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A COMPACT DUAL-BAND PATCH ANTENNA FOR WLAN APPLICATIONS

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Abstract—A compact dual-band patch antenna is proposed and measured in this paper. The proposed antenna employs a U-shaped slot and two mitered corners to achieve two operating frequency bands, 2.30 $\sim$ 2.50 GHz and 4.50 $\sim$ 6.36 GHz, which meet the specifications of IEEE 802.11b/g/a standard for WLAN applications. Full wave analysis is performed to simulate the characteristics of the proposed antenna using CST microwave studio. Moreover, a fabricated prototype which has compact dimensions of 20.0 mm $\times$ 25 mm $\times$ 1 mm exhibits agreement between measured and simulated parameters and radiation patterns.

1. INTRODUCTION

Wireless local area network (WLAN) technology has been widely used for its mobile high-speed accessing. The standard for WLAN applications, IEEE 802.11b/g/a, covers frequency bands of 2.4 G–2.484 GHz, 5.15 G–5.35 GHz and 5.725 G–5.825 GHz. A challenge in designing such wireless communication systems is to design compact, low cost, multiband and broadband antennas [1]. Many designs of dual-band patch antenna have been demonstrated in recent years, and printed monopole antennas with all kinds of improvements to broaden frequency band or multiple resonances are very popular for such designs. For example, the antenna presented in [2] consists of a rectangular patch and straight strips with different length, and the antenna proposed in [3] comprises a direct-radiating patch and a parasitic C-shaped strip. Both of them cover multi bands. Modified Minkowski fractal geometry is used to get multiband frequency

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operations. Meanwhile a modified ground plane on the bottom layer furthermore improves the high frequency performances [4]. Compact slot patch antennas are used frequently to achieve multi bands [5–8]. Some CPW-fed monopole antennas also have been proposed to meet the dual-band requirements, such as G-shaped [9] and triangle-Shaped [10, 11]. Moreover, the triangle antenna with a cross-shape inside even covers the third band centered at 3.4 GHz which is useful for WiMAX [10]. Some planar inverted-F antennas (PIFA) have been investigated for WLAN applications [12–15]. However, those antennas usually use large ground and thick substrate. All these antennas perform well in the bandwidth and radiation characteristic, while a few of them have a relatively bigger size, and therefore are not easy to be integrated with miniaturized mobile communication devices.

A compact CPW-fed patch antenna with slots and mitered corners to meet the specifications of WLAN bands (lower band of 2.40 GHz–2.48 GHz and upper band of 5.15 GHz–5.80 GHz) is proposed. Characteristics of the proposed antenna are simulated using CST microwave studio. Finally, a prototype antenna is fabricated and measured. The experimental results demonstrate good performance of the antenna for WLAN applications.

2. ANTENNA DESIGN

The structure of the proposed antenna is shown in Fig. 1, and the optimized lengths of some parameters are shown in Table 1. This CPW-fed antenna is printed on a 20 mm × 25 mm substrate with relative permittivity of 2.65 and thickness of $h = 1$ mm. The width of the CPW center strip is 4.56 mm, and the gap between the center strip and grounds is 0.2 mm. There are two grounds with length of 4 mm lying symmetrically on each side of the center strip. Two kinds of slots are introduced and two bottom corners of the patch are cut off, in order to make the antenna operate at two bands of 2.40 GHz–2.48 GHz and 5.15 GHz–5.80 GHz well. All the slots have a width of 1 mm, and the dimension of parameters L_1, L_2, L_3 and L_4 are given in Table 1.

Figure 2 shows the current path sketched from CST. It can be seen that the U-slot makes the current path longer, which contributes

Table 1. Dimension of parameters used in the antenna structure.

Parameters	L_1	L_2	L_3	L_4	SW	SL
Dimensions (mm)	11.9	2	5	6.9	5.5	5.5

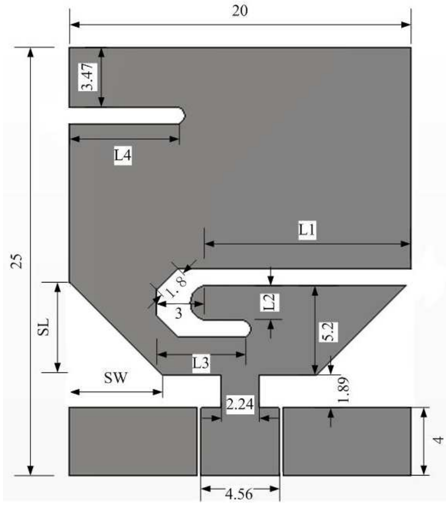

Figure 1. Top view of the antenna (unit: mm).

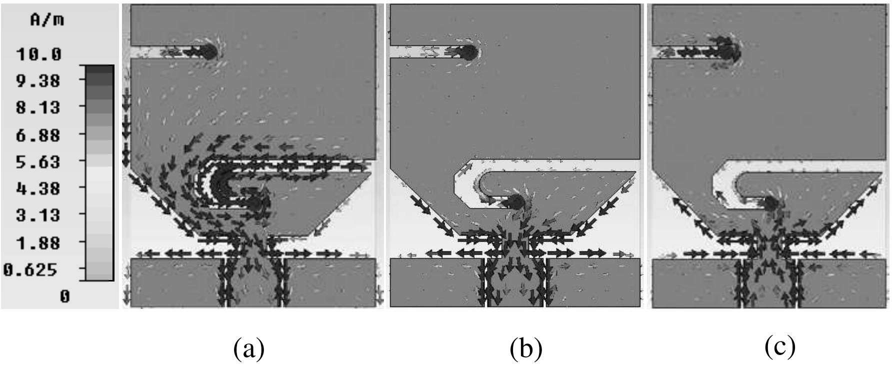

Figure 2. Current path, (a) 2.4 GHz, (b) 5.2 GHz, (c) 5.8 GHz.

mainly to the lower band of 2.30 GHz–2.50 GHz. Since only in-phase current contribute to the radiation, the two hypotenuse edges left by mitered corners contribute to the upper band of 4.50 GHz–6.36 GHz. Certainly the lengths of L_1, L_2, L_3 not only affect the resonance frequency by changing current path, but provide additional reactance which affect the input impedance. Those will be discussed later in the following section.

3. SIMULATED AND EXPERIMENTAL RESULTS

A prototype of the proposed antenna is manufactured (see Fig. 3) and its characteristics are measured. The results of return loss measured by Agilent Network Analyzer N5230 are shown in Fig. 4.

It can be seen from Fig. 4 that the measured return loss is worse than the simulated one at higher frequency band, and the resonance frequency for lower band is about 50 MHz offset from the simulated result. Those errors may be caused by manufacturing accuracy and wedding of SMA connector. However, the -10 dB return loss bandwidths of the prototype cover 2.25 GHz $\sim$ 2.48 GHz and 5.0 GHz $\sim$ 6.2 GHz, which meet the specification of WLAN bands.

The influence of top-left slot length L_4 on the return loss is shown in Fig. 5. It is obvious that the optimized length of L_4 is 6.9 mm. We can see from the plots that the top-left slot mainly affects the upper band, since the change of L_4 shown in Fig. 5 is relatively

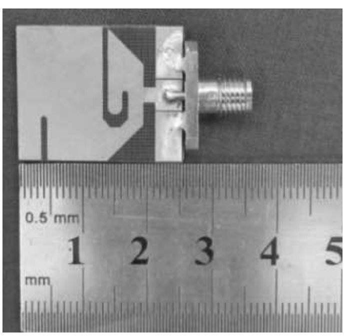

Figure 3. Prototype of the antenna.

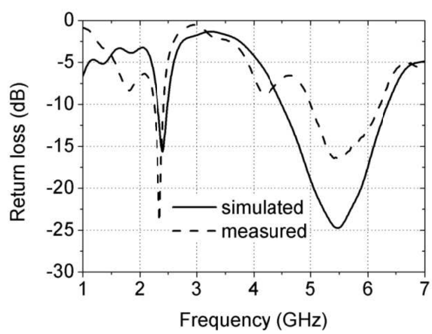

Figure 4. Measured and simulated return loss.

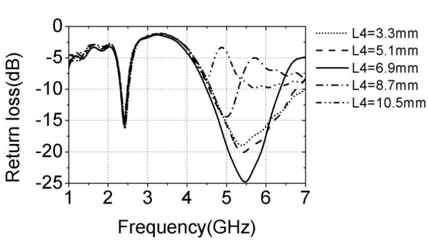

Figure 5. The influence of the top-left slot length on the return loss.

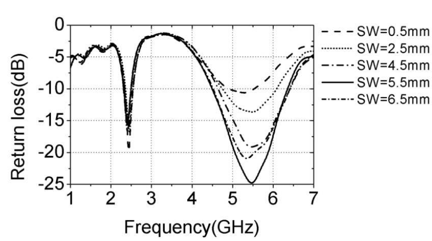

Figure 6. The influence of the SW on the return loss.

small compared to the wavelength of lower band. The slot provides a reactance whose characteristic (inductive or capacitive) depends on the length of L_4, so the return loss at the upper band gradually moves to the optimum and then begins to worsen when length of L_4 keeps increasing.

The effects of the mitered corners on return loss are investigated too and results are shown in Fig. 6. Here, no matter how the length of SW changes, the dimension of the hypotenuse edges is fixed to 7.8 mm in order to keep nearly a quarter wavelength current path for the upper band. Fig. 6 indicates that the optimized SW is 5.5 mm. The distance between the ground and radiation patch varies when SW changes, and therefore influences the coupling between the ground plane and the patch, resulting in a wider impedance bandwidth. Though the dimension of the top-left slot and the mitered corners influence return loss at upper band greatly, they have little effects on lower band.

The dimension of U-slot plays an important role for both lower and upper bands. Fig. 7 and Fig. 8 give the effects of L_1 and L_2 on the return loss. It can be seen that the resonance frequency of lower band increases as the length L_1 decreases gradually, while the bandwidth of upper band does not vary much. However, the change of length L_2 influences not only the lower band but the upper band.

Figure 9 shows both the measured and simulated far-field radiation patterns at the frequencies of 2.4 GHz, 5.2 GHz and 5.8 GHz. These results present good omni-directional patterns in H-plane, and bidirectional in E-plane. The simulated results are in agreements with experimental ones.

Figure 10 shows the simulated gain at lower band and upper band. We can see that the gain at the 2.4 GHz band is about 1.85 dBi, and rises as the frequency increases at the upper band.

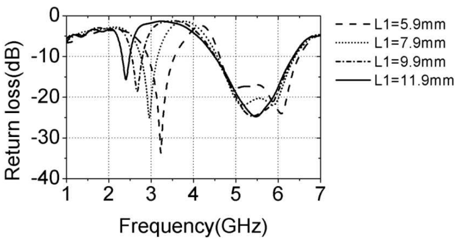

Figure 7. The effect of L_1 on the return loss ($L_2 = 2$ mm).

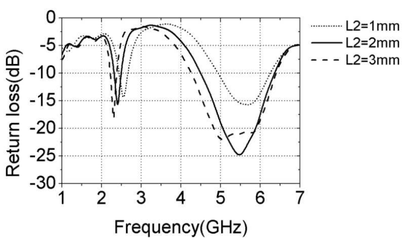

Figure 8. The effect of L_2 on the return loss ($L_1 = 11.9$ mm).

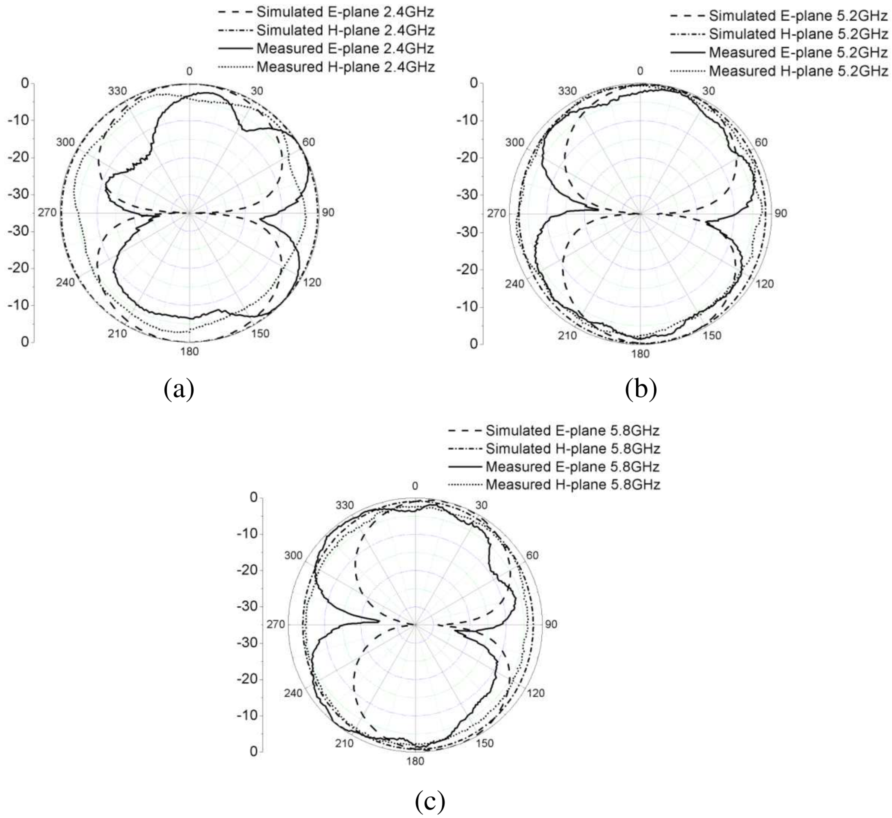

Figure 9. Measured and simulated radiation patterns, (a) 2.4 GHz, (b) 5.2 GHz, (c) 5.8 GHz.

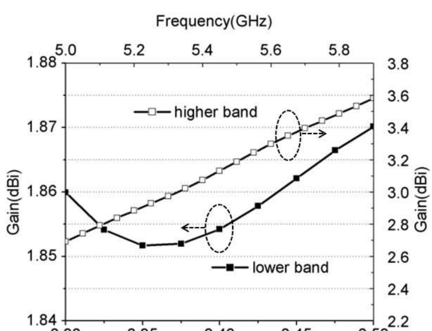

Figure 10. Gain of the proposed antenna.

4. CONCLUSION

A compact CPW-fed patch antenna is proposed and investigated in this paper. U-shaped slot and mitered corners are employed to provide a lower band of 2.40 GHz–2.48 GHz and an upper band of 5.15 GHz–5.80 GHz radiation, which meet the WLAN requirements. A prototype with a dimension of 20 mm × 25 mm × 1 mm is fabricated and measured, and experimental results show agreement with the simulated ones.

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