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Parameters Extraction of Swastika Shaped Metamaterial Absorber

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Abstract: ***In recent days metamaterial is a focus point in the field of microwave engineering. This is in nutshell because of its electromagnetic exquisite properties. These properties include mainly negative real values of permittivity and permeability constants which can be derived from NRW method. In this paper basic of metamaterial, metamatrial absorber, its design and its designing parameters are explained. The simulation has done with the help of CST software and parameters are extracted with the help of MATLAB programming. The boundary condition used in CST software is perfect electric and perfect magnetic (PE-PM) method. Wave port is used in CST software.***

Keyword: Antenna, clocking, Metamaterial, negative refraction, NRW method

1. Introduction

Metamaterials refer to the material which has a property that is not found in the nature. The most important property of them is that they can modify their permittivity and permeability so that they can improve the performance of antenna, coupler and filters. They are artificial materials which are manufactured from metal inclusion embedded in dielectric substrate. The interaction of electromagnetic fields with inclusion creates the resonating behavior of Metamaterials. Metamaterials are basically synthesized by embedding various inclusions with novel geometric shapes and forms in some host media. In the presence of electromagnetic field what will be the system response depends on material parameter permittivity (ε) and permeability (μ).metamaterial absorbers are famous in these days because in absorbers all the incident radiations are converted into heat and get absorbed. When an electromagnetic wave incident on an object so there are three phenomenon of wave are noticed namely reflection, transmission and absorption. to obtain maximum absorption minimization of reflection and transmission are required. for reducing the electromagnetic radiations in microwave components microwave absorbers are used but they have large bandwidth ($\frac{\lambda}{4}$).for overcome this disadvantage metamaterial structures are used. metamaterial structures are ultrathin structures comprising unit cells in sub wavelength regime can be used to obtain near unity absorption through ohmic and dielectric loss. In the Metamaterials permittivity (ε)and permeability (μ) plays important role. Analytical drude-lorentz model [9] and s-parameter-retrieval method [10] known as NICOLSON-ROSS-WEIR (NRW) method are the two methods which are used to evaluate the electromagnetic properties such as complex permeability (μ), the permittivity (ε) and refractive index (n). The NRW method depends on the s parameters extracted from the actual structure, and hence provides more accurate values for the permittivity, permeability and refractive index. In this paper a new swastika like Metamaterials absorber has been presented. We use CST high frequency structure simulator (CST 16.0) which uses finite-difference time- domain (FDTD) method for the extraction of s parameter. MATLAB scripts are used for the calculation of permittivity, permeability and refractive index curves.

2. Basic Design of Metamaterial Absorber

Metamaterials absorbers have usually three layers. Each layer has its own phenomenon.[2]

- First layer of absorber is made up of periodic patterns whose geometrical parameters carefully adjusted to obtain the impedance matching condition.
- The second layer is known as dielectric layer in which EM waves to be dissipated and sometimes play a role of resonance cavity to prolong the time taken by EM waves inside the second layer.
- The third layer is called as metallic plate which is used for blocking remnant transmission.

3. Application of Absorber

Metamaterials possess different characteristics as they are used in different geometric shapes such as single band, dual band, triple band, bandwidth enhanced and broadband operations. They have tunable property because of their design; they can be used to study classical electromagnetic wave theory. The specific applications of absorbers are given below [4]

- To reduce radar cross section
- To reduce EMI
- To shape antenna pattern
- Cavity resonance reduction
- Near field absorber

4. Mathematical Explanation of NRW Method

NRW method is widely used because this method is simple comparatively. This method is given below**(8)**

$$V_1 = S_{21} + S_{11} \qquad (1)$$

$$V_2 = S_{21} - S_{11} \qquad (2)$$

$$\mathcal{E}_r \approx \frac{2}{jk_0 d}\frac{1-V_1}{1+V_1} \quad (3)$$

$$\mu_r \approx \frac{2}{jk_0 d}\frac{1-V_2}{1+V_2} \quad (4)$$

$$\Pi = \sqrt[2]{\mu_r \mathcal{E}_r} \quad (5)$$

Where, $\mathcal{E}_r$is the effective permittivityμ_r is the effective permeability, *d* the thickness of the substrate, $k_0$the wave vector and Ƞ is the refractive index. The NRW method is easy to extract the values of effective permittivity and permeability using *S*-parameters. However, this method does not have any branch index complexity or impedance calculation.

5. Design

In this paper we proposed a Metamaterials structure namely swastika like structure which is printed on FR-4 dielectric substrate backed by copper (annealed) ground. This structure works in X band (10.30 GHz).This design and its simulation has done by using CST software. The proposed basic unit cell structure is shown in Figure 1(a) in which the top layer represent the swastika like structure which is made up with copper annealed metal with the thickness of 0.035 mm .The middle layer is made up of FR-4 dielectric substrate and bottom layer is made up with copper annealed. The dimensions of the unit cell along with the directions of field vectors are shown in figure 1(a).

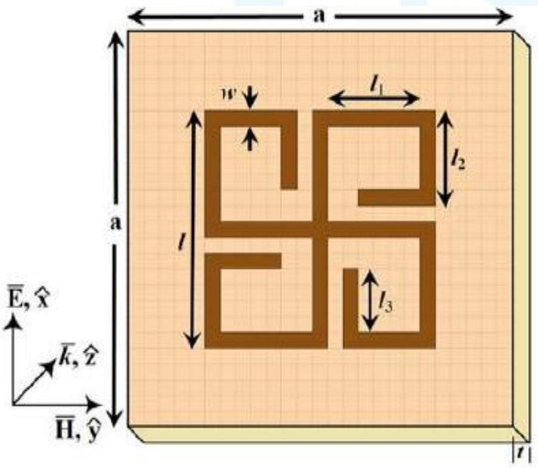

Figure 1(a): Prospective view of the unit cell structure [1]

Geometric dimensions of unit cell structure (dimension in mm)

Symbol	a	l	w	l_1	l_2	l_3	t
Dimension	5	3	0.2	1.2	0.8	1	1

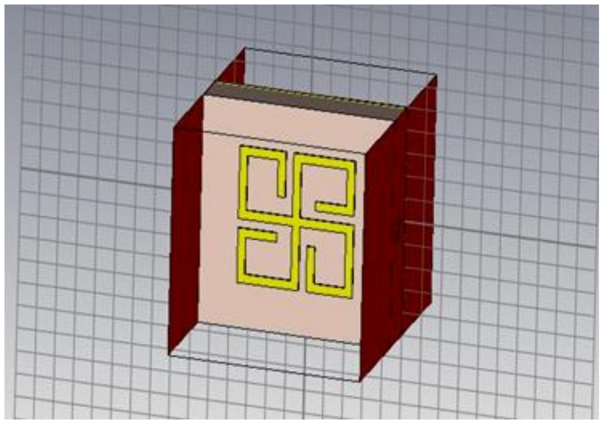

Figure 1(b): Simulated software with wave port swastika like structure shown in figure

There are two ports are used to excite the structure when we applying perfect electric (PE) and perfect magnetic (PM) Boundary condition.

6. Simulation

Simulation process is performed by using CST Microwave Studio (CST MWS 2016).CST Microwave Studio is a dedicated tool for EM simulation of high frequency components. Simulation has done in time domain solver. Time domain solver is general tool which delivers electromagnetic near and far fields as well as S parameters. The application area of time domain solver in periodic structure such as SRR CST MWS features a special periodic boundary implementation, which automatically creates the boundaries for unit cell. By the simulation process S parameters are derived and by using MATLAB programming Real values of permeability (µ)and permittivity(Ɛ) have derived. The reflection coefficient can be derived by R(w)=||S_{11}|^2 and transmission coefficient T(w)=|S_{21}|^2 and then by using the post processing desired value of absorbability is obtained A(w)=1-T(w)-R(w)

7. Parameter Extraction Results

In the absorber calculation firstly S parameters were derived with the help of CST software which is shown in the Figure 2 they play an significant role in designing and then by using MATLAB programming parameters are calculated because they are derived from input output relationship of ports after that with the help of S parameters permeability and permittivity were calculated shown in Figure 3(a) and 3(b).

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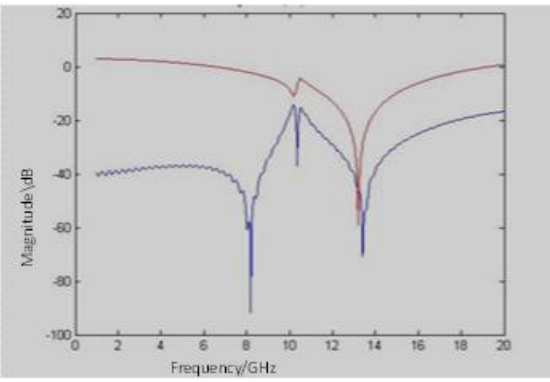

Figure 3: Retrieved effective value of S_{11} and S_{21}

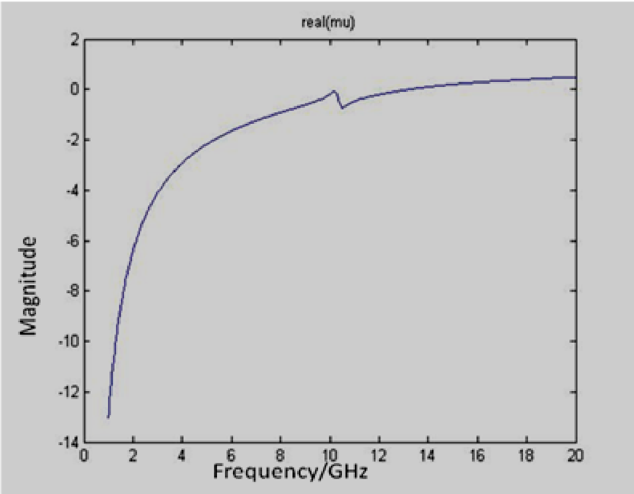

Figure 3(a): Retrieved effective value of μ for metamaterial

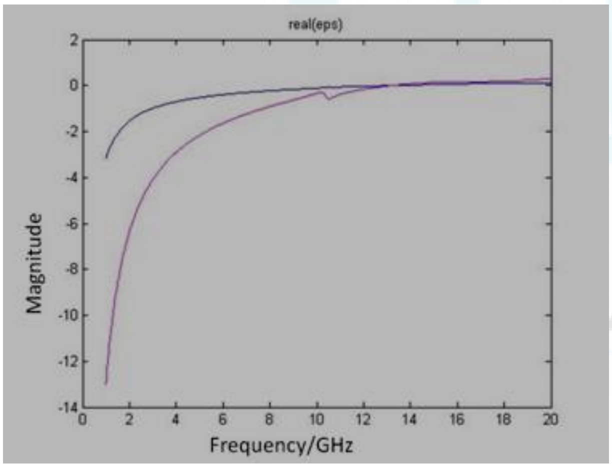

Figure 3(b): Retrieved effective value of Ɛ for Metamaterials

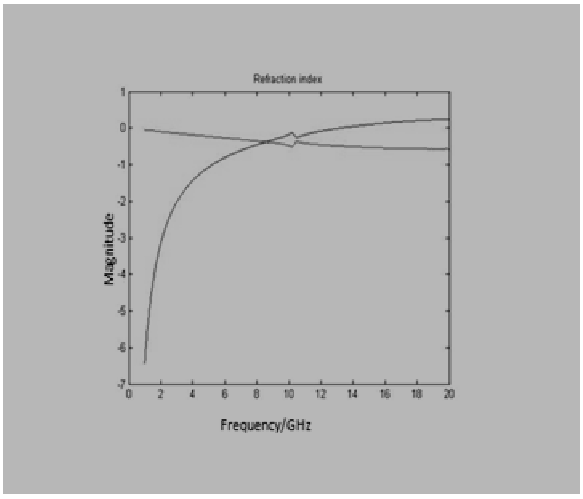

Figure 3(c): Retrieved effective value of n for Metamaterial

8. Conclusion

Swastika shaped metamaterial absorber has presented in this paper. The S parameters are extracted with the help of CST software and design parameters are calculated by MATLAB. Boundary conditions were presented. Perfect electric and perfect magnetic (PE-PM) boundary conditions method was presented. These structures have complex nature, reduction in gain so there is much work to do in this direction.

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