Progress In Electromagnetics Research C, Vol. 5, 13–20, 2008

DESIGN OF A NOVEL MONOPOLE UWB ANTENNA WITH A NOTCHED GROUND

L. Wang, W. Wu, X.-W. Shi, F. Wei, and Q.-L. Huang

National Key Laboratory of Antennas and Microwave Technology
Xidian University
Xi'an 710071, China

Abstract—In this paper, a novel compact monopole ultra-wideband (UWB) antenna with a notched ground is presented. To increase the impedance bandwidth, a notched ground is introduced. The parameters and the characteristics of the antenna are given. It shows good characteristics for UWB, and it satisfies the VSWR requirement of less than 2.0 in the frequency band from 2.55 GHz to more than 13 GHz. The measured radiation patterns show good omnidirectional performance and antenna gains across the operation bandwidth.

1. INTRODUCTION

Recently, Ultra-wideband (UWB) technique has become one of the most fascinating technologies in commercial and military domains. So the United States Federal Communication Commission (FCC) define frequency band from 3.1 to 10.6 GHz, including VSWR less than 2.0, omnidirectional radiation patterns, minimum distortions in the received waveforms, etc. [1]. Ultra-wideband (UWB) communication systems are currently under investigation and have been widely adopted in commercial and military domains, so it is very essential to design a compact wideband antenna. Because of its attractive features, such as low cost, small size and easy fabrication, the printed ultra-wideband monopole antenna has received more and more attention with the development of communication technology. Now various techniques have been developed to cover the entire UWB bandwidth, such as L-/F-shaped probe to feed the patch [1, 2], triangular patch [3], U-/V-slot monopoles [4, 5], and etc. [6–27].

In this paper, a novel planner monopole antenna for UWB applications is proposed, which exhibits better UWB operating characteristics. The proposed antenna not only occupies a small

size but also preserves a very single structure which is easy to be fabricated. With a notched ground, the input impedance matching over a wide frequency range is achieved. It can cover a wide frequency range (2.55 GHz–13.47 GHz) and satisfy the VSWR < 2.0. The detailed design and experimental results are presented and discussed below.

2. ANTENNA DESIGN

The configuration and the photo of the proposed UWB antenna are illustrated in Figure 1 and Figure 2. The designed antenna features a compact size of $45 \times 40\,\text{mm}^2$ and it is printed on conventional FR4

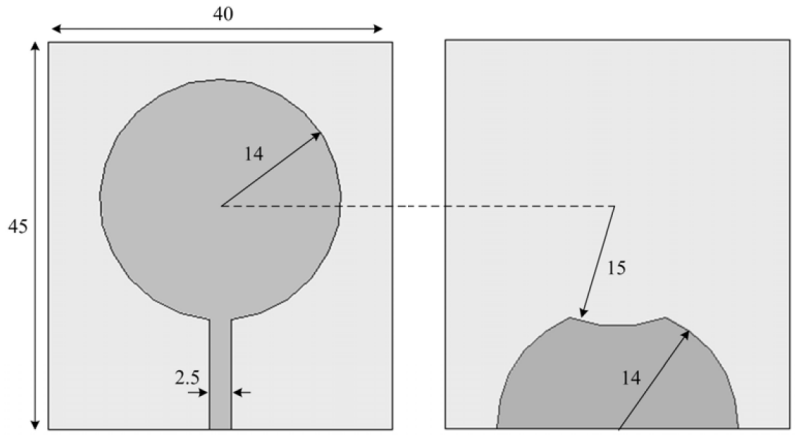

Figure 1. Configuration of the proposed UWB antenna.

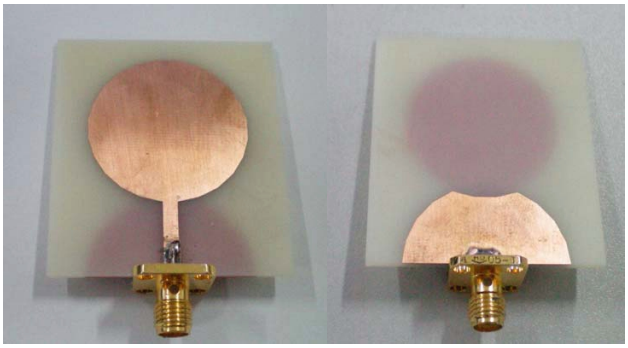

Figure 2. Photo of the proposed UWB antenna.

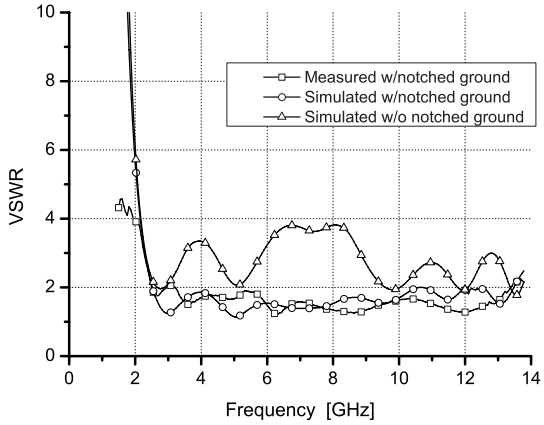

Figure 3. Measured and simulated VSWR of the proposed antenna.

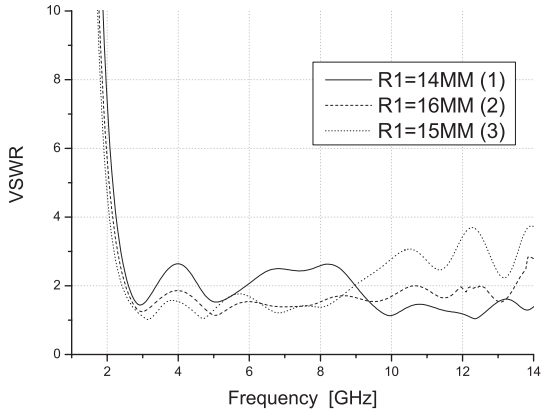

Figure 4. simulated VSWR characteristic for various radius R1.

substrate with thickness of 1.5 mm, and relative permittivity = 4.4. The radiating element is a circular patch and the ground is a semicircle with the same radius. The radiator and the 50 Ω feed line are printed on the same side of the substrate and the ground plane is located on the other side. To improve the impedance matching performance of planar monopole antenna without introducing any size or expense increase, a notched ground is introduced. Therefore, we use a circle with radius $R1 = 15$ mm to cut the ground plane. At last it shows good characteristics for UWB, satisfying the VSWR requirement of less than 2.0 in the frequency band from 2.55 GHz to 13.47 GHz. The optimized design result is presented in Figure 1.

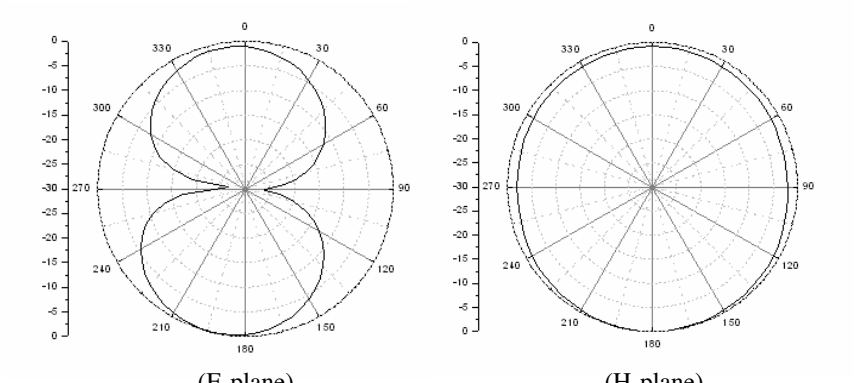

Figure 5. Measured radiation patterns of the proposed antenna at (a) 3.5 GHz; (b) 6.5 GHz; (c) 8 GHz.

3. RESULT AND DISCUSSION

With the optimized parameters in Figure 1, an example monopole antenna was fabricated. Figure 3 shows a comparison between the simulated and measured VSWR of the antenna from 1.5 GHz to 14 GHz. The simulation is carried out by using the Ansoft simulation software HFSSv11.0, and the measured result is obtained by WILTRON37269A vector network analyzer. The impedance bandwidth of the prototype antenna defined by VSWR < 2.0 is from 2.55 GHz to 13.47 GHz with a ratio of about 5.8 : 1. The simulated result of the antenna without a notched ground is also given in Figure 3. Figure 4 shows the simulated VSWRcharacteristics of the antenna for variousvalues of R1 which is the radius of the circle that we use to cut the ground plane. We can see that the radius R1 is a criticalparameter to determine the impedance matching here. It can be seen that this arc notch on the ground could greatly improve the impedance matching performance of planar monopole antenna. Basic agreements are achieved between the simulated result and the measured one; the differences between them may be caused by the soldering effects of an SMA connector, which have been neglected in our simulations.

The radiation patterns have been measured at sampling frequencies of 3.5, 6.5 and 8.0 GHz, which are shown in Figure 5. The proposed monopole antenna exhibits nearly omnidirectional radiation pattern within its working frequency band. Figure 6 presents the measured peak gains of the proposed monopole antenna with a notched ground across its operating bands.

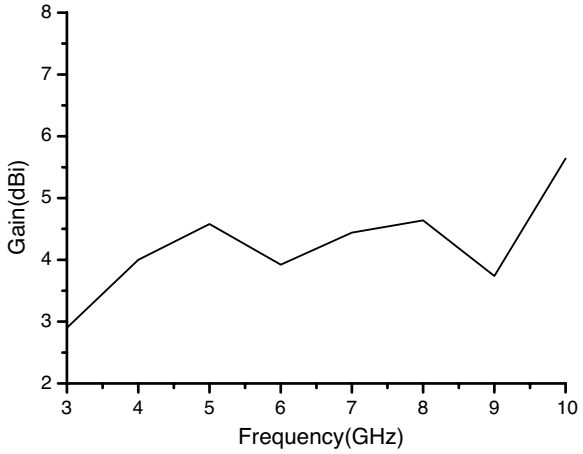

Figure 6. Measured peak antenna gain vs. frequency.

4. CONCLUSION

In this article, a new simple configuration of UWB monopole antenna is designed. In order to improve impedance matching performance, a notched ground is introduced. Good agreement has been obtained between calculated and measured performance. The measured VSWR and radiation patterns show that the antenna can be used effectively for UWB communication.

REFERENCES

1. FCC, Ultra-Wideband Operation FCC Report and Order, Tech. Rep. US47 CFR Part 15, 2002.
2. Luk, K. M., C. L. Mak, Y. L. Chow, and K. F. Lee, "Broadband microstrip patch antenna," *Electron. Lett.*, Vol. 34, 1442–1443, 1998.
3. Ooi, B. L., C. L. Lee, and P. S. Kooi, "A novel F-probe-fed broadband patch antenna," *Microwave Opt. Technol. Lett.*, Vol. 30, 355–356, 2001.
4. Mak, C. L., K. M. Luk, and K. F. Lee, "Wideband triangular patch antenna," *IEE Proc. Microwaves Antennas Propagat.*, Vol. 146, 167–168, 1999.
5. Kim, Y. and D. H. Kwon, "CPW-fed planar ultra wideband antenna having a frequency band notch function," *Electron. Lett.*, Vol. 40, 403–405, 2004.
6. Su, S. W., K. L. Wong, and F. S. Chang, "Compact printed ultra-wideband slot antenna with a bandnotched operation," *Microwave Opt. Technol. Lett.*, Vol. 45, 128–130, 2005.
7. Mazur, M., E. Sedek, and J. Mazur, "Propagation in a Ferrite circular waveguide magnetized through a rotary four-polemagnetic field," *Progress In Electromagnetics Research*, PIER 68, 1–13, 2007.
8. Chen, K.-S. and C.-Y. Chu, "A propagation study of the 28 GHz LMDS system performance with M-QAM modulations under rain fading," *Progress In Electromagnetics Research*, PIER 68, 35–51, 2007.
9. Faiz, J., B. M. Ebrahimi, and M. B. B. Sharifian, "Time stepping finite element analysis of broken bars fault in a three-phase squirrel-cage induction motor," *Progress In Electromagnetics Research*, PIER 68, 53–70, 2007.
10. Srivastava, S. K. and S. P. Ojha, "Enhancement of omnidirectional reflection bands in one-dimensional photonic crystals with

left-handed materials," *Progress In Electromagnetics Research*, PIER 68, 91–111, 2007.

11. Fallahi, R., A.-A. Kalteh, and M. G. Roozbahani, "A novel UWB elliptical slot antenna with band-notched characteristics," *Progress In Electromagnetics Research*, PIER 82, 127–136, 2008.
12. Zhang, G.-M., J.-S. Hong, and B.-Z. Wang, "Two novel bandnotched UWB slot antennas fed by microstrip line," *Progress In Electromagnetics Research*, PIER 78, 209–218, 2008.
13. Dehdasht-Heydari, R., H. R. Hassani, and A. R. Mallahzadeh, "Quad ridged horn antenna for UWB applications," *Progress In Electromagnetics Research*, PIER 79, 23–38, 2008.
14. Sadat, S., M. Fardis, F. Geran, and G. Dadashzadeh, "A compact microstrip square-ring slot antenna for UWB applications," *Progress In Electromagnetics Research*, PIER 67, 173–179, 2007.
15. Sadat, S. and M. Houshmand, "Design of a microstrip squaring slot antenna filled by an H-shape slot UWB applications," *Progress In Electromagnetics Research*, PIER 70, 191–198, 2007.
16. Fallahi, R., A.-A. Kalteh, and M. G. Roozbahani, "A novel UWB elliptical slot antenna with band-notched characteristics," *Progress In Electromagnetics Research*, PIER 82, 127–136, 2008.
17. Kim, J.-H., Y.-H. You, K.-I. Lee, K.-S. Jeong, and J.-H. Yi, "Pilotless synchronization receiver for UWB-based wireless application," *Progress In Electromagnetics Research*, PIER 83, 119–131, 2008.
18. Zaker, R., Ch. 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.
19. Zhang, G.-M., J.-S. Hong, and B.-Z. Wang, "Two novel bandnotched UWB slot antennas fed by microstrip line," *Progress In Electromagnetics Research*, PIER 78, 209–218, 2008.
20. Klemm, M. and G. Troester, "EM energy absorption in the human body tissues due to UWB antennas," *Progress In Electromagnetics Research*, PIER 62, 261–280, 2006.
21. Zhou, L.-L., H.-B. Zhu, and N.-T. Zhang, "Iterative solution to the notched waveform design in cognitive ultra-wideband radio system," *Progress In Electromagnetics Research*, PIER 75, 271–284, 2007.
22. Naghshvarian-Jahromi, M., "Compact UWB bandnotch antenna with transmission-line-fed," *Progress In Electromagnetics Research B*, Vol. 3, 283–293, 2008.

23. Xiao, S.-Q., J. Chen, X.-F. Liu, and B.-Z. Wang, "Spatial focusing characteristics of time reversal UWB pulse transmission with different antenna arrays," *Progress In Electromagnetics Research B*, Vol. 2, 223–232, 2008.
24. Ghassemi, N., J. Rashed-Mohassel, M. H. Neshati, S. Tavakoli, and M. Ghassemi, "A high gain dual stacked aperture coupled microstrip antenna for wideband applications," *Progress In Electromagnetics Research B*, Vol. 9, 127–135, 2008.
25. 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.
26. Yin, X.-C., C.-L. Ruan, C.-Y. Ding, and J.-H. Chu, "A planar U type monopole antenna for UWB applications," *Progress In Electromagnetics Research Letters*, Vol. 2, 1–10, 2008.
27. Wang, F. J., J.-S. Zhang, X.-X. Yang, and G.-P. Gao, "Time domain characteristics of a double-printed UWB dipole antenna," *Progress In Electromagnetics Research Letters*, Vol. 3, 161–168, 2008.