Compact Mu-Negative (MNG) and Double-Negative (DNG) Media Using Bilayered Frequency Selective Surfaces Connected by Vias.

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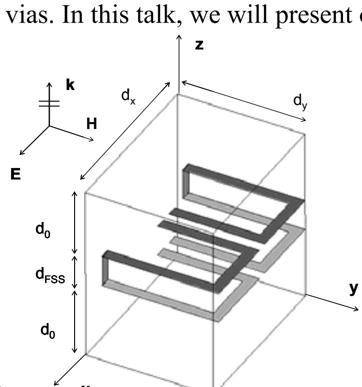
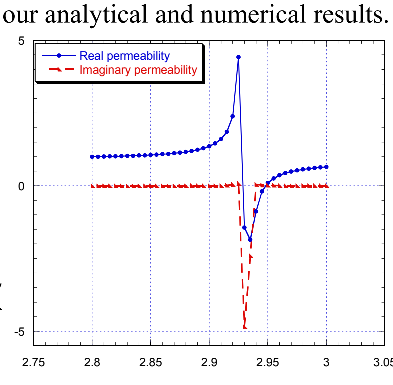
In recent years, the idea of composite materials in which both permittivity and permeability reach negative values at certain frequencies has gained considerable attention among several research groups. In 1967 Veselago first theoretically investigated plane wave propagation in a material whose permittivity and permeability were assumed to be simultaneously negative. In particular, the issue of achieving a negative permeability represents the most challenging aspect in the realization of such media. In 1999, Pendry suggested the use of split-ring resonators in order to obtain a mu-negative (MNG) behavior (Pendry *et al.*, *IEEE Trans. on Microwave Theory and Techniques*, Vol. 47, Issue 11, Nov. 1999 , 2075 – 2084.). Smith, Schultz and their coworkers then experimentally verified the properties of such a MNG structure through their DNG medium. It would be appealing, from a practical point of view, to make use of almost planar layered inclusions to obtain similar effects. To this end, in this work, first we address the synthesis of MNG metamaterials by using planar bi-layered frequency selective surfaces (FSS) connected by vias. The unit cell geometry used in this work is shown in Fig. 1 (a) along with the incident field considered in our analysis. Here, a different shape of resonating ring is employed. The resulting structure may be easier to manufacture and more compact along the direction of propagation of the incident wave. In Fig. 1 (b) we show the equivalent effective permeability numerically calculated for the 3-D elementary cell depicted in fig. 1(a) for the normal incidence. The behavior of the geometry of the MNG resonating cell for oblique TE and TM incidence will also be analyzed. By adding the epsilon-negative behavior of an array of flat wires, a negative index of refraction (DNG) structure may also be achieved. Thus, the design of compact MNG and DNG bulk media may be achieved by using such planar bi-layered frequency selective surfaces connected by vias. In this talk, we will present our analytical and numerical results.



(a)



(b)

Fig. 1 – (a) Elementary 3-D cell employed for the analysis of our MNG structure and relevant incident fields used for the excitation of the structure at normal incidence. Dimensions used in this work are: d_0=7 mm, d_{FSS}=3 mm, d_x= 1.6 cm, d_y= 1.2 cm. (b) Equivalent effective relative permeability numerically evaluated for the proposed MNG structure at normal incidence.