Design of An Internal Penta-band Monopole Antenna for Mobile Handset

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***Abstract* — An internal penta-band monopole antenna with compact size and low cost characteristics is proposed, which can cover GSM850, GSM900, DCS1800, PCS1900 and WCDMA2100 bands simultaneously. The antenna comprises a driven monopole and a parasitic shorted patch, which is used to increase the antenna's bandwidth. A prototype is fabricated and measured. Both of the simulated and measured results show the antenna is featured with the mentioned characteristics, which makes the antenna suitable for mobile handset.**

***Index Terms* — Penta-band, Monopole antenna, Handset antenna.**

I. Introduction

Nowadays, with the increasing development of cellular communication, it is very likely that most electronic devices will include several wireless functionalities. Thus, the mobile handsets with varies type of antennas have been extensively presented. This kind of antennas should be internal, multi-band, low cost, compact size, lightweight and easy fabrication. These desirable features have attracted more and more attentions.

Planar inverted-F antenna (PIFA), which is one of the well-known types of antennas, has many advantages, such as low profile, compact size and multi-band operations[1]. However, this structure suffers from limitation in antenna height to obtain the desired results. As subscribers demand for multi-band operation and the area of the antenna is limited, the traditional type antenna's fabrication is difficult and the production cost becomes high. Compared with PIFA antenna, monopole prevails in ultra thin phones for its very low profile structure, better bandwidth and good efficiency. For such changes, the use of monopole antenna is a good choice.

In the recent published papers [2-5], several internal antennas suitable for mobile phones and smart-phones for multi-band operations were presented. These antennas are preferable for using in mobile systems, including GSM850(824-894MHz), GSM900(880-960 MHz), DCS1800 (1710-1880MHz), PCS1900(1850-1990MHz), WCDMA2100 (1920-2170MHz). However the antennas mentioned above may not be suitable for mobile device for the small size of antenna and its complex electromagnetic environment.

In this paper, we present a compact penta-band monopole antenna with an occupied volume of $25 \times 14 \times 4.5$ mm^3 in the mobile handset which covered the requirement bandwidth of GSM850/900, DCS1800, PCS1900, and WCDMA2100 with sufficient volume. The antenna is composed of a main monopole and a parasitic patch and easily printed on an antenna bracket-a FR4 substrate with low cost . The study is carried out using High Frequency Structure Simulator (HFSS) and experimental results are also given. Details design considerations and the results of the proposed antenna are presented and discussed in the following sections.

II. Antenna Design

The geometry and configuration of the proposed penta-band antenna is shown in Fig 1. A 1.5-mm-thick FR4 antenna substrate with a permittivity of 4.4 and loss tangent of 0.02 is used. The substrate dimension is fixed as $48 \times 14 \times 1.5$ mm^3. Taking into considerations the actual mobile phone structure, all the metallic components of the antenna are printed on the side of the substrate with the size of 25×14 mm^2. And the antenna height from the ground is 4.5 mm. Finally, the main PCB of the dimension 112×62 mm^2 is system ground plane.

TABLE I

Dimensions of the proposed antenna for mobile handset

W1	L1	L2	t1	h	L3	h1
14	48	25	3	4.5	20	1.4

Unit :mm

The antenna design mainly comprises of a driven monopole and a parasitic shorted patch. The monopole is a rectangular patch with two pieces of mental branches. The antenna is excited by a coaxial. The shorter branch resonates at the higher band and the longer branch resonates at the lower band. The longer branch always effect both higher and lower frequencies. The parasitic shorted element is electrically connected to the ground through a mental strip and attached to the side of the antenna bracket, which can expand the antenna's bandwidth. Simulator Ansoft HFSS ver. 13 is used to simulate and optimize the antenna design. The finally chosen dimensions of the proposed antenna are illustrated in table I .

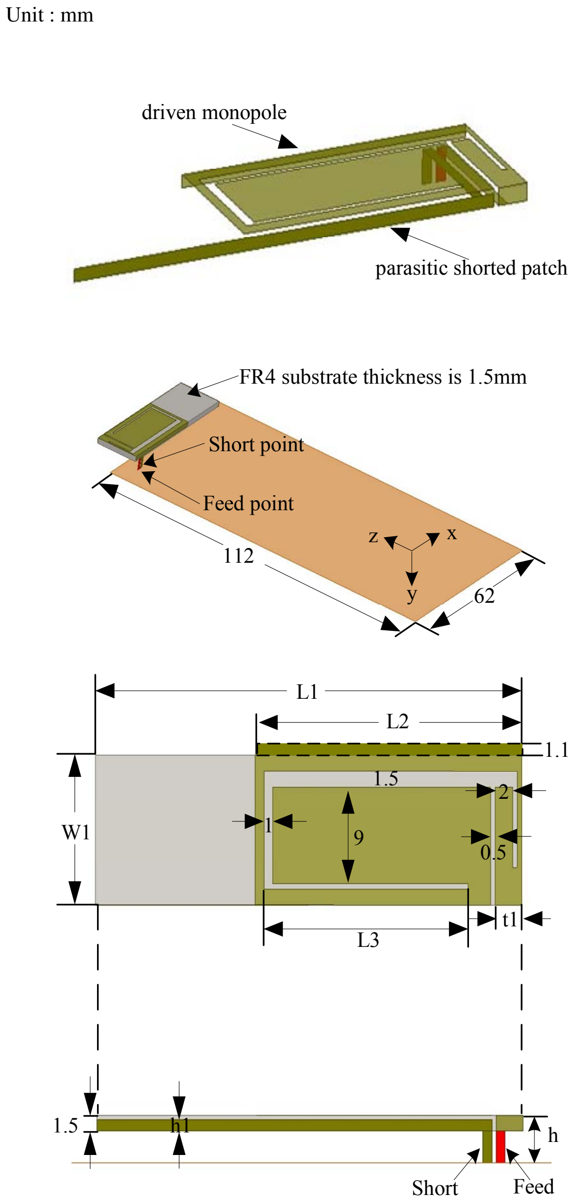


Fig 1. Detailed geometry of the penta-band mobile antenna

III. Simulation and Measurement Results

The proposed monopole antenna is successfully fabricated and measured. A prototype is fabricated as shown in Fig 2, and the results are presented. The measured results were carried out in anechoic chamber using a vector network analyzer (VNA).

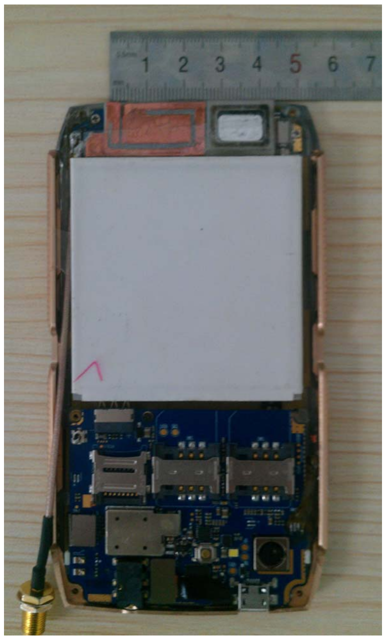


Fig 2. Fabricated penta-band mobile phone antenna

Fig 3 displays the measured and simulated return loss for the proposed antenna. Measured data are seen to substantially agree with the simulated results obtained using Ansoft HFSS. Since the antenna problem of manufacturing precision, the results differ slightly. The measured bandwidths defined by return loss less than -6 dB (widely used for internal mobile handset antennas) are 140MHz (820-960MHz) and 400MHz (1700-2100MHz) respectively. As a results, it can be operated with the GSM850, GSM900, DCS1800, PCS1900 and WCDMA2100 frequency bands.

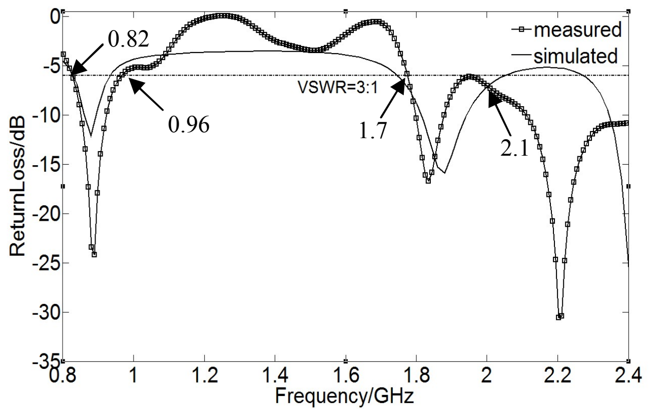
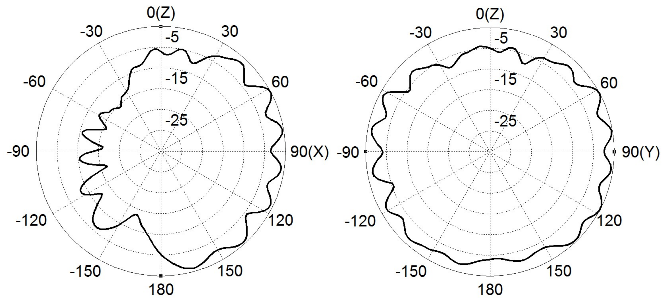
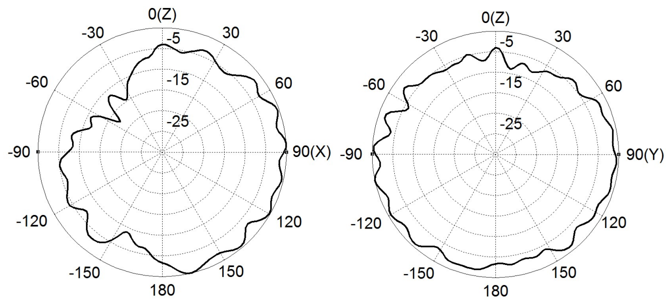


Fig 3. Comparison of simulated and measured reflection coefficient spectra of the proposed penta-band mobile phone antenna

Fig 4 shows the measured radiation patterns of the proposed antenna at f=860, 925 MHz (center frequency of the GSM850 and GSM900 bands). Similar radiation patterns at the two frequencies are observed, both in x-z plane and y-z plane. Similarly, the measured radiation patterns for f=1795, 1920, and 2050 MHz (center frequencies of the DCS, PCS, and WCDMA bands) are presented in Fig 5. For 1920 and 2050 MHz, similar radiation patterns are observed. From these figures, we can see that the antenna has omnidirectional radiation patterns at each operating band, which can meet the demands for mobile devices. In conclusion, the measured radiation patterns for the required bands can acceptable for mobile phone applications.

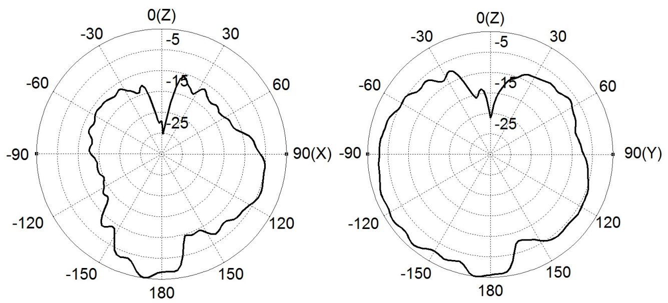


(a) f= 860 MHz

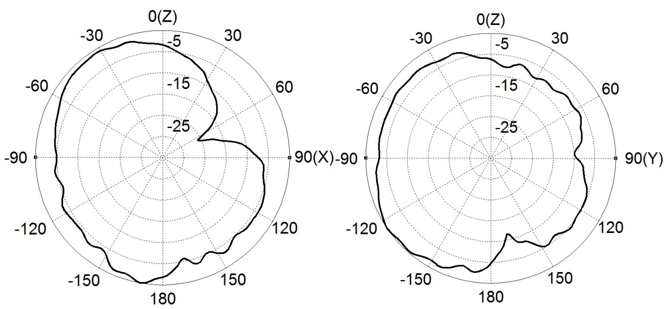


(b) f= 925 MHz

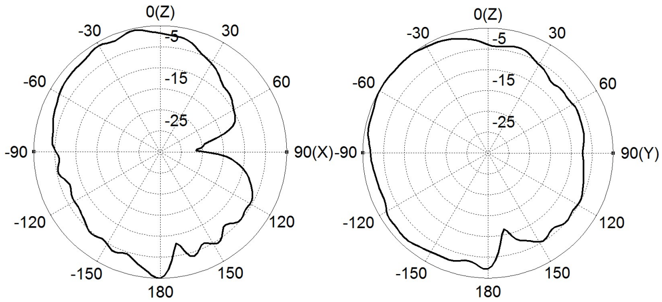
Fig 4 . Measured radiation patterns for the proposed penta-band mobile antenna (a) at 860MHz, (b) at 925MHz



(a) f= 1795 MHz



(b) f= 1920 MHz



(c) f= 2050 MHz

Fig 5. Measured radiation patterns for the proposed penta-band mobile antenna (a) at 1795MHz, (b) at 1920MHz, (c) at 2050MHz

IV. Conclusion

A compact low cost mobile device antenna for penta-band of GSM850/900/DCS/PCS/WCDMA was designed. A prototype of the antenna design was fabricated successfully. Although simple in structure, both the simulated and measured results demonstrate that the antenna covers the required bands. The antenna also shows good radiation characteristics. Thus, the proposed antenna in this letter can be integrated into mobile device as an internal antenna.

Acknowledgment

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