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Wireless Energy Transfer Using Magnetic Resonant Coupling

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Abstract

In this work, a simple system of wireless power transfer was designed and implemented using magnetic resonance principles, a power moves from one point to another through a vacuum without using of wires or any conductor. Results showed that the increase of coil diameter and a number of coils lead to an increase in the generate of magnetic field power. In addition, the power and efficiency of the system decrease with increasing distance between the transmitter and the receivers

Keywords: Wireless Power Transfer, Magnetic Resonant Coupling, Transmitter Coil, Receiver Coil.

1. Introduction

Nowadays, the society becomes more concerned with the wireless communication sources through fixed portable devices, which allows the users to have more advanced options to control their devices in a personal way. Since all devices require an energy source to work perfectly, electrical devices get their energy in two ways, either by having the source of energy built in the device or acquired from the surrounding environment [1, 2].

Wireless power transmission (WPT) is an effective method for the conveyance of electric energy from storage device to another without any wires or plugs through vacuum or atmosphere. It is possible to supply power to those areas where it is hard to convey power using traditional wires [3, 4].

Although power transmission wirelessly can be dated back early for over 1900 years, in Nikola Tesla's experience in trying to power distribution in the large electric fields [5]. This technology has been developed by Kurs *et al*, in 2007 [6], using same frequency of the two magnetic resonant coils to exchange energy efficiently, they managed to transfer fully powering 60 watts with ~40% efficiency over distances in excess two meters.

In this research, we implemented a simple design of WPT basic on magnetic resonant coupling and we tested some factors that affect them.

2. Background theory

Inductive coupling has been one of the most common WPT technologies works on electromagnetism principles.

The moment in which a magnetic field placed next to another magnetic coil, the induction current will appear and produce a magnetic field appears around another loop, which is causing the wireless transfer of energy between the coils as shown in figure (2.1). The energy between the coils transmitted when they have the same resonant frequency[3].

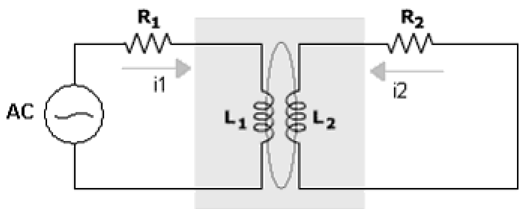

Figure (2.1) magnetic coupling

3. Methodology

A 2N3904 NPN transistor, resistance (1k ohm), L.E.D Light, two batteries 3v and insulated copper wire (0.8mm) were used for the purpose of the study of the transfer of energy wirelessly.

A simple electronic circuit was designed (Fig.3.1), contains two coils with radius 1.8 cm, this circuit connects the electrical energy from a power source (power transmitter Fig.3.2) to the (power receiver Fig.3.3), the connect of energy reach to (5 cm) distance in a safe form and different directions. The sending device communicates with receiving devices and recognizes the location and condition. Moreover, it is sending its energy in the form of wireless waves and specific frequency consequently, thus, no waves were sent randomly in all directions, but according to the receiver and direction case.

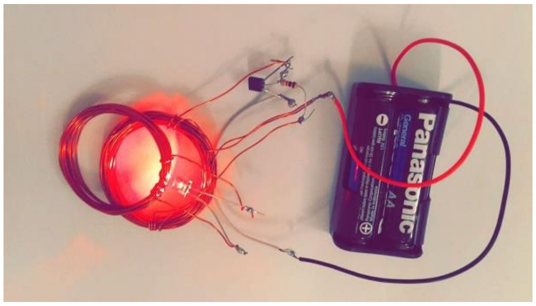

Figure (3.1) simple electric circuit

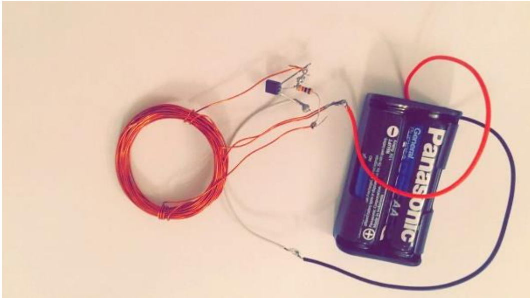

Figure (3.2) power transmitter

Figure (3.3) power receiver

4. Results and Discussion

After completing the design of the device, the measurements to calculate the power of receiver and transmitter was taken by using the following formula

$$P = VI$$

where P is power, V is voltage and I is current.

The efficiency of the system depends on the amount of energy transferred from the transmitted to the receiver circuit. It was calculated by the following expression

$$\eta = \left(\frac{P_{out}}{P_{in}}\right) * 100$$

where η is power efficiency, p_{out} is receiving power and p_{in} is sending power[2].

All the tables and curves are as follows –

Table for Receiving

Table 4.1. *Power calculation of sending*

Distance (cm)	Current (μA)	Voltage (mV)	Power (nW)
0	0.4	14.2	5.68
0.25	0.4	13.3	5.32
0.5	0.4	12.7	5.08
0.75	0.4	12.2	4.88
1	0.4	12	4.8
1.25	0.4	11.9	4.76
1.5	0.4	11.9	4.76
1.75	0.4	11.9	4.76
2	0.4	11.8	4.72
2.25	0.4	11.8	4.72
2.5	0.4	11.8	4.72

Table of Sending

Table 4.2. *Power calculation for receiving*

Distance (cm)	Current (μA)	Voltage (mV)	Power (nW)
0	3.20	2.7	8.64
0.25	2.8	1.3	3.64
0.5	1.15	0.9	1.035
0.75	0.75	0.7	0.525
1	0.51	0.5	0.255
1.25	0.28	0.4	0.112
1.5	0.26	0.4	0.104
1.75	0.15	0.4	0.06
2	0.02	0.3	0.006
2.25	0.01	0.3	0.003
2.5	0	0.3	0

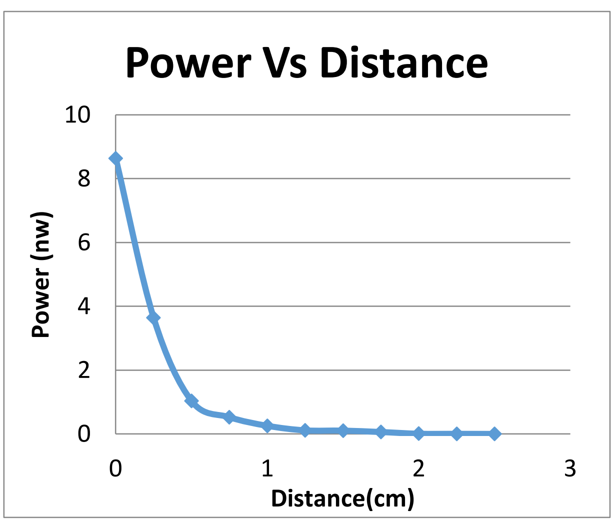

Figure 4.1. *Power and Distance chart*

Table for Efficiency calculation

Table 4.3. *Efficiency calculation*

Distance (cm)	Receiving power (Pout)	Sending power (Pin)	Efficiency (η)
0	8.64	5.68	152.11
0.25	3.61	5.32	67.86
0.5	1.035	5.08	17.84
0.75	0.525	4.88	10.76
1	0.255	4.8	5.31
1.25	0.112	4.76	2.35
1.5	0.104	4.76	2.18
1.75	0.06	4.76	1.26
2	0.006	4.72	0.127
2.25	0.003	4.72	0.064
2.5	0	4.72	0

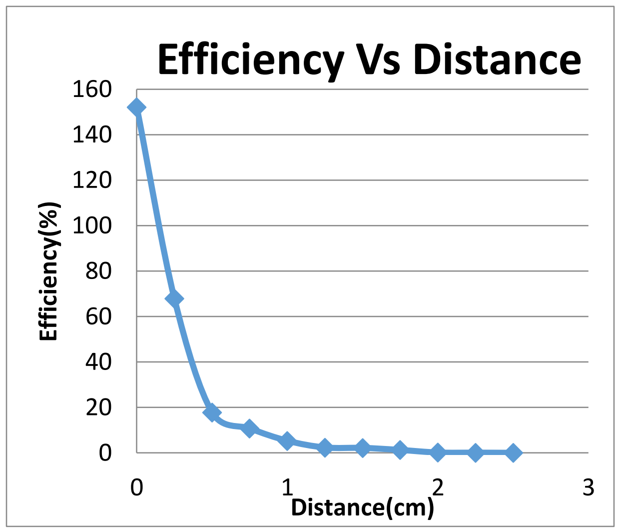

Figure 4.2. *Efficiency and Distance chart*

It is apparent that the power and the efficiency decrease with increasing the distance between the transmitter and receiver as showed in the previous figures. When the larger coil diameter was used, more power was generated to longer distance.

5. Conclusion

In this work, the relation between power and distance as well the relation between efficiency and the distance were examined through the application of the simple system for wireless power transmission using magnetic resonance coupling. It was found that the increase in a number of coils and the distance between two coils of transmitter and receiver effect on the energy transfer wirelessly.

It is recommended to use the wireless energy technology for other useful projects with use a larger diameter of the coil to get better results transfer. This work can be extended to provide electrical and electronic power devices and charging systems, rather than use the current format.

5. Acknowledgement

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6. References

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