Progress In Electromagnetics Research Letters, Vol. 25, 101–107, 2011

DUAL RECTANGULAR RING WITH OPEN-ENDED CPW-FED MONOPOLE ANTENNA FOR WIMAX/WLAN APPLICATIONS

B. Li*, Z.-H. Yan, and C. Wang

National Key Laboratory of Science and Technology on Antennas and Microwaves, Xidian University, Xi'an, Shaanxi 710071, China

Abstract—A coplanar waveguide (CPW)-fed planar monopole antenna with triple-band operation for worldwide interoperability for microwave access (WiMAX) and wireless local area network (WLAN) applications is presented. The antenna comprises dual rectangular ring with open-end. The triple operating bands with 10-dB return-loss bandwidths of about 30.8% ranging from 2.2 to 2.97 GHz, 23.4% ranging from 3.17 to 3.99 GHz, and 25.4% ranging from 4.91 to 6.31 GHz, covering the required bandwidths of 2.4/5.2/5.8 GHz WLAN and 3.5/5.5 GHz WiMAX standards, are obtained.

1. INTRODUCTION

The interest in the research and design of multiband and broadband antennas has increased dramatically in recent years, with the boost in modern wireless communication systems. For short- and long-range applications, many antenna designs which are suitable for WLAN (2.4–2.484, 5.15–5.35, and 5.725–5.85 GHz) and WiMAX (2.5–2.69, 3.3–3.8, and 5.25–5.85 GHz) operations have been studied [1–12]. To adapt to the complicated and diverse WLAN and WiMAX environments, the antennas in these devices should provide stable operations frequency bands. In particular, a great interest in coplanar waveguide (CPW) has been presented because of its many features, such as the simplest structure of a single metallic layer, easy fabrications, lower surface wave loss and smaller occupation. Rectangular ring CPW-fed antennas are capable of providing operation bandwidth for 2.4/5.2 GHz WLAN [13, 14].

Received 20 June 2011, Accepted 18 July 2011, Scheduled 29 July 2011
* Corresponding author: Bo Li (libo_05@163.com).

In this letter, based on the previous work of reference, we demonstrate a dual rectangular ring monopole antenna with an open-end well suited for WiMAX and WLAN operation. The proposed antenna is fed by a CPW structure so that a simple layer is needed, which is able to decrease the complexity of the antenna structure. In this design, the outer big ring with an open-end produces a bandwidth for 3.5/5.5 GHz and impedance matching, thus triple-band operation is achieved. Moreover simple structure which is easy to be processed and measured. Wonderful radiation patterns are the specialty of the proposed antenna. Details of the proposed antenna design and the experimental results are presented.

2. ANTENNA DESIGN

Figure 1 shows the schematic of the proposed planar printed antenna for triple-band operation. The design of the antenna is based on an FR4 substrate with thickness H of 1.6 mm, relative permittivity of 4.4, and area of 44 mm × 48 mm. A transmission line, which consists of a signal strip width of $W2$ and a gap distance of $W3$ between the signal strip and coplanar ground plane, is used for feeding the antenna. Two finite ground planes with the same size of $L9 \times W5$ are simulated symmetrically on each side of the CPW line. The antenna consists of

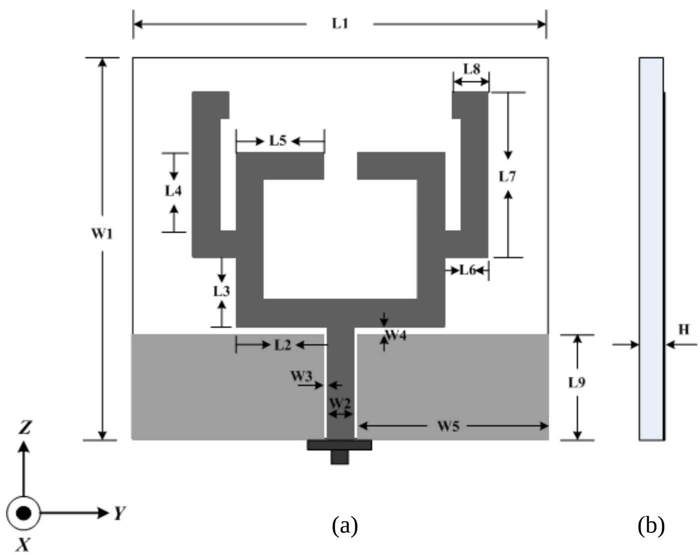

Figure 1. Geometry of the proposed antenna. (a) Top view, (b) side view.

two rectangular rings with open-end. The inner rectangular ring has the lengths $L2 + L3 + L4 + L5$ which are nearly equal to a quarter wavelength of the fundamental mode at 2.4 GHz, and it is used for the 2.4/5.2 GHz bands operations, while the outer rectangular ring has the lengths $L2 + L3 + L6 + L7 + L8$ which are nearly equal to one-half wavelength of the other resonance at 3.5 GHz, and it is used for the 3.5/5.8 GHz bands operations. The inner open end is introduced to improve the impedance characteristic of the lower band of 5.5 GHz, while the outer open end is for upper band of 5.5 GHz. By properly varying the lengths $L3$, $L5$ and $L8$, we can fix the antenna resonance at 2.4, 3.5 and 5.5 GHz. $L3$ is vital to attain triple-band response.

The antenna performance was analysed using a high frequency structure simulator (HFSS). The final antenna dimensions are as follows: $L1 = 48$ mm, $L2 = 10.5$ mm, $L3 = 8$ mm, $L4 = 9$ mm, $L5 = 10$ mm, $L6 = 5$ mm, $L7 = 19$ mm, $L8 = 4$ mm, $L9 = 12$ mm, $W1 = 44$ mm, $W2 = 3$ mm, $W3 = 0.5$ mm, $W4 = 1$ mm, $W5 = 22$ mm.

3. RESULTS AND DISCUSSION

Figure 2 shows the photograph of the proposed antenna. Fig. 3 shows the variation of return loss with different $L3$. $L3$ has a vital effect on the triple-band operation. In Fig. 4, it is shown that only with the inner rectangular ring (denoted as ant 2), dual-band is obtained with worse impedance matching for the lower (2.4 GHz) bands. For the case only with the outer rectangular ring (denoted as ant 3), another dual-band is obtained with the same upper band as ant 2. However, a good triple-band performance can be seen from the proposed antenna with connecting dual rectangular rings (denoted as ant 1). Therefore, it is demonstrated that connecting the two rectangular rings at an optimized offset is very important. The simulated and measured return losses of the proposed antenna are shown in Fig. 5. It can be observed that the measured results reasonably agree with the simulated ones with an acceptable frequency discrepancy. Three

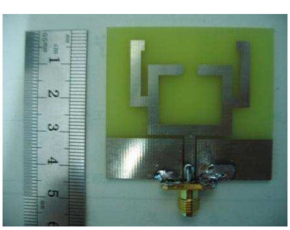

Figure 2. The photograph of the proposed antenna.

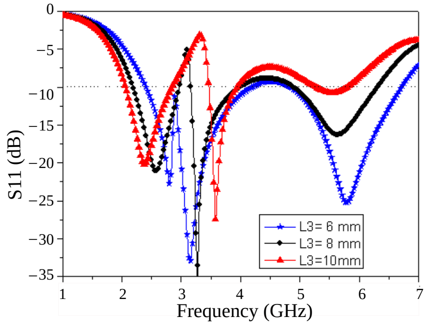

Figure 3. Simulated return loss for the proposed antenna with different $L3$.

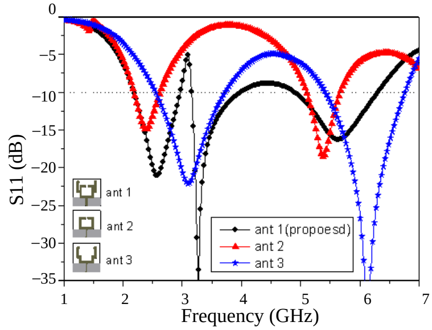

Figure 4. Simulated return loss in the different antenna structure.

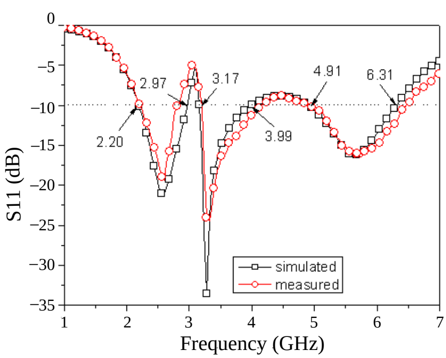

Figure 5. Simulated and measured return losses for the proposed antenna.

resonant modes are obviously excited at frequencies of 2.4, 3.5 and 5.5 GHz, respectively. The obtained 10 dB impedance bandwidths are 0.77 GHz (2.2–2.97 GHz), 0.82 GHz (3.17–3.99 GHz) and 1.4 GHz (4.91–6.31 GHz) corresponding to an impedance bandwidth of 30.8%, 23.4% and 25.4% with respect to the operating resonant frequencies.

The measured radiation patterns of the proposed monopole antenna are shown in Fig. 6, at 2.4, 3.5, 5.5 GHz. The horizontal x-y plane and vertical x-z plane reveal the patterns of typical monopole antennas. Radiation patterns in y-z plane are most like the ones in x-z plane. The measured peak antenna gains for frequencies across the three bands are shown in Fig. 7. The gains are 2.4–3 dBi at 2.4-GHz band, 2.4–4.6 dBi at 3.5-GHz band and 4.6–5.4 dBi at 5.5-GHz band.

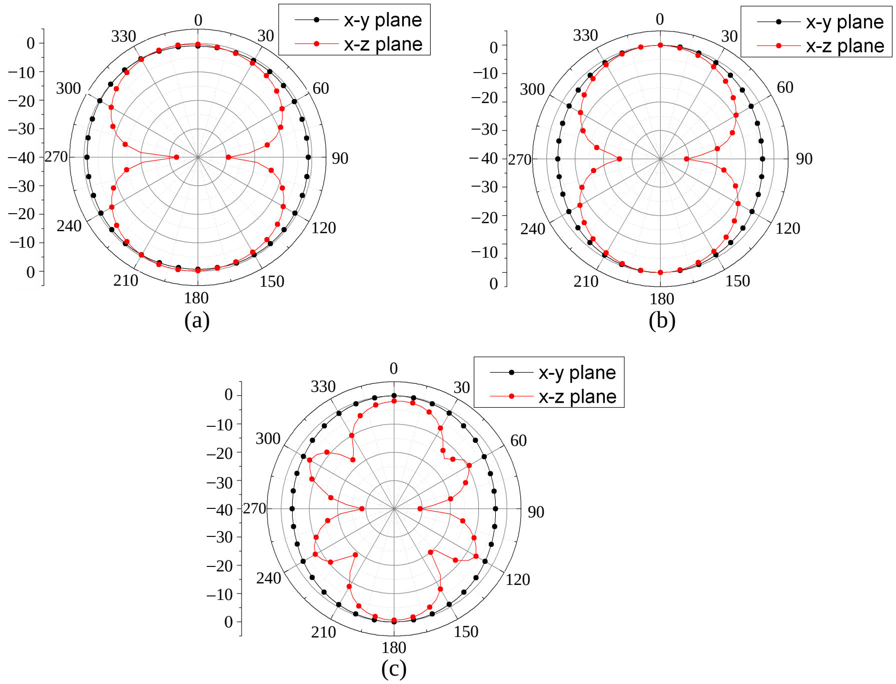

Figure 6. Measured radiation patterns for the proposed antenna at frequencies. (a) $f = 2.4\,\text{GHz}$, (b) $f = 3.5\,\text{GHz}$, (c) $f = 5.5\,\text{GHz}$.

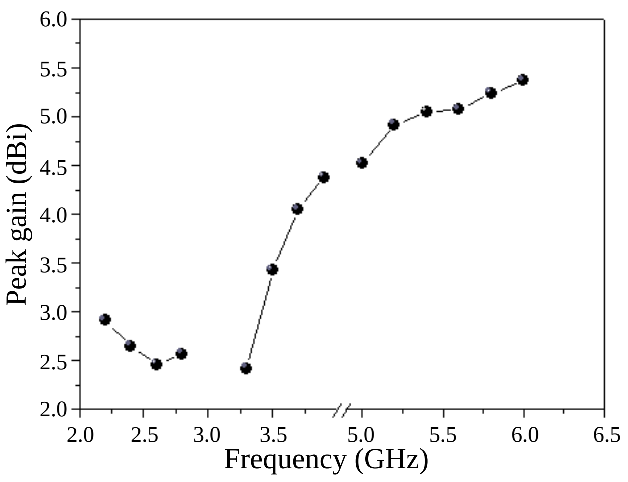

Figure 7. Measured peak antenna gains for the proposed antenna.

4. CONCLUSION

In this design, by using the outer rectangular ring, the proposed antenna can provide sufficient impedance bandwidth and suitable radiation patterns for WiMAX and WLAN systems. By connecting the two rings at an optimized offset and choosing a suitable distance of the open end, triple-band operation is attained. Furthermore, good antenna gains of operating frequencies can also be obtained. Hence the proposed antenna may be a suitable candidate for the tri-band operation in various wireless applications.

REFERENCES

1. Zhang, Q.-Y. and Q.-X. Chu, "Triple-band dual rectangular ring printed monopole antenna for WLAN/WiMAX applications," *Microwave Opt. Technol. Lett.*, Vol. 51, 2845–2848, 2009.
2. George Thomas, K. and M. Sreenivasan, "Compact triple band antenna for WLAN/WiMAX applications," *Electron. Lett.*, Vol. 45, 811–813, 2009.
3. George Thomas, K. and M. Sreenivasan, "Compact CPW-fed dual-band antenna," *Electron. Lett.*, Vol. 46, 13–14, 2010.
4. Gai, S., Y.-C. Jiao, Y.-B. Yang, C.-Y. Li, and J.-G. Gong, "Design of a novel microstrip-fed dual-band slot antenna for WLAN applications," *Progress In Electromagnetics Research Letters*, Vol. 13, 75–81, 2010.
5. Song, Y., Y.-C. Jiao, G. Zhao, and F.-S. Zhang, "Multiband CPW-fed triangle-shaped monopole antenna for wireless applications," *Progress In Electromagnetic Research*, Vol. 70, 329–336, 2007.
6. Li, X., L. Yang, S.-X. Gong, and Y.-J. Yang, "Bidirectional high gain antenna for WLAN applications," *Progress In Electromagnetics Research Letters*, Vol. 6, 99–106, 2009.
7. Ren, W., "Compact dual-band slot antenna for 2.4/5 GHz WLAN applications," *Progress In Electromagnetics Research B*, Vol. 8, 319–327, 2008.
8. Kang, L., Y.-Z. Yin, S.-T. Fan, and S.-J. Wei, "A novel rectangular slot antenna with embedded self-similar T-shaped strips for WLAN applications," *Progress In Electromagnetics Research Letters*, Vol. 15, 19–26, 2010.
9. Wu, Y.-J., B.-H. Sun, J.-F. Li, and Q.-Z. Liu, "Triple-band omni-directional antenna for WLAN application," *Progress In Electromagnetics Research*, Vol. 76, 477–484, 2007.

10. Liu, W. C., "Optimal design of dualband CPW-FED G-shaped monopole antenna for wlan application," *Progress In Electromagnetics Research*, Vol. 74, 21–38, 2007.
11. Jolani, F., A. M. Dadgarpour, and H. R. Hassani, "Compact M-slot folded patch antenna for WLAN," *Progress In Electromagnetics Research Letters*, Vol. 3, 35–42, 2008.
12. Wen, L.-H., Y.-Z. Yin, Z.-Y. Liu, D. Xi, M. Zhang, and Y. Mang, "Performance enhancement of tri-band monopole antenna for WLAN/WiMAX applications," *Progress In Electromagnetics Research Letters*, Vol. 15, 61–68, 2010.
13. Yoon, J. H., "Fabrication and measurement of rectangular ring with open-ended CPW-fed monopole antenna for 2.4/5.2-GHz WALN operation," *Microwave Opt. Technol. Lett.*, Vol. 48, 1480–1483, 2006.
14. Zhang, L., Y.-C. Jiao, G. Zhao, Y. Song, and F.-S. Zhang, "Broadband dual-band CPW-fed closed rectangular ring monopole antenna with a vertical strip for WLAN operation," *Microwave Opt. Technol. Lett.*, Vol. 50, 1929–1931, 2008.