Design of a Compact Microstrip Patch Antenna with Dual Notched Characteristics

Sneha Murali, Arjun Mahesh, Rajesh N.

Abstract**: *The paper presents a microstrip patch antenna with dual band-notched characteristics. The proposed antenna is fed by a thin microstrip patch and provides band-notched characteristics by etching 2 symmetric C-shaped notches and one hollow cylindrical arc-shaped notch and notched partial ground. The antenna size was 30x19 mm2, covering a range from 2.8-12.3 GHz. The UWB covers a large band of frequencies including WLAN band (4.75-5 GHz) and the X-Band (7.75-8.35 GHz). To prevent interference with the operation of our antenna and devices operating in these bands, the frequencies are rejected through notches in the antenna. The simulated results show that the VSWR of the antenna is <-10 in the radiating bandwidth. This can be used in wireless applications.***

Keywords: Dual band notch, frequency notch, monopole antenna, UWB antenna

I. INTRODUCTION

Ultra-wideband (UWB) in wireless communication for short range and high bandwidth communications over a large portion of the radio spectrum at the cost of minimal energy level [1]. In 2002, authorization was given for the use of UWB in the range of 3.1-10.6 GHz without any license by the FCC [2]. This has many practical uses like short-distance applications, such as PC peripherals like keyboards and mouse, or precision radar-imaging technology [3]. For these and few other reasons, there is a lot to need for need for designing practical UWB antennas. To be considered for UWB applications, an antenna has to have a compact profile, wideband impedance matching and omnidirectional radiation patterns [4]. Hence, planar microstrip fed monopole antennas can be used. One of the main advantages of microstrip antennas is that they are very compact, and have low weight and volume [5]. It is also ideal to have notched bandwidth so that it does not interfere with any existing electrical systems such as WLAN or X-band systems [6], which are at 5 GHz and 8-12 GHz respectively. The simplest way to implement notched characteristics is to carve a notch into the radiator plate. This paper describes a realizable method to design a compact planar monopole UWB antenna with multiple band-notched characteristics, using two different types of slots.

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* Correspondence Author

Sneha Murali*, School of Electronics Engineering (SENSE), B. Tech, Electronics and Communication Engineering, Vellore Institute of Technology, Vellore, India. Email: abhee.aj@gmail.com

Arjun Mahesh, School of Electronics Engineering (SENSE), B. Tech, Electronics and Communication Engineering, Vellore Institute of Technology, Vellore, India. Email: arjunamahesh99@gmail.com

Dr. Rajesh N., Department of Communication Engineering, School of Electronics Engineering (SENSE), Senior Assistant Professor, Vellore Institute of Technology, Vellore, India. Email: rajesh.natarajan@vit.ac.in

II. ANTENNA DESIGN

The figure below shows the configuration of the proposed band-notched antenna, which consists of a Planar circular slot UWB antenna with a microstrip feedline, with a pair of symmetrical C shaped slots and a cylindrical arc-shaped slot. The antenna is built on an FR-4 substrate with Permittivity 4.4, and loss tangent of 0.2 over the frequency range. The thickness of the substrate is 1.6mm, and total size is 30x19x1.6 mm^3.

To achieve notched characteristics, inner cylindrical arc shaped notch is etched onto the plane circular radiator plate for the lower notch (4.75 GHz-5 GHz, WLAN band) and the outer C-shaped notches are carved for the higher frequency (7.75 GHz-8.35 GHz X-Band).

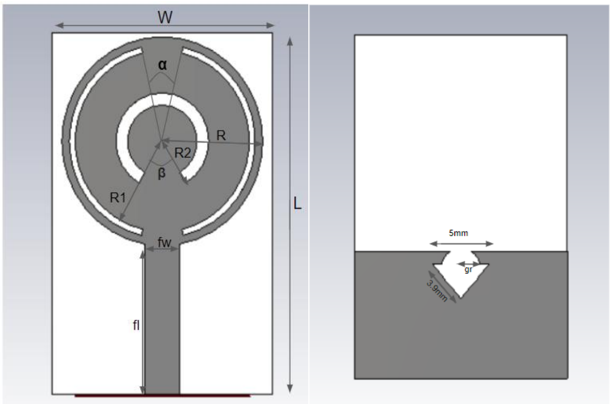

Fig 1. Antenna Design

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One of the proposed frequency notches is in the form of an arc. This arc is defined by the angle **β** and radius R2. The required angle is calculated in such a way that the length of the arc is equal to the result from the formula,

$$f_{notch} = \frac{c}{4L\sqrt{(\varepsilon r+1)/2}} \qquad (1)$$

f_{notch} is the frequency of stopband and c is the speed of light. The circumference of the arc is approximately one-half wavelength at a particular frequency, a destructive interference takes place causing the antenna to be unresponsive at that frequency.

The lower and upper edge frequencies of the stop-band within the bandwidth of the antenna can be controlled by adjusting the parameters of the slot. The second frequency notched in this paper is a set of C-shaped notches carved on either side of the antenna. These notches are defined by the radius of the C shape (cylinder) and the angle of separation between the C shaped arcs (**α**) on either side. The length of each ark is approximately equal to half the wavelength of the particular frequency which corresponds to the notched frequency. The frequency of the slot can be adjusted by changing the parameters. The notch in the ground is added to improve impedance matching of the feed. All the optimized design parameters are depicted in Table I.

Table- I: Antenna Specification

W	L	R	R1	α	R2	β	fw	fl	gr	gr
19	30	8.65	7.75	26	3.5	60	3	12.55	1.75	11.15

III. PARAMETRIC SWEEP

The parameters fw, fl, gr and the distance between ground and radiator plates, are checked at multiple values, and the optimal value is taken.

3.1. Variation of Return Loss with Feed Width

Feed width was varied from 2.5-3.5 millimeters, results are shown in Fig. 2.

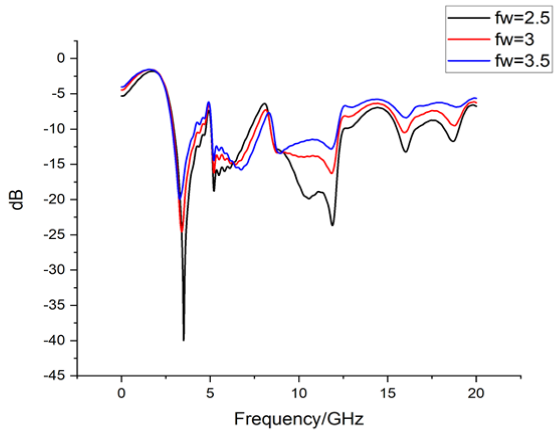

Fig. 2. S11 varying with feed width.

It is seen that as it decreases, resonant frequencies shift to the lower side. The second resonant frequency and third do not change very much, but the first resonant frequency behaviour varies significantly. The change in first resonant frequency improves the antenna bandwidth. Therefore, the impedance matching is better with decreasing size.

3.2. Variation of Return Loss with Feed Length

Feed length has been varied from 11-12.55 millimeters; results are shown in Fig. 3.

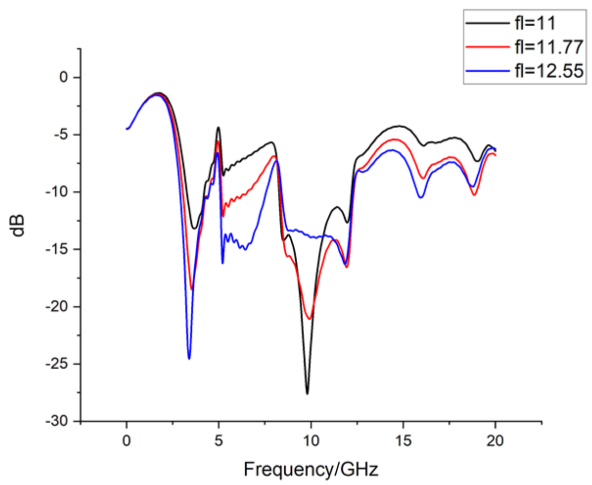

Fig. 3. Variation of S11 with feed length

It is seen that as it decreases, the UWB characteristics get distorted. The second resonant frequency and third do not change very much, but the first resonant frequency behaviour varies significantly. The first length does not give a good antenna bandwidth. Therefore, the impedance matching is better with increasing size.

3.3. Variation of Return Loss with Ground Notch Radius

The radius of the circular notch in the ground is varied from 1.5-2. The results are shown in Fig. 4.

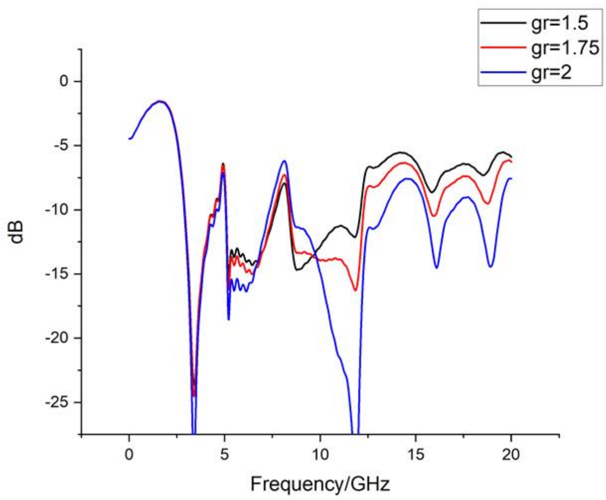

Fig. 4. Variation of S11 with ground radius

It can be seen that as radius decreases, resonant frequencies shift to the upper side. The first few resonant frequencies do not change very much but the last resonant frequency behaviour changes significantly. The impedance matching is therefore seen to be the best with the selected ground radius value.

3.4. Variation of Gap Between Ground and Radiator Plate.

The distance between the edge of the ground plate and the bottom of the radiator plate is varied from 0.7-2.1. The results are shown in Fig. 5.

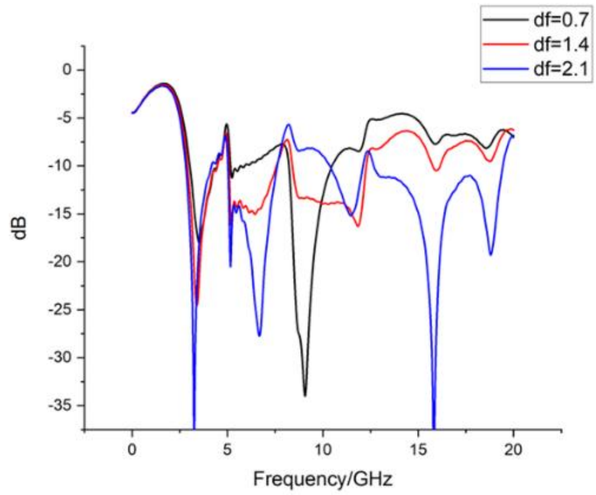

Fig. 5. Variation of S11 with distance between ground and patch

It is seen that as the gap decreases, resonant frequencies shift to the upper side. The first resonant frequency does not radiate very well, but the third resonant frequency behaviour changes significantly. The change in the third resonant frequency improves the antenna bandwidth. Evidently, the impedance matching changes according to the gap between the patch and upper side of the ground plane.

IV. RESULTS AND ANALYSIS

Figure 6 shows the simulated S_{11} Parameter. It is evident that the bands where S_{11}> -10 are 4.75 GHz-5 GHz and 7.75 GHz-8.35 GHz, which covered the two expected notched bands. Therefore, the proposed antenna as designed can reject any interference with WLAN band and Xband communication systems while working in the UWB Band.

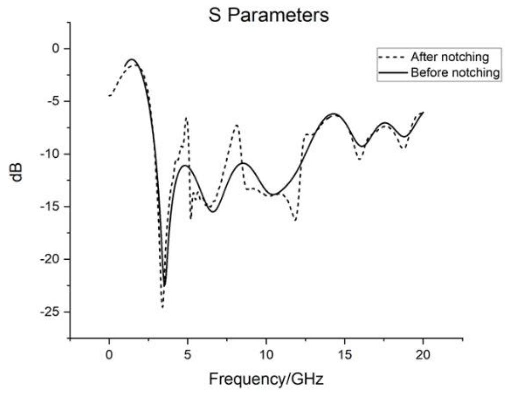

Fig. 6. S_{11} parameters for notched antennas

Fig. 7 and Fig. 8 shows the simulated S_{11} for the antenna with one notch each. From this, we can infer that the 5GHz notch is a result of the inner arc-shaped slot and that the outer C-shaped slots create the 8 GHz notch.

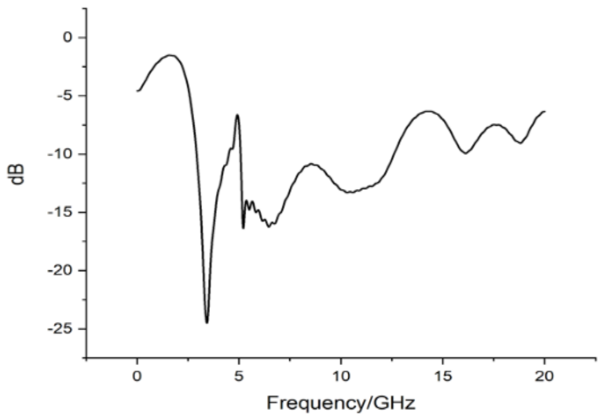

Fig. 7. S_{11} parameters for only inner slot

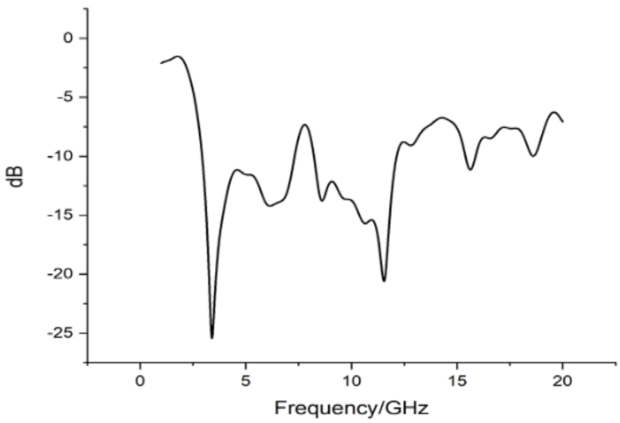

Fig. 8. S_{11} parameters for only outer C-shaped slot

It can be seen from figure 9 that as the first notched band increases in frequency as the angle **β** increases. Similarly, from figure 10 it can be concluded that as **α** increases, the frequency that is notched also increases.

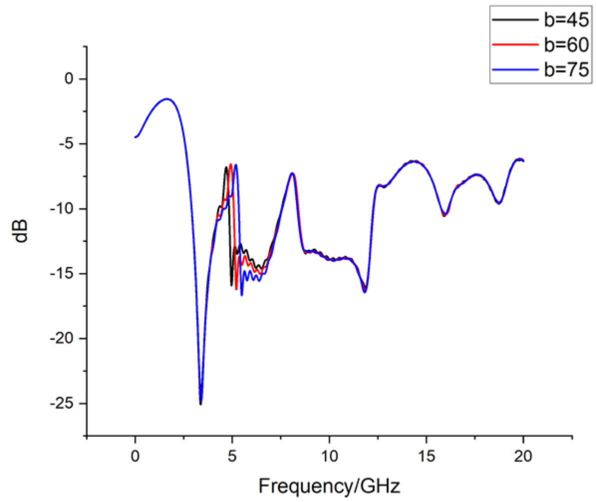

Fig. 9. Variation of S11 with angle used to create inner slot

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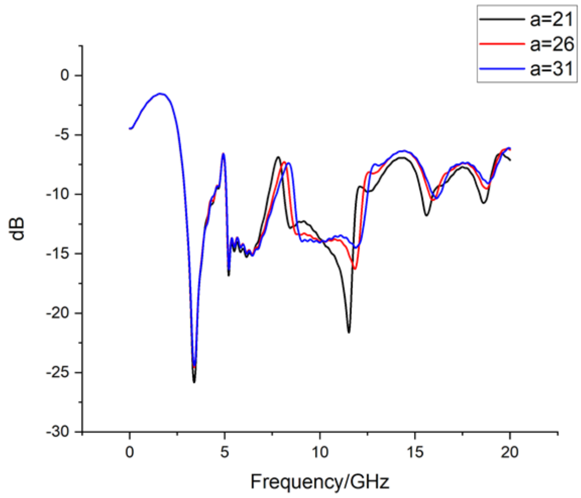

Fig. 10. Variation of S11 with angle used to create outer C shaped slot

Farfield results are plotter at 5 and 8 GHz below in the figure 11 and figure 12.

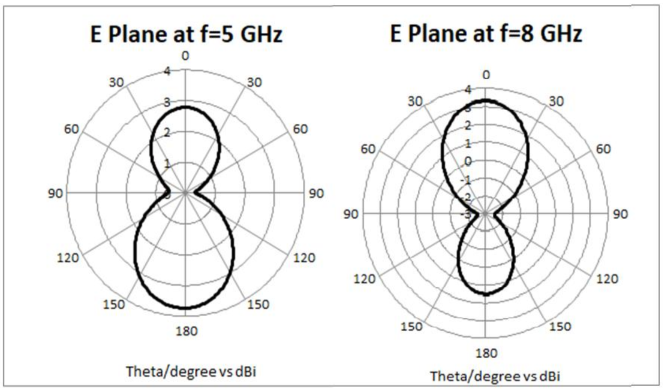

Fig. 11. Farfield results for E plane

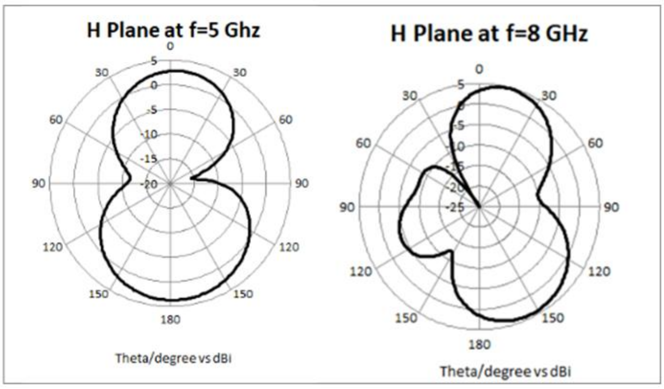

Fig. 12. Farfield results for H plane

The current distribution of the antenna, at 5 and 8 GHz is shown in Fig. 13 and Fig. 14. It can be clearly seen that the inner notch creates stop band at 5 GHz and outer notch creates stop band at 8GHz.

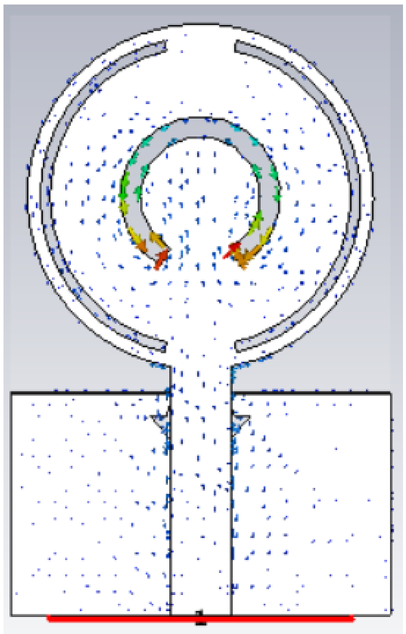

Fig. 13. Current distribution at 5GHz

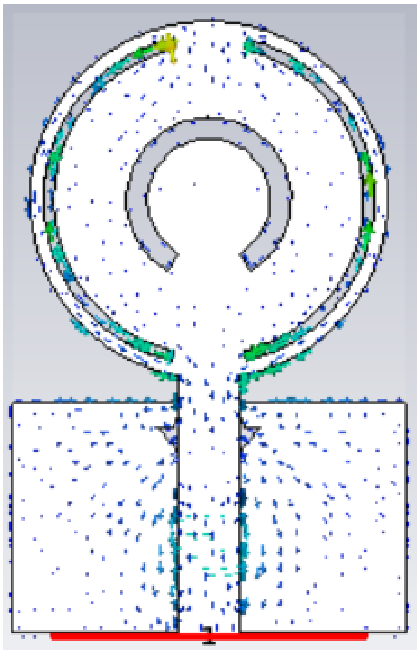

Fig. 14. Current distribution at 8GHz

Table- II: Results

	5GHz (dB)	8GHz (dB)
S11	-6.511	-7.238
VSWR	2.776	2.526
Gain	0.6285	2.0563

V. CONCLUSION

A monopole antenna with dual band-notched characteristics is designed, simulated and found to be operating in the UWB spectrum. Moreover, the proposed antenna can reject dual notched-bands in two frequency bands of WLAN and X-Band by using circular-shaped strips of varying length. Consequently, radiation patterns are nearly Omni-directional. The proposed antenna could be a good candidate of wireless communication systems because of its compact size. The antenna is shown to be much smaller in size than all the other antennas it is compared to, making it more practical for UWB applications.

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AUTHORS PROFILE

Sneha Murali, is currently pursuing her final year Bachelor of Technology in Electronics and Communication Engineering from Vellore Institute of Technology, Vellore, India. An aspiring engineer who is interested in Wireless and Mobile Communication, antennas, Networking and IoT and cloud computing. Email: abhee.aj@gmail.com

Arjun Mahesh is currently pursuing his final year Bachelor of Technology in Electronics and Communication Engineering from Vellore Institute of Technology, Vellore, India. His area of interests are microwave antennas, RFID, machine learning, robotics and M2M communication. Email: arjunamahesh99@gmail.com

Dr Rajesh N., obtained his Bachelor's degree in Electronics & Communications engineering, Master's degree (Communication Systems) and PhD from Anna University, Chennai. He has 2 years of industrial experience and 7 years of teaching experience in reputed private institutions. His research interest includes the design and analysis of UWB antennas, Frequency Selective Surfaces & Planar transmission lines. He has published 13 journal articles in reputed journals and 15 conference publications. Currently he is working as Assistant Professor (Senior) in School of Electronics Engineering, Vellore Institute of Technology, Vellore. Email: rajesh.natarajan@vit.ac.in

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