Hybrid Dual Band High Gain Antenna

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Abstract- This paper presents a hybrid high gain multi-resonance antenna. A rectangular split ring planar metamaterial antenna and rectangular slotted planar antenna are hybridized to achieve multi-resonance and high gain. This work is based on a rectangular slotted antenna of three iterations. The single structure provides both the metamaterial and normal patch antenna performance. The hybrid structure provides a bandwidth of 210 MHz with metamaterial characteristics at 17.28 GHz and bandwidth of 430 MHz as slotted antenna at 21.90 GHz frequency. Antenna gain of 7dBi is achieved with overall dimensions of 40 mm×12 mm×0.787 mm. The simulated results are in good agreement with the experimental findings.
Index Terms- Hybrid antenna, metamaterial antenna, iteration, dual band

1. Introduction

Metamaterials are the artificially engineered structures or materials which shows electromagnetic properties beyond the materials existing in nature. Metamaterial exhibits negative magnetic permeability (μ) and/or negative dielectric permittivity (ε) below plasma frequency whereas the materials existing in nature possesses positive permeability and almost positive permittivity [1]-[3]. Veselago, in 1968 reported an astonishing phenomenon in electromagnetic theory by assuming materials with negative magnetic permeability and permittivity. Further, the research on this phenomenon was preceded by Pendry, Smith and Ziolkowski to study characteristics and applications of metamaterials. The novel characteristics of metamaterials lead to design new devices and applications like planar antennas, frequency selective surfaces, filters, resonators and optical devices. Metamaterial structure consists of split ring resonators to produce negative permeability and thin wire elements generate negative permeability [2]-[4]. R.W. Ziolkowski *et al.* reported that the radiation power of small antennas increases due to the metamaterial characteristics [5].

In microstrip patch antennas, different techniques like insertion of air in the substrates, making the slots, shorting the patch by inserting pin and loading the patch are used to achieve application specific resonant frequency, bandwidth, and radiation patterns [6]. These techniques have certain limitations which restricts the performance of microstrip antennas. The metamaterial planar antennas are superior to microstrip antennas, further their functioning capabilities can be enhanced by blending these techniques to boost their performance and make them more versatile. In this paper a novel hybridized structure of a new slotted type rectangular microstrip antenna and rectangular split ring (RSR) planar metamaterial antenna is presented.

In military and satellite communication services slotted antennas are commonly used due to their compact size, multi-band, high gain and bandwidth performance. But these antennas need improvement in bandwidth and gain. The important advantages of metamaterial antennas are high gain, high bandwidth and higher efficiency in smaller size [2]-[5]. The performance of slotted antennas can be enhanced by hybridizing with metamaterial planar antennas which integrates the features of both antennas. This paper is organized in four folds as section II discusses geometrical details of antenna structures. In section III results and discussions are presented and paper is concluded in section IV.

2. Geometry of Structure

In this section the geometrical figures and dimensions of rectangular split ring, rectangular slotted and hybridized planar antenna structure are discussed. These three antenna structures are designed and simulated using RT Duriod 5880 substrate having thickness h = 0.787 mm and dielectric constant (ε_r) 2.20. The structures are simulated using method of moment based IE3D electromagnetic simulator of Zeland software, incorporation.

2.1 Rectangular Split Ring (RSR) Planar Metamaterial Antenna

Fig.1 shows single rectangular split ring (RSR) planar metamaterial antenna. The geometrical parameters of antenna structure are W_r = 12 mm L_r = 44 mm. The dimensions of width and gap at the split are g = w= 2 mm respectively. The structure is coaxial feed at x = 1.5 mm and y = 7 mm.

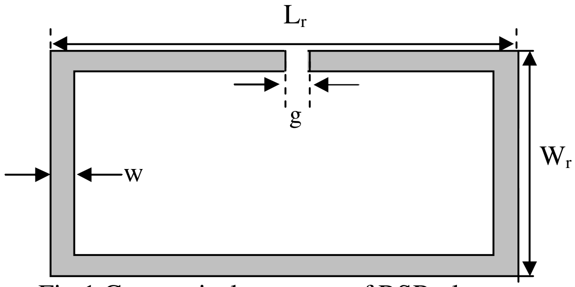

Fig.1 Geometrical structure of RSR planar metamaterial antenna

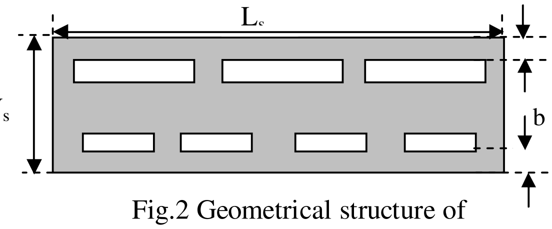

Fig.2 Geometrical structure of rectangular slotted antenna

2.2 Rectangular Slotted Planar Antenna

Fig.2 presents the geometrical structure of rectangular slotted planar antenna. In this structure initially a rectangular plane geometry of this antenna having dimensions L_s = 40mm and W_s = 8 mm is considered. In the next step three rectangular slots of the dimensions width =10 mm and length L= 2 mm which are one fourth of the basic rectangular plane are produced at a=1 mm. This is the first iteration of rectangular slotted antenna geometry. In the second iteration, four rectangular slots of the dimension width = 5 mm and length = 1 mm are created at b = 1.5 mm. The coaxial feed is used to excite the antenna at x= -18 mm and y= -2 mm.

2.3 Hybridized Structure of RSR and Rectangular Slotted Planar Antenna

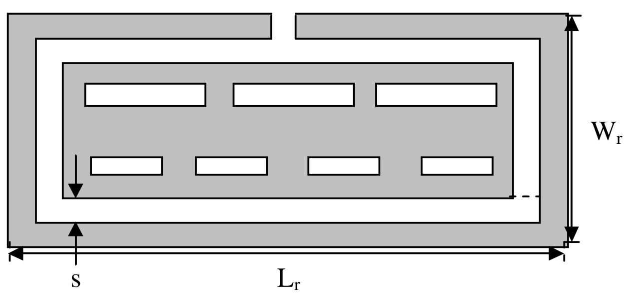

Fig.3 Hybridized structure of RSR planar metamaterial and rectangular slotted antenna

Fig.3 presents the hybridization of single rectangular split ring planar metamaterial antenna and the rectangular slotted antenna. The spacing between the two antenna is s = 2 mm.

3. Results and Discussions

In this section, the reflection coefficient (S_{11}), phase angle (S_{12}) characteristics and radiation patterns of the antenna structures are discussed.

3.1 Rectangular Split Ring (RSR) Planar Metamaterial Antenna

Fig.4 (a) represents the reflection coefficient (S_{11}) and phase angle (S_{12}) characteristics of rectangular split ring planar metamaterial antenna. From figure it is observed that the antenna resonates at resonant frequency 13.57 GHz with bandwidths of 140 MHz. In this frequency band there is appreciable phase reversal which represents the metamaterial behavior. The reflection phase reversal of structure takes place between 180° to -180° in the resonant frequency band. The return loss observed at resonant frequency band is -33.32 dB signifying better matched conditions. Fig. 4 (b) shows the azimuth radiation pattern of antenna indicating gain of 4.3dBi.

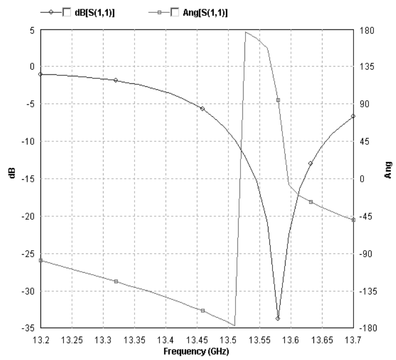

Fig. 4 (a) Reflection coefficient (S_{11}) and phase reversal (S_{12}) characteristics

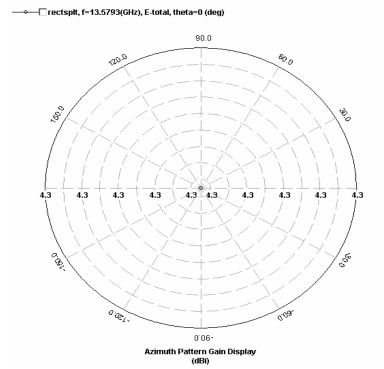

Fig. 4 (b) Azimuth radiation pattern

3.2 Rectangular Slotted Planar Antenna

Fig. 5(a) shows the reflection coefficient (S_{11}) characteristics of rectangular slotted planar antenna. From figure it is observed that the antenna structure generates multi-resonant characteristics. This slotted antenna has three iterations hence it generates three resonant frequency bands at 12.1, 12.7 and 13.6 GHz respectively with better matching. Fig 5(b) represents the azimuth radiation pattern of antenna having gain of 7dBi at 13.6 GHz.

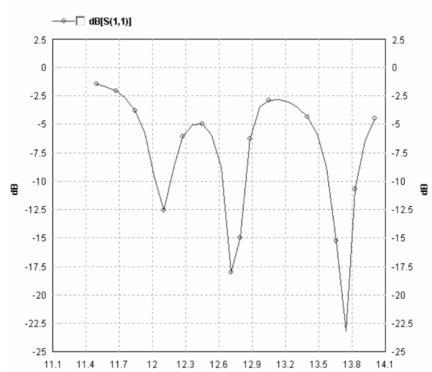

Fig. 5 (a) Reflection coefficient (S_{11}) characteristics

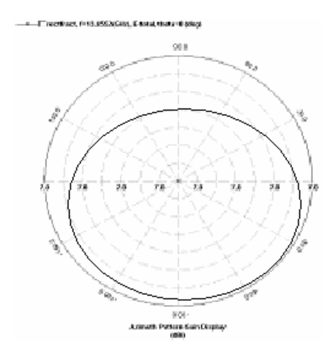

Fig. 5(b) Azimuth radiation pattern

3.3 Hybridized Structure of RSR and Rectangular Slotted Planar Antenna

Fig 6(a) represents the refection coefiicient (S_{11}) and phase angle (S_{12}) chracteristics of hybridized rectangular split ring planar metamaterial and rectangular slotted planar antenna. From this figure it is observed that the hybrid structure generates two resonant frequency bands which is the combination of metamaterial and normal patch antenna performance. The structure resonates at 17.28 GHz with the bandwidth of 210MHz in which it shows the pase reversal thus behaves like a metamaterial antenna. It is also observed that there is appreciable phase reversal between 180° to -180° in the same frequency band; this represents metamaterial behavior of the antenna. In other frequency band of 21.90 GHz this antenna functions as normal patch antenna with bandwidth of 430 MHz. Fig. 6(b) shows the azimuth radiation pattern indicating the gain of 6.10dBi.

In hybrid antenna structure the frequency bands are shifted due to developed effective capacitance and inductance [2], [7]-[8]. These capacitance and inductanceare developed at (a) The spacing 's' beween two antenna elements causes to develop mutual capacitance between two structures and the other capacitance developed at the split of rectangular split ring planar antenna (b) The inductance and mutual inducatnce of entire hybrid antenna structure.

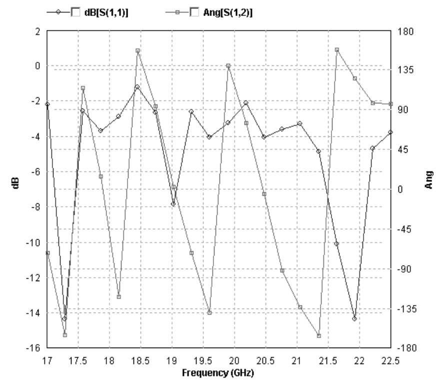

Fig. 6(a) Reflection coefficient (S_{11}) and phase reversal (S_{12}) characteristics

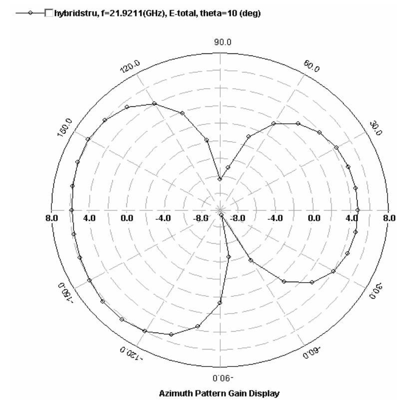

Fig. 6(b) Azimuth radiation pattern

4. Conclusion

This paper presents a novel hybridization of rectangular split ring planar and rectangular slotted planar antenna. Due to hybridization the resonant frequency bands of shows both metamaterial and planar antenna characteristics with high gain. This antenna is useful for airborne radar, mobile and satellite communication services. By using radio frequency microelectromechanical (RF-MEMS) switches the antenna can be operated as metamaterial antenna or slotted antenna or as a hybrid antenna according to the frequency, bandwidth and gain requirement of the applications.

5. References

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