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# Coplanar Wave Guide Fed Dual Band Notched MIMO Antenna

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**ABSTRACT**

A coplanar wave guide fed of semicircle monopole antenna is designed in this work to overcome polarization diversity mimo technique is implemented in this paper. The proposed antenna is designed to notch a particular band of frequencies in UWB range. The designed model is notching the first band from 2 to 5 GHz & the second band from 7 to 11 GHz. The proposed antenna has been fabricated on FR4 substrate with di electric constant 4.4 & tested for its reliability on ZNB20 vector network analyzer. The operating bands will come under WLAN, KU band, satellite communication applications. A peak realized gain of 4.3 dB with radiation efficiency 90% is attained at the operating bands of the designed antenna. At notch band significant gain reduction is observed from the current design. The antenna is showing omnidirectional radiation pattern in the pass band & disturbed radiation pattern in the notch band. Antenna is fabricated with dimensions of 40x68x1.6 mm & simulation works are carried with finite element method based HFSS tool.



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## 1. INTRODUCTION

In the recent years, satellite communication has gained prominence in every field of life. It is leading in the scope of communication because of high speed data transmission, wide bandwidth and extremely low power spectral density for various applications [1]-[2]. For even efficient transmission, the existing interference is to be removed. In most cases, antennas use filters to avoid interferences. In spite of being a simple and effective technique, the use of filters increases the complexity and cost of the antenna system. The key components in Ultra-Wide Band (UWB) are band pass and band stop [3]-[4]. Notch band is also referred as band stop filter which rejects specific band of frequencies or it may be called as band rejection filter or band limit filter or T-notch filter. These notch filters are having narrow bandwidth and high dimension less parameter which is Q factor which is not necessary [5]-[6]. For these notch filters, the amount to which unnecessary signals at the notch frequency must be rejected determines the accuracy of the components, but not the Q, which is governed by desired steepness of the notch i.e., the bandwidth around the notch before attenuation becomes small [7]-[8].

In order to design antennas with band-notched functions, several methods have been proposed, including etching L-shaped, C-shaped, H-shaped, U-shaped, E-shaped, T-shaped, and half-circle slots on the radiation patch or on the ground plane. High data rates with a large signal-to-noise ratio in Wireless Local Area Networks (WLAN) s can be achieved by using multiple-input multiple-output (MIMO) antenna systems [9]-[12]. MIMO systems boost data reliability by using multiple radiators at the transmitting and receiving ends. In order to ensure a minimum correlation in a rich scattering environment, the antenna elements must be kept isolated from the radiation of neighboring elements [13]-[14]. The applications of MIMO systems are not limited to narrow band communications, a number of dual-band has been proposed.

In this article a planar monopole MIMO antenna is designed to notch dual band in the UWB region. The proposed antenna is designed & simulated with different iterations on HFSS tool & prototyped the proposed model on FR4 substrate material. The radiating element is in the form of half circled slot monopole with defected ground structure on the other side of the substrate material. The designed iterations are presented in Figure1 & corresponding dimensions are placed in Table1. Antenna1 is having splittering slot on radiating element in larger dimension. Antenna2 is also having similar kind of slot at bottom side of the radiating element which is nearer to feed line. Antenna3 is showing slot on the feed line itself. Antenna4 is showing slot with optimized dimensions on the patch center. The slot dimensions for each case are given in Figure 2. The main advantage of the proposed antenna is the high rejection band level in the notched region.

## 2. MATERIALS AND METHOD

The design of the proposed antenna is carried out in four stages as shown in Figure 1. Initially a semi circular patch with slot in the MIMO configuration is designed. The slot on the antenna is placed at different locations and optimized configuration is fixed with iteration 4. The notch bands and operating bands are selected properly at same frequency in all these iterations. FR4 Substrate material is providing the support for this geometry from lower side. Copper material is used in the design of patch, feed line and the ground plane. A 50 ohms SMA connector is connected to the port to measure the S-parameters and radiation characteristics. Finite Element Method based Electromagnetic tool HFSS is used in the design and simulation of the current work. The methodology for design and verification is provided in the below section.

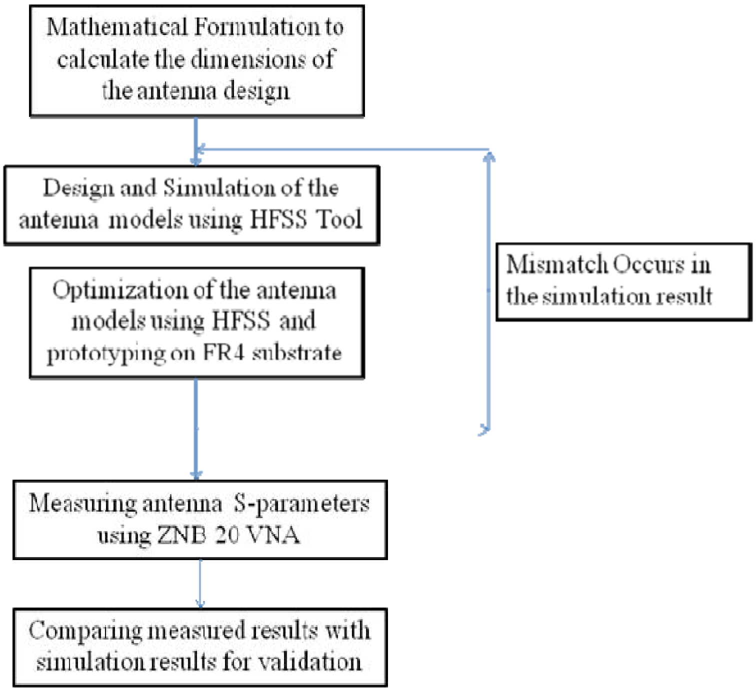
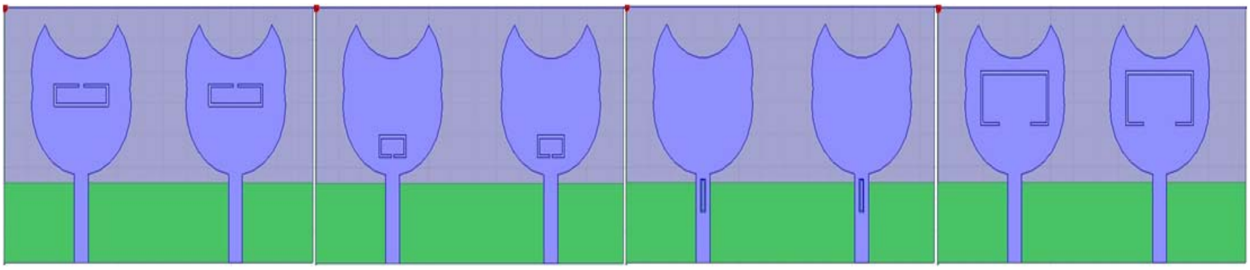



Figure 1. Design and Procedure Methodology

The designed antenna models with iterations are presented in Figure 2. The slot placement for notch band characteristics can be clearly observed from Figure 3.



(a) (b) (c) (d)

Figure 2. Notch Antenna Models, (a) Model 1, (b) Model 2, (c) Model 3, (d) Model 4

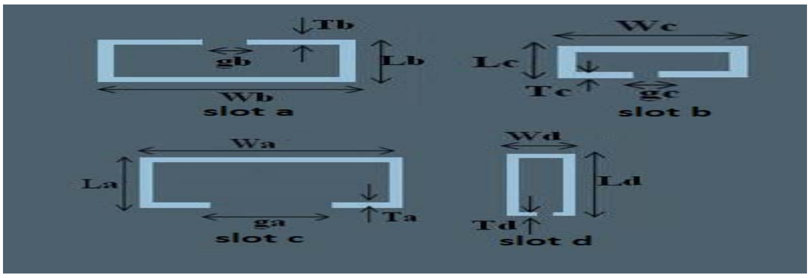



Figure 3. Slot Dimensions on different iterations

## 3. RESULTS AND DISCUSSION

To overall performance of the designed antenna models are analyzed & presented in this section. The reflection coefficient of the designed antenna models are presented in Figure 4. It has been observed that antenna is working in two bands & rejecting other wide bands from 2 to 5 GHz & 7 to 11 GHz. At first fundamental resonant frequency antenna is showing an impedance bandwidth of 33% & at second resonant frequency it is about 16%. Figure 5 shows the S12 characteristics of the four iterations with changing operating frequency. It is been observed that at the operating bands the reflection coefficient is less than -13dB. The VSWR characteristics of four antenna models are shown in Figure 6; a highest rejection of 11dB is attained in the VSWR characteristics of the 3$^{rd}$ iteration model. In the operating bands antenna is showing 2:1 ratio with bandwidth of 2 GHz at fundamental resonant frequency and 1.6 GHz at second resonant frequency. Figure 7 show the impedance characteristics of antenna models with respect to frequency of operation. At 2 resonant modes all the designed models are showing impedance nearer to 40 ohms and in the notch band antennas are showing poor impedance matching characteristics.

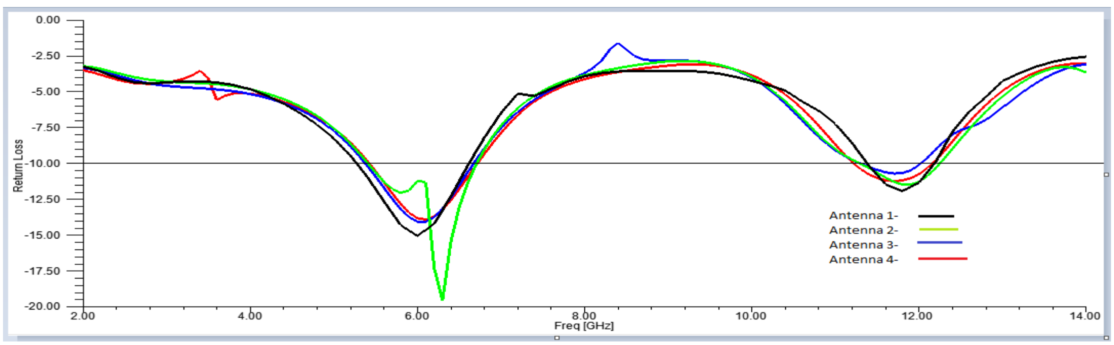



Figure 4. Returnloss of antenna models

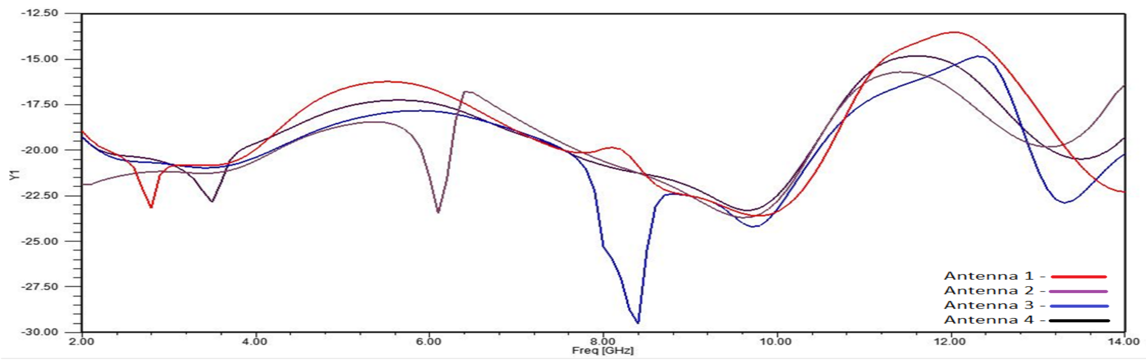



Figure 5. S12 Parameter for antenna models

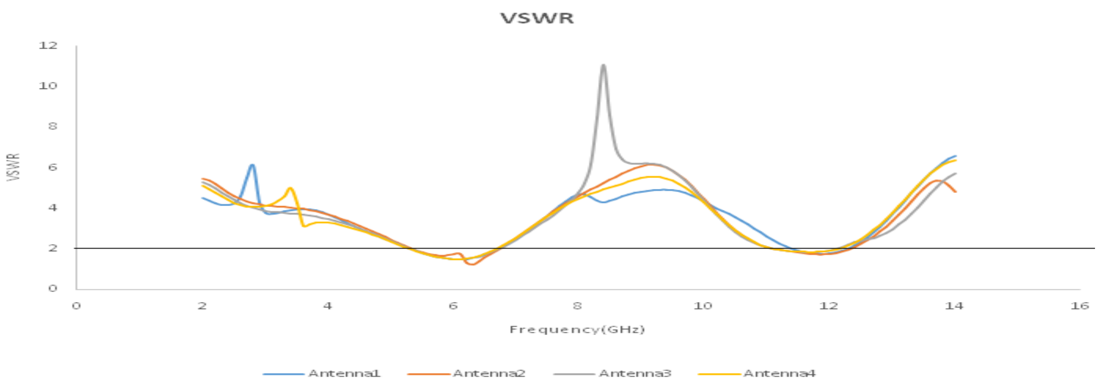



Figure 6. VSWR Vs Frequency

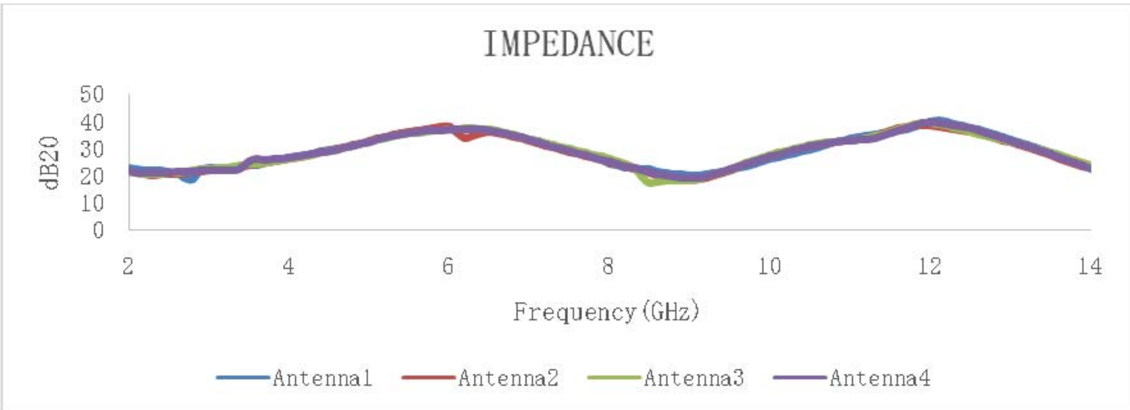



Figure 7. Impedance Vs Frequency

Figure 8 to 15 shows the radiation characteristics of the designed models in pass band & notch band. Antenna1 shows omnidirectional radiation pattern in H plane with low cross polarization at 5.8 GHz. In the notch band the co-polarization level is very less and antenna is giving weak radiation pattern of less than -13dB. Antenna2 is also showing omnidirectional radiation with low cross polarization of -8dB in the notch band the antenna radiation pattern is disturbed in E-plane & showing poor gain characteristics. Antenna3 is showing better radiation characteristics of H-plane at 5.7GHz when compared with earlier iterations. Antenna4 is showing direct to radiation pattern in E-plane & low cross polarization in H-plane.

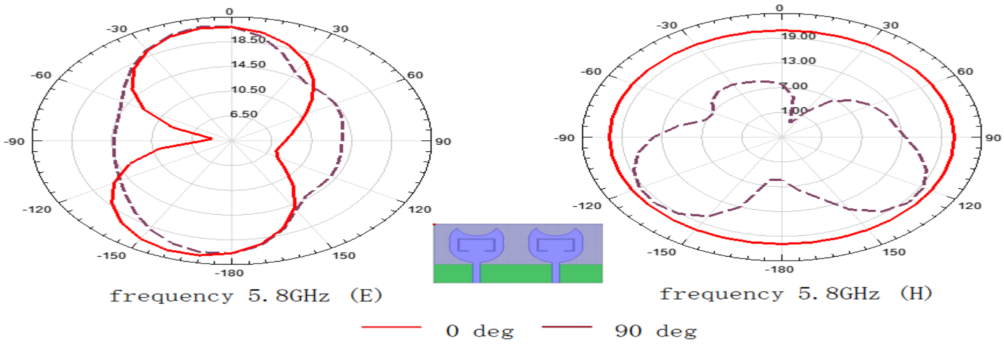



Figure 8. Radiation Pattern of Antenna 1 at 5.8 GHz

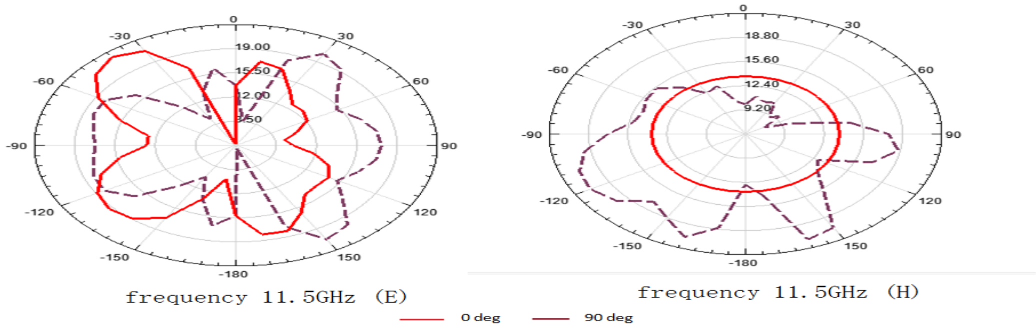



Figure 9. Radiation Pattern of Antenna 1 at 11.5 GHz

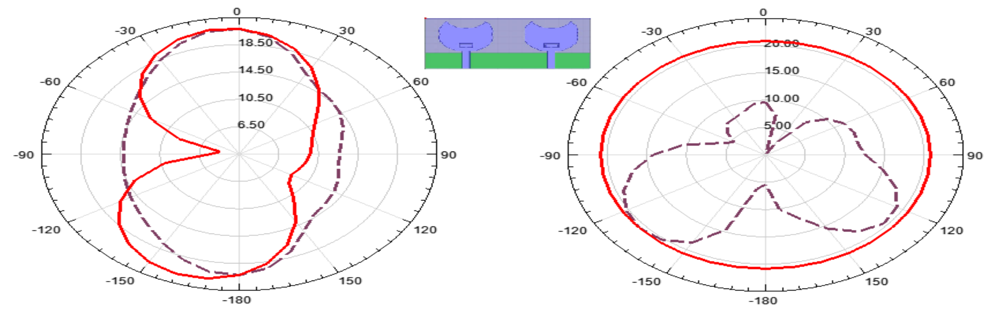


Figure 10. Radiation Pattern of Antenna 2 at 5.9 GHz

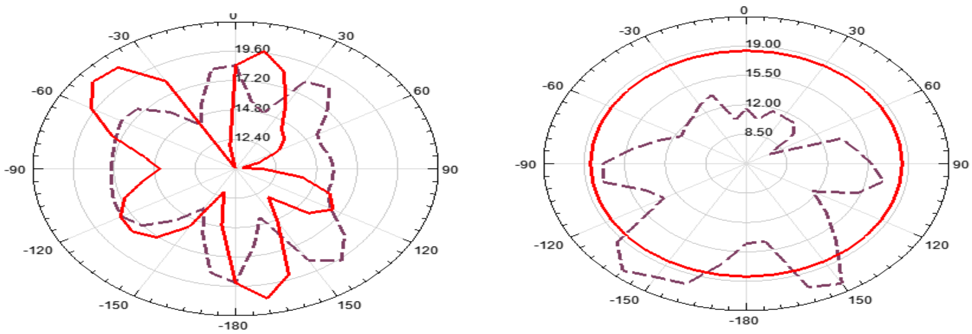


Figure 11. Radiation Pattern of Antenna 2 at 11.8 GHz

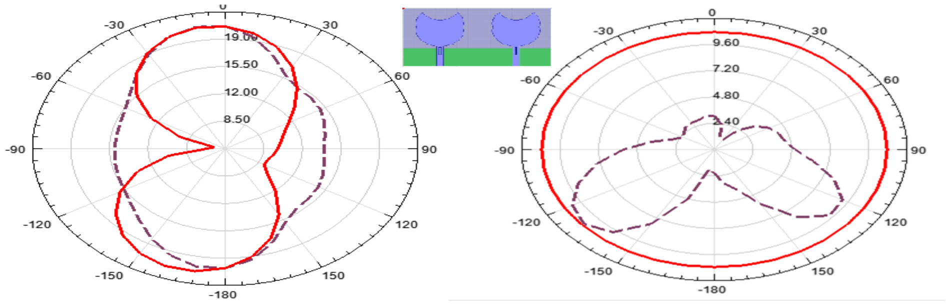



Figure 12. Radiation Pattern of Antenna 3 at 5.7 GHz

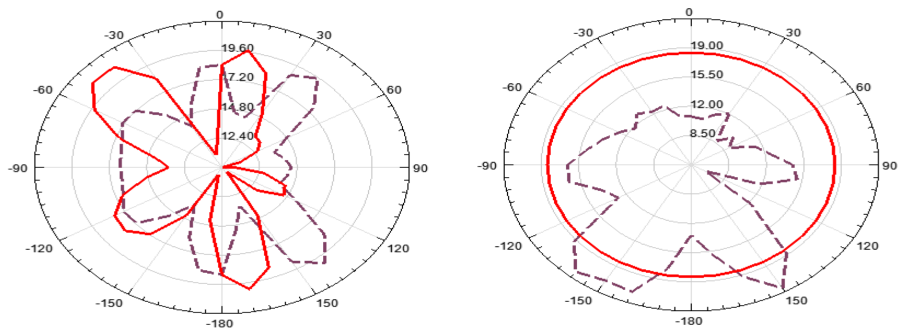



Figure 13. Radiation Pattern of Antenna 3 at 11.6 GHz

The presented results in these figures gives the better understanding regarding the pass band & notch band radiation characteristics.

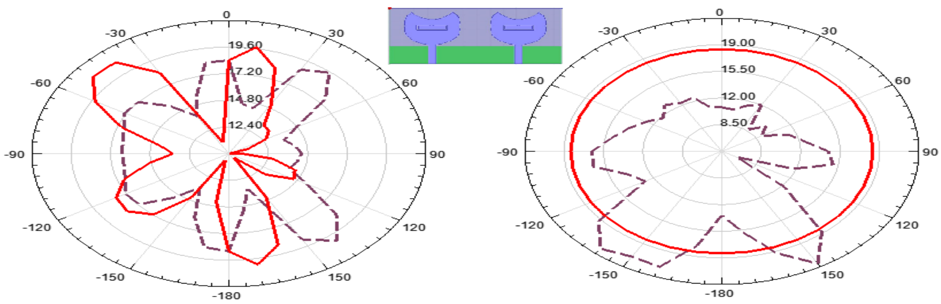



Figure 14. Radiation Pattern of Antenna 4 at 6.2 GHz

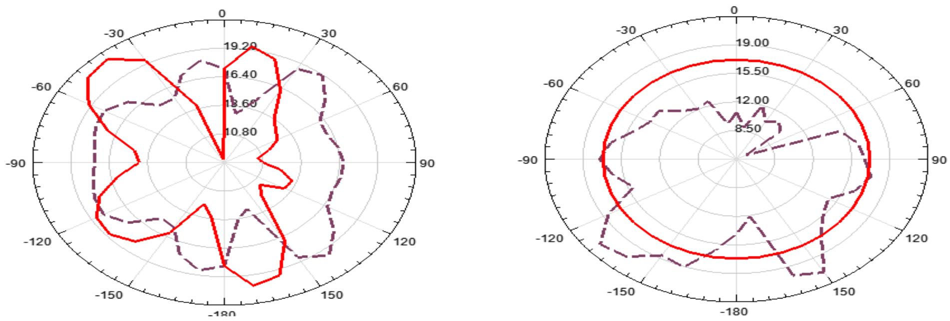



Figure 15. Radiation Pattern of Antenna 4 at 11.5 GHz

Figure 16 to 19 shows the surface current distribution of the designed models at their operating & notch bands. The directions of the currents corresponding to the intensity levels can be clearly analyzed with these figures. At a particular operating band the orientation of current elements in a particular direction will give a clear picture regarding the modes of propagation at that particular band.

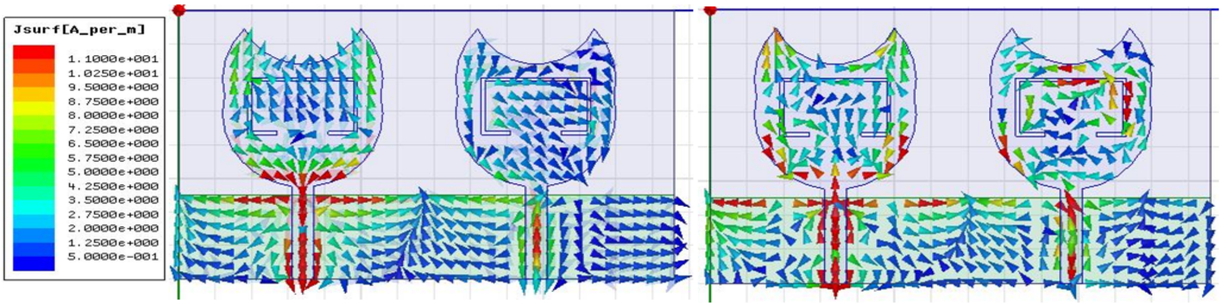



Figure 16. Current distribution on Antenna 1 at 11.5 GHz

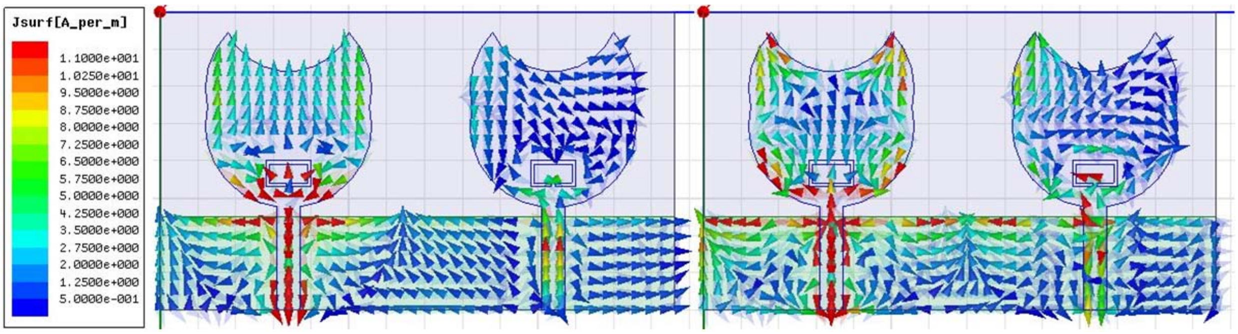



Figure 17. Current distribution on Antenna 2 at 11.8 GHz

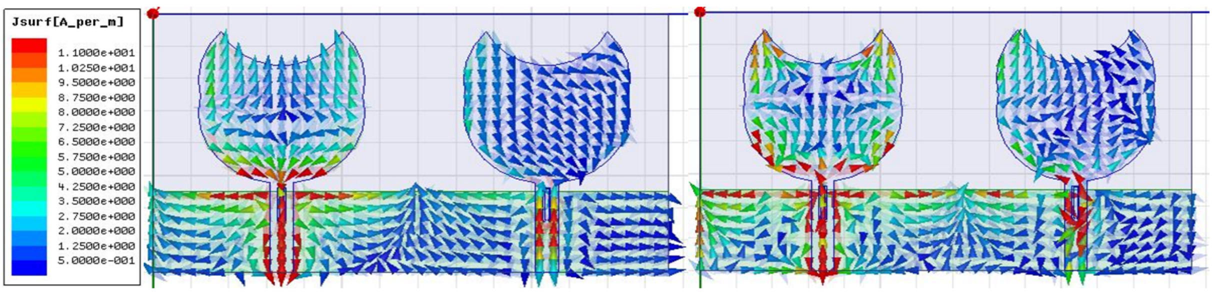



Figure 18. Current distribution on Antenna 3 at 11.6 GHz

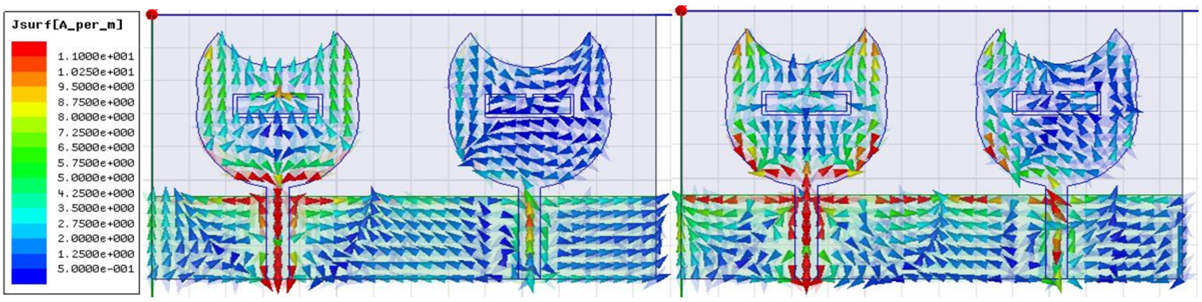



Figure 19. Current distribution on Antenna 4 at 6.2 GHz

Figure 20 shows the gain characteristics of the designed models at their operating bands compared to Antenna models 1 & 2, model 3 & model 4 are showing better gain characteristics at fundamental resonant frequency & at second resonant frequency. Antenna 2 & 4 are showing superior gain characteristics. Efficiency wise also antenna 4 is showing almost 90% efficiency whereas antenna2 is showing poor efficiency of 65% at fundamental resonant frequency. At second resonant frequency all the designed models are showing an average efficiency of 88% in the operating band.

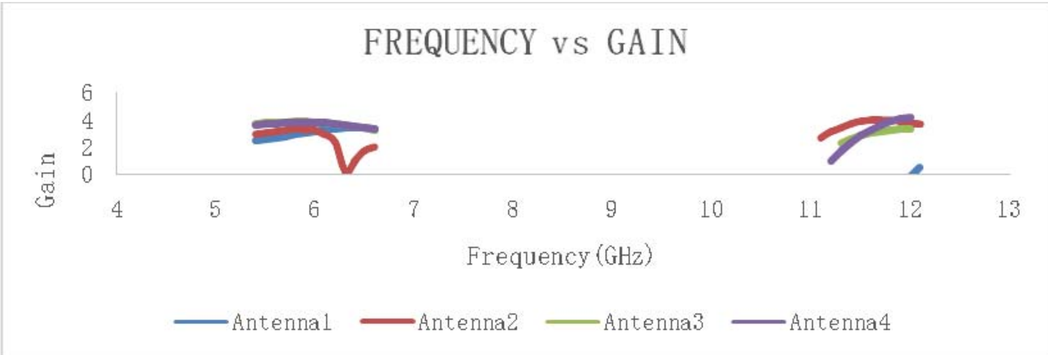



Figure 20. Frequency Vs Gain

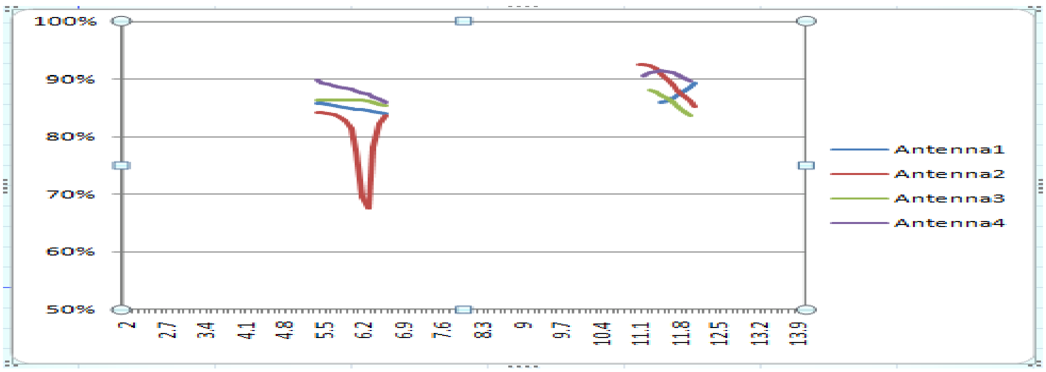



Figure 21. Frequency Vs Efficiency

The frequency vs efficiency plot of Figure 21 gives clear idea regarding the discussed results w.r.t. efficiency of the antenna models. Figure 22 shows the directivity plot of the designed antenna models with operating bands & notched bands basic antenna 1 model is showing poor directivity of less than 1.5dB in the operating bands when compared with other models.

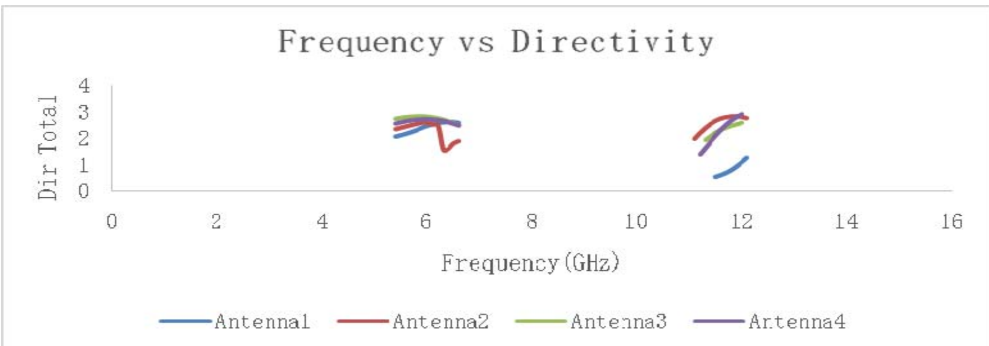



Figure 22. Frequency Vs Directivity

Figure 23 and 24 shows the fabricated antenna model. The proposed antenna model is optimized and prototyped on Fr4 substrate. The real time measurement of the prototyped antenna is taken from ZNB 20 vector network analyzer and presented in Figure 25. The measured results are in good agreement with simulation results of HFSS.

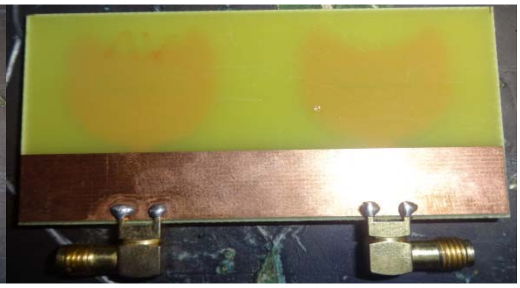


Figure 23. Fabricated Antenna Top View, Figure 24. Fabricated Antenna Bottom View

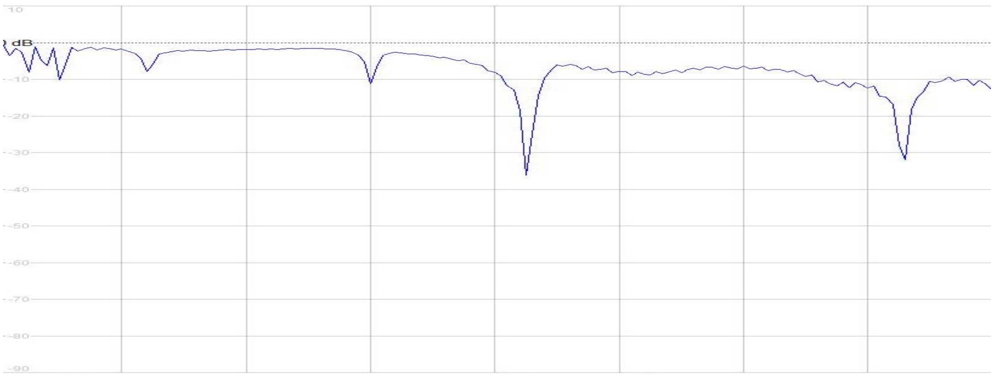


Figure 25. Measured S11 of antenna model on ZNB 20 VNA

## 4. CONCLUSION

A CPW fed dual band notched MIMO antenna is designed and analyzed in this work. The proposed model with MIMO structure is reducing the polarization diversity related issues when placed in the real time environment. The prototyped antenna measurement results on FR4 substrate are providing similar kind of results when compared with simulation of HFSS. The proposed antenna is providing gain of 4 dB and efficiency more than 86% in the operating bands. In the notch bands gain is negative and radiation is very poor. Peak directivity of 3 dB and omni directional radiation in H-plane is attained for the proposed MIMO antenna.

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