

Shorted, folded planar monopole antenna for dual-band mobile phone

Ching-Yuan Chiu, Pey-Ling Teng and Kin-Lu Wong

A novel shorted, folded planar monopole antenna for application in GSM/DCS dual-band mobile phones is proposed. The antenna is easily fabricated from stamping a single metal plate, which is then folded onto a foam base of compact size $5 \times 10 \times 40 \text{ mm}^3$. In addition, the proposed antenna shows a very low profile of 5 mm protruded from the top edge of the system ground plane, making it very promising to be employed within the casing of a mobile phone as an internal antenna.

Introduction: Promising designs of folded planar monopole antennas for mobile phone applications have recently been demonstrated [1–3]. This kind of folded planar monopole antennas are implemented by folding a stamped metal plate into a compact structure and are suitable to be mounted above the top edge of the system ground plane of a mobile phone. These designs, however, require an isolation distance between the antenna and the system ground plane of the mobile phone, which increases the protruded length of the antenna above the top edge of the ground plane.

In this Letter we propose a new design of folded planar monopole antenna to be directly mounted at the top edge of the system ground plane without the need of an isolation distance. In this design the proposed antenna is shorted to the system ground plane, which introduces additional inductance to compensate for the increased capacitance due to the decreased distance between the antenna and the system ground plane, thereby leading to improved impedance matching for the proposed antenna. In addition, the proposed antenna provides two separate resonant paths of different lengths, which effectively generate a lower and a higher resonant mode for GSM (890–960 MHz) and DCS (1710–1880 MHz) dual-band operations.

Antenna design: Fig. 1a shows the geometry of the proposed antenna mounted at the top edge of a ground FR4 substrate, which is treated in this study as the system circuit board of a mobile phone. The FR4 substrate used had a size of $40 \times 85 \text{ mm}^2$, and a ground plane of size $40 \times 80 \text{ mm}^2$ was printed on the back surface of the FR4 substrate, leaving the substrate's top portion (size $40 \times 5 \text{ mm}^2$) ungrounded for accommodating the proposed antenna.

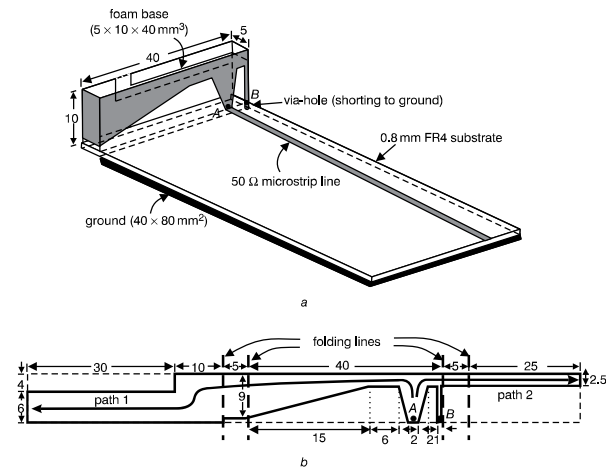


Fig. 1 Proposed antenna

a Geometry of proposed antenna mounted on top edge of grounded substrate considered as system circuit board of a mobile phone
b Proposed antenna unfolded into planar structure

The proposed antenna was easily constructed from folding a planar stamped copper plate (see Fig. 1b) onto a foam base of dimensions $5 \times 10 \times 40 \text{ mm}^3$, and can be surface mounted on the system circuit board using surface mounting technology. The antenna has two separate branches of different sizes: the larger one supports a longer resonant path (path 1) for generating a lower mode for GSM operation, while the smaller one provides a shorter resonant path (path 2) for generating a higher mode for DCS operation. Note that the lengths of paths 1 and 2

are close to one-quarter wavelength at 900 and 1800 MHz, respectively; i.e. both the two branches are operated as a quarter-wavelength structure in this design. Also note that a rectangular notch (size $4 \times 30 \text{ mm}^2$) at the open end of the larger branch is cut to make room for the smaller branch and also to decrease the coupling between the two branches, when the antenna is folded onto the foam base.

The two branches share a common feeding portion and a common shorting strip. The feeding portion has a linearly tapered width from 2 to 6 mm, which helps improve the impedance matching of the antenna. At the open end (point A) of the feeding portion, a 50Ω microstrip line printed on the substrate's front surface is used to feed the antenna. The open end (point B) of the shorting strip is connected to the top edge of the ground plane in back through a via-hole in the substrate. Note that, with the proposed antenna mounted at the top edge of the ground plane shown in Fig. 1a, the protruded length of the antenna above the top edge of the ground plane is 5 mm only, which corresponds to about 1.5% of the wavelength at 900 MHz, making it very promising to be employed within the casing of a mobile phone as an internal mobile phone antenna.

Results: Fig. 2 shows the measured and simulated return loss of a constructed prototype. The measured data in general agree with the simulated results obtained from Ansoft simulation software HFSS. Two separate resonant modes are clearly excited. With the definition of 2.5:1 VSWR (about 7.3 dB return loss), the lower resonant mode has an impedance bandwidth of 109 MHz (852–961 MHz), which covers the GSM band. For the upper resonant mode, the impedance bandwidth reaches 196 MHz (1690–1886 MHz), also covering the bandwidth of the DCS system.

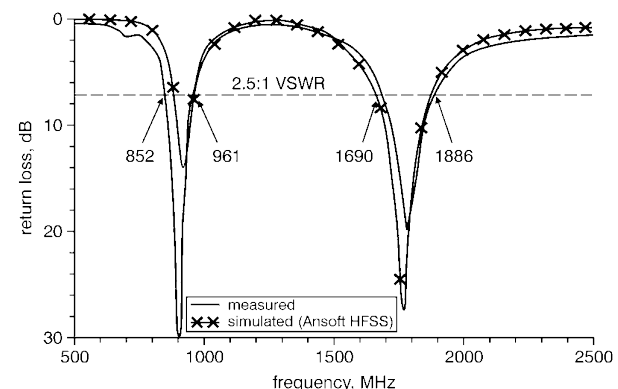


Fig. 2 Measured and simulated return loss

Figs. 3 and 4 plot, respectively, the measured radiation patterns at the centre frequencies (925 and 1795 MHz) of the GSM and DCS bands. A monopole-like radiation pattern at 925 MHz is seen. Measurements at other frequencies across the GSM and DCS bands were also conducted, and the measured results showed similar radiation patterns as those plotted in Figs. 3 and 4. Fig. 5 shows the measured peak antenna gain. For the GSM band, the antenna gain level is stable and about 1.2 dBi. Across the DCS band, the antenna gain is about 1.7–2.3 dBi.

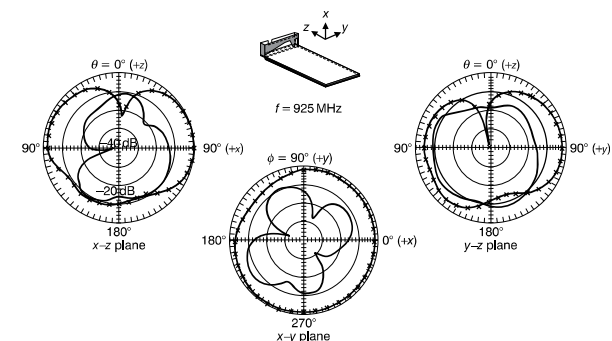


Fig. 3 Measured radiation patterns at 925 MHz

— E_θ
--- E_ϕ

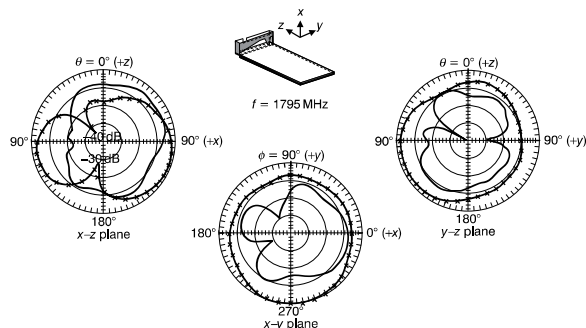


Fig. 4 Measured radiation patterns at 1795 MHz

— E_{θ}
— E_{ϕ}

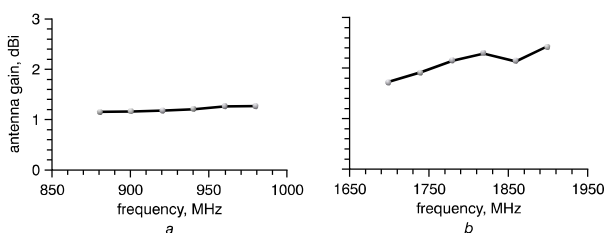


Fig. 5 Measured antenna gain
a GSM band b DCS band

Conclusions: A dual-band folded planar monopole antenna suitable for using surface mounting technology for practical application in GSM/DCS mobile phones has been proposed and tested. The proposed antenna can be easily constructed by folding a stamped metal plate onto a foam base of compact size, and is very promising to be employed as an internal mobile phone antenna.

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