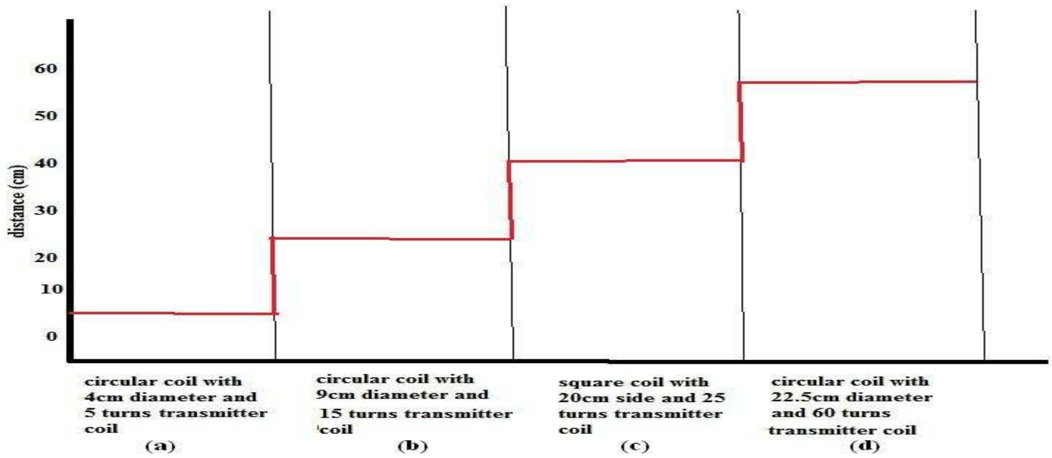


Fig.9 Graph showing the performance of various coils

a) Circular coil with 4cm diameter and 5 turns can produce a transmission range around 5cm and can make a led blink.
b) Circular coil of 9cm diameter and 15 turns can produce a transmission range around 25cm which also can make a led blink.
c) Square coil of 20cm side and 25 turns can produce a transmission range around 40cm which make led's blink at a faster rate.
d) Circular coil with 22.5cm diameter and 60 turns can produce a transmission range around 55cm which can make high power led's blink at a rapid speed which cannot be recognized by the human eye and appears as the led's are glowing continuously.

CONCLUSION

Coils of various sizes and shapes have been tested and worked upon but maximum distance was produced only by this design with maximum diameter and number of turns. The Current delivered to the load at receiver can be increased by adopting thicker wires for the coil and the voltage can be increased by increasing the number of turns in the coil. The maximum distance of transmission was observed when the transmitter coil and the receiver coil were identical in the dimensions. Improvisation of the design for longer distances can be obtained by amending the power capability of the driver circuit and also by increasing the operational frequency of the oscillator. This design can be further improved to adopt for home appliances operating at higher voltage and current ratings.

Acknowledgements
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