An Inverted-F Antenna for 2.4/5 GHz WLAN Applications

2.4/5 GHz 무선랜 대역용 Inverted-F 안테나

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Abstract

An inverted-F antenna for wireless local area network(WLAN) is presented. The proposed design is based on the typical dual-band planar inverted-F antennas(PIFA), which have two tunable resonant modes. The low-profile antenna is built by stamping and designed to be mounted on the metal frame of the laptop LCD panel. The obtained antenna can perform in 2.4 GHz and 5 GHz bands and be adopted for other wireless applications. All the measurements are performed in the actual test fixture.

요 약

본 논문에서는 무선랜용 역 F형 안테나가 소개되었다. 제안된 안테나는 두 개의 가변 공진 모드를 갖는 일반적인 평판 역 F형 안테나를 기본으로 설계되었다. 이 소형 안테나는 금속판을 각인(stamping)하여 제작되었고 노트북의 LCD 양 측면의 보호용 금속 지지대에 장착할 수 있다. 그리고 이 안테나는 2.4 GHz와 5 GHz 대역에서 동작하며 다른 무선통신기기들에도 적용될 수 있다. 모든 실험은 안테나가 실제 측정용 노트북에 장착된 상태에서 이루어졌다.

Key words : Inverted-F Antenna, Dual-Band, WLAN

Ⅰ. Introduction

With the revolution of wireless communication, development efforts for portable devices have been focused on smaller size, lightweight, and better performance. This has resulted in a great deal of interest in developing multi-band and low-profile internal antennas in wireless communication systems. An internal antenna makes the devices look better and it is not prone to breakage. In the previous studies pertaining to the dual-band operating frequency, various types of internal antennas have been developed in the personal wireless communication systems[1]~[3]. The PIFA has become the most promising choice for the above applications due to the compact size and low-profile. However, the bandwidth of a typical PIFA has been limited by its available volume and the height between the ground plane and the antenna radiating plate is the most critical parameter. To avoid the height limitation, various design techniques have been reported[4]~[7] and adopted in the commercial mobile products[7].

In this article, we present a inverted-F for WLAN applications. The IEEE802.11 presents the first standard for WLAN products. It has been represented an important milestone in WLAN systems since 1997. In 1999, the IEEE approved both the 802.11a and 802.11b standards. 802.11b has been dominant market choice in commercial wireless applications. 802.11b, now popu-

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larly known as Wi-Fi, specified operation in 2.4 GHz and could achieve speed up to 11 Mbps using direct sequence spread spectrum(DSSS) technology. In recent years, the demand for further expansion of wireless systems has been shifting from existing standard to 802.11a and a new standard 802.11g brings the advantage of higher speeds, while maintaining backward compatibility with existing 802.11b. 802.11a specified operation in 5 GHz and at speed up to 54 Mbps using orthogonal frequency division multiplexing(OFDM). As an example, most of laptops in today's market have been incorporating both the 802.11a and 802.11b technology since early 2002. 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. In the 5 GHz, there are three operation bands depending on the countries so our current antenna design is focusing on expanding the covering frequency range up to 5.85 GHz. Previous efforts for developing dual-band antenna for mobile phones are limited in typical PIFA[4]~[9]. Recently various printed antennas on the PCB[1],[2] and metal stamping antennas have been proposed due to the increased demands in wireless system applications. In this study, we propose an inverted-F antenna supporting 802.11a and 802.11b. The antenna is built by stamping and designed to be installed on the metal frame of the laptop LCD panel. The geometry is based on typical internal multi-band antennas for mobile phone[4]~[9], which achieve the multi-band operation by having two different frequency resonant modes on the radiation patch. The proposed antenna has also two radiating elements covering each low and high band. 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

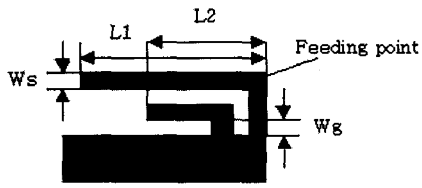

Fig. 1. Antenna configuration.

providing fully optimised antennas in actual system environment. However, the simulation tool we used has been a useful guideline in our antenna design. The geometry of proposed IFA with a metal stamping is shown in Fig. 1 and the radiating part has two arms folded from the ground post.

In order to get the dual band operation, the optimum length of each arm(L1, L2) and the gap(Wg) between two arms are determined based on the simulation result shown in Fig. 2. In addition to the arm length and gap, the size of ground plane also affects to the electrical performance. In the presented antenna, the feeding point is on the first arm, which has dimension of 26 mm in length(L1) and 1.5 mm in width(Ws) and generate low resonance for 2.4 GHz band. The second arm(L2) produces the other resonance in 5 GHz and has dimension of 15 × 1.5 mm. The gap between two arms (Wg) is chosen as 1.5 mm and the width of the ground posts from ground plane to the arms are 3 mm. And the ground plane in the same plane with two arms is size of 27 × 7 mm. All of the dimensions mentioned above are optimised in the specific laptop we used for measurements. Fig. 3 presents a manufactured antenna

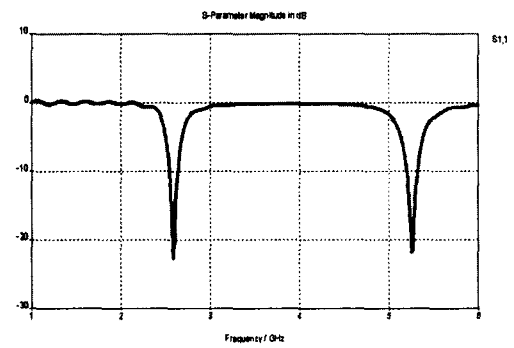

Fig. 2. Simulation result.

Fig. 3. Manufactured antenna picture.

Fig. 4. Mounted antenna on the laptop.

that has the folded structure to mount on the LCD metal frame. Fig. 4 shows the mounted antenna on the laptop and all the following measurements are done in exactly this condition. After we tried many positions, we come to a conclusion that the best location of the antennas in laptops is to place the antenna on the laptop display as high as possible. But this location might force a design trade-off between the antenna's visibility and the cable loss.

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 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. The VSWR and gain was measured at the cable connector. Fig. 5 presents the measured VSWR and shows fairly good performance in both frequency bands.

The radiation pattern and gain are tested in an anechoic chamber. The measurement was normally taken in the horizontal plane with antenna installed in

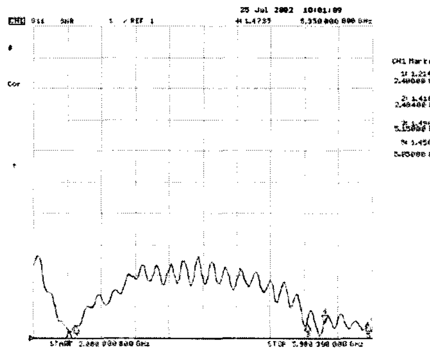

Fig. 5. Measured VSWR.

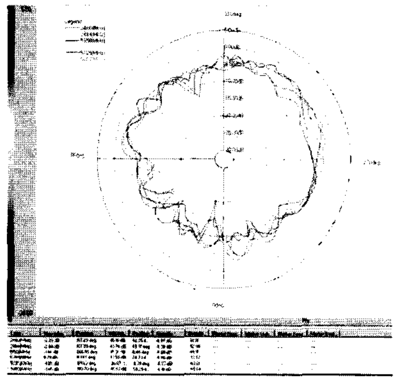

Fig. 6. Measured radiation pattern(X-Y plane).

the laptop. However, this recognizes that some antenna implementations have better gain at angles other than the horizontal plane. Implementation of this sort shall be acceptable if a system can demonstrate a test methodology that proves the gain, measured at an angle not to exceed 45 degrees from the horizontal plane, meets the requirements of the manufacturer. The angle between the display panel and the laptop base is in 90 degrees. The numbers and test methodology in the specifications would be really depend on the system manufacturers. Fig. 6 shows the radiation pattern in X-Y plane. The average gain in the 2.4 GHz and 5 GHz band have a level of ~ -3 dBi and ~ -4 dBi, respectively. The gain at 5 GHz is normally 1 dB lower than that of 2 GHz due to the cable loss. The average combined gain are increased to ~ -1 dBi and ~ -2 dBi due to the antenna diversity. This meets the typical specifications to most of the wireless applications. Fig.

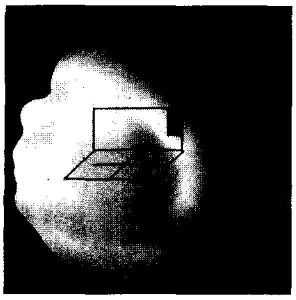

Fig. 7. 3-D radiation pattern at 2.4 GHz.

7 shows the three-dimensional radiation pattern at 2.4 GHz measured in SATIMO chamber. The radiation pattern shows that the laptop LCD panel affects to the antenna radiation and antenna diversity would be helpful to improve the system performance.

Ⅲ. Conclusions

A novel flexible inverted-F antenna for dual-band operation in WLAN applications is proposed. The proposed antenna has wide-band 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 plan.

References

[1] S. H. Yeh, K. L. Wong, "Dual-band F-shaped monopole antenna for 2.4/5.2 GHz WLAN application", *IEEE Antennas and propagation Society International Symposium*, vol. IV, pp. 72-75, 2002.

[2] D. Liu, E. Flint and B. Gaucher, "Integrated laptop antennas-Design and evaluation", *IEEE Antennas and propagation Society International Symposium*, vol. IV, pp. 56-59, 2002.

[3] W. S. Chen, T. W. Chiou and K. L. Wong, "Compact PIFA for GSM/DCS/PCS triple-band mobile phone", *IEEE Antennas and propagation Society International Symposium*, vol. IV, pp. 528-531, 2002.

[4] M. Ali, G. J. Hayes, H. S. Hwang and R. A. Sadler, "Design of a multiband internal antenna for third generation mobile phone handsets", *IEEE Transactions on Antennas and Propagation*, vol. 51, no. 7, pp. 1452-1460, Jul. 2003.

[5] I. Egorov, Z. Ying, "Low profile built-in multi-band antenna", *U. S. Patent number 6326921*, 2001.

[6] I. Pankinabo, "Antenna construction including a ground plane and radiator", *U. S. Patent number 6297776*, 2001.

[7] F. Geeraert, "Dual band antenna for a handset", *U. S. Patent number 6307512*, 2001.

[8] G. Zhou, "Internal multi-band antenna for mobile communications", *U. S. Patent number 6466170*, 2002.

[9] D. Nghiem, "Folded quarter-wave patch antenna", *U. S. Patent number 6008762*, 1999.

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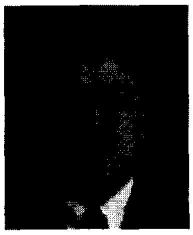

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