UWB METAMATERIAL ANTENNA AND APPLICATIONS

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***Abstract*- A negative index metamaterial antenna is presented in this paper for ultra-wideband (UWB) applications. The proposed antenna is composed of rectangular type complementary split ring resonator (CSRR) wire that exhibit negative electrical permittivity (ε) and negative magnetic permeability (μ). The radiating patch may be square, rectangular, thin strip (dipole). The proposed antenna utilizes CSRRs in the ground plane altering the effective medium parameter of the sustrate. . All these shapes are designed with the intention to ameliorate the bandwidth and return loss along with size reduction. The results obtained from the simulation studies shows that the antenna has good radiation characteristics for the UWB applications.**

KEYWORDS: UWB antenna, Metamaterials, Wireless Communications, split ring resonator.

I. INTRODUCTION

Meta materials are recently developed artificial materials. It's the only material in the world having negative permittivity, negative permeability and negative refractive index. Due to having these three negative properties it exhibits unusual properties compared to readily available materials[1]. Micro strip patch antennas are among the most common antenna types in use today, particularly in the popular frequency range of 1GHz onwards. Micro strip UWB antennas have become more promising for modern wireless devices due to wide bandwidth, capability of high data rate communication for short range devices, low power consumption, low cost and low interference[2].

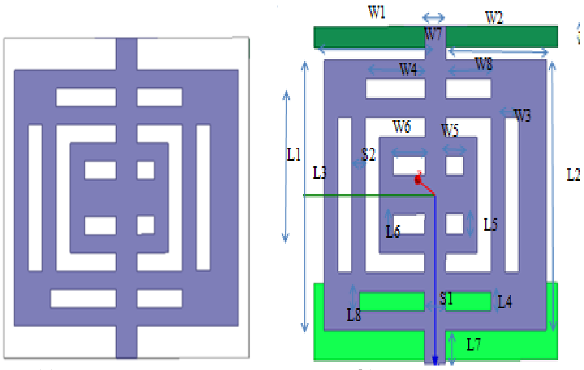
Ultra wide band is the band which occupies greater than 500MHz of bandwidth or greater than 25% of the operating frequency. FCC allocated the 3.1-10.6GHz spectrum for unlicensed use[3].

Recently, lots of research have been done for artificial material or metamaterials whose property does not exists in nature but can be designed using metallic and dielectric structure to show properties like negative refractive index (NRI) behavior and left handed material (LHM) behavior [4].

II. RELATED WORK

The simulation software Ansoft HFSS 13.0 is used for antenna design and analysis purpose. The geometry of the proposed antenna is shown in Fig.2, which is designed on low cost FR4 substrate (permittivity 4.4)with height 1.6mm. The important properties of the substrate which are taken into consideration are relative dielectric constant, loss tangent and thickness substrate. There are number of substrate that can be used for the design of microstrip antenna, and their dielectric constant are usually in the range of $2.2 \leq \varepsilon r \leq 12$.

The prototype was proposed using split ring resonators (SRR's). The SRR's may take various shapes in which here square shaped SRR's are considered. The SRR's basically consists of two loops: a smaller loop incorporated within the bigger one, with slots incorporated onto each at opposite ends. The SRR is a magnetically resonant structure that responds to a perpendicular magnetic field, which can be used to create negative permeability, gaps added to the rings introduces capacitance effect, which allows control in the resonant characteristic of the structure [8-9].



(a)Top View (b) Bottom View

Figure 2:- Geometry of proposed antenna configuration

Table I :- Dimensions (in mm) of Designed Metamaterial UWB Antenna

PARAMETER	DIMENSION	PARAMETER	DIMENSION	PARAMETER	DIMENSION
Wsub	8.5	W2	3.5	W6	1.1
Lsub	8.5	L2	6.8	L6	0.5
Wg1	8.5	W3	0.5	W7	0.7
Lg1	0.5	L3	3.9	L7	0.9
Wg2	8.5	W4	2.1	W8	1.6
Lg2	2	L4	0.5	L8	0.5
W1	3.5	W5	0.7	S1	0.7
L1	6.8	L5	0.5	S2	0.5

III. METAMATERIAL AND PARAMETER CONCEPTS

The ISM structure is designed and simulated using EM solver Ansoft's HFSS. With extracted s-parameter matrix, value of refractive index n and wave impedance z was calculated using the following equations (Sabah, 2012; Smith et al., 2001).

$$n = \frac{1}{kd}\cos^{-1}\left[\frac{1}{2S_{21}}\left(1 - S_{11}^{2} + S_{21}^{2}\right)\right] \quad \text{------ (1)}$$

$$Z = \sqrt{\frac{(1+S_{11})^2 - S_{21}^2}{(1-S_{11})^2 - S_{21}^2}} \quad \text{-------- (2)}$$

The value of effective permittivity ε and effective permeability μ may be computed by

$$\varepsilon_{eff} = \frac{n}{z} \text{ and } \mu_{eff} = n * z \quad \text{------- (3)}$$

An improved parameter retrieval method given in (Liu and Wang, 2012) is as follows:

$$n = \frac{\ln\left(\frac{S_{21}}{1-S_{11}\frac{z-1}{z+1}}\right)}{ikd} \quad \text{------- (4)}$$

Where, k is wave number, d is thickness of unit cell. Refractive index versus frequency curve using Equation (4) and wave impedance using Equation (2) are shown in figure.

The Permittivity and permeability of the medium are related to S-Parameter by the Equation (5) and (6) below

$$\varepsilon_{eff} = \frac{2}{jk_0 d} * \frac{1-V_1}{1+V_1} \quad \text{------ (5)}$$

$$\mu_{eff} = \frac{2}{jk_0 d} * \frac{1-V_2}{1+V_2} \quad \text{------ (6)}$$

Where k_0 is a number equivalent to $\frac{2\pi}{\lambda_0}$,d is the thickness of the substrate

$$V_1 = S_{21} + S_{11} \quad \text{-------- (7)}$$

$$V_2 = S_{21} - S_{11} \quad \text{-------- (8)}$$

After calculating permeability and permittivity using above equation , refractive index 'n' can be computed using:

$$n = \pm\sqrt{\mu_{eff} * \varepsilon_{eff}} \quad \text{------ (9)}$$

IV. RESULT AND DISCUSSIONS

The structure is simulated using Ansoft-HFSS and the simulated result of the proposed antenna is shown in figure 3, from the simulated result. The simulated return loss S(11) obtained using HFSS and depicted in Figure 3 Curve of a metamaterial antenna at an intrinsic variations frequency of 7GHz. It is evaluated for 4GHz to 12GHz. The measured result demonstrates, the -10dB return loss simulated bandwidth of the proposed antenna in between 6.5 GHz–

10.4GHz. The minimum value of S(11) is found to be -41dB at 8.6 GHz.

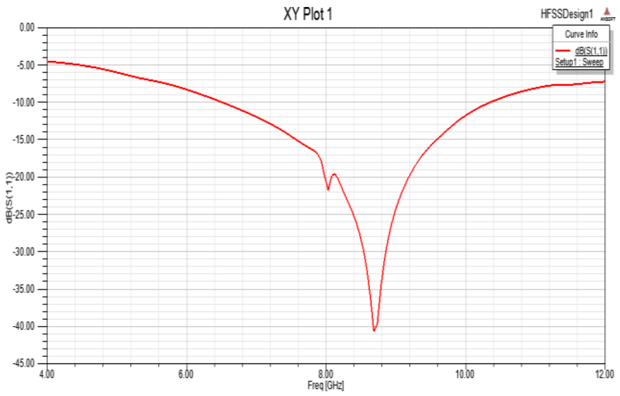


Figure 3:- The simulated Return loss of the designed metamaterial antenna at 7GHz.

The simulated VSWR of the final designed metamaterial antenna at frequency 7GHz. VSWR less than 2 is obtained with value 1 at 8.6GHz. which indicates that the antenna has UWB features behavior satisfying the VSWR requirement of less than 2 in the same frequency band[10-12].

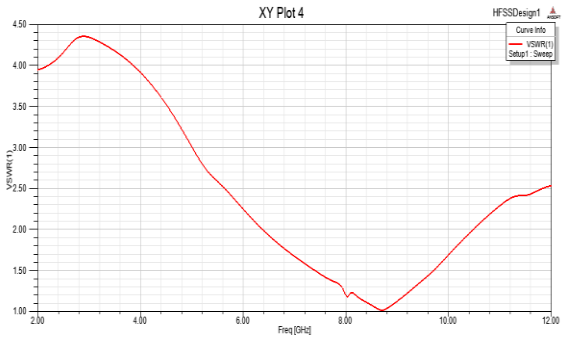


Figure 4:- The simulated VSWR of the final desinged metamaterial antenna at frequency of 7GHz.

The antenna achieved peak gain 0.34831, efficiency 91.62% and an omnidirectional pattern, which are plotted in figures 6, respectively. From the figure 4, it can be seen that simulated radiation pattern of the proposed antenna at 7GHz of near ephi field radiation and far hphi field radiation.

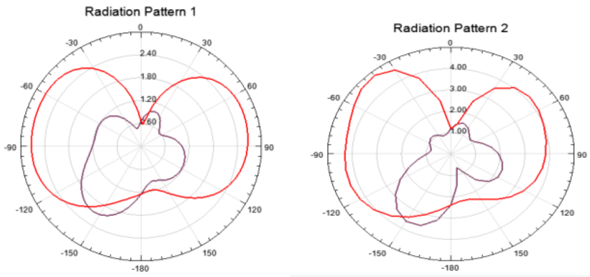


Figure 5:- Simulated Radiation Pattern of the proposed antenna at 7GHz

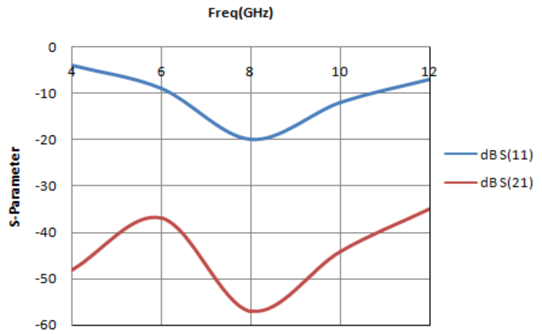


Figure 6:- The simulated S-Parameter of metamaterial antenna at 7GHz.

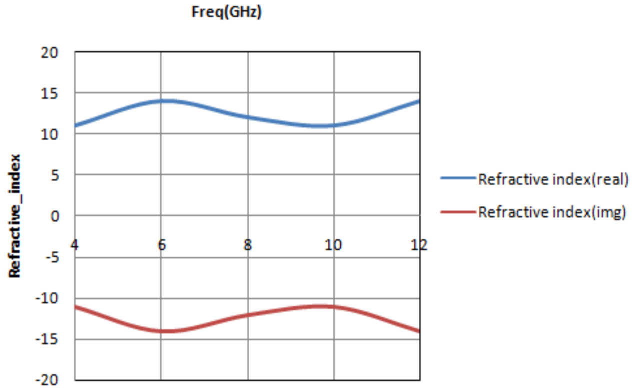


Figure7:- The simulated Refractive Index of metamaterial antenna at 7GHz.

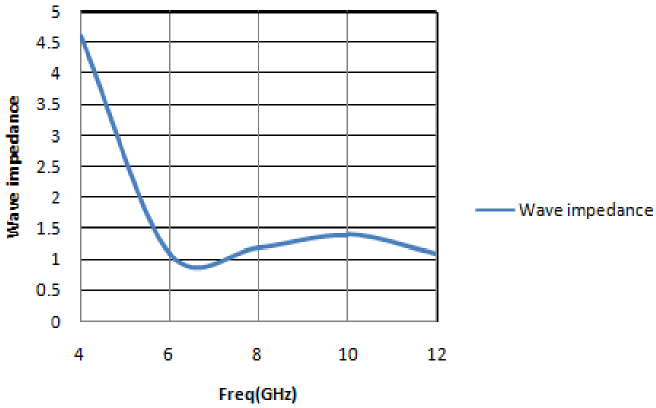


Figure 8:- The simulated Wave impedance of metamaterial antenna at 7GHz.

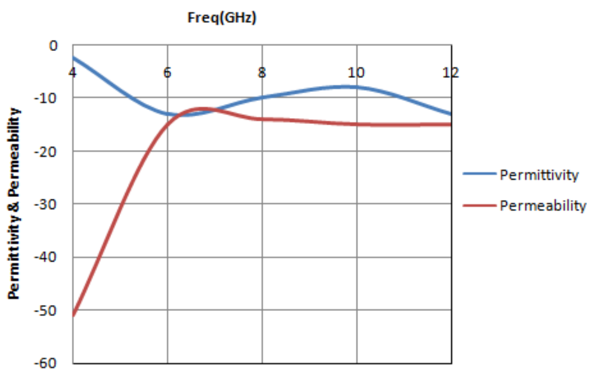


Figure 9:- The simulated Permittivity & Permeability of metamaterial antenna at frequency 7GHz.

V.CONCLUSION

By observing the simulated results it is very clear that the compact metamaterial antenna gives better gain and efficiency compared to an ordinary patch antenna which is very useful for point to point wireless propagation. The results show that the proposed LHM can be used very effectively in producing materials with negative index. A metamaterial based compact antenna for FCC's UWB application is presented. Due to the unusual properties of the metamaterials by using HFSS the antenna gives overall efficiency of 92.62 and a VSWR of 1 at 6.4GHz frequency which is very good for point to point wireless communication and wireless LANs.

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