Design of a Triple-Band Planar Inverted-F Antenna For Cellular /PCS/ DMB applications

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I. INTRODUCATION

Due to the rapid development and widespread usage of various communication systems, multiband internal antennas are necessary for recent mobile handsets [1]-[3]. To meet the antenna requirement for hand-held terminal, the size reduction is one of the key requirements while maintaining the good multiband and wideband performance. Furthermore, a small intenna that can be integrated into the handset offers many advantages over the conventional external monopole or helical antennas.

A potential candidate for such antennas is a planar inverted-F antenna (PIFA) [4]-[7]. However one of the principal disadvantages of basic PIFA elements is its narrow bandwidth of about 4 to 12% for return loss less than -10dB.

In this paper, a triple-band PIFA is designed to operate at the center frequencies of 870 MHz, 1800 MHz and 2650 MHz. The introduction of a slant slot into the main patch generates three separate resonant modes for desired triple-band operation while the use of U-shaped patch is used for impedance matching PCS/DMB bands and size reduction. This antenna has enough bandwidth (≤ -10 dB) to cover the Cellular (824-894 MHz), PCS (Personal Communication Service, 1750-1870 MHz) and DMB (Digital Multimedia Broadcasting, 2605-2655 MHz) service at the same time.

II. ANTENNA DESIGN

Fig.1 shows the proposed antenna mounted on a ground plane having dimensions of 62 × 44 mm. The antenna consists of a u-shaped patch with a slant slot at the top layer, a ground plane at the bottom, and CPW-feed structure on the ground plane. A 50 Ω CPW feed line having a metal strip width W_{f1} = 3 mm and a gap distance W_{f2} = 0.3 mm, is used to excite the proposed antenna.

The antenna has overall dimensions of 15 mm (W_P) × 44 mm (L_p) × 8 mm (h). The main patch is located along the left side of the ground plane.

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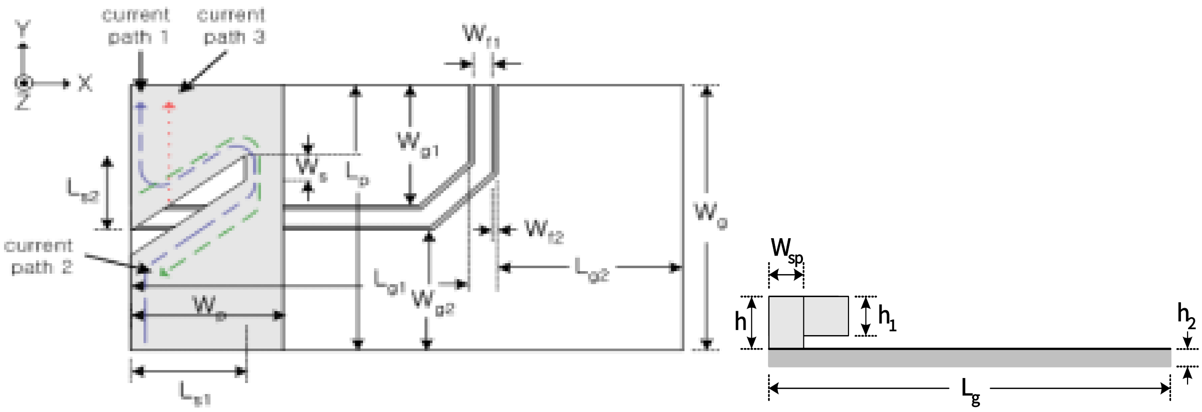


(a) (b)

Fig. 1. The Geometry of proposed antenna. (a) top view; (b) side view .

To obtain the triple resonant frequencies, slant slot with dimensions of L_{s1}, L_{s2} and W_s is located in the middle of the main patch. The analysis of current distribution on the radiating patch reveals that the current path 1 generates the first resonance at 850 MHz. Resonances at 1850 and 2650 MHz are mainly due to the current path 2 and 3, respectively. In addition, the u-shaped patch is used for antenna size reduction [6] and impedance matching [7].

To achieve the best matching and enhance bandwidth performance, the length and height of U-shaped patch are optimized. The resonant frequencies, input impedance, and bandwidth characteristics at each resonant frequency are analyzed as a function of geometrical parameters in Table 1.

Table 1: Resonant frequency, input impedance, and bandwidth characteristics as a function of geometrical parameters. (F_n: n th resonant frequency, $VSWR_n$: input impedance at n th resonant frequency and BW_n: n th bandwidth)

	F_1	F_2	F_3	$VSWR_1$	$VSER_2$	$VSWR_3$	BW_1	BW_2	BW_3
L_{s1} ↑	↓	↓	↓						
L_{s2} ↑		↓	↓					↓	
W_s ↑		↓	↓	↓	↓				
W_{sp} ↑		↑						↓	
h ↑		↓	↓						

III. Experimental results

Fig. 2 shows the simulation return loss against frequency for the proposed antenna with various height of U-shaped patch, h = 6, 8, 9. A decrease in h increases the upper frequencies. Fig. 3 shows the measured return loss characteristics of the proposed antenna. The optimized design parameters for the proposed antenna are W_p=15 mm, L_p=W_g=44 mm, L_g=62 mm, W_s=4 mm, L_{s1}=9 mm, L_{s2}=9 mm, W_{sp}=4 mm, h=8 mm, h_1=7 mm, h_2=1.6 mm, W_{g1}=18.4 mm, W_{g2}=23 mm, L_{g1}=47 mm, L_{g2}=11.4 mm, W_{f1}=3 mm and W_{f2}=0.3 mm.

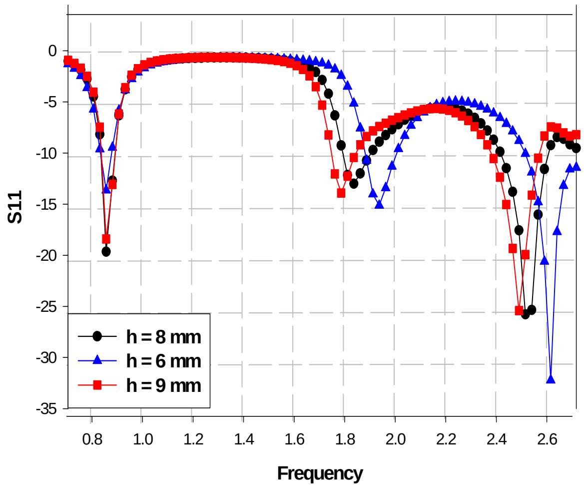


Fig. 2.simulated return loss for different height (h)

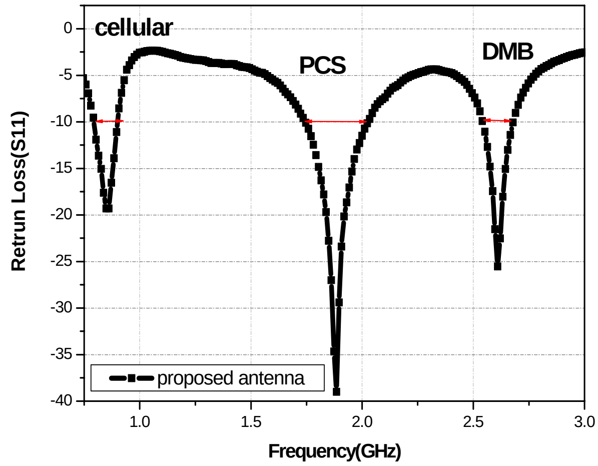
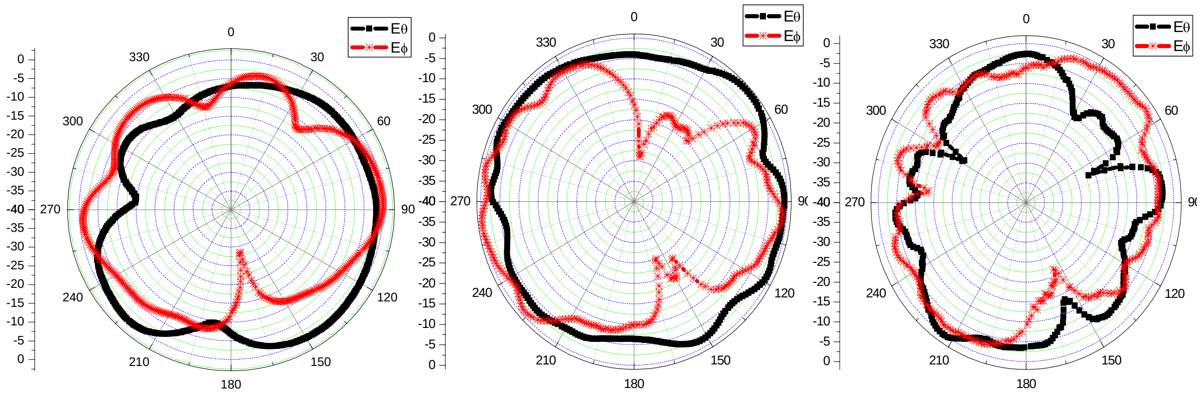


Fig. 3.measured return loss of the antenna with slant slot

The measured impedance bandwidths for return loss of less than –10 dB are 100 MHz (800-900 MHz) at the low band, as large as 260 MHz (1740-2000 MHz) at the first high band and 130 MHz (2550-2680 MHz) at the second high band, respectively. The measured characteristics can meet all the bandwidth requirements for mobile handsets operating at Cellular, PCS, and DMB bands.

The measured far-field radiation patterns in the x-z plane at 850, 1810, and 2630 MHz are shown in Fig. 3, respectively. Good radiation patterns are obtained in the x-z plane for all for frequency bands.



(a) (b) (c)

Fig. 4. Measured radiation pattern in x-z planes at (a) 850 MHz. (b) 1810 MHz. (c) 2630 MHz

The measured gain listed in Table 1 has the highest value of 0.95 dBi at 2630 MHz and the lowest value of –1.4 dBi at 850MHz.

The most critical parameters controlling the resonant frequency return loss characteristics, and bandwidths of proposed triple-band PIFA and their parametric performance are summarized in Table 2.

Table 2: Measured Gains

Frequency (MHz)	850	1810	2630
Gain (dBi)	-1.4	0.4	0.95

IV. Conclusion

In this paper, a novel triple and broadband PIFA to satisfy the Cellular, PCS, and DMB services at the same time is proposed. The designed antenna is implemented on a ground plane of dimension of 62 × 44 mm. The measured results show that the return loss characteristics are satisfied in all three-frequency bands and reasonably good radiation characteristics are achieved. The proposed antenna can be one of the best candidates for hand-held applications.

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