Numerical Analysis of a Tunable Magnetic Resonator

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Since the split-ring resonator (SRR) was proposed by Pendry et al., it has been extensively investigated analytically, numerically, and experimentally. In our recent work, we proposed an efficient technique based on the quasi-static Lorentz theory to analyze a metamaterial composed of a 3-D array of small inclusions. This technique has been successfully applied for the analysis of media with a SRR and a stacked split-ring resonator (SSRR) which is a modified split-ring resonator and consists of two split-rings with one split-ring placed on the top of another. The previous research has supported the unique feature of this medium as a metamaterial, that is, it has negative permeability values at a certain frequency range which is due to its resonating structure, and its resonance frequency is determined by the size of the ring ($\approx 0.1\lambda$) and the spacings.

In this paper, a SSRR will be further modified by inserting auxiliary lumped elements, such as an inductor and/or a capacitor, between the split of each ring with the purpose of alternating the electric and magnetic dipole moments and improving the material characteristics. We will present numerical simulation results showing the effect of the auxiliary lumped elements. Through the numerical experiments, it will be shown that the resonance frequency of the proposed resonator structure can be controlled by adjusting the auxiliary lumped elements, and in addition, the size of the ring resonator can be reduced to an order of 0.01λ that is one tenth that of the split ring resonator by choosing the proper lumped elements. Further improvements, such as a wider bandwidth which may be able to be achieved by utilizing a variable capacitor, will be discussed.