An Internal PIFA for 2.4/5 GHz WLAN applications

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Abstract- **This paper presents a internal planar inverted-F antenna (PIFA) for 2.4/5 GHz Bluetooth and WLAN applications. The proposed antenna has a small ground plane with the achievement of impedance bandwidth of 110 MHz (2.38 ~ 2.49 GHz) in the Bluetooth band and 900 MHz (5.1 ~ 6.0 GHz) near 5 GHz in WLAN band within 2:1 voltage standing wave ratio (VSWR), and an approximately omni-directional radiation pattern is obtained. It also shows a good antenna gain. These features make it alternative for use in dual-band WLAN antenna.**

I. INTRODUCTION

Recently, note book computers are increasingly being equipped with wireless local area networks (WLAN) for the IEEE 802.11b (2.4 - 2.48 GHz), 802.11a (5.15 - 5.35 GHz, 5.725 - 5.825 GHz) in the US and HIPERLAN/2 (5.15 - 5.35 GHz, 5.47 - 5.725) protocols in Europe [1], [2]. In particular, the dual band 802.11a/b and HIPERLAN/2 antennas are required toward a small size and high gain while retaining the high efficiency. Internal PIFAs are very suitable in WLAN applications since they are compact, low profile and easy to manufacture [3].

This paper investigates the miniature internal PIFA for the dual band 802.11a/b and HIPERLAN/2. Both the radiation patch and small ground plate are made of a copperplate with a thickness of 0.2 mm. It is directly fed by a 50Ω coaxial cable. It can be easily placed along the perimeter or at the corners of the display panel of the notebook computer [2]. A proposed antenna is designed to resonate at the frequencies of 2.4 GHz and 5 GHz band by adjusting a location of a shorting pin and a length of a radiation element. The proposed antenna can achieve the impedance bandwidth of 110 MHz at the lower frequency of 2.4 GHz band (2.38 - 2.49 GHz) and 900 MHz at the higher one of 5 GHz (5.1 - 6.0 GHz). Especially, the wide band performance can be able enough to cover the 802.11a/b in the US and HIPERLAN/2 band in Europe. The radiation pattern is approximately omni-directional at each associated frequency band. The proposed antenna can provide a sufficient bandwidth for the applications of IEEE 802.11a/b and HIPERLAN/2 bands and a high gains with 2.39 dBi at 2.44 GHz and 3.70 dBi at 5.8 GHz, respectively.

II. THE PROPOSED ANTENNA DESIGN AND PERFORMANCES

Fig. 1 and 2 shows the structure of the proposed dual-band antenna with PIFA type. It is consist of a radiation element with a hook shape and a rectangular ground plate with a small size. The radiation element is physically supported by a coaxial cable and shorting pin. They are electronically consist of a feeding structure. The 50Ω coaxial cable directly feeds to a radiation patch by an inner conductor. The outer one is vertically connected to the small ground plate. The total size of the proposed antenna has the volume of $47.5 \times 20 \times 7$ mm^3. For achieving the resonant mode at 2.4 GHz band, the resonant length marked in **Path *A*** starting from the shorting point to the open end of the radiation patch is chosen to be about 32 mm corresponding approximately to a quarter wavelength of 2.4 GHz, as shown in Fig. 1 and Fig. 2 (a). The length between the feeding and shorting point marked in **Path *B*** is about 12 mm in Fig. 1 and Fig. 2 (c). It is selected to an electrically quarter wavelength at the resonant frequency of 5.5 GHz band. In order to determine the dual resonant frequencies, Fig. 3 shows the variations of VSWR values according to the different position of the short pin and the length of a radiation element. Fig. 3 (a) indicates the each associated VSWR graphs with the three different values of ⓐ with the fixed length of ⓑ = 16 mm. The variations of a length, a_L and a_R, are 2 mm in an opposite direction and the compared total lengths of ⓐ are 10 mm, 12 mm, and 14 mm from a reference line (r_a) to the shorting point. As shown in Fig. 1, the variations of a shorting position make the length of **Path *A*** and **Path *B*** change, simultaneously. When the length of ⓐ is shorter (ⓐ=10mm), the lower resonant band shifts to left and the higher one to right at the same time. It is because that the shorter the length of ⓐ, the longer the one of **Path *A*** regarded to the Bluetooth band and the shorter the one of **Path *B*** related to the WLAN band, simultaneously. Similarly, Fig. 3 (b) shows the variation of VSWR in terms of three different values of ⓑ with the fixed length of ⓐ = 12 mm. The variations of a length, b_L and b_R, are also 2 mm in an opposite direction and the compared total lengths of ⓑ are 14 mm, 16 mm, and 18 mm from a reference line (r_b) to the folded radiation element. When the length of ⓑ is shorter (ⓑ=14 mm), the lower resonant band shifts to right. On the other hand, the higher one shifts a little. It is because that the shorter the length of ⓑ, the shorter the one of **Path *A***. However, the one of **Path *B*** is constant. Each length of **Path *A*** and **Path *B*** has dominant roles of the each associated frequency, 2.4 GHz and 5 GHz band, respectively. The optimized values of ⓐ and ⓑ covering the dual frequency WLAN bands are 12 mm and 16 mm, respectively. In order to optimize the antenna performance, SEM CAD (Simulator Platform for Electromagnetic Compatibility Antenna Design and Dosimetry; SPEAG) is utilized for tuning each associated

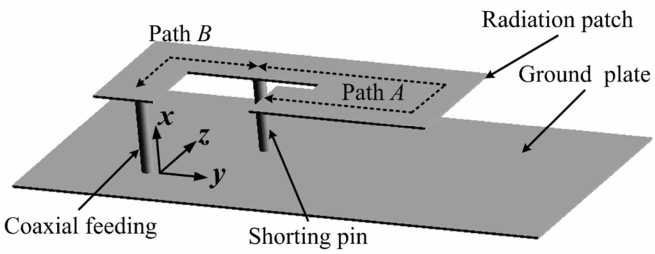

Fig. 1. Geometries of the proposed antenna in 3-D

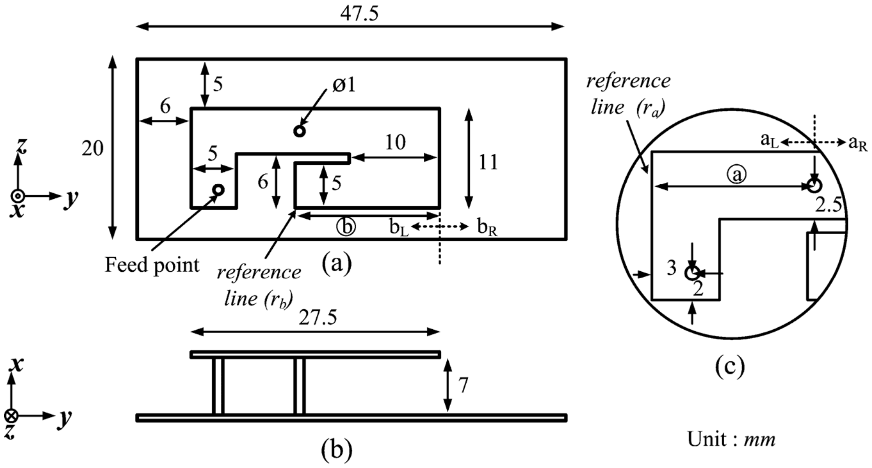

Fig. 2. Geometries and dimensions of the proposed antenna in 2-D
(a) Top view (b) Front view (c) Feeding and shorting locations

parameter of the antenna structure. The measured results are performed with Agilent 8722ES network analyzer.

III. RESULTS

equation. The measured and simulated VSWR results in terms of frequency are compared in Fig. 4. There is a good agreement with each other. The measured impedance bandwidth (VSWR $\leq$ 2) at the lower frequency band is about 110 MHz from 2.38 GHz to 2.49 GHz, which meets the bandwidth requirement for IEEE 802.11b applications. As for the upper band, the impedance bandwidth is about 900 MHz from 5.1 GHz to 6.0 GHz, which also covers the required bandwidth for IEEE 802.11a and HIPERLAN/2. Fig. 5 and 6 show the measured and simulated radiation patterns at 2.44 GHz and 5.5 GHz, respectively. The radiation patterns are approximately omni-directional. There is vulnerable to the measurement error due to the positioning effect of the feeding cable. Although there are slightly discrepancy between the simulated results and measured ones, it is seen that they show a similar tendency. The maximum measured and simulated radiation gains are 2.39 dBi and 2.29 dBi at 2.44 GHz and 3.70 dBi and 4.03 dBi at 5.8 GHz, respectively.

IV. CONCLUSIONS

A dual-band antenna with a simple structure for 2.4/5GHz Bluetooth and WLAN bands has been proposed and investigated. To cover the dual band, a position of the shorting pin and length of the radiation element are adjusted. It has relatively broader impedance bandwidths covering the 2.4 GHz (2.38 GHz – 2.49 GHz) and 5 GHz (5.1 GHz – 6.0 GHz) bands. The proposed antenna has an approximately omni-directional radiation patterns and high gain. These structural features and electrical properties are very attractive for WLAN applications.

ACKNOWLEDGMENT

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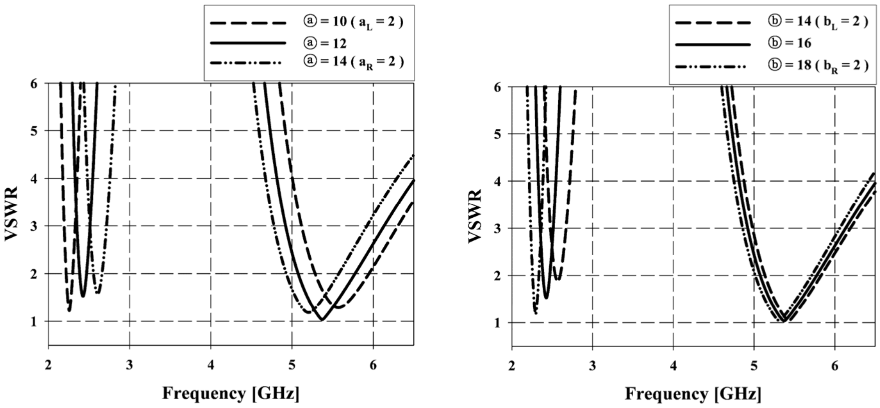


(a) The variations of length ⓐ (b) The variations of length ⓑ

Fig. 3. Simulated VSWR according to the lengths of ⓐ and ⓑ (Unit: mm)

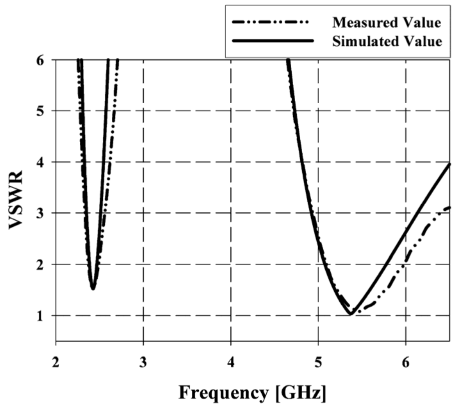
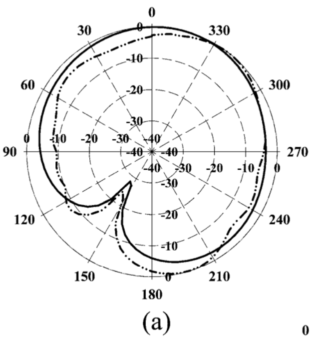
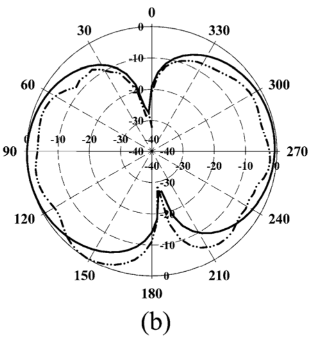


Fig. 4. Measured and simulated results of VSWR



(a)



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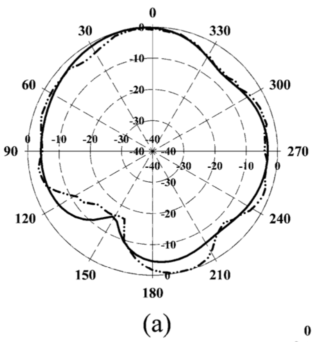

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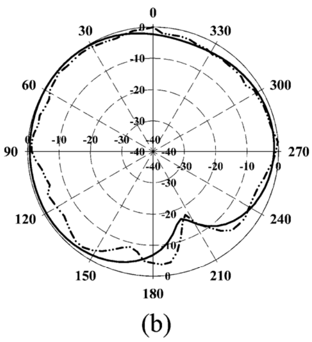

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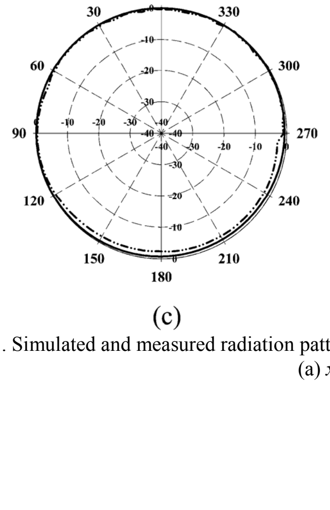

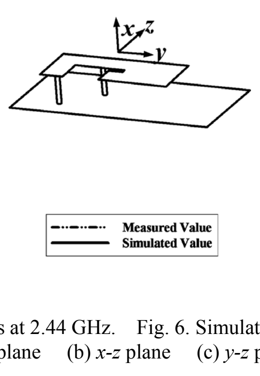

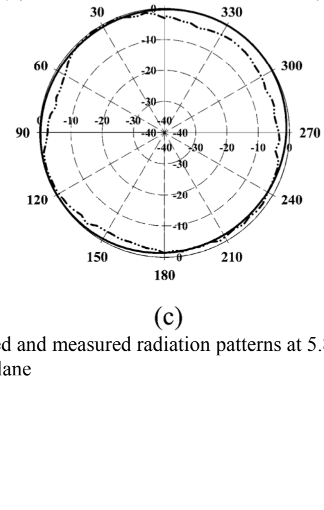

(c) (c)

Fig. 5. Simulated and measured radiation patterns at 2.44 GHz. Fig. 6. Simulated and measured radiation patterns at 5.8 GHz

(a) *x-y* plane (b) *x-z* plane (c) *y-z* plane