Thin Internal Planar GSM/DCS Mobile Phone Antenna

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***Abstract* — This paper reports a novel thin internal planar antenna with a small thickness of 3 mm for GSM/DCS mobile phone applications. The antenna is a planar inverted-F antenna having a slit-loaded top patch of 23 × 50 mm^2, which provides two resonant paths for 900/1800 MHz operation. By incorporating the truncation of a small rectangular portion (5 × 50 mm^2) off the ground plane below the top patch, the antenna shows two wide bandwidths covering the GSM and DCS bands. The proposed thin internal planar antenna is especially suited for applications in thin mobile phones.**

***Key words:* antennas, mobile antennas, GSM/DCS mobile phone antennas, mobile phone antennas, dual-band antennas.**

I. INTRODUCTION

Planar antennas, such as the PIFAs (Planar Inverted-F Antennas), have the attractive features of low profile and small size, and have been widely applied in mobile phones as internal antennas [1]. For providing wide bandwidths to cover the operating bands of the GSM (Global System for Mobile Communication, 890-960 MHz) and DCS (Digital Communication System, 1710-1880 MHz) cellular systems, this kind of internal planar mobile phone antennas usually requires a thickness of about 6 ~ 10 mm for the air-layer substrate between the antenna's top patch and ground plane. This requirement in a thick air-layer substrate limits the application of the internal planar antennas in a thin mobile phone with a thickness of about 10 mm, which is becoming very attractive for mobile phone users and is considered as one of the major trends for mobile phone developments in the near future.

In this paper we present a novel thin internal planar mobile phone antenna with an air-layer substrate thickness of 3 mm only. The antenna is a PIFA with a defected ground plane and can generate two wide bandwidths to cover the GSM/DCS operations. In addition, although the air-layer substrate thickness is relatively much smaller, the top patch of the proposed antenna requires a size of 23 × 50 mm^2 only, which is comparable to those of the conventional thick PIFA designs for internal mobile phone antennas [1]. Details of the proposed antenna are described, and experimental results of the constructed prototype are presented and discussed.

II. Antenna Design

Fig. 1(a) shows the geometry of the proposed thin internal planar mobile phone antenna for GSM/DCS operation. Detailed dimensions of the antenna's top patch are shown in Fig. 1(b). The antenna is mounted at the top portion of a ground plane of dimensions 50 × 95 mm^2, which is treated as the system or main ground plane of a practical mobile phone. Between the top patch and ground plane is an air-layer substrate, which is selected to be 3 mm to achieve a thin profile for the antenna. Note that the antenna's top patch faces a defected ground plane, wherein a small rectangular portion (5 × 50 mm^2) is truncated at the top of the ground plane. With this defected ground plane configuration, which is much simpler than the slotted or modified ground plane for improving the bandwidths of internal PIFAs for mobile phones [3, 4], the impedance bandwidths of the proposed thin mobile phone antenna can be effectively enhanced.

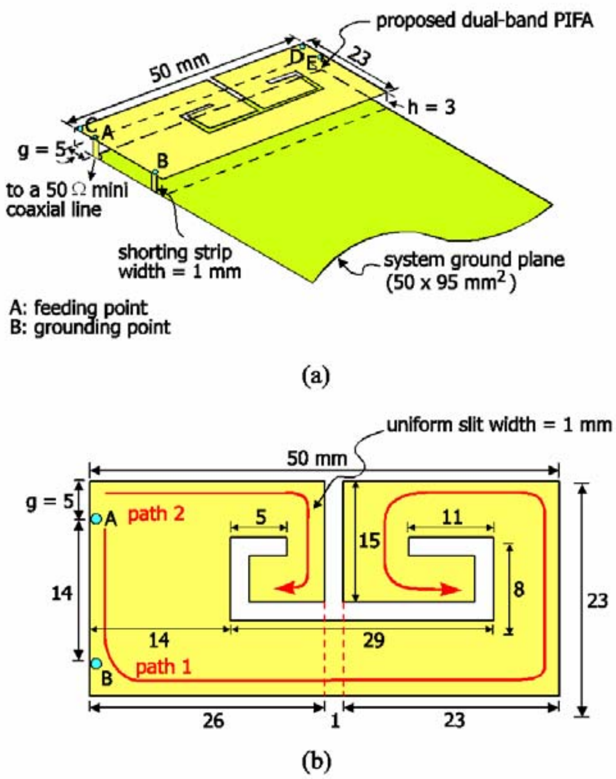

Fig. 1 (a) Geometry of the proposed thin internal planar mobile phone antenna for GSM/DCS operation. (b) Detailed dimensions of the top patch of the antenna.

Also note that in the antenna's top patch, a branch-line slit is embedded [2], which separates the top patch into two sub-patches (branches 1 and 2 in the figure). The two sub-patches are operated as quarter-wavelength structures. The sub-patch of branch 1 provides a resonant path (path 1) for generating a resonant mode at 900 MHz, while the sub-patch of branch 2 provides a resonant path (path 2) for a resonant mode at 1800 MHz. With the presence of the simple defected ground plane proposed here, the two resonant modes at 900 and 1800 MHz show wide bandwidths (based on 2.5:1 VSWR, which is generally accepted for internal mobile phone antennas) covering the GSM and DCS bands.

It should also be noted that the feeding point of the antenna is located at point A shown in Fig. 1, which is chosen to be at the corner of the top edge of the ground plane. This feeding point arrangement is helpful in efficiently exciting the internal PIFA to result in an enhanced bandwidth. For the shorting point of the antenna, it is located at point B shown in Fig. 1. For achieving good impedance matching, a large spacing of 16 mm between the feeding and shorting points is required for the proposed antenna.

III. Experimental Results and Discussion

The proposed thin internal planar mobile phone antenna was constructed and tested. Fig. 2 shows the measured and simulated return loss of the constructed prototype. The simulated results are obtained using Ansoft simulation software HFSS (High Frequency Structure Simulator) [5]. Agreement between the measurement and simulation is seen. Two wide resonant modes are successfully excited. The lower mode shows an impedance bandwidth, defined by 2.5:1 VSWR, of 85 MHz (880 ~ 965 MHz), which covers the required bandwidths of the GSM system. The upper mode also shows a wide bandwidth of 175 MHz (1710 ~ 1885 MHz), satisfying the required bandwidth of the DCS system.

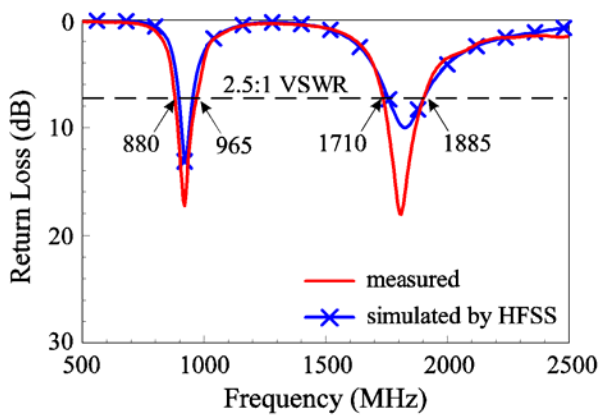

Fig. 2 Measured and simulated return losses.

Figs. 3 and 4 plot the measured radiation patterns at 900 and 1800 MHz for the constructed prototype. The radiation patterns show no special distinctions compared to those of the conventional internal PIFAs for mobile phones [1]. Fig. 5 shows the measured antenna gain for frequencies over the operating bands. As seen in Fig. 5(a) for the GSM band, the antenna gain varies in a range of about 0 ~ 1.8 dBi. As for the DCS band shown in Fig. 5(b), the antenna gain varies from about 1.7 ~ 3.6 dBi.

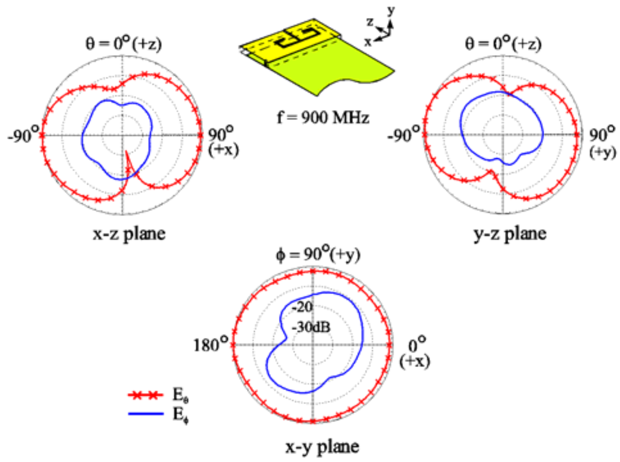

Fig. 3 Measured radiation patterns at 900 MHz for the antenna studied in Fig. 1.

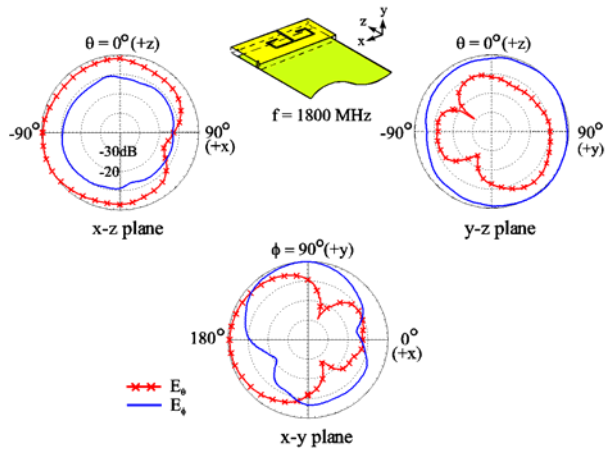

Fig. 4 Measured radiation patterns at 1800 MHz for the antenna studied in Fig. 1.

To further analyze the effect of the small truncated ground portion, the simulated return loss as a function of g is shown in Fig. 6. The impedance bandwidths of the lower and upper bands are seen to increase with increasing value of g. Similarly, with an increase in the antenna height h, increased impedance bandwidths of both the lower and upper bands are also observed, see the results shown in Fig. 7.

IV. Conclusion

A thin internal dual-band PIFA design for GSM/DCS mobile phones has been proposed, fabricated, and tested. The proposed antenna has a thin profile of 3 mm only. In addition, the total occupied volume of the antenna is only about 3.5 cm^3 (3 × 23 × 50 mm^3), which is comparable to that of conventional internal PIFA designs for mobile phones. With the use of a simple defected ground plane for the proposed antenna, two wide bandwidths covering the GSM and DCS bands have been obtained. In addition, good radiation performances over the two operating bands have also been obtained.

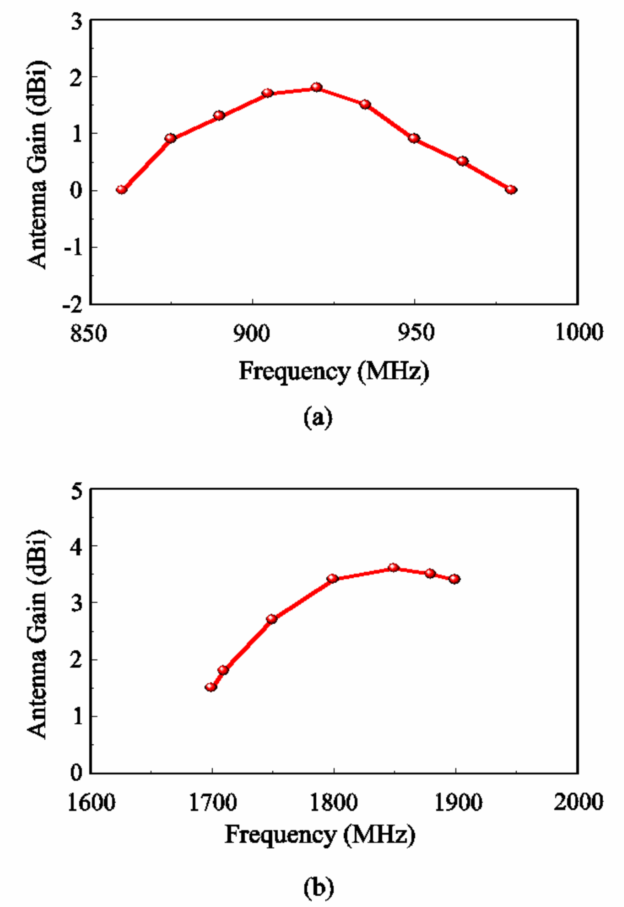

Fig. 5 Measured antenna gain. (a) The GSM band. (b) The DCS band.

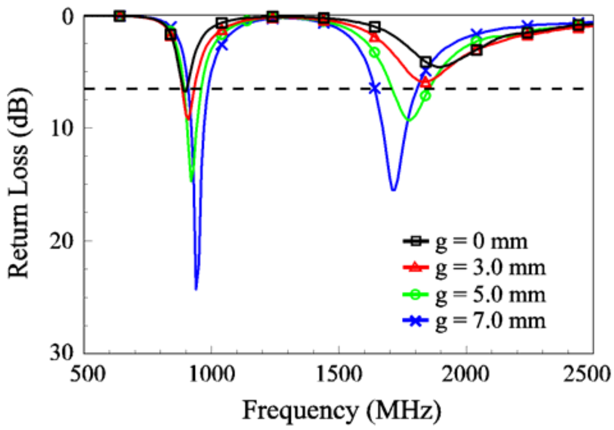

Fig. 6 Simulated return loss as a function of the distance g off the ground plane.

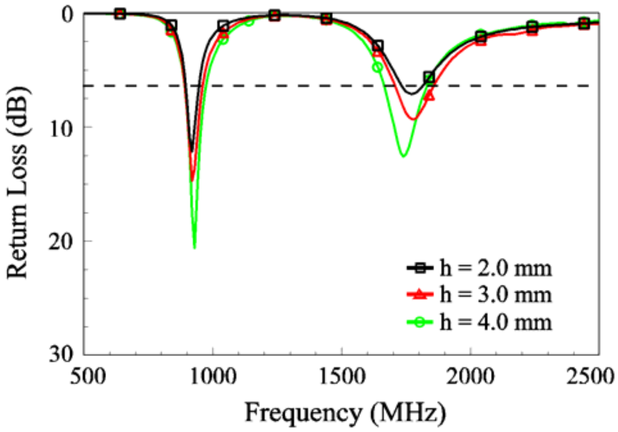

Fig. 7 Simulated return loss as a function of the antenna's height h.

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