Design and Comparison Wireless Power Transfer Base on Copper (Cu) and Aluminium (Al) Rings Loop Magnetic Coupling

Toto Supriyanto, Asri Wulandari, Teguh Firmansyah, and Suhendar

***Abstract*—Magnetically coupled coils have been widely used for a variety of applications requiring contactless or wireless power transfer (WPT). In this paper, the wireless power transfer (WPT) using Copper (Cu) and Aluminium (Al) as magnetic coupling is designed, fabricated and measured. A main problem of wireless power transfer (WPT) is about low efficiency. As state of the art, this research will investigate the effects of the use of copper and aluminum as magnetic coupling. A Copper (Cu) and Aluminium (Al) are used as transmitter (Tx) and receiver (Rx) vice versa. A power analysis has been carried out to identify the efficiency system. The measurement result shown that the wireless power transfer (WPT) using aluminum as transmitter (Tx) and receiver (Rx) have the highest efficiency. The overall efficiency of the power being transferred is about 7,51%-10,8% at distance 20 cm. This research shown that aluminum can consider as a material for the wireless power transfer with magnetic induction method.**

***Index Terms*—Wireless power transfer, receiver, transmitter, copper, aluminium.**

I. Introduction

Nowadays, magnetically coupled coils have been widely used for a variety of applications requiring contactless or wireless power transfer (WPT). Tesla has demonstrated that, for a pair of magnetically coupled resonators with one used as a transmitting unit and the other as receiving unit, optimal wireless power transfer could occur at the resonance frequency of the resonators [1]. A pair of L-C loop resonators for wireless power transfer proposed by Tesla shown in Fig. 1.

The most popular wireless power transfer technique used in biomedical implanted devices is near-field inductive coupling. Researches have indicated that if near-field techniques are used and if the range of energy transfer distance is of the order of tens of centimeters, the overall efficiency of the power being transferred is only about 1%-2% [2].

The magnetically coupled resonators were presented for wireless power transfer. It now becomes possible to transmit power efficiently at ranges longer than that realized using inductive coupling schemes [3]. For low-power applications, wireless power transfer has found applications in battery charging for portable electronic products such as mobile phones [4]-[7], and mobile laptop charging [8], [9].

In Fig. 2 show, typical exponential decay curve of the efficiency as a function of transmission distance for wireless power transfer (WPT).

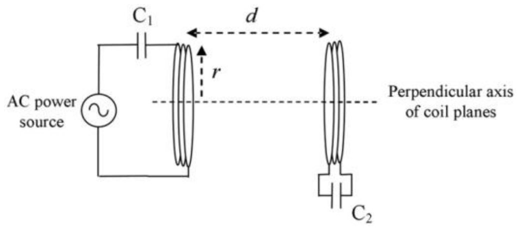

Fig. 1. A pair of L-C loop resonators for WPT [10].

A main problem of wireless power transfer (WPT) is about low efficiency. As state of the art, this research will investigate the effects of the use of copper and aluminum as magnetic coupling.

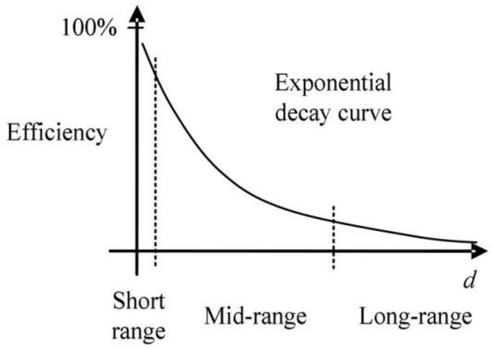

Fig. 2. Typical exponential decay curve of the efficiency [10].

II. Wireless Transfer Power

If two resonators are placed in proximity to one another such that there is coupling between them, it becomes possible for the resonators to exchange energy. The efficiency of the energy exchange depends on the characteristic parameters for each resonator and the energy coupling rate between them. The dynamics of the two resonator system can be described using coupled-mode theory [11], or from an analysis of a circuit equivalent of the coupled system of resonators shown in Fig. 3.

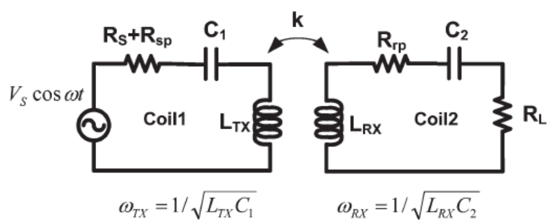

Fig. 3. A circuit equivalent of the coupled system of resonators [11].

Magnetically coupled resonator. k is the coupling

Manuscript received August 21, 2015; revised January 6, 2016.
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doi: 10.18178/ijiee.2016.6.2.605

coefficient between the *TX* and *RX*. R_S and R_L are source and load resistances, respectively. R_{sp} and R_{rp} are the parasitic resistances of the *TX* and *RX* coils.

A. Efficiency

The efficiency η is defined as the ratio between the total power dissipation in the load and the total power supplied by the sources [12] where I_1 and I_2 are the phasors of rms currents of coils 1 and 2.

$$\eta = \frac{R_L\left|I_2\right|^2}{(R_S + R_{Sp})\left|I_1\right|^2 + (R_L + R_{rp})\left|I_2\right|^2} \tag{1}$$

Thus the efficiency, is maximized when [12].

$$\omega \cong \omega_{RX} \tag{2}$$

The resonant frequency of the *TX* should be the same as that of the *RX*.

B. Design Wireless Power Transfer

The design Wireless Power Transfer using Copper (Cu) and Aluminium (Al) Magnetic Coupling is following a flow chart shown in Fig. 4.

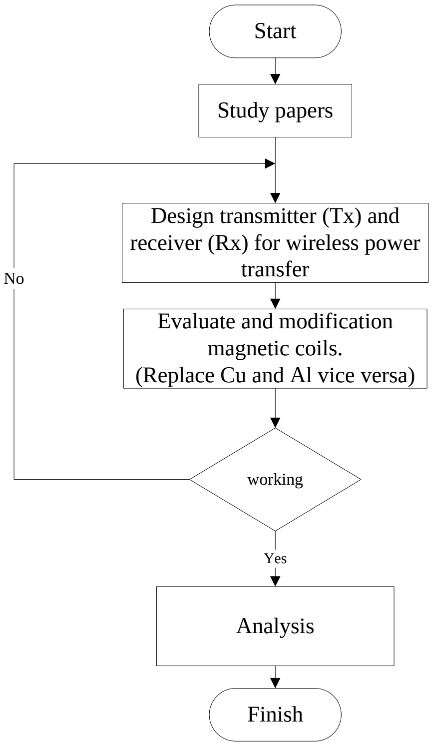

Fig. 4. A flow chart this research.

Generally Wireless Power Transfer consists of a power supply, oscillator circuit, and magnetic coils as Transmitter. The receiver consisting of a full wave rectifier circuit, load, and magnetic coils.

C. Power Suplly (AC-DC Converter)

The power suplly circuit shown in Fig. 5. IC LM317 regulator is used which has an input voltage range from 1.2 to 25 volts and a maximum output current of 1.5 Amperes.

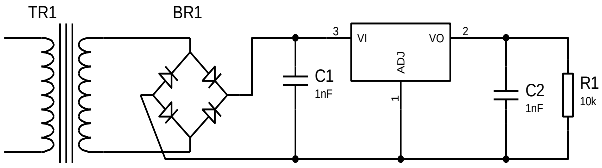

Fig. 5. AC-DC converter.

D. Oscillator as a Source Power

Royer oscillator circuit is used at this research shown in Fig. 6. Royer oscillator have strong oscillation signal with simple circuit.

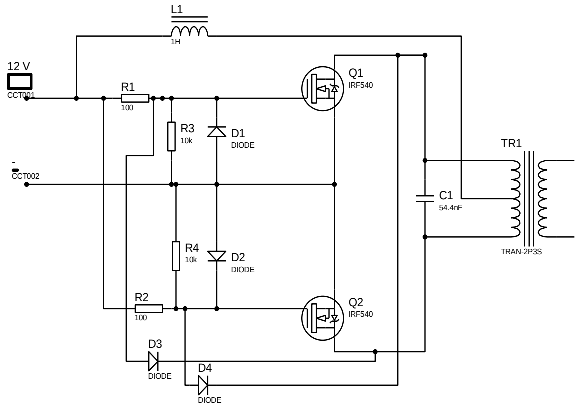

Fig. 6. Royer oscillator.

E. Copper (Cu) and Aluminium (Al) for Magnetic Coil

Copper is a chemical element with the symbol Cu (from Latin: cuprum) and atomic number 29. It is a ductile metal with very high thermal and electrical conductivity. Pure copper is soft and malleable, a freshly exposed surface has a reddish-orange color. It is used as a conductor of heat and electricity, a building material, and a constituent of various metal alloys.

Aluminium is a chemical element in the boron group with symbol Al and atomic number 13. It is a silvery white, soft, ductile metal. Aluminium is the third most abundant element (after oxygen and silicon), and the most abundant metal, in the Earth's crust.

F. Full Wave Rectifier Circuit

The receiver consisting of a full wave rectifier circuit, load, and magnetic coils. Shown in Fig. 7.

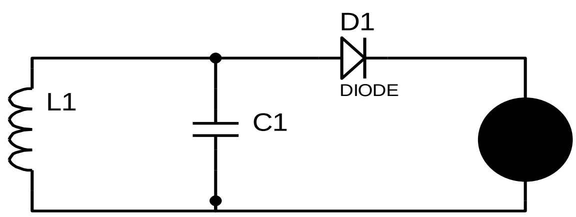

Fig. 7. A full wave rectifier circuit.

III. Experimental Setup

The experiments in this paper shown in Fig. 8 to Fig. 11. Next step is changes value of the distance between the coils. And then measured power on the receiver, so the efficiency values obtained.

Fig. 8. Wireless power transfer with copper (Cu) transmitter (*TX*) and copper (Cu) receiver (*RX*).

Fig. 9. Wireless power transfer with copper (Cu) transmitter (*TX*) and aluminium (Al) receiver (*RX*).

Fig. 10. Wireless power transfer with aluminium (Al) transmitter (*TX*) and copper (Cu) receiver (*RX*).

Fig. 11. Wireless power transfer with aluminium (Al) transmitter (*TX*) and aluminium (Al) receiver (*RX*).

IV. Units

After changes value of the distance between the coils. A power analysis has been carried out to identify the efficiency system. Fig. 12 shows the power transmitter and Fig. 13 shows the power receiver.

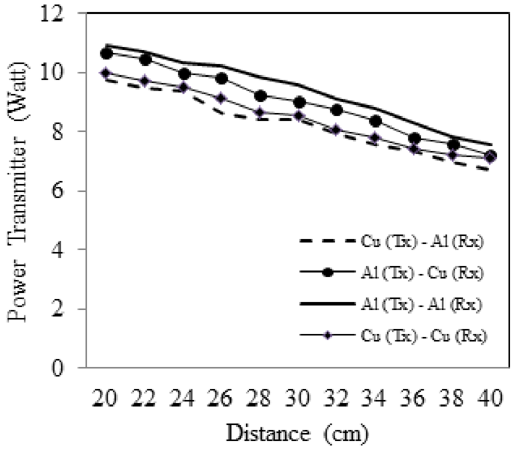

Fig. 12. Power Transmitter (Watt).

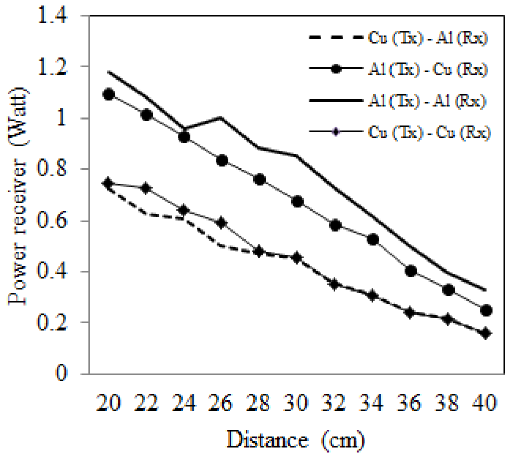

Fig. 13. Power Receiver (Watt).

Efficiency is very influential in the distance, increasing the distance between the transmitter with the receiver will decrease power efficiency of wireless power transfer. Comparison power efficiency shown in Fig. 14.

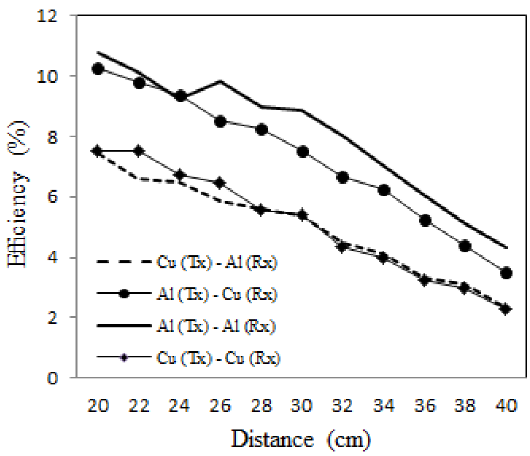

Fig. 14. Efficiency (%).

V. Conclusion

It can be concluded that the efficiency using aluminum as magnetic coils is higher than copper magnetic coils. The overall efficiency of the power being transferred is about 7,51%–10,8%. This research proves that aluminum is considering use as a material for the wireless power transfer with magnetic induction method.

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