Linearly-Polarized Patch PIFA for GPS/GLONASS Operation inside a Metal Back Cover Tablet

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Abstract **- A linearly-polarized (LP), planar inverted-F antenna (PIFA) embedded inside a tablet computer with a complete, metal back cover for global positioning system (GPS) and global navigation satellite system (GLONASS) operations is proposed. The antenna was constructed by stamping a flat plate with dimensions 6 mm × 9 mm × 50 mm. The patch PIFA was fed and short-circuited at the top patch above the antenna ground with a vertical ground wall, connecting therebetween and facing the interior of the tablet. Effects of various antenna locations on the right-hand circularly-polarized (RHCP) and the left-hand circularly-polarized (LHCP) patterns were also analyzed.**

Index Terms **— Patch antennas, global positioning system antennas, global navigation satellite system antennas.**

I. Introduction

Global positioning system (GPS) functionality has been added in mobile devices for years. Conventional GPS antennas use patch antennas that are fed on a square ground because the circular polarization (CP) characteristics are affected when the antennas are excited on an asymmetrical, rectangular ground [1]. However, for practical applications, neither a square system ground nor enough space for half-wavelength patchs is provided. In fact, linearly-polarized (LP) antennas are widely utilized in mobile phones and tablets to achieve CP operation [2]. There has been a trend that combines both GPS by the United States and global navigation satellite system (GLONASS) by the Soviet Union on the market. Thus, the antennas need to operate in the band of 1575~1615 MHz. Further, more and more industrial designs demand a complete, metal-finish look for notebooks and tablets, such that lighter and thinner computers are made possible. However, it will make the antenna designs more difficult because large input resistance can be induced by strong coupling between the antenna and the metal cover. Not many research papers have tackled the study of the antennas for the tablet with a complete, metal back cover. In this paper, a planar-inverted-F antenna (PIFA) is introduced to provide GPS and GLONASS operations and at the same time, to function in a large-sized (11~13 inches) tablet computer with a complete, metal back cover. The antenna is a LP, short-circuited patch, which resonates with its quarter-wavelength mode. The antenna can fit in the space between the back cover and the front, plastic bezel along the edge of the tablet. The metal cover was treated as a large antenna ground. To satisfy the requirement of the GPS/GLONASS system field test with the tablet computer in the landscape and the bottom-down operating modes for user experience, the CP radiation property with respect to various antenna locations on the metal cover was also investigated.

II. Antenna Design

Fig. 1 shows the proposed antenna affixed to a 0.8-mm-thick metal plate of size 190 mm × 300 mm, treated as a metal back cover for a 12-inch tablet computer. The design concept was also proven to be applicable to the 11- or 13-inch tablet. The antenna was constructed from one-piece, stamped metal plate. The antenna was further fed by a short, 50-Ω mini-coaxial cable. The PIFA operates as a quarter-wavelength resonant structure. The achievable impedance bandwidth can be tuned by various antenna parameters. The preferred antenna parameters were attained by parametric studies with the aid of the electromagnetic-field simulation tool. The antenna consists mainly of three portions: a top patch, a vertical ground wall, and an antenna ground. The vertical ground connects the top patch and the antenna ground with the patch's radiating edge facing the tablet's exterior and the vertical ground facing the interior. This configuration is beneficial because the ground wall can be utilized to alleviate the interaction between the antenna and the nearby conducting components [3].

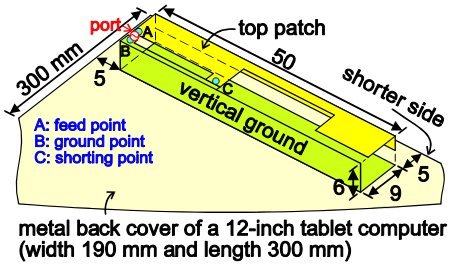

Fig. 1. Configuration of the proposed GPS/GLONASS antenna.

III. Results And Discussion

Fig. 2 shows the measured and the simulated return losses. The input matching over the GPS/GLONASS band meets 10 dB return loss. Fig. 3(a) and (b) shows the measured and the simulated, two-dimensional (2D) radiation patterns in the *y-z* plane. The measured results are similar to the simulation with discrepancies found in the *–z* direction due to the radiation at θ of 180 degrees not measured in the SATIMO system [4]. Notice that it is required to conduct the GPS/GLONASS system field tests in the landscape and the bottom-down operating modes for the large-sized tablet computers for user experience. In this case, the radiation patterns in the *y-z* plane defined here for the antenna measurement are important. The *+z* direction (the direction above the panel) and the *–y* direction (in the direction of the near-zenith coverage when the tablet used in the landscape mode) are the two major

observation directions for the criteria, in which the relative magnitude of the right-hand circular polarization (RHCP) is required to exceed that of the left-hand circular polarization (LHCP). The RHCP is required for the GPS, GLONASS, and others [5]. From the results, the RHCP is all larger than the LHCP in both the +*z* and the –*y* directions.

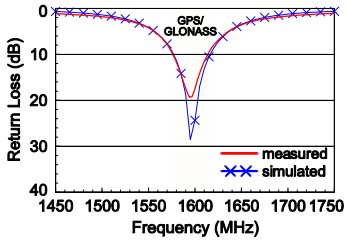

Fig. 2. Measured and simulated return loss for a prototype: S = 3 mm; L = 7 mm; W = 11 mm.

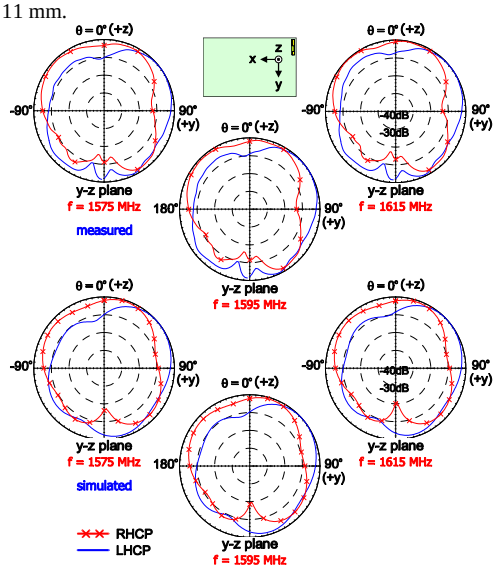

Fig. 3. 2D radiation patterns in the y-z plane at 1575, 1595, 1615 MHz for the prototype studied in Fig. 3: (a) measured; (b) simulated.

Fig. 4 shows the 2D radiation patterns in the *y*-*z* plane for the antenna in the three main locations. The bottom edge can be occupied by the input/output (I/O) connectors and is in close proximity to the keyboard in the emerging detachable notebooks; thus, it is not considered deploying antennas there around. The RHCP and the LHCP for the antenna placed along the right edge are similar to the LHCP and the RHCP for the antenna on the left [see Fig. 4(a) and 4(c)]. This indicates that the propagation direction of the CP waves can be substantially different when the antenna is set on the opposite side of the tablet. To meet the above-mentioned criteria, the near optimal locations in this study is between the top-right (DR = 5 mm) and the middle-right (DR = 65 mm) locations. Further, the CP property of the antennas located on the top edge can not satisfy the said requirement. The top-middle location with DT = 5 mm shows the worst case. Fortunately, this location is often reserved for the front camera module. The measured antenna gain and the radiation efficiency against frequency were studied. The RHCP gain is seen at a level of about 3.4 dBic with the antenna radiation efficiency exceeds 76%.

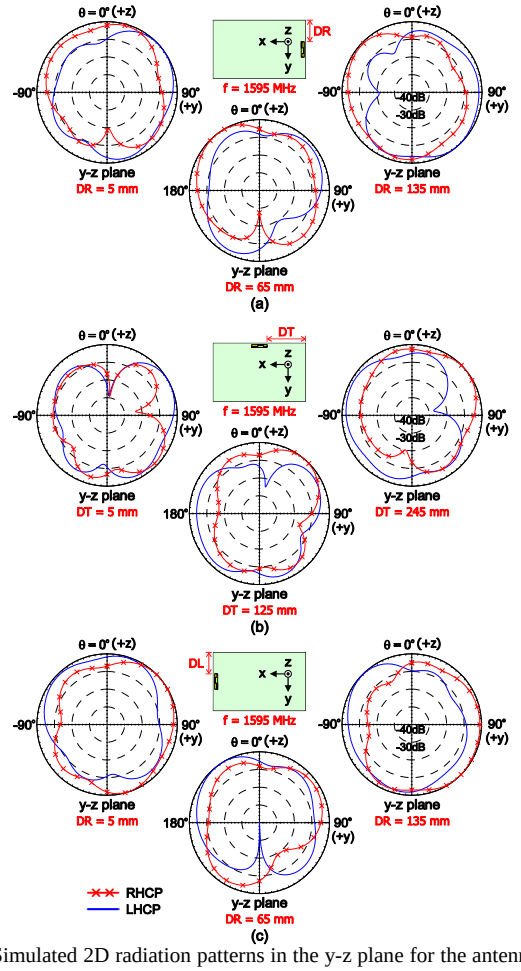

Fig. 4. Simulated 2D radiation patterns in the y-z plane for the antenna along (a) the right, (b) the top, and (c) the left edge of the metal back cover.

IV. Conclusion

An internal, GPS/GLONASS, patch-PIFA design for tablet computers has been presented. The PIFA can be affixed to the internal side of the metal back cover of the tablet. The antenna design shows good input matching over the bands. The antenna yields a peak-gain level of about 3.4 dBic with the radiation efficiency exceeding 76%. Effects of various antenna locations on the metal cover on the RHCP and LHCP radiation patterns were studied. The results show that with the antenna placed at the proper location, the gain of the RHCP patterns becomes larger than that of the LHCP patterns in the desired directions.

References

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