FOLDED MONOPOLE ANTENNA FOR DUAL-BAND WLAN OPERATIONS

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1. Introduction

Recently, wireless communication for the WLAN (wireless local-area network) has gone through the rapid growth. In the 2.4 and 5 GHz WLAN system, the frequencies are at 2.4~2.484 GHz for IEEE 802.11b and at 5.15~5.35 and 5.725~5.825 GHz for IEEE 802.11a, respectively. It is necessary that the electronic equipments effectively cover both 2.4 and 5 GHz bands. Therefore, it is desirable for an antenna to be able to achieve 2.4/5 GHz dual-band operation and numerous antenna designs have been reported [1]. However, most of these antennas have inadequate coverage at the 5 GHz band. Some of recently proposed designs provide sufficient coverage of 5.15~5.825 GHz by using the additional resonance of a meandered wire and the folded dipole [2-4].

In this paper we propose a new compact folded monopole antenna for dual-band WLAN operations. The proposed antenna has a compact size of 6 × 5 × 8 mm$^3$ by folding and meandering. This size is smaller in area and volume than that of the previous antennas. This antenna achieves a sufficient coverage at the 5 GHz band by using a shorting strip that causes multiple current paths.

2. Antenna design

Fig. 1a) shows the structure and dimensions of the proposed folded monopole antenna. The radiating element has compact dimensions of 6 × 5 × 8 mm$^3$ caused by folding and meandering and is suspended by a foam that has the relative permittivity of about 1. The antenna is excited by using a microstrip line of 50 ohms and the FR4 substrate that has the thickness of 1.6 mm and the relative permittivity of 4.6. The ground plane is 40 × 45 mm$^2$ and is printed on the back of the substrate. Fig. 1b) shows the unfolded planar structure of the radiating element and is included to help understanding the proposed antenna. For comparison, a folded and meandered monopole antenna without shorting strip is shown in Fig. 1c) as a reference antenna. In the reference antenna, the unfolded length of the radiating element is about 39 mm. It is a little larger than λ/4 at the resonance frequency (2.4GHz). The proposed antenna is constructed by adding a shorting strip to the reference antenna (see Fig. 1a) ). The shorting strip makes multiple current paths that cause the multiple-resonance. Due to multiple-resonance the proposed antenna can cover the 2.4/5 GHz WLAN bands. Since the length of the current path is reduced by the shorting strip, the length of the radiating element for the proposed antenna is...
increased compared with that of the reference antenna for the resonance at 2.4 GHz.

![Fig. 1](image-url)  
**Fig. 1** Structure and dimensions (in mm)  
- a) Proposed antenna for dual-band operation  
- b) Unfolded planar structure of proposed antenna  
- c) Reference antenna for single-band operation

3. Experimental results

The measured return losses of the proposed antenna and the reference antenna are shown in Fig. 2, together with the simulated one obtained from HFSS simulation software [5]. The reference antenna is resonant at 2.4 GHz with the 10 dB return-loss bandwidth of about 330 MHz. However, the proposed antenna
antenna is resonant at 2.4 GHz, 5.64 GHz, and 7.23 GHz. In the lower band of 2.4 GHz, the 10-dB bandwidth is about 210 MHz (2.34 ~ 2.55 GHz) or about 8.6% for the center frequency of 2.445 GHz, which meets the bandwidth requirement for IEEE 802.11b. In the upper band of 5 GHz, the 10-dB bandwidth is about 840 MHz (5.10 ~ 5.94 GHz) or about 15.2% for the center frequency of 5.52 GHz, which also meets the bandwidth requirement for IEEE 802.11a. Good agreement is observed between the measured and simulated results.

Fig. 3 and 4 show the measured radiation patterns of the proposed antenna at 2.4 and 5.6 GHz, respectively. The radiation patterns in the x-y plane is nearly omnidirectional at both 2.4 and 5.6 GHz. In other operating frequencies the similar radiation pattern was measured.

Fig. 3 Measured radiation patterns at 2.4 GHz for proposed antenna

Fig. 4 Measured radiation patterns at 5.6 GHz for proposed antenna
The gain is measured as shown in Fig. 5. The 2.4 GHz band has a peak antenna gain of about 3.2 dBi and small gain variations (less than about 0.8 dBi) are seen. On the other hand, the peak antenna gain of the 5 GHz band reaches about 3.5 dBi and the gain variations are less than about 1.2 dBi.

Fig. 5 Measured antenna gains for proposed antenna
a) 2.4 GHz band b) 5 GHz band

4. Conclusions

A new dual-band folded monopole antenna has been proposed and implemented. The proposed antenna has the compact size of $6 \times 5 \times 8$ mm$^3$ by folding and meandering and covers 2.4 GHz (2.4–2.484 GHz) and 5 GHz (5.15~5.825 GHz) bands by the shorting strip that causes multiple current paths. Good radiation characteristics and moderate gains have been obtained for both bands.

References