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Tri-Strip Monopole Antenna for LTE, WLAN and WiMAX Communication Applications

C. Karthik[1], K. Murali Babu[2], K. Lakshmi Narasamma[3], Ch. Sandhya[4], and L. Bharath[5]

[1]Associate Professor, Department of Electronics and Communications Engineering, PACE Institute of Technology & Sciences, Ongole, Andhra Pradesh, India
[2]Professor, Department of Electronics and Communications Engineering, PACE Institute of Technology & Sciences, Ongole, Andhra Pradesh, India
[3]Assistant Professor, Department of Electronics and Communications Engineering, PACE Institute of Technology & Sciences, Ongole, Andhra Pradesh, India
[4,5] UG Student, Department of Electronics and Communications Engineering, PACE Institute of Technology & Sciences, Ongole, Andhra Pradesh, India

Correspondence should be addressed to C. Karthik; karthick_c@pace.ac.in

ABSTRACT- In this research, we present a Tri-strip monopole antenna for LTE, WLAN (Wireless Local Area Network) and WIMAX (Wireless interoperability for microwave access) Applications. This is due to the fact that wireless applications is not needed to connect all operating frequencies simultaneously, Which will effect improving functionalities without increasing size of antenna. A miniaturized triple wideband coplanar waveguide-fed patch antenna with the defected ground structure isused for LTE, WLAN and WIMAX applications. The proposed antenna with overall size of 40 mm×40 mm×1mm and the design simulation are carried on a Rogers RT/ duroid 5880 substrate using HFSS v.13.0 simulation software. The proposed antenna shows the gain of 9dB at notch band frequency therefore it is good for its working conditions. Moreover, the proposed antenna is fabricated with a new metamaterial approach by placing the unit cell we have observed the triple band notch characteristics and depth in resonant frequency. There is enhancement in gain and radiation patterns, return loss is analyzed and parametric analysis is presented for optimization of antenna. The average gain that is observed through the band is 3.5dB and the average radiation efficiency that is observed for the model is 94%.

KEYWORDS- Coplanar Waveguide (Cpw) Feed, Defected Ground Structure (DGS), Patch Antenna, Triple-Band Antenna, Wideband antenna, LTE, WLAN/WiMAX applications.

I. INTRODUCTION

FCC has introduced UWB technology as one of the most prominent technologies for the wireless multimedia system which is having high data rate. Due to the added advantage of gain and impedance bandwidth varying from 3.1 to 10. 6GHz. These antennas have favorable factors like compact in size low-cost and must present Omni directional radiation pattern. The recent advancements such as metamaterials, AMC, FSS and conformal antennas are designed to work at these frequencies only. Antennas which are having the simple structures with less design parameters and should have wide impedance bandwidth with stable polarization characteristics across the entire covered band. The most important thing in antenna operation is the band coverage towards the commercial applications and to know the notching in the undesired bad of operation.

Wen-Chung Liu, et al. proposed a compact coplanar waveguide (CPW)-fed patch antenna designed by simply embedding two types of shaped slots into a rectangular patch for achieving dual-band operation [1]

Yue Zhuo, et.al. proposed a compact dual patch antenna. The proposed antenna employs a U-shaped slot and two mitered corners to achieve two operating frequency bands, 2.30-2.50 GHz and 4.50-6.36 GHz, which meet the specifications of IEEE 802.11b/g/a standard for WLAN applications [2]. Amit Kumar, et.al proposed a CPW-Fed MIMO antenna for dual-band applications of range 2.4/5.8 GHz ISM band and 2300 MHz LTE-4G band. In this to isolate 3.5GHz WiMAX high traffic Rectangular Split-Ring-Resonator is used [3]. Ruchita Sonak, et.al proposed a coplanar waveguide-fed open-ended zeroth order resonating dual-band metamaterial antenna. Two resonant bands are produced by this antenna at 1.22GHz and the second occurs at 4.88 GHz to 7.24 GHz [4]. Jingjing Zhang, et.al proposed practical coplanar waveguide fed uwb antenna with reconfigurable dual band-notched. In this the notch characteristics are realized in 5.1 ~ 5.9 GHZ and 7~7.8GHZ and the bandwidth is increased 137% ranging from 3 to 16 GHZ due to cpw feeding [5]. Rajan Vivek, et.al proposed Compact Capacitive Coupled Triple Band Planar Inverted F antenna. This antenna is printed on an FR4 epoxy substrate of dielectric constant with a size of 40mm,5mm,6mm. These antenna is operated at three bands 1.8 to 1.9 GHZ for GSM 1800, 2.5 to 2.6GHZ for LTE 2500 and 3.3 to 3.4GHZ for WIMAX applications [6]. Tingting Chen, et.al proposed novel CPW-fed planar monopole antenna with broadband circular polarization. The impedance bandwidth is increased to 89.2% due to the CCSP design and also the whole CP bandwidth is covered 71% [7]. Ronak Vash, et.al proposed A coplanar waveguide (CPW)-fed flexible dual-band antenna using graphene as conducting material and Kapton polyimide as a substrate. The receiving wire shows expanded impedance data transmission because of the utilization of CPW-feed [8]. Sumeet S. Bhatia, et.al proposed wideband antenna using truncated corners partial ground plane loaded with L-shaped stubs and inverted T-shaped slots. The antenna performance was improved due to the L shaped stubs and inverted L shaped stubs [9]. Seyed Sasan Haghighi, et al. [10] proposed an antenna which works at triple band where the author used substrate integrated waveguide. Here the work is based on the left- handed structures which usually call as metamaterials. In Vaibhav, et al. [11] proposed a ultrawideband ultrathin metamaterial absorber which is used to absorb the radiated frequency. The absorbers are based on the metamaterial inspired split ring resonators.

II. ANTENNA DESIGN AND ANALYSIS OF CPW FEED ANTENNA

It consists of two triangular split ring resonators and a co-planar wave guide (CPW). "Rogers RT/ duroid 5880" is used as a substrate for antennas whose relative permittivity is 2.2. The overall dimension of substrate is 40 × 40 × 1 mm3. The designed antenna works for various applications like Mobile Satellite Services (MSS), WIMAX, Airport Surveillance Radar and S-Band applications. This antenna design is simulated using ANSOFT HFSS. The schematic diagram of antenna1 is shown in Fig. 1 The detailed dimensions of antenna1 are mentioned. The proposed dimensions of antenna Ig = 14.5, Wg = 13, Wf = 5.5, gf = 0.2, a1 = 16, a2 = 10, G = 2, W = 1

Antenna3 also operates in the same frequency bands as antenna1 but this is proposed in order to improve S11 results of antenna2. Here a complementary shape with two rectangular split ring resonators is designed and is directly inserted on the left part of ground in antenna2 which results in antenna3 design. Schematic diagram of antenna3 is in figure 5. The detailed dimensions of antenna3 are mentioned in table 1.

Figure 1: Proposed base antenna

Ig = 14.5, Wg = 13, Wf = 5.5, gf = 0.2, a1 = 10, a2 = 16, G = 2, W = 1, D = 1, Is = 13, bs = 5.5, ws = 1

The above figure 3. represents the new approach of split ring resonator that is using now a day. The split in the ring produces wavelength much larger than normal rectangle. The second split ring resonator which is proceeded towards the first one produces capacitance. These are all due to gap between the rectangular split ring resonator. The unit cell analysis is carried by giving perfect electric conductor to split sides and the perfect magnet to the top side which was clearly explained in the above figure and the remaining sides of the box are assigned with wave guide ports. Fig. 1 is the proposed base antenna and Fig. 2 is the proposed antenna.

Figure 2: Proposed antenna

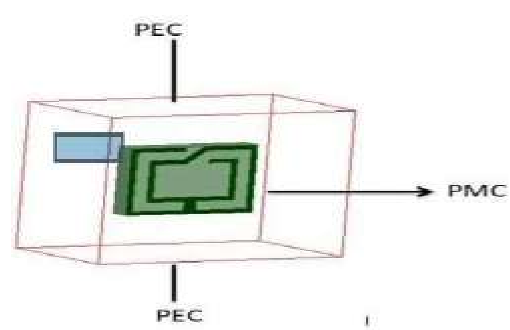

Figure 3: Unit cell Analysis

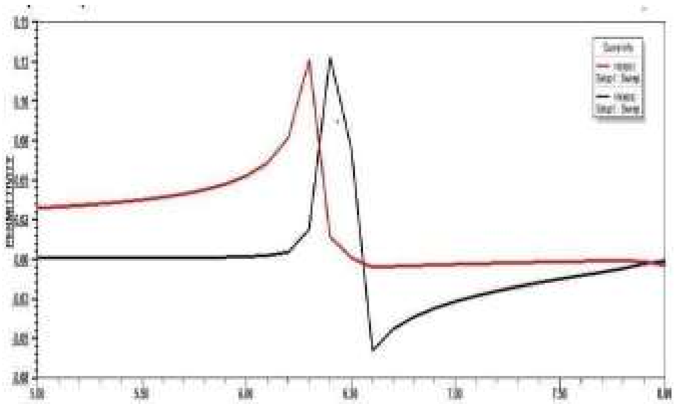

Figure 4: Permittivity vs Frequency

The above figure gives the result of permittivity and frequency graph shown in Fig. 4. At the working band frequency, the antenna exhibits the negative permittivity which shows the properties of the metamaterial. So, from the above results we can say that antenna exhibits metamaterial properties. Final design of the proposed antenna shown in Fig. 5.

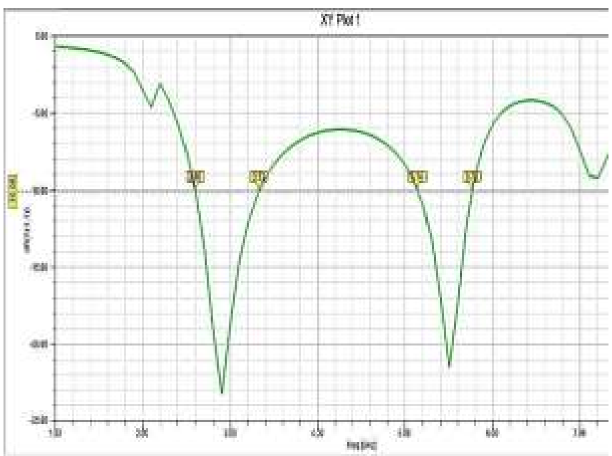

Figure 5: Proposed antenna

III. RESULTS AND DISCUSSIONS

The following are the results obtained after simulating antenna2 and antenna 3 in Ansoft HFSS.

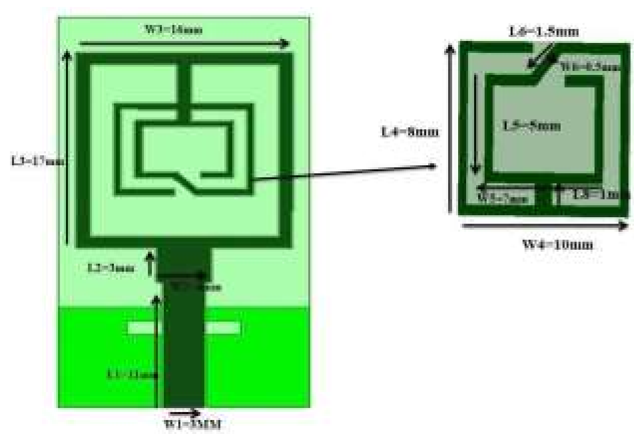

Figure 6: Return loss for base model

Fig. 6. In this plot it is observed that the 1st band frequency at 2.5 GHz with a return loss of - 28 dB. The basic antenna which we had projected is working at the frequency of WLAN application only. Therefore, this antenna is used for single application purpose only. The above graph results show that the return loss vs frequency curves.

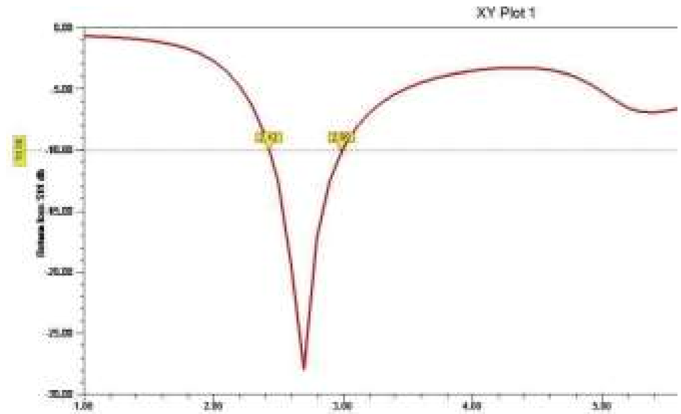

Figure 7: Frequency response for second antenna

In this plot it is observed that the 1st band frequency at 2.6 GHz to 3.33GHz with return loss of-24 dB and 2nd band frequency at 5.14GHz to 5.73GHz with a returnloss of -22dB shown in Fig. 7. The antenna is going to work at two different frequency which is said tobe working of dual band frequencies like Upper WLAN and the figure gives the notation of return loss vs frequency.

Table 1: Optimized dimensions of proposed antenna

Ls	34mm	W6	0.5mm
Ws	18mm	L7	3.4mm
L1	11mm	W7	1mm
W1	3mm	w5	7mm
L2	3mm	H	1.6mm
W2	4mm	a	1mm
l3	17mm	G1	1.75mm
W3	16mm	Lg	8.5mm
L4	8mm	Wg	18mm
W4	10mm	Ws1	8.2mm
L5	5mm	Ls1	1.2mm
L6	1.5mm	L8	1mm

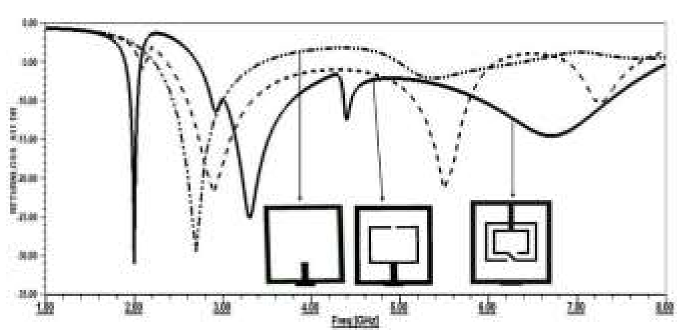

Figure 8: Return loss for final proposed antenna

In this plot shown in Fig. 8. it is observed that the 1st band frequency at 1.95-2.04GHz and 2nd band frequency at 2.87-3.76GHz and the 3rd band frequency working at 5.92-7.20GHzwith a maximum return loss of -30dB.The antenna is going to work at three different frequencies which is said to be working of triple band frequencies like Upper WLAN LTE 33-37and LTE 43-44. The figure gives the notation of return loss vs frequency.

From the above table it is clearly shown that the proposed antenna has more return loss and it has multiband operating function so this is used as the finally projected antenna because the base antenna which we had proposed has return loss of 28dB and it is used for single band application only and second model is used for upper WLAN and has maximum return loss of 22dB only and the finally proposed antenna has maximum return loss when compared to the previous proposed antenna and it is used for triple band application purposes also so we has preferred this model and in results comparison we got the best results compared to the previous models.

Fig. 9 shows the VSWR measurement for the base model antenna. From, the figure it is clearly known that the working band 2.4GHz it shows a value of 1 as a VSWR measurement as it represents there is maximum percentage of impedance matching is occurring at the working band

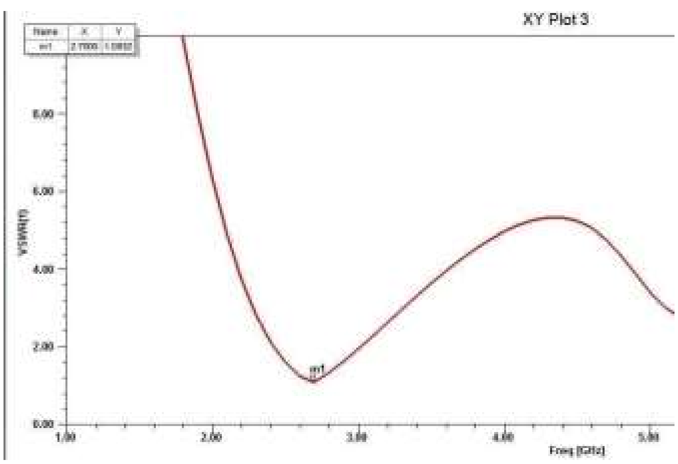

Figure 9: VSWR of the proposed model

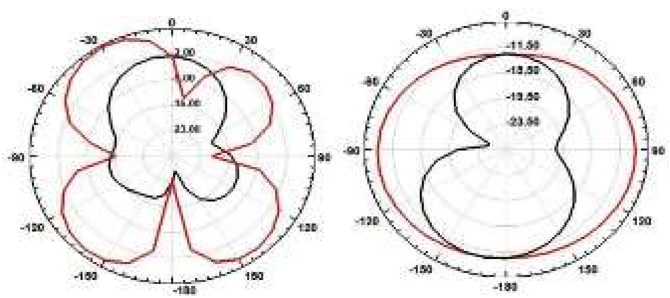

Figure 10: Radiation pattern of the base model, (a). E-plane and H-plane for simulated radiation pattern at 2.4 GHz. (b). 4 GHz

The proposed prototype antenna is virtually placed on XY-plane the above radiation patterns shows the azimuth and elevation angles at frequencies 2.4GHz. The above diagram shows that the dipole pattern. The radiation pattern indicates Omni directional pattern in H-plane and Omni directional at 0degree or elevation angels. This is the basic proposed model which can be used for single application purpose. The proposed prototype antenna is virtually placed on XY-plane the above radiation patterns shows the azimuth and elevation angles at frequencies (4GHz) shown in Fig. 10. The above diagram shows that the dipole pattern. The radiation pattern indicates Omni directional pattern in H-plane and Omni directional at 0degree or elevation angles.

The proposed prototype antenna is virtually placed on XY-plane the above radiation patterns shows the azimuth and elevation angles at frequencies (2-3.3 GHz). The above diagram shows that the dipole pattern. The radiation pattern indicates Omni directional pattern in H-plane and Omni directional at 0 degree or elevation angels. There is no deviation in the radiation patterns both are assumed to be same at 2-3.3 GHz.

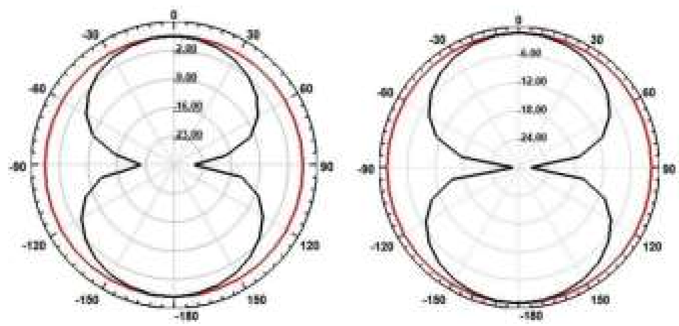

Figure 11: E-plane and H-plane simulated radiation pattern at working band 6GHZ and notch band 2.2GHz

Figure shows the radiation patterns at working band frequency of 6GHzand notch band frequency of 2.2GHz. From the above results at working band frequency of 6GHz shown in Fig. 11, there are many side lobes which are bent at certain angles like 20, 92,180 degrees. When we came back to notch band frequency 2GHz there is a small deviation compared to working band frequency. The side lobe is bend at an angle of 15 compared to working band frequency.

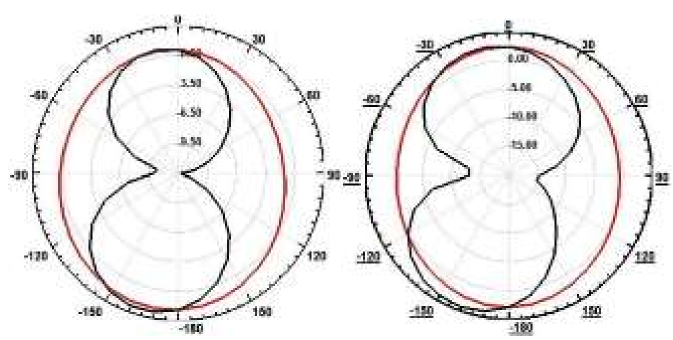

Figure 12: E-plane and H-plane simulated radiation pattern at notch band frequencies 3.2 GHz and 5.4 GHz

The proposed prototype antenna is virtually placed on XY-plane the above radiation patterns shows the azimuth and elevation angles at frequencies (3.2-5.4GHz) shown in Fig.12.

The above diagram shows that the dipole pattern. The radiation pattern indicates Omni directional pattern in H-plane and Omni directional at 0degree or elevation angels. There is a small deviation at the frequency of 5.4GHz.
The above figure shows the current distribution for both the working band and notch band frequency. The color of distribution shows the different in the flow of currents and their directions. The red color in the above figure indicates that the has more density at working band and the direction of flow of current is from port to towards the slot. Where the green color

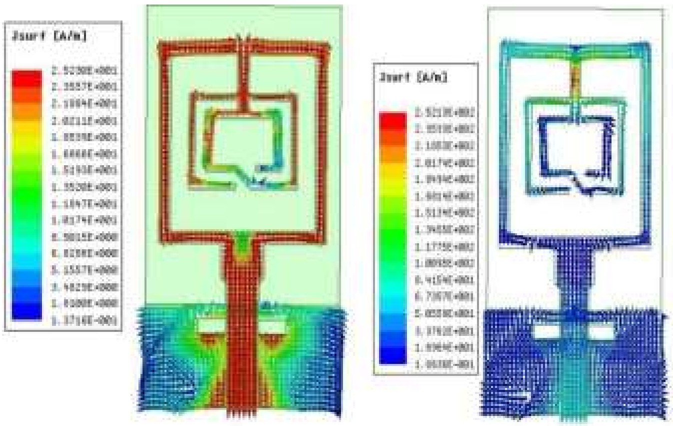

Figure 13: Working band 2 GHz and 2.2 GHz

indicates radiating place in the current distribution. Where the blue color in the diagram indicates that the current density is less compared to working band, we can say that the current density is more at working band compared to notch band. Therefore, there is a maximum current distribution at the working band frequency of 2GHz shown in Fig. 13.

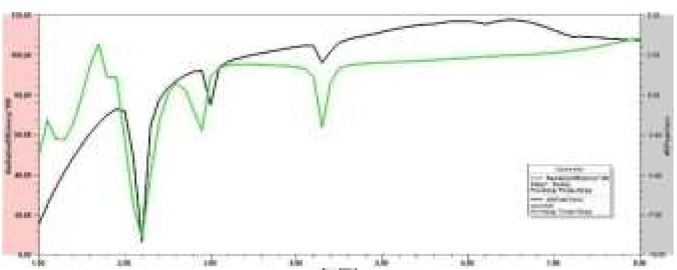

Figure 14: Radiation efficiency for base model

The above figure 14 shows the results of radiation efficiency for the base model antenna shown in Fig. 14. For antenna the maximum and minimum radiation efficiency values are there if an antenna exhibits the radiation efficiency value of 100 shows the it is perfect and good working but for building of such type of antenna is impossible because there in nature, we have some losses so no antenna can exhibit 100 efficiencies. The antenna at the working band of 2.4GHz exhibits the radiation efficiency of 96.15. The above graph is taken from radiation efficiency vs frequency curve.
The above figure shows the results for the radiation efficiency and gain for the proposed antenna shown in Fig. 15 and 16. The radiation efficiency for the proposed antenna is 98 and the gain at the working band frequency is -9dB which is the maximum gain at the working and notch band frequency.

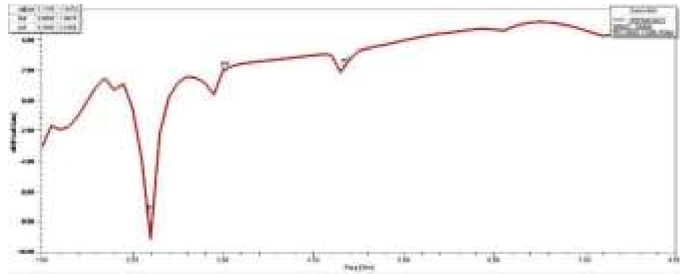

Figure 15: Radiation efficiency for proposed model.

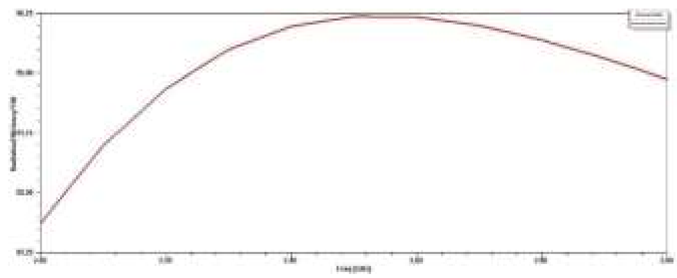

Figure 16: Gain of the base model

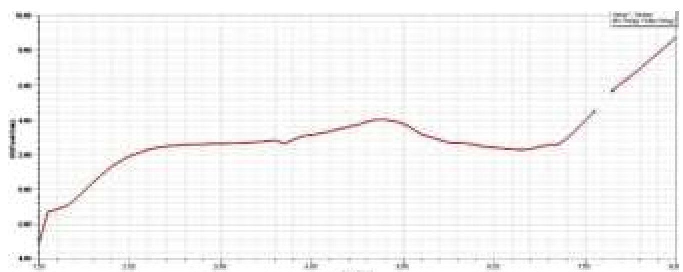

Figure 17: Gain for the proposed model

The above figure shows gain for the proposed model is -9dB which is the maximum gain of the antenna at the working band conditions shown in Fig. 17.

IV. CONCLUSION

The conclusion deals with the summary of the entire research work. In this research, endeavors have been made for designing of the metamaterial inspired multiband monopole antenna with ground defected structure with split ring resonators are designed and simulated using Ansoft HFSS. The antenna 3 which is designed is fora single band application that is working at a frequency of 2.4GHz that is used for WLAN application and antenna 4 operates at two frequency bands covering applications like upper WIMAX and S-Band applications. By adding complementary rectangular split ring resonator in antenna4 it is working for multi band operations like LTE (33-35), LTE (44-45) and also for WLAN applications it showed better return loss plot compared to antenna2. The proposed antenna shows the gain of 9dB at notch band frequency therefore it is good for its working conditions. The proposed antennas have the advantage of simple structure making them easy for fabrication. From the above results and discussions, we can say that an antenna that is fabricated with a new metamaterial approach by placing the unit cell we have observed the triple band notch characteristics and depth in resonant frequency. There is enhancement in gain and radiation patterns, return loss is analyzed and parametric analysis is presented for optimization of antenna. The average gain that is observed through the band is 3.5dB and the average radiation efficiency that is observed for the model is 94%.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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