A Metal-plate Monopole Antenna for UMTS Mobile Phones with E911 Function

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Abstract

A metal-plate monopole antenna for UMTS (Universal Mobile Telecommunication System) mobile phones with the E911 function for locating wireless users is presented. The antenna is easily fabricated from a single metal plate and occupies a cross-sectional area of 9.5 × 10 mm² and a length of 23 mm. Further, the antenna shows a wide operating bandwidth of about 905 MHz (1502−2407 MHz), making it easy to cover the UMTS band and the GPS (Global Positioning System) operation at 1575 MHz for mobile/E911 dual-mode operation of a mobile phone.

Key words- Mobile antennas, wideband monopole antennas, mobile phone antennas, UMTS antennas, GPS Antennas, E911

1. INTRODUCTION

Planar metal-plate monopole antennas are easy to implement and can provide a wide impedance bandwidth [1, 2], making them very promising to be applied to mobile wireless devices. For this promising application, we propose in this paper an antenna suitable to be applied in UMTS mobile phones with the E911 function for locating wireless users. Note that the E911 is an automatic number identification (ANI) and automatic location information (ALI) technology, and has been mandated by FCC (Federal Communications Commission) that all mobile phones in the United States must be equipped after December 2001. In order to provide the E911 function, a linearly polarized antenna for receiving the GPS signal at 1575 MHz has also been recommended, especially for operating in heavy multipath environments [3]. The proposed antenna shows a compact structure with volume of 10 × 20 × 23 mm³ occupied, and yet provide a wide operating bandwidth of about 905 MHz (about 1502−2407 MHz in this study), covering the universal mobile telecommunication system (UMTS, 1920−2170 MHz) band for mobile communications and the global positioning system (GPS) band at 1575 MHz for the E911 function. Details of the antenna design are described, and the experimental results of the constructed prototype are presented.

2. ANTENNA DESIGN

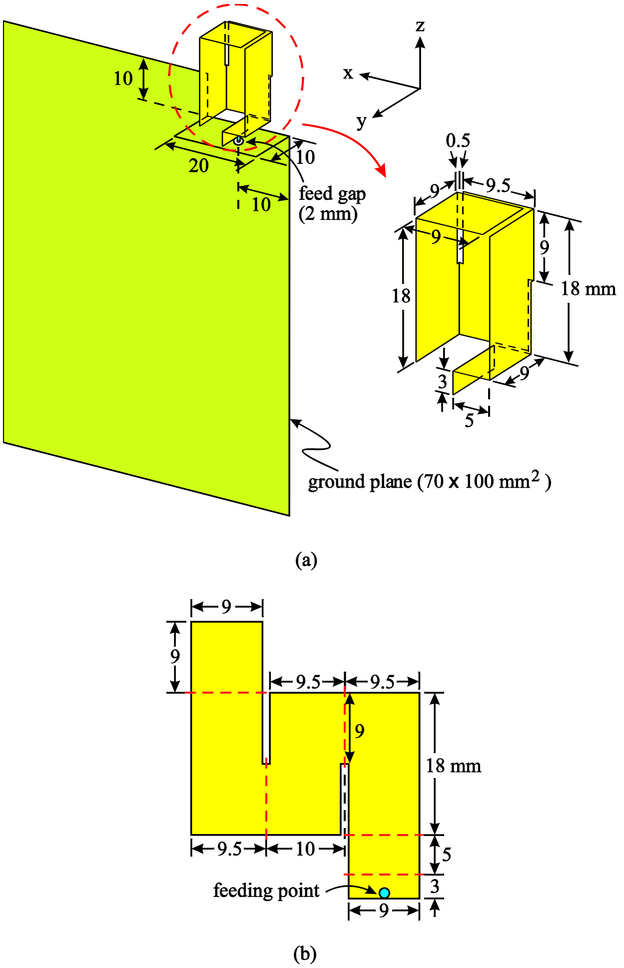

Fig. 1 (a) Geometry of proposed metal-plate monopole antenna; (b) dimension of a single metal plate used for fabricating the antenna (the dashed lines denote bending).

Figure 1(a) shows the geometry of the proposed stubby monopole antenna for a UMTS mobile phone with the E911 function. A photo of the constructed prototype is shown in Figure 2. Note that the ground plane in the figure has dimensions of 70 × 100 mm² and is considered to be the main ground plane of a mobile phone, especially a personal digital assistant (PDA) phone. Note also that, in order to accommodate the antenna, only a small volume of 10 × 20 × 10 mm^3 at one of the upper corners of the system ground plane is required.

Fig. 2 Photo of a constructed prototype of the proposed antenna.

The stubby monopole antenna is placed at the notched corner at the top edge of the ground plane. The proposed antenna is arranged to occupy a small area of 10 × 20 mm^2 in the system ground plane (see the rectangular notch cut in the ground plane), so that the antenna has a small protruded length above the top edge of the ground plane. By bending a single metal plate (a 0.2−mm copper plate was used in this study), shown by the five dashed lines shown in Figure 1(b), the proposed antenna is obtained. The antenna occupies a small cross-sectional area of 9.5 × 10 mm^2 and a length of 21 mm, and has a feed gap of 2 mm to a small ground plane (10 × 20 mm^2) protruded from the main ground plane. It is also noted that with the selection of about 10 mm square-cylindrical diameter in this study, the antenna is thinner than most of the present-day mobile phones and PDA phones. Across the feed gap is the probe pin or central conductor (diameter 1.2 mm) of a 50 Ω SMA connector located below a via-hole in the small protruded ground plane for testing the antenna in the experiment.

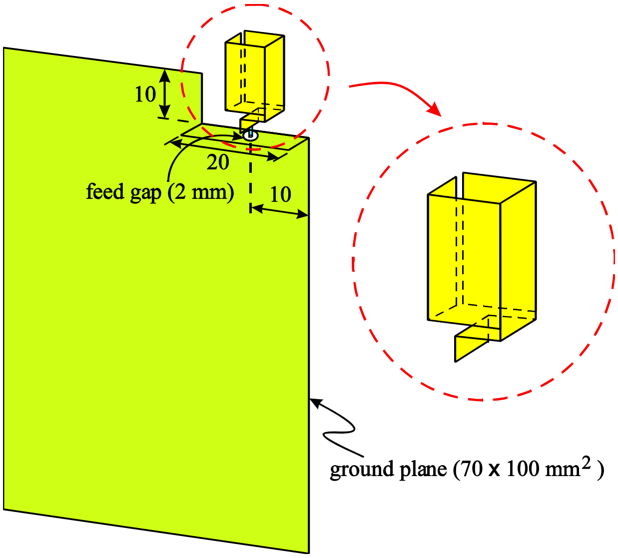

Fig. 3 Geometry of the wideband stubby monopole antenna with a step-shaped input-matching section in [4].

The length of the metal plate is selected to be about 73 mm (about 41% of the wavelength at 1.7 GHz), which generates a wide resonant mode at about 1.7 GHz in this study. It is further found that a much better impedance bandwidth can be achieved by bending the lower portion of the metal plate [shown in Figure 1(b)], that is, a step-shaped input-matching section, as seen in Figure 1(a). This effect is largely because, the step-shaped input-matching section provides additional coupling between the proposed antenna and the small antenna ground plane, which helps improve the impedance matching of the antenna, leading to a much wider impedance bandwidth obtained. Also note that, by viewing in the lower portion of the metal plate in Figure 1(a), the proposed monopole antenna has a configuration similar to that of a wideband stubby monopole antenna with a step-shaped input-matching section [4] (see Figure 3). In addition, due to the step-shaped input-matching section, the monopole height is reduced from 28 to 23 mm, which helps achieve a compact size for the antenna.

3. Experimental Results and Discussion

With the design dimensions shown in Fig. 1, the proposed antenna system was constructed and studied. Figure 4 shows the measured and simulated return loss for the constructed prototype, and results indicate that a wide impedance bandwidth (10 dB return loss) and good agreement between the measured and simulated are obtained. The impedance bandwidth centered at 1954 MHz is about 905 MHz or 46.3%, which makes the antenna easily cover the UMTS band and the GPS band at 1575 MHz for the E911 function. The radiation characteristics were also studied. Figure 5 plots the measured radiation patterns at the center frequency (2045 MHz) of the UMTS band. Note that, in each figure, the radiation patterns in three principal planes are normalized with respect to the measured peak gain of the antenna. These obtained radiation patterns in general are similar to the recent study (the antenna is placed on a small ground plane at the notched corner of the main ground plane) [5], with no special distinction observed. Figure 6 shows the measured radiation patterns of the GPS band at 1575 MHz. Comparable E_θ and E_ϕ components are observed, which are expected to be advantageous for application in a heavy multipath environment for E911 operation [3]. Figure 7 shows the measured antenna gain and simulated antenna efficiency against frequency. The antenna gain in general increase with frequency and varies in a range of about 2.6−3.7 dBi across the bandwidth. Good radiation efficiency is also obtained, and it is found to be in the range of about 77 ~ 86% from the simulated results obtained from Ansoft simulation software HFSS [6].

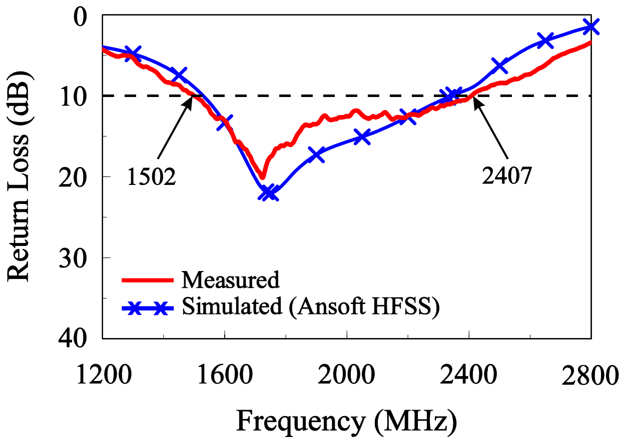

Fig. 4 Measured and simulated return loss for proposed antenna.

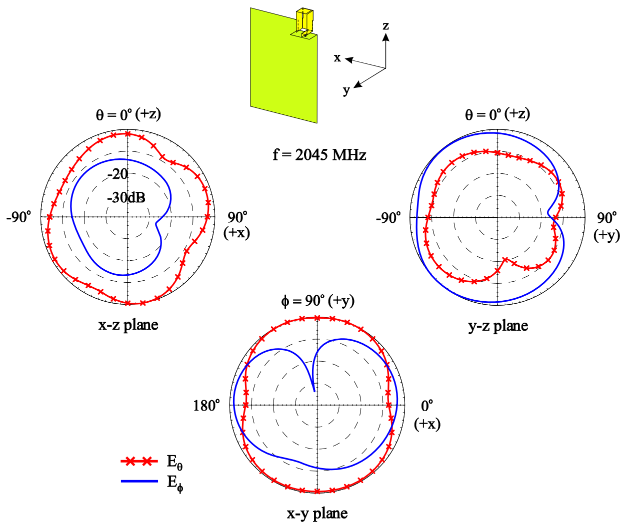

Fig. 5 Measured radiation patterns at 2045 MHz.

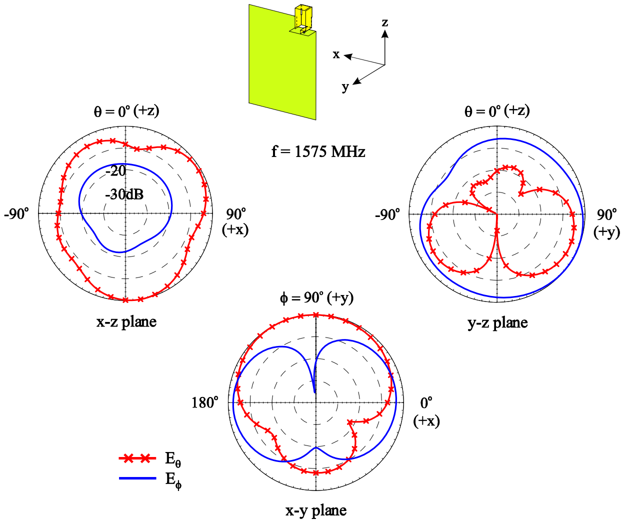

Fig. 6 Measured radiation patterns at 1575 MHz.

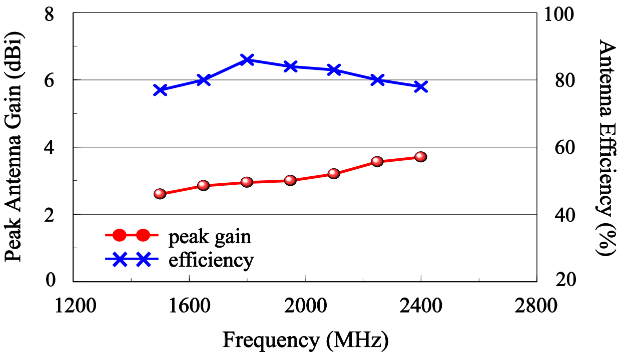

Fig. 7 Measured antenna gain and simulated antenna efficiency against frequency.

4. Conclusion

A metal-plate monopole antenna suitable for UMTS mobile phones with the E911 function has been proposed. The antenna has a simple configuration and is easy to implement at a low cost. In addition, a small protruded length above the top edge of the ground plane has been successfully obtained. A wide operating bandwidth of about 905 MHz has been achieved, which makes the antenna very promising for PDA phones for UMTS/E911 dual-mode operation. The experimental results indicate that good radiation characteristics over the UMTS band and GPS operation at 1575 MHz were obtained.

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