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TRIPLE-BAND OMNI-DIRECTIONAL ANTENNA FOR WLAN APPLICATION

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Abstract—A triple-band omni-directional antenna which comprises three pairs of dipoles placed back to back and printed on a dielectric substrate is presented. A prototype is constructed and tested. The experimental results show that the 10 dB return loss bandwidth (VSWR < 2.0) in 2.4 GHz, 5.2 GHz and 5.8 GHz reaches as much as 130 MHz, 500 MHz and 200 MHz, respectively. Moreover, the radiation patterns are almost omni-directional in the azimuthal plane. Peak antenna gain is 1.63 dBi, 2.36 dBi and 1.54 dBi, which indicate that the proposed antenna can be used as a triple-band antenna for the WLAN application.

1. INTRODUCTION

Recent development of modern wireless and mobile communication has evoked increasing demands for novel antennas with a multi-band operation. For instance, wireless local area networks (WLAN) for the IEEE 802.11b and IEEE 802.11a operate in 2.4–2.48 GHz, 5.15–5.35 GHz and 5.725–5.825 GHz. Several design methods of antennas for WLAN application have been developed. Many novel antenna structures for single, dual, or multiple bands have been proposed [1–5]. Among them, printed antennas are desirable for their compact size and low cost. However, printed triple-band omni-directional antennas have been seldom proposed.

In this paper, we propose a printed tri-band omni-directional antenna using back-to back dipole radiators. Three pairs of dipoles are placed back to back and printed on a dielectric substrate to generate tri-band operation which is suitable for both the IEEE 802.11b and the IEEE 802.11a. The proposed antenna shows advantages of small size, low cost and good omni-directional radiation characteristics. Details of the antenna design are described and both simulated and measured results are presented in the following sections.

2. ANTENNA DESIGN

Fig. 1 illustrates the geometry and configuration of the proposed triple-band omni-directional antenna, which is printed on a dielectric substrate of width and length. The proposed antenna structure is symmetrical with respect to the central line of the ground plane. The antenna comprises six half-wavelength dipoles. The central line of the ground plane divide the antenna into two sides (left side and right side). There are three dipoles located at each side. Each dipole is formed by two sections, which are printed on the front surface and the back surface of the substrate with the same dimensions, respectively. As illustrated in the Figure 1, the arm lengths of the three pairs of dipoles at the same side are l_1, l_2 and l_4, respectively. The different lengths of the dipoles lead to three different center frequencies corresponding to the lower, middle, and upper bands. By the way, the high frequency dipoles are connected to the feed line and the ground plane through vias in our design.

Due to the symmetrical structure, the left and right dipoles form three pairs of dipoles. Each pair is placed back to back to realize omni-directional radiation patterns. A 2-section impedance transformer is designed as feed line to improve the impedance matching in both the lower, middle and upper frequency bands. A narrow ground plane of the feed line is selected to obtain good omni-directional radiation performance in the azimuthal plane.

3. SIMULATED AND EXPERIMENTAL RESULTS

The proposed antenna is printed on an inexpensive FR4 substrate with a relative permittivity of 4.4 and thickness of 0.5 mm. Other dimensions of the antenna are shown in Fig. 1 in detail. The antenna structure is simulated using Ansoft High Frequency Structure Simulator (HFSS). In Fig. 2, the VSWR against frequency curves with various dipole arm lengths are presented. It is obvious that each band can be modified by adjusting the arm length of the corresponding dipoles with slight affection to the other bands.

Fig. 3 shows the photographs of the fabricated antenna. The simulated and measured results of VSWR are illustrated in Fig. 4. It is seen that good agreement between the measured and simulated data is achieved. The measured impedance bandwidth ($VSWR \leq 2$) is about 130 MHz (from 2.39 GHz to 2.53 GHz), 500 MHz (from 4.8 GHz

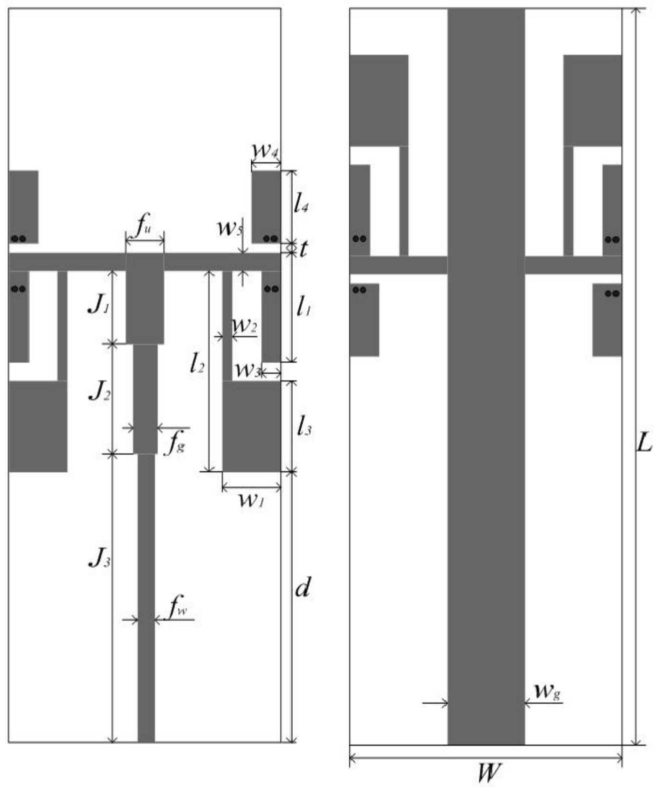
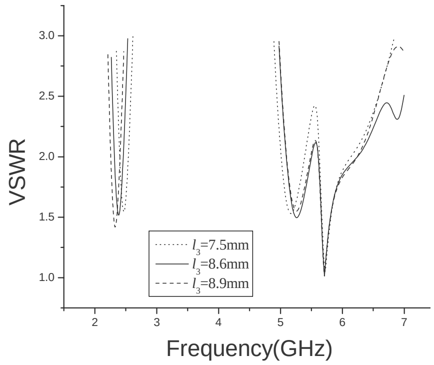


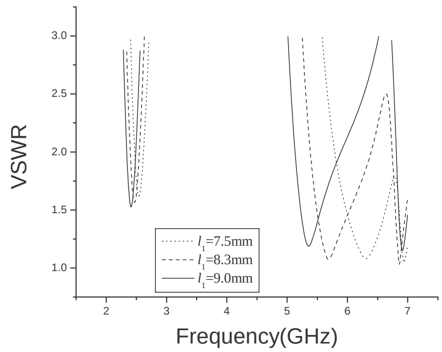
Figure 1. Geometry of the proposed omni-directional antenna. Dimensions: $l_1 = 8.6$ mm, $l_2 = 19.4$ mm, $l_3 = 8.8$ mm, $l_4 = 5.7$ mm, $w_1 = 3.5$ mm, $w_2 = 0.5$ mm, $w_3 = 1.5$ mm, $w_4 = 2$ mm, $w_5 = 1$ mm, $J_1 = 8.5$ mm, $J_2 = 8.5$ mm, $J_3 = 26.5$ mm, $f_u = 2.3$ mm, $f_g = 1.5$ mm, $f_w = 0.87$ mm, $t = 0.5$ mm, $d = 24.1$ mm, $w_g = 5$ mm, substrate size $(W \times L) = 15 \times 70\,\text{mm}^2$.

to 5.38 MHz) and 200 MHz (from 5.7 MHz to 5.9 MHz), respectively, which meet the bandwidth requirement for IEEE 802.11b and IEEE 802.11a applications.

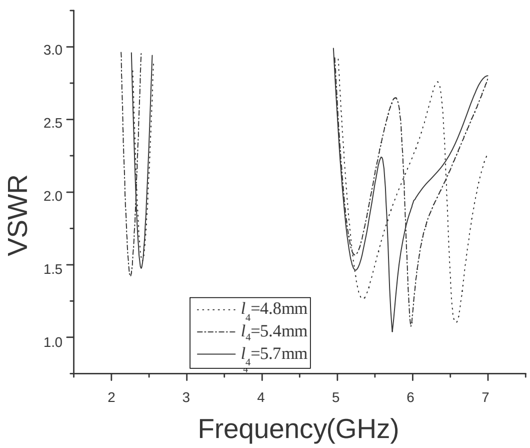
Fig. 5 shows the measured and simulated radiation patterns at 2.45 GHz, 5.2 GHz and 5.85 GHz, respectively. It can be seen that the radiation patterns are approximately omni-directional in all operating bands. The maximum simulated radiation gains are 1.63 dB, 2.36 dB and 1.54 dB at 2.45 GHz, 5.2 GHz and 5.85 GHz, respectively.



(a)

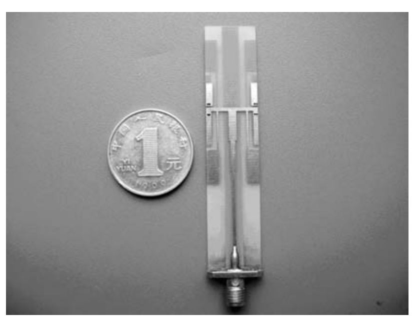


(b)

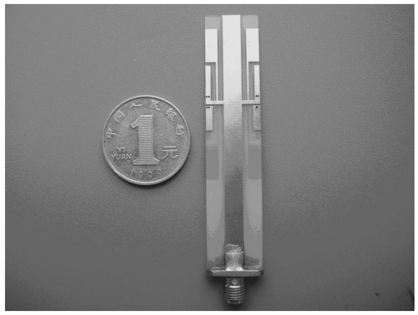


(c)

Figure 2. VSWR with various dipole arm lengths. (a) VSWR with various l_3. (b) VSWR with various l_1. (c) VSWR with various l_4.



(a)



(b)

Figure 3. Photograph of the proposed tri-band antenna. (a) Front view. (b) Back view.

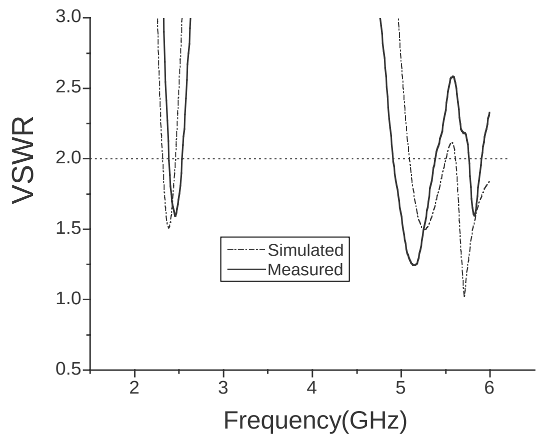
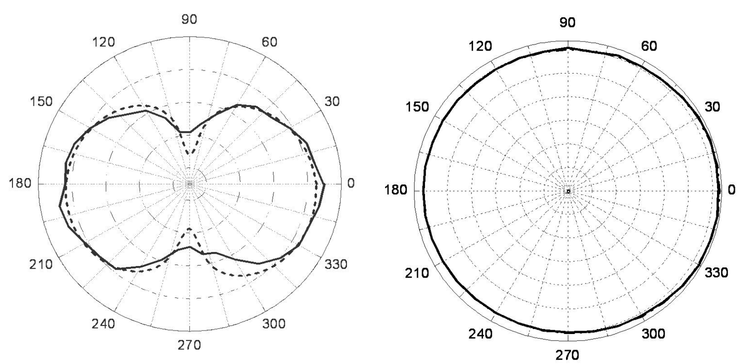
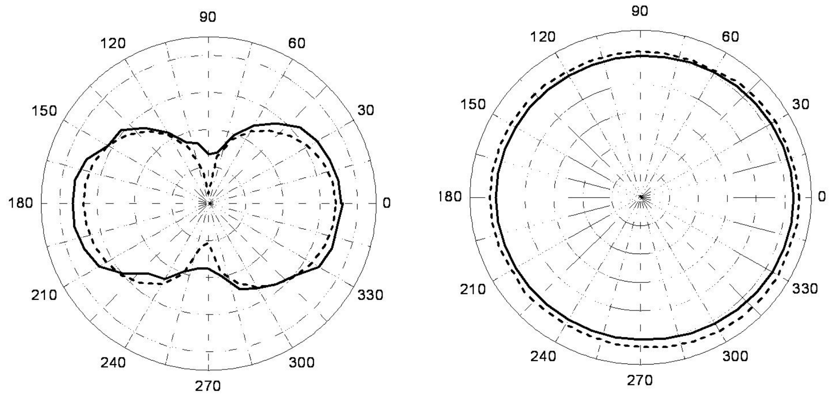


Figure 4. Simulated and measured VSWR of the proposed antenna.



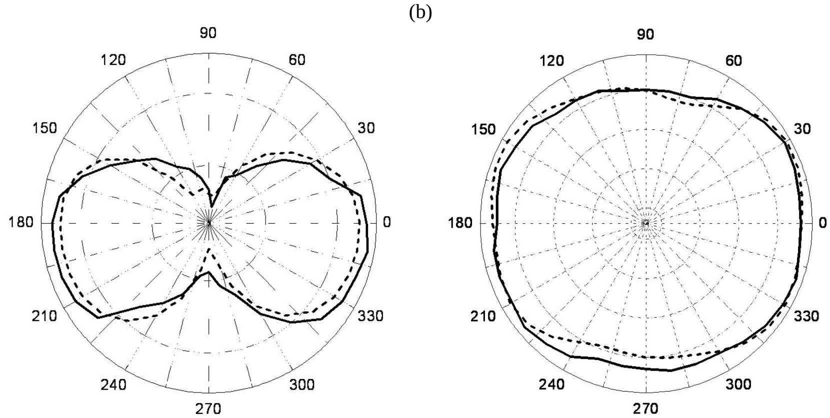
E-plane H-plane

(a)



E-plane H-plane

(b)



E-plane H-plane

(c)

Figure 5. Radiation patterns for the proposed antenna (measured (—) and simulated (...)). (a) 2.4 GHz. (b) 5.2 GHz. (c) 5.8 GHz.

4. CONCLUSION

A novel planar structure of tri-band omni-directional antenna is presented in this paper. A prototype is constructed to cover the 2.4/5.2-GHz and 5.8 GHz bands for WLAN operation. The antenna is not only has good omni-directional radiation performance, but also has the advantages of low cost, small size and easy manufacture. Simulated and experimental results indicate that the proposed antenna is suitable for the application of tri-band WLAN routers and access points (AP) devices.

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