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Resonance Coupling Technique for Wireless Energy Transfer

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Abstract: *Resonance coupling is a new technique for wireless energy transmission, which can transfer energy in middle distance. The purpose of this project is to build the prototype model to prove and demonstrate the concept of wireless energy transfer based on resonance coupling. It consists of a transmitter as an electromagnetic resonator and a receiver to which the device to be powered is attached. This paper analyzed the wireless transmission mechanism based on the coupling model of two type coils with 4 type different turn, and studied the relationship among output voltage, output current, distance, coil sizes and design application. Furthermore, based on resonances theory, we had provided an energy wirelessly to light on a led, turn on dc motor, phone charging and light on bulb within the distance for 0cm untill 5cm which uses magnetic field as transmission medium. Experimental results have validated the proposed design method.*

Keywords: *resonance coupling, wireless transfer energy, coil, rectifier, control circuits.*

I. INTRODUCTION

Wireless Transfer Energy (WET) is defining efficient transmission of electric power from one point to another through vacuum or an atmosphere without the use of wire or any other substance**.** The energy can be transmitted using microwaves, electromagnetic induction or lasers. For the first planning, this project will be design bases on the principle of electromagnetism induction. That is, when AC source passes through a coil, magnetic field will be generated around the coil. At the moment, if another coil is put aside it, the magnetic field will also appear around the other coil, which is the reason that the wireless energy transmission is set up between those two coils. Energy will be transfer when both coils will have same resonant frequency [2-5].

Fig 1: Illustration of wireless transfer energy system by using electromagnetic induction**.**

Non-contectless wireless energy transmission has been developed recently, which bases on the principle of electromagnetism induction. That is, when AC source passes through a coil, magnetic field will be generated around the coil. At the moment, if another coil is put aside it, the magnetic field will also appear around the other coil, which is the reason that the wireless energy transmission is set up between those two coils [1]. Like that, resonance coupling is a special circumstance of non-contectless wireless energy transmission, where the special is: all coils used for resonance coupling operate in resonant state. Resonance occurs when the self-resonant frequency of coils equal to the frequency of AC power supply, when the equivalent circuits of coils in high frequency have the minimum impedance. Then, the most energy will be transferred from the resonant path. The schematic of resonance coupling wireless energy transmission system was showed in fig.2.It includes two spatial isolated hollow coils: one is LS, which sends the energy inducted from the high frequency power supply; the other is LD, which receives energy from LS. These two coils have the same sizes and operate at the resonant state [1].

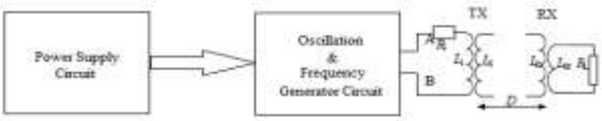

Fig 2: Principle of the resonance coupling

II. EXPERIMENTAL RESULTS

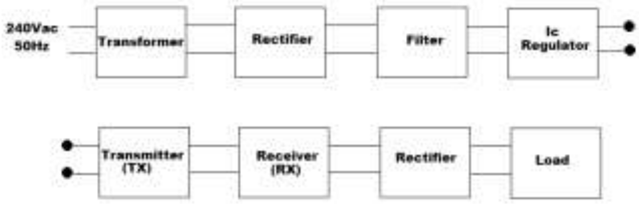

Fig 3: Block diagram of the system.

Fig 3 shows how the connection was be made in order to get the signal from power supply to the load. Transmitter part is very important to transmit the energy for the receiver. If the transmitter part not function as well that mean that system cannot function. In order receiver to get energy from transmitter, need to determine what the value of multilayer inductor.

$$L = \frac{0.8r^2N^2}{6r + 9l + 10d}$$

Where L is the inductance (H), r is the radius of coil (inch), l is the physical length of coil winding (inch), N is the number of turns and d is the depth of coil (inch).

Table 1: Transmitter Multilayer Air Core Inductor.

Types	Turn of Coil	Radius of Coil	Physical Length of Coil	Depth of Coil
0.8 mm	50	1.457 inch	0.63 inch	0.236 inch
0.8 mm	25	1.457 inch	0.63 inch	0.079 inch
1.2 mm	50	1.457 inch	0.63 inch	0.315 inch
1.2 mm	25	1.457 inch	0.63 inch	0.197 inch

Table 2: Receiver Multilayer Air Core Inductor.

Types	Turn of Coil	Radius of Coil	Physical Length of Coil	Depth of Coil
0.8 mm	25	0.984 inch	0.276 inch	0.236 inch

Table 1 and table 2 show the characteristics of transmitter and receiver multilayer Air Core Inductor. This project will demonstrate with 2 type transmitter of the copper winding with 4 types of turn.

Table 3: Types of transmitter.

0.8mm	1.2mm
50 TURN	50 TURN
25 TURN	25 TURN

Also, design, measured voltage and current for the distance, and analyzed using graph the performance of the design. For the receiver, 4 types of application was design, which are:

1. 3V LED.
2. 3V Bulb.
3. 5V Dc Motor.
4. Phone Charging.

For the measurement, 1 type receiver was used which is 0.8mm, 25 Turn with 2.2K load resistor.

Fig 4: The Prototype Model of Wireless Energy Transfer.

According to the circuit in Fig 4, the prototype model has been made. It is combination of the power supply and control circuit. For transmitter part, the coil turn is 50 and 25 turns with the diameter of the conductor section is 0.8mm and 1.2mm.The capacitor 4.7nF and 471pF has been connected in series to setup the resonance frequency of transmitter inductor. At receiver part, the number of coil turn is 25, 0.8mm. The supplied voltage for this prototype model is 240Vac and step down using transformer 12V AC. After that voltage regulator was used to supply to control circuit. The supply for control circuit is 12Vdc. Then control circuit will change the Dc voltage to the Ac voltage. So, when the AC power has been supplied through the transmitter coil, magnetic field will be generated around the coil. Thus, when we put the receiver coil near the transmitter coil, induced current will be produced and caused the magnetic field around the other coil and the electrical energy from transmitter will be transferred to the receiver to up 10Vac. At receiver part, it was receive Ac voltage and it was change to Dc voltage by using bridge diode (Rectifier). The maximum distance that the electrical energy can be transferred is 6cm-8cm, depend on size and diameter of transmitter and receiver. More distance, electrical energy still can be transferred but in very little value.

A. The relationships between output voltage and distance measured at receiver.

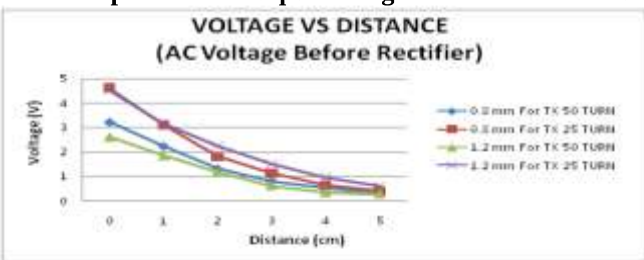

Fig 5: Output Voltage versus Distance AC Voltage before rectifier.

Fig 5 show the output voltage of receiver is decrease when the distance between transmitter coil and receiver coil is increase. This is because when the receiver coil is more far away from the transmitter coil, the magnetic field that cross between transmitter coil and receiver coil will also decrease. For the voltage each turn, we can see that less turn it will increase the output voltage. More turn will decrease the output voltage and the voltage for turns 25 for the 1.2mm and 0.8mm almost same at the nearest distance but it was chage at longest distance.

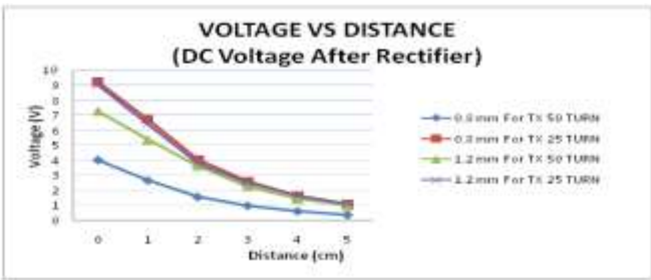

Fig 6: Output Voltage versus Distance DC Voltage after rectifier.

Fig 6 show the output voltage of receiver is decrease when the distance between transmitter coil and receiver coil is increase. This is because when the receiver coil is more far away from the transmitter coil, the magnetic field that cross between transmitter coil and receiver coil will also decrease. For the voltage each turn, we can see that less turn it will increase the output voltage. More turn will decrease the output voltage and the voltage for turns 25 for the 1.2mm and 0.8mm almost same at the nearest and longest distance.

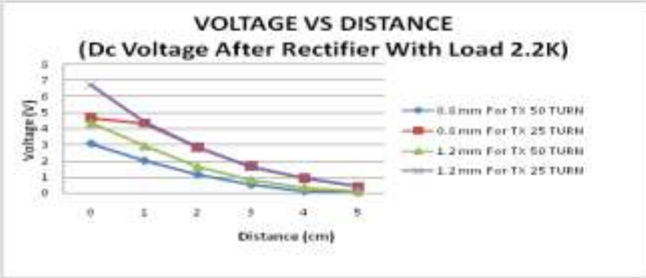

Fig 7: Output Voltage versus Distance DC Voltage after rectifier with load 2.2K resistor.

Fig 7 show the output voltage of receiver is decrease when the distance between transmitter coil and receiver coil is increase. This is because when the receiver coil is more far away from the transmitter coil, the magnetic field that cross between transmitter coil and receiver coil will also decrease. For the voltage each turn, we can see that less turn it will increase the output voltage. More turn will decrease the output voltage and the voltage for turns 25 for the 1.2mm and 0.8mm almost same at the longest distance but it was chage at nearest distance.

B. Efficiency.

Table 4: Summary of the efficiency.

Types	Efficiency
0.8mm, 50Turn	20.16%
0.8mm, 25Turn	30.43%
1.2mm, 50Turn	28.47%
1.2mm, 25Turn	43.9%

Table 4 shows the summary of the efficiency each type of the transmitter involved of this project. Based on the calculation, efficiency for the 1.2mm, turn 25 is highest than others but, for the current and voltage are not suitable for the load because need the stable current and voltage. If refer to the graph before, the value of voltage for the less turn is high than more turn, but current is less.

For the four type of the turn, turn 50 for 1.2mm is good and suitable to light ON led, bulb, turn ON Dc motor and phone charging.

Fig 8: Light ON led

Fig 9: Light ON bulb.

Fig 8 and 9 shows the demo of the application models for this wireless energy transfer. All application models were tasted on 1.2mm, Turn 50. For the others turn, it cannot support only led can light ON because the current for the others turn is low and not stable.

III. CONCLUSION

Wireless energy transfer is completely has potential to be improved and magnetic resonance coupling is most feasible method in wireless energy transfer. Otherwise, in this paper also proved that the electrical energy transmission will be occurred in most efficient at the resonance frequency. The application was used to prove this by using cell phone, dc motor, led and bulb. In addition, it can conclude that the maximum output voltage at receiver of the resonant wireless energy transfer depends on the size of coil and the input voltage. The transfer energy could be effectively by increasing the input voltage. The size and frequency of the device also should be taken into account since the resonance wireless energy transfer device works in the medium or high frequency range of electromagnetic field. The higher the frequency, the closer is the common coil and capacitor to the resonant condition.

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