An Internal Quad-Band Printed Monopole Antenna for Oval-Shaped Mobile Phones

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Abstract — An internal quad-band printed monopole antenna for oval-shaped mobile phone applications is presented. The appearance of the proposed antenna is an oval, and the antenna occupies a compact area of the upper part of the oval system ground plane. The printed monopole antenna has two branches, which generate two bands at about 833 MHz and 1820 MHz. The obtained bandwidth covers GSM 850 (824-894 MHz), GSM 900 (880-960 MHz), DCS 1800 (1710-1880 MHz) and PCS 1900 (1850-1990 MHz) bands. Details of the antenna design and results are presented and discussed.

I. INTRODUCTION

Until now internal antennas for rectangular shape phones have been developed rapidly and there have been many kinds of internal antenna designs for rectangular shape mobile phones, such as PIFA (Planar Inverted-F Antenna) [1-3], monopole [4,5] and IFA (Inverted-F Antenna) [6,7]. Many of these internal antennas cover the GSM850, GSM900, DCS and PCS bands, or even UMTS (Universal Mobile Telecommunication System) band.

Previous researches focuses on the rectangular shape mobile phones, so the shapes of ground plane and the antenna radiating element are approximately rectangular. Recently, some concept phones, whose appearances are oval, have been proposed [8-12] and have attracted a lot of attention. In particular, the effect of the long-axis length of oval shape mobile ground plane on the antenna bandwidth has been investigated [13], in which the optimal length for the antenna to achieve the maximum bandwidth was given. Also, an internal planar inverted-F antenna (PIFA) for oval-shaped mobile phone was proposed in [13].

In this article, an internal quad-band printed monopole antenna for oval-shaped mobile phones is presented. The configuration of the antenna is shown in Fig. 1. As the antenna is designed for the oval-shaped mobile phones, the shapes of the ground plane and the antenna radiating element are oval. The antenna has a planar configuration and is easy to be implemented by printing it on the system circuit board of the mobile phone. In addition, the antenna occupies a compact area, yet providing two wide bands which cover the GSM850, GSM900, DCS and PCS bands. The proposed antenna design is described in detail in Section II, and simulated and measured results of the proposed antenna are presented and discussed in Section III.

II. ANTENNA STRUCTURE

The front view and side view of the proposed antenna are shown in Fig. 1 (a) and Fig. 1 (b), respectively; and the detailed dimensions of the antenna for an optimized design are shown in Fig. 1 (c). For the widths of slits, which are not illustrated in Fig.1 (c), are the same and equal to 1 mm.

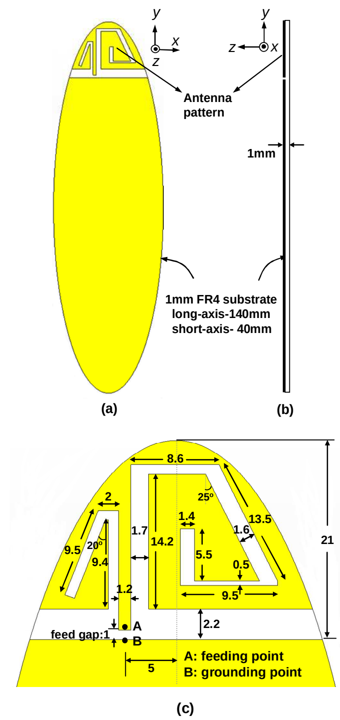


Fig. 1. (a) Front view of the proposed antenna for oval shape mobile phones. (b) Side view of the proposed antenna. (c) Detailed dimensions of the antenna pattern for an optimized antenna design (unit: mm).

The antenna is printed on the top part of an oval-shaped FR4 substrate (thickness 1mm, relative permittivity 4.4), which is considered as the system circuit board of the oval-shaped mobile phone. The long axis and short axis of the system ground are selected as 140 mm and 40 mm, respectively. It should be mentioned that for the oval shape ground plane the optimal length to achieve maximum antenna bandwidth of the low band GSM based is about 150 mm [13], which is much longer than the optimal length for the rectangular ground plane case. Both the antenna radiating element and the ground plane are printed on the one side (e.g., the front side) of the FR4 substrate. The antenna has a 1 mm feed gap across point A and the top edge of the system ground plane B. As shown in Fig.1 (c), the radiating element is a part of an oval and several slits are embedded in the printed monopole, which separate the antenna into two resonant paths. The longer path starts from the feed point and follows the right strip of the antenna to the open end, while the shorter one is from the feed point and follows the left strip to the open end. The longer path generates the resonance at about 888 MHz and the shorter one forms the resonance at about 1820 MHz.

III. RESULTS

Fig. 2 shows the simulated and measured return loss of the proposed antenna. The simulated results are obtained using CST MWS [14], and good agreement between the measured and simulated results are obtained. It is clearly seen from Fig. 2 that two operating bands (determined at 6 dB level) are obtained. The bandwidth of the low band reaches 144 MHz that covers both the GS M850 and GSM 900 bands (824 – 960 MHz), whereas the high band has a bandwidth of 320 MHz that covers both the DCS and PCS bands (1710 – 1990 MHz).

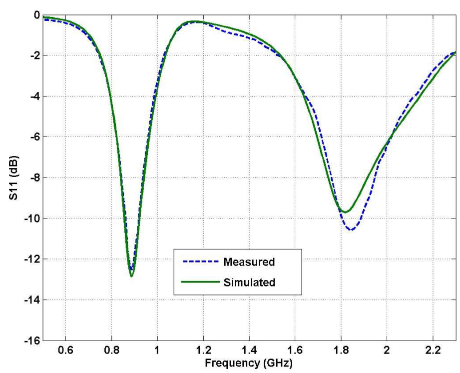
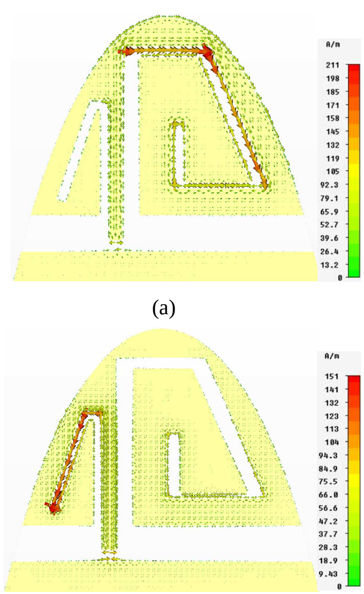


Fig. 2. Simulated and measured return loss of the proposed antenna.



(a)

(b)

Fig. 3. Surface current distributions on the antenna at (a) 888 MHz and (b) 1820 MHz.

Fig. 3 shows the simulated surface current distributions at 888 MHz and 1820 MHz, which are the simulated resonant frequencies of the two bands. For 888 MHz, a stronger surface current distribution is observed along the longer path. This indicates that the longer path is the major radiating element for the proposed antenna at GSM 850 and GSM 900 bands (i.e., the low band of the antenna). For 1820 MHz, it is observed that surface current distribution is mainly along shorter path. That means the shorter path contributes to the DCS and PCS bands (i.e., the high band of the antenna).

IV. CONCLUSIONS

An internal quad-band printed monopole antenna suitable for oval shape mobile phones application has been proposed and studied. The antenna has a planar structure with a simple pattern, making it easy to fabricate at a low cost. The antenna can generate two wide bands at about 900MHz and 1800MHz for the quad-band operation. The work carried out in this paper would be very useful to design internal printed antenna for oval-shaped mobile terminals.

V. REFERENCES

[1] P. Lindberg, "Wide-band active and passive antenna solutions for handheld terminals," Ph.D dissertation, Uppsala University, Sweden, Feb. 2007.

[2] K. L. Wong, Y. C. Lin, and T. C. Tseng, "Thin internal GSM/DCS patch antenna for a portable mobile terminal," *IEEE Trans. Antennas Propag.*, vol.54, pp. 238-242, Jan. 2006.

[3] K. L. Wong and C. H. Huang, "Bandwidth-enhanced internal PIFA with a coupling feed for quad-band operation in the mobile phone," *Microwave and Optical Technology Letters*, vol. 50, pp. 683-687, Mar. 2008.

[4] K. L. Wong, G. Y. Lee, and T. W. Chiou, "A low-profile planar monopole antenna for multiband operation of mobile handsets," *IEEE Trans. Antennas Propag.*, vol. 51, pp. 121-124, Jan. 2003.

[5] C. H. Chang and K. L. Wong, "Small-size printed monopole with a printed distributed inductor for penta-band WWAN mobile phone application," *Microwave and Optical Technology Letters*, vol. 51, pp. 2903–2908, 2009.

[6] C. W. Chiu and Y. J. Chi, "Planar hexa-band inverted-F antenna for mobile device applications," *IEEE Antenna and Wireless Propagation Letters*, vol. 8, pp. 1099-1102, 2009.

[7] Y. W. Chi and K. L. Wong, "Internal compact dual-band printed loop antenna for mobile phone application," *IEEE Trans. Antenna Propag.*, vol. 55, pp. 1457-1462, 2007.

[8] J. F. Scalisi, "Oval shaped pager/phone device," U.S. Patent D445777S, July 31, 2001.

[9] R. Tubl. (2008, May 6). Egg, An oval concept phone [Online]. Available: http://www.sizlopedia.com/2008/05/06/egg-concept-mobile-phone/

[10] S. Fortier. (2008, April 23). Nokia Roxo Phone [Online]. Available: http://www.concept-phones.com/nokia/nokia-roxo-phone-treat-her-like-a-lady/

[11] R. Penev. (2009, May 21). New handset Designs [Online]. Available:http://www.concept-phones.com/cool-concepts/han-dset-designs-rumen-penev/

[12] T. Riddle. (2009, Dec. 11). Motorola Twirl Concept Phone [Online].Available:http://www.cameraphonesplaza.com/motorola-twirl-concept-phone/.

[13] Y. Du and A. Zhao, "An internal Quad-band antenna for oval-shaped mobile phones," *IEEE Antennas and Wireless Propagation Letters*, pp. 830-833, vol. 9, 2010.

[14] CST-Microwave Studio, 2009 ed., Computer Simulation Technology, Darmstadt, Germany, 2009.