DIRECT MEASUREMENTS OF EVANESCENT WAVE GROWTH INSIDE PASSIVE SPLIT-RING-RESONATOR BASED METAMATERIALS

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It has been shown theoretically (J. B. Pendry, *Phys. Rev. Lett.*, **85**, 3966, 2000) that evanescent waves in air are exponentially enhanced inside a finite negative index of refraction slab having the relative permittivity and permeability equal to -1. Recent experiments (A. Grbic and G. V. Eleftheriades, *Phys. Rev. Lett.*, **90**, 137401, 2003) demonstrated subwavelength focusing in a 2D transmission line analog of a NIM, it has yet to be shown directly that this phenomenon occurs through the evanescent wave growth that was theoretically predicted. Fabricating an electromagnetic metamaterial NIM with the material parameters required, however, is challenging because the normally material must be tuned to have the relative permittivity and permeability extremely close to -1.

To circumvent the extreme sensitivity of the evanescent wave enhancement property to the material parameters, we show that the basic phenomenon occurs under relaxed conditions for a single transverse wavenumber and use this approach in our measurements. More specifically, we analyze theoretically and experimentally a three slab configuration (air-material-air) inside a rectangular metallic waveguide excited below its cutoff frequency. This type of excitation produces evanescent waves of known transverse wavenumber inside the waveguide. We use this property to show that there is always a frequency for which an evanescent wave of a selected transverse wavenumber (for example the TE_{10} mode) is enhanced inside an isotropic negative-permeability-positive-permittivity metamaterial composed of split-ring-resonators (SRRs). We further show how this frequency can be found experimentally, and present measurements of the electric field distribution inside the three slabs considered above that closely match the theoretically predicted fields, thus confirming the behavior of evanescent waves in a finite NIM predicted by Pendry.

We also analyze the effect of the loss on the performance of the particular metamaterial considered and show that despite losses the magnitude of the enhancement of the chosen mode is comparable to what would be obtained inside an ideal, lossless metamaterial.

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2. B - Fields and Waves

3. (a) S-B1

4. C - Contributed Paper

5. No special instructions