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

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I. INTRODUCTION

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 antenna 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.
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)

<table>
<thead>
<tr>
<th></th>
<th>$F_1$</th>
<th>$F_2$</th>
<th>$F_3$</th>
<th>VSWR$_1$</th>
<th>VSER$_2$</th>
<th>VSWR$_3$</th>
<th>BW$_1$</th>
<th>BW$_2$</th>
<th>BW$_3$</th>
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<tbody>
<tr>
<td>$L_{s1}$ ↑</td>
<td>↓</td>
<td>↓</td>
<td>↓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>$L_{s2}$ ↑</td>
<td>↓</td>
<td>↓</td>
<td>↓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$W_s$ ↑</td>
<td>↓</td>
<td>↓</td>
<td>↓</td>
<td>↓</td>
<td>↓</td>
<td>↓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$W_{sp}$ ↑</td>
<td>↑</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$h$ ↑</td>
<td>↓</td>
<td>↓</td>
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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
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.

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.

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>
<thead>
<tr>
<th>Frequency (MHz)</th>
<th>850</th>
<th>1810</th>
<th>2630</th>
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<tbody>
<tr>
<td>Gain (dBi)</td>
<td>-1.4</td>
<td>0.4</td>
<td>0.95</td>
</tr>
</tbody>
</table>

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 \(62 \times 44\) 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.

Acknowledgement: This work was supported by the Korea Research Foundation Grant.(KRF-2004-042-D00155)

Reference