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A COMPACT DUAL INVERTED C-SHAPED SLOTS ANTENNA FOR WLAN APPLICATIONS

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Abstract—A novel design of a compact dual inverted C-shaped slots antenna for dual-band (IEEE 802.11 b/g, 2.4–2.484 GHz and IEEE 802.11 a, 5.15–5.35/5.725–5.825 GHz) WLAN applications is proposed in this paper. The antenna is based on dual inverted C-shaped slots and a μ-shaped feeding structure. These fundamental configurations are applied to achieve two operating bands with resonating frequencies at about 2.45 GHz and 5.5 GHz to cover the dual WLAN bands. The proposed antenna is fabricated and tested. The simulated and measured results show that the slot antenna obtains two independent operation bands of 2.4–2.515 GHz and 5.14–5.85 GHz for $S_{11} \leq -10$ dB, and also stable gain characteristic with peak gain variations less than 1 dBi for both the bands. Details of the analysis and research progresses are shown in the following sections to illustrate the design steps and the performance of the proposed antenna.

1. INTRODUCTION

Because of its high transmitting data rates, the wireless local area network (WLAN) is of wide application in modern electronic communication systems, such as desktop computers, mobile phones, personal digital assistants, etc. For these applications, small antennas for WLAN operation have been reported recently [1–4]. These antennas can cover several or all operating bands of the WLAN operation in IEEE 802.11 b/g (2.4–2.484 GHz) and IEEE 802.11 a (5.15–5.35/5.725–5.825 GHz) [1–5]. Therefore, compact, multi-band WLAN antennas has become a trend. For this requirement, monopole

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and slot antennas are the excellent candidates. Comparing with the monopole antennas [5, 6], slot antennas have the advantages of simple structure, flexible design, wide bandwidth and easy integration with other active circuits [7, 8]. Many versatile slots are applied [7–14]. [7] shows a large circular slot with an offset microstrip-fed line. And in letter [8], a large rectangular slot is adopted fed by T-shaped strips. However, these slots are comparatively big size, especially when the condition is rigorous. [9–12] are the other types of small slots antenna for multi-band application, for example, the dual rectangular loops antenna [9], dual annual-ring antenna [10–12] are selected, also these are confirmed good multi-band characteristic, but with a little large size or complex constructions. In paper [13], an S-shaped slotted patch antenna is proposed, and in letter [14], an asymmetrical C-shaped slot microstrip antenna is also designed, these antennas [13, 14] are of good performance for their applications. However, multilayer configuration is adopted, which may bring some disadvantages, such as high-cost, difficult to fabrication and testing.

In this article, based on the former works, a compact dual inverted C-shaped slots antenna is put forward. The outer inverted C-shaped slot is used to cover the low band (2.4–2.484 GHz) of WLAN, while the inner is designed for the high band. At the same time, the μ-shaped feeding strip helps to improve the higher band impedance matching to achieve the desired operation band (5.15–5.825 GHz). The antenna is easy to match a 50 Ω coaxial connector. Simulation reveals that the antenna is not only convenient to be tuned, but also compact.

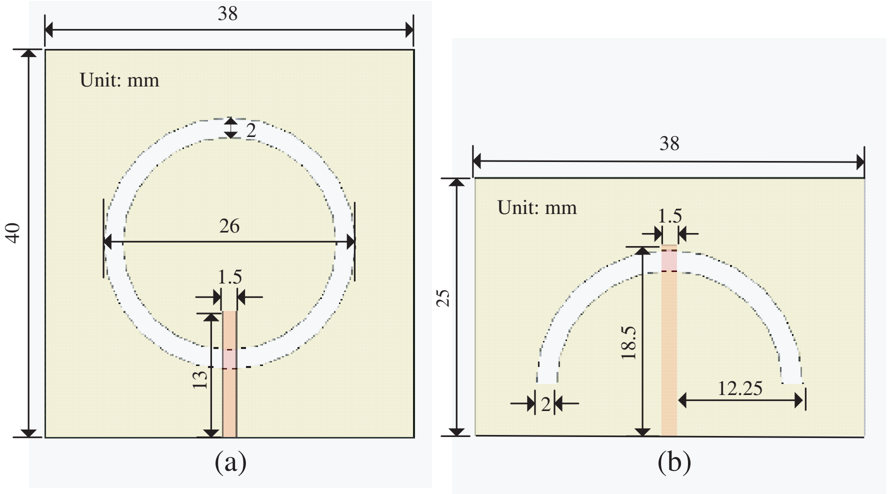
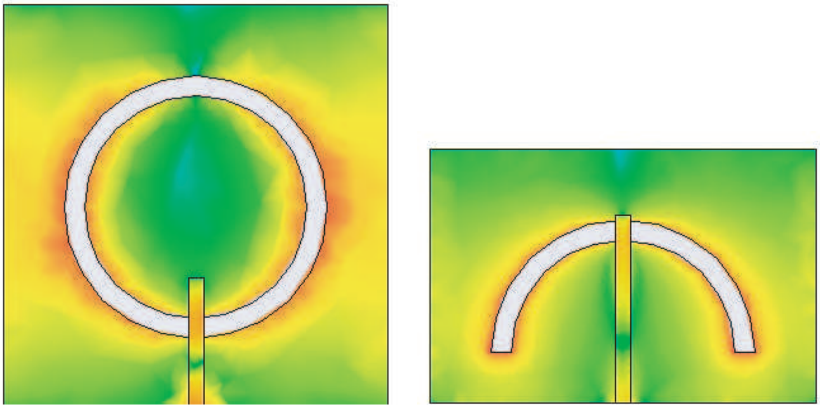


Figure 1. The geometry of (a) Conventional circular loop slot antenna; (b) Inverted C-shaped slot antenna.

Measured result shows that the antenna can provide the impedance bandwidth of 115 MHz (2.4–2.515 GHz) and 710 MHz (5.1–5.85 GHz) for multi-band WLAN applications.

2. ANTENNA ANALYSIS AND DESIGN

Before designing the proposed inverted C-shaped slots antenna, it is necessary to analyze the traditional circular loop slot antenna for comparison. They are all fabricated on an FR-4 substrate with relative permittivity of 4.6, thickness of 0.8 mm. All the following simulated results are obtained from the commercially available software, Ansoft HFSS or CST STUDIO. The detailed configurations of the two different types of antenna are shown in Fig. 1. Both the antennas resonate at about 2.45 GHz, but as depicted in Fig. 2, the magnitude of the surface current distribution at each surface of the antenna is different, there are two minimal magnitudes of the surface current of the conventional circular loop antenna, while the proposed is only one. So, the resonating length of the conventional circular loop slot is λ (the wavelength of resonance), but the proposed inverted C-shaped slot is only $\lambda/2$. Moreover, the total size of the proposed antenna is smaller than the conventional. Distinctly, the later will be more appealing. Therefore, to acquire dual-band for WLAN applications, two inverted C-shaped slots have been proposed, which will resonant at the frequency of about 2.45 GHz and 5.5 GHz, respectively. The



(a) (b)

Figure 2. The magnitude of the surface current distribution. (a) Conventional circular loop slot antenna; (b) Inverted C-shaped slot antenna.

particular configurations are shown in Fig. 4.

Another attractive matter is the fact that the resonant mode of the inverted C-shaped slot is determined by the length of it, and not affected by the different feeding structure, which can be proved by the surface current distribution of the slot. Fig. 3 indicates the surface current distribution of the slot under the edge feeding technique. From the figure, it is not difficult to find that the maximal magnitude of the surface current is at the both ends of the slot, while the minimal is at the center, which is the same as Fig. 2(b). Therefore, the design of the feeding structure of the antenna may be flexible to select. Based on the design of the two inverted C-shaped slots and for ease of feeding, the inner slot is center fed, while the outer slot is edge fed, and thus the μ-shaped feeding structure, which is shown in Fig. 4, is generated.

According to the above analysis, the dual inverted C-shaped slots antenna is designed. Explicit configurations of the antenna are depicted in Fig. 4. Benefiting from the antenna structure and

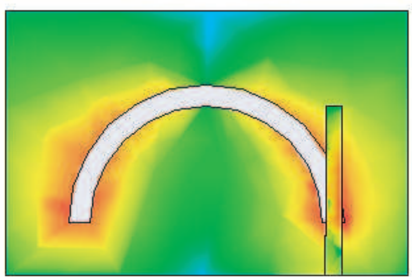


Figure 3. The surface current distribution fed by edge feeding method.

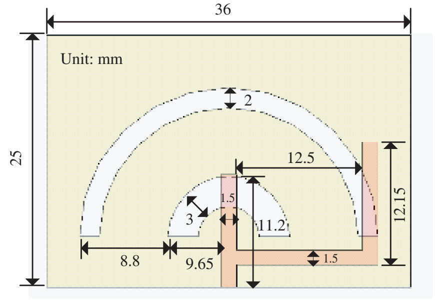
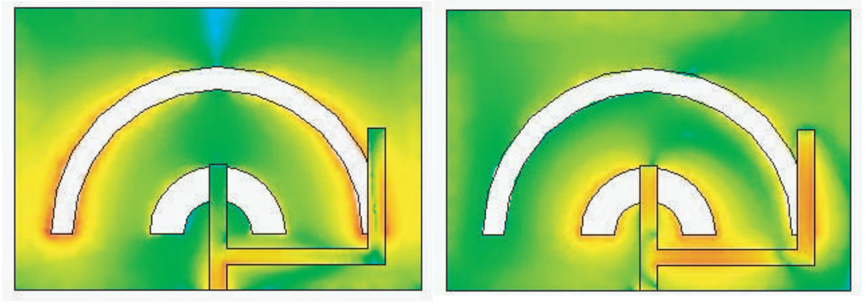


Figure 4. Configurations of the proposed antenna.



(a) (b)

Figure 5. The surface current distribution at (a) 2.45 GHz; (b) 5.5 GHz.

its aforementioned feeding methods, the simulation of the antenna is simplified accordingly. Fig. 5 shows the magnitude of the surface current of the antenna at different frequencies. It is clear to see the outer C-shaped slot is designed for the resonating mode at 2.45 GHz. At the 5.5 GHz, things are a little different, besides the inner C-shaped slot is resonated for about 5.5 GHz, the outer slot also generates higher resonating mode combing with the feeding strip, and thus achieving wide bandwidth.

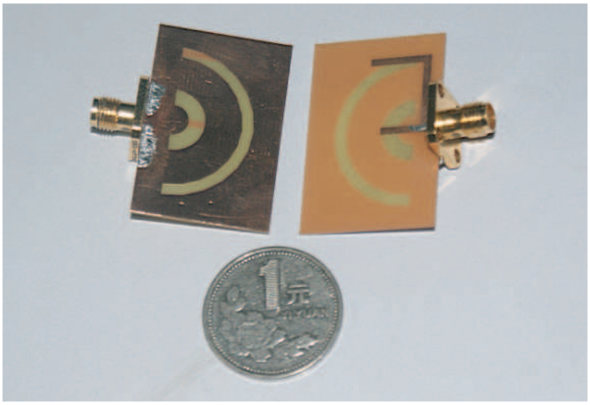


Figure 6. Photograph of the proposed antenna.

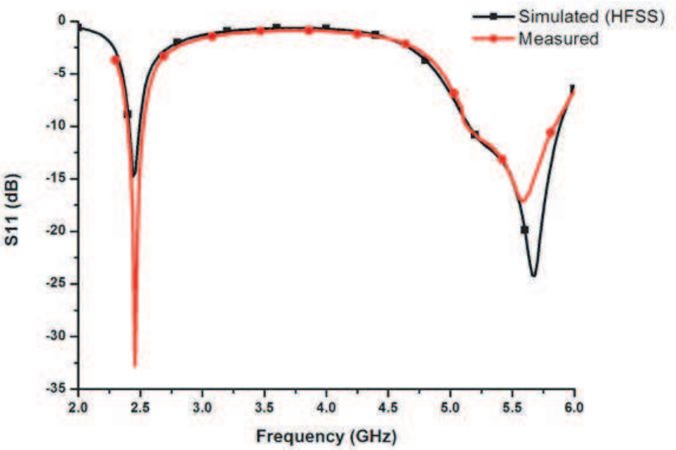


Figure 7. Measured and simulated parameters of S_{11}.

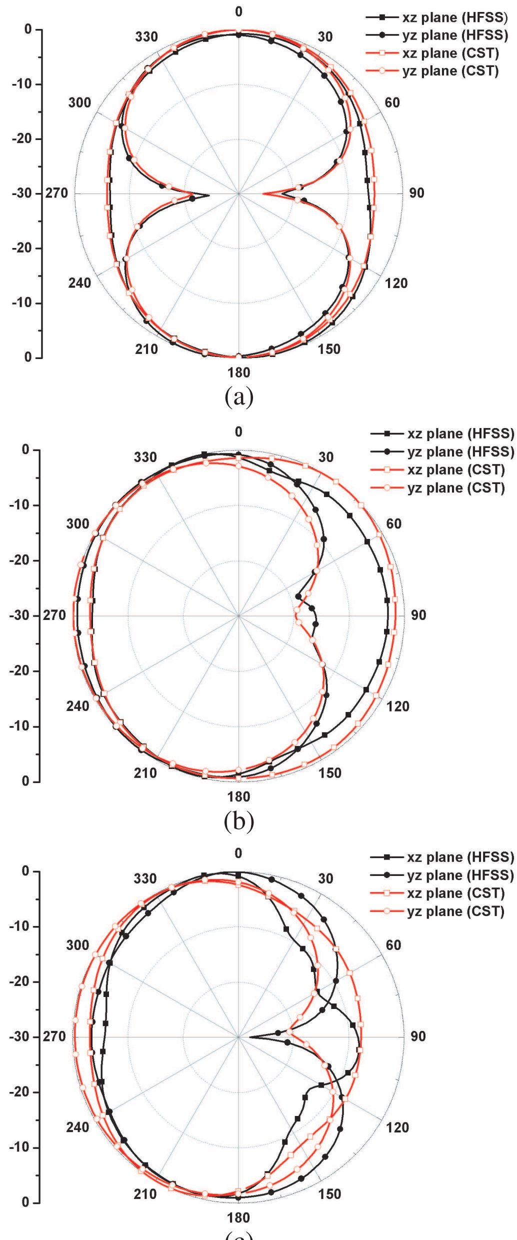


Figure 8. Radiation patterns of the proposed antenna simulated by Ansoft HFSS and CST STIDIO. (a) 2.4 GHz; (b) 5.2 GHz; (c) 5.8 GHz.

3. RESULTS AND DISCUSSION

The proposed dual inverted C-shaped slots antenna is fabricated and tested. Fig. 6 shows the photograph of the proposed antenna. Measured parameter of S_{11} is plotted in the Fig. 7 along with the corresponding Ansoft HFSS simulated result, which shows a good agreement. Result shows that the proposed antenna can get dual bandwidths of 115 MHz (from 2.4 to 2.515 GHz) and 710 MHz (from

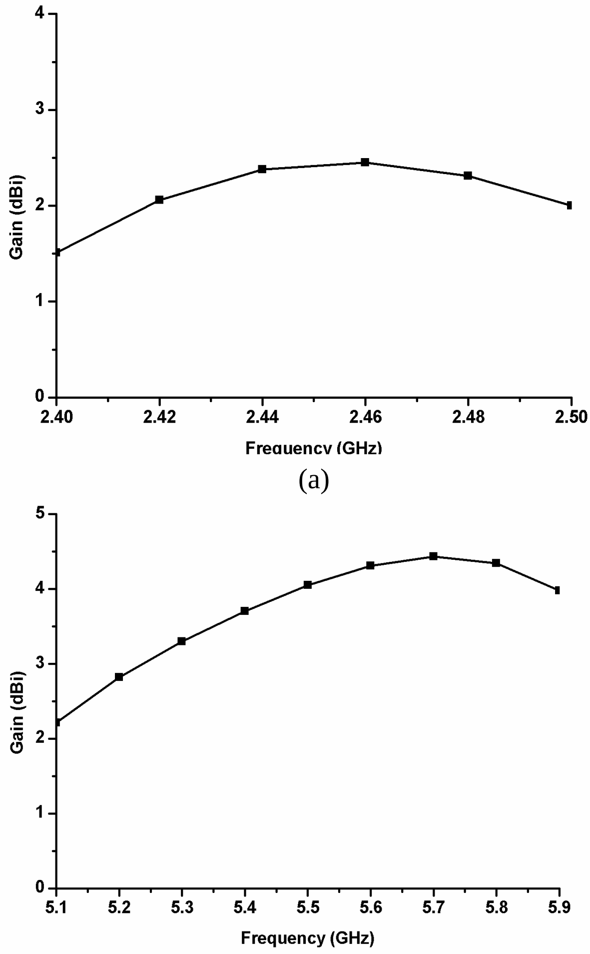


Figure 9. Measured peak gain of the antenna at dual bands. (a) Low band (2.4–2.484 GHz); (b) High band (5.15–5.825 GHz).

5.14 to 5.85 GHz) for $S_{11} \leq -10$ dB, which satisfy the 2.4 GHz, 5.2/5.8 GHz WLAN requirements, respectively. Fig. 8 demonstrates the normalized yz and xz plane of the proposed antenna radiation patterns simulated by HFSS and CST at 2.4 GHz, 5.2 GHz and 5.8 GHz. From the figure, we can find that there is a good agreement between two simulation results. As discussed in the foregoing paragraphs, perhaps because of the higher resonating modes generated by the outer slot and the feeding strip, the omnidirectional radiation patterns at the high WLAN band (5.2/5.8 GHz) are not as good as the low band (2.4 GHz). In the Fig. 9, there is the measured peak gain of proposed antenna, and their peak gains do not change very seriously (less than 1 dB) at their operation bands.

4. CONCLUSION

In this paper, a dual-band inverted C-shaped slots antenna with μ-shaped feeding structure has been analyzed, designed and tested. The proposed antenna has the advantages of small size, easy fabrication, and simple construction for the WLAN application. Measured results show that the antenna can have the operation bands of 2.4–2.515 GHz and 5.14–5.85 GHz to cover the WLAN operation bands (2.4–2.484 GHz, 5.15–5.35 GHz, and 5.725–5.825 GHz). Simultaneously, good radiation patterns and stable peak gains are also obtained. Both the simulated and measured results confirm that the proposed antenna can be a good candidate for the WLAN applications.

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