Printed Folded Antenna for Dual-Band WLAN Operations

Gyoo-Soo Chae · Young-Ki Cho

Abstract

A novel printed inverted-F antenna for dual-band WLAN is presented. The proposed design is based on the folded quarter-wave antennas, which have a conductor plate having two arms. An extremely thin prototype antenna is fabricated according to the simulation result. The obtained antenna can perform in IEEE802.11a, b(2.4～2.484 GHz and 5.15～5.35 GHz bands) and be adopted for laptop applications. All the measurements are performed in the actual test fixture.

Key words : Printed Inverted-F, Folded Antenna, Dual-Band WLAN, Laptop Application.

Ⅰ. Introduction

There has been a great deal of interest in developing multi-band antennas in wireless communication systems. With the revolution of wireless communication, studies and development efforts have been focused on smaller size and better performance antennas[1],[2]. The resonant length of the conventional patch antenna is approximately $\lambda_0/2$, which is not applicable in current communication devices due to the size constraints. It has been well known that by placing a shorting wall, the resonant length can be reduced to $\lambda_0/4$. A current study .introduces a folded shorted-patch, which can be further reduced to $\lambda_0/8$[3]. However, previous efforts for developing dual-band and wideband antennas are limited in typical planar inverted-F antenna (PIFA)[4],[5]. Recently, various printed antenna structures have been proposed due to the increased demands in wireless system applications[6]~[10]. In this study, we propose a printed inverted-F antenna supporting in dual-band WLAN operations and the geometry is basically a folded quarter-wave antenna[5]. The proposed folded plate is chosen to reduce the antenna size and also incorporating additional frequency band. In the previous studies pertaining to the IEEE 802.11 a, b standard operating frequency 2.4 GHz and 5 GHz, various types of antennas have been developed in the personal wireless communication systems[6]~[10]. 802.11b has been dominant market choice in commercial wireless applications. In recent years, the demand for further expansion of wireless systems has been shifting from existing standard to dual-band covering frequency range of 2.4 GHz and 5 GHz. Owing to the rapid progress in WLAN communications, the antenna developments have also demanded multi-band operations in the 2.4 GHz and 5 GHz. As an example, most of laptops will incorporate 802.11a and 802.11b technology, which can provide data rates up to 54 Mbps and 11 Mbps, respectively. In the 5 GHz, there are other operation bands depending on the countries so our future antenna design will be focusing on expanding the covering frequency range up to 5.85 GHz. Simulation and measured results are presented and compared.

Ⅱ. Antenna Design and Measurement

Engineers are always confronted with engineering trade-offs between technical rigor and time to market. There are numerous electromagnetic simulation tools for antenna design, but even state of the art tools are not providing fully optimised antennas in actual system environment. CST MWS used here has been a useful guideline in our antenna design. Fig. 1 shows the proposed antenna configuration and the coordinate system used here. The radiating plate of the presented antenna has two arms folded at the one end of the arm and printed on the 0.1 mm thick copper film. The fabricated antenna with feeding geometry is shown in Fig. 2. In order to get the dual-band operation, the optimum length of each arm and the gap between two arms are determined based on the simulation result shown in Fig. 4. In addition to the arm length and gap,

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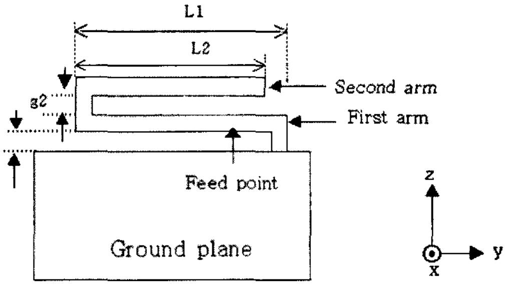

Fig. 1. Antenna configuration and the coordinate system.

the size of ground plane also affects to the electrical performance. In the presented antenna, the feeding point is on the first arm and 3 mm apart from the ground post as shown in Fig. 2. The first arm has dimension of 20 mm($\approx 0.15\lambda_0$) in length(L_1) and 1 mm in width and normally generate resonance for 2.4 GHz band. And the second arm produces the other resonance in 5 GHz and has dimension of 15mm in length(L_2) and 1 mm in width. The first gap(g_1) between the ground plane and the first arm is 2.5 mm and the second gap(g_2) between two arms is chosen to be

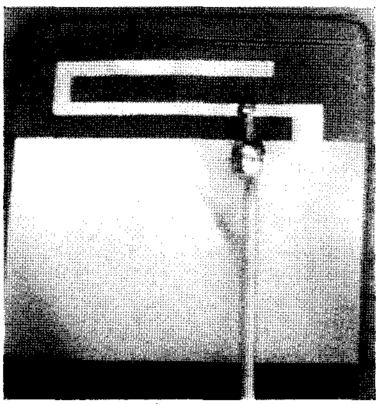

Fig. 2. Fabricated antenna with feeding geometry.

2 mm. And the ground plane is size of 20×30 mm and it is normally put underneath the LCD panel when the antenna is installed in the LCD top. All of the dimensions mentioned above are optimised in the specific laptop we used for measurements. The coax cable we used here is a 1.13 mm diameter and 500 mm long single shielded cable manufactured by Nessei Electric Company with part number RF-MF5016. The cable diameter may need to be increased by 1.38 mm to minimize the loss in the 5 GHz band. The cable with a Hirose U.FL-LP-066 connector is connected to the antenna feeding point. In the wireless systems, the RF connector will mate to a Hirose U.FL-R-SMT receptacle. An SMA conversion adaptor with part number HRMP-U.FLJ was used to get all the following results. Fig. 3 shows the antenna location on the test fixture and the test condition. The note-PC is normally sitting on a non-conductive table and the LCD is opened that the angle from the keyboard shall be approximately 110°, which is normal user position. Fig. 4 presents the return loss of the simulation and measurement of the presented design and shows fairly good performance in both frequency bands. The return loss in the 2.4 GHz(2.4~2.484 GHz) and 5 GHz(5.15~5.35 GHz) shall not exceed −10 dB over the specified frequency band to satisfy typical commercial WLAN specifications. However, for the 5 GHz band, the bandwidth is only 430 MHz(4.9~5.33 GHz), which is not enough to cover the entire 5 GHz band in WLAN system. In the future work, we will suggest an improved design to expand the bandwidth in 5 GHz band(5.15~5.85 GHz). The frequency shift is observed in the measurement result due to the LCD metal frame and plastic cover. The LCD metal frame, which is attached around the LCD panel and the dimension is 5 mm width and 2 mm thickness, is apart 7 mm from the feeding point on

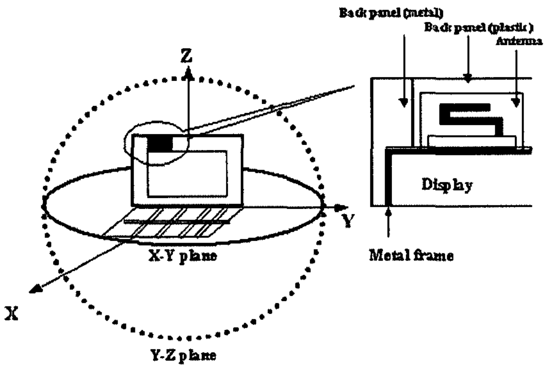

Fig. 3. Antenna location and test condition.

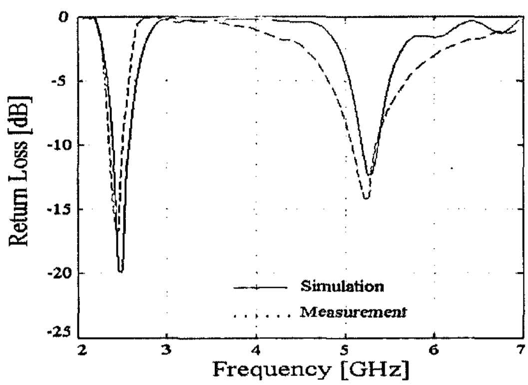

Fig. 4. Predicted and measured return loss.

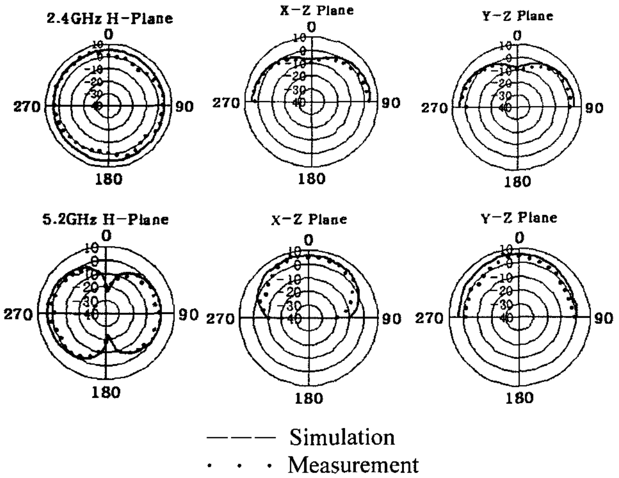

Fig. 5. Simulated and measured results for the radiation pattern(dB).

the first arm. The plastic cover is made of polyvinyl chloride(PVC) and the antenna is put on the cover as shown in Fig. 3. Fig. 5 shows the radiation patterns of the simulation and measurement. We note that the resultant electric field is the vector combination of the vertical and horizontal components. The measured average gain in the 2.4 GHz and 5 GHz band have a level of ∼−3 dBi and ∼−4 dBi, respectively. The average gain is normally to be obtained from pattern of the antenna in the azimuth plane(x-y plane in Fig. 3). However, some antenna implementations often have better gain at angles other than the horizontal plane. This sort of antenna is normally accepted in the commercial WLAN systems if the results are measured at an angle not to exceed 45 degrees from the horizontal plane. The peak gain in the 2.4 GHz band is about 3∼4 dBi, while that in the 5 GHz band is about 1∼2 dBi. This meets the typical specifications to most of the wireless applications.

III. Conclusions

A novel printed inverted-F antenna for dual-band operation in WLAN applications is proposed. The proposed antenna has good characteristics in the 2.4 GHz and 5 GHz bands and manufacturing and installation in the fixtures are very simple and easy. It is also easy to tune the antenna in lower and higher bands by controlling two arms. In the future study, we will investigate the coupling effects in the gap between two arms and more detailed theoretical calculation of the length of arms including effects by ground plane and LCD metal frame.

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