Hindawi Publishing Corporation
International Journal of Antennas and Propagation
Volume 2014, Article ID 195749, 4 pages
http://dx.doi.org/10.1155/2014/195749

Research Article

Compact Dual-Band Dipole Antenna with Asymmetric Arms for WLAN Applications

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Received 6 January 2014; Accepted 12 February 2014; Published 17 March 2014

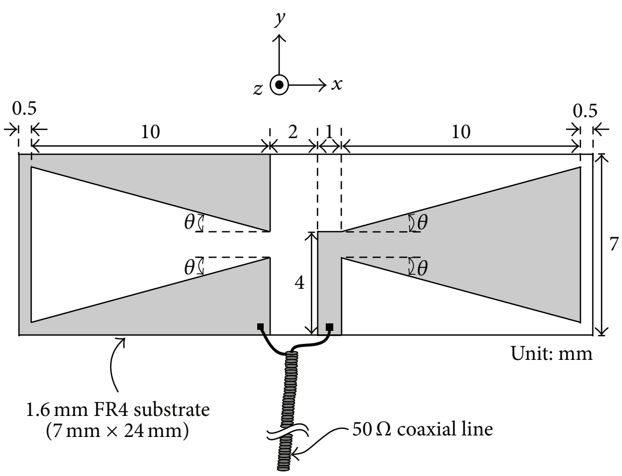
Academic Editor: Yingsong Li

A dual-band dipole antenna that consists of a horn- and a C-shaped metallic arm is presented. Depending on the asymmetric arms, the antenna provides two −10 dB impedance bandwidths of 225 MHz (about 9.2% at 2.45 GHz) and 1190 MHz (about 21.6% at 5.5 GHz), respectively. This feature enables it to cover the required bandwidths for wireless local area network (WLAN) operation at the 2.4 GHz band and 5.2/5.8 GHz bands for IEEE 802.11 a/b/g standards. More importantly, the compact size (7 mm × 24 mm) and good radiating performance of the antenna are profitable to be integrated with wireless communication devices on restricted RF-elements spaces.

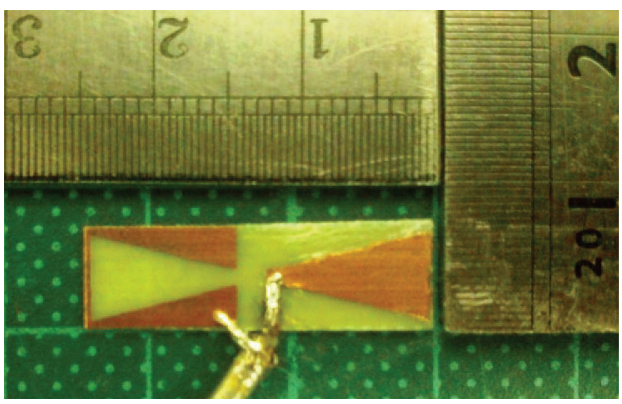
1. Introduction

Recently, wireless local area network (WLAN) has been one of the most significant applications of the wireless communication technology due to its rapid growth and abundant demands of short-range radio systems. WLAN is restricted by several communication standards, such as IEEE 802.11 a (2400–2480 MHz) and IEEE 802.11 b/g (5150–5825 MHz). Hence, high-performance dual-band antennas are widely developed. Among dual-band antennas, the asymmetric dipole antenna is a promising candidate because it provides two distinct resonant modes for achieving dual-band operation. In previous studies, a meandered strip was embedded as an unequal-arms dipole antenna for WLAN operation in 2.4 and 5.2 GHz bands [1]. An asymmetry structure of printed dipole antenna with a double-sided and center-feed design for dual-band (2.4/5 GHz) WLAN applications was reported [2]. A printed dipole antenna consisted of two asymmetric tapered arms [3] and an asymmetric dipole composed of a meandered feed line connected to a rectangular radiating element and its asymmetric counterpart with C-shaped parasitic strip [4] were advanced. A rectangular and a circular radiating element acting as asymmetric arms of a dipole to cover 2.4/5.2/5.8 GHz WLAN bands was employed [5]. A top-loading, an asymmetric coplanar waveguide, and a stepped-feeding structure for WLAN and long term evolution (LTE) operations were demonstrated [6]. However, they still have some drawbacks. For example, the unequal-arms dipole [1] cannot provide 5.8 GHz (5725–5875 MHz) band operation. The double-sided configuration [2, 5] may raise manufacturing difficulty and cost. The uniplanar asymmetric dipole [3] still occupied a large area (44 mm × 15 mm). The constitutions [4, 6] were complex, which may curtail the radiating performance (lower gain value and higher cross-polarization level).

In this paper, a dual-band dipole antenna with asymmetric metallic arms for wireless local area network (WLAN) operations is proposed. By varying the angle of two radiating arms, the proposed antenna can achieve 2.4 GHz (2400–2484 MHz) and 5 GHz (5150–5825 MHz) bands for IEEE 802.11 a/b/g standards. Simultaneously, the simple geometry provides an easy fabrication and a reasonable cross-polarization level. Its compact size (7 mm × 24 mm) is satisfactory to be installed in narrow locations of wireless devices. Details



(a)



(b)

FIGURE 1: (a) Geometry and (b) photograph of proposed dual-band dipole antenna for WLAN applications.

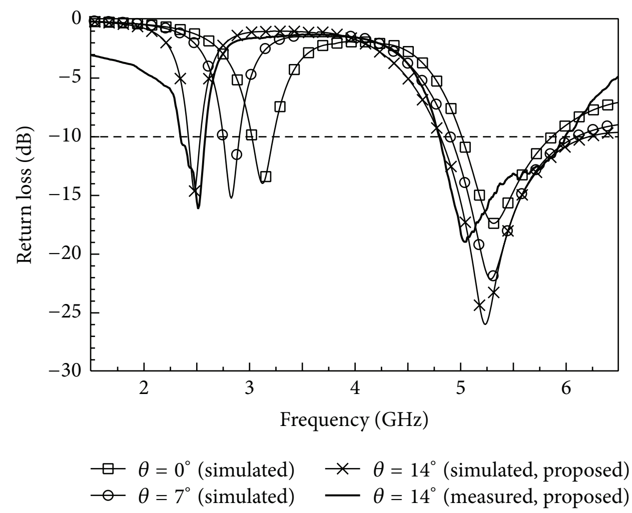
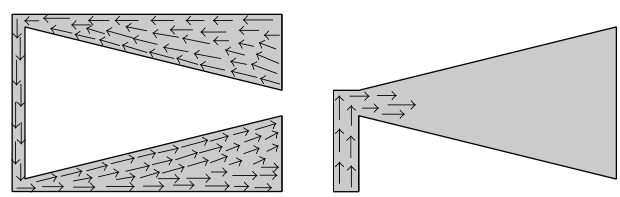
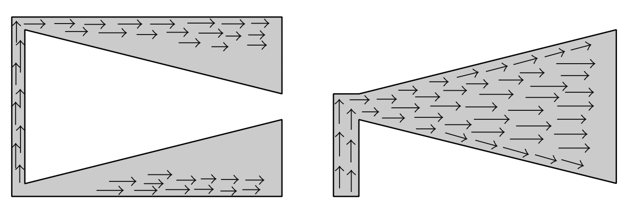


FIGURE 2: Simulated and measured return loss versus frequency for various θ.



(a) 2.45 GHz



(b) 5.5 GHz

FIGURE 3: Simulated surface electrical current distributions obtained at (a) 2.45 and (b) 5.5 GHz for proposed antenna.

of the design concepts are described and the experimental results of the constructed prototype are discussed.

2. Antenna Design and Experimental Results

Figure 1 shows the geometry of the proposed dual-band dipole antenna with asymmetric arms for 2.4/5.2/5.8 GHz WLAN applications. The antenna was printed on an FR4 dielectric substrate with size of 7 mm × 24 mm, thickness of 1.6 mm, and relative permittivity $\varepsilon_r = 4.4$. A 50 Ω coaxial line was introduced for feeding the RF signal. The dipole antenna was composed of two radiating elements: a horn- and a C-shaped metallic arm.

Figure 2 shows the simulated and measured return loss as a function of θ of the horn- and C-shaped metallic arm versus frequency. In this experiment, the simulations were computed with Ansoft HFSS and the measurements were obtained with an R&S ZVB 40 vector network analyzer. Obviously, the lower band shifts toward lower frequency whereas the upper band changes slightly as θ varied from 0° to 14°. For the lower band, the larger angle θ increases the resonant current path and thus causes a lower frequency. For the upper band, the larger angle θ introduces a wider spreading range of resonant current paths along the horn-shaped arm and thus causes a larger impedance bandwidth. The measured lower band has a −10 dB impedance bandwidth of 225 MHz (2321–2586 MHz), which covers the 2.4 GHz band (2400–2484 MHz). Furthermore, the measured upper band has a −10 dB impedance bandwidth of 1190 MHz (4805–5995 MHz), which is sufficient for the 5 GHz (5150–5825 MHz) band. The results exhibit an acceptable agreement between the measurement and the simulation.

The excited surface current distributions simulated via Ansoft HFSS at 2.45 and 5.5 GHz are illustrated in Figures 3(a) and 3(b), respectively. For the lower band excitation, the main surface current distribution is observed around the C-shaped arm and the total current length (=28 mm) is about a quarter-wavelength corresponding to 2.45 GHz. For the upper bands, the main surface current distribution is noted on the horn-shaped arm and the total current length (=14.5 mm) is about

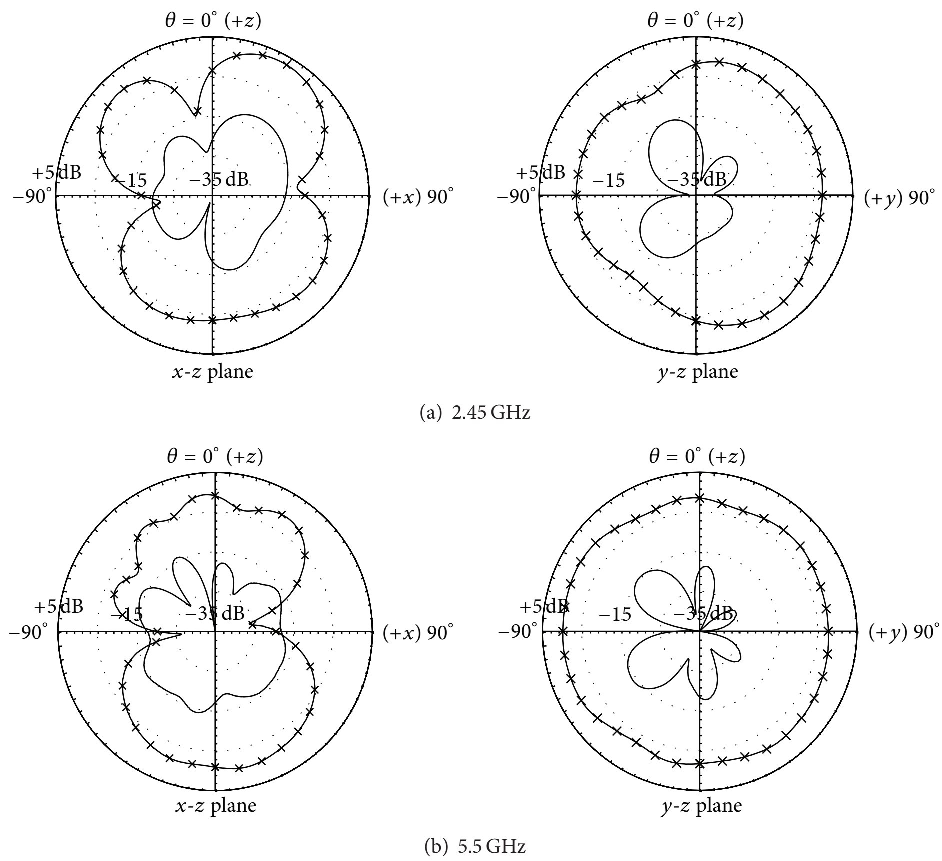


Figure 4: Measured radiation patterns of proposed antenna obtained at (a) 2.45 and (b) 5.5 GHz. –×– copolarization — cross-polarization.

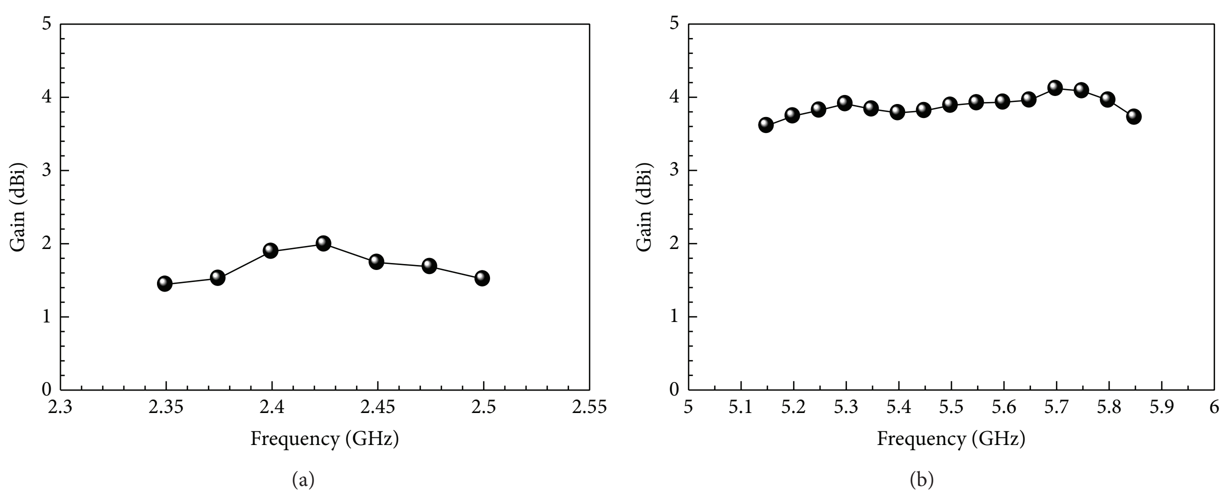


Figure 5: Measured antenna peak gain values versus frequency at (a) 2.35–2.5 and (b) 5.15–5.85 GHz of proposed dual-band antenna.

a quarter-wavelength corresponding to 5.5 GHz. Noticeably, the current on the horn-shaped arm mainly propagates in x-axis direction. The increasing θ did not change the current path in x-axis direction. On the other hand, the larger length of C-shaped arm due to the increase of θ causes a longer current path in the lower band. This feature clarifies that the varied θ mainly affect the lower band but not the upper band.

Figure 4 describes the measured radiation pattern at 2.45 and 5.5 GHz. A figure-of-eight radiation pattern in the x-z plane and a nearly omnidirectional radiation pattern in the y-z plane were obtained. The results in x-z plane indicate that the radiation intensity in $\pm x$ directions is much smaller than that in $\pm z$ directions. A reasonable cross-polarization level is obtained due to the simple geometry of the proposed antenna. Figure 5 plots the measured antenna peak gain against frequency. The gain varies in a range of 1.4–2 dBi at the lower band and 3.6–4 dBi at the upper band. The gain values within the operation bands are generally stable.

3. Conclusion

A dual-band dipole antenna with asymmetric arms for 2.4/5 GHz WLAN application has been successfully designed and implemented. Both −10 dB bandwidths of the lower and upper bands are satisfied for IEEE 802.11 a/b/g standards. Reasonable radiating performance of the proposed antenna is suitable for complex wave propagation environments. Furthermore, the antenna has a compact size of 7 mm × 24 mm, which makes it easy to be integrated with the RF terminals of the wireless devices for satisfying miniaturizing tendency.

Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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