# A Compact UWB Antenna with Single Wide Band-Notch for WLAN Band

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## ABSTRACT
In this paper the design of a novel and compact ultra-wideband(UWB) printed monopole antenna with band notch characteristic of size 24 x 32 $mm^2$ is proposed. This antenna is designed to cover the FCC bandwidth for UWB applications(3.1 -10.6 GHz) and have a band-notch to cover the 5.15-5.825 GHz band. The simulated and measured results show that the proposed antenna achieves a wide bandwidth from 3 to 14 GHz with successful band-notching.

## General Terms
UWB Antennas, Planar antennas et. al.

## Keywords
UWB Antennas, Printed monopole antennas, Band notching, HFSS.

## 1. INTRODUCTION
Ultra-wideband (UWB) has come up as a revolutionary and contemporary wireless technology which has generated a great deal of interest for use in the industry and academia. Ultra- Wideband (UWB) commonly refers to signal or system that either has a large relative bandwidth or a large absolute bandwidth [1]. The rapid progress of UWB as a high data rate wireless communication technology has mainly been spurred on by the release of a bandwidth of 7.5 GHz (from 3.1 GHz to 10.66 GHz) for ultra wideband (UWB) applications by the Federal Communications Commission (FCC), by far the largest spectrum allocation for unlicensed use the FCC has ever granted[2].

As is the case in any conventional wireless communication systems, an antenna plays a very fundamental role in UWB systems but the challenges faced in designing a UWB antenna are many more. A good candidate for UWB applications are printed monopole antennas due to their compactness, light weight and simple structure. Many kinds of UWB antennas have been designed and presented [1, 3, 4, 5, 6, 7]. Interference is a serious problem for UWB application systems. The existing Wireless Local Area Network(WLAN) and IEEE 802.11a systems operating in the frequency band (5.150-5.825 GHz) can cause interference with UWB systems. Therefore a band stop filter is required to reduce interference between the UWB systems and these existing wireless systems. Thus UWB antennas are being designed using frequency rejected function technique to get space efficiency in them.

Here we propose a single wide band-notched compact UWB antenna simulated using the commercial tool Ansoft HFSS. The band-notching is obtained by embedding a U shape slot in the radiating patch. A partial ground plane is used to increase the bandwidth of the antenna. Section two presents the details of the antenna structure and design parameters. Lastly comparison of the results obtained is done followed by the conclusion.

## 2. UWB ANTENNA DESIGN
The geometry of the proposed antenna with a single wide band-notch is shown in Figure 1.It is fabricated on a 24 x 32 $mm^2$ FR4 substrate with a dielectric constant of 4.4 and substrate thickness of 1.6mm.The radiating patch is in the form of a rectangle with a U-slot on it for frequency filtering. Tapered section connects the patch to the feed-line. Tapering is used to improve the matching over the entire bandwidth. A partial ground plane having the length of 11.5 mm is used on the other side of the substrate. It consists of a slot of dimensions 3.5 x1.5 $mm^2$ just behind the transmission line to improve the bandwidth.

The resonant length of a microstrip patch can be obtained by using simple relations of the effective relative dielectric constant as a function of the substrate parameters and the operating frequency as follows[8]

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + 12\frac{h}{W}\right]^{\frac{-1}{2}} \quad (1)$$

$$W = \frac{c}{2f}\sqrt{\frac{2}{\varepsilon_r + 1}} \quad (2)$$

$$L_{eff} = \frac{c}{2f\sqrt{\varepsilon_{reff}}} \quad (3)$$

$$\Delta L = 0.5h \quad (4)$$

$$L = L_{eff} - 2\Delta L \quad (5)$$

where c is the speed of light in free space, L and W are the length and the width of the resonant patch antenna respectively. By simulating different patches with substrate parameters, it is possible to obtain the appropriate values as the patch does not have a ground plane on the other side of the substrate as shown in Figure 1.

To obtain the frequency rejection characteristic a U slot is inserted in the patch as shown in Figure 1.The rejected frequency is assumed to be as

$$f_{notch} = \frac{c}{2L_{slot}\sqrt{\varepsilon_{eff}}} \qquad (6)$$

where $L_{slot}$ is the total length of the slot, $\varepsilon_{eff}$ is the effective dielectric constant, and c is the speed of light. We take the total slot length calculated from (6) into account initially and then adjust the geometry of the design. The prototype of the proposed antenna has been fabricated as shown in Figure 2. The parameters of the proposed antenna are given in Table 1.

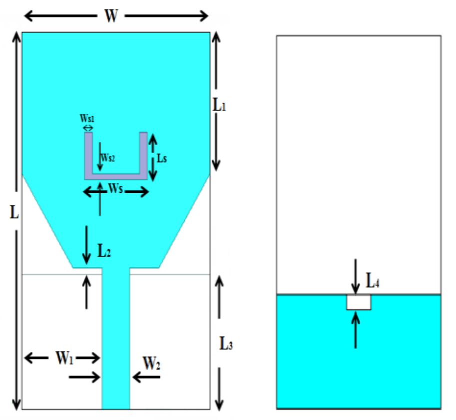



**Figure 1. Geometry of proposed antenna**

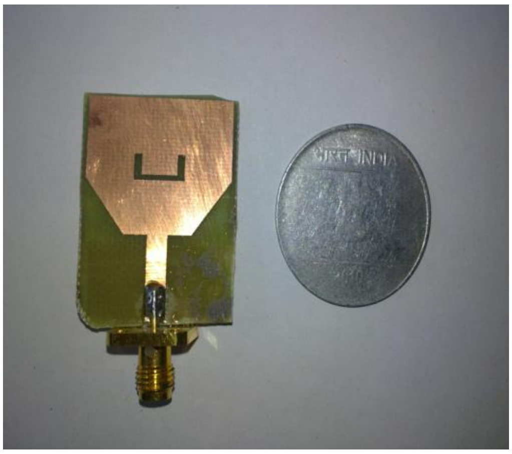


**Figure 2. Snapshot of fabricated antenna**

**Table 1. Detailed Parameters For The Proposed UWB Antenna.**

| Serial no. | Symbols Used | Dimensions(mm) |
|---|---|---|
| 1 | L | 32 |
| 2 | W | 24 |
| 3 | $L_1$ | 18.7 |
| 4 | $L_2$ | 0.5 |
| 5 | $L_3$ | 11.5 |
| 6 | $L_4$ | 1.5 |
| 7 | $W_1$ | 10.25 |
| 8 | $W_2$ | 3.5 |
| 9 | $L_s$ | 3.5 |
| 10 | $W_s$ | 9 |
| 11 | $W_{s1}$ | 1 |
| 12 | $W_{s2}$ | 0.5 |

**RESULTS AND DISCUSSION**

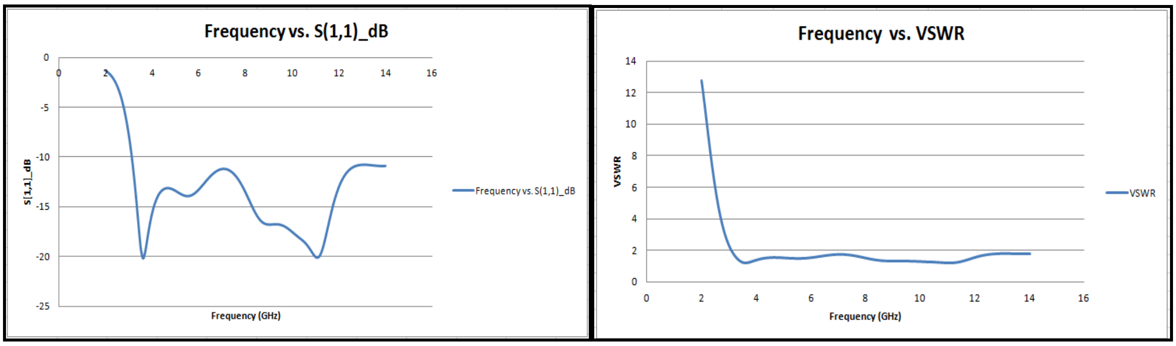
Simulations have been carried out with the Ansoft HFSS to determine the UWB antenna's performance parameters of impedance bandwidth (VSWR< 2) and radiation patterns then compared with the measured results. Parametric study of the band notch parameter Ls (mm) is also done using the commercial software tool HFSS. Table 2. shows the variations of the bandwidth notched or filtered as the slot length ls is varied. The length Ls is taken to be 3.5mm as the bandwidth notched satisfies the frequency range of WLAN band and the band notched is narrower for Ls (3.5mm) as compared to the other slot lengths.

**Table 2. Variation of Bandwidths notched with varying slot length Ls in simulation.**

| Ls (mm) | Bandwidths Notched |
|---|---|
| 3 | 6 - 6.7 GHz |
| 3.1 | 5.7 - 6.4 GHz |
| 3.2 | 5.9 - 6.5 GHz |
| 3.3 | 5.7 - 6.4 GHz |
| 3.4 | 5.8 - 6.3 GHz |
| 3.5 | 5.1 - 5.9 GHz |

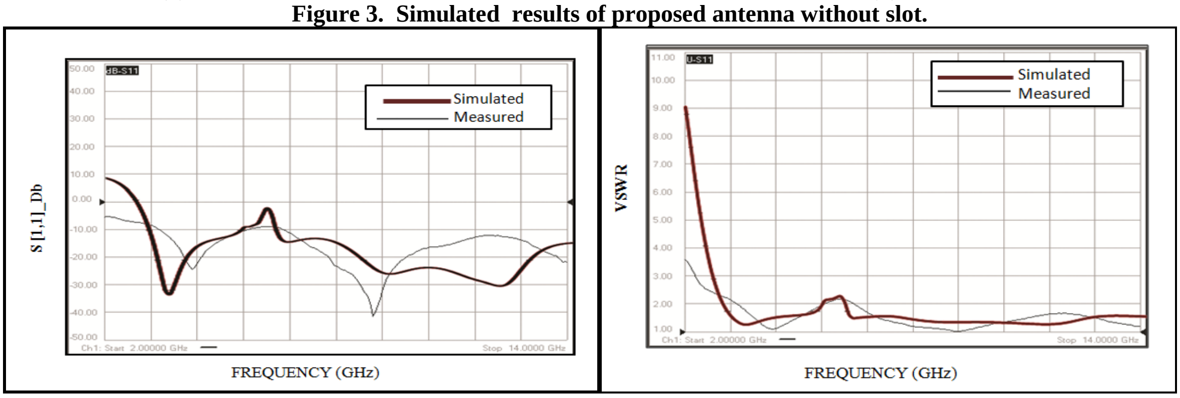
## 2.1 Impedance Bandwidth

The $S_{11}$ curve and the VSWR curve of the proposed antenna without slot is shown in Figure 3(a) & (b). Figure 4 shows the variations of the measured and simulated results for the proposed UWB antenna with the slot. The fabricated antenna achieves a bandwidth of 3.1 to 14 GHz successfully and also a band-notching effect or filtering effect in the frequency range from 5.1 to 6 GHz is obtained. The measurements were done using vector network analyser (VNA, PNA N5230A, Agilent Technologies) in uncontrolled environment.




**(a)Return loss curve** **(b) VSWR curve**

**Figure 3. Simulated results of proposed antenna without slot.**

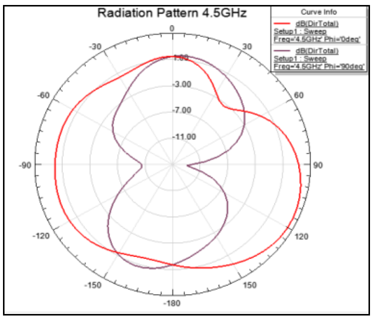



**(a)Return loss curve** **(b) VSWR curve**

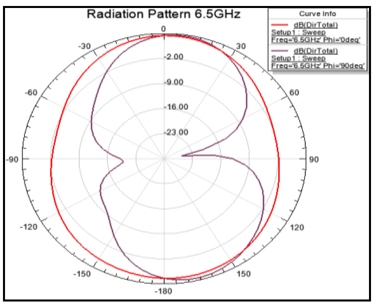
**Figure 4. Comparision of simulated and measured results of proposed antenna.**

## 2.2 Radiation Patterns

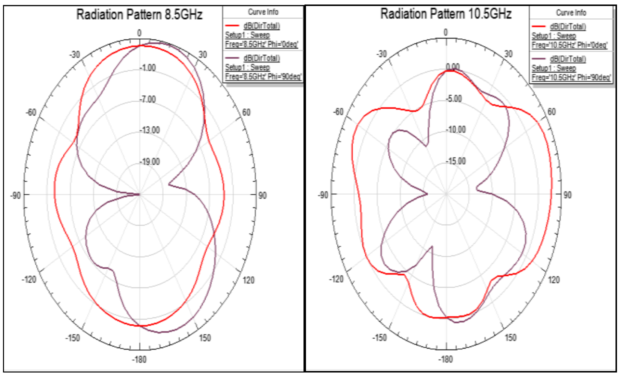
The radiation patterns have been measured using C-band (4-8GHz) and X-band (8-12.4GHz) Microwave benches (Vidyut Yantra Udyog). Figure 5 shows the simulated radiation patterns of the proposed antenna at 4.5, 6.5, 8.5 and 10.5GHz. The measured far field radiation patterns of the proposed antenna at 6.5,8.5,10.5GHz are plotted in Figure 6. It is clearly seen that the radiation patterns of E-plane are monopole like and H-plane radiation patterns show almost omni-directional characteristic.




**(a) At 4.5GHz**

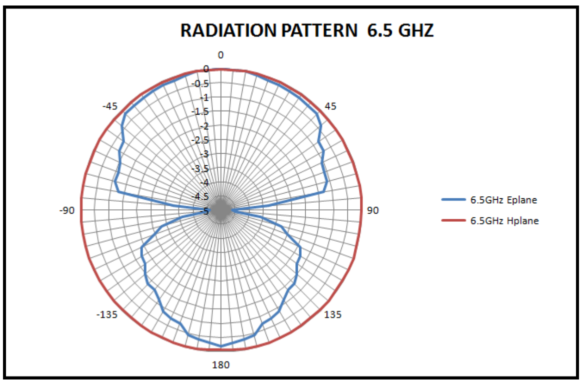



**(b) At 6.5GHz**

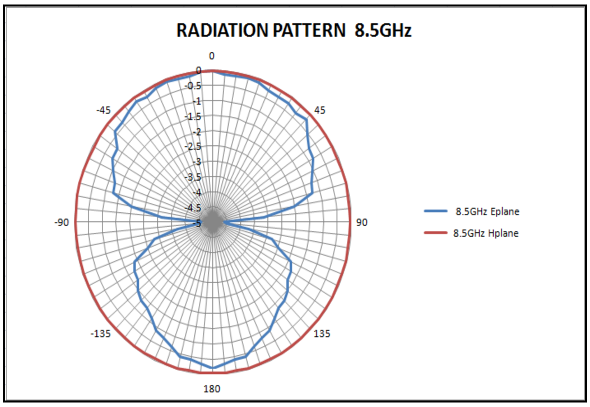



**(c) At 8.5GHz** **(d) At 10.5GHz**

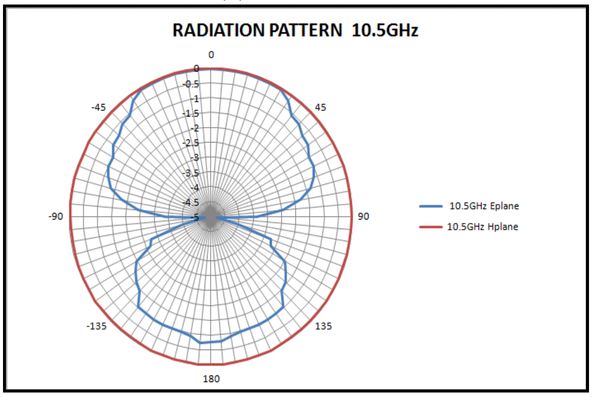
**Figure 5. Simulated Radiation patterns for original dimensions of the proposed UWB antenna (a) at 4.5 GHz (b) at 6.5GHz (c) at 8.5GHz (d) at 10.5GHz.**




**(a) At 6.5GHz**




**(b) At 8.5GHz**




**(c) At 10.5GHz**

**Figure 6. Measured Radiation patterns of the proposed UWB antenna (a) At 6.5GHz (b) At 8.5GHz (c) At 10.5GHz.**

## 3. CONCLUSION

A new single wide band-notched UWB antenna has been designed, simulated, measured and fabricated. The frequency notch function is obtained by adding a U shape slot in the radiating patch. The simulation results obtained by Ansoft HFSS software show good agreement with the measured results. The proposed antenna shows good UWB performance in the range of 3.1 -14 GHz and achieves band notching from 5.1 - 6GHz to avoid interference with WLAN and IEEE 802.11a. Thus this antenna could be good for UWB application.

## 4. ACKNOWLEDGMENTS

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