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Metamaterial Multiband Antenna for Wireless Application

Nader AZIZI[1], Javad NOURINIA[2]

[1] Department of Electrical Engineering, West Azarbaijan Science and Research branch, Islamic Azad University, Urmia, Iran.

(E-Mail: n_azizi_info@yahoo.com)

[2] Department of Electrical Engineering, Urmia University, Urmia, Iran.

Corresponding Author: (E-Mail: j.nourinia@urmia.ac.ir)

Abstract- *In this work a Multi-band antenna along with the innovative metamaterial structure is proposed which consists of a circular geometry incorporated with c shaped structure. This work is mainly focused on increasing the potential parameters of planar antennas and analyzing the multi band operation of proposed antenna. The impedance bandwidth of proposed antenna are covered and utilized frequency range of (2.6~3.1 GHz), (3.5~4.4 GHz) and (4.7~6.2 GHz). For verifying that the proposed metamaterial structure possesses Negative values of Permeability and Permittivity within the operating frequency ranges, Nicolson-Ross-Weir method (NRW) has been employed. For simulation purpose HFSS Software has been used.*

INTRODUCTION

In the recent years the development in communication systems requires the development of low cost, minimal weight, low profile antennas that are capable of maintaining high performance over a wide spectrum of frequencies. The future development of the personal communication devices will aim to provide image, speech and data communications at any time, and anywhere around the world. This indicates that the future communication terminal antennas must meet the requirements of multi-band or wideband operations to sufficiently cover the possible operating bands. The performance of the fabricated antenna was measured and com-pared with simulation results [1]. Moreover, we have also indicated the appropriate choice of particular metamaterial for different specific purposes like antenna size reduction and other mode modification-related applications [2]. The performance of a rectangular patch antenna array on a metamaterial substrate was studied relative to a similar array constructed on a conventional FR4 substrate [3]. In modern wireless communication systems, the microstrip patch antennas are commonly used in the wireless devices. There-fore, the miniaturization of the antenna has become an important issue in reducing the volume of entire communication system [4].

In modern wireless communication systems, the microstrip patch antennas are commonly used in the wireless devices. The demand in commercial and military wireless systems is due to capabilities of proposed Antenna such as low weight, low profile, low cost, easily combined with de-sign and technology, and relatively simple fabrication. All these antennas can also fabricate using HFSS simulation software and get very sharp characteristics. Proposed Antenna can be largely used in many wireless communication systems because of their low profile and light weight Microstrip antennas are largely used in many wireless communication systems because of their low profile and light weight [5].

The theoretical concept of metamaterials to increase the transmitting power was given by Victor Veselago (1968), Engheta and Ziolkowski (2006), Pendry (2000) Garg et al. An array of metallic wires can be used to obtain negative permittivity and split ring resonators for negative permeability (Pendry et al., (1999). By using the available information a structure composed of split ring resonator and thin wire fabricated by Smith et al. (2001) possessed the negative permittivity and permeability simultaneously. This structure was named as LHM (Wu et al., 2005) (Burokur et al., 2005). Metamaterial is an artificial material that exhibits unique properties in electromagnetic spectrum unlike those of conventional materials available in nature [6]-[7]. The conventional material available in nature have positive magnetic permeability and almost positive dielectric permittivity, whereas metamaterial exhibits negative permeability, μ and/or negative permittivity, ε. Due to these significant features metamaterial is also referred to as single negative(SNG) or double negative(DNG) material [6]-[8]. In metamaterial, the refractive index is negative i.e. the group and phase velocity of the electromagnetic wave appears in opposite direction. The reversed direction of propagation with respect to direction of energy flow leads to reversed Doppler shift. These materials are also referred to as negative index material (NIM) because the refractive index is negative hence both refracted and incident wave remains on same side [6-12].

The potential applications of metamaterials at microwave frequencies include (a) substrate materials for antenna and microwave component designs and fabrications, and (b) absorbers for engineering and radar applications. Split ring resonators (SRRs) [12] and some other planar structures [12-18] were applied to enhance the return loss.

In this paper a novel shape of SRR metamaterial structure is used to antenna patch that provide an antenna with multiband application.

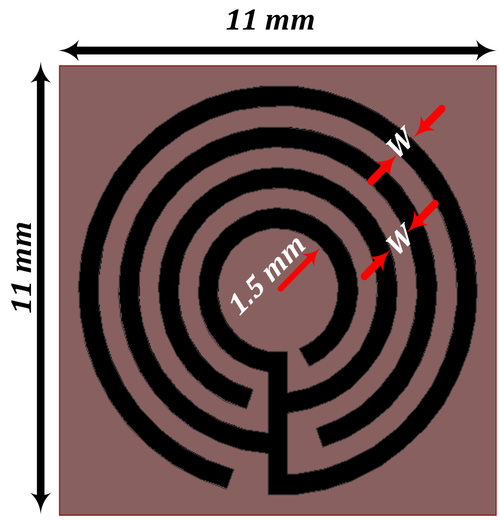


Fig. 1. Structure of metamaterial unit cell (w=1 mm)

Metamaterial unit cell structure and result

In order to calculate the S-Parameters, the proposed metamaterial structure is placed between the two waveguide ports [15], [16] at the left and right hand side of the X axis. In Fig.4, Y-Plane is defined as Perfect Electric Boundary (PEB) and Z-Plane is defined as the Perfect Magnetic Boundary (PMB) to create internal environment of waveguide. The simulated S-Parameters are then exported to Microsoft Excel Program for verifying the Double-Negative properties of the proposed metamaterial structure. Nicolson-Ross-Weir (NRW) technique [8], [10] has been used for obtaining the values of permittivity and permeability. Equations used for calculating permittivity & permeability using NRW approach [9]-[10], [12], [18].

$$\mu_r = (2 \times c \times (1 - v_2))/(\omega \times d \times i \times (1 + v_2) \quad (1)$$

$$\varepsilon_r = \mu_r + (2 \times S_{11} \times c \times i)/(\omega \times d) \quad (2)$$

$$v_2 = S_{21} - S_{11} \quad (3)$$

Where

ε_r = Permittivity

μ_r = Permeability

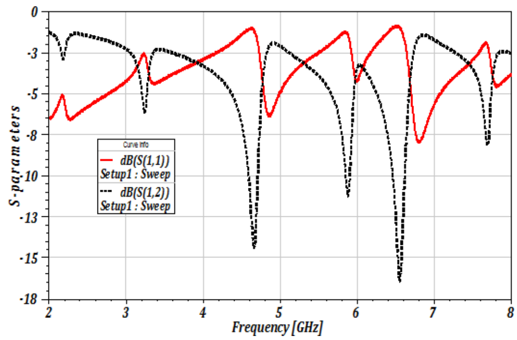
ω= Frequency in Radian,

d = Thickness of the Substrate,

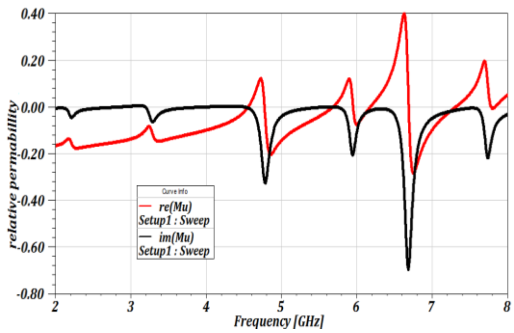
c = Speed of Light, and

v_2 = Voltage Minima

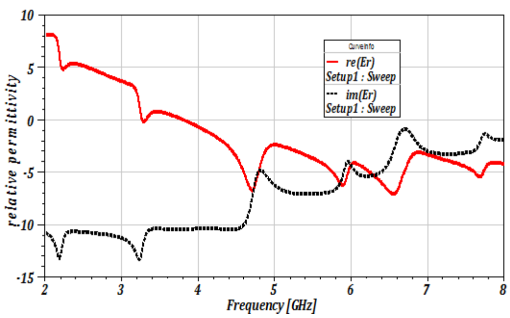
The configuration of the novel metamaterial model that is investigated in this paper is shown in Fig. 1.The results of the return loss and relative constitutive parameters of the unit cell (permittivity and permeability) are shown in Fig. 2 a, b and c respectively. The constitutive parameters are calculated from S-parameters by using retrieval method introduced in (1-3). As it is seen from Fig. 4, both of the permittivity and permeability parameters are negative in a specific frequency band. So this structure shows double negative property and it can be used as a DNG medium.



(a) S-parameters



(b) μ



(b) ε

Fig. 2. The simulated parameters of unit cell

ANTENNA CONFIGURATION AND RESULT DISCUSSION

Fig. 5 shows the geometry of the proposed antenna. The substrate width is 20 mm and its length is 22 mm. This antenna is fed by a CPW line inset feed. The width of the feed line 3.1 mm and the depth of the inset 7mm have been adjusted to match the antenna impedance to 50 Ω. The distance between inset line and the patch (y) is 1.2 mm.

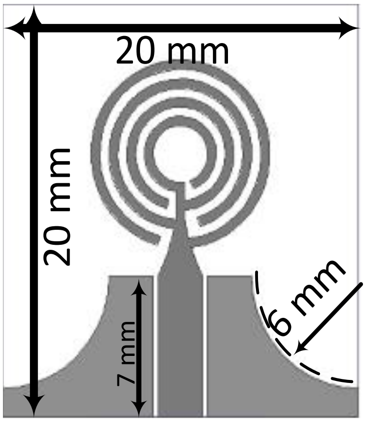


Fig. 3. Antenna dimension

Four steps of antenna design is shown in Fig 4 and simulated return loss result of four steps of antenna is presented in Fig. 5. The comparison between simulated and measured return loss of antenna is indicated in Fig. 6. As presented in Fig. 7 the pattern of antenna is omnidirectional.

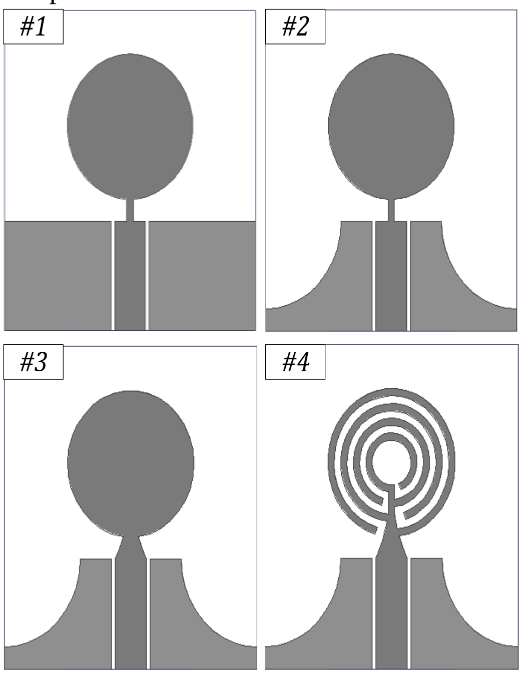


Fig.4. four steps of antenna design

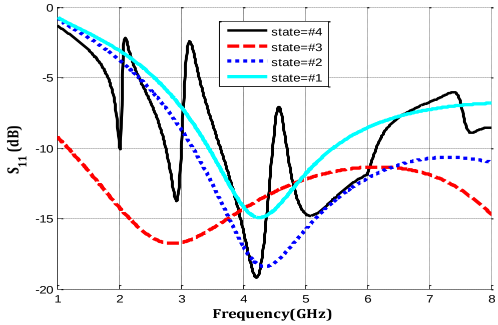


Fig.5. return loss of antenna at mentioned four steps

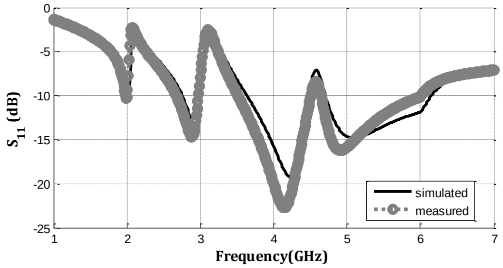


Fig. 6 comparison between simulated and measured return loss

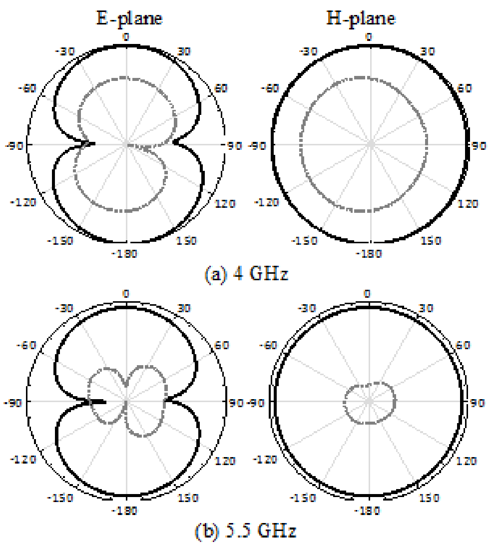


Fig. 7. Measured pattern of proposed antenna The prototype of antenna is illustrate in Fig. 8.

Fig. 8. The prototype of proposed antenna

Conclusion

On the basis of the simulated results it is observed that the proposed antenna parameters has improved significantly by employing proposed metamaterial structure at 1.6 mm layer from the ground plane of the antenna. There are very less variations have been observed between the measured results and the simulated result of proposed antenna. Along with these improvements it has also been verified that this structure satisfies Double Negative property within the operating frequency ranges.

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