Novel Ultra-Wide Band (UWB) Antenna with Dual Band Notch Characteristics for Short Distance Wireless Telecommunication Applications

R.Kalyan¹ Dr.K.T.V.Reddy² Dr.K.Padma Priya³

¹Research Scholar,
Department of ECE, JNTUA College of Engineering, JNTUA, Anantapuramu, Andhra Pradesh, India.
r.kalyanreddy@gmail.com

²Director, Pranveer Singh Institute of Technology, Kanpur, Uttar Pradesh, India.

³Professor, Department of ECE, JNTUK College of Engineering, JNTUK, Kakinada, Andhra Pradesh, India.

Abstract

In this paper a novel, simple design, compact size, and low cost ultra-wide band (UWB) circular monopole micro strip patch antenna with dual band notch characteristics is presented. The first notch at WLAN (5.5GHz) frequency is achieved by the Double inverted Balloon shaped slot on the ground plane and the second notch at frequency (9.2GHz) is achieved due to a small slot on the patch. The proposed antenna is designed on FR4 substrate with size in mm. of Length 32, Width 52, and height 1.6. The antenna achieves the operational bandwidth from 3.1GHz to more than 10.6GHz which is...
used to increase the data transfer rate for short distance wireless telecommunication applications.

**Key Words and Phrases:** Ultra-Wide Band, Dual band notch, Double inverted Balloon shape, Circular monopole micro strip patch antenna.

## 1 Introduction

Ultra-Wide Band micro strip antennas are being more interesting, attractive & promising wireless topic since Federal communication commission (FCC) introduced the unlicensed 10-dB band of 7.5 GHz (3.1 – 10.6 GHz) with an -41.5dBm/MHz effective isotropic radiated power spectral density as UWB communications is utilized for short distance wireless telecommunications in 2002 [1]. UWB technology then became more advanced research topic in short distance wireless telecommunication technology having the advantage of simplicity, low spectral power density, less expensive, less power consumption, less interference, and easy installation with an additional advantage of faster data transfer rate as compared to other wireless technologies. Due to this huge demand in the UWB communication system many UWB antennas have been designed time to time. Beyond the advantages the UWB antennas have many practical problems in designing. In designing the antenna practical problems include return loss, impedance matching, radiation characteristics, interference, compact size, less manufacturing cost etc. Electromagnetic interference problems are the serious problems in this communication because of other existing narrow band services that are present in the same UWB frequency bandwidth. In the recent years WLAN (5.5GHz) frequency for many applications, has grown very widely and is existing in the same UWB frequency band. Also if we are using this UWB communication in satellite base stations, satellite frequency (9.2GHz) is also present in the same UWB frequency range. An UWB antenna with band filtering characteristics are required to mitigate the potential interferences. It is very much desirable to design the antennas without external filtering structures to minimize the footprint of the antenna system, and the cost.

Printed circular monopole antenna designed on the substrate with a double inverted balloon shaped slot on the ground plane achieves high
band width for ultra-wide band. Many printed antennas are reported time to time [2]-[5]. Since there are some narrow bands in between this ultra-wide band which create the interference in UWB we need to create band notched characteristics. So many Conventional techniques are already reported to design ultra-wide band antenna with band notched characteristics. There are papers which have been reported like etching of different slots on the radiating patch, the ground plane and on the feed line, using the electromagnetic band gap structures at the feed line, using the resonators in between the patch and the ground plane, by adding the additional filters on the patch, use of resonated cells on the coplanar waveguide, use of tuning stubs, use of folded stubs, meandering of ground plane and embedment of strip lines [6]-[12]. Here we are introducing a novel UWB circular monopole micro strip antenna with dual band notch characteristics which gives a good results in terms of return loss, VSWR, Radiation pattern, directivity and Gain. The paper starts with the designing of UWB antenna and the design is extended to get the first notch and then second notch. The design is carried out by the structural simulator of high frequency structural simulator HFSS of ANSOFT Corporation. The results are validated by using the parametric study. Parametric setup has been carried out for the variation of the both notches. The details of the antenna without notches and with notches is given in the following sections.

2 Antenna Design

In the antenna design first we are investigating the ultra-wide band in first section and in second section we are finding the notches.

A. UWB circular monopole antenna design

In designing of ultra-wide band antenna a slot on the ground plane gives good coupling between the patch and the ground plane. So we have taken a small rectangular slot on the ground plane and for this slot we have added a circular slots to improve the resonance, the coupling increases if we add the circle for the slot as well as the band width is not up to the mark. So we have added another circular shaped slot to increase the resonance. This cutting of slots increase the resonance of the patch and ground plane and increase the band width.
Fig. 1. Geometry of proposed UWB antenna with double inverted balloon shaped slot on the ground plane and a small rectangular slot on the radiating patch with band notch characteristics.

The antenna is having the overall dimensions of length 32mm and width 57mm and height 1.6mm and the substrate used is FR4 epoxy with the tangent 0.02, relative permittivity 4.4. All the dimensions are listed in the table below.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Length in MM</th>
</tr>
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<tbody>
<tr>
<td>L</td>
<td>32</td>
</tr>
<tr>
<td>W</td>
<td>57</td>
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<tr>
<td>L1</td>
<td>7.5</td>
</tr>
<tr>
<td>L2</td>
<td>4</td>
</tr>
<tr>
<td>L3</td>
<td>11</td>
</tr>
<tr>
<td>L4</td>
<td>5</td>
</tr>
<tr>
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<tr>
<td>W1</td>
<td>3.2</td>
</tr>
<tr>
<td>W2</td>
<td>7</td>
</tr>
<tr>
<td>W3</td>
<td>3</td>
</tr>
</tbody>
</table>

Table 1. Variable values of the proposed UWB antenna

The design have been started with the single square slot on the ground plane as shown in figure 2 the return loss for the different lengths is shown in the figure 2 the variation in length is studied with the parametric analysis.

The antenna proposed in figure 2 is having a small rectangular slot on the ground plane which is having the length of S1l of 11mm. the parametric analysis for the different s1l values have been studied here in figure 3.
Fig. 2. Antenna with small rectangular slot on the ground plane

The antenna shown in figure 2 is plotted in the figure 3 the parametric setup is done for s11 for different lengths of y=10mm, y1=11mm, y2=13mm, y4=14mm but the UWB is not achieved.

![Graph showing S11 variation with frequency for different values of s11 with small rectangular slot on the ground plane.](image)

Fig. 3. S11 variation with frequency for different values of s11 with small rectangular slot on the ground plane

To achieve the UWB the antenna should have the good resonance between patch and ground plane and the variation of return loss with S11 is shown in figure 3. There is no any variation in the band width, so we have etched the two circular slots on the ground plane as shown in figure 3.
Fig. 4. Antenna with small rectangular slot attached with two circles on the ground plane

The antenna has the attached circles, if we increase the radius r2 of the slots the antenna return loss variation is shown in the figure 5. The antenna is not giving the exact results for ultra-wide band. Increase in the radius of the circle is giving the result as shown in figure 5. The band width is increased but the resonance is not exactly to get ultra-wide band the variation of r2 for different values of y=1mm, y1=2mm, y2=3mm, y3=4mm is shown in figure 5.

Fig. 5. S11 variation with frequency for the small rectangular slot on the ground plane
To increase the band width another two circular slots is etched on the ground plane and it is named as dual inverted balloon shaped slot on the ground plane as shown in figure 6. The radius of the circles is represented as $r_3$

![Antenna with double inverted balloon shaped slot on the ground plane](image)

**Fig. 6.** Antenna with double inverted balloon shaped slot on the ground plane

The antenna is achieving a good resonance when we are using the double inverted balloon shaped slot on the ground plane. Where as the antenna is also getting a band notched characteristics without any

![S11 variation with frequency](image)

**Fig. 7.** S11 variation with frequency for the inverted balloon shaped slot on the ground plane
external filters and any other slots on the ground plane, this is novel technique where we are achieving the notch as well as the UWB both with this inverted baloon shaped slot. And the variation of different values of r3 in terms of y=6mm, y1=6.2mm, y2=6.4mm, y3=6.6mm, y4=6.8mm, y5=7mm is shown in figure 7. For different values of r3 in terms of y shows that the y5 which is 7mm gives a good result of this antenna to achieve ultra wide band and the notch at WLAN (5.5GHz).

B. UWB circular monopole antenna with band notched characteristics

The band notched characteristics is achieved due to dual inverted balloon shaped slot on the ground plane gives one notch at WLAN (5.5GHz) frequency. And another slot etched on the radiating patch near the feed line to get the notch at satellite frequency (8.7 GHz). And the antenna is shown in the figure 1.

3 Experimental Results

Antenna as shown in the figure 1 gives good UWB and the notched characteristics. Results and discussion is shown in this section

3.1 Return loss (S11) variation with frequency

The variation of the return loss with frequency is shown in the figure 8. Which is representing that the proposed antenna is having the bandwidth from 3.1 to 118GHz which is below -10dB generating the UWB. The notches are also represented in the figure.

![return loss vs frequency](image)

**Fig. 8.** S11 variation with frequency for the proposed ultra-wide band antenna with dual band notched characteristics
3.2 Voltage standing wave ratio (VSWR) variation with frequency

The proposed antenna with variation of VSWR with respect to frequency is shown in the figure 9 which is representing that the antenna has VSWR below 2dB for UWB range excluding the two notched bands.

![VSWR vs Frequency](image)

**Fig. 9.** VSWR variation with frequency for the proposed ultra-wide band antenna with dual band notched characteristics

3.3 Gain of the antenna

The proposed antenna with the variation of the gain with frequency is shown in figure 10. Which shows the gain value is above 0dB over the UWB range and at the two notches the gain is below 0dB which

![Gain vs Frequency](image)

**Fig. 10.** Gain variation with frequency for the proposed ultra-wide band antenna with dual band notched characteristics
represents that the antenna is rejecting the particular frequencies. And the overall gain is approximately 3dB and the peak gain is at 6.6GHz with 6.6dB.

3.4 Impedance

The proposed antenna is given with an impedance of 50 ohm. The figure 11 represent the variation of impedance with frequency, which is having the approximate value over UWB region and the maximum impedance at the notched bands.

![Impedance vs frequency](image)

**Fig. 11.** Impedance vs frequency for the proposed ultra-wide band antenna with dual band notched characteristics

3.5 Radiation pattern of the antenna

![Radiation pattern](image)

**Fig. 12.** Two dimensional radiation pattern of the proposed ultra-wide band antenna with dual band notched characteristics
Fig. 13. Three Dimensional radiation pattern of the proposed ultra-wide band antenna with dual band notched characteristics

3.3 Fields of the antenna

The E and H fields of the proposed antenna is plotted for patch and the ground plane in figure14.

Fig. 14. E-Field overlay of proposed ultra-wide band antenna with dual band notched characteristics

Fig. 15. H-Field overlay of proposed ultra-wide band antenna with dual band notched characteristics
4 Conclusion

A circular monopole ultra-wide band micro strip antenna with double inverted balloon shaped patch on ground plane has been presented. The antenna gives a good bandwidth of 3.1 to 11.8GHz. Which can be used for ultra-wide band applications. A balloon shaped slot is etched on the ground plane to get the good resonance between radiating patch and ground plane. Also the notch is present due to the slot on the ground plane. For another notch there is a small rectangular slot on the patch. So this antenna achieves an ultra-wide band bandwidth and two narrow band rejections. This antenna can be excellent for ultra-wide band applications like satellite base stations, submarines and the high data transfer applications in medical field.

References
