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Development of Wireless Power Transfer for Low Voltage Application

M. F. Ismail[1,*], M. H. Harmizon[1], L. D. Hui[1], G. Z. Wei[1]

[1]Centre for Diploma Studies,
Universiti Tun Hussein Onn Malaysia Pagoh Campus, 84600 Johor

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Abstract: The development of wireless power transfer for low voltage application is proposed inthis paper. The main objective of this project is to transfer electrical energy wirelessly without connected by wire from source to load. Furthermore, this project aim to help on reduce cable wasted on the Earth, this is because wireless use lesser wire and doesn't require to plug in and plug out frequently and help to tidy up mixed power cable of electronics. Then also achieve the effective range for wireless power transfer for more than direct touching (0cm). The concept of the wireless phone charger is using 2 copper coil which designed to transmit and receive voltage over air medium. It also use diode and capacitor on the receiver side to maintain a stable voltage over time to charge the phone. The projects will to reduce cable been throw away and easier the charging of mobile phone. Some practical studies on effect of coil diameter and range between transmitter, Tx and receiver, Rx has been done to figure out the optimum electrical energy transfer to the load, result was 2cm coil diameter had been selected as transmitter.

Keywords: Wireless Power Transfer, Copper Coil

1. Introduction

Wireless power transfer is the transmission of electrical energy without wires. Wireless power transmission technologies use time-varying electric, magnetic, or electromagnetic fields [1]. This project is focusing on development of wireless power transfer application. An extensive research is done to rectify the output necessary for receiver. The findings from practical studies are gathered and used obtain optimized transmitter.This project is target to design a prototype for this technology and achieve a transfer range of more than 0cm. The scope of this project is to design a optimized prototype which is suitable for this technology, transmitter and receiver can transmit and receive electrical power in range of more than 0cm and consumer or user can use this prototype to charge his/her mobile phone. Project methodology is using DC as source and copper coil as transmitter and receiver to transfer power through air. It is expected that the project gives benefits to both parties, the development team and also researchers [2].

Some researches have been done on Wireless Power Transfer. In [3], an experiment showing the action of the A. C. transformer and which can be performed with high frequency currents is shown at Figure 1 below. Two coils of wire about 24" in diameter, are constructed with the number of turns

*Corresponding author: ifaizal@uthm.edu.my

indicated in the diagram. When the primary is connected to the condenser and the spark gap, as shown, the 110 volt 16 C. P. or a 40 watt lamp connected to the secondary, will light up even when the primary and secondary coils are separated a distance of 1 foot or more, depending upon the size of the transformer or spark coil used for the exciter [3].

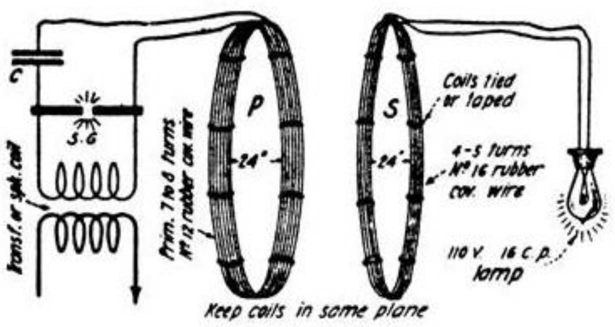


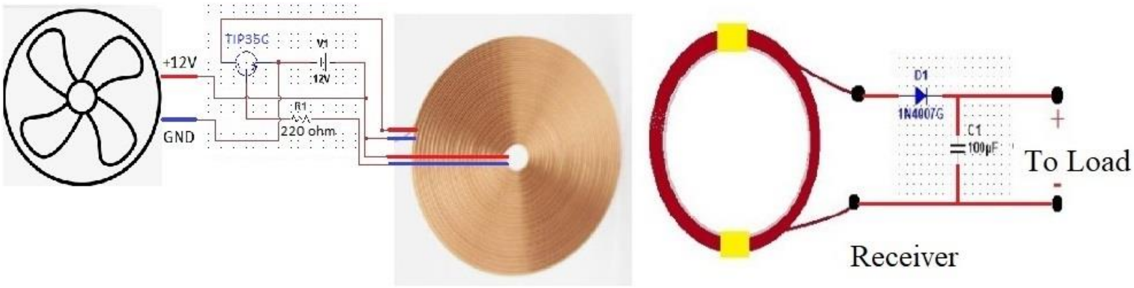
Figure 1: Diagram of one of Tesla's wireless power experiment [3]

In 2007, a physics research group at the Massachusetts Institute of technology (MIT), led by Professor Marin Soljacic, presented a coupled magnetic resonance power transfer system and his success to wireless powering of a 60W light bulb with 40% efficiency at a 2m distance using two 60cm-diameter coils, they called it "Witricity" [4]. Recently in 2008, Intel reproduced the MIT group's experiment and wirelessly powering a light bulb at 75% efficiency, but for a shorter distance [5]. In 2015, Dr. Rim, a professor of Nuclear and Quantum Engineering at KAIST University, and his team used inductive power transfer and transmitted it to a distance of 3-5m where efficiency is 29%, 16%, 8% for 3m, 4m and 5m, respectively [6]. They used 20kHz signals as input signal.

2. Methodology

The circuit is operated from a 12V/1.5 amp source. For transmitter, 14 SWG, 2mm inner diameter for copper and 2mm for insulator, 4.5m speaker cable, was roll from diameter inner diameter 2cm as shown in Figure 2 for 15 turns as for copper coils. The number of turns (coils) may selected approximately in accordance with the supply voltage value, that is around 15 to 20 turns for each halves of the transmitter coil. Higher turns will result in lower current and boosted voltage radiations and vice versa. A NPN-type transistor, TIP35C and a 330ohm resistor was connected to the copper coil as shown in Figure 2. A 12V DC mini fan was connected parallel to the power source for cooling down the TIP35C transistor.

On receiver side, a 24 SWG, 0.5mm inner diameter, 1.7m enameled copper wire, was roll for diameter of 10cm as shown in Figure 2 for 15 turns for copper coils. A 1N4007 Diode is connected series and parallel to a 100uF capacitor before connected to the load. The Figure 2 show the configuration for the circuit of the system. The Figure 4 shows the simple diagram of the system. Figure 3 shows the simple flow diagram for this wireless charger system.



(a) (b)

Figure 2: Circuit of (a) Transmitter and (b) Receiver for the wireless charger

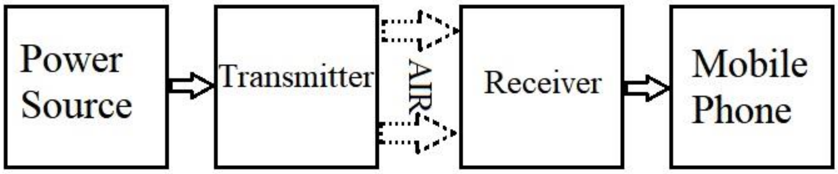


Figure 3: Simple Diagram of Wireless Charger for Mobile Phone

3. Results and Discussion

The result and analysis data will be explain in this section. Table 1 and Figure 4 shows the results of output voltage when distance between transmitter, Tx and receiver, Rx is change from 0.2, 1.2, 2.2, 3.2 and 4.2 cm respectively, and repeated for different number of turn of transmitter coil from 15, 12 and 9 turns respectively. The inner diameter for the transmitter is remain as 4cm. This experiment was use mobile phone connected as load and measured voltage by using multimeter.

Table 1: Result for Distance between Tx and Rx versus output voltage with Fixed Inner Diameter (4cm)

Distance between Tx and Rx , cm	**Output Voltage, V**		
	number of turn, n=15	number of turn, n=12	number of turn, n=9
0.2	17.26	16.98	8.31
1.2	10.37	10.14	4.75
2.2	6.74	6.71	3.27
3.2	5.33	5.18	2.25
4.2	3.79	3.41	1.69

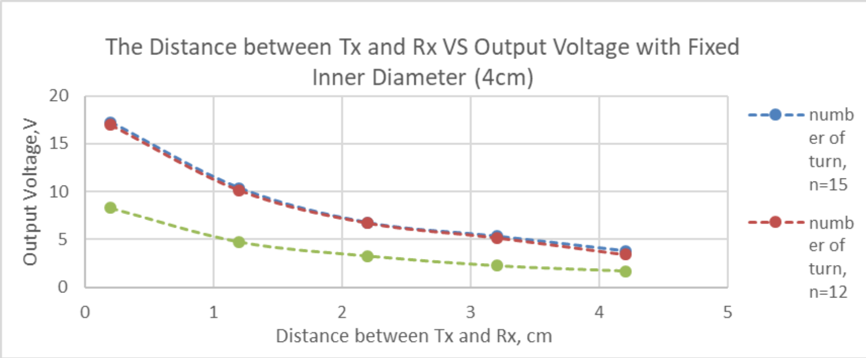


Figure 4: Graph of Output Voltage,V drop when Inner Diameter is 4cm

The input voltage for the transmitter is 9 volts while the average output voltage of the receiver is around 7.079 volts. From that the calculated efficient of the system is around 78.66%. When the distance between the transmitter and the receiver become smaller, the output voltage become higher. This is because when the distance is small, the power can transfer through the magnetic flux is more efficient.

Table 2 and Figure 5 shows the results of output voltage of receiver when distance between transmitter, Tx and receiver, Rx is change from 0.2, 1.2, 2.2, 3.2 and 4.2 cm respectively, and repeated for different number of turn of transmitter coil from 15, 12 and 9 turns respectively. The inner diameter for the transmitter is remain as 2cm.This experiment was use mobile phone connected as load and measured voltage by using multimeter.

Table 2: Result for Distance between Tx and Rx versus output voltage with Fixed Inner Diameter (2cm)

Distance between Tx and Rx , cm	**Output Voltage , V**		
	number of turn, n=15	number of turn, n=12	number of turn, n=9
0.2	17.44	17.12	8.54
1.2	10.5	10.38	4.91
2.2	6.8	6.73	3.51
3.2	5.38	5.24	2.45
4.2	3.88	3.67	1.86

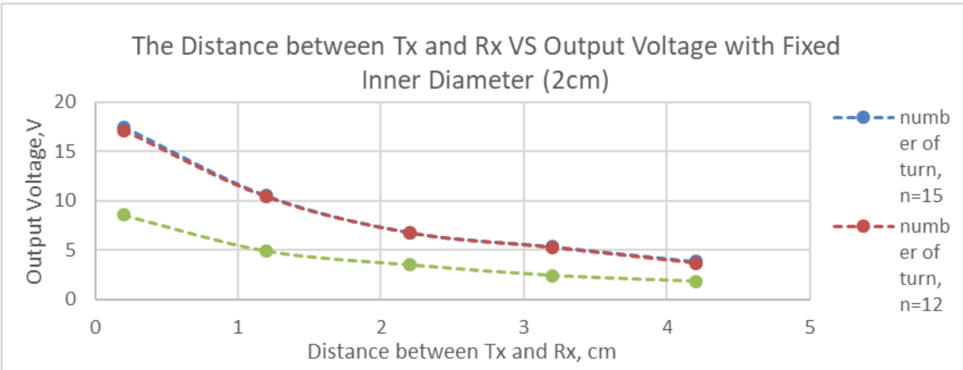


Figure 5: Graph of Output Voltage,V drop when Inner Diameter is 2 cm

The input voltage for the transmitter is remain as 9 volts while the average output voltage of the receiver is 7.227 volts. From that the calculated efficient of the system is around 80.30%., which is better than 4cm inner diameter. When the inner diameter of the transmitter coil is smaller, the output voltage become higher. This is because when the inner diameter of the coil become smaller the magnetic flux become more focus on the centre point, so the power can transfer more efficient. From these experiments, we can conclude that when distance between transmitter and receiver increase, Output Voltage decrease; when the number of turn increase, the Output Voltage increase; when inner diameter of transmitter coil increase, the Output Voltage decrease. Figure 6 shown the completed prototype for Transmitter and Receiver while Figure 7 shown the prototypes that functioning for charging mobile phone. Receiver was placed right on the top of the transmitter to obtain the suitable voltage for charging electronic device.

Figure 6: Photo of Transmitter and Receiver Prototype.

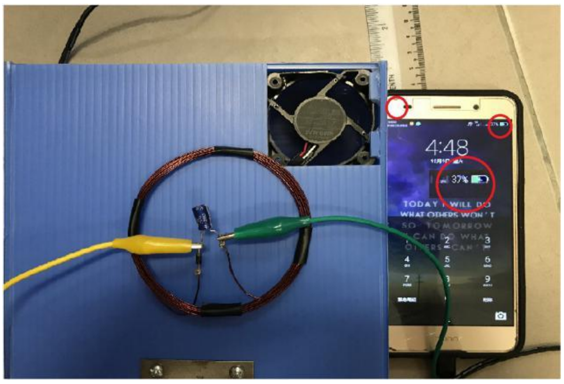


Figure 7: Photo of Functioning Prototype.

4. Conclusion

In this study, the proposition of Wireless Power Transfer technology implementation in charging up mobile phone and other low voltage appliances using accomplished. Furthermore, this system is designed with simple circuit and low cost to domestic users. Consequently, it will help to tidy up cables and help to reduce power cable disposal due to malfunction of power cables. Instead of charging for low voltage applications, high voltage up to 240 volts should be considered as well as for future work. From this, we can power up the electrical appliances by using this technology and further eliminate messy power cable from electrical appliances and leave only 1 or more transmitter for wireless powering from distance. Next, we recommend to improve further efficient for this project so that power loses can be reduce and higher voltage applications can be developed. Therefore, wireless power transfer will no longer only can powering low voltage electronics.

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