Polarization-independent negative index metamaterial

Morteza Karami*, Steven Kitchin and Michael A. Fiddy
Center for Optoelectronics and Optical Communications, University of North Carolina at Charlotte, 9201 University City Blvd, Charlotte, North Carolina 28223, USA
*e-mail: mkarami@uncc.edu

Abstract: We have designed a polarization-independent left-handed metamaterial, and describe its electromagnetic properties. A 3D crossed design based on a meandering wire structure is demonstrated as a polarization insensitive metamaterial with negative effective index.

OCIS codes: (160.3918) Metamaterials; (350.3618) Left-handed materials; (260.2065) Effective medium theory; (260.5430) Polarization; (260.5740) Resonance; (230.4110) Modulators

1. Introduction

We have designed and tested a 3D metamaterial which has a polarization-independent transmission spectra.

![Figure 1](image)

Figure 1. (a) Unit cell design of mirrored S-resonator metamaterials. (b) Transmission spectrum for different angles of linearly polarized normal incident wave (propagation in z) for the case where g=1.5mm. (c) Extracted refractive index of normal incident for polarization along y.

The design is based on S-shaped resonator whose properties have been studied before [1–3]. The starting point is achieving negative effective parameters using a S-shaped resonators as shown in Figure 1(a). The S-features are embedded in a dielectric, for example with $\varepsilon=2.25$. We use S-shaped resonators with dimensions of $d_z=4.48$ mm, $d_y=4.18$ mm, and $g=1.5$ mm; its trace width is 0.34 mm for side arms and 0.64mm for elsewhere, and it has thickness of 0.04mm. The transmission spectrum of metamaterial constructed with this unit-cell meta-atom is shown in Figure 1(b); a strong magnetic resonance is observed at frequency 5.7 GHz for p-polarization of normal incident excitation propagating along z direction, and it vanishes gradually by tilting the polarization from y to x direction. This metamaterial is strongly birefringent and only has left-handed properties for a TM wave.

2. Polarization Independence

A crossed pair of mirrored S-resonators will couple into orthogonal polarizations and hence all of their superpositions. We simulated a series numerical experiments using this element with different lateral periodicity, $\Lambda_x$, and retrieved effective parameters [4]. The optimum lateral periodicity was found that gave a negative index over 7.3-8 GHz. Figure 2 shows the design and as can be seen in figure 2(b), by increasing lateral periodicity of the structure, a blueshift occurs in its strong magnetic resonance which is seen at 7.3 GHz.
3. Conclusion

A new polarization-insensitive left-handed metamaterial is presented based on S-shaped resonators. Numerical results demonstrate polarization properties and effective refractive indices. These structures can be fabricated for microwave use using 3D printing techniques and experimental results will be presented.

4. References