

A Novel Wireless Power Transmission System Using Microstrip Coil Structure with Ferrite and Dielectric Layers

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Abstract –In this paper, a novel wireless power transmission (WPT) system composed of microstrip coils with ferrite and dielectric layers is proposed. The structure of each microstrip coil includes a loop one placed outside and a spiral one put inside. It would be concluded that the transfer efficiency of the proposed WPT system with load of 50 Ohm can get up to around 59.7% at the resonant frequency of 13.56 MHz.

Index Terms — Wireless power transmission, Microstrip coil, Magnetic resonant coupling, Ferrite.

1. Introduction

In recent years, a great deal of research has been focused on the WPT issue because of its convenience in power charging device. Generally, the wireless power transfer methods can be divided into three categories: inductive transfer, radiative transfer and resonant transfer ways, which has been analyzed and summarized in Ref. [1]. Among these three methods, the resonant transfer way can deliver power with higher efficiency than the radiative transfer way and over larger range than the inductive transfer way, which was mentioned in Ref. [2]. Therefore, the resonant transfer way is chosen in this paper for the design of WPT system. In Section 2, a WPT system by replacing the wire coils designed in Ref. [3] with the microstrip coils, would be presented. Besides, two two-layer substrates made up of FR4 and ferrite were set respectively under transmitting coil (Tx) and above receiving coil (Rx) so as to improve the transfer efficiency, the effect of which has been demonstrated in Ref. [4] and Ref. [5]. Finally, our designed WPT system would be shown to be well resonant at the center frequency of 13.56 MHz with the transfer efficiency of around 59.7%.

2. Structure Design and Simulation Results

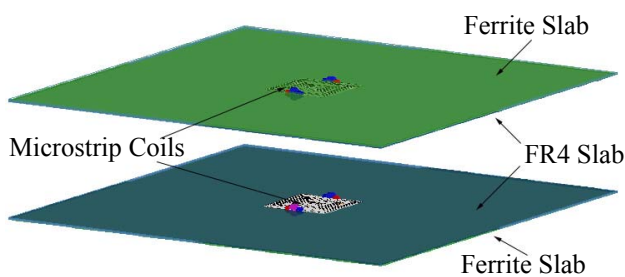


Fig. 1. Overall view of WPT system.

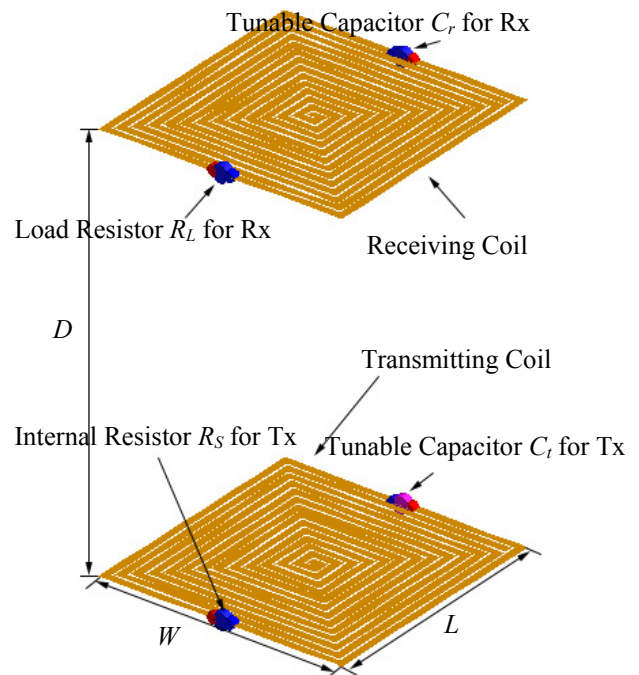


Fig. 2. Overall view of transmitting coil and receiving coil.

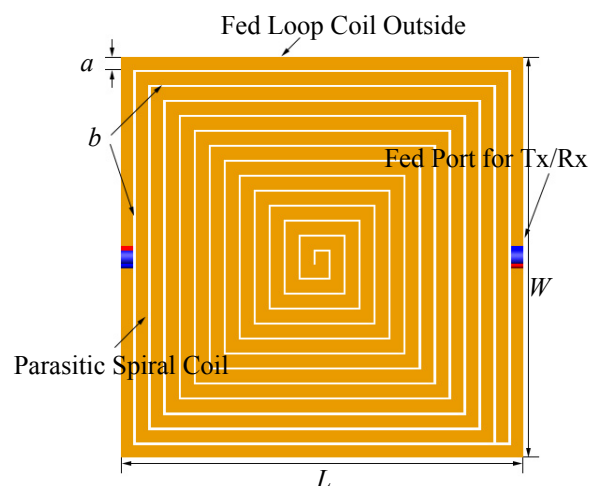


Fig. 3. The structure of transmitting coil or receiving coil.

In order to be compatible with the PCB designed for electronic mobile devices, a wireless power transfer system using coil microstrip antennas has been proposed in this

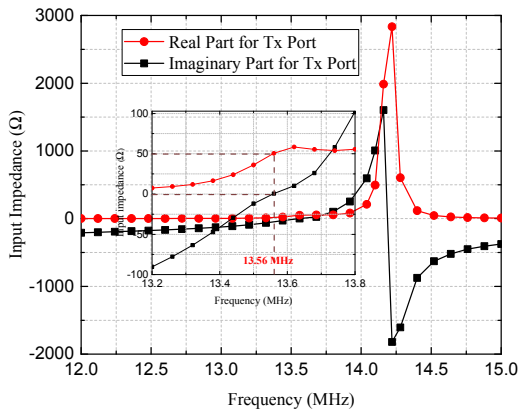


Fig. 4. Input impedance of WPT system calculated from fed port of Tx.

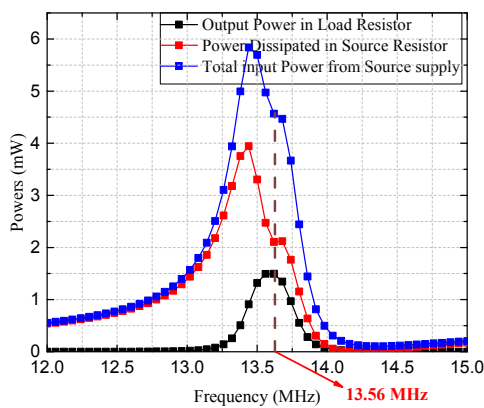


Fig. 5. Three power parameters of WPT system.

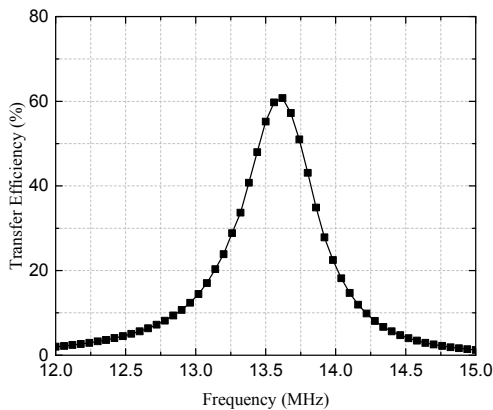


Fig. 6. Transfer efficiency of WPT system.

paper. The system was designed and optimized by using FEKOTM, which is a commercial software based on method of moments (MoM). The whole structure of the proposed WPT system is drawn as in Fig. 1. The microstrip coil antenna is cladding on FR4 with the thickness of 2.0 mm. Moreover, the ferrite layer of 3.0 mm thickness set together with the FR4 layer, intends to uniform and reflect the magnetic-field energy for further transferring. The ferrite's relative permeability and the magnetic loss tangent were set to be 1000 and zero. The overall view of the transmitting coil

and receiving coil is depicted as in Fig. 2. They are faced with each other and the distance between them is $D = 30.0$ cm. As drawn in Fig. 3, the transmitting/receiving antennas are made up of the port fed loop coil and the parasitic spiral coil, both of which are the microstrip design. The width of all microstrip lines is $a = 5.685$ mm and the in-between gap is $b = 1.0$ mm. Through optimization, the length of the transmitting/receiving antenna structure is $L = 179.5$ mm and its width is $W = 178.5$ mm, which is made of copper. The input source is with voltage magnitude of $|V_s| = 1.0$ V and an internal resistor of $R_s = 50 \Omega$, while the output terminal is a load resistor of $R_L = 50 \Omega$. In addition, two equal tunable capacitors of $C_t/C_r = 30.65$ pF are set to connect with the transmitting/receiving coils so that the whole system can be well resonant at the frequency of 13.56 MHz.

To sweep the frequency band from 12.0 MHz to 15.0 MHz, the input impedance of the WPT system has been shown as in Fig. 4. It can be found that the impedance value matches well with $(50.0 + j 0.0) \Omega$ at the point of 13.56 MHz. Here, the transfer efficiency defined as [3] follows

$$\eta_{eff} = [P_l / (P_l - P_s)] \times 100\% , \quad (1)$$

where P_l , P_i and P_s are the power output from load resistor, total input from source supply, and dissipated in source resistor, as shown in Fig. 5 respectively. Therefore, the transfer efficiency reaches 59.7% at the frequency of 13.56 MHz as depicted in Fig. 6.

3. Conclusion

A wireless power transfer system using microstrip coil based on the magnetic resonant coupling has been designed and optimized by using a full-wave numerical method. This microstrip coil system can reach its maximum power transfer efficiency of nearly 60% and the impedance matches well with 50Ω at the resonant frequency of 13.56 MHz.

Acknowledgment

The authors thank the assistance in simulation with FEKO from their engineers during the research process.

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