Design and Implementation of Internal Multi-Band Folded Monopole Antenna for Mobile Handset Applications

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Abstract— **In this paper, we designed and fabricated a multi-band folded monopole antenna for mobile handsets that can be used for multiple services. The proposed antenna, with a small size of 28.060 × 12.665 × 5.035㎣ can provide sufficient bandwidth to cover the GSM900 (Global System for Mobile Communications: 880-960 MHz), DCS (Digital Cellular System: 1710-1880 MHz), K-PCS (Korea-Personal Communication Service: 1750-1870 MHz), Wibro (2300-2390 MHz) and Bluetooth (2400-2483 MHz) bands.**

Index Terms **— Multi-band, Internal antenna, Folded antenna, Monopole.**

I. INTRODUCTION

MODERN mobile handsets are essentially required to operate at multiple frequency bands to facilitate their use in various communication environments. Also, the trend of the mobile phones is getting smaller and slimmer because of the consumer's needs and the multiple functions [1][2]. These handsets facilitate both international roaming and connectivity to local devices. At the same time, the wireless handset has adapted the popular internal antenna structure. In addition, there is a great demand for reducing the handset size, which remains relatively large in modern mobile handsets due to the presence of various integrated components for different applications. Therefore, small sized multiple antennas for wireless terminals are urgently needed for the mobile handset industry [3].

Many planar monopole antennas have been developed to meet the needs of multi-band operation and multimedia handset antennas for third generation mobile systems, such as the folded monopole antenna type, and planar inverted-F antenna (PIFA) type. Especially, monopole antennas have found widespread applications in wireless mobile communications systems [4]-[10].

In this paper, we propose an internal antenna for multi-band operation covering the GSM900 (Global System for Mobile Communications: 880-960 MHz), DCS (Digital Cellular System: 1710-1880MHz), K-PCS (Korea-Personal Communication Service: 1750-1880 MHz), Wibro (2300-2390 MHz), and Bluetooth (2400-2483 MHz) bands. The measured results of the fabricated antenna are compared with the simulated ones which were obtained using an Ansoft HFSS (High Frequency Structure Simulator) based on the finite element method [11].

II. PROPOSED ANTENNA

Fig.1 and table 1 show the geometry and parameters of the proposed folded monopole antenna. The size of the antenna in this paper is 28.060 × 12.665 × 5.035 ㎣. For the design proposed herein, the antenna is fabricated on an inexpensive FR4 substrate with a dielectric constant of 4.4 and substrate thickness of 1.60㎜. The ground size is 80 × 40㎟.

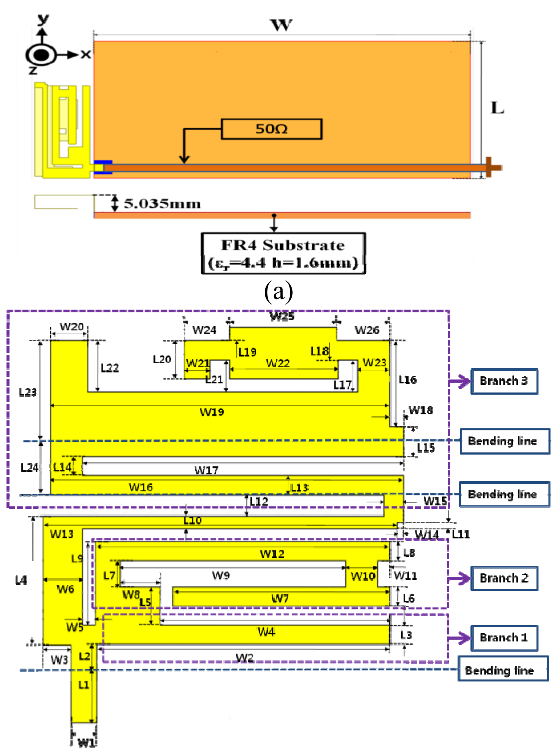

Fig. 1. Geometry of the proposed antenna. (a) Top and side views. (b) Detail dimensions of the proposed antenna.

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The proposed antenna has three branch lines. Branch line 1 is the shortest branch and the nearest branch from the feeding point. Branch 1 influences the whole impedance matching. Branch line 2 is on the top layer. It corresponds to the resonant frequency of the DCS and K-PCS bands. Branch line 3 is the longest branch and corresponds to the lowest resonant frequency band [12].

TABLE I
DESIGN PARAMETERS OF THE PROPOSED ANTENNA

Parameter	Length(mm)	Parameter	Length(mm)
W	8.000	L	4.000
W_1	2.000	L_1	5.035
W_2	22.860	L_2	1.035
W_3	2.200	L_3	1.500
W_4	18.000	L_4	10.000
W_5	1.000	L_5	3.000
W_6	3.060	L_6	1.500
W_7	16.950	L_7	2.000
W_8	3.000	L_8	1.500
W_9	17.500	L_9	6.500
W_{10}	2.500	L_{10}	1.000
W_{11}	1.000	L_{11}	0.500
W_{12}	23.000	L_{12}	1.630
W_{13}	27.560	L_{13}	1.500
W_{14}	0.500	L_{14}	1.500
W_{15}	1.500	L_{15}	2.334
W_{16}	27.500	L_{16}	6.700
W_{17}	25.000	L_{17}	2.500
W_{18}	1.000	L_{18}	1.500
W_{19}	26.500	L_{19}	1.000
W_{20}	2.940	L_{20}	3.000
W_{21}	2.000	L_{21}	2.500
W_{22}	8.500	L_{22}	4.000
W_{23}	2.560	L_{23}	8.004
W_{24}	3.500	L_{24}	4.035
W_{25}	8.400		
W_{26}	4.160		

III. SIMULATION AND MEARSUREMENT

The characteristics of the proposed antenna were simulated using HFSS of Ansoft which is based on the finite element method (FEM). The measurements of the implemented antenna were conducted in an anechoic chamber equipped with an HP 8510C network analyzer and a far field measurement system.

Fig. 2 shows the excited surface current distributions obtained from the HFSS simulation in the radiation element of the proposed antenna at 920 MHz, 1795 MHz and 2392 MHz. For the 920 MHz excitation, a large surface current distribution is observed along branch line 3. This implies that branch line 3 is the major radiation element for the proposed antenna at 920MHz and it is operated as a quarter-wavelength structure. For the 1795 MHz operation, branch line 2 plays the major role. For the 2392 MHz band, branch lines 1 and 2 contribute to the radiation.

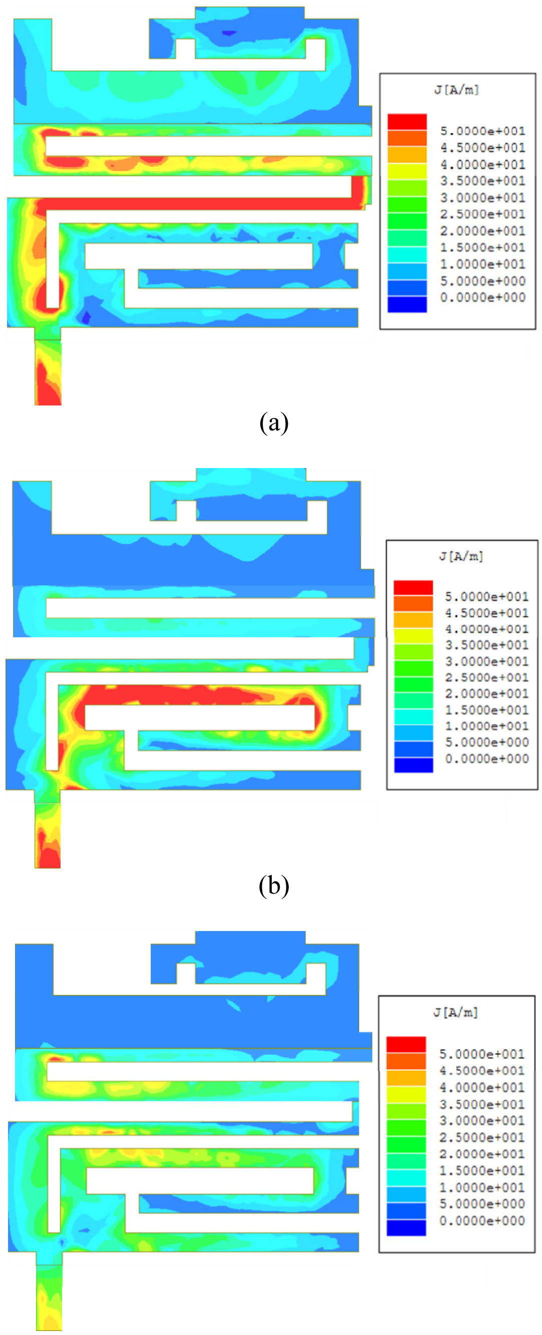


Fig. 2. Current distribution of the proposed antenna.(a) Current distribution at 920 MHz. (b) Current distribution at 1795 MHz. (c) Current distribution at 2392 MHz.

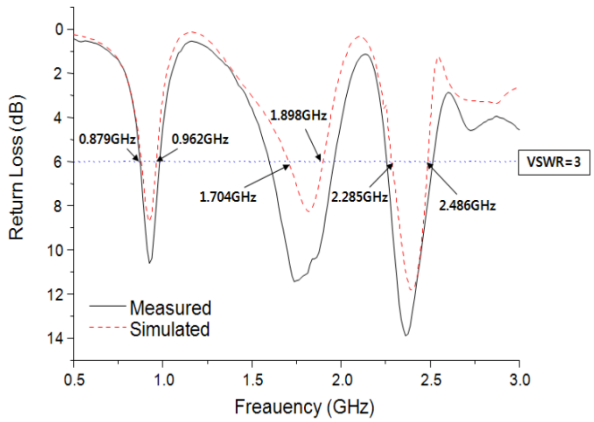
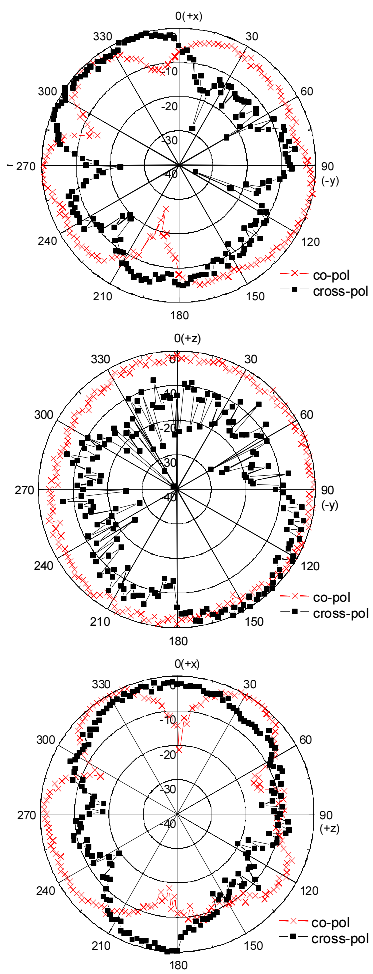
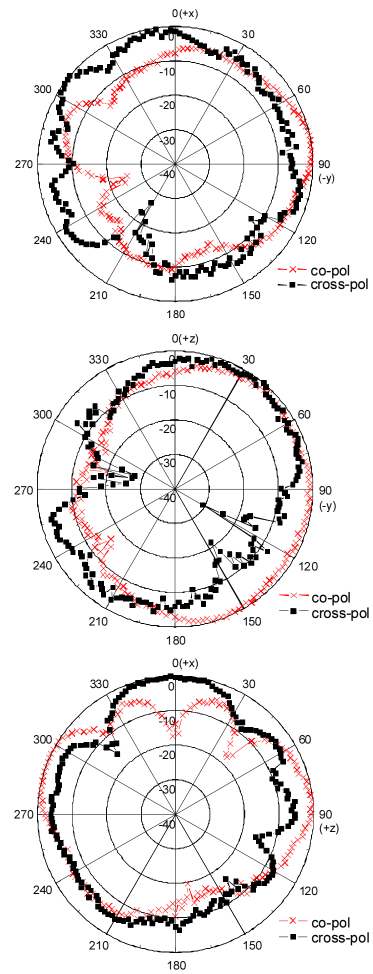


Fig. 3. Simulated and measured return loss characteristics.

Fig. 3 shows the measurement and simulation results for the return loss of the proposed antenna. Reasonable agreement is observed between the measurement and simulation, and three operating bands are obtained.



(a)



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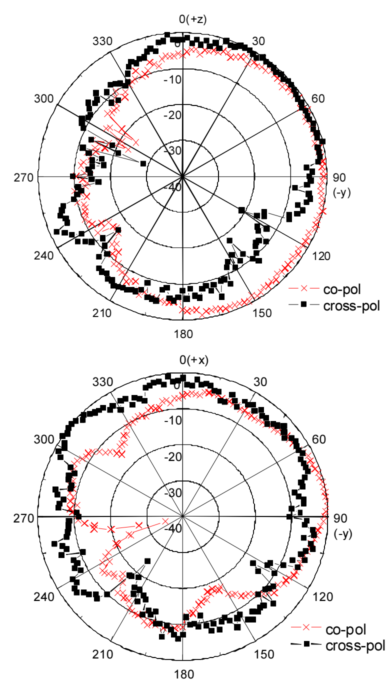

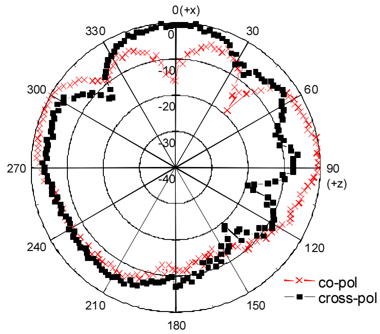

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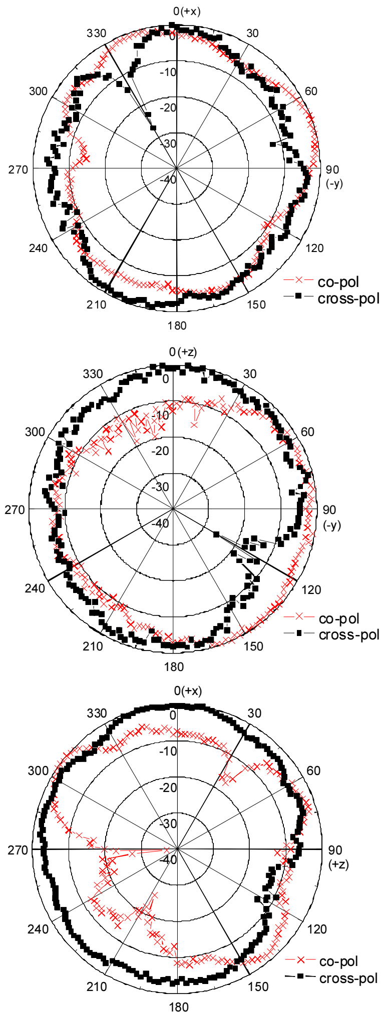

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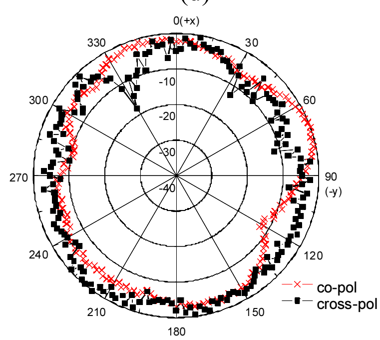

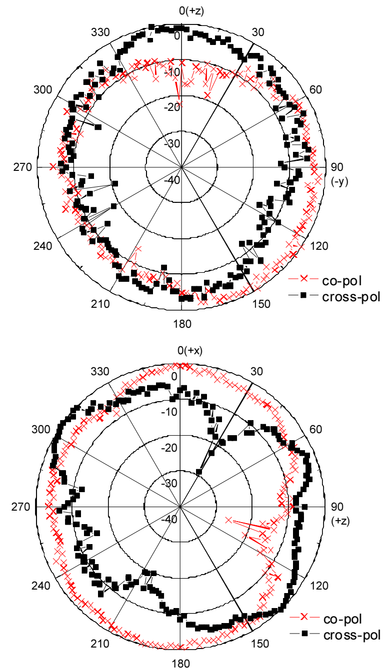

(e)

Fig. 4. Measured co-polarization and cross-polarization radiation patterns. (a) at 920 MHz. (b) at 1795 MHz. (c) at 1810 MHz. (d) at 2345 MHz. (e) at 2442 MHz.

For the GSM (at 920 MHz) band, a peak antenna gain of -1.895dBi and maximum average antenna gain of -5.610 dBi are observed. For the DCS (at 1795 MHz) band, a peak antenna gain of 5.716dBi and maximum average antenna gain of -0.790 dBi are observed. For the K-PCS (at 1810 MHz) band, a peak antenna gain of 5.495 dBi and maximum average antenna gain of -1.190 dBi are observed. For the Wibro (at 2345 MHz) band, a peak antenna gain of 4.338 dBi and maximum average antenna gain of -0.170 dBi are observed. For the Bluetooth (at 2442 MHz) band, a peak antenna gain of 4.413 dBi and maximum average antenna gain of 0.090 dBi are observed. The measured co-polarization and cross-polarization radiation patterns of the implemented antenna in the x-y plane, y-z plane and x-z plane, at five different frequencies are illustrated in Fig. 4. The radiation patterns reveal that the antenna has omnidirectional radiation characteristics.

IV. CONCLUSION

We proposed a multi-band internal monopole type antenna for mobile handsets. We designed and implemented the multi-band internal monopole type antenna for the GSM900, DCS, K-PCS, Wibro and Bluetooth bands with branch lines. The antenna size of the sample design is 28.060 × 12.665 × 5.035 ㎣. The ground size is

80 × 40 ㎟. The current distribution is simulated. The proposed antenna shows monopole-like radiation patterns. The measured peak gains are -1.895 dBi at 920 MHz, 5.716 dBi at 1795 MHz, 5.495 dBi at 1810 MHz, 4.338 dBi at 2345 MHz and 4.413 dBi at 2442MHz. These features are attractive for GSM/ DCS/ K-PCS/ Wibro/ Bluetooth applications. The proposed internal monopole type antenna has good radiation pattern characteristics; therefore, we expect the proposed internal monopole type antenna can be applicable to multi-band mobile handsets.

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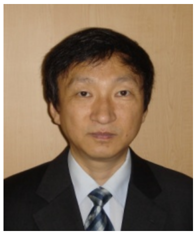

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