New Compact Six-Band Internal Antenna

Yong-Xin Guo, *Member, IEEE,* and Hwee Siang Tan

***Abstract*—A novel compact six-band internal handset antenna for covering the GSM (890–960 MHz), GPS (1575 MHz), DCS (1710–1880 MHz), PCS (1880–1990 MHz), UMTS (1900–2200 MHz), and ISM (2400–2480 MHz) bands is presented. The proposed antenna consists of two layer patches and a folded stub and occupies a total volume of $36 \times 17 \times 8$ mm^3. Details of the antenna as well as the measured results will be presented.**

***Index Terms*—Antennas, internal antennas, multiband antennas, planar inverted-F antennas (PIFAs), small antennas.**

I. Introduction

THE rapid growth in mobile communication systems leads to a great demand in developing small antenna with multiband functions. Internal antennas have several advantages over conventional monopole-like antennas for mobile handsets. They are less prone to damage, compact in total size and aesthetic from the appearance point of view. Hence, small- and low-profile structures such as planar inverted-F antennas (PIFAs) that can be mounted on portable equipment are becoming very attractive for mobile communications [1], [2]. Many new multiband designs based on PIFA concepts for achieving operation at two or more of the GSM900, DCS1800, PCS1900, UMTS2000, and ISM2450 bands have been reported in the open literature [3]–[15]. In the United States, mobile phones should provide GPS positioning information to ensure compliance with the emergency call E911 mandate. This requires the mobile phone to be able to operate at the GPS band. The antennas at this GPS band for emergency call applications can be linearly polarized [16], [17].

This Letter presents a novel compact six-band internal antenna for mobile handsets covering the GSM900, GPS1570, DCS1800, PCS1900, WCDMA2000, and ISM2450 bands. The proposed antenna consists of two layer patches and a folded stub. The two patches share a common shorting strip, while the folded stub is not grounded. The antenna was realized within a volume of $36 \times 17 \times 8$ mm^3.

II. Antenna Design

Figs. 1 and 2 show the proposed antenna mounted on a ground plane of dimension 80×36 mm. The antenna is comprised of a main plate at the top layer, a ground plane at the bottom layer, a parasitic plate in between, and a folded stub perpendicular to the two plates. The structure is supported by foam. The main and parasitic plates share a common shorting strip connected to the ground plane. The main plate and the folded stub share a common feeding strip connected to a 50-Ω transmission line etched on the back of the ground plane. The two plates alone can have a quad-band operation as discussed in [13]. By adding a folded stub, an additional resonance can be introduced, which can also enhance the resonance at the high band, resulting in a six-band antenna. A small capacitive load [4] is applied to tune the low band. The antenna has overall dimensions of length 36 mm, width 17 mm, and height of 8 mm. The designed parameters and their values of the proposed antenna are listed in Table I.

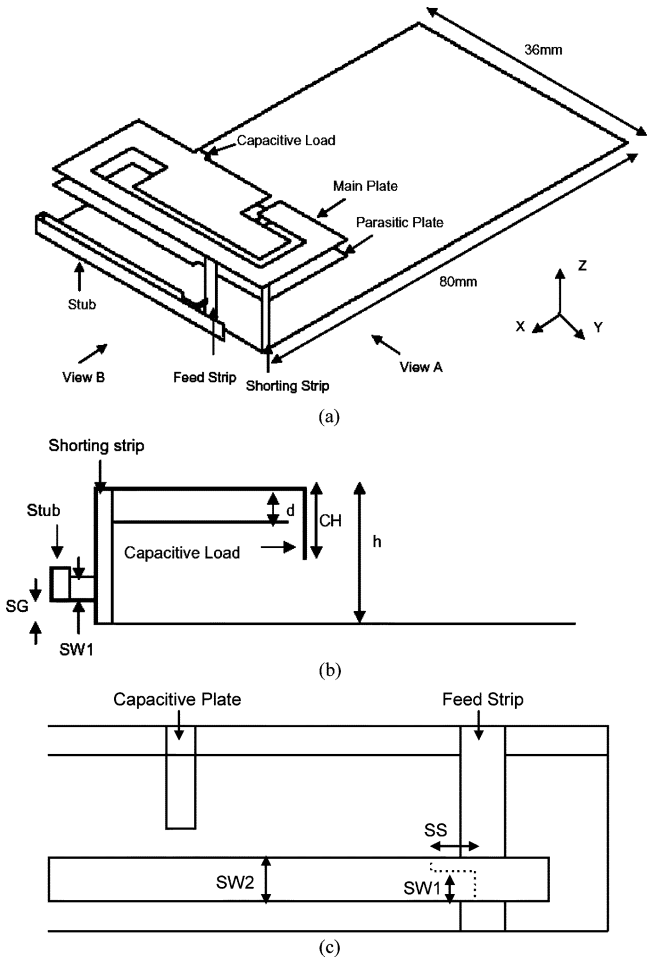

Fig. 1. Geometry of the proposed antenna. (a) 3-D View. (b) View A. (c) View B.

III. Experimental Results and Discussion

The measured return losses for the newly proposed antenna with a folded stub and the original quad-band antenna without the folded stub as in [13] are shown in Fig. 3. For the proposed

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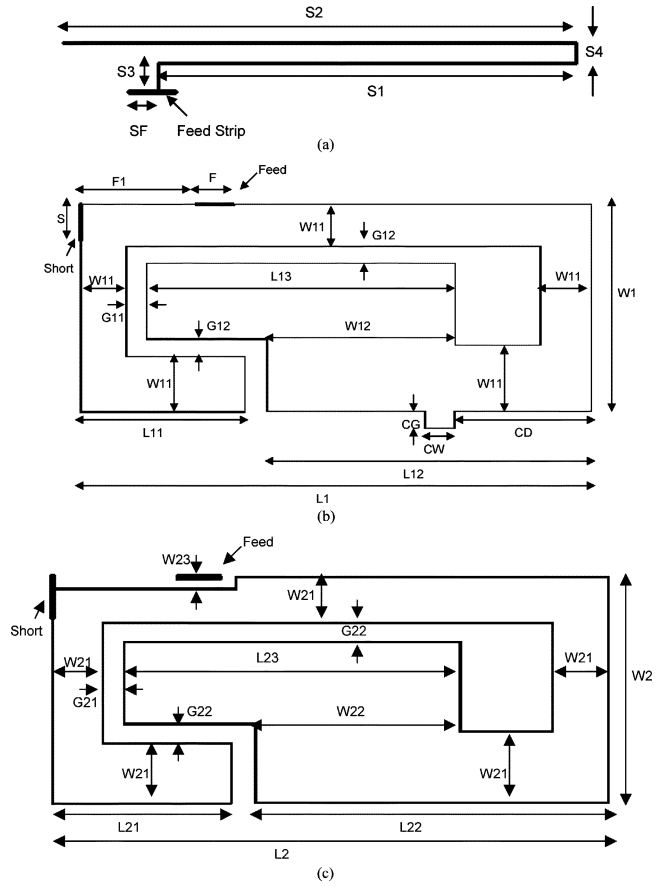

Fig. 2. Close up view. (a) Stub. (b) Main plate. (c) Parasitic plate.

TABLE I
DESIGNED PARAMETERS AND VALUES OF THE PROPOSED ANTENNA

Parameter	Value (mm)	Parameter	Value (mm)	Parameter	Value (mm)	Parameter	Value (mm)
L1	36	W11	3	d	2	SS	3
L2	36	W21	3	CD	12	SW1	2
L11	13	W12	10	CG	1	SW2	3
L21	13	W22	10	CH	4	S1	21
L12	22	G11	1	CW	2	S2	31
L22	22	G12	1	F	3	S3	3
L13	20	G21	1	F1	10	S4	1
L23	20	G22	1	S	2		
W1	12	G23	1	SF	2		
W2	12	h	8	SG	1		

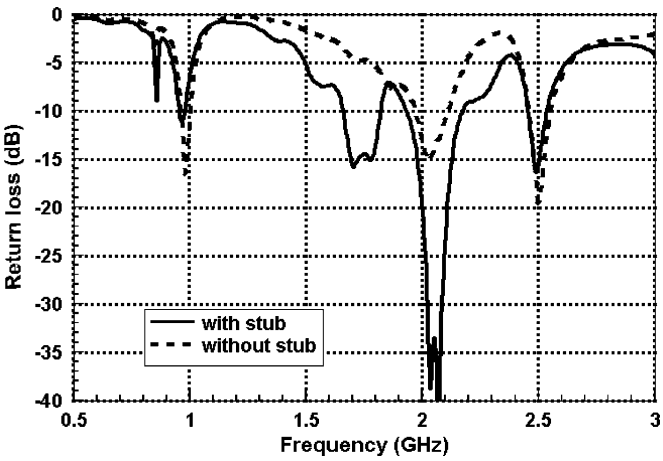

Fig. 3. Measured return losses.

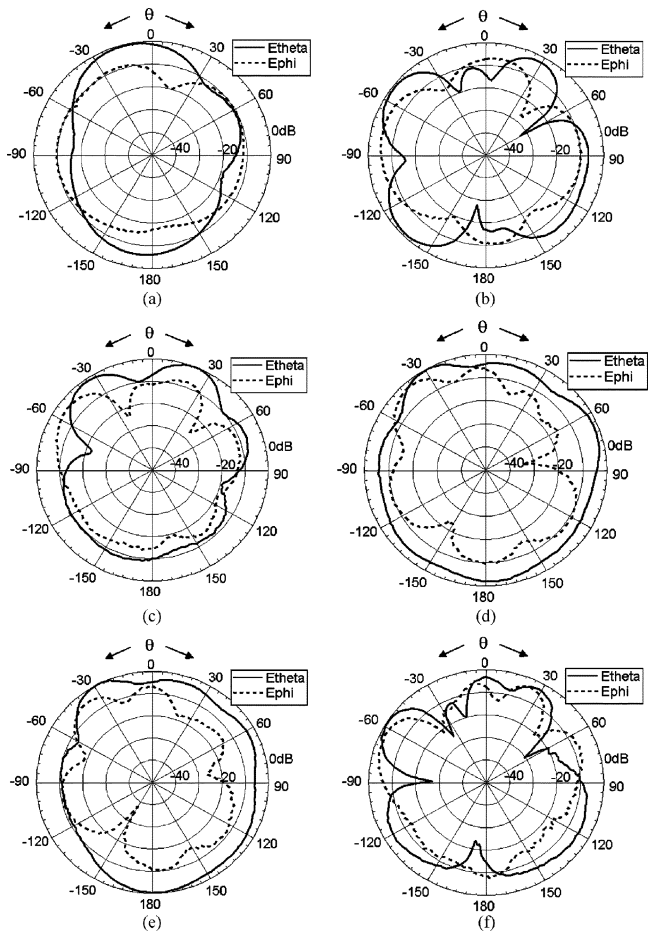

Fig. 4. Measured radiation patterns, 10 dB/div. (a) 1.0 GHz. (b) 1.575 GHz. (c) 1.8 GHz. (d) 1.9 GHz. (e) 2.0 GHz. (f) 2.5 GHz.

TABLE II
MEASURED GAINS

Frequency (GHz)	1	1.57	1.8	1.9	2.1	2.2	2.3	2.5
Gain (dBi)	0	1.2	3.5	1.4	4.7	3.8	5.1	1.8

antenna, the measured bandwidths for a -6 dB return loss are 70 MHz (930.25 $\sim$ 1000.25 MHz) at the low band, 796 MHz (1.518 $\sim$ 2.314 GHz) at the first high band, and 165 MHz (2.422 $\sim$ 2.587 GHz) at the second high band. From the measured results, it is confirmed that the antenna is capable of meeting the bandwidth requirement for mobile handsets operating at GSM, GPS, DCS, PCS, UMTS, and ISM bands. Note that all the frequencies of the proposed prototype are around 5% higher than the standard communication spectrum. This is to account for the effects of the plastic casing over the antenna as in [5] and [17]. Regarding Fig. 3, it is observed that the folded stub not only introduces one additional band (GPS at 1575 MHz), but it also enhances the bandwidth in the DCS, PCS, and UMTS bands. As such, a six-band internal antenna was realized.

The measured far-field radiation patterns in the x-z plane at 1, 1.57, 1.8, 1.9, 2, and 2.5 GHz are shown in Fig. 4. Moreover, good omnidirectional radiation patterns were also obtained in the y–z plane for all the measured resonant frequencies. They

are not shown for brevity and are similar to those of other integrated antennas for mobile handsets [1], [2]. The measured gains are listed in Table II. Referring to Fig. 4, the overall shape of the radiation patterns can be suitable for some mobile communications terminals.

IV. Conclusion

This letter has presented a compact six-band internal antenna for mobile handsets. The antenna is able to operate at the GSM, GPS, DCS, PCS, UMTS, and ISM bands and its performance is verified by experimental results.

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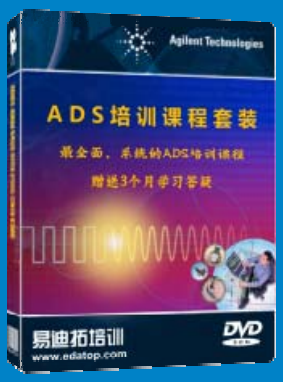

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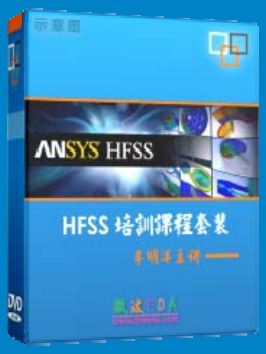

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