Experimental investigation of wireless power transfer with metamaterial

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I. INTRODUCTION

Recently, the research and development of wireless power transfer (WPT) is actively pursued with the high demand for wireless charging in the modern electronics. However, most of the current WPT systems have limited power transfer distance and efficiency as they adopt the inductive coupling approach. An alternative is to use magnetic resonance (MR), with which metamaterials can be used to improve efficiency [1]. Metamaterials are artificially engineered materials that have uncommon electromagnetic properties, such as evanescent wave amplification and negative refraction [2]. The metamaterial WPT reported are not easy to implement and more experimental study at midrange distance is still needed to be investigated.

In this work, an experimental investigation on the power transfer efficiency of the metamaterial based WPT is performed. A 4-coil system operating at 4.6MHz is reported.

II. WPT system design

A. 4-coil System

As shown in Fig. 1 (a), a self-resonant transmission (Tx) coil and a receiver (Rx) coil have an outer diameter of 60cm, 12 turns and a pitch of 1cm. The source and load coils were built as a single turn loop with a diameter of 40cm. Capacitors are connected parallelly in order to resonate at the operating frequency. The overall 4-coil system operates at 4.6 MHz.

B. Metamaterial unit cell

As shown in Fig1(b), the metamaterial unit cell was fabricated using a copper wire covered by PVC and a wire diameter is 0.255mm. The metamaterial unit cell has double layers, each of which is composed of 10 and 9 turns and a unit cell diameter is 9cm. This unit cell resonates at 4.6 MHz. The metamaterial slab will consist of 7×7 unit cells.

III. Experimental results

The overall efficiency of WPT is measured using a network analyzer. Table 1 shows the measurement result of power transfer efficiency. When a metamaterial slab is added in the system, the efficiency is improved.

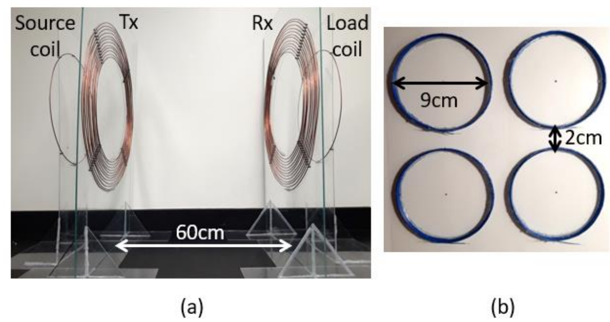

Figure 1: (a) Fabricated 4-coil wireless power transfer system, (b) Fabricated metamaterial unit cells

Table 1: Measurement result of transfer efficiency

Distance	Efficiency	Resonant frequency
30cm	85 %	4.73 MHz
40cm	81 %	4.68 MHz
50cm	77 %	4.68 MHz
60cm	69 %	4.64 MHz
70cm	56 %	4.6 MHz
80cm	42 %	4.6 MHz
90cm	40 %	4.6 MHz
100cm	39 %	4.6 MHz

IV. Conclusion

In this work, we show a magnetic resonance based wireless power transfer with a metamaterial slab and its experimental study for efficiency enhancement. The transfer efficiency without metamaterial is measured. When the metamaterial slab is located between the transmitter and receiver coils, WPT efficiency can be characterized.

REFERENCES

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