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Design of Metamaterial Based Microstrip Antenna With Multiband Frequency Application

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Abstract- This paper introduced a new low cost, compact and robust microstrip antenna based on metamaterial split ring resonator property to replace the existed antenna by small size and multiband Frequency antenna. The proposed antenna is designed with multi rectangular patches and simulated for different frequency. By using the metamaterial property, the bandwidth of the antenna has been improved. The gain of the antenna has also improved. The Return loss of the antenna for 3.9 GHz, 4.2 GHz, 5.6 GHz, 7.1 GHz, 8 GHz and 8.2 GHz are -23dB, -22dB , -16dB , -11dB, -27dB and -26dB resp.

Keywords-*Microstrip Antenna, Metamaterial Structure, Directional antenna*

I. INTRODUCTION

There are many techniques to improve antenna gain, such as antenna array, yagi antenna and disk antenna….etc. but they also increase unfavourable antenna volume, wet and cost. In the past few years, new methods to improve antenna gain by using metamaterial technology are proposed. Recently the performance of metamaterial antennas is admired by the antenna and microwave researchers due to their astonishing and extraordinary electromagnetic Properties. These antennas are becoming functional for modern satellite, wireless and mobile communication technologies for high speed voice, data and multimedia communication. Metamaterial is artificially engineered structure or material which exhibits electromagnetic properties beyond the materials existing in nature [1]. Metamaterial exhibits negative magnetic permeability (μ) and/or negative dielectric permittivity (ϵ_r) below plasma frequency whereas the materials existing in nature possesses positive permeability and almost positive permittivity. In recent years, there has been growing interest of the research fraternity in study of metamaterials. Metamaterials usually gain their properties from structure rather than composition, using small in homogeneities to create effective macroscopic behaviour. The metamaterials are defined as artificial materials having ability to exhibit an electromagnetic response not readily found in naturally occurring material such as, negative refractive index and Metamaterials are often characterized in terms of their effective material parameters, such as electric permittivity and magnetic permeability. These parameters can either be both negative, and only one of them may be negative. The former is referred to as left-handed metamaterials (LHM), double negative (DNG), or negative refractive index material (NRIM). The latter is known as single negative material (SNG).The function of the metamaterials can be explained by the simple example. Imagine a fabric that is composed of many threads placed down horizontally. Light is then added to the fabric, but it can only travel across the threads themselves. All of the nooks in between the separate threads are inaccessible to the light because the light can only travel along the threads. If you then make a hole in this fabric, the light that follows the threads goes around the hole because it can only travel on the thread. If you place an object in the hole, the light functions the same way and just goes around the object in the whole. By doing this, the metamaterials are able to guide the light around the object without making the light refract or reflect which results in invisibility. If the light waves are able to be guided around the object and back to its original course, there would not be a shadow created either. Because the light waves are guided around the object, essentially to the light and the human eye the object in non-existent.

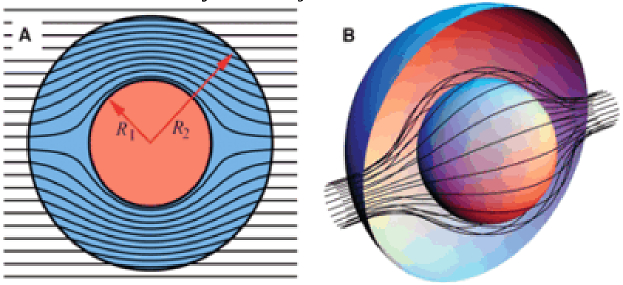

Figure 1: Light waves in metamaterial are guided around the object. [25]

They show promise for optical and microwave applications such as new types of beam steerers, modulators, band-pass filters, lenses, microwave couplers, and antenna systems. Furthermore, the lower density of materials means that components, devices, and systems can be lightweight and small, while at the same time enhancing system and component performance.Metamaterials consist of periodic structures. An electromagnetic is the metamaterial affects electromagnetic waves by having structural features smaller than the wavelength of light. In addition, if a metamaterial is to behave as a homogeneous material accurately described by an effective refractive index, its features must be much smaller than the wavelength. For microwave radiation, the structures need only be on the order of few centimetres. Microwave frequency metamaterials are usually synthetic, constructed as arrays of electrically conductive elements (such as loops of wire), which have suitable inductive and capacitive characteristics. These are known as split-ring resonators. Another structure which can exhibit sub wavelength characteristics are frequency selective surfaces (FSS) known as Artificial Magnetic Conductors (AMC) or alternately called High Impedance Surfaces (HIS). These also have inductive and capacitive characteristics, which are directly related to its sub wavelength structure.

II. PROPOSED WORK

In this section, the designing procedure will be discussed for proposed metamaterial based basedmicrostrip antenna having CRLH transmission line structure. The high frequency structure simulator is used to analyse the results. The purpose of this CRLH transmission line structure is to implementation of a multi-band antenna, reducing the size of antenna and improvement in various parameters such as gain, bandwidth, return loss and VSWR. The results obtained are analysed in terms of return loss, radiation pattern, voltage standing wave ratio (VSWR) and bandwidth.To the dimension point of view, the geometrical details of diamond shaped split ring structures in normal cut configurations are presented and width and spacing between two split rings are 0.5mm and 2 mm. The side length of the ring is L=11 mm. FR4 proxy substrate having thickness h = 1.6mm and dielectric constant (ε_r) 4.4 is used to design and simulate both configurations of the antenna structure. The structures are simulated using HFSS electromagnetic simulator software.

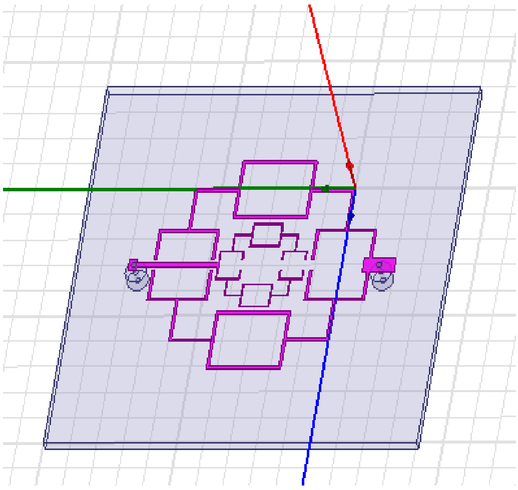

Figure 2. Proposed Design

III. RESULTS

Return loss or VSWR is good when the curve has a deep and wide dip, which shows the antenna with good bandwidth. The VSWR, which can derive from the level of reflected and incident waves, is also an indication of how closely or efficiently antenna terminal input impedance is matched to the characteristics impedance of the transmission line. Consequently, the narrower the dip is, the bigger the risk that desired channels would be also reflected away. A 3-8 GHz frequency range below -10dB VSWR is obtained. Multiband operation of the designed antenna is explained by using the Return loss versus frequency graph shown in figure 5.4. The return loss of3.9 GHz, 4.2 GHz, 5.6 GHz, 7.1 GHz, 8 GHz and 8.2 GHz are -23dB, -22dB , -16dB , -11dB, -27dB and -26dB resp. The bandwidth of the proposed antenna is greater than that of reference antenna. It can be found by locating two points on the return loss curve which shows the more bandwidth rather than reference model.

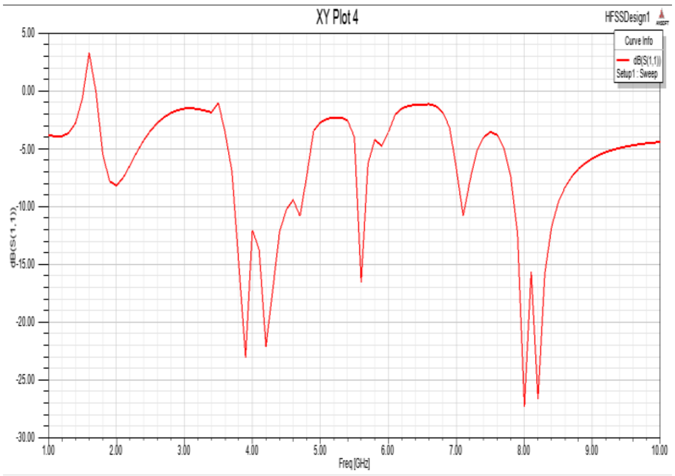

Figure 3. Return Loss

Fig. 4 shows the input impedance smith chart for the proposed model. Maximum power will be transferred if the impedance of the antenna is matched to those of the load. Rms of 0.157 and bandwidth of is 0.2 GHz attained from the simulated results.

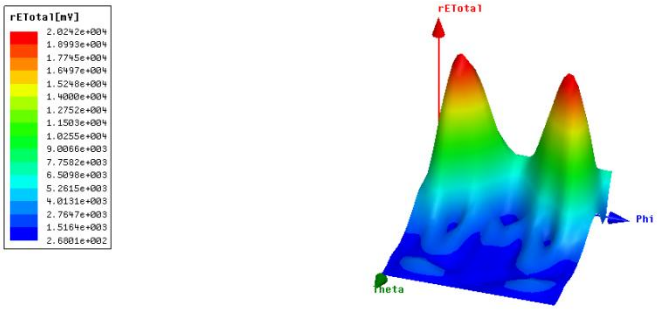

Figure 4. 3D Rectangular Plot

The radiation pattern or antenna pattern is a graphical representation of radiation (far field) properties of an antenna. A spatial pattern of electric or magnetic field is called the field pattern. A cross section of this field pattern in any particular plane is called the radiation pattern in that plane. Fig. 4 gives the radiation pattern of antenna gain theta in polar coordinates as well as in 3D.

Figure 5 3D Polar Plot

IV. CONCLUSION

In this dissertation work, multiband split ring patch antenna has been obtained by applying split ring resonator. The proposed geometry was based on square ring in which a slit was inserted on one side.The proposed geometry was simulated in HFSS using FR4 as the substrate material. The design were compared minutely in terms of return loss, bandwidth, VSWR and gain. The designs are showing multiband performance ranging between 1.0 GHz to 10.0 GHz. There has been a considerable improvement in Gain by using FR4.

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