Design of Dual-Band MIMO Antennas with Isolation Enhancement

Ching-Lieh Li*, Yu-Feng Shih and **Yen-Ting Wu**
Department of Electrical and Computer Engineering, Tamkang University,
Tamsui, New Taipei City, Taiwan, 25137
Email: li@ee.tku.edu.tw, see0207@hotmail.com, wubachee@gmail.com

Abstract: In this paper, we propose a planar dual-band MIMO antenna with improved isolation for WLAN applications (2.45 GHz and 5~6 GHz). The MIMO antenna consists of two antenna elements that are perpendicularly placed in order to achieve the polarization diversity for the high band, such that the coupling between the antenna elements can be reduced. On the other hand, additional slot cut on the common ground plane is introduced to further enhance the isolation for the low band. Simulated and experimental results show that the proposed techniques can effectively inhibit the coupling.

1. Introduction

The multiple-input multiple-output (MIMO) technology had been used in various applications, such as the WiFi and the 4G LTE, to achieve the high-speed transmission. In other words, MIMO is a key technology to significantly improve the network capacity and data throughput, while preserving the limited spectrum resources. This, in turn, issues a challenge for the antenna size and the isolation between antenna elements [1-2].

The mutual coupling refers to the transfer of energy from one radiating element to other radiating elements. Substantially, the closer the two radiating elements get, the more the coupling increases; and hence reduces the total radiation efficiency, especially for those having a common ground plane [3]. The development and design of a high isolation (and/or decoupling) MIMO antenna system is now an interested area of researchers [4-6].

A number of techniques had been used to enhance the isolation between the antennas. They, in general, can be classified into two categories: 1) blocking methods, the mutual coupling is blocked to reduce the amount; 2) cancelling methods, via the introduction of an additional coupling path to cancel the original mutual coupling. Apparently, they are the use of defected ground plane [7], resonator structure [8], decoupling structure [9], neutralization strip [10], antenna orientation [11] , etc.

In this paper, we propose a planar dual-band MIMO antenna with improved isolation for WLAN applications (2.45 GHz and 5~6 GHz). The MIMO antenna consists of two antenna elements that are perpendicularly placed in order to achieve the polarization diversity for the high band, such that the coupling between the antenna elements can be reduced. On the other hand, additional slot cut on the common ground plane is introduced to further enhance the isolation for the low band.

2. Antenna Structure and Experimental Results

As shown in figure1, the MIMO antenna consists of two antenna elements. Each element consists of two antenna components: one is a narrow slit antenna (for low band 2 4GHz) the other is a dipole antenna (for high band 5~6GHz). These two antenna elements are perpendicularly shared the same ground (white)

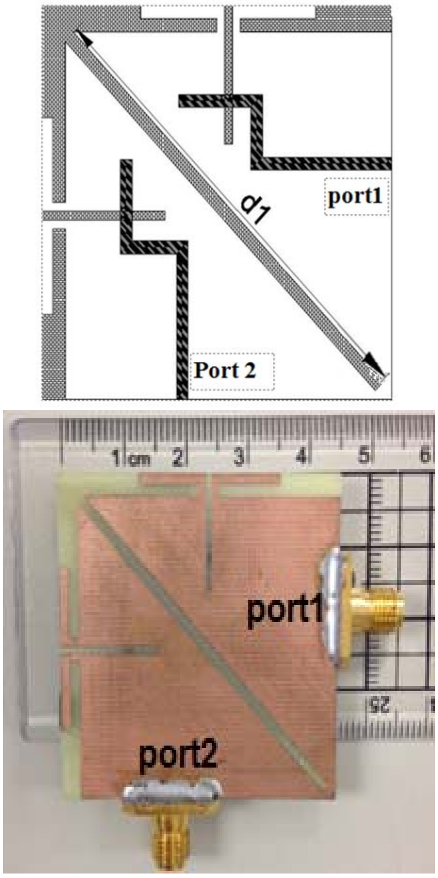

Figure 1 The schematic (top) and the photo (bottom) of the MIMO antenna structure.

The MIMO antenna is made using FR4 board of size 44x44mm^2 and thickness 0.8mm. The black line is the microstrip feed line. A slot cut (of length d1 and width 1.41mm) on the common ground plane is introduced.

Figure 2 shows the S parameters vs. d1 (d1:0mm~56.57mm) for the low band(2.4~2.5GHz). It should be noted that the ground plane is cut into two halves as d1=56.57. It is observed that S21 is about -10dB when d1=0mm or d1=56.57mm. In additions, |S21| is the lowest and isolation is the best as d1=56.15mm.

Figure 3 shows the S11 and S21 results of the proposed MIMO antennas. The simulated and measured results compared quite well. The measured |S21| is about -22dB for the low band (2.4~2.5GHz) and -26dB for the high band (5~6GHz).

Table 1 shows the measured antenna gain 3.5~6dBm and the efficiency 52%~79% for the proposed antenna.

3. Conclusion

It is thus confirmed that the proposed techniques can effectively inhibit the coupling to avoid mutual coupling of the MIMO dual-band antenna elements. In general, the antenna design is able to meet the demands of |S11|<-10dB and |S12|<-20dB for S parameters, efficiency >50%, while its scope of application covers IEEE (802.11a / b / g / n / ac) WLAN bands.

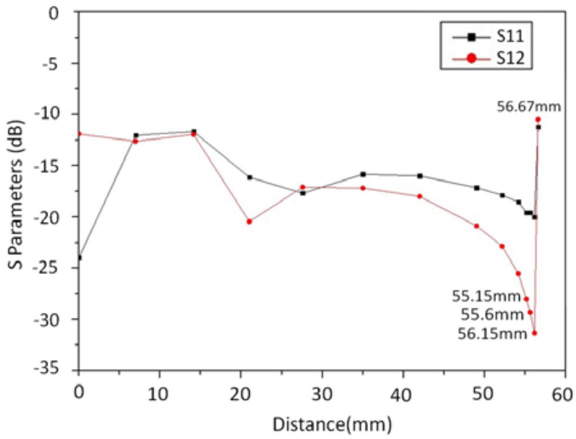

Figure 2 ｜S11｜& ｜S21｜ vs the slot length (d1)

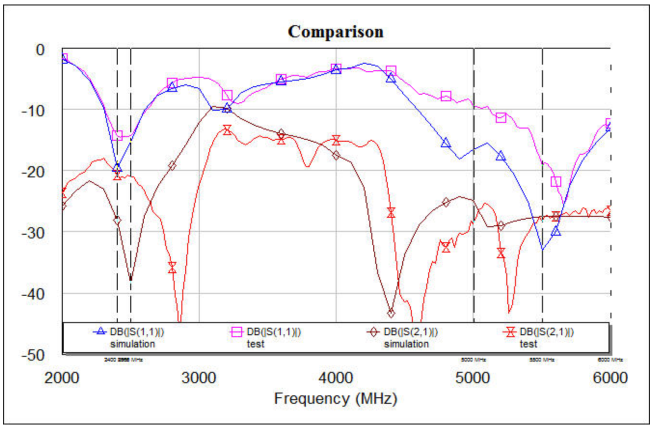

Figure 3 The S11 and S21 details of the MIMO antennas

Table 1: The measured gain and efficiency

Frequency (MHz)	Port1		Port2	
	Gain (dBi)	Efficiency (%)	Gain (dBi)	Efficiency (%)
2400	4.5224	52.726	3.5089	60.234
2500	3.8519	53.004	3.6503	59.954
5000	4.0172	68.973	3.7771	66.149
5500	4.3694	68.430	4.5519	73.018
6000	6.0639	79.165	5.5570	78.535

References

[1] J. W.Wallace, M. A. Jensen, A. L. Swindlehurst, and B. D. Jeffs, “Experimental characterization of the MIMO wireless channel: Data acquisition and analysis,” IEEE Trans. Wireless Commun., vol. 2, pp. 335–343, Mar. 2003.

[2] Wireless LAN specification to provide significantly improved data throughput and range, The IEEE Standard Association [Online] Available: http://www.ieee.org/about/news/2009/11september.html

[3] M. Han and J. Choi, “Multiband MIMO antenna with a band stop filter for high isolation characteristics,” Antennas and Propagation Society International Symposium, 2009, pp. 1-4.

[4] Z. Li and Y. Rahmat-Samii, “Optimization of PIFA-IFA combination in handset antenna designs,” IEEE Trans. Antennas Propag., vol. 53, pp. 1770–1778, May 2005.

[5] K.-C. Chim, K. C. L. Chan, and R. D. Murch, “Investigating the impact of smart antennas on SAR,” IEEE Trans. Antennas Propag., vol. 52, pp. 1370–1374, May 2004.

[6] O. Kivekäs, J. Ollikainen, T. Lehtiniemi, and P. Vainikainen, “Effect of the chassis length on the bandwidth, SAR, and efficiency of internal mobile phone antennas,” Microwave Opt. Technol. Lett., vol. 36, no. 6, pp. 457–462, Mar. 20, 2003.

[7] D. Ahn, J. S. Park, C. S. Kim, J. Kim, Y. Qian, and T. Itoh, “A design of the low-pass filter using the novel microstrip defected ground structure,” IEEE Microw. Theory Tech., vol. 49, no. 1, pp. 86–93, Jan. 2001.

[8] S.Yoo; S.Kahng, “A Compact MIMO Antenna using ZOR Split Ring Resonator Radiators with a Decoupling Structure,” Microwave journal, vol. 54, no. 11, pp. S26-S31, November,2011.

[9] S.-C. Chen, Y.-S.Wang, and S.-J. Chung, “A decoupling technique for increasing the port isolation between two strongly coupled antennas,” IEEE Trans. Antennas Propag., vol. 56, no. 12, pp. 3650–3658, Dec. 2008.

[10] S. Su, C. Lee, and F. Chang, “Printed MIMO-Antenna System Using Neutralization-Line Technique for Wireless USB-Dongle Applications,” IEEE Transactions on Antennas and Propagation, vol. 60, no. 2, pp. 456-463, 2012.

[11] M. Karaboikis, C. Soras, G. Tsachtsiris, and V. Makios, "Compact dual-printed inverted-F antenna diversity systems for portable wireless devices," IEEE Antennas and Wireless Propagation Letters, vol. 3, no. 1, pp.9-14, 2004.