Internal Two-PIFA System with Comparable Polarization Radiation for Metal Back Cover Tablet

Saou-Wen Su, Fang-Hsien Chu, and Damer Lin
EM & Wireless Communication R&D Department, ASUS, Taipei 11259, Taiwan

***Abstract* – A two-PIFA system suited to functioning inside the tablet computer with a complete, metal back cover for 2.4-GHz wireless local area network (WLAN) operation is proposed. The antenna was constructed by stamping a flat plate and bent two times to form a compact structure. The PIFA was fed and short-circuited at the top patch above the antenna ground with a vertical ground wall connecting therebetween. The two PIFAs were symmetrically located on the metal cover and grounded therein. The results showed that comparable E_θ and E_φ fields were obtained for the tablet used in the three major positions, the landscape, portrait, and bottom-down modes.**

***Index Terms* — Planar inverted-F antennas (PIFAs), tablet-computer antennas.**

I. Introduction

Tablet computers or tablets are becoming more and more popular in the recent years [1]. This wireless device stands out among the mobile phones, notebooks, and the others on the market because of larger touch panel (compared with mobile phones) and lighter weight (compared with notebooks). The back cover of the tablets are usually made from non-conductive materials because the antenna designs are more difficult in the environment of a metal cover tablet. Not many papers have presented the antennas for the tablet with a metal cover, which motivates us to develop a new antenna design suited to functioning inside a complete, metal, back-cover tablet. In this paper, a new patch, planar-inverted-F antenna (PIFA), which was constructed by stamping a flat plate and occupied a volume of 5 × 9 × 30 mm^3, is introduced to form a two-PIFA system in the tablets. The PIFA was fed and short-circuited at the top patch and on the same plane above the antenna ground with a vertical ground wall connecting therebetween. The two-antenna system was of a symmetrical structure, and the performance of each PIFA is the same. The antenna was designed to allow the surface currents to flow along the three main directions, including the lateral direction of the top patch, the feeding/shorting direction, and the direction of the vertical ground, all perpendicular to each other. In this case, the vertical (E_θ field) and the horizontal (E_φ field) polarization are quite comparable for the tablet in the landscape, portrait, and bottom-down modes. This property is beneficial to the end user having a common WLAN access point (AP), which usually generates vertically polarized waves.

II. Antenna Design

Fig. 1 shows the proposed two-PIFA system mounted on a 0.8-mm, thick plate of size 185 mm × 240 mm, treated as a metal back cover for an 11-inch tablet computer. Notice that the design concept is applicable to a 12/13-inch tablet. The PIFAs are arranged in a symmetrical fashion with respect to the metal cover, which is considered to be an antenna ground in this design. The antennas are identical in size and spaced 30 mm (D) apart. Each antenna occupies a volume of 5 × 9 × 30 mm^3 and is set 3 mm gap from the shorter edge of the ground. The antenna parameters were attained by the rigorous parametric studies with the aid of the electromagnetic-field (EM) simulation. For studying, the antenna is decomposed into four portions: a radiating top patch, a soldering portion, an antenna ground, and a vertical wall. The PIFAs 1 and 2 are fed at ports 1 and 2 at the top patch above the antenna ground and short-circuited to vertical wall connecting therebetween. The PIFAs operate as quarter-wavelength resonant structures. The achievable impedance bandwidth can be tuned by parameters F, S, and G. The proposed structure allows the surface currents to flow along the three main directions, including the lateral direction of the top patch, the feeding/ shorting direction, and the direction of the vertical ground wall, all perpendicular to each other. In this case, it can be expected that the vertical (E_θ field) and the horizontal (E_φ field) polarization of the antenna radiation in the three major cuts is comparable.

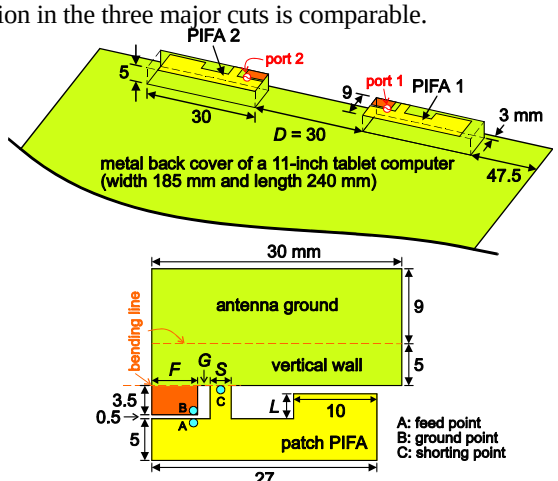

Fig. 1. Configuration the two-PIFA system affixed to the metal back cover.

III. Results And Discussion

Fig. 2 shows the measured reflection coefficients and the isolation. The measured input impedance over the band is all below –10 dB. The isolation between the two PIFAs is less than –17 dB. When the distance D between the two PIFAs is further reduced, the isolation (S_{21}) can be deteriorated, and the achievable impedance bandwidth is also decreased. The simulated surface-current distributions are presented in Fig. 3. The currents are plotted in the form of vectors, and the

magnitude scale of the currents is kept the same. The current strength on the antenna ground is the least, and the directions of the currents are opposite to those on the top patch and the feeding/shorting portions. The currents on the antenna ground should affect less the radiation patterns. The surface currents are equivalently large on the top patch, feeding/shorting portions, and the vertical wall, which are all perpendicular to each other. The results suggest that the antenna system is capable of generating comparable vertical (E_θ field) and horizontal (E_φ field) polarization for the tablet computer in the landscape, portrait, and bottom-down modes.

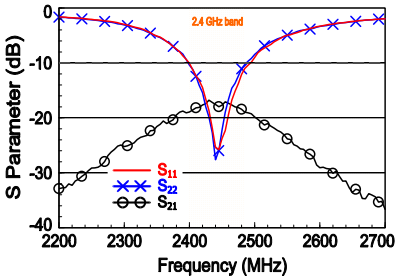

Fig. 2. Reflection coefficients (S_{11} for PIFA 1; S_{22} for PIFA 2) and isolation (S_{21}) between the antennas; F = 5.5 mm, S = 2.5 mm, G = 1.5 mm, L = 3 mm.

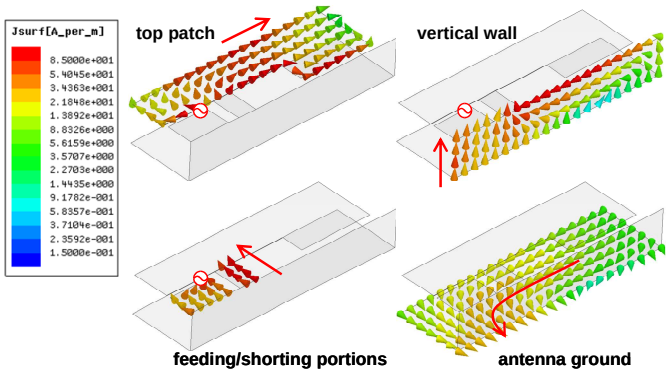

Fig. 3. Simulated surface currents at 2442 MHz for PIFA 2 studied in Fig. 2.

Fig. 4 shows the measured radiation patterns at 2442 MHz, the central frequency of the 2.4 GHz band, in E_θ and E_φ fields for PIFAs 1 and 2. Because of the three common usage modes for tablet computers, the two-PIFA system was measured in the case of the tablet in the landscape, portrait, and bottom-down positions. Usually, the throughput tests are conducted in the horizontal cut (that's, the *x-y* plane here for the three cases) for each position of the tablet. Thus, the radiation properties in the *x-y* plane for the three cases are studied with the measurement coordinate redefined accordingly. Comparable E_θ and E_φ fields of the antennas are first obtained [2, 3]. This characteristic retains the advantage of combating the complex propagation in the rich-scattering WLAN environment. Second, the E_θ fields in the *x-y* plane (horizontal plane for tablet in landscape, portrait, and bottom-down arrangements) also show nearly omnidirectional radiation patterns and very few nulls < –15 dB. This behavior greatly benefits data throughput and coverage for the end user having a conventional WLAN AP that generates vertically-polarized waves.

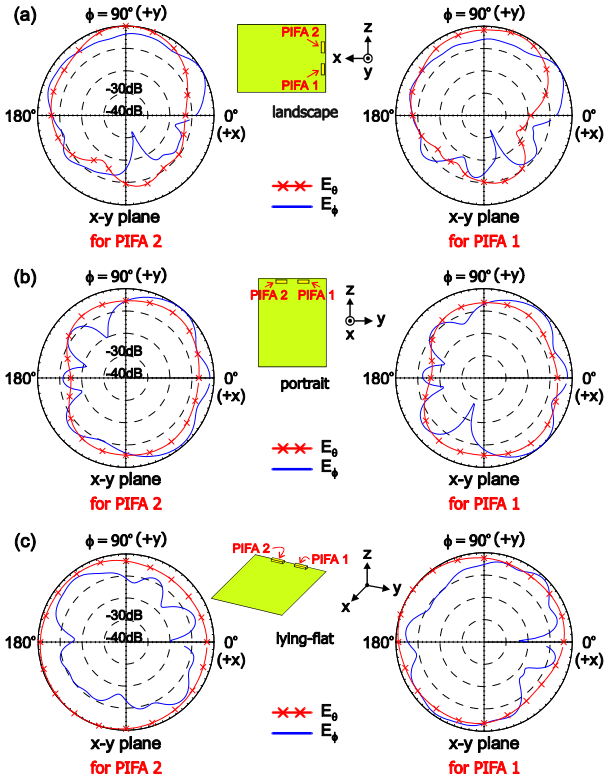

Fig. 4. Measured 2-D radiation patterns at 2442 MHz for the prototype studied in Fig. 2: horizontal cut for the tablet computer in the (a) landscape, (b) portrait, and (c) bottom down positions.

IV. Conclusion

An internal, two-WLAN-antenna system utilizing the patch-PIFA design for tablet computer applications has been presented. The PIFA can be directly affixed to the inner side of the metal back cover of the tablet. The antennas are easy to manufacture and show good input matching with port isolation below –15 dB over the 2.4 GHz band. In addition, because the structure of the PIFA is designed to allow the surface currents along the three main directions perpendicular to each other, the obtained vertical and the horizontal polarization are quite comparable such that the E_θ field in the horizontal plane with more constant gain for the tablet in the landscape, portrait, and bottom-down modes is achieved. This characteristic is attractive for the end user having a commonly available WLAN AP, which usually generates vertically polarized waves. The antenna yields peak gain of about 3.3 dBi with radiation efficiency exceeding 60%.

References

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