Wireless Power Transfer System for External Memory Hard by using Small Magnetic Coils

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***Abstract* - A miniature magnetic resonance coil for an external memory disk is presented. The proposed resonance coils are derived from a spiral structure and two capacitors through the analysis of input impedance. The measured resonance frequency and efficiency are 1.78 MHz and 82.3% at normalized distance 6 ㎝ and the diameter size of the Rx spiral coil is 7cm.**

***Index Terms* — Wireless power transmission, magnetic resonance, wireless charge, magnetic coils.**

1. Introduction

Many researchers have developed the wireless charging system using the magnetic coupling or magnetic resonance [1~8]. In this paper, we extend previous studies of coupled magnetic resonance into reducing size of the coils for a small external memory hard.

The diameter of TRx magnetic resonance coils is not the same. The diameter of Rx coil is even smaller than that of Tx coil by using the impedance matching technology. The resonance frequency is 1.78 MHz. Diameters of TRx' spiral coil are 15 cm and 7 cm. The proposed coil structure is expected to be applied for energy transfer technology of various home electrical devices as well as portable devices.

2. Architecture of wireless power transmission system

Fig. 1 depicts the schematic diagram of the wireless power transmission system. The proposed wireless power transmission system consists of a 15W class D power transmitter, two magnetic resonance couplers and 10W full bridge RF rectifier receiver. The diameter size of the spiral coil is 15 ㎝ (0.9 λ/1000). The receiver is composed of RF

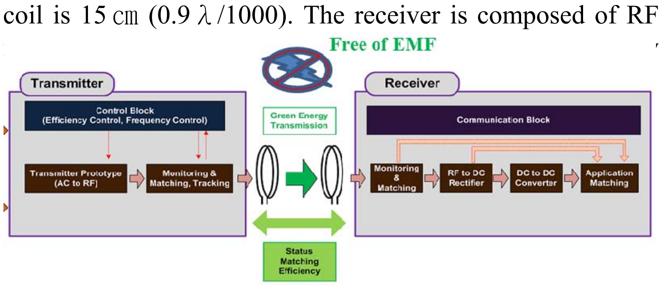


Fig. 1 Schematic diagram of the power transmission system

As portable devices get smaller, reducing the element is important factor for wireless power transfer, and coil's size is constrained by the small portable devices. Power transfer efficiency is strongly related to the quality factor(Q) of the coils as well as the coupling coefficient between the two coils. The efficiency depends on the size, structure, physical distance, relative location of the coils and impedance matching in this system. Basically, the coupling coefficient between the coils is decreased if the distance between the coils is increased. The series quality factor is proportional to L(inductance) and f_0(resonance frequency). It is inversely proportional to R(resistance). High Q is required to obtain longer wireless power distance [1, 2].

Fig. 2 shows the coil structure proposed in this paper. As shown in fig 2, the diameter of TRx magnetic resonance coils is not the same. The diameter of Rx coil is even smaller than that of Tx coil by using the impedance matching technology. Here, we make load impedance matching by using a series capacitor and a parallel capacitor circuit. The resonance frequency is 1.78 MHz. Diameters of TRx' spiral coil are 15cm and 7cm.

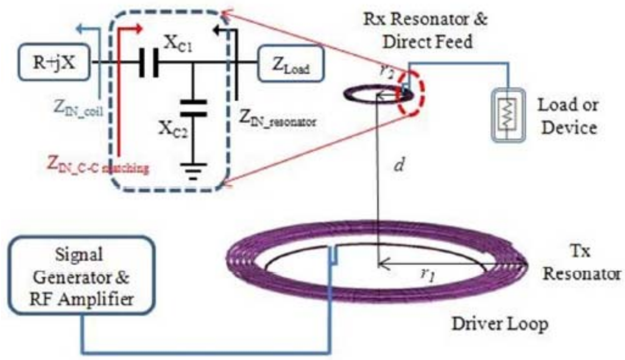
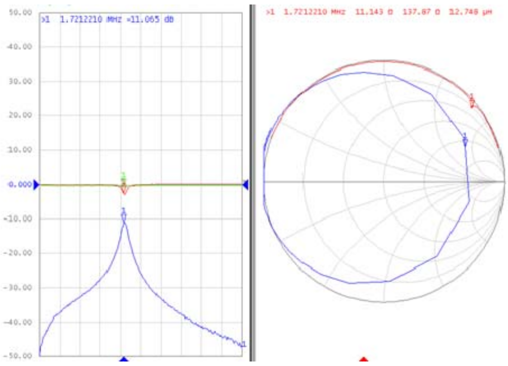
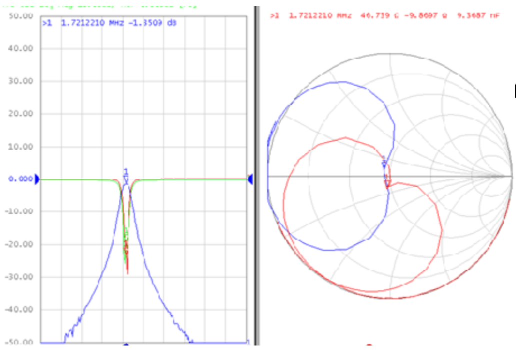


Fig. 2. Structure of TRx small magnetic resonance coils and C-C matching circuits.

Fig. 3 shows the TRx coil's transfer characteristic before and after C-C matching circuit. The output impedance of the Rx coil is R+jX. The input impedance(Z_{IN}_resonator) of a Tx coil including a C-C matching circuit is equal to the load resistor(Z_{Load}.).

This C-C matching circuit has two functions. One is resonance function at the wanted frequency and the other is an impedance matching of a wireless power transmission system.





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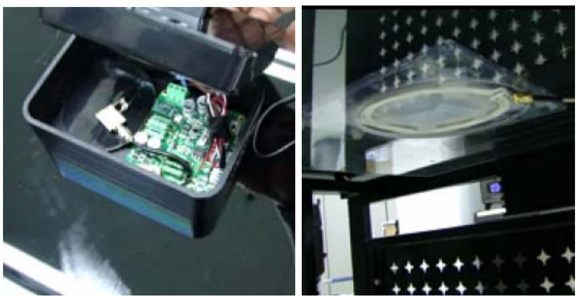
(b) Transfer characteristic(S_{21}) after C-C matching.

Fig. 3. TRx coil's transfer characteristic.

3. Result of system

As shown in fig. 4, to transfer the power energy into the external memory disk, the wireless power transmission technology using magnetic resonance coils was used.

(a) An external memory disk.



(b) TRx module of WPT system.

Fig. 4. WPT system for an external memory disk.

The resonance frequency and transmitting power is 1.78MHz and 15W, respectively. And there is a glass desk and the distance(d) between Tx-coil and Rx-coil is7cm. Both coils are made of a copper and have one layer coil and two capacitors to make impedance matching. The compact external memory disk is composed of a Rx-coil, a receiving module. The entire DC to DC efficiency of this WPT system is 54%.

4. Conclusion

In this paper, the 1.78MHz, 15W power transmission system is designed, implemented and applied to real wireless power transmitter system. By the measurement result, the entire efficiency of this WPT system is 54%. We designed and fabricated a 15W class-D power transmitter, two magnetic resonance couplers and 10W full bridge RF rectifier receiver. This paper also describes the simple miniatured magnetic resonance coils for wide wireless power transfer applications.

Acknowledgment

This work was supported by the National Research Council of Science & Technology (NST) grant by the Korea government.

References

[1] Andre Kurs, Arsteidis Karalis, Robert Moffatt, John joannpoulos, Peter Fisher, Marin Soljacic, "Wireless Power Transfer via Strongly Coupled Magnetic Resonances," Science Magazine, Vol. 317, No.5834, pp.83-86, 2007.

[2] Alanson P. S., "Analysis, experimental results, and range adaptation of magnetically coupled resonators for wireless power transfer," IEEE Trans. On Industrial Electronics, vol. 58, no.2, pp. 544–554, 2011.

[3] S.W. Choi and M.H. Lee, "Coil-Capacitor Circuit Design of a Transcutaneous Energy Transmission System to Deliver Stable Electric Power," ETRI Journal, Vol. 30, No. 6, Dec. 2008

[4] PowerMat Inc., http://www.powermat.com, Nov. 2009.

[5] J. Heikkinen, and M. Kivikoski, "Low-profile circularly polarized retifying antenna for wireless power transmission at 5.8 GHz," IEEE Microwave and wireless components letters vol. 14, no.4, pp. 162-164, 2004.

[6] Tianliang Yang, Chunyu Zhao, and Dayue Chen / Shanghai Jiao Tong University, China, "Feedback Analysis of Transcutaneous Energy Transmission with a Variable Load Parameter," ETRI Journal, Vol. 32, No. 4, Aug. 2010

[7] W. J. Byun, B. S. Kim, K. S. Kim, et al., "40 GHz Vertical Transition with a Dual-Mode Cavity for a Low-Temperature Co-fired Ceramic Transceiver Module," ETRI Journal, vol. 32, no. 2, April 2010, pp. 195-203.

[8] ICNIRP, "Guidelines for limiting exposure to time-varying electric, magnetic, and electromagnetic fields," ICNIRP, vol.74, no.4, pp. 511-512, 1998.