DUAL BAND DIPOLE-LOADED NOTCH ANTENNA

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Abstract

This paper presents a dipole-loaded notch antenna designed for the operation of the dual-band WLAN application. The antenna structure starts with a quarter-wavelength slit cut on a ground plane with suitable addition of a planar wire dipole connected to the open ends of the notch. The monopole notch is designed to radiate at the low frequency band, 2.4 GHz for IEEE 802.11b/g, while the planar wire dipole is responsible for the other band, 5.2/5.8 GHz for IEEE 802.11a. It is found that the wire dipole has the side effect of reducing the slit length due to its capacitive loading effect at the low frequency band. The parametric study is performed to demonstrate the characteristics of the proposed antenna, from which the guidelines for the design of the proposed antenna are provided.

1. INTRODUCTION

For communication systems of wireless local area network (WLAN), there is a continuous need for dual-band/multi-band planar low-profile antennas because of the various services available and the limited space on the handset/mobile devices [1]. For practical applications to cover the WLAN operation, the lower band ranges from 2.4 to 2.484 GHz for IEEE 802.11b/g and the upper band covers frequency band from 5.15 to 5.825 GHz for IEEE 802.11a. Reactive loading technique by utilizing a parasitic wire element has been proved to be effective to create an additional resonant frequency for dual-band antennas [2~5].

In this paper a new dual-band notch antenna loaded with a planar wire dipole is proposed for achieving two separate large bandwidths. A slit cut at the edge of a ground plane as a radiator is inherently a quarter wavelength magnetic monopole. To extend the use of a simple slit cut on the ground plane for the purpose of dual-band operation a planar wire dipole is proposed to load the simple notch antenna. The monopole notch is designed to radiate at the lower frequency band, 2.4 GHz, while the planar wire dipole is responsible for the upper frequency band, 5.2/5.8 GHz. The planar dipole wire also helps to reduce the slot length due to its capacitive loading effect at the lower frequency band. On the other hand, the crossover of microstrip line and notch serves as a balun to equally feed the planar dipole for the upper frequency band. The proposed antenna is suitable for the hand-held/mobile devices such as PDA or notebook computer for WLAN applications.

2. ANTENNA DESIGNS

The proposed notch antenna operated at the bands of 2.4, 5.2 and 5.8 GHz is shown in Figs.1 (a)~(b). The antenna consists of a slit cut on the edge of the finite ground plane with size 32×41 mm^2 and fed by a bent 50ohm microstrip line. At the open ends of the notch a planar wire-type dipole is connected. The purpose of adding the planar wire dipole is to introduce another radiator at the upper frequency band in addition to the notch. As a given slit length is specified, the dipole length L_d, the feeding length d_f and the feeding position L_2 need to be adjusted carefully to achieve good impedance matching at 2.4 GHz and 5~6 GHz.

Fig.2 shows the effects of the dipole length upon the return loss versus frequency, for the cases of L_d=9, 10 and 11mm, respectively. As L_d increases the resonant frequency for the upper frequency band 5~6 GHz decreases as shown. It should be noted that the lower frequency band 2.4 GHz is nearly unaffected by the variation of the dipole length since the notch is the actual radiator for the 2.4 GHz band in this case. Fig. 3 shows the effects of the slot length upon the return loss versus frequency, for the cases of L_s=11.52, 12.52 and 13.52mm, respectively. As L_s increases the resonant frequency for the lower frequency band 2.4 GHz decreases. It should be noted that the upper frequency band 5~6 GHz is relatively unaffected by the variation of the slot length since the planar dipole is the actual radiator for the 5~6 GHz band in this case.

Fig.4 shows the effects of the feeding position upon the return loss versus frequency for the cases of L_2 =7.7, 8.7 and 9.7mm, respectively. The feeding position apparently affects the responses of both the lower and the upper frequency bands, which is quite reasonably. Similarly, the feeding length has strong effects on the responses of return loss for both the lower and the upper frequency bands. It should be noted that Figs.2~4, etc., provide the guidelines needed for the design of the proposed antenna. The detailed dimensions of the prototype antenna are listed in Fig.1 (b). The resulted overall slot length 12.52mm is only 56% of a simple (unloaded) monopole notch with notch length 22.35mm. The slot width W_s about 0.5~1mm and the feeding pin width W_p about 0.5~1.5mm are found well suited for this antenna structure. The effects of the ground size are also investigated. It is found that the ground length L_g has relatively small effects upon the characteristics of the bandwidth, while the reduction of the ground width W_g from 41mm to 31mm, as an example, would ruin the 2.4 GHz band but keep the 5~6 GHz unchanged.

3. EXPERIMENTAL RESULTS

The antenna prototypes are designed and fabricated on a cheap FR4 board ($\varepsilon_r = 4.4$, $\tan\delta = 0.015$) with thickness h=0.8mm. The proposed antenna is designed with the aid of the EM simulation software IE3D^{TM} and verified by experiments [6]. The planar wire dipole and the slit cut is formed on the ground side of the substrate, while the 50ohm feeding line is etched on the other side. The measured and simulated return loss, S11, of the proposed notch antenna is shown in Fig. 5. The measured characteristics compare quite well with the simulated results.

Figs. 6(a) and 6(b) show the measured E-plane (YZ-plane) and H-plane (XZ-plane) radiation patterns at 5.8 GHz. The E-plane co-polarization pattern is similar to that of the ideal half-wavelength (IHW) slot antenna except that the cross polarization is higher. The H-plane co-polarization pattern is not as isotropic as the IHW slot antenna. The worsening of the omni-directional property is due to the unbalanced excitation of the planar dipole. Similar phenomena are observed for the radiation patterns at the frequency 5.2 GHz. The measured antenna gains are 3.4dBi and 4.2dBi, respectively, for the frequencies of 5.2 and 5.8 GHz. The radiation patterns at the frequency 2.4 GHz, omitted here for brevity, are quite similar to those of the IHW slot antenna except that the cross polarization is higher. The measured antenna gain at the frequency 2.4 GHz is ~0.8dBi.

4. CONCLUSIONS

A notch antenna designed for the purpose of dual-band operation is achieved. The proposed antenna is implemented by suitably adding a planar wire dipole to the open ends of the notch. The monopole notch is designed to radiate at the 2.4 GHz band, while the planar dipole is arranged to radiate at the other band, 5.2/5.8 GHz. The planar dipole has the side effect of reducing the slot length from 22.35mm to 12.52mm due to its capacitive loading effect at the lower frequency band. The crossover of microstrip line and notch serves as a balun to equally feed the planar dipole for the upper frequency band, although certain amount of unbalanced power is observed that leads to the non-isotropic H-plane radiation pattern at the upper band. Future works may include the reduction of the unbalanced feeding effect.

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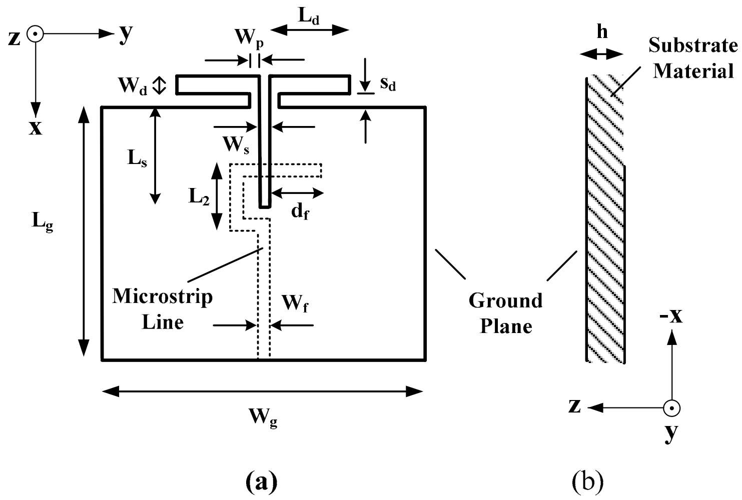

Fig. 1 (a) Top view and (b) side view of the proposed notch antenna loaded with a planar wire dipole. The dimensions (all in mm) are : W_d=1.9, W_g=41, L_g=32, W_f=1.4, W_s=1, L_s=12.52, d_f=6.8, L_d=10, W_d=1.9, s_d=1, W_p=1 and L_2=8.7

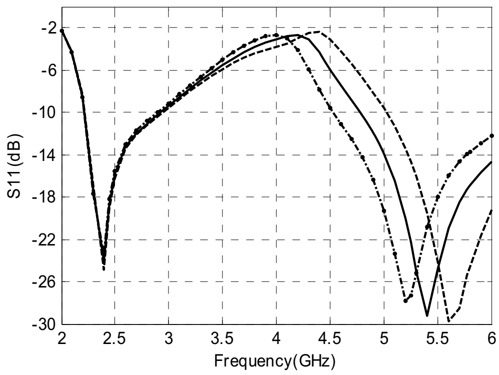

Fig. 2 The effects of the dipole length upon the return loss versus frequency for the cases of L_d=9mm (dashed line), 10mm (solid line) and 11mm (dash dot line with dots).

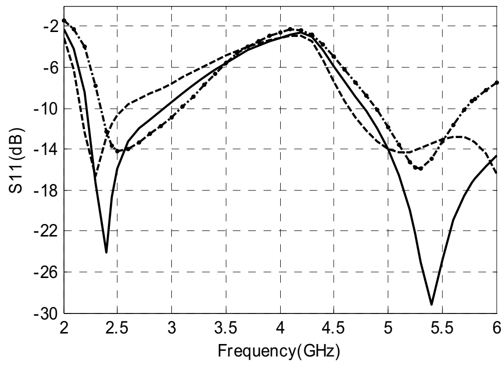

Fig. 4 The effects of the feeding position upon the return loss versus frequency for the cases of L_2=7.7mm (dashed line), 8.7mm (solid line), and 9.7mm (dash dot line with dots).

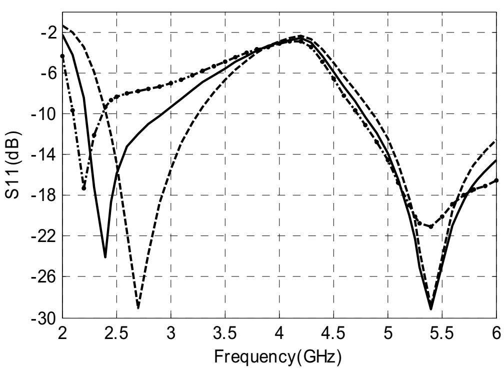

Fig. 3 The effects of the slot length upon the return loss versus frequency for the cases of L_s=11.52mm (dashed line), 12.52mm (solid line), and 13.52mm (dash dot line with dots).

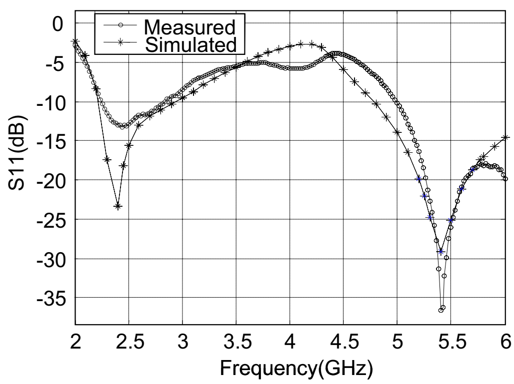

Fig. 5 The simulated and measured return loss of the proposed notch antenna in Fig. 1.

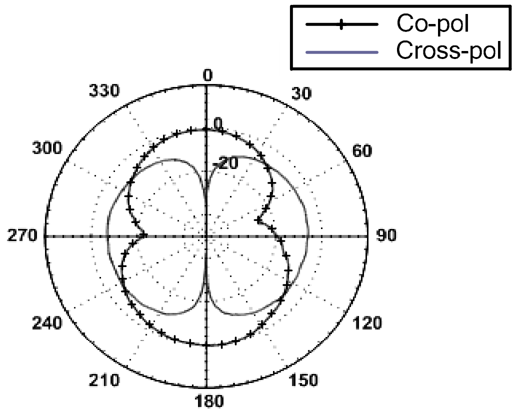

Fig. 6(a) The radiation patterns of the proposed notch antenna at 5.8 GHz : E-plane (YZ-plane)

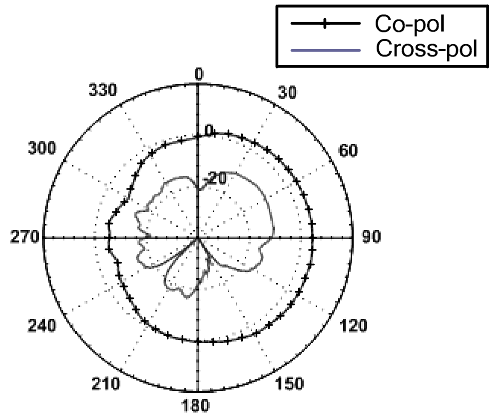

Fig. 6(b) The radiation patterns of the proposed notch antenna at 5.8 GHz : H-plane (XZ-plane)