Design of a Novel Multiband Internal Antenna for Personal Communication Handsets

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***Abstract*—Modern personal communication handsets are required to operate at multiple frequency bands for location independent operation and enhanced functionality. This poses an important challenge for antenna designers to build multiband antennas within the limited allowable space. In this paper, a compact PIFA based internal antenna is proposed for GPS, DCS, PCS, UMTS, WiBro, ISM/Bluetooth and WLAN standards. Measured VSWR of the antenna is within the acceptable limit over all the frequency bands with reasonable radiation performance. Height of the antenna is 4.0 mm resulting in a total volume of 2.4 cm^3 that makes it attractive for modern slim personal communication handsets.**

***Index Terms*— handset antenna, internal antennas, multiband, PIFA, slim antenna.**

I. Introduction

Modern mobile phone handsets are required to operate at multiple frequency bands to provide various communication services [1]-[3]. The demand of compact, light weight and multifunctional handsets puts more stringent requirements on the antenna design. Novel antenna designs are needed to meet the requirements of these emerging trends in mobile communication. Standard Planar Inverted-F Antenna (PIFA) is a promising structure as a starting element to realize multiband antennas [4]. Multiple resonances in the antenna structure are excited by creating slots in the radiating element or resonating strips are judicially located in the antenna structure. Impedance matching at different frequency bands is usually improved by using parasitic elements and reactive loading at appropriate locations in the antenna structure [5]. Size reduction is usually achieved using shorting pins, stubs and folding or meandering the resonators in an appropriate from [6]. Various multiband PIFA based designs are reported in the literature [7]-[12]. These antennas occupy a volume ranging from 4.6 cm^3 to 5.2 cm^3. Excessive height of 7 mm or 8 mm makes these antenna structures less attractive for modern slim handsets that require reduced height antennas with additional resonance to cover Wireless Local Area Network (WLAN) standards.

In this paper, a novel PIFA based antenna is proposed as an internal antenna for slim personal communication handsets. The antenna is designed to operate at GPS (5.75 GHz), DCS (1710-1880 MHz), PCS (1880-1990 MHz), UMTS (1900-2200 MHz), WiBro (2300 - 2390 MHz), ISM / Bluetooth (2.4 - 2.48 GHz) and WLAN (5.1–5.9 GHz) frequency bands. The antenna consists of a basic PIFA radiator with slits in the main element for multimode excitation in the structure. Dimensions of the slits are optimized to improve S_{11} at the targeted frequency bands. A prototype antenna is fabricated using a flat copper sheet of 0.2 mm thickness and characterized for the return loss and radiation performance. Measured and simulated results are in good agreement.

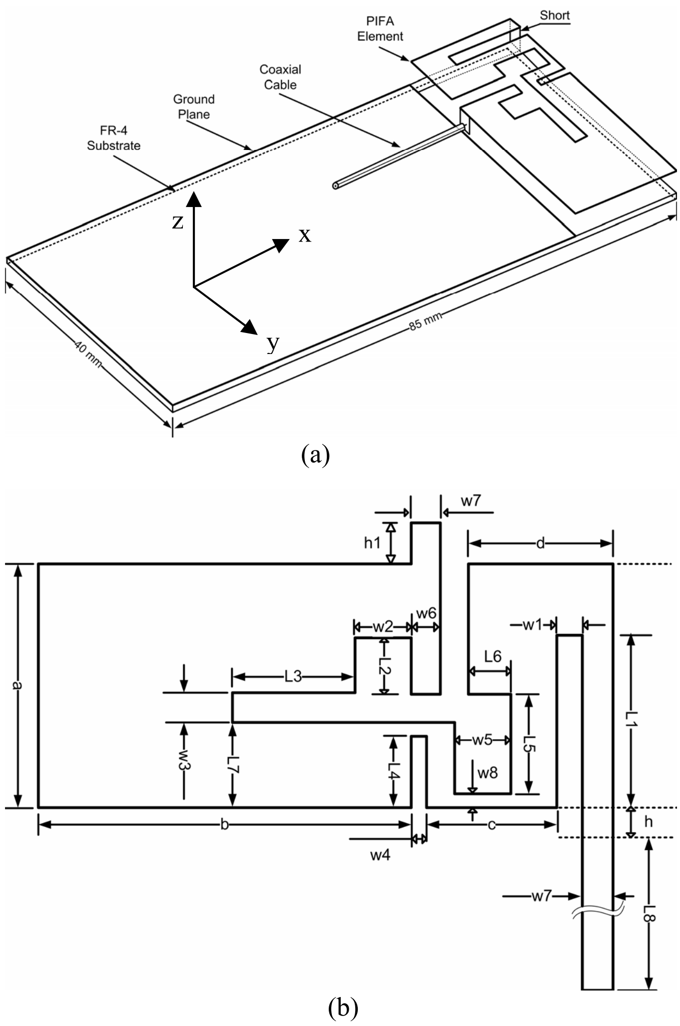

Figure 1: Geometry of the proposed antenna (a) 3-D view (b) Planar view with dotted bending lines

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II. ANTENNA DESIGN

Geometry of the proposed antenna is shown in Fig. 1. The antenna is designed in a rectangular area of 40 mm × 15 mm with a height of 4 mm and located at the top of FR-4 (ε_r = 4.6, loss tangent = 0.01) substrate. Size of the FR-4 substrate is 40 mm × 85 mm which is considered to be the size of a practical mobile phone. The basic antenna is a standard Planar Inverted F Antenna (PIFA) element with a single short circuiting point. Resonating paths in the basic PIFA structure are selected to get resonances at 2.0 GHz and 5.0 GHz. Slots are then created in the radiating patch to control the current flow on the antenna surface. Slot dimensions are optimized using High Frequency Structure Simulator (HFSS) to improve the return loss across the targeted frequency bands. Optimized dimensions of the proposed antenna are given in Table 1. Slot length L_1 and width W_1 are optimized to improve the bandwidth for DCS band while the length L_3 and width W_3 are used to enhance the bandwidth to cover ISM (2.42 GHz – 2.5 GHz) and WLAN (5.17 GHz – 6.0 GHz) frequency bands. Dimensions of the feed and short circuiting strips are optimized for better impedance matching over the desired frequency bands.

A prototype antenna is fabricated using a copper sheet of 0.2 mm thickness and bended at the locations shown dotted in Fig.1b, to realize the 3-D dimensional antenna structure.

TABLE 1
DIMENSIONAL DETAILS OF THE PROPOSED ANTENNA

Parameter	Value (mm)	Parameter	Value (mm)	Parameter	Value (mm)
a	15	L_2	4.0	W_2	4.0
b	26	L_3	8.5	W_3	2.0
c	9.0	L_4	5.0	W_4	1.0
d	10	L_5	7.0	W_5	3.0
h	4.0	L_6	2.0	W_6	2.0
h_1	3.0	L_7	6.0	W_7, W_8	2.0
L_1	12	W_1	2.0	L_8	17

III. SIMULATION AND MEASUREMENT RESULTS

Prototype antenna is characterized by measuring input reflection coefficient and the far field radiation patterns in x-y, x-z and y-z planes. Simulated and measured VSWR are compared in Fig. 2. VSWR is less than 2.0 at all the frequency bands except at 2.4 GHz where it is in between 2.0 and 2.3. Far field radiation patterns (co-polarization and cross-polarization) in the three principle planes are measured in an RF anechoic chamber and acceptable radiation performance is achieved. Measured far-field radiation patterns in the x-y plane, x-z plane and y-z plane at different frequencies are plotted in Figures 3, 4 and 5. Radiation patterns at other frequencies are not shown in the paper. Radiation performance of the antenna is acceptable at all the frequency bands. Measured peak gain of the antenna is given in Table 2.

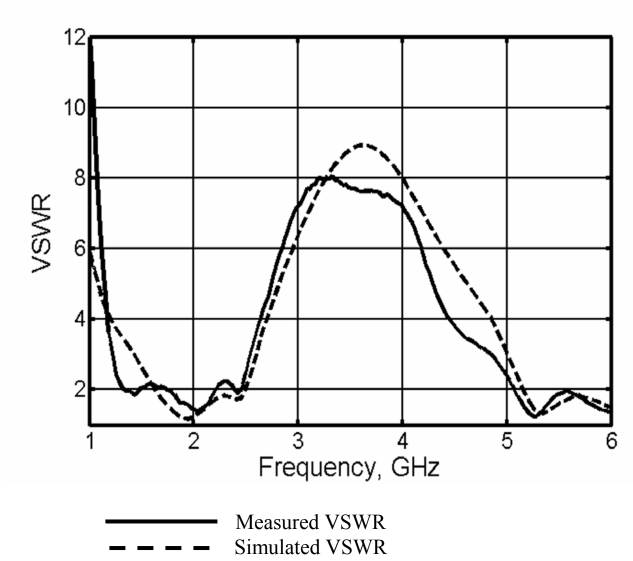

Fig. 2. Simulated and measured VSWR of the proposed antenna

TABLE 2
MEASURED GAIN OF THE PROTOTYPE ANTENNA

	1.71 GHz	1.8 GHz	2.0 GHz	2.35 GHz	2.42 GHz	2.5 GHz	5.4 GHz
GAIN (dB)	2.25	3.24	3.65	3.07	2.4	2.4	4.12

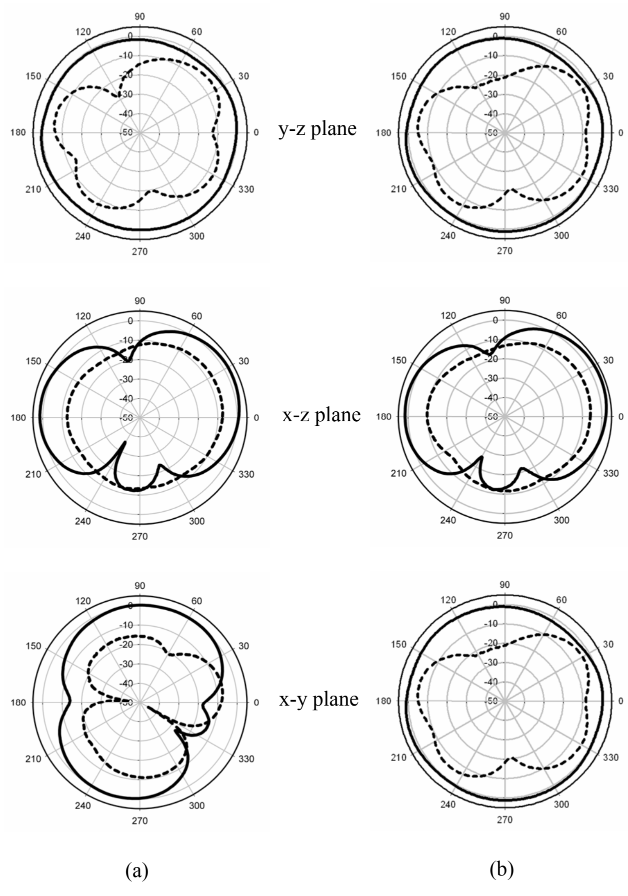

Fig. 3. Measured radiation patterns at (a) 1.71 GHz (b) 1.8 GHz

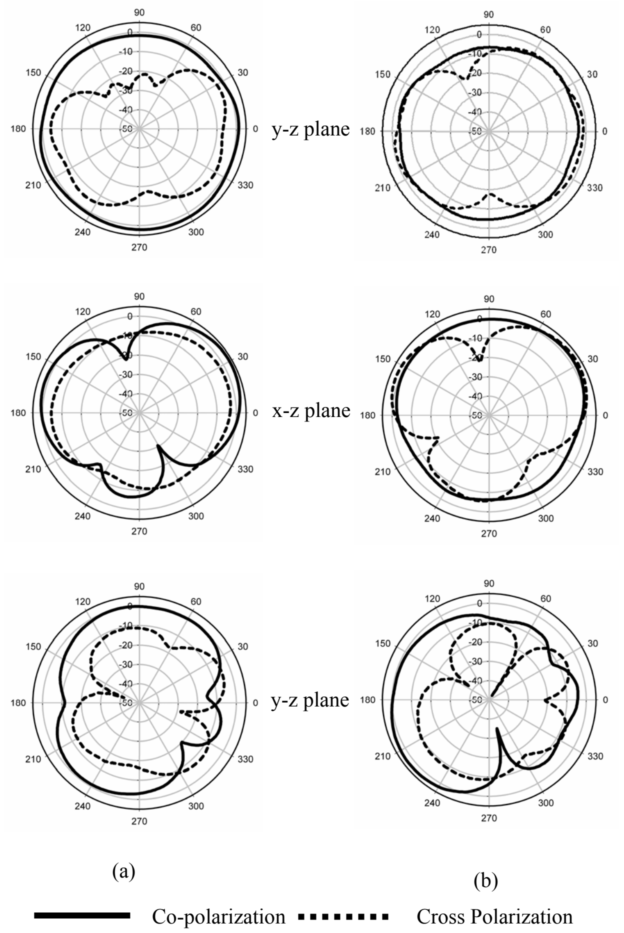

Fig. 4. Measured radiation patterns (a) 2.0 GHz (b) 2.35 GHz

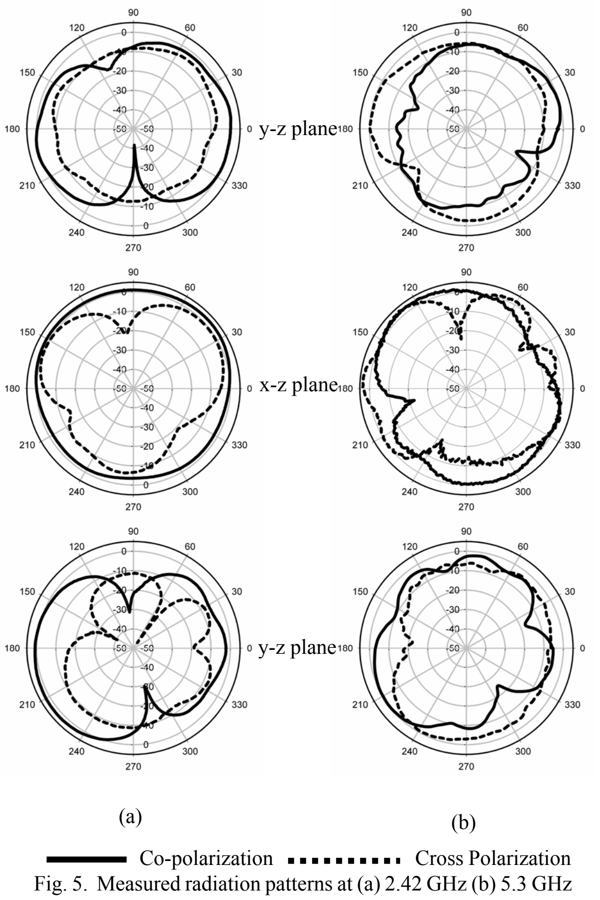

Fig. 5. Measured radiation patterns at (a) 2.42 GHz (b) 5.3 GHz

V. CONCLUSIONS

A novel PIFA based, reduced height internal antenna has been proposed for personal communication handsets to operate at GPS, GSM, DCS, PCS, UMTS, WiBro , Bluetooth/ISM and WLAN frequency bands. Measured VSWR of the antenna is less than 2.0 at all the frequency bands except at ISM band where it is less than 2.3. Antenna has good radiation performance with reasonable gain over the targeted frequency bands. The antenna is compact with a total volume of 2.4 cm^3 that makes it attractive for modern multi standard slim personal communication handsets.

ACKNOWLEDGMENT

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