Design and Simulation of Double "S" Shaped Metamaterial

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Abstract

Metamaterials are defined as artificial electromagnetic structures based on the assembly of magnetic resonators and infinitely long metal rods at sub wavelength scale, which have the negative permittivity and the negative permeability simultaneously in a specific frequency range. However there are also some new metamaterial structures being explored which exhibit the same behavior. In this paper, we present the design, and simulation of a double S-shaped metamaterial in the microwave range. The design tool is the HFSS software which uses the finite element method. The extraction of effective parameters by the method of reflection- transmission coefficients demonstrates the metamaterial behavior of the said structure.

Keywords: *left handed metamaterial, double "S" structure, negative refraction, simulation.*

1. Introduction

In 1968, the Russian physics scientist V. Veselago suggested a new type of material which has simultaneously negative permittivity and negative permeability, and he presented general properties of electromagnetic wave propagation in such material [1]. He theoretically created a lossless meta-material and showed the extraordinary properties of this material which is not found in nature, in particular a negative refraction, a negative group speed, the reversal of Doppler Effect and Cerenkov radiation.

The Veselago's intuition remained silent for 29 years until year 1996 when Prof J.B Pendry proposed his design of Thin-Wire (TW) structure that exhibits the negative value of permittivity ε [2] and the Split Ring Resonator (SRR) with a negative value of permeability μ in 1999 [3]. Later, Smith and his colleagues demonstrated a new metamaterial that shows simultaneously negative permittivity and permeability and carried out microwave experiments to test its unusual properties in 2000 [4]. The first experiment showing negative refraction was

disciplines, such as filter, waveguide, resonator and antenna [6].

Several appointments appeared since the synthesis of such a medium; left hand medium [1-5], media with negative refractive index [7], "backward-wave" which wants to say medium where the wave moves behind [8], DNG (double negative materials) [9] and meta-matérial.

The meta-material is thus an assembly of two structures, one which has a negative permeability (SRR) and the other which has a negative permittivity (TW).

Nevertheless, several work showed the possibility of synthesis of a similar medium by the means of various forms, in particular the omega form [10], the U form [11], the V form [12], and the triangular form [13].

In this paper we present a structure which has the characteristic to have at the same time a negative permeability and a negative permittivity. By the means of the commercial software HFSS which uses the finite elements as calculation method , and in normal incidence, the « S » parameters for a single unit cell is calculated with the mentioned boundaries along the wave propagation, and by inversion technique of the Fresnel coefficients [14], the effective material parameters are given. From the simulation results, the real part of the refractive index is found to be negative at frequencies where both real parts of the permittivity and permeability are negative. Thus we show that there is a frequency band where the effective refractive index of the medium is negative.

2. Retrieval procedure

To obtain the effective electromagnetic parameters of the structure, a theory of homogenization is used. The main purpose of this theory is to describe in a simple and macroscopic way the microscopic complexity of the response of objects to an incident electromagnetic