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Dual-Band MIMO Antenna with High Isolation Application by Using Neutralizing Line

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Abstract—In this letter, a dual-band Multiple Input Multiple Output (MIMO) antenna system with high isolation is presented. This design consists of two dual-band monopole antennas and neutralizing transmission line. For each antenna element, the operating frequency band covers from 2.4 GHz to 2.6 GHz and 5.2 GHz to 6 GHz. To improve the isolation between these two antenna elements spacing only $0.1225\lambda_0$ at 2.45 GHz, a neutralization decoupling transmission line is introduced. The measured return loss results of these two antennas are better than 10-dB in operating frequency band. The measured isolation between the two antennas is better than 15 dB. The envelope correlation coefficient (ECC) is smaller than 0.01 of whole operating frequency band. The peak gain of this design is better than 2 dBi in operating bands. This configuration can be applied for Wireless local area network (WLAN), WiMAX and Bluetooth communication system.

1. INTRODUCTION

In recent years, wireless communication systems require much higher data rates to accommodate various multimedia services. For the requirement of high bit error rate (BER) wireless communication with high channel capacity and reliability, multiple-input multiple-output (MIMO) system is a preferred approach. In the multifunctional wireless communication application, MIMO antenna system should have compact structure and high isolation.

Since MIMO antenna system requires high isolation, several techniques have been proposed to enhance isolation between the elements of a MIMO antenna system. Metallic electromagnetic band gap (EBG) structures on the substrate of the antennas have been demonstrated to improve the isolation by [1]. The defect ground system (DGS) on the ground plane is also an approach to enhance isolation presented by [2]. Adding the parasitic elements in the MIMO structure is another effective method proposed by [3]. Recently, a new approach called neutralization technique has been presented for mobile applications [4, 5]. With the neutralization method, the isolation can be improved since the current of the element antennas of MIMO is neutralized.

In this letter, a MIMO antenna structure is presented with the neutralization technique to achieve high isolation between the signal ports. Each antenna element is monopole; meanwhile, the spacing of these two elements is only about $0.1225\lambda_0$ at 2.45 GHz. According to the measurement results, the proposed MIMO can cover 2.45 GHz band (2.4 GHz–2.4835 GHz), 5.2 GHz band (5.15 GHz–5.35 GHz) and 5.8 GHz band (5.725 GHz–5.825 GHz). The isolation is better than 15 dB with the MIMO structure size only $0.16\lambda_0 \times 0.32\lambda_0$ at 2.45 GHz.

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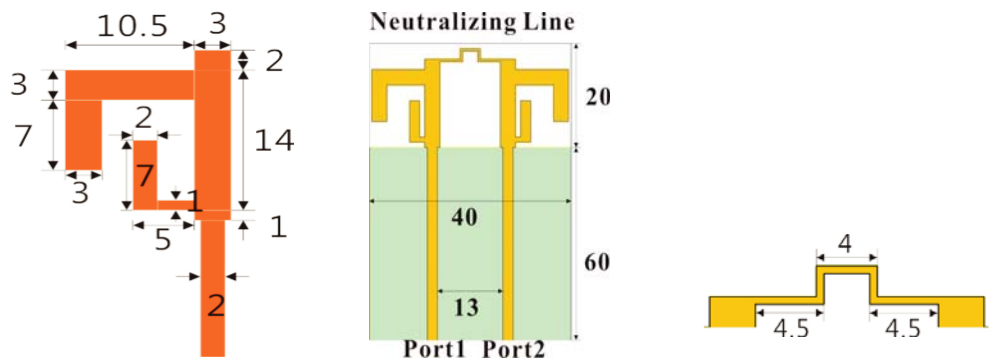
2. ANTENNA DESIGN

The structure of the proposed printed MIMO antenna system is displayed in Fig. 1. As shown in Fig. 1(a), the antenna element is the single monopole antenna. The design concept is based on a simple C-shaped dual-band monopole antenna which has two current paths to generate two operating bands. As proposed in [7–10], the compact multi-band monopole antennas are usually the meander type structures such as S-shaped, F-shaped and C-shaped ones. These antenna configurations can provide multiple current paths to generate multiband operation.



(a) monopole (b) MIMO (c) neutralizing

Figure 1. The structure of proposed MIMO (unit: mm).

In this work, the proposed MIMO is fabricated on an FR-4 substrate, with dielectric constant of $\epsilon_r = 4.4$, dielectric loss tangent of $\tan\delta = 0.02$ and thickness of $h = 1.6$ mm. The area which the two antennas occupied is $20 \times 40\,\mathrm{mm}^2$, and the ground plane of the MIMO antenna system is rectangular with size of $60 \times 40\,\mathrm{mm}^2$. Fig. 1(b) displays the entire MIMO structure. The spacing of these two antenna elements is only about $0.1225\lambda_0$ at 2.45 GHz. The detailed dimension of the neutralizing line is shown in Fig. 1(c). The unit is millimeter for all the values. The neutralizing line is added to improve the isolation between these two antennas in the rather small spacing since it can be seen as an inductance to neutralize the capacitance of these two antennas. Fig. 2 demonstrates the comparison result of the cases with and without neutralizing line technology. According to the results, the isolation can be improved to better than 15 dB by utilizing neutralizing line in MIMO system.

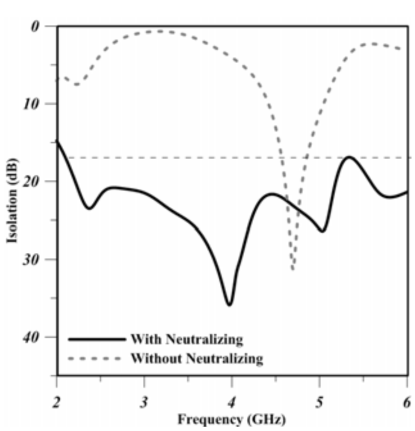
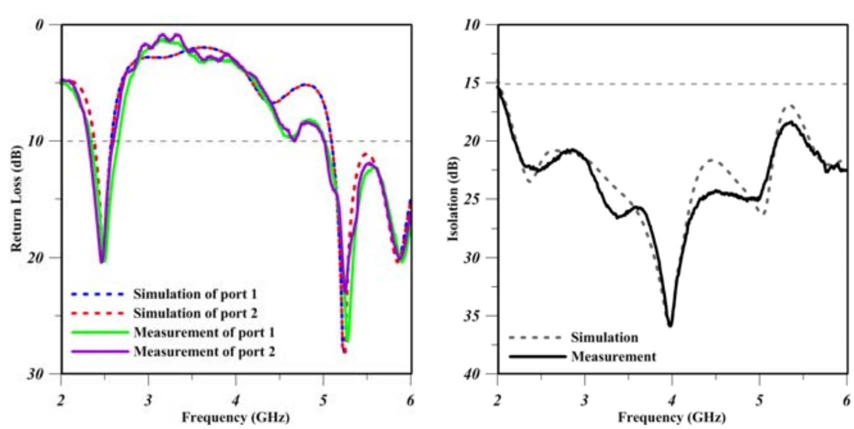


Figure 2. The simulated isolation of the cases which are with and without neutralizing line technology.



(a) Return loss (b) Isolation

Figure 3. Comparison return loss and isolation of simulated and Measured results.

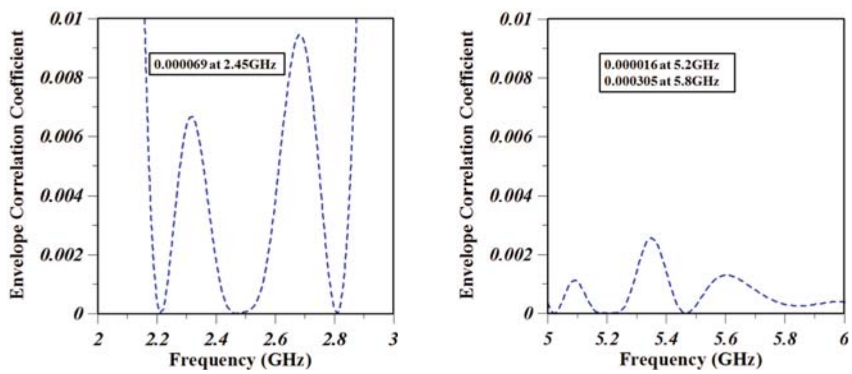
3. MEASUREMENT RESULTS

The return loss and isolation results of the simulation and measurement are displayed in Fig. 3. According to the results, the impedance bandwidth includes 2.45 GHz band (2.4 GHz–2.4835 GHz), 5.2 GHz band (5.15 GHz–5.35 GHz) and 5.8 GHz band (5.725 GHz–5.825 GHz), which can be applied to Bluetooth, WLAN and WiMAX systems. Meanwhile, the isolations between these two monopole antennas are better than 17 dB at 2.45 GHz bands and 20 dB at 5.2 GHz and 5.8 GHz bands by using the neutralizing line to decrease the coupling effect of these two antennas.

For MIMO antenna system, the envelope correlation coefficient (ECC) is a significant parameter. Generally, the ECC is used to evaluate the diversity capability of a multi-antenna system. The ECC can be computed from the S-parameters using the following formula: [6]

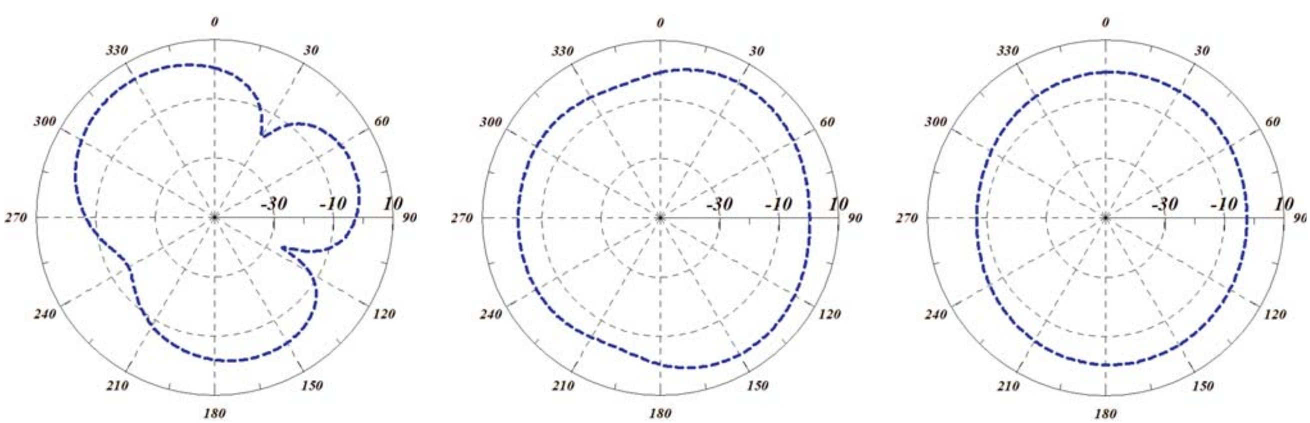
$$\rho_e = \frac{|S_{11}^* S_{12} + S_{21}^* S_{22}|^2}{(1 - (|S_{11}|^2 + |S_{21}|^2))((1 - (|S_{22}|^2 + |S_{12}|^2))} \tag{1}$$

Figure 4 shows the ECC of the proposed MIMO antenna structure. For antenna diversity, the acceptable value of the envelope correlation coefficient is less than 0.01. In this design, the ECC is only 0.000069 at 2.45 GHz which is shown in Fig. 4(a). Meanwhile, the ECCs displayed in Fig. 4(b) are merely about 0.000016 and 0.000305 at 5.2 GHz and 5.8 GHz, respectively. The measurement radiation pattern results of these three operating frequency bands are shown in Fig. 5, Fig. 6 and Fig. 7, respectively. According to these results, the radiation pattern is near the omni-direction pattern for these three



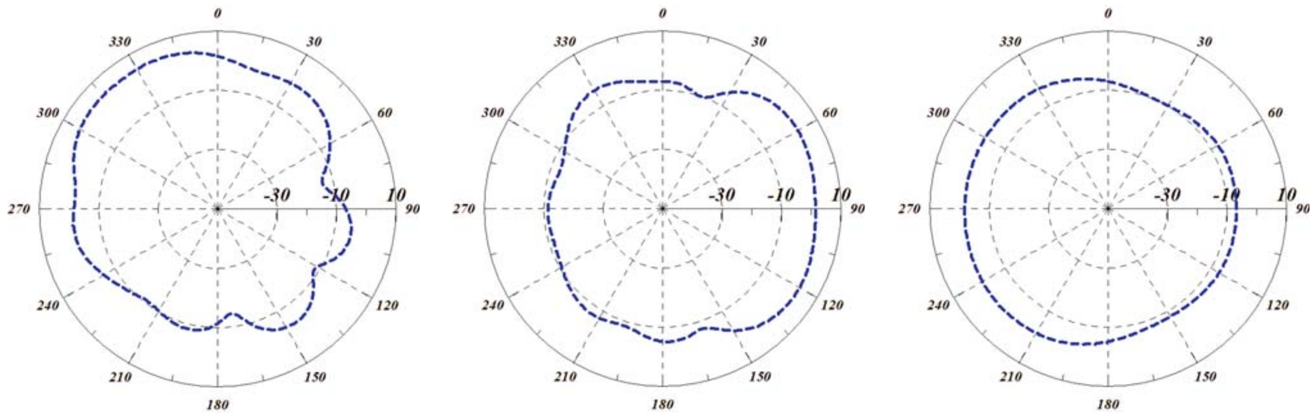
(a) 2 GHz band (b) 5 GHz band

Figure 4. Envelope correlation coefficient.



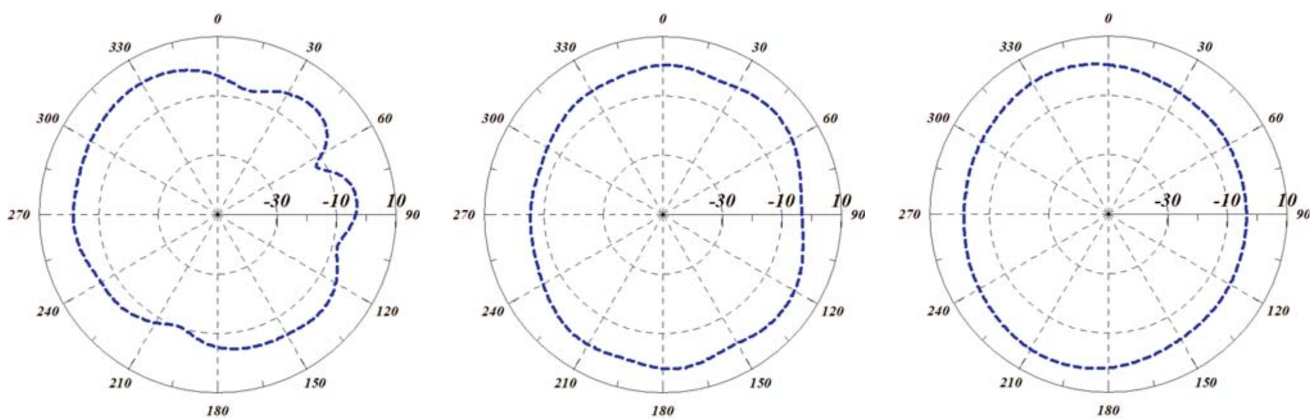
(a) *XY*-plane (b) *XZ*-plane (c) *YZ*-plane

Figure 5. Measured radiation pattern of 2.45 GHz.



(a) *XY*-plane (b) *XZ*-plane (c) *YZ*-plane

Figure 6. Measured radiation pattern of 5.2 GHz.



(a) *XY*-plane (b) *XZ*-plane (c) *YZ*-plane

Figure 7. Measured radiation pattern of 5.8 GHz.

operating bands. The peak gain of the proposed MIMO antenna system is 2 dBi at 2.45 GHz, 4 dBi at 5.2 GHz and 3 dBi at 5.8 GHz.

4. CONCLUSION

In this letter, a dual-band MIMO antenna system with high isolation is proposed. The high isolation is achieved by using the neutralizing line between the two antenna elements at these operating bands. The two antenna elements are only spacing about $0.1225\lambda_0$ at 2.45 GHz. Measurement results show that the operating frequency bands can cover 2.45 GHz, 5.2 GHz and 5.8 GHz bands with isolation better than 15 dB for each desired band. The antenna gain is better than 2 dBi at operating frequency band. Furthermore, this proposed MIMO structure also has high diversity gain since it has extremely low envelope correlation. This design is suitable for wireless communication systems such as WLAN, WiMAX and Bluetooth.

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REFERENCES

1. Yang, F. and Y. Rahmat-Samii, "Microstrip antennas integrated with electromagnetic band-gap (EBG) structures: A low mutual coupling design for array application," *IEEE Trans. on Antennas and Propagat.*, Vol. 51, No. 10, 2936–2946, 2003.
2. Salehi, M., A. Motevasselian, A. Tavakoli, and T. Heidari, "Mutual coupling reduction of microstrip antennas using defected ground structure," *10th IEEE Singapore International Conference on Communication systems, ICCS 2006*, 1–5, Singapore, Oct. 2005.
3. Li, Z., Z. Du, and K. Gong, "A dual-slot diversity antenna with isolation enhancement using parasitic elements for mobile handsets," *Asia-Pacic Microwave Conference, APMC*, 1821–1824, Singapore, Dec. 2009.
4. Diallo, A., C. Luxey, P. L. Thuc, R. Staraj, and G. Kossiavas, "Enhanced two-antenna structures for universal mobile telecommunications system diversity terminals," *IEE Proceedings Microwaves, Antennas and Propagation*, Vol. 2, No. 1, 93–101, 2008.
5. Luo, Q., J. R. Pereira, and H. M. Salgado, "Reconfigurable dual-band C-shaped monopole antenna array with high isolation," *Electon. Lett.*, Vol. 46, No. 13, 888–889, 2010.
6. Blanch, S., J. Romeu, and I. Corbella, "Exact representation of antenna system diversity performance from input parameter description," *Electon. Lett.*, Vol. 39, No. 9, 705–707, 2003.
7. Tsai, C-.C, W.-C. Hsia, and C.-Y. Huang, "S-shaped monopole antenna for dual-band WLAN applications," *Asia-Pacic Microwave Conference, APMC*, 1–3, Bangkok, Thailand, Dec. 2007.
8. Li, F., L.-S. Ren, G. Zhao, and Y.-C. Jiao, "Compact triple-band monopole antenna with C-shaped and S-shaped meander strips for WLAN/WiMAX applications," *Progress In Electromagnetics Research Letters*, Vol. 15, 107–116, 2010.
9. Lu, J.-H. and Y.-S. Cai, "Planar compact multi-band C-shape monopole antenna with inverted L-shape parasitic strip for WiMAX applications," *Progress In Electromagnetics Research C*, Vol. 20, 17–29, 2011.
10. Yao, J., F.-S. Zhang, X. Q. Jiao, and H. Bai, "Tri-band slotted F-shaped antenna with dual-polarization characteristics for WLAN/WiMAX applications," *Progress In Electromagnetics Research Letters*, Vol. 40, 181–190, 2013.