Ellipsoidal Negative Parameters Metamaterial Subwavelength Radiators

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Small antennas with wideband impedance characteristics are of significant interests in many areas, in particular, modern wireless systems. The main challenge is to squeeze the resonant dimension of antenna while maintaining other radiation features. Recently, there have been some novel methods to develop subwavelength radiators utilizing negative parameters materials.

In this paper, the resonance performance of electrically small-size ellipsoidal radiators made of negative ε (ENG) or negative μ (MNG) metamaterials is theoretically investigated. It is demonstrated how the material polarization can successfully provide resonance radiation at the negative material constitutive parameters. The dependence of resonant frequency on the shape of structure is formulated. Special cases, such as, sphere, thin disk, and long rod are investigated. It is assumed that the size of ellipsoid is much smaller than the wavelength in the vacuum and in the material. Hence, the quasi-static model can be applied to formulate the problem with a very good accuracy, and predict the physical parameters of the antenna. It is demonstrated that for a spherical geometry the resonance occurs for $\varepsilon_r = -2$ while a thin disk resonates at smaller negative permittivity and long rod requires a larger negative permittivity. A full wave Finite Difference Time Domain technique is also applied to numerically model the structure and validate the derived theory.

The creation of small antennas utilizing negative permeability materials is also addressed by proposing a MNG radiator excited by a slot feed as a dual of the ENG antenna. The obtained observations will be of great benefit for successful design of arbitrary shaped metamaterial-based subwavelength antennas.