Dual-Band Monopole Antenna with Wide Bandwidths for WLAN Applications

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Abstract

A simple dual-band monopole antenna with wide bandwidths in each band is proposed for WLAN applications. The proposed structure consists of two inverted-L sections printed on the same side of the substrate and fed by a 50 Ω microstrip line. The proposed antenna is designed to have wide bandwidth characteristics in the WLAN (IEEE 802.11a/b) bands. The effect of various parameters on the antenna performance has been studied in detail. The antenna is fabricated using the optimized parameters and it is observed that, the proposed structure offers wide bandwidths in the 2.4 GHz and 5 GHz WLAN bands. The simulated and measured results for the optimized geometry are in good agreement.

1. INTRODUCTION

Wireless local-area networks (WLAN) that allow wireless connectivity between different equipment such as laptops etc. have experienced tremendous growth in the past few years. There are two frequency bands designated for WLAN network: 2.4 GHz band spanning frequencies in the range 2400 – 2484 MHz operating as per IEEE 802.11b standards and the 5 GHz band spanning frequencies in the range 5150 – 5350 / 5725 – 5825 MHz operating as per IEEE 802.11a standards, 5150 – 5350 / 5470 – 5725 MHz operating as per HIPERLAN/2 standards. Presently, the 2.4 GHz band is widely used for WLAN applications and it is estimated that in the future the 5GHz band would be more popular. As a result, if the same electronic equipment is to be used for IEEE 802.11a/b and HIPERLAN/2 applications, it is necessary that the antenna be able to cover all the application bands.

At present, numerous dual-band designs for WLAN applications have been reported in the literature [1]-[9]. Some of these designs do not provide adequate bandwidth at the 5 GHz band, for example [2]-[4]. With large bandwidths in each band, fabrication tolerances in practical applications can be relaxed. Some techniques for obtaining large bandwidths in the 5 GHz band are recently reported [5]-[9].

In this letter, we propose a dual-band antenna design using a double-inverted-L monopole antenna. The proposed antenna looks similar in shape to the one reported in [3] but offers much more wider bandwidths in both 2.4 and 5 GHz bands.

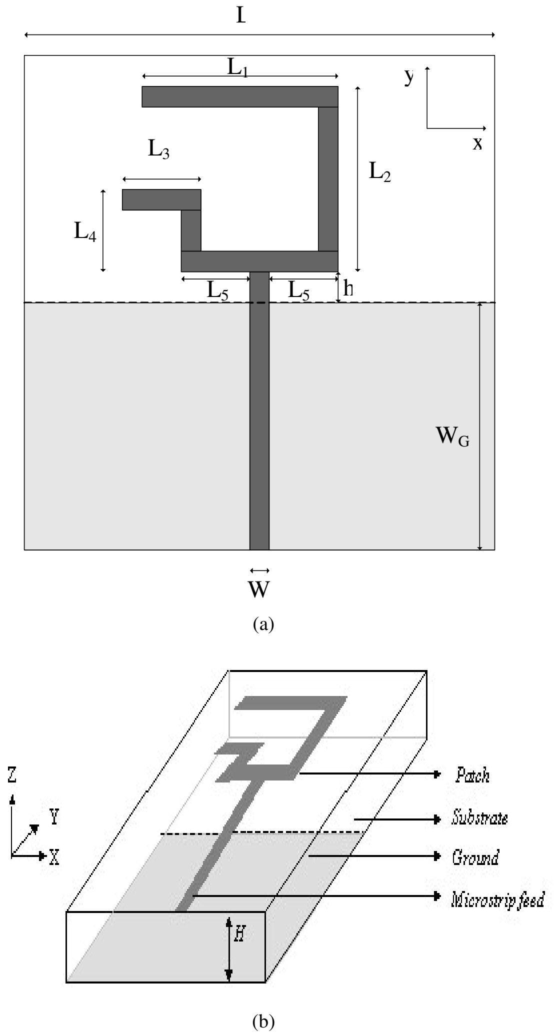


Fig 1: Geometry of the dual inverted-L shaped monopole antenna. (a) Top View, (b) 3D view.

Also, the present antenna is better in terms of fabrication tolerances than the one reported in [3]. The proposed antenna is compact in size, and provides very large bandwidths for applications in IEEE 802.11a/b and HIPERLAN2 systems. The proposed design is described in detail and experimental results of the prototype are presented and compared with the simulated results.

2. ANTENNA DESIGN

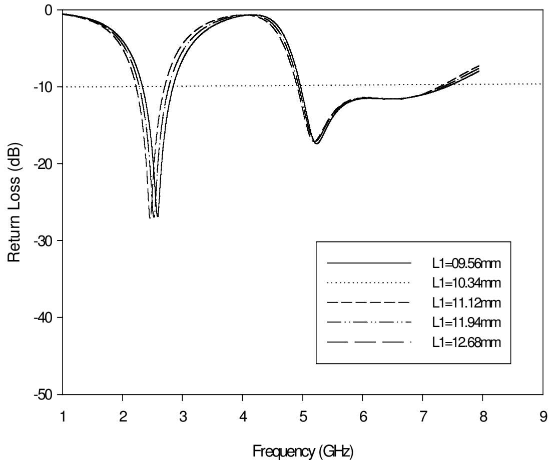
Fig. 1 shows the geometry of the proposed monopole antenna. The antenna consists of two inverted-L elements fed by a 50Ω microstrip line on one side of the substrate. The sections L1 and L2 form the first inverted-L element and the sections L3 and L4 form the second inverted-L element. The ground plane on the back side has the dimensions L x W_G mm^2. The final radiating structure consists of the two inverted-L elements connected in series. The distance between the end of the monopole and the terminal of the microstrip line is denoted as 'h'. The longer inverted-L element for 2.4 GHz WLAN band has a total length of 31.43 mm ($L_1 + L_2 + L_5 + h$) which is around $0.25\lambda_{2.4}$, where $\lambda_{2.4}$ is the free-space wavelength at 2.4 GHz. The shorter element for higher WLAN band has a total length of 16.33 mm ($L_3 + L_4 + L_5 + h$) which is around $0.28\lambda_{5.2}$, where $\lambda_{5.2}$ is free-space wavelength at 5.2 GHz. To keep the design simple, line width for all the sections (L_1, L_2, L_3, L_4 and L_5) is chosen same as that for a 50Ω microstrip line.

The antenna is simulated using commercially available TLM based software MicroStripes [10] for parameter optimization. In the following section, results of the parametric study and comparison of simulated and measured results for the optimized geometry are presented.

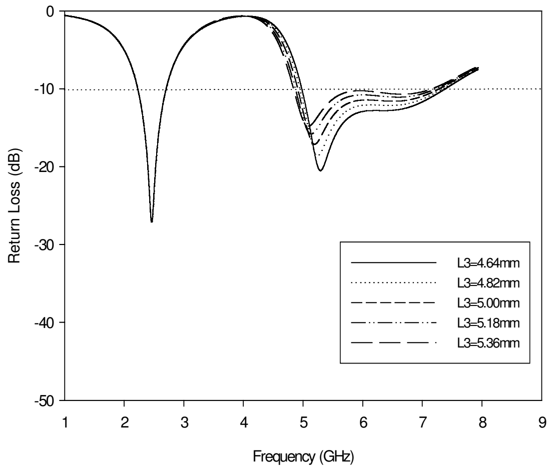
3. RESULTS AND DISCUSSION

As mentioned earlier, the geometry shown in Fig. 1 is simulated using commercially available software MicroStripes [10]. The ground plane dimensions are chosen as 50.8mm x 28.8mm (L × W_G). Other dimensions are as follows: L = 50.8 mm, W_G = 28.8 mm, W = 1.832 mm, L_1 = 11.1 mm, L_2 = 14 mm, L_3 = 5 mm, L_4 = 5 mm, L_5 = 5 mm, h = 2.33 mm and H = 0.762 mm.

Initially the effect of lengths L_1 and L_3 on the return loss characteristics of the antenna is studied. Fig. 2 shows the simulated results of this study. It is seen from fig. 2 that lengths L_1 and L_3 affect the centre frequencies in the lower and upper WLAN bands respectively, without affecting the other band. The bandwidth in each band remains nearly the same with change in either L_1 or L_3. The effect of L_2 and L_4 is expected to be similar as they only add to the total path lengths in the lower and upper WLAN bands respectively. It is expected that if L_2 is decreased or L_4 is increased by larger amounts, both the bands would be affected. In such a case L_1 and L_3 would come much closer and coupling between them would affect frequencies and bandwidths in both the WLAN bands. In order to avoid this and offer better fabrication tolerances, L_2 and L_4 are suitably chosen.



(a)



(b)

Fig 2: Return loss versus frequency for various values of (a) L1 and (b) L3

The final structure has L_1 = 11.12 mm which gives centre frequency of the lower WLAN band at 2.4 GHz and L_3 = 5.0 mm which gives the centre frequency of the higher WLAN band at 5.2 GHz. The optimized geometry is fabricated on a dielectric substrate of relative permittivity ε_r = 3.2 and height H = 0.762 mm. The measured and simulated return loss performance is depicted in fig. 3. It is seen that they compare well in both the WLAN frequency bands. The measured bandwidth obtained in the 2.4 GHz WLAN band is 22% (2.04 – 2.56 GHz) that covers the IEEE 802.11b WLAN band (2.4 –

2.484 GHz). The measured bandwidth obtained in the 5.2 GHz WLAN band is around 37% (5 – 7.88 GHz) that covers the IEEE 802.11a WLAN (5.15 – 5.35 GHz / 5.725 – 5.825 GHz) and also the HiperLAN/2 (5.15 – 5.35 GHz / 5.47 – 5.725 GHz). Hence, the proposed antenna gives sufficient bandwidths in both the WLAN bands allowing better flexibility in terms of fabrication tolerances.

Typical radiation characteristics for the proposed dual-band antenna are next studied. Figures 4–5 show the measured radiation patterns including the co- and cross- polar components in the y-z and x-z planes for the antenna at 2.4 GHz and 5.8 GHz, respectively. It is observed that the proposed antenna in general shows monopole-like radiation patterns, though not very close to those of a conventional monopole antenna. Moreover, since the proposed pattern is not symmetric, the radiation patterns in the x-z and y-z planes are not symmetrical. In addition, it is also found that the co- and cross polar components are comparable except at 2.4 GHz in the y-z plane. This is probably due to the result of strong horizontal components of the surface current on the radiating patch as argued in [6]. This characteristic could be an advantage for better transmission capabilities in a multi-path environment [6].

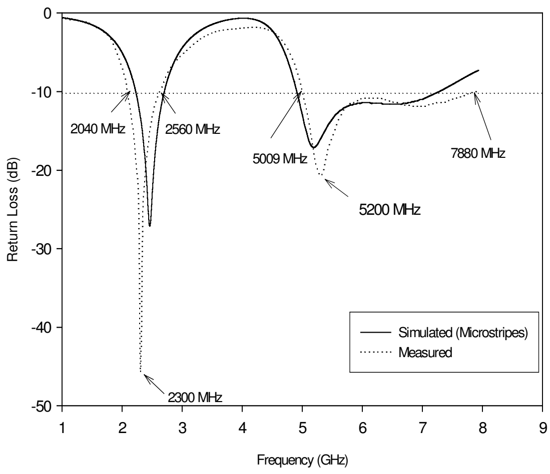


Fig 3: Measured and simulated return loss of dual inverted L-shaped monopole antenna

4. CONCLUSIONS

A dual–band monopole antenna with two inverted L-shaped radiating elements is proposed for IEEE802.11a/b WLAN applications. The proposed antenna provides wide bandwidths of 22% and 37% in the 2.4 and 5 GHz WLAN bands. Due to its wide band characteristics, the antenna offers considerable fabrication tolerance. The proposed antenna is compact and easy to fabricate and thus suitable for commercial applications.

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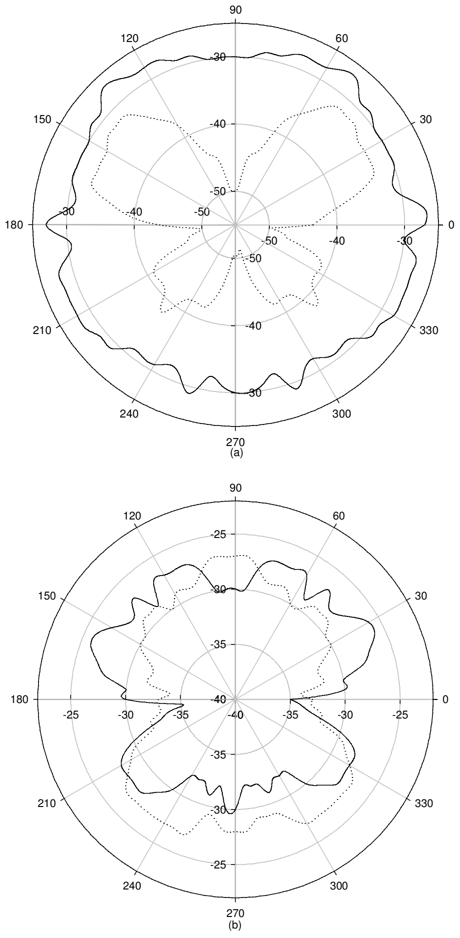

Fig. 4: Measured Y-Z cut radiation patterns at (a) 2.4 GHz and (b) 5.8 GHz.

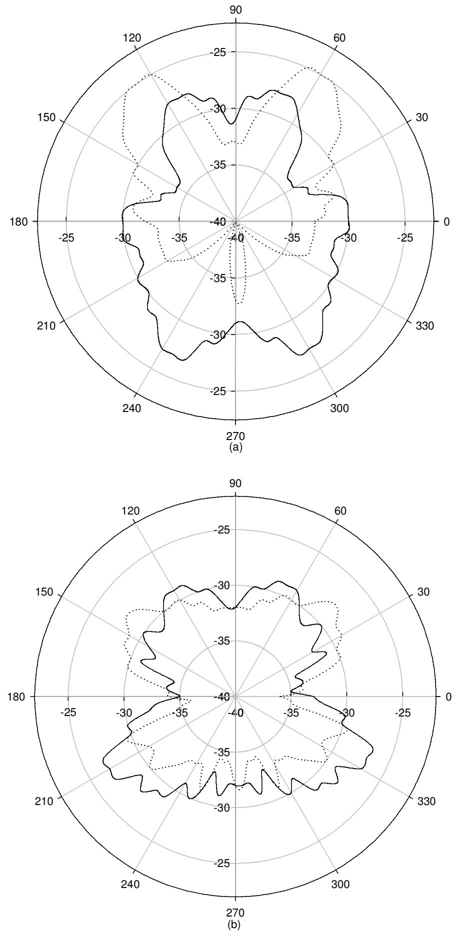

Fig. 5: Measured X-Z cut radiation patterns at (a) 2.4 GHz and (b) 5.2 GHz.