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CPW-Fed Dual-Band MIMO Antenna with Common Radiating Element

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Abstract—A novel CPW-fed dual-band multiple-input multiple-output (MIMO) antenna with a common radiating element for WiMax/3.5G and WLAN/5.8G is proposed in this paper. The proposed MIMO antenna which has dimensions of 30 mm × 30 mm × 1.6 mm consists of an irregular ring-shaped ground plane and a shared radiating element. Furthermore, this MIMO antenna has a good performance in the port isolation by using a T-shaped structure and four slots on the ground. The measured bandwidths of the designed MIMO antenna are 3.32–3.74 GHz and 5.45–6.05 GHz. In the meantime, the measured isolation of the MIMO antenna is higher than 20 dB in both bands.

1. INTRODUCTION

The demand for increased channel capacity and higher data rate in wireless and mobile communication has been rapidly increasing. Besides, high radiation efficiency and low cost should also be focused on. To achieve these requirements, MIMO technology is employed. By placing multiple antennas at transferring and receiving terminals in the system, multiple parallel wireless routes are produced. So higher channel capacity and data rate can be achieved without extra power or spectrum [1].

In [2], an MIMO antenna using a T-shaped common grounding element is designed. The proposed MIMO antenna works for Mobile WiMax service including two radiating elements. [3] shows a dual-broadband MIMO antenna (includes GSM1800/1900, UMTS2000, LTE2300/2600, and WLAN2.4/5-GHz), which consists of an outer loop coupled by an inner loop. And the isolation of the antenna is higher than 15 dB. Chung and Yoon provide a novel integrated MIMO antenna with low mutual coupling characteristic among [4]. In the test, good impedance matching and enhanced isolation performances of the MIMO antenna are observed. In [5], the technology of connecting neutralization line is provided to improve the isolation performance. In addition to this technology, researchers have also summarized many other effective methods for improving the isolation characteristic of the antenna, such as half-wavelength slot etched ground [6], lumped component [7], protruded ground branch [8], etc.

In this paper, we use a creative structure called common radiating elements to design a CPW-fed dual-band MIMO antenna, which can guarantee better performances.

2. ANTENNA DESIGN

Figure 1 exhibits the construction of the designed antenna which is designed on a low-cost 1.6 mm-thick FR-4 substrate with the whole size of $30 \times 30\,\mathrm{mm}^2$. The relative permittivity and loss tangent of FR-4 substrate are 4.4 and 0.02. It contains a trapezoidal structure of radiating elements and an irregular ring-shaped ground plane. Obviously, the two ports of the radiators are fed by coplanar waveguide (CPW).

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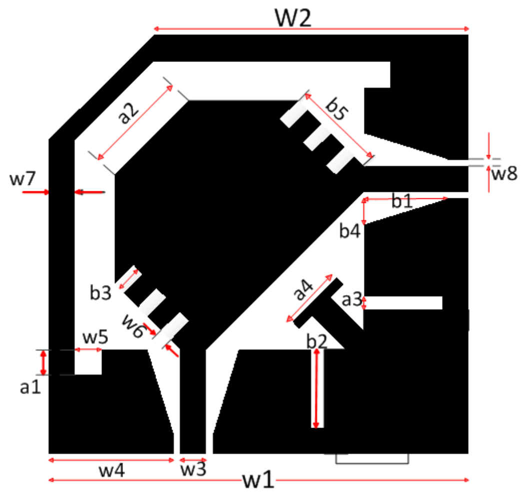


Figure 1. Geometry of CPW-fed MIMO antenna.

Table 1. Parameters of the MIMO antenna.

parameters	$w1$	$w2$	$w3$	$w4$	$w5$	$w6$	$w7$	$w8$	
Value (mm)	30	22.2	2	6.6	0.5	1	2	0.9	
parameters	$a1$	$a2$	$a3$	$a4$	$b1$	$b2$	$b3$	$b4$	$b5$
Value (mm)	1	12	0.5	5	4.1	4.5	2.5	1.3	6

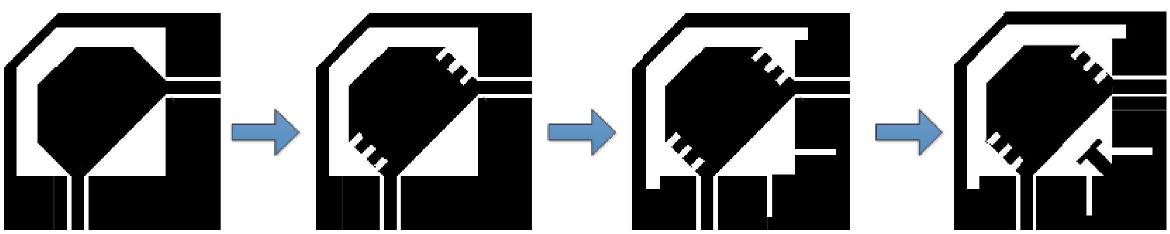
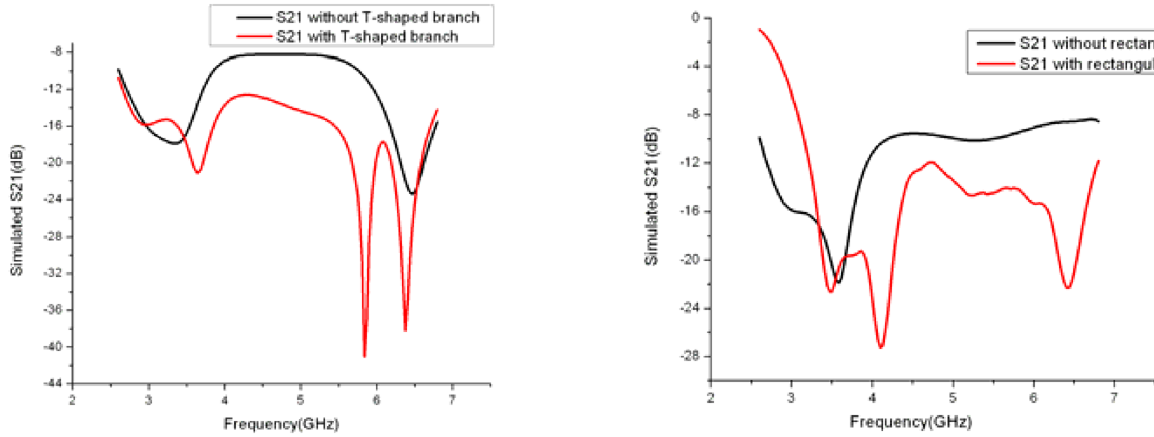


Figure 2. The process of this antenna design.

The trapezoidal structure of radiating elements can produce two frequency bands etched with six rectangular slots. By adjusting the length of the rectangular slots, the useful working frequency band of the MIMO antenna can be reached. At the same time, the isolation can be improved between 2 ports. There are four identical triangle slots near the two ports which further improve the matching of the antenna and an irregular ring-shaped ground plane which is beneficial to the matching of the antenna. Furthermore, we add a T-shaped branch and four rectangular slots which contribute to the isolation of the designed antenna. The whole antenna is symmetrical. By using the High-Frequency Structure-Simulator (HFSS), we can get suitable behaviours of the designed antenna and the detailed parameters of the MIMO antenna which are given in Table 1.

Figure 2 shows the process of this antenna design. At the beginning, the original MIMO antenna can create two frequency bands; however, these two frequency bands are not what we want. So we add six slots on the radiating element. Then in order to get good isolation of the antenna, we add four rectangular slots on the ground and a T-shaped branch. In Figure 3(a), we can find the differences of S_{21} in two curves. The T-shaped branch can clearly improve and adjust the isolation of the antenna. In Figure 3(b), we have set the MIMO antenna without four rectangular slots. Finally, we can conclude that four slots on the ground are useful, which can improve the isolation particularly in the high frequency band.



(a) (b)

Figure 3. Simulated S_{21} of the antenna, (a) with and without T-shaped branch on the ground, (b) with and without four rectangular slots on the ground.

3. EXPERIMENTAL RESULTS AND DISCUSSION

Based on the design model in Figure 1, the proposed antenna is fabricated whose prototype is shown in Figure 4. In this figure, the CPW-fed ports are linked with two 50-Ω SMA connectors. The return loss and isolation of the presented antenna are measured by the Agilent E8363B vector network analyser.

Through the testing of the designed antenna, Figure 5 shows the simulated and measured S-parameters of the proposed antenna. According to the measured results, the impedance bandwidth (defined by $|S_{11}| \leq -10\,\mathrm{dB}$) is 5.45–6.05 GHz and 3.32–3.74 GHz which can faultlessly cover the band of WLAN (5.725–5.825 GHz) and WiMax (3.40–3.69 GHz). In the meantime, as observed in Figure 5(b), the measured isolation is better than 20 dB in the working bands of WLAN and WiMax. These good measured results indicate that the presented antenna is suitable and useful for MIMO systems.

In the measurement of the radiation patterns of the presented antenna, port 1 of the designed antenna is excited, while port 2 is terminated with 50 Ω load, and vice versa. The final test results in 3.5 and 5.8 GHz are shown in Figure 6. From the results of the test, we have observed E-planes and H-planes at 3.5 and 5.8 GHz of the two ports. So we conclude that the designed antenna is useful. Figure 7 provides the peak gains of the proposed MIMO antenna. It can be seen that the peak gains are less than 1.5 dBi in the frequency band of the WiMax and less than 2.3 dBi in the frequency band of WLAN.

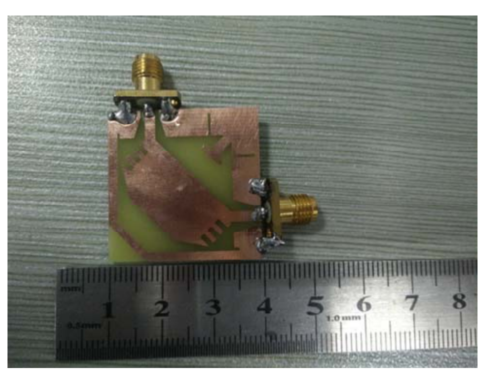
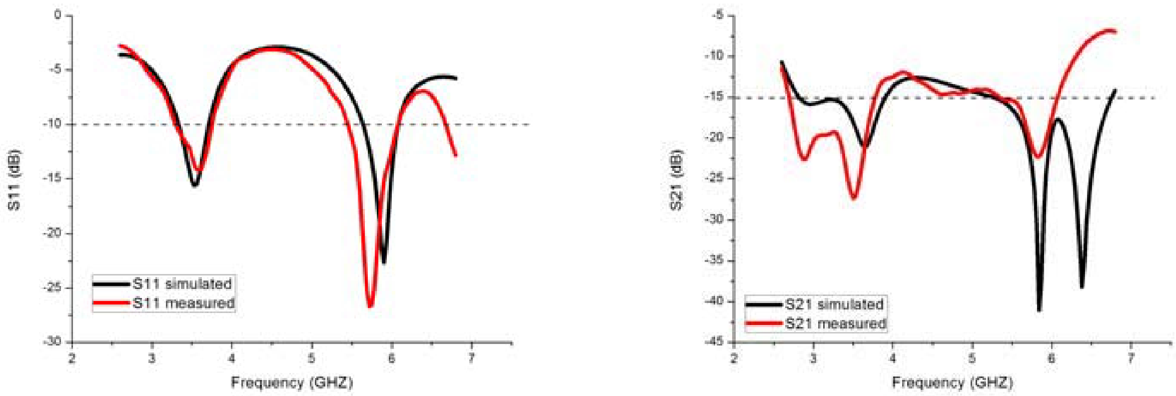
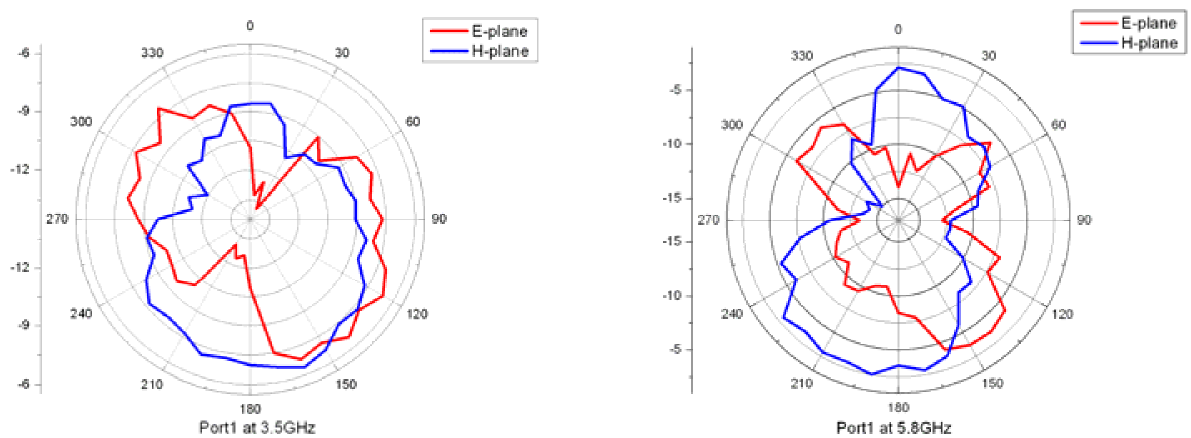


Figure 4. Photograph of the CPW-fed MIMO antenna.

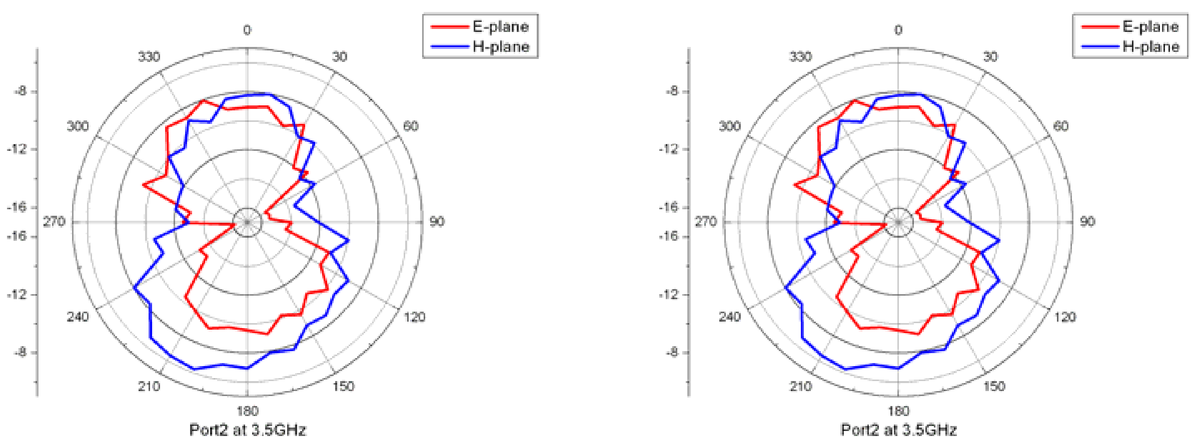


(a) (b)

Figure 5. Measured and simulated S-parameters of the designed antenna, (a) S_{11}, (b) S_{21}.



(a)



(b)

Figure 6. Measured radiation pattern of the proposed antenna at 3.5 and 5.8 GHz: (a) Port 1 at 3.5 and 5.8 GHz; (b) Port 2 at 3.5 and 5.8 GHz.

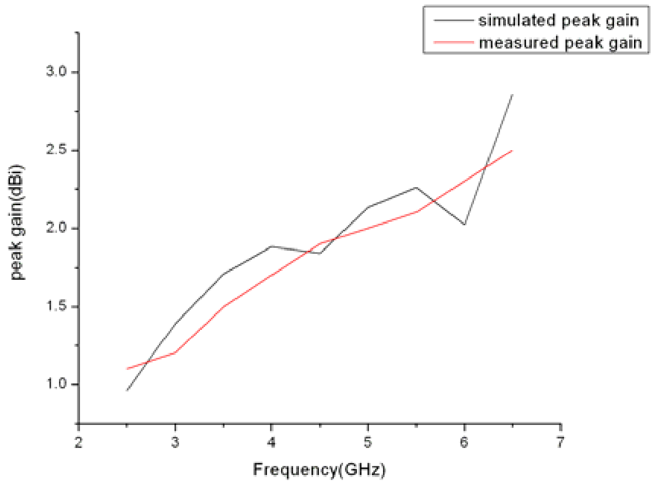


Figure 7. Measured and simulated peak gains.

4. CONCLUSION

In this letter, a novel dual-band MIMO antenna with a CPW-fed structure is proposed. The designed MIMO antenna has a creative structure which contains an irregular ring-shaped ground plane and a common radiating element with the size of 30 mm × 30 mm × 1.6 mm by using an FR4. This kind of antenna works well which can support the WLAN of 5.8G and WiMax of 3.5G, and its measured isolation is less than −20 dB in the band of the WLAN and WiMax. In addition, the antenna exhibits favorable radiation characteristics and stable gain across the effective working bands. Therefore, the designed CPW-fed dual-band MIMO antenna is suitable for wireless devices.

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