Internal Multiband Antenna for WLAN/WiMAX Dual-Network Operation for Laptop Applications

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Abstract

A novel multiband antenna suitable for application as an internal laptop antenna for 2.4/5.2/5.8 GHz WLAN (Wireless Local Area Network) and 2.5/3.5/5 GHz WiMAX (Worldwide Interoperability for Microwave Access) operation is presented. The proposed antenna comprises metal-plate radiating elements as arms 1, 2, and 3, an inverted-L shaped shorting strip, and a parasitic element short-circuited to the ground plane. The radiating elements effectively control four excited resonant modes to be able to operate in WLAN/ WiMAX dual-network operation. The proposed antenna is promising to be embedded within the narrow spacing between the casing of the laptop computer and the supporting metal frame of the display as an internal antenna. In addition, the antenna is also suitable to be integrated into the supporting metal frame of a laptop-computer display as an integrated antenna.

Key words- antennas, internal laptop antennas, multiband antennas, WLAN antennas, WiMAX antennas.

1. Introduction

Conventional metal-plate antennas have been applied in a laptop or notebook computer for WLAN operation in the 2.4 GHz band (2400 ~ 2484 MHz) and 5.2/5.8 GHz (5150 ~ 5350/5725 ~ 5825 MHz) band [1-4]. This kind of conventional antennas can be embedded in narrow spaces (usually less than or about 10 mm) between the casing of the laptop computer and the supporting metal frame of the display as internal antennas. For WLAN operation, however, the operating range is mainly limited to be about 100 meters. By incorporating the existing WLAN system with the new communication system of WiMAX (Worldwide Interoperability for Microwave Access) [5-8], which can provide a long operating range of up to about 30 miles with a high data rate of about 75 Mbps for mobile broadband wireless access, a seamless internet access for wireless users becomes possible.

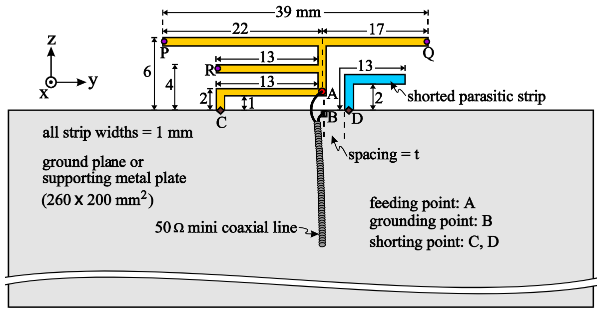
For this perspective dual-network WLAN/WiMAX application, we present in this paper a novel multiband antenna for operating as an internal antenna for the laptop computer. The proposed antenna comprises metal-plate radiating elements as arms 1, 2, and 3, an inverted-L shaped shorting strip, and a parasitic element short-circuited to the ground plane. The radiating elements effectively control four excited resonant modes for covering the 2.4/5.2/5.8 GHz WLAN bands and the 2.5/3.5/5 GHz (2500 ~ 2690/3400 ~ 3600/5250 ~ 5850 MHz) WiMAX bands. Details of the proposed multiband antenna are described in this paper, and experimental and simulation results of the constructed prototype are presented.

2. Antenna Design

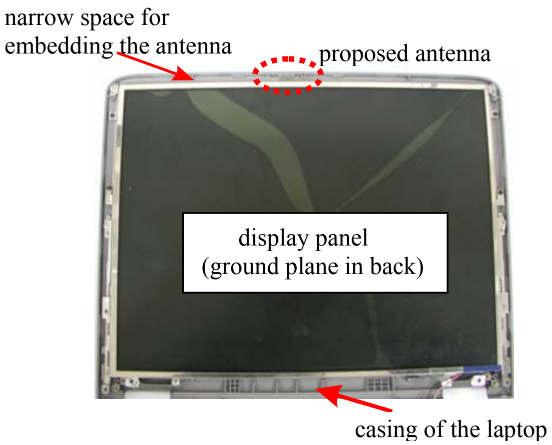
Fig. 1(a) shows the geometry of the proposed internal multiband antenna. The proposed antenna is mounted above the top edge of a large ground plane of 260×200 mm^2, which is considered here as the supporting metal frame for the display of the laptop. The antenna is fed by using a 50 Ω mini coaxial line, with its central conductor connected to point A (the feeding point) and its outer ground sheath connected to point B (the grounding point). The proposed antenna was fabricated from line-cutting a 0.2 mm brass sheet in this study, and then connected to the ground plane. For practical applications, the proposed antenna and the ground plane (metal frame) together can also be fabricated from stamping a large metal plate, that is, the proposed antenna becomes an integrated antenna for laptop applications. A picture showing the proposed antenna mounted on a laptop (the display portion only) for practical application is shown in Fig. 1(b). With the presence of the display, the measured results are about the same as those presented in Section 3. No special distinctions were observed.

The proposed antenna occupies an area of 6×39 mm^2, and mainly comprises: a radiating strip as arm 1 of length 28 mm [from point A to the open end at point P], a radiating strip as arm 2 of length 23 mm [from point A to the open end at point Q], a radiating strip as arm 3 of length 15 mm [from point A to the open end at point R], an inverted-L shaped shorting strip of length 15 mm, and a parasitic element short-circuited to the ground plane. The shorted parasitic element in this study is an inverted-L shaped strip of length 13 mm, with its horizontal portion above the top edge of the ground plane a distance of 2 mm, and its vertical portion having a distance of t to the feeding and grounding points (points A and D). The parameter t determines the behavior of shorted parasitic strip.

All of the strip widths are set to 1 mm, and the four radiating elements (arm 1, arm 2, arm 3 and the parasitic strip) all operate as quarter-wavelength resonant structures in the proposed antenna, and are expected to generate a first resonant mode at about 2.5 GHz, a second resonant mode at about 3.5 GHz, a third resonant mode at about 5.2 GHz, and a fourth resonant mode at about 5.7 GHz. Good impedance matching of the first three resonant modes contributed from arm 1, arm 2 and arm 3 are easily achieved by adjusting the length of the inverted-L shaped shorting strip, which is expected to introduce additional inductance to compensate for the possible large capacitance contributed from between the radiating strips as arms 1, 2, 3, and the ground plane, thereby making it easy to achieve good impedance matching for the proposed antenna. As for the fourth resonant mode generated by the parasitic strip, its impedance matching is mainly controlled by the parameter *t*. By adjusting the value of *t*, good impedance matching the fourth resonant mode can be achieved. Then, by further adjusting the length of the parasitic strip, the resonant frequency of the fourth resonant mode can be shifted to achieve a wider impedance bandwidth in the 5 GHz band, formed by the third and the fourth resonant modes, for the proposed antenna. Detailed effects of the parameter *t* on the impedance bandwidth obtained are explored with the aid of Fig. 3 in Section 3.



(a)



(b)

Fig. 1 (a) Geometry of the proposed internal multiband antenna for WLAN/ WiMAX dual-network operation in a laptop computer. (b) Picture showing the proposed antenna mounted on a laptop (the display portion only) for practical application.

3. Experimental Results and Discussion

Based on the design dimensions shown in Fig. 1(a), the proposed internal multiband antenna was constructed and studied. Fig. 2 shows the measured and simulated return loss of the constructed prototype. The simulated results are obtained using Ansoft simulation software HFSS (High Frequency Structure Simulator) [9], and agreement between the simulation and measurement is obtained. There are four resonant modes excited at about 2.5, 3.5, 5.2, and 5.7 GHz, which are effectively controlled by arms 1, 2, 3, and the parasitic strip in the proposed antenna. From the measured results, the first resonnat mode has an impedance bandwidth (defined by 2:1 VSWR) of 565 MHz (2211 ~ 2776 MHz), which covers the 2.4 GHz WLAN band and 2.5 GHz WiMAX band and is mainly controlled by arm 1 of the antenna. The second resonant mode has an impedance bandwidth of 270 MHz (3358 ~ 3628 MHz), covering the 3.5 GHz WiMAX band and controlled by arm 2 of the antenna. Then, combining the third resonant mode and the fourth resonant mode can achieve an impedance bandwidth of 720 MHz (5145 ~ 5865 MHz), satisfying the required bandwidths of the 5.2/5.8 GHz WLAN band and 5 GHz WiMAX band and effectively controlled by arm 3 and the parasitic strip of the antenna.

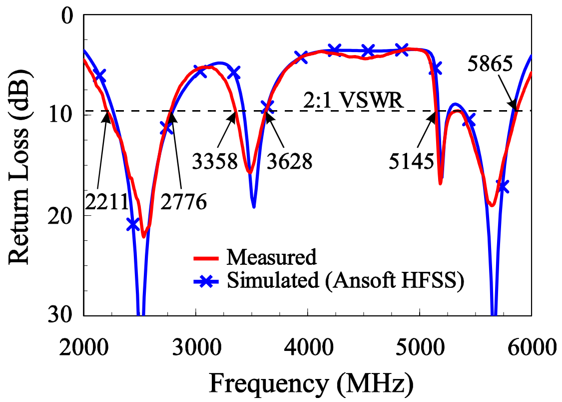


Fig. 2 Measured and simulated return loss for the proposed antenna shown in Fig. 1 with $t = 0.7$ mm.

Effects of the parameter *t* of the parasitic strip on the impedance bandwidth obtained were analyzed using the Ansoft simulation software HFSS. Fig. 3 shows the simulated return loss for the proposed antenna as a function of *t*. The value of *t* is varied from 0.3 to 0.9 mm. It is first observed that the first resonant mode has slight frequency shifting. In the meanwhile, by increasing *t* from 0.3 to 0.9 mm, the parasitic strip is moved farther to the feeding and grounding points that can decrease the interference caused by the parasitic strip on the surface current distributions associated with arms 1, 2, and 3. In this case, the second, third, and fourth resonant modes can be excited with good impedance matching when selecting a proper *t* of 0.7 mm, resulting in an increase in the impedance bandwidth obtained. This behavior suggests that, for achieving enough impedance bandwidth in the 3.5/5 GHz bands, the parasitic strip is better to be placed farther (larger than 0.5 mm) to the feeding/grounding points in the proposed design.

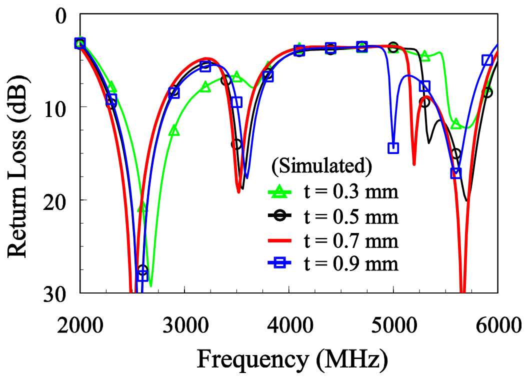


Fig. 3 Simulated return loss for the proposed antenna as a function of the spacing *t*.

Radiation characteristics of the constructed prototype were also studied. Figs. 4, 5, and 6 plot the measured radiation patterns at 2500, 3500, and 5500 MHz, respectively. In the azimuthal plane (*x-y* plane), near-omnidirectional radiation patterns for E_θ component (vertical polarization) are obtained. In addition, it is observed that the amplitude of E_ϕ component (horizontal polarization) is comparable to that of E_θ component. This radiation characteristic is advantagous, because the wave propagation environment is usually complex for WLAN/WiMAX operation in practical applications. Also note that the radiation characteristics at other frequencies over the impedance bandwidth of the antenna were also investigated. The measured results show similar radiation patterns as plotted here. That is, stable radiation patterns are obtained for the proposed antenna.

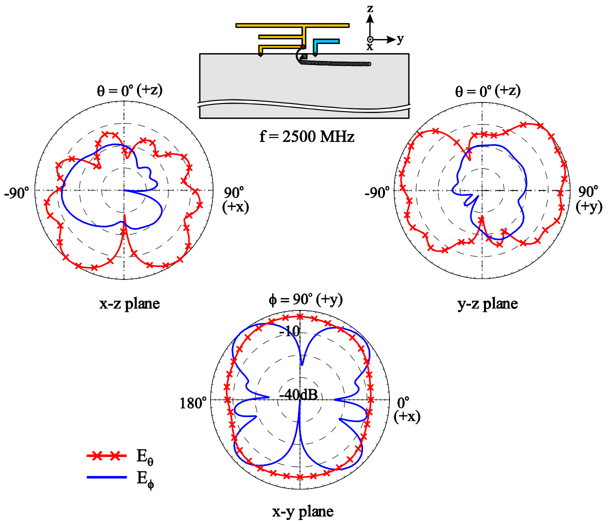


Fig. 4 Measured radiation patterns at 2500 MHz for the proposed antenna.

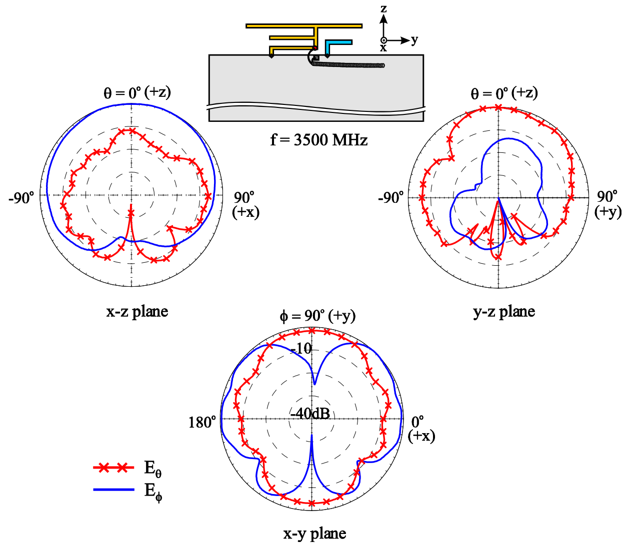


Fig. 5 Measured radiation patterns at 3500 MHz for the proposed antenna.

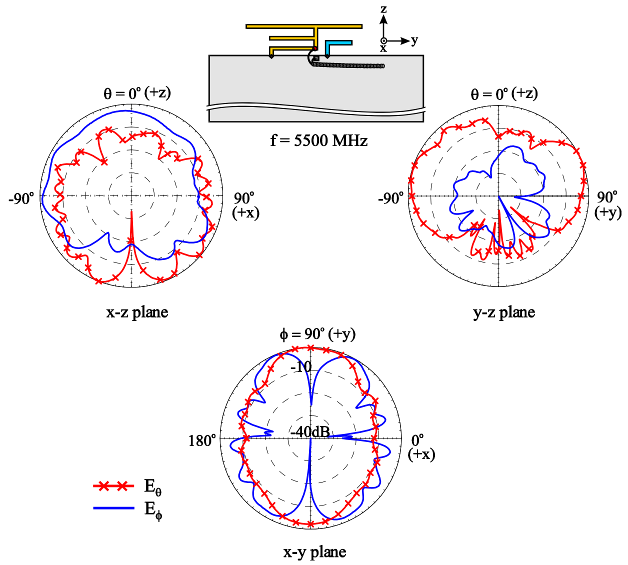


Fig. 6 Measured radiation patterns at 5500 MHz for the proposed antenna.

Fig. 7 presents the measured and simulated peak antenna gain against frequency. Argeement between the measured and simulated results is seen, and good antenna gain is obtained. Over the first operating band of the antenna, the measured antenna gain is in a range of about 2.8 ~ 3.4 dBi [see Fig. 7(a)]. For the second operation band as shown in Fig. 7(b), the measured antenna gain ranges from about 3.2 to 3.9 dBi. For the third operation band as shown in Fig. 7(c), the measured antenna gain is about 4.4 ~ 5.4 dBi. Small differences between the measured and simulated data are also obtained.

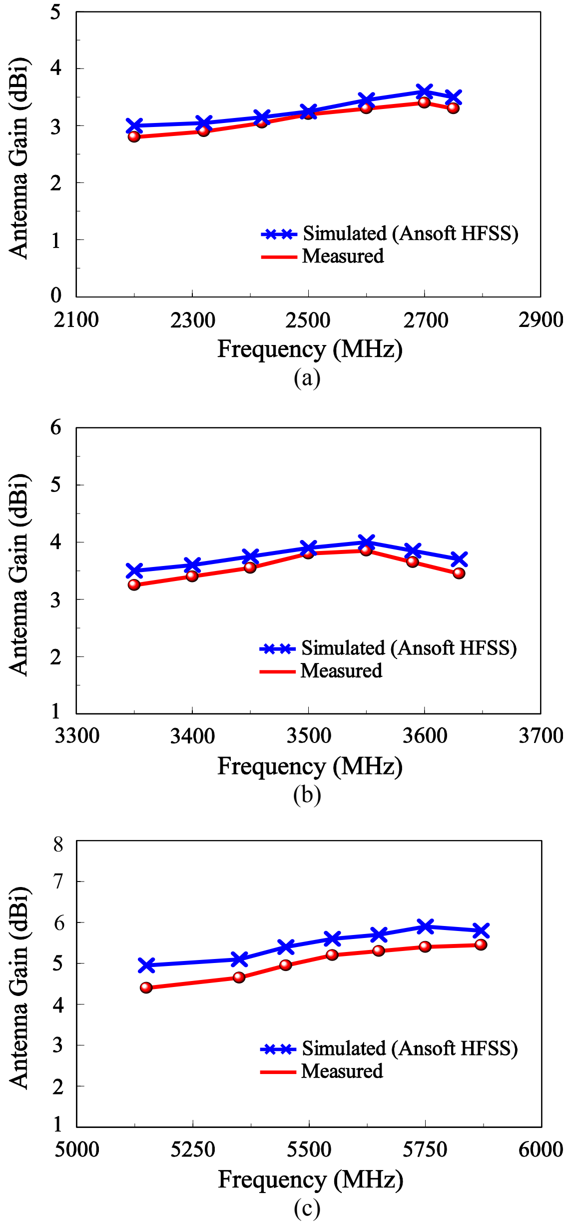


Fig. 7 Measured and simulated antenna gain versus frequency for (a) the first operating band, (b) the second operating band, and (c) the third operating band.

4. Conclusion

A novel multiband antenna for WLAN/WiMAX dual-network operation has been proposed and experimentally studied. Three operating bands of the proposed antenna centered at about 2.5, 3.5, and 5.5 GHz have been obtained, which easily cover the 2.5/5.2/5.8 GHz WLAN operation and the 2.5/3.5/5 GHz WiMAX operation. For frequencies over the three operating bands, good radiation characteristics have also been obtained for the proposed multiband antenna. On the other hand, the proposed antenna is very promising to be embedded within the narrow space between the casing and the top edge of a laptop display as an internal antenna. In addition, the antenna is also suitable to be integrated into the supporting metal frame of a laptop-computer display as an integrated antenna.

References

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