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A WIDE OPEN U-SLOT ANTENNA WITH A PAIR OF SYMMETRICAL L-STRIPS FOR WLAN APPLICATIONS

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Abstract—A wide open slot antenna with a pair of symmetrical L-strips for dual-band WLAN applications is proposed in this paper. A T-shaped monopole is used to cover $5.15 \sim 5.825$ GHz. To achieve dual-band characteristic, a pair of symmetrical L-strips is embedded in the wide open U-slot to generate another band covering $2.4 \sim 2.48$ GHz. The two bands are relatively independent from each other. The proposed antenna has the advantages of simple structure and excellent performance on the WLAN 2.4/5.2/5.8 GHz bands. The measured results of the fabricated antenna show that the impedance bandwidths are 150 MHz from 2.37 to 2.52 GHz and 1270 MHz from 4.83 to 6.10 GHz, which cover all the desired operating bands. Furthermore, the antenna design and some significant parametric studies are also described in detail.

1. INTRODUCTION

Today, the rapid progress of WLAN techniques and wireless communication systems leads to the development of various dual-band WLAN antennas, which should have good impedance match and steady radiation patterns over the two bands of $2.4 \sim 2.48$ GHz and $5.15 \sim 5.825$ GHz. In the past, different types of antennas had been proposed to achieve these requirements. And, a whole host of multi-branched monopole antennas with various shapes, such as double T shape [1], double S shape [2], G shape [3] and flower shape [4], have been designed and developed for WLAN or multi-band applications.

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Recently, another candidate to realize a multi-band characteristic is the slot antenna [5–7], which has been widely used owing to the advantages of small size, wide bandwidth and less conductor loss. Many latest studies on slot antennas have been presented [8–11]. Various slot structures have been utilized for multi-band antennas, such as annular slot [8], square slot [9], meander slot [10], elliptical slot [11], etc. These design approaches and implementations have also been demonstrated to fulfill the desired dual-band requirements. Although these proposed antennas in [8, 9] achieve good multi-band characteristic, their overall sizes are somewhat large for wireless communication. Moreover, the other antenna designs in [10, 11] are obviously very complicated even if their sizes are reduced greatly. Traditionally, the closed slot antenna fed by microstrip ended with a rectangular stub can generate a wide bandwidth [12, 13]. In the latest literatures [14–16], it is found that open slot antennas show better performance. Especially, the wide open slot antenna becomes an excellent candidate for wideband application. However, these open-slot antennas are rarely studied for dual-band applications.

In this paper, a novel wide open U-slot antenna with a pair of symmetrical L-strips for WLAN applications is proposed. To obtain dual-band WLAN operation, two L-shaped strips [17–19] are embedded in the wide open U-slot, thanks to that an additional resonate mode is obtained to cover the $2.4 \sim 2.48$ GHz band. Moreover, the operation band is quite independent from the upper one. The antenna not only covers the two bands of WLAN operation easily, but also has a simple symmetrical structure. Here, the proposed antenna has been simulated, fabricated and tested. The measured results agree well with the simulated data, showing that it can be potentially used for WLAN operation. In addition, the current distributions and some significant parametric studies are also given to show the principle of proposed antenna clearly.

2. ANTENNA DESIGN

Figure 1 shows the geometry of the proposed antenna, which is designed and fabricated on a substrate with relative permittivity of 2.65, thickness of 1 mm, and a total area of $38 \times 38\,\text{mm}^2$. The open U-slot consists of a rectangular slot, whose length is 32.8 mm and width is 21.8 mm, and a semi-elliptical slot, whose major axis radius is 16.4 mm and miner axis radius is 8.85 mm. A T-shaped radiator fed by a $50\,\Omega$ microstrip line has a horizontal arm and a vertical arm as described in Figure 1. This simple design with the wide open U-slot can obtain a wide resonant frequency range at the upper WLAN

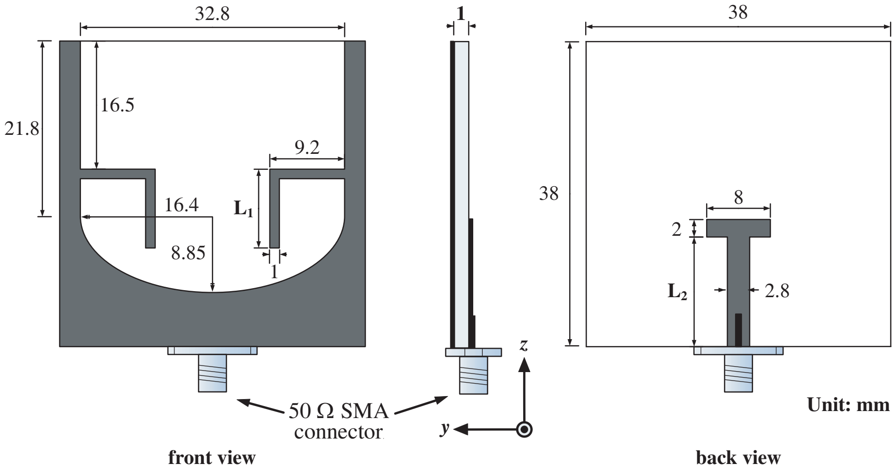


Figure 1. Geometry of the proposed antenna.

band. For achieving dual-band operation, a pair of symmetrical L-strips is embedded in the wide open U-shaped slot on the ground. With this pair of symmetrical L-strips, an additional lower resonant band is generated effectively. The detailed parameters are shown in Figure 1. Herein, the widths of L-strips are fixed at 1 mm, and the lengths of L-strips have two available parameters, respectively. These two irrelevant bands can be easily adjusted by the two key parameters L_1 and L_2, which are almost independent from each other.

With the aid of Ansoft HFSS, the design parameters of the proposed antenna are optimized for dual-band WLAN applications, which have an appreciative impedance bandwidths of reflection coefficient < -10 dB. The optimum design parameters are shown as follows: $L_1 = 9$ mm and $L_2 = 14$ mm. A prototype of the demonstrated antenna fabricated according to the aforementioned design results is shown in Figure 2.

3. RESULTS AND DISCUSSION

The prototype of the proposed antenna has been constructed and experimentally studied. With the help of Ansoft HFSS and WILTRON37269A vector network analyzer, the simulated and measured reflection coefficients with and without a pair of L-shaped strips are compared in Figure 3. Obviously, a pair of L-strips leads to a lower resonance frequency band of WLAN, besides that the T-shaped monopole can achieve higher WLAN resonance frequency

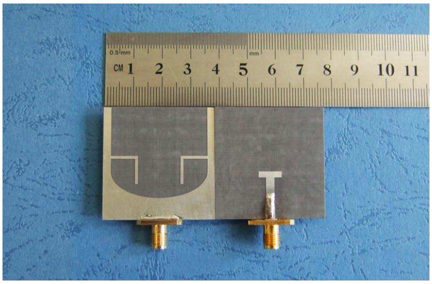


Figure 2. Photograph of the proposed antenna.

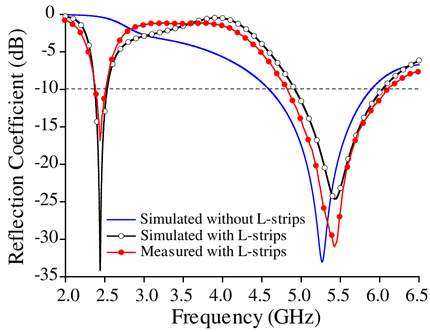


Figure 3. Simulated and measured reflection coefficients of the proposed antenna with parameters $L_1 = 9\,\text{mm}$ and $L_2 = 14\,\text{mm}$.

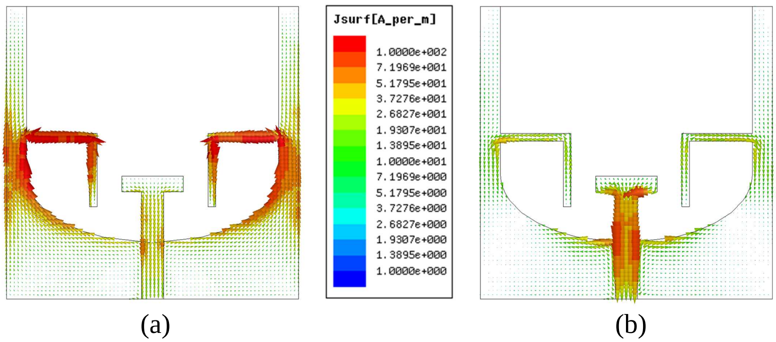


Figure 4. Current distributions at (a) 2.4 GHz and (b) 5.5 GHz.

band. Meanwhile, it can be seen from Figure 3 that the L-strips do not have much effect on the higher resonance frequency band. With a pair of symmetrical L-strips embedded in wide open U-slot, the proposed antenna can easily achieve the dual-band WLAN operation. The measured impedance bandwidth of the lower frequency band is 150 MHz (2.37 $\sim$ 2.52 GHz), and the upper band impedance bandwidth is 1270 MHz (4.83 $\sim$ 6.10 GHz), which can completely meet the requirements for dual-band WLAN applications.

The simulated surface current distributions on the proposed antenna at 2.4 and 5.5 GHz are shown in Figure 4. It can be seen clearly that the U-shaped open-slot with a pair of L-strips contributes to the 2.4 GHz resonance, and the T-shaped monopole leads to 5.5 GHz

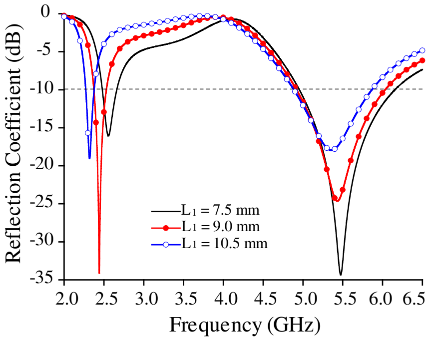


Figure 5. Simulated reflection coefficients for different values of L_1. (Another parameter: $L_2 = 14\,\text{mm}$).

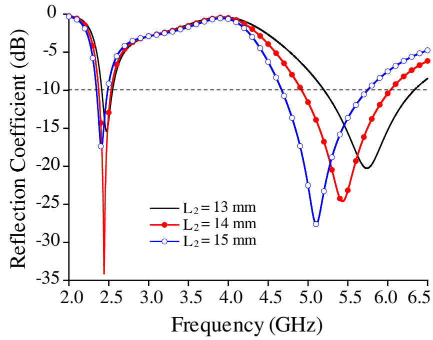
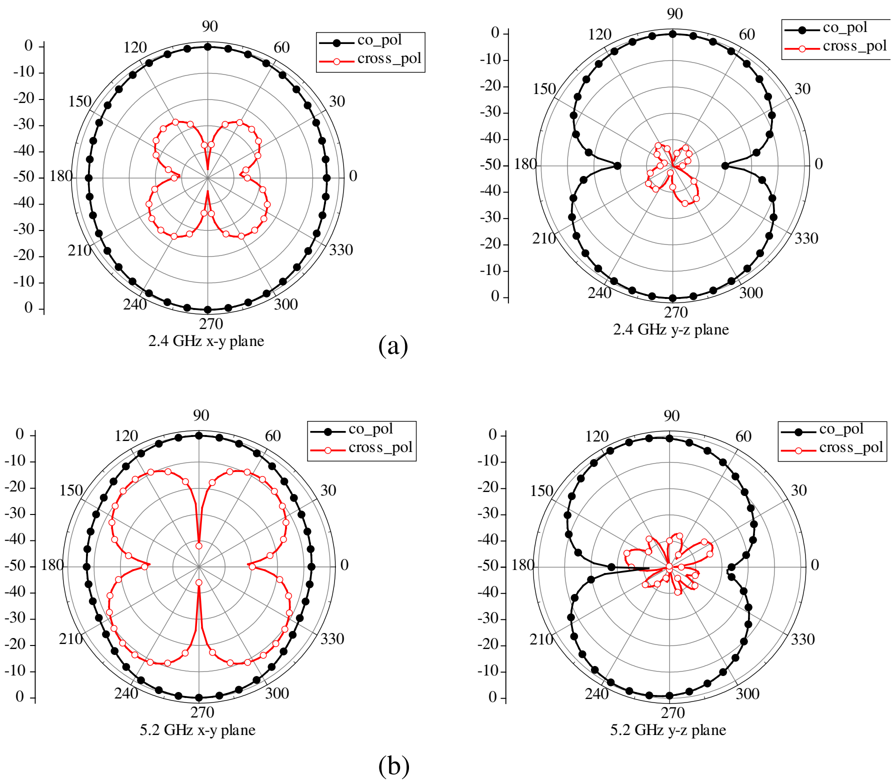
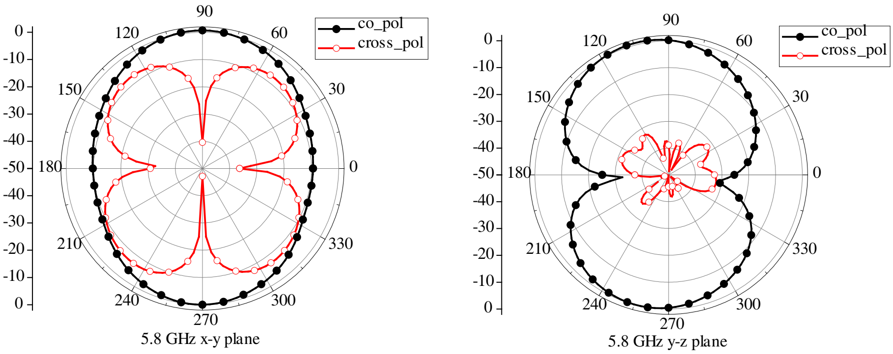


Figure 6. Simulated reflection coefficients for different values of L_2. (Another parameter: $L_1 = 9\,\text{mm}$).





(c)

Figure 7. Radiation patterns for the proposed antenna at (a) 2.4 GHz, (b) 5.2 GHz, (c) 5.8 GHz.

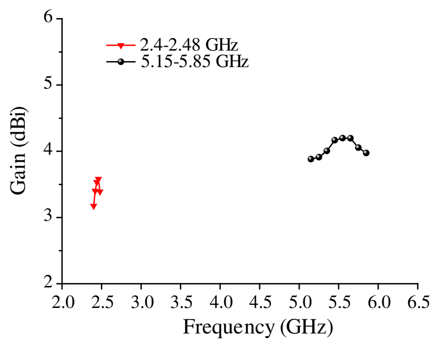


Figure 8. Peak gains for the proposed antenna.

resonance, respectively.

Figures 5 and 6 present the reflection coefficient curves for the proposed antenna with various key parameters (L_1, L_2) of the length of L-strips and the length of the T-shaped monopole, respectively. The reflection coefficient characteristics with the different values of L_1 are demonstrated in Figure 5. As L_1 varies from 7.5 to 10.5 mm, the lower resonance frequency is step-down while the higher frequency band almost stands still. In other words, the parameter L_1 has a strong effect on 2.4 GHz WLAN band. As shown in Figure 6, it is obvious that the higher resonance frequency of the proposed antenna is affected intensely by L_2. Through the analysis of the two key parameters, the optimal values are as follows: $L_1 = 9$ mm and $L_2 = 14$ mm.

The simulated far-field radiation patterns of both co-polarization and cross-polarization in x-y plane (H-plane) and y-z plane (E-plane) are also given in Figure 7. From the results of radiation patterns at 2.4, 5.2 and 5.8 GHz, respectively, it can be seen that the proposed antenna has nearly omni-directional radiation patterns in x-y plane and monopole-like radiation patterns in y-z plane. Finally, the antenna peak gains achieved along y-axis are presented in Figure 8. The obtained average gains are 3.37 dBi (3.16 $\sim$ 3.58 dBi) at lower band and 4.03 dBi (3.88 $\sim$ 4.19 dBi) at upper band, respectively.

4. CONCLUSION

A wide open slot antenna for dual-band WLAN applications has been designed, fabricated and tested in this paper. By using a pair of symmetrical L-strips and a T-shaped monopole radiator, the proposed antenna can realize dual-band characteristic to fill the WLAN 2.4/5.2/5.8 GHz operation. Experiment results show impedance bandwidths of 6.1% at center frequency 2.445 GHz and 23.2% at center frequency 5.465 GHz, and the average gains are about 3.37 dBi and 4.03 dBi respectively. The two operation bands are generated by the pair of L-strips and T-shaped monopole separately, which affect each other very slightly, providing the convenience for adjusting. Therefore, the proposed antenna can become an excellent candidate for dual-band WLAN applications.

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