Effect of Ground Plane on a Tapered U slot Ultra Wideband Antenna

Qurratulain
Department of Electronics and Communication Engineering, Birla Institute of Technology, Mesra, Ranchi-835215, Jharkhand, India.

Neela Chattoraj
Department of Electronics and Communication Engineering, Birla Institute of Technology, Mesra, Ranchi-835215, Jharkhand, India.

ABSTRACT
This paper presents the design and results of a compact tapered U slot UWB printed monopole microstrip antenna. The planar, very small, thin UWB antenna fed by a single 50Ω microstrip line with truncated ground plane is excited by a coaxial SMA connector. The simulation was done using Ansoft High Frequency Structure Simulator (HFSS) software. Extensive investigations and parametric analysis is also carried out on the same radiator design by varying the dimensions of the ground plane and study the effect on UWB performance parameters. The antenna is fabricated and the measured impedance bandwidth defined by VSWR<2 obtained is 10.46GHz(3.54-14GHz) for partial ground plane size and a narrow band is obtained for infinite ground plane size respectively. The simulated results of impedance bandwidth, radiation patterns and group delay are well supported by measurement.

General Terms
UWB Antennas, Planar antennas et. al.

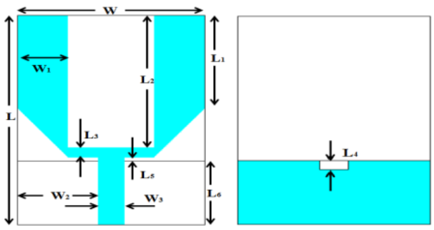
Keywords
UWB Antennas, Printed monopole antennas, Ground plane effect, HFSS.

1. INTRODUCTION
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].

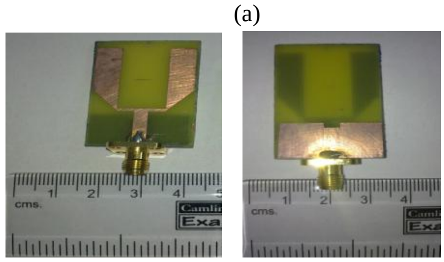
As is the case in any conventional wireless communication systems, an antenna plays a very fundamental role in UWB systems but the challenges faced in designing a UWB antenna are many more. A good candidate for UWB applications are printed monopole antennas due to their compactness, light weight and simple structure. Many kinds of UWB antennas have been designed and presented [1, 3, 4, 5, 6, 7].

In this paper the design of a small and compact tapered U slot printed monopole antenna is proposed in ultra wideband. The proposed antenna has been designed in three steps. First the planar PCB antenna design is introduced and described. Also the various design considerations and dimensions are summarized. The UWB antenna is realized on commercially available low cost substrate glass epoxy and UWB performance parameters like VSWR, radiation patterns and group delay are studied. This is followed by a parametric study done on ground plane using Ansoft HFSS to study the effect of ground plane on the antenna performance. The simulated and measured results are found to be in good agreement.

2. UWB ANTENNA DESIGN
The geometry of the proposed antenna is shown in Fig. 1(a) and the snapshot of fabricated antenna is shown in 1(b). The planar, very small, thin UWB antenna is etched on a 24 x 36 mm^2 Glass epoxy substrate having a relative permittivity of 4.36 (loss tangent of 0.02) and a substrate height of 1.567mm. The antenna fed by a 50Ω microstrip line with truncated ground plane is excited by a coaxial SMA connector. The U slot radiating patch is used to reduce the size of the antenna. It is connected to the transmission line by tapered edges to obtain better impedance matching. It also consists of a slit in the partial ground to improve the bandwidth. Table I shows the dimension parameters of the proposed antenna.



(a)



(b)

Figure 1. Geometry for the proposed antenna (a) Front view & backside view (b) Snapshot of fabricated UWB Antenna.

Table 1. Detailed Parameters For The Proposed UWB Antenna.

Serial no.	Symbols Used	Dimensions(mm)
1	L	36
2	W	24
3	L_1	16
4	L_2	22.7

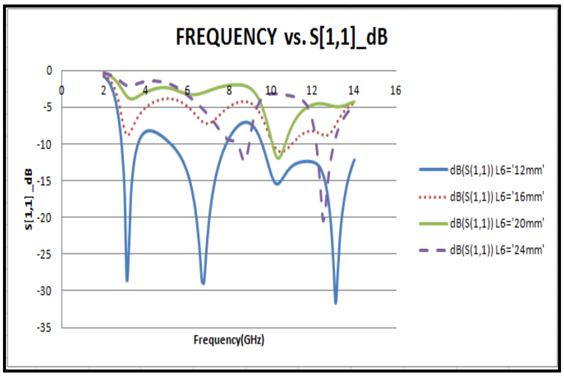
5	L_3	1.3
6	L_4	1.5
7	L_5	0.5
8	L_6	11.5
9	W_1	6.5
10	W_2	10.25
11	W_3	3.5

3. RESULTS AND DISCUSSION

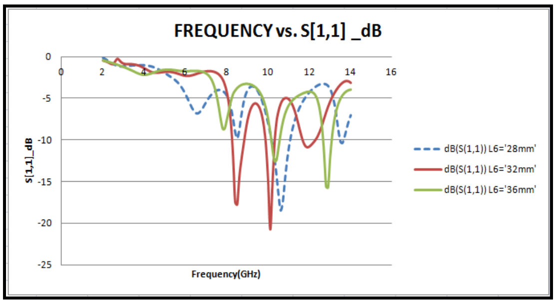
Simulations have been carried out with the Ansoft HFSS to determine the UWB antenna's performance parameters of impedance bandwidth (VSWR< 2), radiation patterns and group delay and then compared with the measured results.

3.1 The effect of the Ground plane size on bandwidth

The ground plane dimensions are very important parameters in the design of the UWB microstrip monopole antennas because the bandwidths depend very strongly on the ground plane sizes. Figure 2 shows the return loss curves for different values of ground plane sizes. The width W of the ground plane is kept constant at 24mm and ground plane length L_6 is varied in steps of 4mm from 12mm to 36mm.Figure 2(a)&(b) show the comparison of the bandwidths obtained with different ground plane sizes with length (L_6) varied. Figure 2(c) shows the measured result of the proposed antenna with infinite ground plane size which in this case is the size of the substrate $24x36mm^2$. It can be seen that the antenna behaves as a narrowband antenna when the ground plane size is the same as substrate size that is $24x36mm^2$ whereas the same antenna design behaves as ultra-wideband antenna when it has a partial ground plane of size $24x11.5mm^2$ as seen in Figure 3.



(a)



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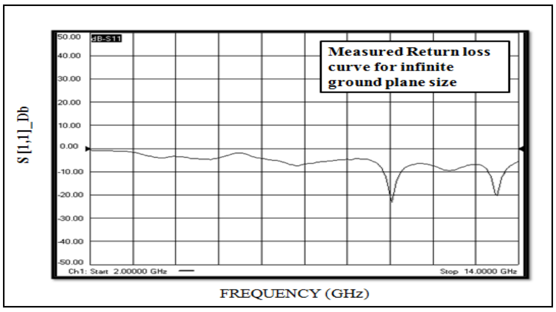


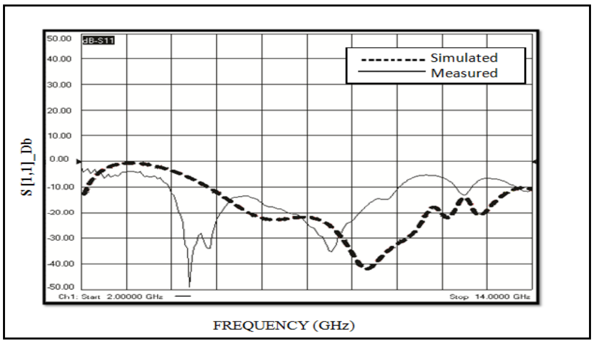
(c)

Figure 2. (a),(b) Comparison of return loss curves for different ground plane sizes (length L_6 varied in steps of 4mm)&(c) Measured return loss curve for infinite ground plane size.

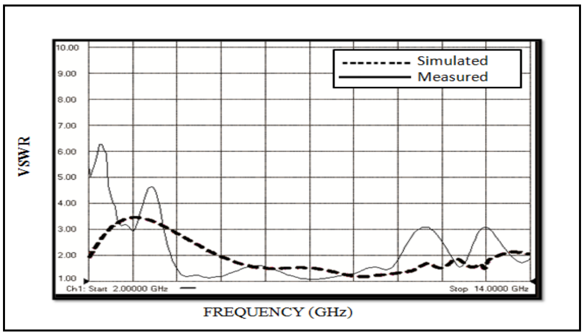
3.2 Impedance Bandwidth and Group Delay

Figure 3. shows the variations of the measured and simulated S_{11} curves and VSWR curves for the proposed UWB antenna. The measurements were done using vector network analyzer (VNA, PNA N5230A, Agilent Technologies) as shown in figure 5. It is observed that the measured result for the proposed antenna has an improved bandwidth (VSWR<2) from 3.54-14GHz in comparison to the simulated result of 4.2 – 14GHz.

The physically constrained antenna is successfully fabricated on the low cost substrate without degrading the performance parameters. Some differences in the simulated and measured results are seen. One of the reasons is that measurement is done in un-controlled environment. Another reason for degradation of antenna performance parameter is that the antenna is fed by a microstrip line, so misalignment occurs because etching is required on both sides of the dielectric substrate.



(a)Return loss curve



(b) VSWR curve

Figure 3. Comparision of simulated and measured results of proposed antenna.

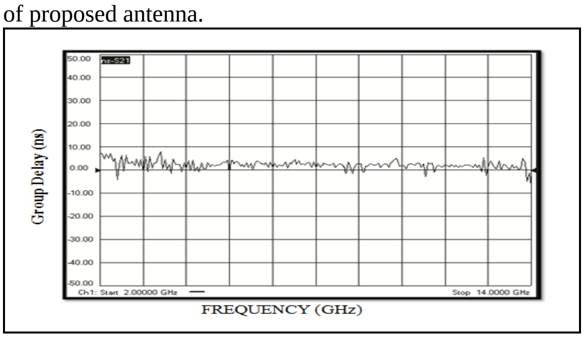
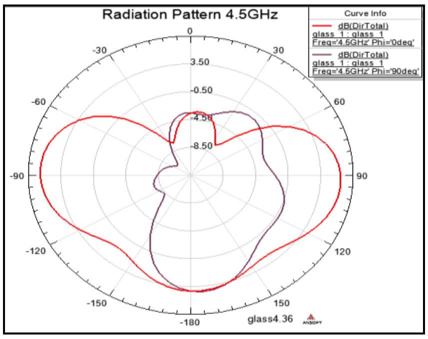


Figure 4.Group delay of the UWB antenna

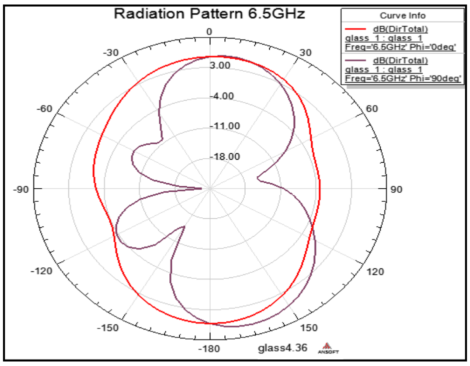
Figure 5. Photograph of the measuring instrument VNA

3.3 Radiation Patterns

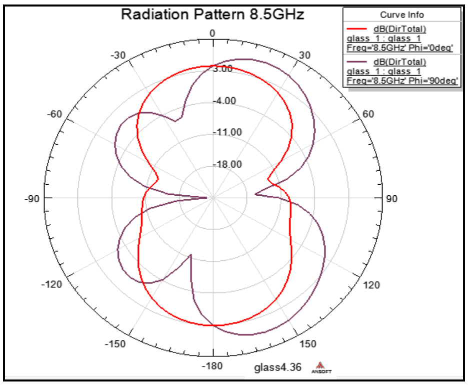
The radiation patterns were measured using C-band (4-8GHz) and X-band (8-12.4GHz) Microwave benches (Vidyut Yantra Udyog). Figure 6 shows the simulated radiation patterns of the proposed antenna at 4.5, 6.5, 8.5 and 10.5GHz.The measured far field radiation patterns of the proposed antenna at 6.5,8.5,10.5GHz are plotted in Figure 7. It is clearly seen that the radiation patterns of E-plane are monopole like and H-plane radiation patterns show almost omni-directional characteristic.



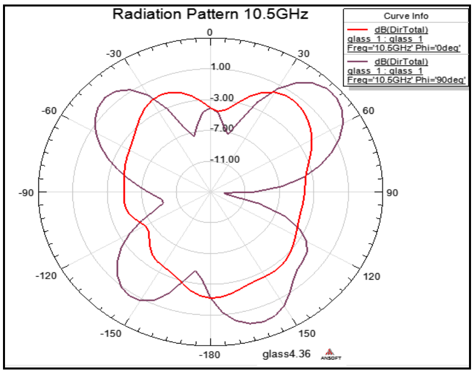
(a) at 4.5GHz



(b) at 6.5GHz

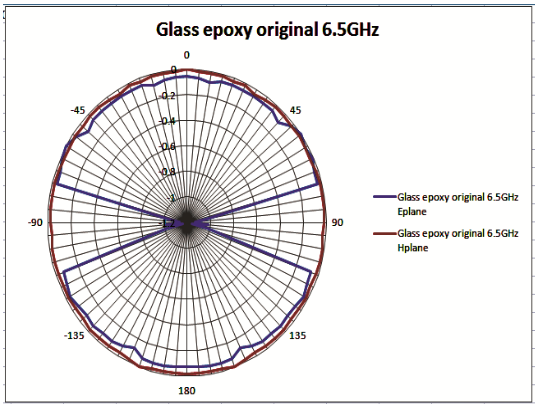


(c) at 8.5GHz

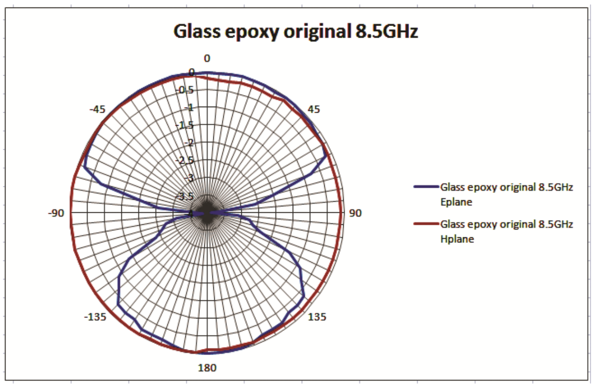


(d) at 10.5GHz

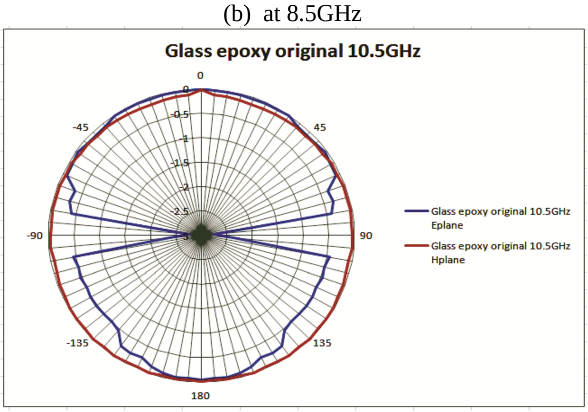
Figure 6. Simulated radiation patterns for UWB antenna with Truncated ground plane size 24x11.5mm^2.



(a) at 6.5GHz



(b) at 8.5GHz



(c) at 10.5GHz

Figure 7. Measured radiation patterns for UWB antenna with Truncated ground plane size 24x11.5mm^2.

4. CONCLUSION

In this paper a new and small U-slot UWB monopole antenna is proposed on glass epoxy substrate. The simulation results obtained by HFSS show good agreement with the measured results. Through parametric study a new and compact antenna is designed, simulated, measured, fabricated successfully on glass epoxy with very large impedance bandwidth satisfying the performance characteristics for ultra wideband applications. Group delay which is a meaningful parameter for UWB applications is investigated and the variations obtained are also good and within the acceptable limit. In addition, the simulated and measured radiation patterns in the H-plane are nearly omni-directional at the three frequencies. Therefore, this antenna is a good candidate for UWB wireless applications.

5. ACKNOWLEDGMENTS

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6. REFERENCES

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