META MATERIAL ANTENNA FOR WIRELESS SYSTEM USING HFSS SOFTWARE

Miss DIVYA.P[1], Mr. M. Rama Krishna [2]

[1]*Student, Department of ECE, Andhra Loyola Institute of Engineering and Technology, Vijayawada, India*

[2]*Associate Professor, Department of ECE, Andhra Loyola Institute of Engineering and technology , Vijayawada, India*

***Abstract*: In recent years, the demand for miniaturization and integration of many functions of telecommunication equipment is of great interest, especially devices that are widely used in life such as mobile communication systems, smart phones, handheld tablets, GPS receivers, wireless Internet devices, etc. To satisfy this requirement, the mobile device components must be compact and capable of multifunction, multi frequency band operation. There are micro strip antenna technology miniaturized by means of high-permittivity dielectric substrate, using shorting wall, shorting pins, some deformation, as the fractal geometry is, and others. However, these methods have disadvantage such as narrow bandwidth and low gain. A new solution that is of great interest to designers is the use of electromagnetic metamaterials for antenna design. The use of metamaterials in antenna design not only dramatically reduces the size of the antenna but can also improve other antenna parameters such as enhancing bandwidth, increasing gain, or generating multiband frequencies of antennas operations.**

Keywords*: *Negative refractive index, Negative permeability.

1. Introduction

Metamaterials (meta means "beyond" in Greek) are new artificial materials with usual electromagnetic properties that are not found in naturally occurring materials. All natural materials Such as glass, diamond and such have positive electrical permittivity magnetic permeability and an index of refraction. In these new artificially fabricated materials termed as negative index materials (NIM) or double negative (DNG) media or left handed (LH) materials or backward wave (BW) media all these materials parameters are negative. With these unusual material parameters new kinds of miniaturized antennas and microwave components/devices can be created for these wireless communications and the defence industries.

At its most basic level, we are bringing the idea of an antenna down to the nanoscale. Back in the day before cable and satellite, TVs had metal antennas. If your picture wasn't very good, you would get up and physically reconfigure the antenna geometry to change its performance. Those antennas were designed for radio waves that were centimetres to meters in length. We are working to create nanoscale antennas that would be able to respond to visible light with wavelengths of 400 to 700 nanometres, or infrared light, where wavelengths are on the order of a micron. By configuring the geometry of these antennas individually and in collections, we can engineer systems that can interact with and manipulate light in entirely new ways.

These tiny antennas are many orders of magnitude smaller than a TV antenna. Fortunately, the development of the modern electronic integrated circuit platform over the last half-century has produced mature technological processes that can help us define nanoscale features. We use those same patterning technologies to make these nanoscale antennas.

CLASSIFICATION OF METAMATERIALS

Electromagnetic field is determined by the properties of the materials involved. These properties define the macroscopic parameters permittivity ε and permeability μ of materials. On the basis of permittivity ε and permeability μ, the metamaterials are classified in following four groups as shown in Fig.1.

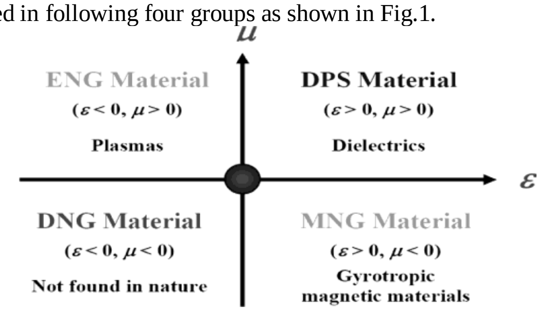

Fig.1 Classification of Meta Materials

A. Double Positive (DPS) Material

The materials which have both permittivity & permeability greater than zero ($\varepsilon > 0$, $\mu > 0$) are called as double positive (DPS) materials. Most occurring media (e.g. dielectrics) fall under this designation.

B. Epsilon Negative (ENG) Material

If a material has permittivity less than zero and permeability greater than zero ($\varepsilon < 0$, $\mu > 0$) it is called as epsilon negative (ENG) material. In certain frequency regimes, many plasmas exhibit these characteristics.

C. Mu Negative(MNG)Material

If a material has permittivity greater than zero & permeability less than zero ($\varepsilon > 0$, $\mu < 0$) it is called as mu negative (MNG) material. In certain frequency regimes, some gyro tropic material exhibits these characteristics.

D. Double Negative (DNG) Material

If a material has permittivity & permeability less than zero ($\varepsilon < 0$, $\mu < 0$) it is termed as double negative (DNG) material. This class of materials can only been produced artificially.

2. Existing Method

With the fast development of the wireless communication technologies, having lightweight, low profile, superior performance, multi-band, low frequency band operation antennas are in good need to satisfy the increasing number of service bands, especially the Global system for mobile communication (GSM-900, GSM-1800), Global positioning system (GPS), Wireless LAN (WLAN) at 2.4 GHz and 5 GHz, Long term evolution (LTE) cover three bands, where the lower band includes frequency range of (698–966 MHz), middle band in the range of (1.427–2.69 GHz) and higher band in the range of (3.4–3.8 GHz). The Unlicensed National Information Infrastructure (U-NII) band is used in IEEE 802.11a devices and by different Internet Service Providers (ISPs).

U-NII low (5.15–5.35 GHz) for WLAN operation, U-NII mid (5.47–5.725 GHz) for WiFi operation and U-NII high (5.725– 5.875 GHz) for WLAN operations. Bluetooth works at (2.4–2.85 GHz) frequency, which is in ISM (Industrial, Scientific and Medical) band, for WiMax 2.3 GHz, 2.5 GHz, 3.5 GHz is used by Internet Service Provider in the United State and other countries.

So, for satisfy the demand short distance wireless communication systems uses different methods, such as use the thickness of substrate materials, patches with multiple layers, insertion of slots/ slits, use of metamaterial and modification of radiator shape have been observed to increases the performance of the antennas. Compared with the conventional antenna, the metamaterial antenna can effectively decrease the number of the antenna elements and enhance the performance of the antenna.

At present, using metamaterial to enhance the performances of antenna, like, bandwidth, gain and efficiency is a demand of advance communication systems to support more user having lightweight, superior performance, multi-band, high data rate, etc. Nowadays, in the wireless communication a revolutionary has been created with the help of several communication systems, such as, 4 G mobile communication, Bluetooth, WLAN, WiFi, GPS, WiMAX, etc.

Today the electronics system design industry have become increasingly focused on realizing smaller electronic devices while maintaining or increasing the performances. Due to the effective and optimal performances metamaterial antennas are appearing as potential structures for future wireless communication systems.

3. Proposed Method

Nowadays, WLAN or Wireless Local Area Network has become more popular. For examples, the portable devices like laptop, notebook, PDA, and mobile phones are incorporated with WiFi and Bluetooth technologies to connect. This IEEE 802.11b/g is operating at 2.40 GHz. Since 1999, researchers have proposed many structure designs to form metamaterials structure.

Metamaterial or left handed material is the artificial substrate that did not exist in the real nature. Metamaterial had been categorized structure or design that has the simultaneously negative permeability and permittivity. This metamaterial structure can significantly give effect to the application that had been designed. This structure also can miniaturize the size of the patch antenna or other medium that researcher used for its design. Sometimes, it can achieve better return loss (S_{11}) performances compared to the normal antenna design without metamaterial structure.

The metamaterial structure also can give impact to improving the antenna directivity gain. There are many metamaterial

structures had been proposed by many researchers. The most popular structures are electromagnetic band gap (EBG), split ring resonator (SRR), artificial magnetic conductor (AMC), photonic band gap (PBG).

Split ring resonators (SRRs) design is used to produce the negative dielectric constant (permittivity) and negative permeability. This structure sometime called Double Negative Material or DNG. The metamaterial artificial left-handed materials (LHMs) were initially discovered by Victor Veselago but other researcher in this field cannot apply this design in the practical application for the next 30 decades. Smith and his group have been fabricated the first artificial metamaterial in millennium. Their design depends on Pendry split ring resonator-base artificial negative magnetic permeability medium.

The split ring resonator can be applied in many designs such as antennas, microwave absorber, filter, frequency selective surface and others. There are many types of split ring resonator that have been designed by a few researchers. Edge coupled SRR (EC-SRR) was the initial first design by Pendry.

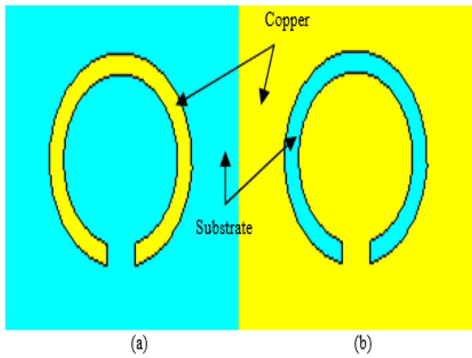

Fig.2 (a) Normal edge couple split ring resonator, (b) Complimentary edge couple split ring resonator

In this SRR design, there are two concentric metallic split rings, printed on a microwave dielectric circuit board. Figure 2 shows the different between normal and complimentary edge couple split ring resonator. The complementary of split ring resonator structure is obtained by replacing the copper parts with substrate material, and the substrate material with copper parts.

The second type is the broadside-couple SRR (BC-SRR). This design was proposed by Marques to avoid the ECSRR bianisotropy. It has the additional advantage of potentially much smaller electrical size.

Another type of SRR design is nonbianistropic SRR (NB-SRR) that proposed by also by the same researcher. He had been designing this SRR to avoid EC-SRR bianistropy while keeping an uniplanar design. The other design by Marques was Double-Split SRR (DS-SRR). This is an alternative way to obtain inversion symmetry by introducing additional cuts in the

EC-SRR design. Spiral SRR (S-SRR) also is one of the designs that apply for SRR.

This SRR design is a well-known resonator in planar microwave circuitry. This design can provide a strong magnetic dipole at resonance, thus being useful for left-handed material (LHM) design.

The design consists of two copper rings that opening at the same side, not like before. The researcher claims that this design can be approximately 20 % smaller than normal split resonator. Other types of SRR structure is H-Shaped split ring resonator (HS-SRR) by and twisted split ring resonator by.

The performance of the normal patch antenna with single complimentary SRR patch antenna. Four different shapes of single complimentary split ring resonator structure had been incorporated into the microstrip patch antenna - square, circular, triangular, and rhombic shown in fig 3

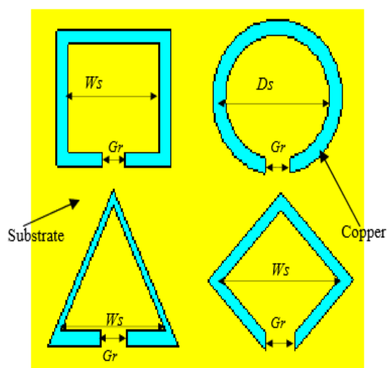

Fig. 3 Single complementary split ring resonator structure of the antenna design with 4 different shapes – square, circular, triangular and rhombic

4. Metamaterial Antenna

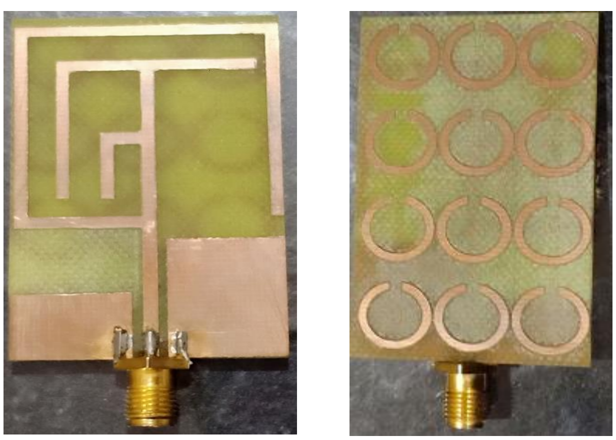

Fig.4 Fabricated geometry of the proposed: (a). Front view of metamaterial antenna (b).Back view of metamaterial antenna with circular SRR.

5. Simulation and Fabricated Antenna Results

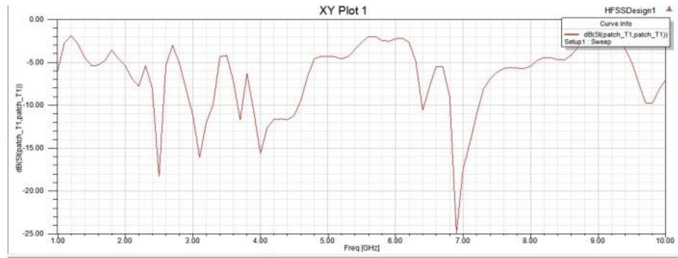

Fig. 5 S_{11} Parameter

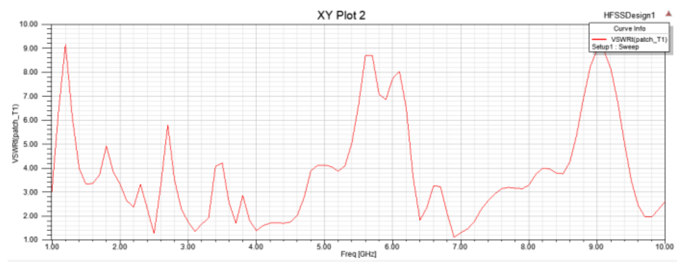

Fig. 6 VSWR Output

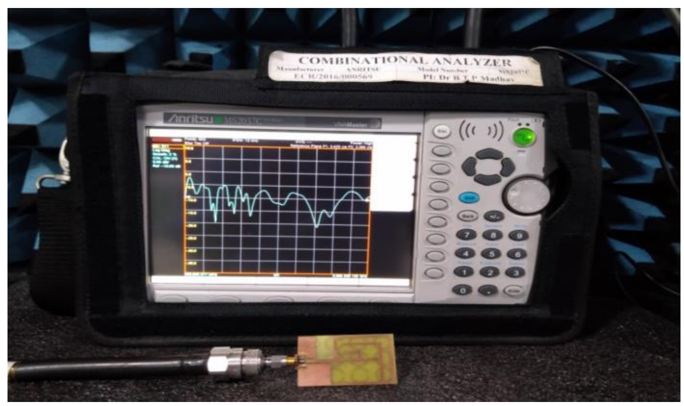

Fig.7 Fabricated Antenna s_{11} Parameter Output

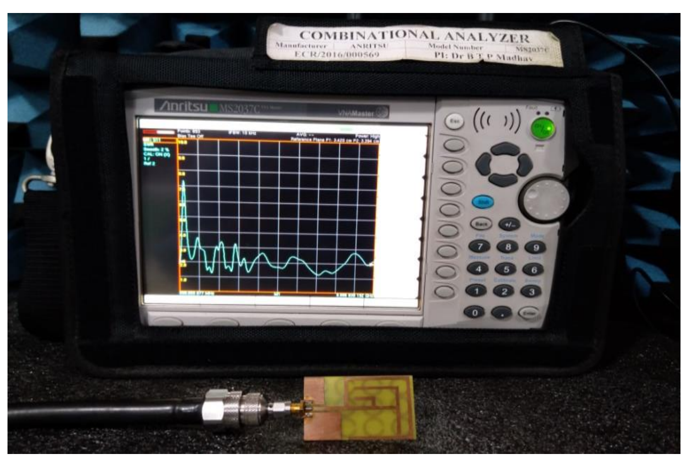

Fig.8 Fabricated Antenna VSWR Output

6.Conclusion

To adjust with the modern wireless communication systems, a metamaterial inspired antenna with covering multiple band frequencies is designed, analysed and measured in this project. Simulation and fabricated results are approximately equal to each other. The antenna can be fabricated easily as well as cheap, simple and compact for all small portable devices. Moreover, the proposed without MMs antenna and with MMs antenna have stable radiation characteristics, high efficiency and good candidate for LTE, Bluetooth, WiMAX, etc. applications.

6. Future Scope

Metamaterials is the new filed of research, without any doubt it becomes an extremely exciting research area. The researchers from multiple disciplines are being attracted towards metamaterials because of its unique electromagnetic properties.

In this project, a short review of the history of metamaterials, various types of applications and different modeling methods of metamaterials have been discussed. Metamaterials can be used for the performance and enhancement of micro strip patch antennas. Metamaterial antenna is made by loading the metamaterial structure over the substrate. There are different kind of metamaterial substrates. If change the metamaterial substrate will change in the parameter of antenna.

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