A Novel Structure of Metameterial with High Bandwidth for Wireless Power Transfer Systems

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Abstract—**As an artificial material, the metamaterial has great applications in radar, stealth and electronic countermeasure because of its special electromagnetic properties. Considering its negative permittivity and negative permeability, the metamaterial is applied in wireless power transfer system to improve its performance. In this paper, a novel structure of metamaerial is designed. This metamaterial has high bandwidth which is suitable to be applied in wireless power transfer system. The simulation results indicate that this novel structure metamaterial has greater flexibility in the wireless power transfer system.**

Index Terms—**Metamaterial, negative properties, resonant frequency, wireless power transfer system.**

I. Introduction

The previous researches indicate that the metamaterial can improve the wireless power transfer systems' performance because it can focus the near-field electromagnetic wave [1,2]. In order to couple the metamaterial and the wireless power transfer system, the electric resonant frequency and the magnetic resonant frequency of the matematerial should be equal to the operation frequency of the system.

In this paper, a novel structure of metamaterial is proposed and analyzed using finite element method. It is found that the relative bandwidth is significantly larger. Based on structure element coplanar coupled, it has the advantages of simple structure, easy regulation analysis, high frequency bandwidth and easy to expand for 2D and 3D.

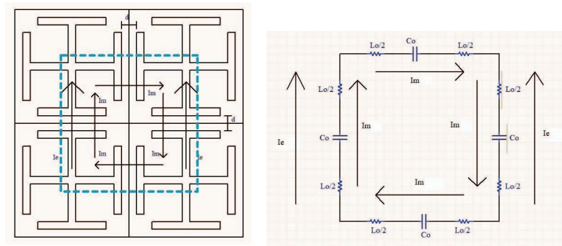
II. Proposed Model

The unit structure of metamaterial is shown in Fig. 1(a). In this model, the electric field spreads along Y direction, and the vertical magnetic field spreads along Z direction, and electromagnetic wave propagates along X direction. The equivalent circuit of middle region under the action of electromagnetic field is shown in Fig. 1(b). The electric resonant frequency and magnetic resonant frequency can be expressed as

$$\omega_e = \frac{1}{\sqrt{L_0 C_0}}; \qquad \omega_m = \frac{1}{\sqrt{4L_0 \times C_0 / 4}} = \frac{1}{\sqrt{L_0 C_0}} \qquad (1)$$

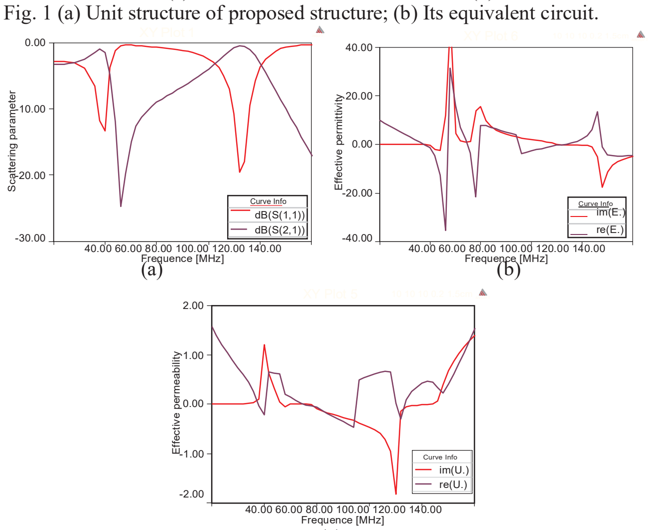
where, L_0 is the inductance of copper strip ,C_0 is the capacitor of two adjacent copper wire. Hypothesis the circuit is lossless, we can get

$$\varepsilon_r = 1 - \frac{\frac{2S}{\varepsilon_0 \otimes V}}{L_0(\omega_0^2 - \omega^2)}; \qquad \mu_r = 1 - \frac{\frac{S^2\omega^2}{\otimes V}}{4L_0(\omega_0^2 - \omega^2)} \qquad (2)$$



(a) (b)

Fig. 1 (a) Unit structure of proposed structure; (b) Its equivalent circuit.



(c)

Fig. 2 (a) Scattering parameter of the proposed model; (b) Effective permittivity of proposed model; (c) Effective permeability of proposed model.

III. Initial Results

To verify the performance of unit coplanar coupled metamaterial, it is simulated using finite element method and the results are shown in Fig. 2. From Fig. 2(a), it can be seen that there is a transmission peak and its corresponding low reflectance near 60MHz. The real part of effective permittivity and effective permeability also change from positive to negative, which indicates that electrical resonance frequency and magnetic resonant frequency of the model are both in the vicinity of 60MHz as shown in Fig. 2(b) and Fig. 2(c).

The detail results will be given in full paper.

References

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