Design and Optimization of Multilayer Ideal Cloak

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Abstract

The development in metamaterial science and technology has created many exhilarating applications in microwave to optical frequency region in which invisibility cloaking [1] is one of the exciting application. In recent years, the RCS reduction characteristics of cloaking structures have been widely investigated as it found extensive applications in stealth platform. Maxwell's equation with transformation theory [2] is the fundamental principle behind the operation of the invisibility cloak in anisotropic medium. The design of invisibility cloak for arbitrary shape is the optimal version of EM stealth property in which the electromagnetic waves are controlled and guided within the cloaking shell by applying the prescribed spatial variation in the constitutive parameters. The spatial variation in the material properties like relative permittivity and permeability is performed using the coordinate transformation, resulting in bending of EM waves around the object. Calculation of the relative permittivity and permeability tensors [3] is one of the promising challenges in the design of invisibility cloak. In aerospace applications, invisibility implies hiding information about the target from detecting objects like radar. This can be achieved by reducing the radar cross section of the object by using various stealth technologies and as a result, achieving no absorption and reflection of the energy by the object [4-6].

This paper deals with the design of cloaking structure for aerospace domain in accordance with the transformation optics theory. The design and simulations of spherical cloaking has been performed using RF module of FEM based COMSOL Multiphysics® software. Figure 1 shows the cloaking effect through 2D electric field distribution and bending of electric filed has been clearly observed. The performance of the designed cloak is analyzed by comparing the RCS of PEC without cloaking and with multilayer cloaking shells. The RCS comparison plot in Mie region is represented in Figure 2. As the number of layers increased there is a reduction in RCS and with 4 layers of cloaking shell, RCS value was reduced to 24 dB as compared to PEC. From Figure 2, it is seen that the RCS reduction is more in C-band and hence the operating frequency can be chosen in this band to get a better performance.

Reference

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Figures used in the abstract

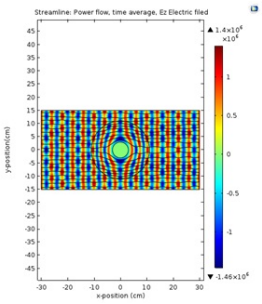

Figure 1: 2D spherical cloak ,Electric filed patterns, with stream lines indicating the direction of power flow.

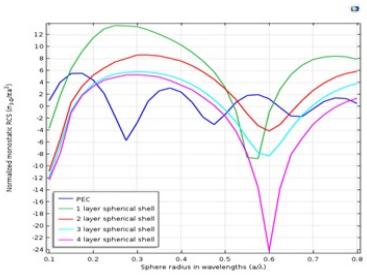

Figure 2: RCS comparison plot between PEC and Multilayer Cloaking Shell.