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Planar Cone-shaped Monopole Antenna with Tapered Ground for UWB Application

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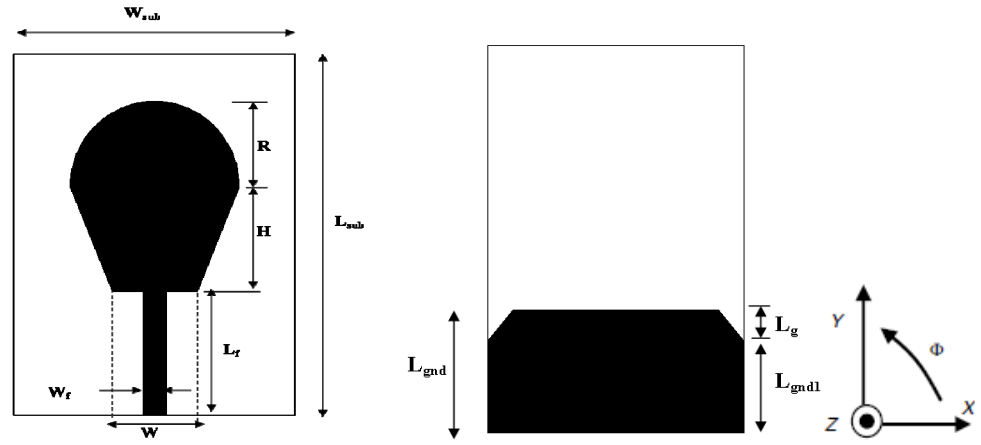
1. Introduction

Compared to the narrow band antenna design, ultra wideband (UWB) antenna design has a lot of challenges. One of such challenge is the requirement that the return loss must be below 10dB bandwidth from 3.1-10.6GHz throughout the UWB frequency range. Other challenges include low cost, small size, light weight and good radiation patterns [1]. One of the characteristic of conventional planar monopole antenna have narrow impedance bandwidth due to their high quality factor [2].

For on-body communications, the UWB antenna design become even more challenging as the design have to include other important on-body antenna requirements. The antenna should be insensitive to the close proximity effects and must have radiation pattern in the intended direction that could minimizes the link loss [3]. Additionally, the Planar Inverted Cone Antenna (PICA) designs have been investigated to further enhance the UWB wireless communication applications. The PICA original design approach was proposed by Suh [4]. Later, several researchers have developed different variations of the PICA [5, 6]. One of the PICA antenna designed is printed slot planar inverted cone antenna proposed in [7] which has good return loss results for the UWB frequency band and the antenna size was $60x60mm^2$. However, some of the notable disadvantages of such variations include large physical size and protruding part which makes it unsuitable for applications in portable communications and on-body communication [7]. Thus, in this paper a planar cone-shaped monopole antenna with tapered ground plane for UWB application has been investigated. The proposed antenna is low profile, compact and small in size with improved performance. The antenna can be used in wireless communication and on-body communications. The results of return loss and radiation pattern are presented in the paper.

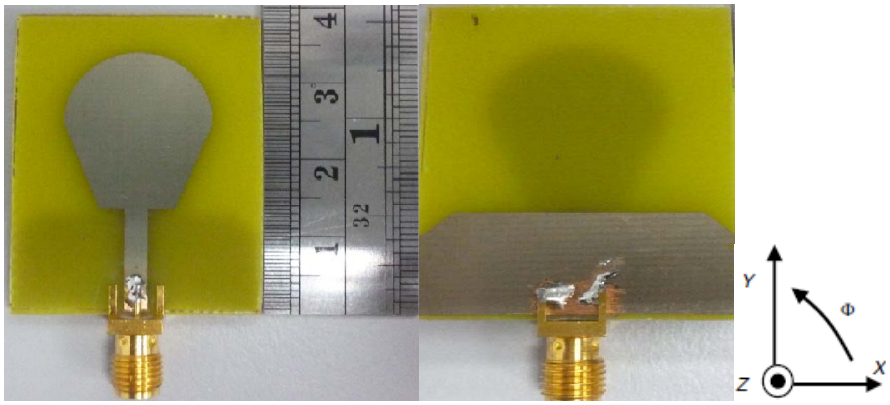
2. Antenna Design

The planar cone-shaped monopole antenna is printed on FR4 substrate of thickness 1.6mm, permittivity 4.4 and loss tangent 0.019. The overall dimension is $30x38mm^2$. The geometry and the parameters of the proposed antenna are shown in Fig. 1.The antenna comprises of a semi-circular shape patch radiating element of radius R and is connected to a trapezoidal shape patch. The patch has base width, W and upper width equal to the radius of the semi circular patch. The two shapes are connected through the micro strip, fed with width, W_f and is fixed to 2.5mm. Partial ground plane of width W_{sub} and length, L_{gnd} is placed at the back of the substrate, and is separated by radiating elements of gap, g. The ground plane is tapered in order to enhance the impedance bandwidth. The impendence bandwidth was improved by chamfering the ground plane 4mm at an angle of 45^o. The antenna is fed by microstrip line and simulated using CST Microwave studio. The parameters of the final design are shown in Table 1. The fabricated antenna is shown in Fig. 2.



(a) (b)

Figure 1: Geometry of the Proposed Antenna (a) front view (b) back view



(a) (b)

Figure 2: Prototype of the Proposed Antenna: (a) front view and (b) back view

Table 1: Optimal Antenna Parameters (Millimeter)

Notation	L_{gnd}	L_{gnd1}	L_g	L_f	L_{sub}	W	W_f	W_{sub}	R	g	H
Value	11	8	3	12	38	12	2.5	30	9	1	11

3. Result and Discussion

Fig. 3 shows the effect of varying base width, W of the radiating element of the proposed antenna using simulation. The value of W was varied from 6mm to 12mm. The smaller the value of the base width, the narrower the impedance bandwidth and vice versa. It has been observed that the proposed antenna is dependent on the base width W and radius R of the semi-circular disc of the proposed antenna. The results show that the antenna's base width is an important parameter in determining the impedance matching of the proposed antenna. The parametric studies yield the value $W = 9mm$ as the optimal value of the base width of the proposed cone-shaped monopole antenna which gives better performance in terms of return loss, radiation pattern and gain.

Fig. 4 shows the simulated and measured return loss results of the planar cone-shaped monopole antenna. The simulation result of the designed antenna shows good performance which provides the bandwidth of approximately 150% (2.75 to 20GHz) at return loss of 10dB. The measurement result gives the bandwidth of 139.6% (2.4GHz to 13.5GHz) with variation in some of the frequencies due to bad performance of FR4 substrate at higher frequencies. At return loss of

6dB the measurement results are good for the bandwidth of 144.8% (2.4GHz to 15GHz). The measurement result satisfies the UWB antenna requirements and therefore a great improvement as the antenna is low profile, compact and small in size. The measured and simulated return losses are in good agreement, with slight variation in some of the frequency bands. Nevertheless, the measured and simulated results follow the similar shape.

Fig. 5 and Fig. 6 show the simulated and measured radiation pattern of E- and H-planes respectively at 2.45GHz and 5.8GHz. It can be seen that the radiation pattern is close to omnidirectional.

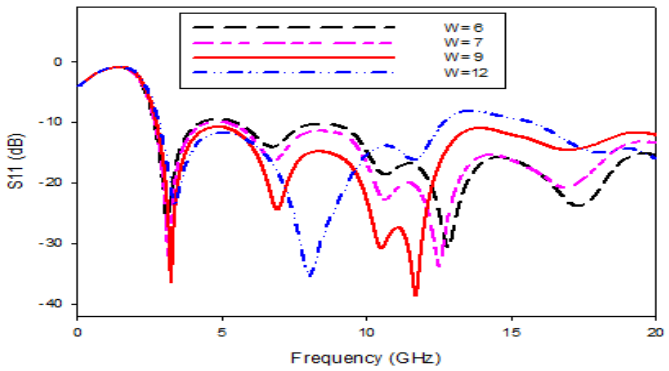


Figure 3: Simulated Return Loss of the Proposed Antenna with Different values of Base Width (W).

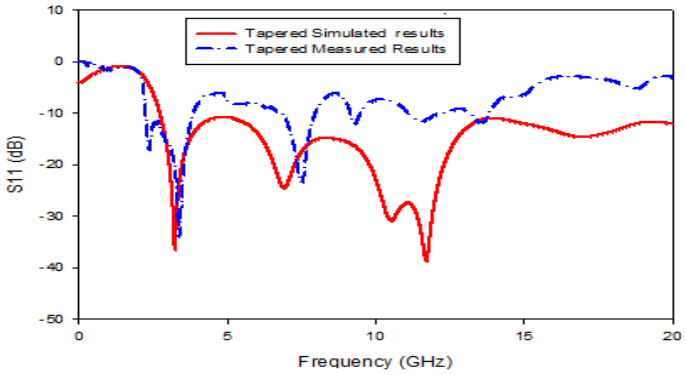
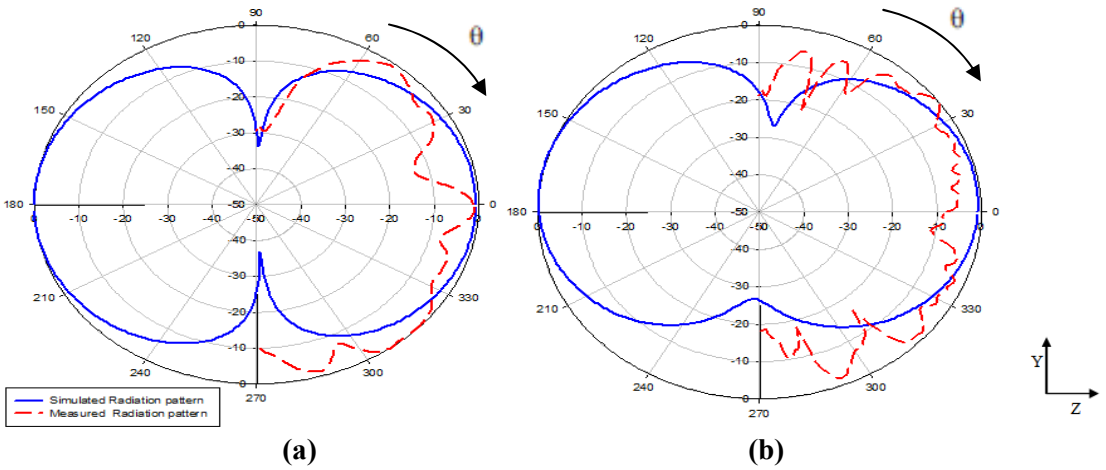
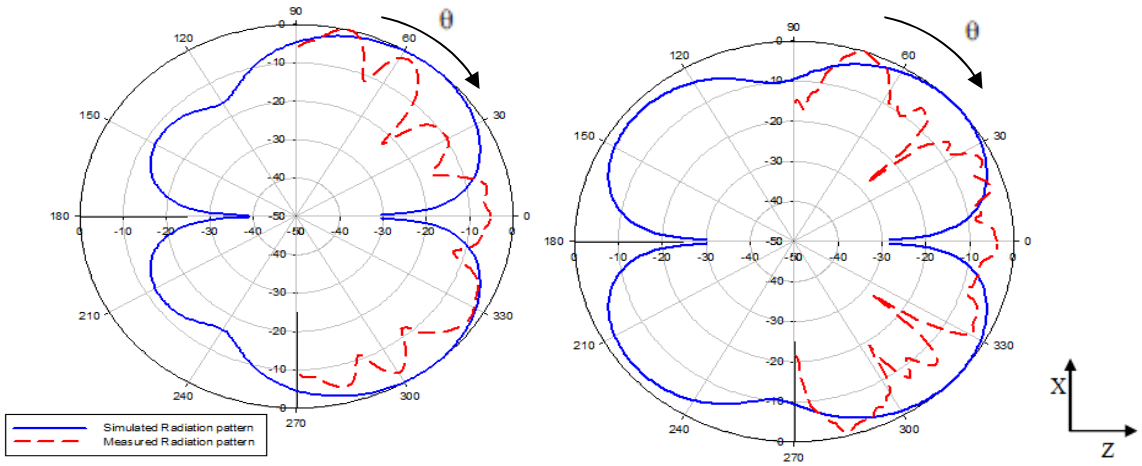


Figure 4: Comparison of Measured and Simulated Return Loss of the Proposed Antenna with Tapered Ground Plane



(a) **(b)**

Figure 5: Measured and Simulated Radiation Pattern of the Proposed Antenna for E-Plane (a) 2.45GHz and (b) 5.8GHz



(a) **(b)**

Figure 6: Measured and Simulated Radiation Pattern of the Proposed Antenna for H-Plane (a) 2.45GHz and (b) 5.8GHz

4. Conclusion

The planar cone-shaped monopole antenna with tapered ground plane has been proposed. The proposed antenna showed good performance which provides a wide bandwidth. The measured bandwidth is approximately 140% (2.4GHz to 13.5GHz) at return loss of 10dB with some deviation in some frequencies. The proposed antenna is low profile, compact and small in size with improved performance for UWB wireless communication and on-body communication.

Acknowledgments

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References

[1] R. A. Sadeghzadeh-Sheikhan, M. Naser-Moghadasi, E. Ebadifallah, H., Rousta, M. Katouli, B. S Virdee, "Planar monopole antenna employing back-plane ladder-shaped resonant structure for ultra-wideband performance," Microwaves, Antennas & Propagation, IET, vol. 4, pp. 1327-1335, 2010.

[2] C. Y. Chiu, H. Wong, C. H. Chan, "Study of small wideband folded-patch-feed antennas," Microwaves, Antennas & Propagation, IET, vol. 1, pp. 501-505, 2007.

[3] M. R. Kamarudin, Y. I. Nechayev, P. S. Hall, "Antennas for on-body communication systems," in Antenna Technology: Small Antennas and Novel Metamaterials, IWAT 2005. IEEE International Workshop on, pp. 17-20, 2005.

[4] S. Seong-Youp, W. L. Stutzman, W. A Davis, "A new ultrawideband printed monopole antenna: the planar inverted cone antenna (PICA)," Antennas and Propagation, IEEE Transactions on, vol. 52, pp. 1361-1364, 2004.

[5] T. Weihua, S. Zhongxiang, "A planar multi-band antenna for portable devices," in Antennas and Propagation Society International Symposium, IEEE, pp. 2641-2644, 2006.

[6] S. Seong-Youp, W. Stutzman, W., Davis, A., Waltho, and J Schiffer, "A novel CPW-fed disc antenna," in Antennas and Propagation Society International Symposium, IEEE, vol. 3, pp. 2919-2922, 2004.

[7] C. Shi, P. Hallbjorner, A. Rydberg, "Printed Slot Planar Inverted Cone Antenna for Ultrawideband Applications," Antennas and Wireless Propagation Letters, IEEE, vol. 7, pp. 18-21, 2008.