Progress In Electromagnetics Research Letters, Vol. 2, 1–10, 2008

A PLANAR U TYPE MONOPOLE ANTENNA FOR UWB APPLICATIONS

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Abstract—An ultra-wideband (UWB) U type monopole antenna fed by a coplanar waveguide (CPW) is proposed. It has low profile and very compact size (14.48 mm × 28.74 mm × 0.8 mm). It provides an wide impedance bandwidth ranging from 3.08 GHz to about 12.75 GHz adjustable by variation of its parameters, such as the relative permittivity and thickness of the substrate, width, and feed and ground plane dimensions. Parametric study is presented. Details of the proposed ultra-wideband design are described. Simulation results are presented and discussed in this paper.

1. INTRODUCTION

UWB applications have gained much attention in the field of antenna designs because of the ultra-wideband feature for high data-rate applications [1, 2]. According to the FCC of definition of UWB, fractional bandwidth measured at -10 dB points $>$ 20% or total bandwidth $>$ 500 MHz [3]. And the commercial uses of frequency band 3.1 GHz to 10.6 GHz for radar, location tracing, and data transmissions were also approved by FCC in 2002 [4]. To satisfy such requirement various wideband antennas have been studied [5–21]. But some of them cannot cover the whole bandwidth [5–8], the others may have quite complicated 3D structures [6, 9, 10]. Among many possible alternatives, monopole antennas have been extensively investigated because of their attractive features such as light weight, simple structure and ease of mass production and many results have been obtained [5, 9, 11–14].

In this paper, we present a CPW-fed U type monopole antenna for UWB operations. Details of the antenna design are described and simulation results are presented and discussed. The simulated return loss shows that the proposed antenna achieves an impedance bandwidth ranging from 3.08 GHz to over 12.75 GHz. The proposed antenna presents omnidirectional patterns across the whole operating band.

2. ANTENNA DESIGN

2.1. Geometry of the Proposed Antenna

Figure 1 shows the geometry of the proposed CPW-fed U type monopole antenna. This antenna is printed on FR4 substrate of 0.8 mm thickness with relative dielectric constant $\varepsilon_r = 4.4$. The total size of the antenna including ground plane is 14.48 mm × 28.74 mm. A 50 ohms CPW transmission line, having a single strip of width $Wc = 1.5$ mm and a gap of distance $g1 = 0.3$ mm, is used to excite U type-loaded. There are two slots near point ***A*** where the 50 ohms CPW transmission line is connected with a radiation element for enhancing impedance matching. By selecting proper parameters the proposed antenna, it is found that return loss of the proposed antenna has good impedance matching. The singled-layered, CPW-fed structures and small total size makes the proposed antenna easy to integrate with RF front end. The parameters of the proposed antenna are given in Table 1.

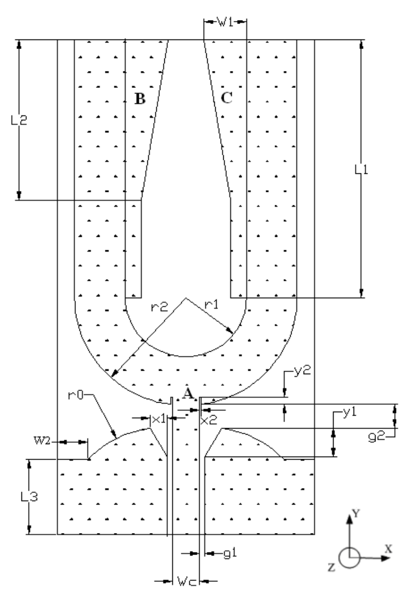


Figure 1. Schematic diagram of the proposed antenna.

Table 1. Parameters of the initial antenna.

Parameters	Wc	g1	g2	r0	r1	r2	L1	W1	L2	W2	L3	x1	y1	x2	y2
Value	1.5 mm	0.3 mm	1.3 mm	6.19 mm	3.4 mm	6.25 mm	15 mm	2.4 mm	9.25 mm	1.73 mm	4.4 mm	0.94 mm	1.69 mm	0.1 mm	0.44 mm

2.2. Frequency-Domain Performances of the Proposed Antenna

The simulation results were obtained by using High Frequency Structure Simulator (HFSS) [22]. Figure 2 shows the return loss curve for the proposed antenna, the bandwidth covers the frequency range from 3.08 GHz to 12.75 GHz with the return loss less than −10 dB.

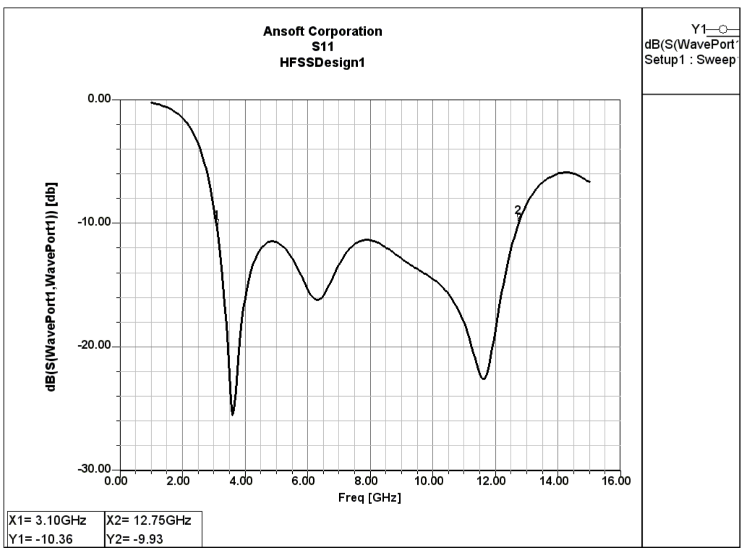
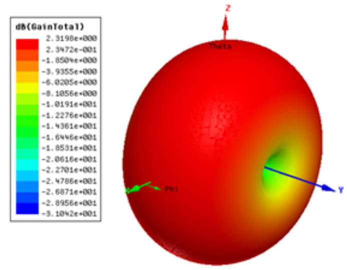
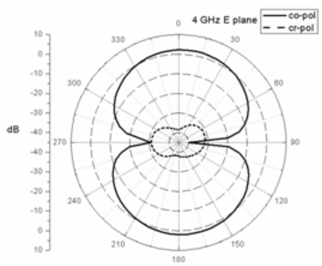


Figure 2. Simulated return loss of the proposed antenna.

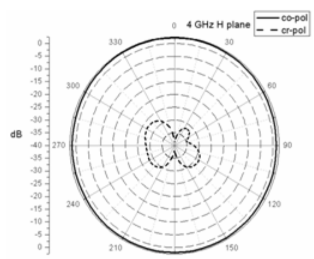
The simulated radiation patterns at 4 GHz, 7 GHz, and 9 GHz are shown in Figure 3. From the 3D view of the antenna radiation pattern we can see that the main beams are shifted toward to the Y-axis slightly. In the H plane, the proposed antenna shows an omnidirectional radiation characteristic across the whole operating band, but larger fluctuations appears in the E plane. They deteriorate because the equivalent working area is different in the wide operation frequency. Of course, the seriously unequal phase distribution and larger magnitude of high order mode at higher frequencies on the slot are not improved also play a part in the deterioration.



3D view of the radiation pattern at 4 GHz

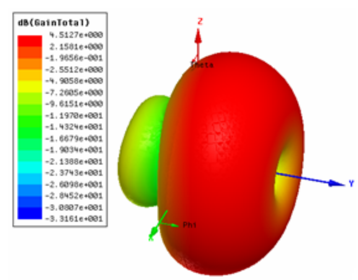


4 GHz E plane (Y-Z plane)

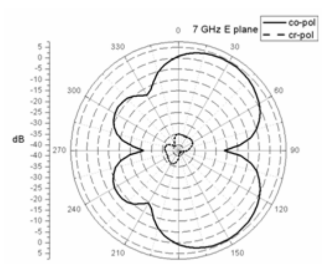


4 GHz H plane (X-Z plane)

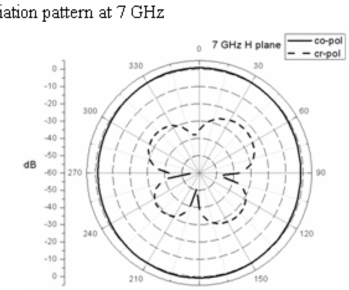
(a)



3D view of the radiation pattern at 7 GHz

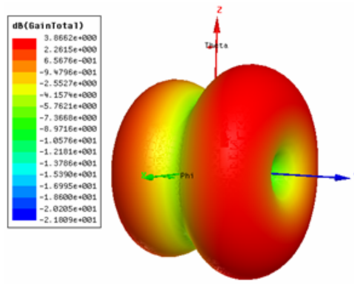


7 GHz E plane (Y-Z plane)

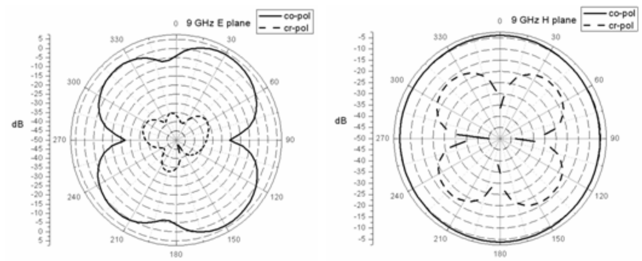


7 GHz H plane (X-Z plane)

(b)



3D view of the radiation pattern at 9 GHz



9 GHz E plane (Y-Z plane) 9 GHz H plane (X-Z plane)

(c)

Figure 3. Simulated radiation patterns of the proposed antenna, (a) E and H planes at 4 GHz, (b) E and H planes at 7 GHz, (c) E and H planes at 9 GHz.

Furthermore, Figure 4 shows the antenna gain against frequency of the proposed antenna. The simulated gains of proposed antenna within the operation frequency bands range from 1 dBi to 5.3 dBi.

2.3. Parametric and Geometry Studies of the Proposed Antenna

Based on this design, some sensitive dimension parameters will be studied numerically in order to know the influence of these parameters on the antenna's input performance. In the numerical simulation, only one parameter was varied every time, whereas the others were kept constant.

The effect of varying $L1$ on the input performance is plotted in Figure 5. It seems that the greater the length, the wider the lower frequency band in the vicinity of 3.1 GHz, a starting frequency of UWB antennas. However, we should consider both the small volume and the impedance bandwidth. Thus we selected $L1 = 15$ mm.

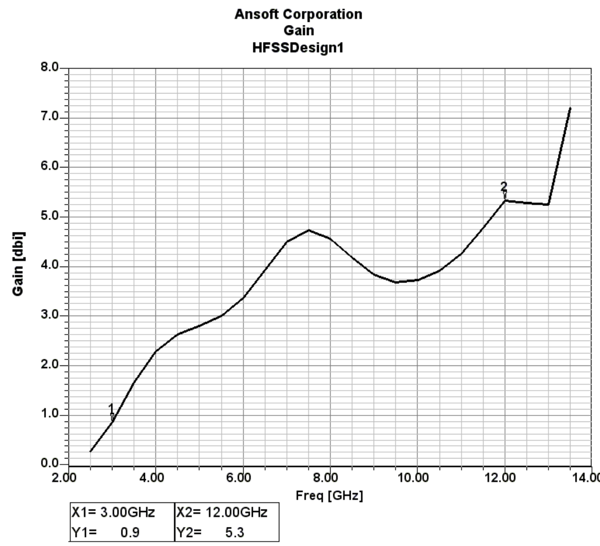


Figure 4. Simulated gain of the proposed antenna.

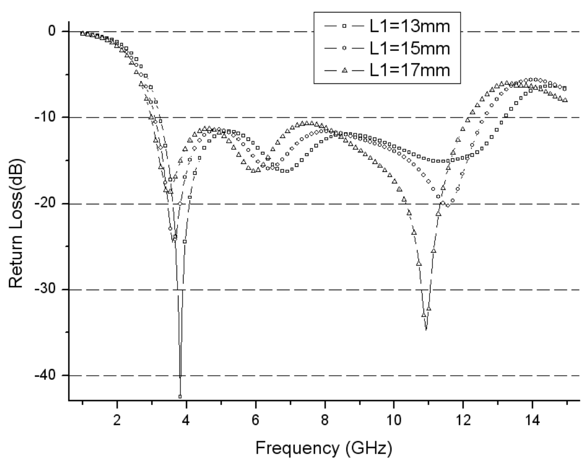


Figure 5. Simulated return loss of the proposed antenna with different $L1$.

As shown in Figure 6, the small changes in the spacing between edge of ground plane and U type-loaded ($g2$) has an effect on the impedance matching of the proposed antenna. The reason is that the extended reinforced capacitance that results from the spacing between edge of ground plane and U type-loaded cancels the inductance of the antenna.

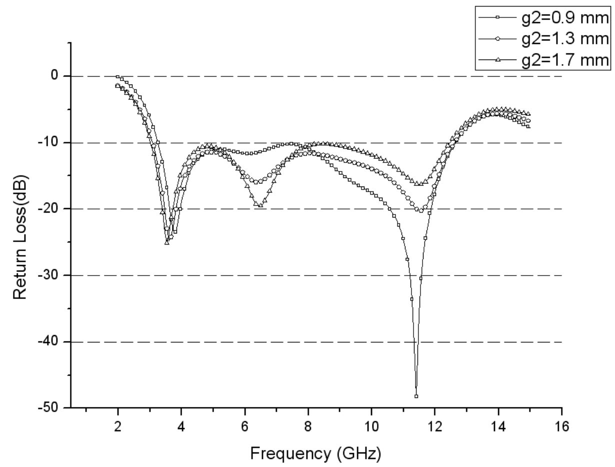


Figure 6. Simulated return loss of the proposed antenna with different $g2$.

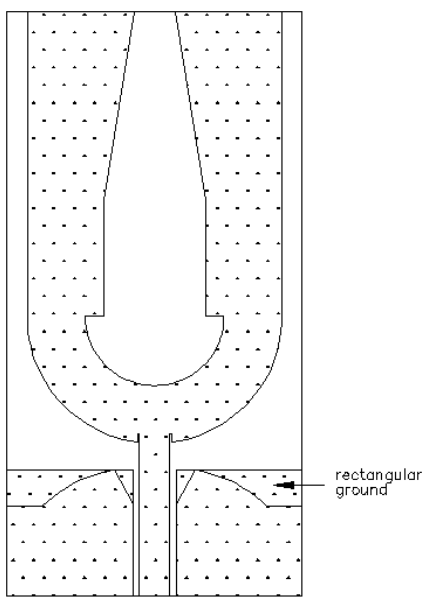


Figure 7. Antenna with the rectangular ground (AWRG).

We also compared two different antennas (Figure 7, Figure 8) with the proposed one. Both side edges of the ground plane were constructed in a part of a circular shape to reduce the beam tilting and obtain wide bandwidth in the proposed antenna. But in order to make the simulation accurately, we still reserve a rectangular part of the ground. As shown in Figure 9, we can see that the rectangular ground made the return loss at the central frequency band deteriorative. And the additive patches ***B*** and ***C*** were used to further improving the in-band antenna matching.

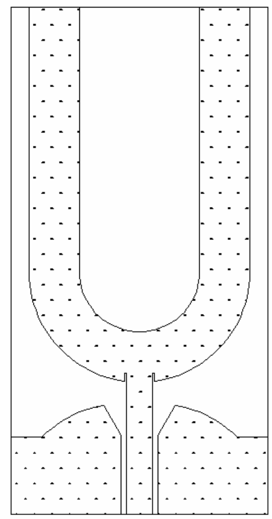


Figure 8. Antenna without B and C (AWTBC).

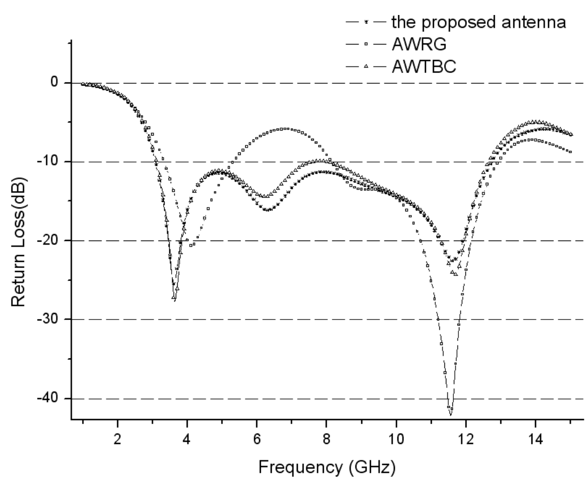


Figure 9. Simulated return loss of the three different antennas.

3. CONCLUSIONS

An ultra-wideband (UWB) U type monopole antenna fed by a coplanar waveguide (CPW) is proposed. The return loss, radiation patterns and gain of the antenna have been investigated intensively. From the above results, it may be concluded that the proposed antenna is compact with the maximum size is 14.48 mm by 28.74 mm. The simulated return loss of proposed antenna is from 3.08 GHz to 12.75 GHz. In the H plane, the proposed antenna shows an omnidirectional radiation characteristic across the whole operating band. Its compact size and UWB performance make the proposed antenna useful for broadband wireless communication systems such as a UWB system.

REFERENCES

1. Chen, C.-H., C.-L. Liu, C.-C. Chiu, and T.-M. Hu, "Ultra-wide band channel calculation by SBR/image techniques for indoor communication," *J. of Electromagn. Waves and Appl.*, Vol. 20, No. 1, 41–51, 2006.
2. El-Fishawy, N., M. Shokair, and W. Saad, "Proposed Mac protocol versus IEEE 802.15.3a for multimedia transmission over UWB networks," *Progress In Electromagnetics Research B*, Vol. 2, 189–206, 2008.
3. Stroh, S., "Ultra-wideband: Multimedia unplugged," *IEEE Spectrum*, Vol. 24, Sep. 2003.
4. Anon, "FCC first report and order on ultra-wideband technology," Feb. 2002.
5. Chang, D.-C., M.-Y. Liu, and C.-H. Lin, "A CPW-fed U type monopole antenna for UWB applications," *Antennas and Propagation Society International Symposium, 2005 IEEE*, Vol. 2A, 512–515, July 3–8, 2005.
6. Mallahzadeh, A. R., A. A. Dastranj, and H. R. Hassani, "A novel dual-polarized double-ridged horn antenna for wideband applications," *Progress In Electromagnetics Research B*, Vol. 1, 67–80, 2008.
7. Chen, Y.-L., C. Ruan, and L. Peng, "A novel ultra-wideband bow-tie slot antenna in wireless communication systems," *Progress In Electromagnetics Research Letters*, Vol. 1, 101–108, 2008.
8. Abbaspour, M. and H. R. Hassani, "Wideband star-shaped microstrip patch antenna," *Progress In Electromagnetics Research Letters*, Vol. 1, 61–68, 2008.
9. Suh, S.-Y., W. L. Stutzman, and W. A. Davis, "A new ultra-wideband printed monopole antenna: The planar inverted cone antenna (PICA)," *IEEE Trans. AP*, Vol. 52, No. 5, 1361–1364, 2004.
10. Abbas-Azimi, M., F. Arazm, J. Rashed-Mohassel, and R. Faraji-Dana, "Design and optimization of a new 1–18 GHz double ridged

guide horn antenna," *J. of Electromagn. Waves and Appl.*, Vol. 21, No. 4, 501–516, 2007.

11. Zaker, R., C. Ghobadi, and J. Nourinia, "A modified microstrip-fed two-step tapered monopole antenna for UWB and wlan applications," *Progress In Electromagnetics Research*, PIER 77, 137–148, 2007.
12. Eldek, A. A., "Numerical analysis of a small ultra wideband microstrip-fed tap monopole antenna," *Progress In Electromagnetics Research*, PIER 65, 59–69, 2006.
13. Liu, W. C., "Optimal design of dualband CPW-fed G-shaped monopole antenna for wlan application," *Progress In Electromagnetics Research*, PIER 74, 21–38, 2007.
14. Kharakhili, F. G., M. Fardis, G. Dadashzadeh, A. A. K. Ahmad, and N. Hojjat, "Circular slot with a novel circular microstrip open ended microstrip feed for UWB applications," *Progress In Electromagnetics Research*, PIER 68, 161–167, 2007.
15. Rajabi, M., M. Mohammadirad, and N. Komjani, "Simulation of ultra wideband microstrip antenna using EPML-TLM," *Progress In Electromagnetics Research B*, Vol. 2, 115–124, 2008.
16. Hosseini, S. A., Z. Atlasbaf, and K. Forooraghi, "Two new loaded compact planar ultra-wideband antennas using defected ground structures," *Progress In Electromagnetics Research B*, Vol. 2, 165–176, 2008.
17. Khan, S. N., J. Hu, J. Xiong, and S. He, "Circular fractal monopole antenna for low VSWR UWB applications," *Progress In Electromagnetics Research Letters*, Vol. 1, 19–25, 2008.
18. Ren, W., J. Y. Deng, and K. S. Chen, "Compact PCB monopole antenna for UWB applications," *J. of Electromagn. Waves and Appl.*, Vol. 21, No. 10, 1411–1420, 2007.
19. Gopikrishna, M., D. D. Krishna, A. R. Chandran, and C. K. Aanandan, "Square monopole antenna for ultra wide band communication applications," *J. of Electromagn. Waves and Appl.*, Vol. 21, No. 11, 1525–1537, 2007.
20. Ren, W., Z.-G. Shi, and K. S. Chen, "Novel planar monopole uwb antenna with 5-GHz band-notched characteristic," *J. of Electromagn. Waves and Appl.*, Vol. 21, No. 12, 1645–1652, 2007.
21. Zhou, H.-J., Q.-Z. Liu, J.-F. Li, and J. Guo, "A swallow-tailed wideband planar monopole antenna with semi-elliptical base," *J. of Electromagn. Waves and Appl.*, Vol. 21, No. 9, 1257–1264, 2007.
22. Ansoft High Frequency Structure Simulator (HFSS), Ver. 10.0, Ansoft Corporation.