Progress In Electromagnetics Research Letters, Vol. 24, 139–147, 2011

MINIATURIZED MODIFIED DIPOLES ANTENNA FOR WLAN APPLICATIONS

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Abstract—In this paper, a novel double-band integrated antenna for applications in WLAN is presented and studied. Based on the mature dipole theory, radiation elements are printed on the two faces of a low cost FR4 substrate. The two dipoles are designed on the sides of the feedline, which can reduce the impact of each other availably. The distance between the two arms and the width of the arms plays an important role in improving the impedance matching. Furthermore, by folding the arms efficiently, the current distribution of the proposed antenna is extended, and the dimensions of the proposed antenna can be reduced. The size of the designed antenna is just $34\,\text{mm} \times 24\,\text{mm} \times 1\,\text{mm}$ (about $0.27\lambda \times 0.19\lambda \times 0.008\lambda$, λ is the wavelength relative to the frequency 2.4 GHz). Moreover, the prototype of the antenna is constructed and tested, which shows a good agreement with simulated result. The measured bandwidths, ranging from 2.35 GHz to 2.61 GHz and from 4.7 GHz to 6.0 GHz respectively, are obtained with return loss less than -9.54 dB (about 2 : 1 VSWR). The proposed antenna covers 2.4/5 GHz WLAN bands, and radiation patterns with good omni-directional radiation in the operating frequency are observed.

1. INTRODUCTION

In recent years, with the fast development of modern wireless technology, there has been much interest in developing a small size system with the ability to integrate more than one communication

Received 12 May 2011, Accepted 2 June 2011, Scheduled 10 June 2011

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standard for enhancing mobile performance. Moreover, it is well-known that the antenna is one of the crucial components which determine the performance of the communication system. Therefore, the miniaturized antenna with multiband characteristic is studied widely to fulfill the demand [1–4]. On the other hand, microstrip antennas have been attached great attention due to their many attractive advantages, such as simple design, light weight, low cost and high reliability. For this application, there are some methods used in microstrip antennas area to achieve the multiband characteristic, for example, multi-radiation elements [5, 6] and gap loading [7, 8].

Wireless communication for WLAN (wireless local-area network) applications has experienced tremendous growth in the past years. WLAN communications can provide quick and easy wireless connection among PCs, laptops and other equipments within a local environment where a fixed communication infrastructure does not exist or where such access is not permitted [9]. In order to satisfy IEEE 802.11a/b/g/n standards, multiband antennas operating at 2.4-GHz (2400–2484 MHz) and 5-GHz (5150–5950 MHz) frequency bands are highly desired. Therefore, multiband antennas for WLAN applications become a hot research point in the past decades and many technologies for miniaturized antenna with multiband functionality have been proposed [10–18]. However, most proposed antennas are monopoles [13–18] which usually require large grounds, so the size of the antenna is big, which increases the limits of the practical applications.

In this paper, a novel dual-band integrated modified dipoles antenna for WLAN applications has been presented and studied. The designed construction is better than monopole. Firstly, the characteristic is not restricted by the size of the ground, which can realize the miniaturization easily. Secondly, based on the mature principle of the dipole, the proposed antenna has good radiation characteristic. The idea of the proposed antenna evolves from [10–12]. Two dipoles with different lengths are printed on the two side of the feedline to reduce the impaction of each other, which are not nested with each other. The dimensions of the designed antenna are obviously reduced by folding the arms effectively. As a result, compared with antennas in [10–12], the proposed antenna is much small. The size of the designed antenna is just 34 mm × 24 mm × 1 mm (about $0.27\lambda \times 0.19\lambda \times 0.008\lambda$, λ is the wavelength relative to the frequency 2.4 GHz).

In addition, it is worth explaining that the whole antenna is constructed from low cost FR4 board with the thickness of 1 mm. Moreover, the construction of the proposed antenna is simple, so the fabrication is easy. The proposed antenna has been simulated, fabricated and measured, and the details of the antenna design as well as the experimental results are presented and discussed as below.

2. ANTENNA DESIGN

Figure 1 shows the configuration of the proposed antenna based on the mature principle of the dipole. The antenna is etched on an inexpensive FR_4 substrate ($\varepsilon_r = 4.4$) with the size of $W \times L$. The radiation element is fed by a 50-Ω coaxial cable through a tapered microstrip with the height of $(h_1 + h_2)$ and the beveling α_3, which can improve the energy transmission and broaden the bandwidth effectively. By introducing multi-radiation elements, the proposed antenna mainly consists of two different dipoles on the two sides of the feedline to realize multiband characteristic, and the same length arms of the dipole are mirror-symmetric printed on the different faces of the substrate. Furthermore, in order to realize the miniaturization, the four arms are effectively folded to extend the current path.

The long arms, with the width of l_w and the length of $(l_1 + l_2 + l_3)$, are located upon the short arms with the width of s_w and the length of $(s_1 + s_2 + s_3)$, and the distance between them is d. The resonant frequency and the bandwidth of the operating frequency can be controlled by the width of the arms (l_w and s_w) and the distance between each other (d). Meanwhile, in order to reduce the reflection effectively, bevelings that equal to 45° are added on the corners of all arms. Other detail variables are labeled in Fig. 1.

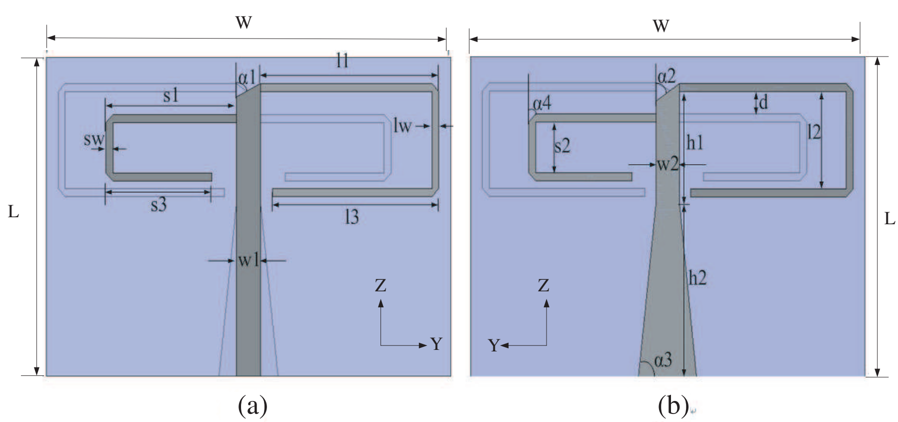

Figure 1. The configuration of proposed antenna. (a) Front view. (b) Back view.

3. RESULTS AND DISCUSSION

The designed antenna was simulated using Ansoft HFSS 12 (high-frequency structure simulator) based on FEM (Finite Element Method). By means of quite a number of simulation, the optimum designed dimensions (units: mm) are selected: $W = 34$, $L = 24$, $l_1 = 15$, $l_2 = 7.3$, $l_3 = 14$, $l_w = 0.6$, $s_1 = 11$, $s_2 = 3.8$, $s_3 = 8.9$, $s_w = 0.6$, $\alpha_1 = 63.4°$, $\alpha_2 = 56.4°$, $\alpha_3 = 6.6°$, $d = 1.5$, $w_1 = 2$, $w_2 = 2$, $h_1 = 8.4$, $h_2 = 13$. The effects of varying the parameter value on the bandwidth and radiation features will be discussed in more details.

As shown in Fig. 1(b), the feedline is tapered. The introduction of the bevelings on the feedline is crucial for the proposed antenna. Fig. 2 displays the comparison of the antenna with and without bevelings. It is obvious that bevelings improve the impedance matching effectively, especially the bandwidth of the high frequency, because they can reduce the reflection loss of the antenna and increase the energy transmission.

The two different printed dipoles realize the multiband character. By properly adjusting the size and position of the long and the short arms, the resonant frequency and bandwidth that fulfill the requirements of WLAN standard are obtained.

Because of the interaction of each other, the distance between the two dipoles plays an important role in adjusting the resonant frequency. According to the return loss curves of Fig. 3, it is clear that the resonant frequency gets lower for 2.4 GHz frequency band and becomes higher for 5 GHz frequency band when the distance d gets bigger, so $d = 1.5$ mm is the option value for WLAN applications.

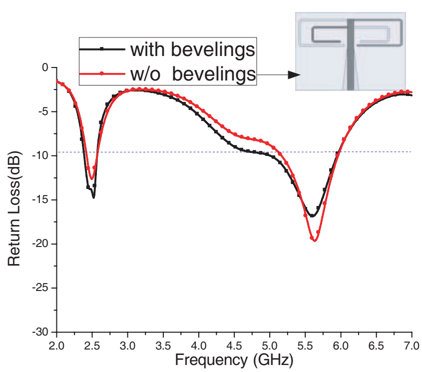

Figure 2. Comparison of simulated return loss for proposed antenna with/without bevelings.

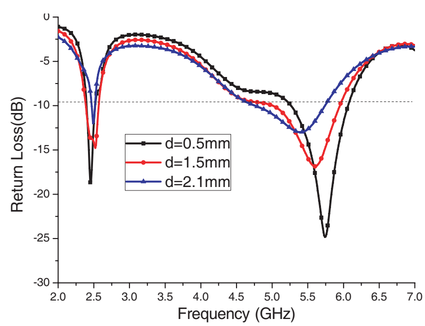

Figure 3. Simulated return loss varying with d.

On the other hand, Fig. 4 and Fig. 5 show that the simulated return loss varies with the width of long arm (l_w) and short arm (s_w) separately. It is evident that the width of arms can affect the bandwidth of each other and the resonant frequency, so it is certain that $l_w = 0.6\,\mathrm{mm}$ and $s_w = 0.6\,\mathrm{mm}$ are the best. Furthermore, in order to realize the miniaturization effectively, it is proposed that the arms of the dipoles are folded.

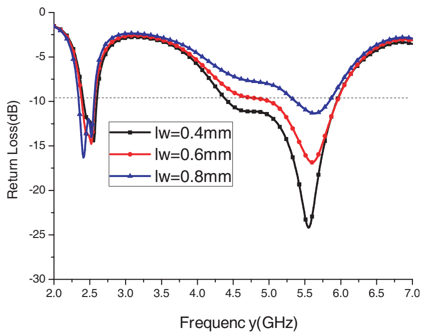

Figure 4. Simulated return loss varying with l_w.

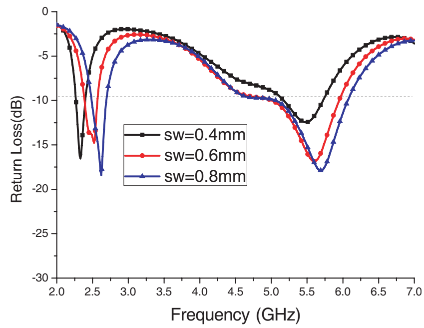

Figure 5. Effect of sw on the simulated return loss.

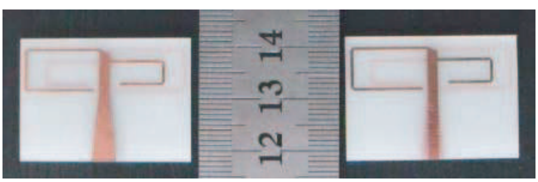

Figure 6. The photograph of the proposed antenna.

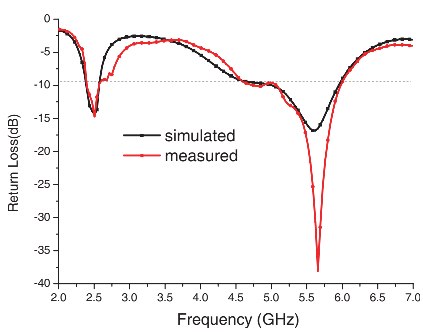

Figure 7. Simulated and measured return loss of the proposed antenna.

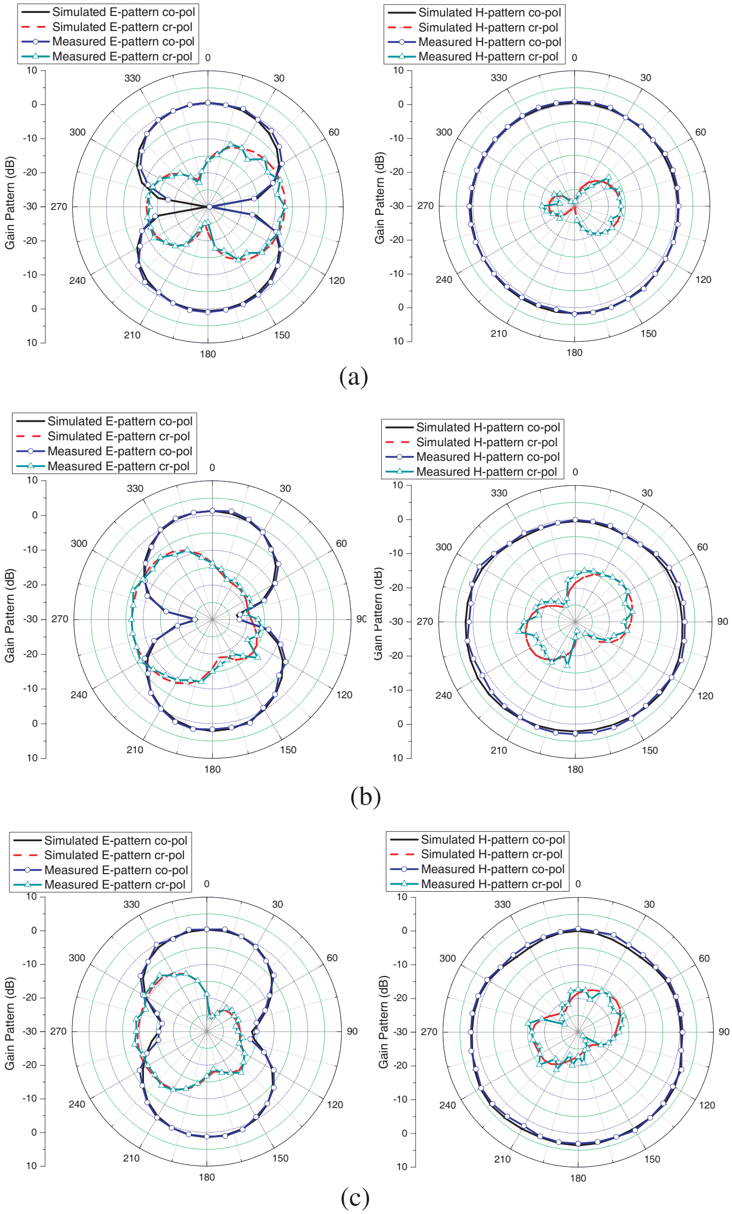

Figure 8. Measured and Simulated radiation patterns, (a) at 2.4 GHz, (b) at 5.2 GHz, (c) at 5.8 GHz.

The photograph of the antenna is described in Fig. 6. It is measured by Wiltron 37269A Network Analyzer. Fig. 7 shows the measured and simulated return loss, which displays a good agreement between the measured results and simulated results. The discrepancy between them may caused by the tolerance of the substrate, the inaccurate dimensions in the fabrication and the difference of the simulated and measured environments. However, it is acceptable. In Fig. 7, it is clearly seen that the measured double frequency bands with return loss less than -9.54 dB (about $2:1$ VSWR) are from 2.35 GHz to 2.61 GHz for the lower frequency and from 4.7 GHz to 6.0 GHz for the higher frequency separately, which cover WLAN application 2.4/5 GHz.

The far-field radiation characteristics have also been studied. Fig. 8 shows the simulated and measured radiation patterns of the proposed antenna at frequencies 2.4 GHz, 5.2 GHz, and 5.4 GHz, separately, which displays the E-plane radiation patterns (xy plane) and the H-plane radiation patterns (xz plane), respectively. As expected, very good omni-directional patterns are obtained for all frequency bands in the H planes and the E planes are close to bidirectional patterns. However, due to the introduction of vertical length l_2 and s_2, the cross polarization in the E-plane is relatively large in the high frequency. Furthermore, the measured maximum gain against frequency across the two bands is shown in Fig. 9. Over the band 2.35–2.5 GHz, the antenna gain varies from 1 to 1.7 dB. For the 5–6 GHz band, the antenna gain varies from 3.2 to 4.1 dB.

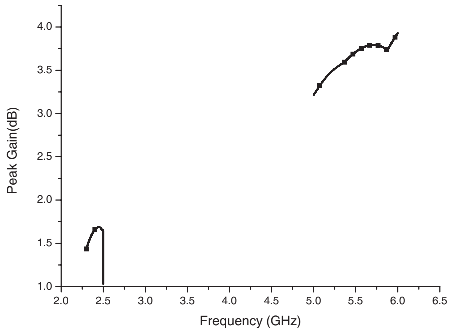

Figure 9. Measured maximum antenna gain against frequency for the proposed antenna.

4. CONCLUSION

A novel dual-band antenna with double modified dipoles has been designed and tested. By reasonably adjusting the width and positions of the two different dipoles and skillfully folding the dipoles arms, the proposed antenna realizes multiband characteristic, and it is miniaturized (the size of antenna is about $0.27\lambda \times 0.19\lambda \times 0.008\lambda$, and λ is the wavelength relative to the frequency 2.4 GHz). Furthermore, the proposed antenna has a simple configuration and is easy to implement at a low cost. The double frequency bands with return loss less than -9.54 dB (about 2 : 1 VSWR) are from 2.35 GHz to 2.61 GHz for the lower frequency and from 4.7 GHz to 6.0 GHz for the higher frequency, respectively. Good radiation pattern is also obtained. In other words, the performance of the proposed integrated modified antenna is very applicable for WLAN applications. In addition, according to the method in this paper, it is easy to design miniaturized multiband antennas at arbitrary bands.

ACKNOWLEDGMENT

The authors would like to express their thanks to the support of the NSFC of P. R. China under Grant (No. 60671056).

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