INTERNATIONAL JOURNAL OF ADVANCE RESEARCH, IDEAS AND INNOVATIONS IN TECHNOLOGY

ISSN: 2454-132X
Impact Factor: 6.078
(Volume 7, Issue 3 - V7I3-1620)
Available online at: https://www.ijariit.com

The design of ultra-wide band circular monopole antenna with Quad-Band Notch characteristics

Vaka Gayathri
vgayathri4692@gmail.com
Bapatla Women's Engineering College, Bapatla, Andhra Pradesh

Gumma Kalyani
kalyani.gumma422@gmail.com
Bapatla Women's Engineering College, Bapatla, Andhra Pradesh

Thulabandula Venkata Lakshmi Ravali
ravalithulabandula@gmail.com
Bapatla Women's Engineering College, Bapatla, Andhra Pradesh

Nuti Ramya Krishna
ramyasnupi12@gmail.com
Bapatla Women's Engineering College, Bapatla, Andhra Pradesh

Rayapati Ruchitha
rayapatiruchitha@gmail.com
Bapatla Women's Engineering College, Bapatla, Andhra Pradesh

ABSTRACT

A novel microstrip fed Ultra-wide band (UWB) with quad notch characteristics is presented in this paper to avoid the interference of narrow bands. The proposed antenna is having the size of 55x56x1.6 mm^3 falsified on FR4 epoxy substrate. Based on the methodologies, the first notch is created to attenuate the WiMAX (World Interoperability for Microwave Access) of range 2.94-3.7GHz by using T slot. The two rectangular slots are used to reject the INSAT (Indian National Satellite) band of the range 4.5-4.8GHz and of WLAN (Wireless LAN) band of the range 5.1-5.9GHz. These three notch band characteristics are attained by etching the notches on the radiation patch and the fourth notch is created by etching U shaped slot in the feed which attenuates the ITU (International Telecommunication Union) band of the range 7.4-8.7GHz. All simulations are performed using HFSS software. The simulated antenna yields a good impedance bandwidth of 2-11GHz with Return loss (S11) ≤ -10dB, VSWR< 2 and exhibits good radiation properties except at the notch band range. The peak gain of more than 2.2dBi and an efficiency of above 90% is obtained from 2-11GHz excluding at the notched narrow bands.The obtained results depict that the antenna is very well suitable for real-time UWB applications.

Keywords— *UWB antenna, Quad notches, narrow band ranges, Interference, HFSS Software*

1. INTRODUCTION

In recent years, UWB has attained the concentration of many researchers due to the advantages of simple structure, convenient feeding structure, wide bandwidth and its cost effectiveness [1-2]. UWB has many uniquely attractive features such as high data rate, coexistence with existence narrow band systems and low power consumption etc. The federal communication commission (FCC) has prescribed 3.1 to 10.6 GHz range of commercial ultra-wide band communication systems [3]. UWB systems include the narrow frequency bands of 2.94-3.7 GHz (WiMAX band), 5.1-5.9 GHz (WLAN-band), 4.5-4.8 GHz (INSAT band), 7.4-8.7 GHz (ITU band) etc [4], which may generate interference with UWB systems. The interference levels caused by the nearby systems can be suppressed by using RF filtering, using lumped elements, using CPW resonators, using meander lines (MLs), embedding a slit in the feed line, cutting different kinds of slots in the radiation patch and ground plane etc [5]. The UWB antenna with band stop characteristics is a straight forward and effective solution to restrain the interference of signals for UWB communication [6]. Several printed monopole UWB antennas (PMA) have various geometries, but the foremost common shapes of PMAs employed by researches for UWB applications are rectangular, circular, square, triangular, elliptical and hexagonal etc [7-10].

In this paper, we propose a simple circular UWB antenna design [11] with quad band notched characteristics [12-14]. A T-shaped slot on the circular radiation patch notched WiMAX range i.e., (2.8-3.8GHz) frequency range. The two rectangular-shaped slots on the circular radiation patch notched the WLAN (5.13-5.9GHz) and INSAT (4.4-5.0GHz) respectively. A U shaped slot is cut in the feed of the circular patch to generate the fourth notched band in ITU band (7.38-8.9GHz). The equivalent design model, return loss (S11), VSWR, surface current distributions, peak gain, radiation efficiency and antenna radiation patterns at different frequencies are discussed in this paper.

2. ANTENNA DESIGN

2.1. Antenna Geometry

A simple UWB antenna and antenna with notch band characteristics are represented in Fig 1(a). The proposed antenna was printed on FR4 substrate with a thickness of 1.6mm and relative permittivity (ε_γ) of 4.4, dielectric loss tangent (tanδ) of 0.019. The volume occupied by the designed microstrip patch antenna is 55x56x1.6 mm ^{3}. The upper radiating part comprises of a circular patch of radius of 12mm and the resonant frequency 10.6 GHz. The microstrip matching should be 50Ω to be matched perfectly. Here the quad notches which are shown in Fig. 1(b) are introduced to avoid interference between UWB and other wireless services. The quad slots (T-slot, two Rectangular-slots and U-slot) were adjusted by varying their length. By optimising the ground structure and the radiation patch with the notch band characteristics, good results are obtained.

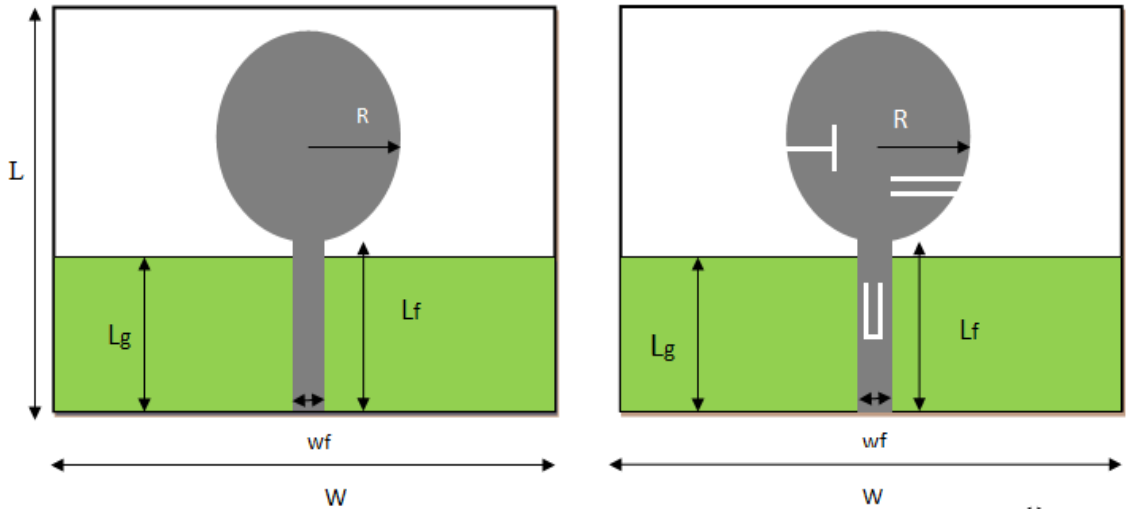
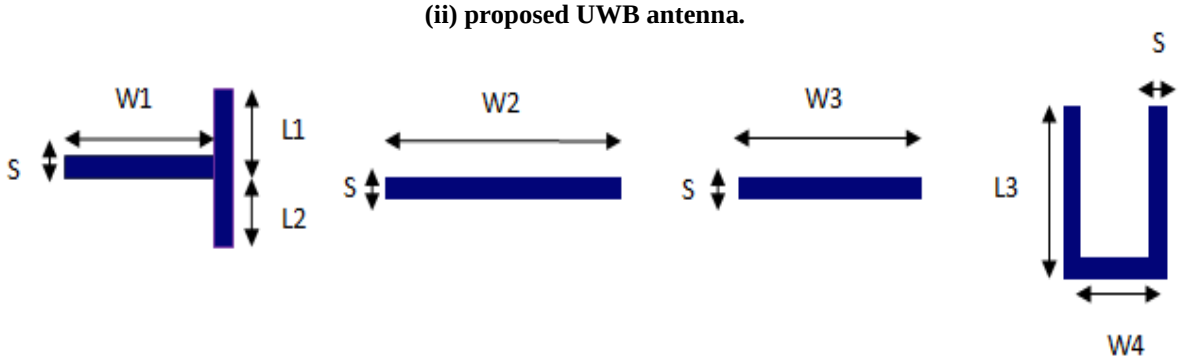


Figure 1(a). Geometry of the UWB antenna (i) conventional UWB circular patch antenna (ii) proposed UWB antenna.



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

Figure 1 (b). (a) T-shaped slot, (b) Upper Rectangular-shaped slot, (c)Lower Rectangular-shaped slot, (d) U-shaped slot

HFSS software is used to simulate the antenna and following are the dimensions presented in the table 1.

Table 1. Proposed UWB antenna dimensions

Parameter	Value (in mm)	Parameter	Value (in mm)
L	55	L_1	3.5
W	56	L_2	2.5
L_f	20.59	W_1	7
W_f	3	W_2	0.3
L_G	20	W_3	8.1
R	12	L_3	5.4
S	0.3	W_4	1.3

2.2. Antenna Evaluation and Working

The evaluation of the quad band notched antenna is depicted in Fig 2.The simple UWB antenna is working in the range of 2-11 GHz. Antenna-1 constitutes of single notch with T shape on the radiating patch which notches the range from (2.94-3.7 GHz) represented in fig-2(a). Antenna-2 constitutes of dual notches i.e., with T and rectangular shaped slots which attenuates the ranges (2.94-3.7GHz) and (4.5-4.8GHz) respectively depicted in fig-2(b).Antenna-3 comprises of triple notches on the radiating patch which notches the narrow band ranges i.e., (2.94-3.7GHz),(4.5-4.8GHz),(5.2-6.1GHz) respectively shown in fig-2(c).The proposed antenna with quad notches is designed by placing the U shaped slot in the feed.The proposed antenna is capable of notching 4 narrow band such as WiMAX(2.94-3.7GHz), INSAT(4.5-4.8 GHz, WLAN(5.2-6.1GHz) and ITU(7.4-8.7GHz) shown in fig.2(d). The simulated return loss parameters (S11) and VSWR are presented in fig 3 and fig4.

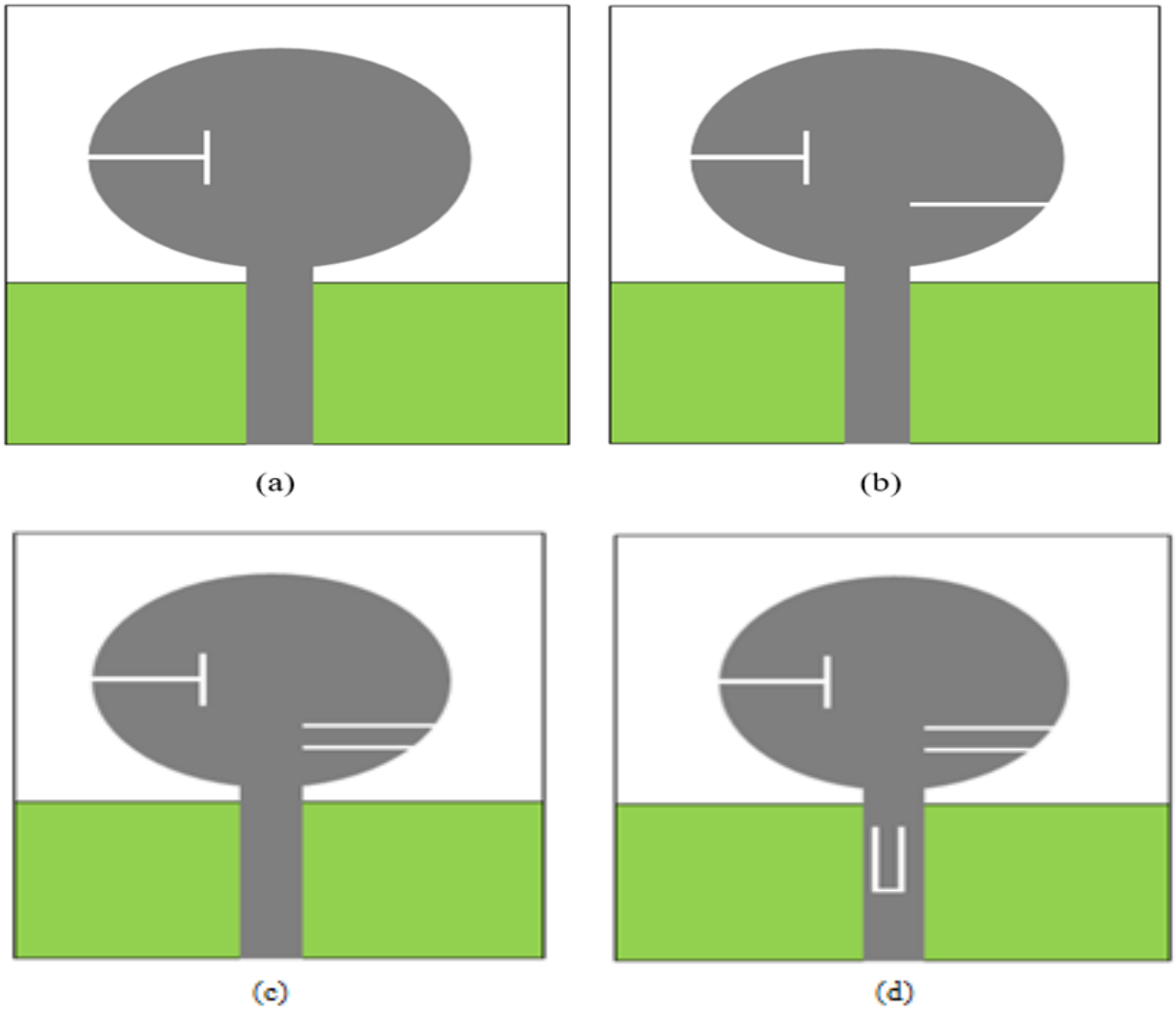


Figure 2. The evolution of antenna design (a)Ant-1 (b) Ant-2 (c) Ant-3 (d)Proposed-Ant

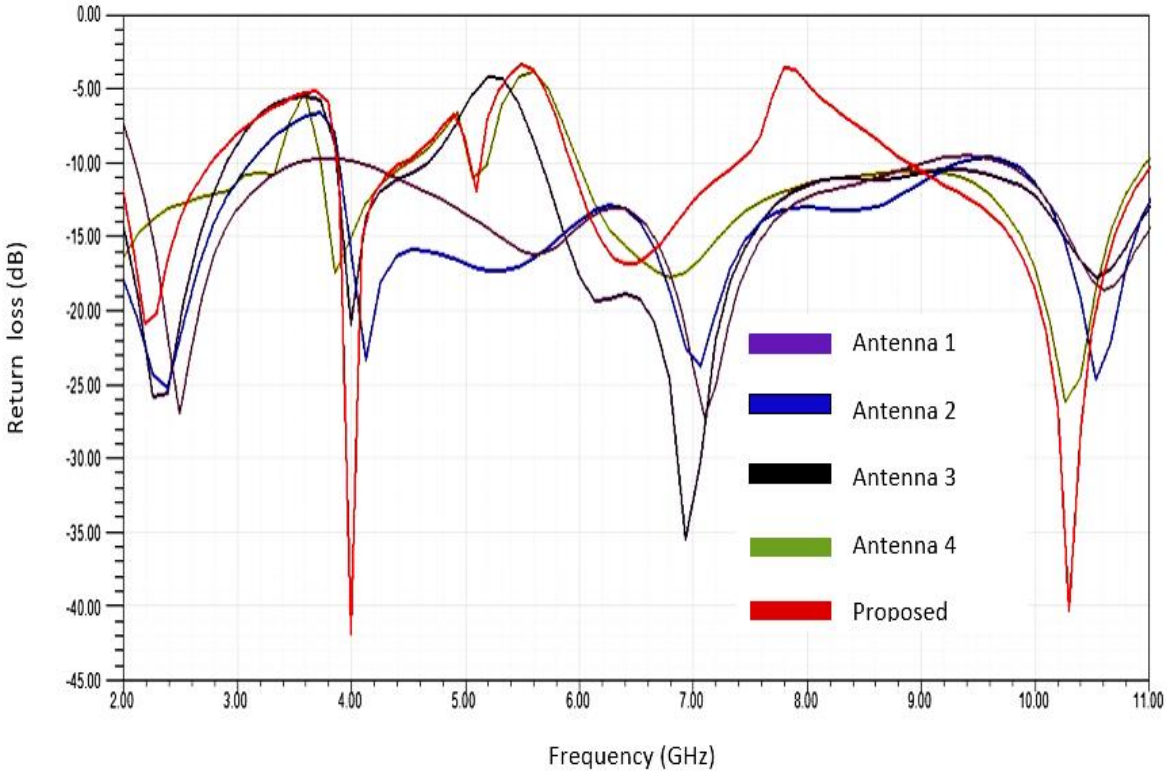


Figure 3. Simulated Return Loss Parameters of Antenna at five Stages

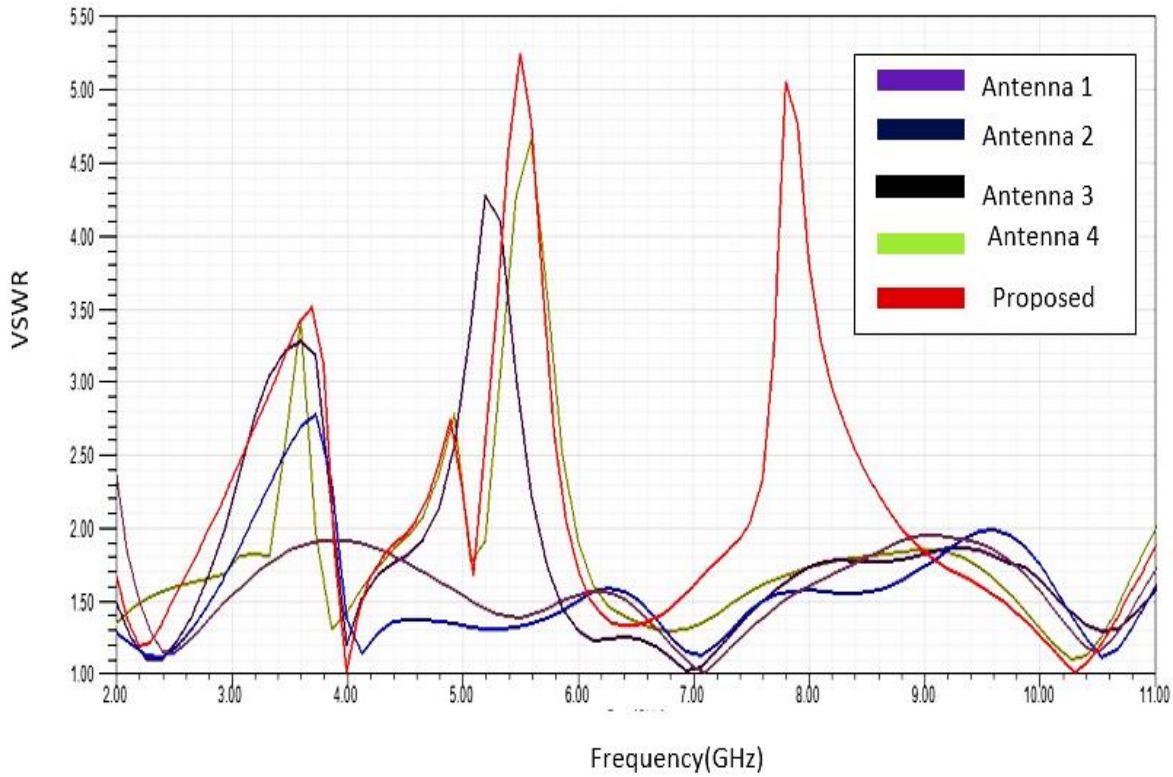


Figure 4. Simulated VSWR Parameters of Antenna at five Stages

2.3 Effects of T-shaped slot, Rectangular and U-shaped slot:

The effects of T, two rectangular and U-shaped slots on the return loss, VSWR etc, of UWB antenna are presented in this section. In this design, notched characteristics are obtained by the T-slot on the left edge of the UWB monopole, upper rectangular slot on the right edge of the monopole, another lower rectangular slot at the edge of the circular radiating patch and U-slot on the microstrip feed line. The notching slots can exhibit different notching charactertics based on different lengths. In this paper, the lengths of the slots at center frequencies are having lengths of $\frac{\lambda}{4}, \frac{\lambda}{4}, \frac{\lambda}{2}, \frac{\lambda}{4}$ respectively, where λ is the guided wavelength expressed in equation (1)

$$\lambda = \frac{c}{f_N\sqrt{(\varepsilon_r+1)/2}} \tag{1}$$

where ε_r *is the* dielectric constant of FR4 substrate

The length of the slots can be determined by using the following two equations (2) & (3)

$$L_{N1} = L_{N2} = L_{N4} = \frac{c}{4f_N\sqrt{(\epsilon_r+1)/2}} \tag{2}$$

$$L_{N3} = \frac{c}{2f_N\sqrt{(\epsilon_r+1)/2}} \tag{3}$$

Where c is the velocity of light

f_N is the center frequency of the narrow band

$$f_N = \frac{f_L+f_u}{2} \tag{4}$$

where

f_L is the lower frequency of narrow band

f_u is the upper frequency of narrow band

$L_{N1}, L_{N2}, L_{N3}, L_{N_4}$ represents the lengths of the slots.By making use of equations (2) & (3), the desired notch lengths can be selected.

With ϵ_r of 4.4 , the calculated total lengths are 13.748 mm at 3.32 GHz, 9.815 mm at 4.65 GHz, 8.078 mm at 5.65 GHz and 11.34 mm at 8.05 GHz. Whereas the total length with which the slots are desinged are 13 mm at 3.7 GHz , 9.009 mm at 4.9 GHz, 8.109 mm at 5.5 GHz and 12.15 mm at 7.8 GHz.

From equations (2) & (3), it is clear that the length of the slot is inversely proportional to its notch frequency, f_N. The notch center frequency increases as the length of the slot decreases and viceversa.

3. RESULTS AND DISCUSSION

The return loss of the proposed antenna is depicted in Fig.5 . The proposed antenna offers good impedance matching from 2 to 11 GHz, with a return loss of ≤ -10dB except at the notched bands.

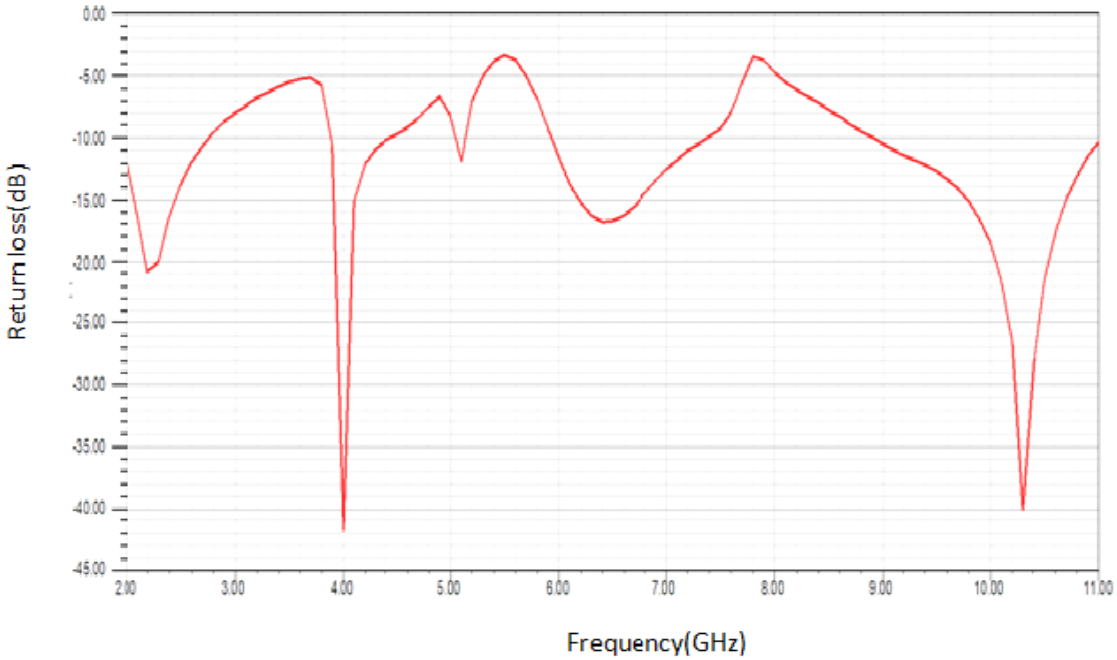


Figure 5.Return loss parameter of the proposed antenna

The following fig 6 represents the surface current distributions at 3.32GHz, 4.65GHz, 5.65GHz, 8.05GHz respectively, and at the resonant frequency of 10.4GHz. These figs i.e 6 (a-d) illustrates that the antenna does not radiate energy near the narrow band notching slots. Hence, the antenna effectively suppresses the frequency interference from the existing narrow band systems. Fig-6(e) i.e., at 10.4 GHz, depicts that the current is flowing along the feed, radiating circular patch and a very small amount of current around the slots. Therefore,the proposed antenna radiates more energy with a good return loss of less than -10dB.

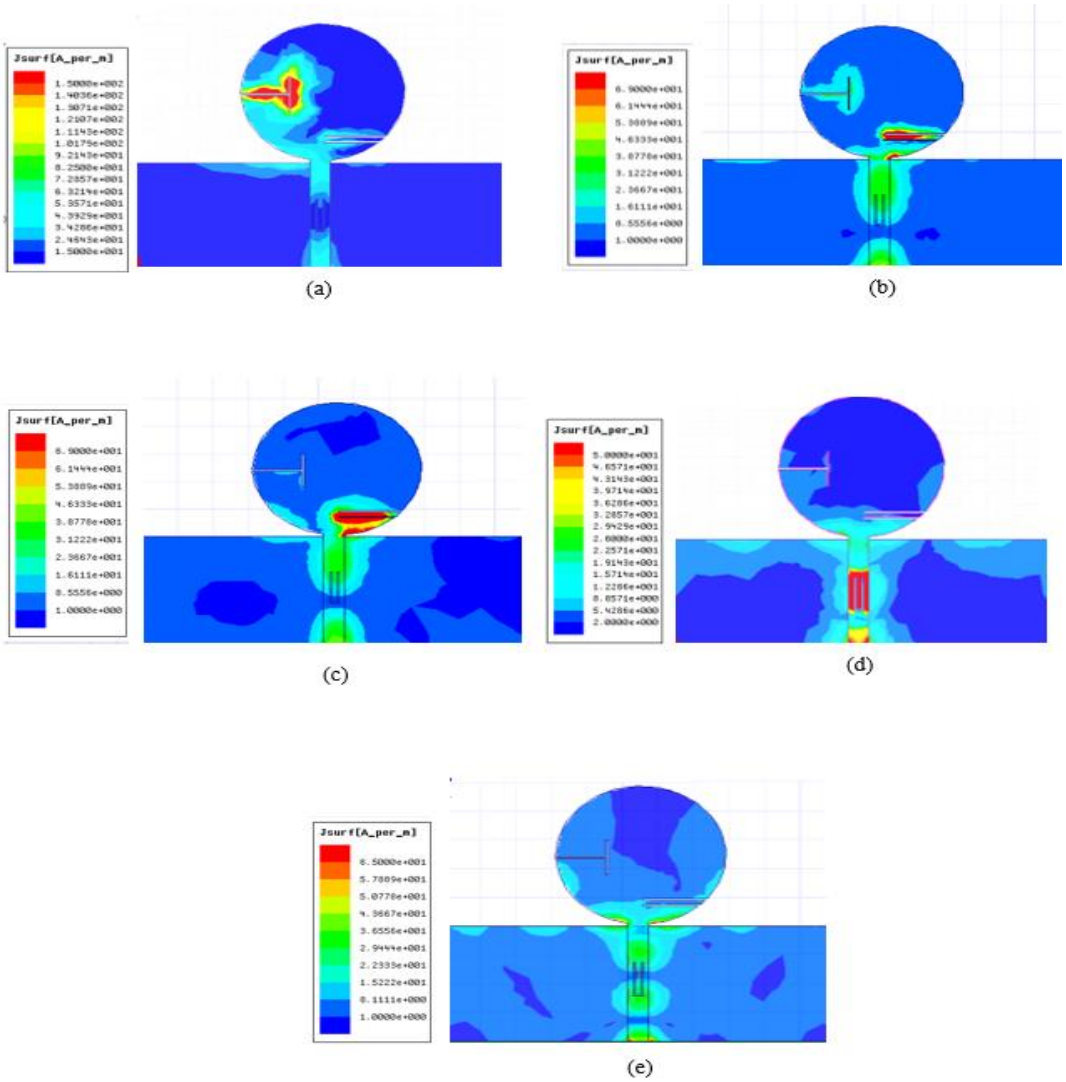


Figure 6 Surface current ditubutions

The 2D radiation patterns of the proposed antenna at 2.2GHz, 4GHz, 5.1GHz, 10.3GHz respectively, are visualized in fig-7(a-d). The antenna achieves nearly the quasi-omni directional pattern on H-plane and bidirectional pattern on the E-plane

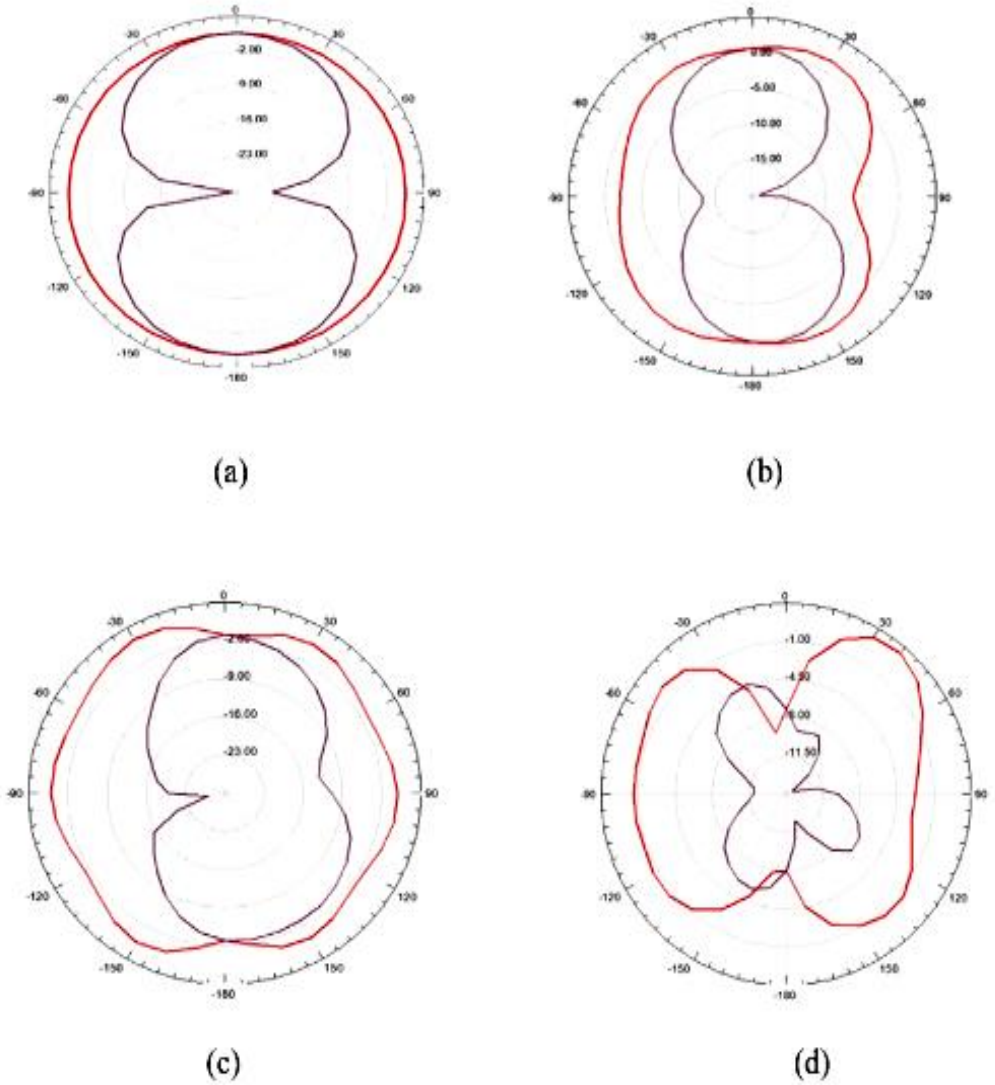
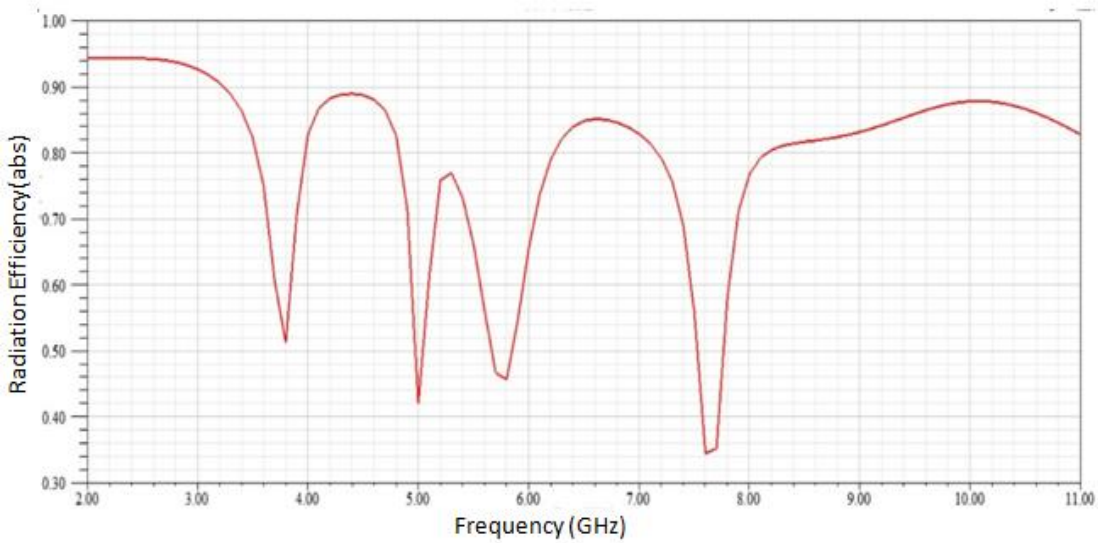


Figure 7. 2-D Radiation pattern (violet colour represents E-plane, Red colour represents H-plane)

The radiation efficiency and peakgain of proposed antenna are shown in the fig 8(a) and (b). For the proposed antenna,the gain of more than 2.2dBi and efficiency of above 90% is obtained from 2 to 11 GHz excluding at the notching narrow bands. The obtained less peakgain and radiation efficiency at the notched bands confirms that the proposed antenna greatly suppresses the interference from the narrow band systems.



(a)

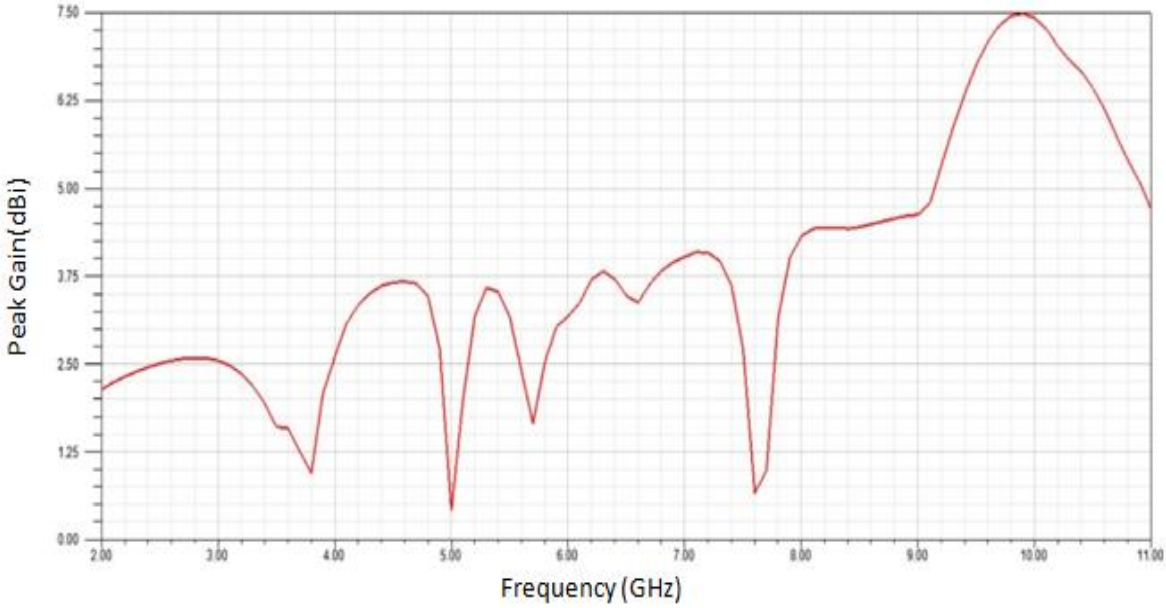


Figure 8.(a)Radiation efficiency(abs) (b) peakGain(dBi)

References

[1]. Introduction to Ultra-wideband Communications, Nekoogar.book, August 2005.

[2]. Introduction to Ultra Wideband for Wireless Communication, Nikookar, homayoun, Prasad. [3]. Design of UWB planar antenna with improved cut-off at the out-of-band frequencies Marek E Bialkowski, Amin M Abbosh IEEE Antennas and wireless propagation letters 7, 408- 410, 2008

[4]. A Compact Ultra Wideband Antenna with Triple Band-Notch Characterstics, A.K Gautham, Binod Kumar Kanaujia, International Journal of Microwave And Wireless Technology 8(07).

[5]. Design of band-notched characteristics for compact UWB monopole antennas., Weng, Yuan fan.

[6]. Dual notch band UWB antenna with improved notch characteristics Amir Sohail, Khurram Saleem Alimgeer, Adnan Iftikhar, Bilal Ijaz, Kang Wook Kim, Wahab Mohyuddin Microwave and Optical Technology

[7]. A. Acampora and M. Krull, "A new approach to peer-to-peer wireless LANs based on ultrawide band technology, "wireless Networks, vol.14, no, 3, pp335-346, (2008).

[8]. K. G. Thomas and M. Srinivasan,'' A Simple ultrawide band planar rectangular printed antenna with band dispersion," IEEE Transactions on Antennas and propagation, vol. 58, no.1, pp.27-34, (2010).

[9]. A.M. Abbosh and M. E. Bialkowski," Design of ultrawide band planar monopole antennas with circular and elliptical shape," IEEE Transactions on Antenna and Propagation, vol. 56, no.1, pp.17-23, (2008).

[10]. R. K. Saraswat and M. Kumar, A frequency band reconfigurable UWB antenna for high gain applications, "Progress in Electromagnetics Research B, vol.64, pp. 29-45, (2015).

[11].2016 International Conference on Control, Instrumentation, Communication and Computational Technologies(ICCICCT). " Design of Circular Patch for Ultra Wide Band Apllications"., M.Karmugil and K.Anusudha.

[12]. The Design of Ultra Wide Band Circular Monopole Antenna With Triple Band Notch Characterstics., " International Journal of Future Generation Communication And Networking Vol. 13, No. 3, (2020), pp. 621-631".

[13]. Compact Monopole Antenna Quadruple Notched Characterstics Planar UWB by Mahendra Mohan Sharma, Jitendra Kumar Deegwal, Ashok Kumar, and Mahesh Chandra Govil.

[14]. FACTA UNIVERSITATIS Series: Electronics and Energetics Vol. 31, No 4, December 2018, pp. 627-639A QUAD-BAND MONOPOLE ANTENNA WITH DEFECTED GROUND PLANE FOR L-BAND/WIMAX/WLAN APPLICATIONS.

BIOGRAPHIES

G. Kalyani
Assistant Professor
Bapatla Women's Engineering College, Bapatla, Andhra Pradesh, India

V. Gayathri
Student,
Bapatla Women's Engineering College, Bapatla, Andhra Pradesh, India

T. Venkata Lakshmi Ravali
Student,
Bapatla Women's Engineering College, Bapatla, Andhra Pradesh, India

N. Ramya Krishna
Student,
Bapatla Women's Engineering College, Bapatla, Andhra Pradesh, India

R. Ruchitha
Student,
Bapatla Women's Engineering College, Bapatla, Andhra Pradesh, India

