

High Integration Internal GSM/DCS Monopole Antenna for Mobile Phone

Chia-Lun Tang, Tzu-Hao Lu, and Shih-Huang Yeh
Industrial Technology Research Institute
195 Sec. 4, Chung Hsing Rd., Chutung, Hsinchu 310, Taiwan,
allentang@itri.org.tw

Abstract

A novel internal monopole antenna with integrated shielding case for application in mobile phone is presented. The proposed antenna module is constructed from a single metal plate that is folded into a shape that provides both a RF shielding case covers an RF front module and a dual-band monopole antenna applies for GSM and DCS band operating. By this high integration antenna design, the antenna will not need any more isolation distance for getting good impedance bandwidth, thus the antenna has a compact size and is placed closed to the RF shielding case. In this paper, the GSM/DCS dual-band internal monopole antenna has been realized into a mobile phone Nokia 3310, and the cost and size of the proposed antenna will be better than the original antenna design (planar inverted-F antenna) of Nokia 3310.

1. INTRODUCTION

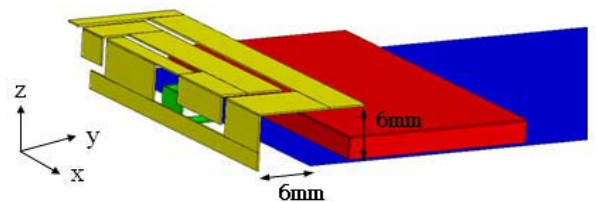
In the recent year, the slight mobile phone or PDA smart phone has already become more popular gradually, thus how to lead an efficient usage of internal space inside the handheld mobile device will be an important thing. Many low profile internal monopole antennas have been proposed [1]-[3]. In general, the impedance bandwidth of the internal monopole is easily to be affected by nearby components and RF shielding case. Therefore, an isolation distance between the antenna and nearby elements is required to keep the good performance of the antenna. But this is not expected antenna design in very limited space of the handheld mobile devices. There are some high integration internal antenna designs that integrated with shielding case or digital camera [4]-[8]. They are always required to solve the EM coupling between the antenna and nearby components when the high integration antennas have been designed.

In this paper, we presented a novel integration design of an internal monopole antenna and RF shielding case for application in GSM/DCS mobile phone. The proposed antenna can be easily fabricated by folding a single metal plate. Therefore, it has advantages of compact size and low cost, especially on antenna height about of 6 mm, that is low profile than other handheld phone antenna designs. The antenna covers the bandwidth requirements of GSM (890-960 MHz) and DCS (1710-1880 MHz). The antenna has

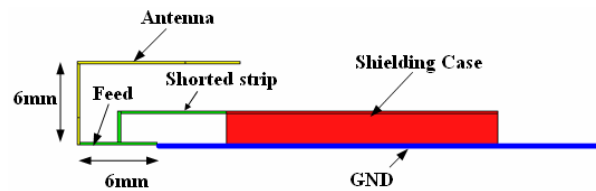
dimensions of $40 \times 12 \times 6$ mm³. Details of the design considerations of the proposed design and the experimental results of the constructed prototype are presented and discussed

2. ANTENNA DESIGN

Fig. 1 (a), (b) shows the configuration and side view of the proposed internal monopole antenna integrated with the RF shielding case, which is mounted at the top of the system ground plane of a mobile phone. This highly integrated internal antenna module is composed by a dual-band antenna, a shorted strip, a feed line and a RF shielding case. The dual-band antenna has two separate branches of different length excited by feed line. The longer resonant path generates the lower mode for GSM operation, and the shorted one generates the higher mode for DCS operation. Note that both the two branch paths are closed to one-quarter wavelength at 900 and 1800 MHz, respectively. The portion of the dual-band antenna and RF shielding case are placed above the system ground plane, which has dimensions of 42×108 mm², a real size of the mobile phone.



(a) Configuration of the proposed antenna



(b) Side view

Fig. 1: Geometry of the proposed high integration GSM/DCS antenna in a mobile phone.

The proposed antenna is easily to be fabricated by folding along two bending lines of the single metal plate shown in Fig. 2, which can be made by line-cutting or stamping a 0.2-mm-thick copper sheet. The proposed antenna has dimensions of $40 \times 12 \times 6 \text{ mm}^3$, and supports by air or plastic. The dual-band antenna and RF shielding case are connected through a shorted strip of width 3 mm. The distance between the shorted strip and the feed line will be chosen a narrow width to achieve a good performance of the antenna impedance bandwidth, without the need of an isolation distance between the antenna and the ground plane. In this case, the total antenna height above the system ground plane is only 6 mm, and 6 mm protruding from the edge of the system ground plane. Therefore, the proposed antenna with compact size and low profile is very suitable to be an internal antenna for mobile phone application. The proposed GSM/DCS internal monopole antenna has been realized and replaces the PIFA (planar inverted-F antenna) into Nokia 3310, shown in Fig. 3. More measured results will be discussed in next section.

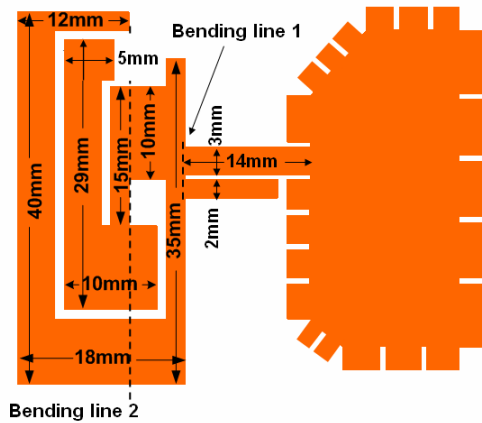


Fig. 2: Detailed dimension of a single metal plate for fabricating the proposed antenna integrated with shielding case.

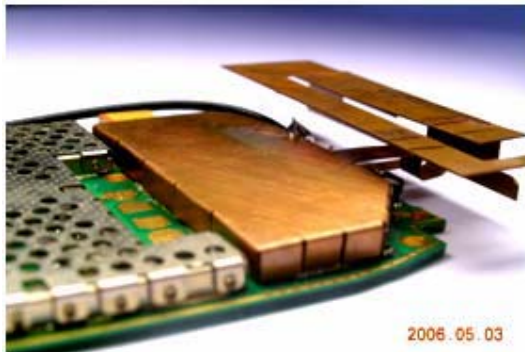


Fig. 3: Photo of the proposed antenna mounted at the top portion of the system ground plane in Nokia 3310.

3. EXPERIMENTAL RESULTS AND DISCUSSION

Fig. 4 shows the measured return loss of the constructed prototype, shown in Fig. 3. From the results, two separate resonant modes at about 900 MHz and 1800 MHz are clearly excited. With the definition of 2.5:1 VSWR (7.3 dB return loss), the lower mode has an impedance bandwidth of 70 MHz (890-960 MHz), which satisfies the operating bandwidth of the GSM band. For the higher mode, the impedance bandwidth achieves 220 MHz (1700-1920 MHz), also covering the bandwidth of the DCS system.

The radiation characteristics of the proposed antenna were also studied. Fig. 5 shows the measured radiation patterns at 900 MHz and 1800 MHz, respectively. We can see that the radiation characteristics of the antenna are monopole-like that suitable for mobile device application. The good omnidirectional radiation patterns in x-z plane are seen both in GSM and DCS band. The measured antenna gain for frequencies across the GSM and DCS band are shown in Fig. 6. At the GSM band, the antenna gain lever is about 0-1.2 dBi. Across the DCS band, the antenna gain is about 1.8-4.3 dBi.

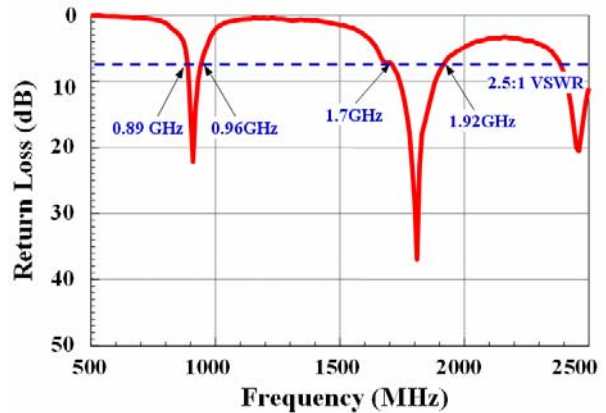
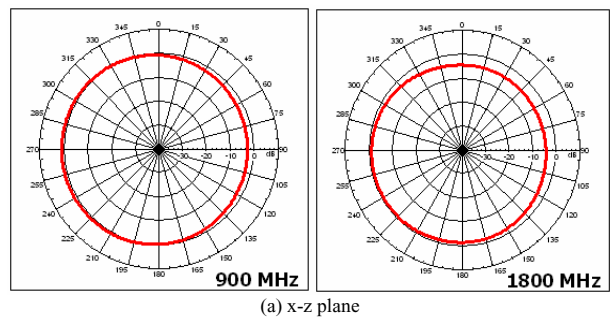


Fig. 4: Measured return loss of the antenna shown in Fig. 3.



(a) x-z plane

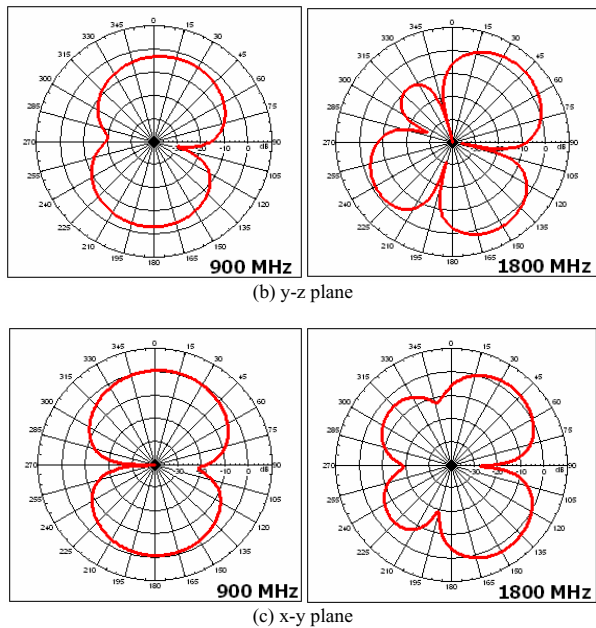
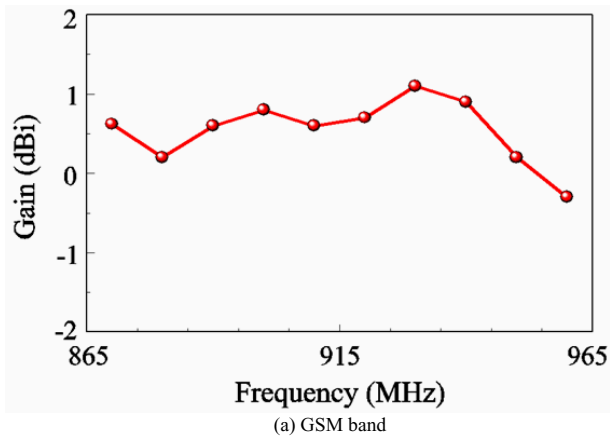
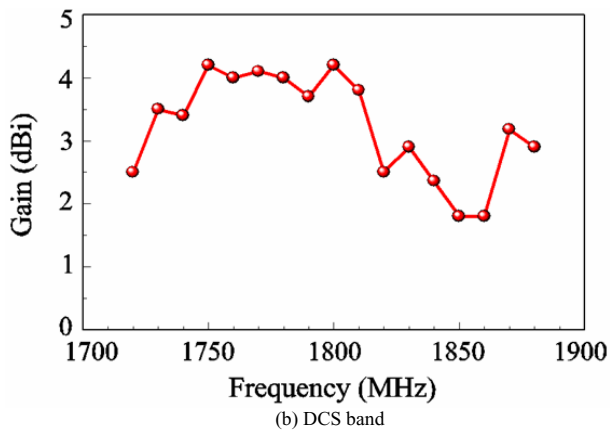


Fig. 5: Measured radiation patterns at 900 MHz and 1800 MHz for the antenna shown in Fig. 4.



(a) GSM band



(b) DCS band

Fig. 6: Measured antenna gain of the proposed antenna.

4. CONCLUSION

A novel internal GSM/DCS monopole antenna with integrated a RF shielding case has been proposed. The proposed antenna and the RF shielding case can be easily constructed by folding a single metal plate, and therefore the cost of the proposed antenna is significantly reduced. This internal monopole antenna occupies a small size of $40 \times 12 \times 6 \text{ mm}^3$, and has a lower antenna height above the system ground plane that is very suitable for slight mobile phone applications. The impedance bandwidths of dual operating mode are satisfied, and furthermore good radiation characteristics have also been observed. The proposed antennas have potentially applications in wireless mobile communication devices such as cellular phone or PDA smart phone. More detailed results of the proposed design will be described in the presentation

REFERENCES

- [1] K.L. Wong, Planar antennas for wireless communications, Wiley, New York, 2003.
- [2] C.Y. Chiu, P.L. Teng and K.L. Wong "Shorted, folded planar monopole antenna for dual-band mobile phone," *Electron. Lett.*, vol. 39, pp. 1301-1302 Sept. 2003.
- [3] G.L. Lee, H.T. Chen and K.L. Wong "A low-cost surface-mount monopole antenna for GSM/DCS operation," *Microwave Opt. Technol Lett*, vol. 37, pp. 2-4, April 2003.
- [4] S.W. Su and K.L. Wong, "Internal monopole antenna integrated with a shielding metal case for UMTS mobile devices," *Microwave Opt. Technol Lett*, vol. 48, pp. 162-165, Jan 2006.
- [5] S.W. Su, K.L. Wong, C.L. Tang and S.H. Yeh "Wideband monopole antenna integrated within the front-end module package," *IEEE Trans Antennas Propagat*, vol. 54, pp. 1888-1891 June 2006.
- [6] A.C.W. Wong and W.H. Leung, "Integrated inverted F antenna and shield can," U.S. patent 6,867,746 B2, Mar. 15, 2005.
- [7] S.L. Chien, H.T. Chen, C.M. Su, F.R. Hsiao and K.L. Wong "Planar inverted-F antenna with a hollow shorting cylinder for internal mobile phone antenna," *IEEE Antennas Propagat, Soc Int Symp. Dig.*, vol. 2, pp. 1947-1950, June 2004.
- [8] C.L. Tang, S.H. Yeh and Z.H. Lu, "Apparatus of antenna with heat slug and its fabricating process," U.S. patent 7,042,398, May 24, 2006.