A High Port Isolation MIMO Antenna System for 2-6 GHz Wide-Band AP Applications

Shun-Min Wang[1], Lih-Tyng Hwang[1], Chung-Yi Hsu[1], Fa-Shian Chang[2], and Chih-Fang Liu[2]
[1]Institute of Communications Engineering, National Sun Yat-Sen University
[2]Dept. of Electronics, Cheng Shiu University
Kaohsiung 804, Taiwan
*E-mail: fiftyohm@mail.nsysu.edu.tw

Abstract - A novel wide-band multiple-input multiple-output (MIMO) antenna system with high port isolation is proposed. The antenna system consists of three equally spaced antennas mounted on a hollowed triangle ground. The antenna system was designed to operate at frequency bands between 2 and 6 GHz. Each antenna mainly comprises of a shorted, inverted wide L (shorted iWL, a unique feeding design), sitting on a vertical ground attached to the horizontal plane of triangular shape. From simulation and experimental results, the proposed MIMO system exhibited superb characteristics at 2.4, 3.5 and 5 GHz bands, with significant isolation performance due to the design of the practical and novel ground structure.

***Index Terms* — Wide-band Antennas, MIMO antenna, Polarization, Port isolation.**

I. INTRODUCTION

Recently, the multi-band or broadband antennas have attracted intense interest in antenna design for wireless communication systems [1, 2]. The planar monopole antenna is a good candidate because of its simple structure, low cost, and easy-to-manufacture characteristics. There are also many published studies on antenna designs for wireless local area network (WLAN) and World Interoperability for Microwave Access (WiMAX) at 2.4 GHz (2.4–2.48GHz), 3.5 GHz(3.4-3.6 GHz), and 5 GHz (5.15–5.85GHz) bands [3, 4].

Many 802.11n wireless products, which utilize the multi-band or broadband antennas, are in fact available in the marketplace [5, 6], and some of them utilized multi-input multi-output (MIMO) technology on their designs [7, 8]. Numerous research papers on MIMO antennas embedded in mobile devices, i.e. the client end, have also been reported [9]. However, only a few studies, which address access-point (AP) application, i.e., the server end, were published [10]. In this article, we present a MIMO antenna design, consisting of three antennas with 3-D metal structures, for AP applications.

Design and experimental results for the proposed MIMO antenna are presented in the following sections.

II. ANTENNA DESIGN

Fig. 1 shows the geometry of the proposed MIMO antenna. The system consists of three antennas denoted as ant-1, 2, 3 and are 120° apart. The three antennas are mounted on separated vertical ground planes, which sit on a horizontal hollowed triangular plane. The vertical ground size is about 50×40 mm^2. The antennas were all formed of a rectangular patch, which size was 41×20 mm^2 and bent for miniaturization purpose. The antennas were grounded by a fine metal piece for impedance matching, Fig. 1c. The MIMO antennas were each excited by a mini coaxial-line. The hollowed triangular ground was designed to achieve in-band isolation.

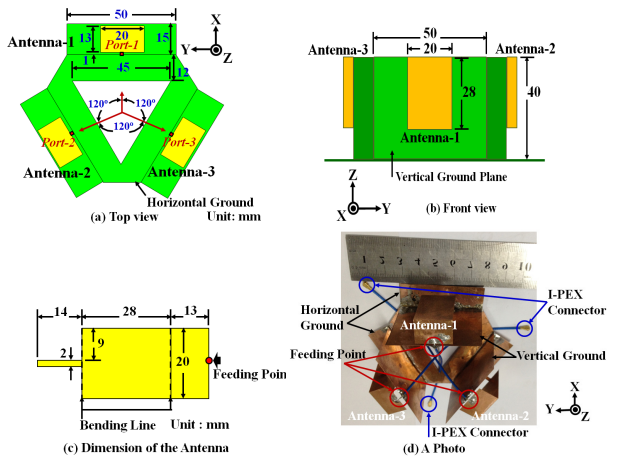

Fig. 1. Configuration, photo, and dimensions of the proposed antenna.

III. EXPERIMENT AND RESULTS

The measured return losses of the antennas are shown in Fig. 2. The antenna are shown to have good matching (S_{NN}) and isolation (S_{MN}) characteristics (S_{NN} < -10 dB and S_{MN}<-20 dB, M, N=1, 2, 3) over the frequency bands.

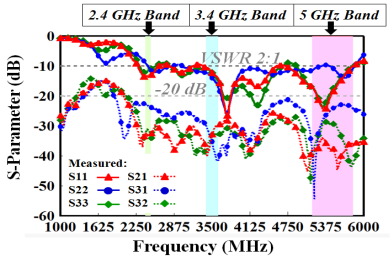

Fig. 2. Measured S-parameter (S_{NN}/S_{MN}) of the proposed MIMO antenna.

Figure 3 shows the far-field, 2-D radiation patterns at the 2.44, 3.5, and 5.25 GHz for antennas 1. Specifically, the figure demonstrates polarization diversity in the radiation patterns of antenna 1 at the operating bands. In this design, three antennas are spaced 120° apart; therefore, their main beams would also be 120° apart. This polarization also results in superb isolation for the MIMO antenna system.

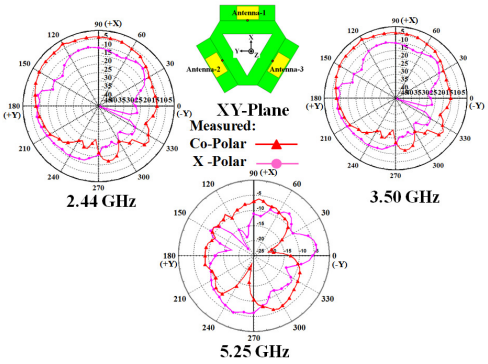

Fig. 3. Measured 2-D radiation patterns at 2.44, 3.5, and 5.25 GHz bands for antenna 1.

Figure 4 shows the peak gain and the antenna radiation efficiency for the proposed antenna (ant-1). The measured peak gain varied from 3 to 5 dBi, and the radiation efficiency is greater than 80 %. In Figure 5, measured Envelope Correlation Coefficient (ECC, ρ_e) among the three antennas is shown. It was obtained using a Bluetest reverberation chamber. ECC was less than about 0.03 in the operation band, up to the measurement capability.

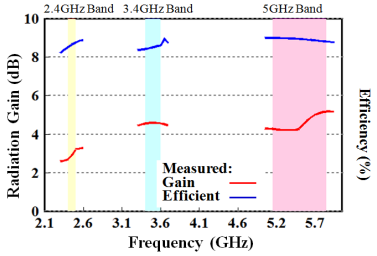

Fig. 4. Measured antenna gain and radiation efficiency for the proposed antenna.

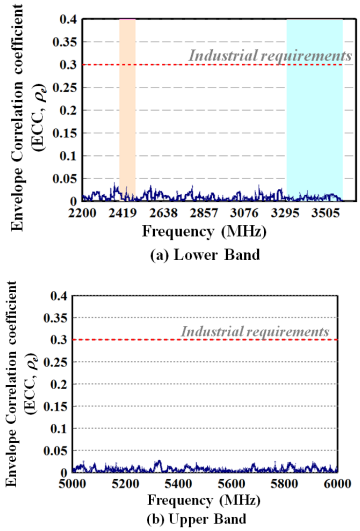

Fig. 5. Measured Envelope Correlation Coefficient (ECC) for the proposed antenna.

IV. Conclusion

A novel wide-band MIMO antenna system with high port isolation is proposed. The antenna consists of three antennas for MIMO AP applications. They sit on a vertical ground attached to a hollowed, triangular, horizontal ground designed to achieve high in-band isolation. The antenna has a unique feed structure, i.e., a shorted, inverted wide L (iWL).

The antenna have good matching and isolation characteristics (S_{NN} < -10 dB and S_{MN}<-20 dB, M, N=1, 2, 3) over a wide frequency range of 2.3-5.9 GHz. The antenna yields peak gains varied from 3 to 5 dBi, and antenna radiation efficiency were about 80~90 % at the operation bands. The antenna port Envelope Correlation Coefficient (ECC) was less than about 0.03. Moreover, the antenna is easy to fabricate and suitable for any access point (AP, i.e., hot spot) applications at the WLAN/WiMAX bands.

Acknowledgment

The authors wish to acknowledge the support of Taiwan's National Science Council through the grants of NSC 101-2221-E-110-075, NSC 101-2632-E-230-001-MY3, and NSC 102-2221-E-110-013-MY3.

References

[1] J. Cao, X. Zhao, C. Liu, and L. Yan, "A Planar Compact Triple-Band Monopole Antenna for WLAN/WIMAX Applications," Progress in *Electromagnetic Research Letters*, Vol.29, 2012, pp. 15-23.

[2] J.A. Ansari, et al., "Compact Triple U-Shaped Slot Loaded Circular Disk Patch Antenna for Bluetooth and WLAN Application," International Journal of *Microwave and Optical Technology*, Vol.6, No.2, 2011, pp. 91-99.

[3] V. Niranjan, A. K. Saxena, and K. V. Srivastava, "CPW-Fed Slot Patch Antenna for 5.2/5.8 GHz WLAN Application," *PIERS* Proceedings, Kuala Lumpur, Malaysia, March 27-30, 2012, pp. 1350-1352.

[4] H. S. Ding, Z. Q. Li, and P. Gao, "An Ultra-Compact Dual-Band Antenna with Tuning Arms for WLAN Applications," Progress in *Electromagnetic Research Letters*, Vol. 21, 2011, pp. 109-117.

[5] J. K. H. Gamage, M. Engjom, and I. A. Jensen, "Design of a low profile multi-band antenna for vehicular communication system," Proceedings of *7th European Conference on Antennas and Propagation* (EuCAP), 2013, pp. 1273-1277.

[6] M. Park, T. Son, and Y. Jo, "Hybrid Antenna Suitable for Broadband Mobile Phone MIMO System," Proceedings of *the International Symposium on Antennas & Propagation* (ISAP), 2013, pp.111-114.

[7] J.-H. Chou and S.-W. Su, "Internal Wideband Monopole Antenna for MIMO Access-Point Applications in the WLAN/WiMAX Bands," Progress in *Microwave and Optical Technology Letters*, Vol.50, No.5, 2008, pp. 1146-1148.

[8] S.-M. Wang, L.-T. Hwang, F.-S. Chang and C.-F. Liu, "Design of high port isolation access point MIMO system using centrally located hexahedron," Progress in *Electronics Letters*, Vol.50, No.4, 2014, pp. 248-249.

[9] W.-J. Liao, T.-G. Ma, C.-F. Yang, and H.-W. Liu, "Novel Antenna Designs for Applications in Modern Wireless Communication Systems," Proceedings of *7th European Conference on Antennas and Propagation* (EuCAP), 2013, pp. 380-384.

[10] S.W. Su, "High-gain, short-circuited six-monopole-antenna system for concurrent, dual-band WLAN access points," Progress in *Microwave and Optical Technology Letters*, Vol.52, 2010, pp. 2728–2732.