

# Design and Implementation of Internal Multi-band Folded Monopole Antenna for Mobile Station

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**Abstract**— In this paper, we designed and implemented an internal multi-band folded monopole antenna for mobile handset. The proposed antenna covers Global System for Mobile Communications (GSM900: 880~960 MHz), Digital Communications System (DCS: 1710~1880 MHz), US-Personal Communications Service (US-PCS: 1850~1990 MHz), Bluetooth(2400~2484 MHz), WiMAX(3400~3600 MHz), and Wireless Local Area Network (WLAN: 5150~5350 MHz, 5725~5875 MHz) band for Voltage Standing Wave Ratio (VSWR)  $\leq 3$ . The measured peak gains of the implemented antenna are -1.78dBi at 920MHz, 2.72dBi at 1795MHz, 2.25dBi at 1920MHz, 2.34dBi at 2442MHz, 2.11 dBi at 3550MHz, and 2.04 dBi at 5250MHz.

**Index Terms**— Folded Monopole Antenna (FMA), Intenna, Mobile Station, Multi-band.

## I. INTRODUCTION

RECENTLY, it is strongly required for the mobile station to cover multi-band with a single internal type antenna. It has a close relation with an international roaming, multimedia service, wireless internet connection with a single terminal. Therefore, these demands for wireless terminal are an explosive issue. So, there are strong demands for small, lightweight, and compact mobile stations. These demands also require the development of a low-profile internal antenna with superior performances in terms of the impedance bandwidth and gain. However, the design of an internal antenna is technically challenging due to the limited antenna volume and influence of the mobile station housing and human body. The folded monopole type antenna is a good candidate for a mobile station because of its simple structure, omni-directional radiation pattern, low profile, and lightweight characteristics [1-5].

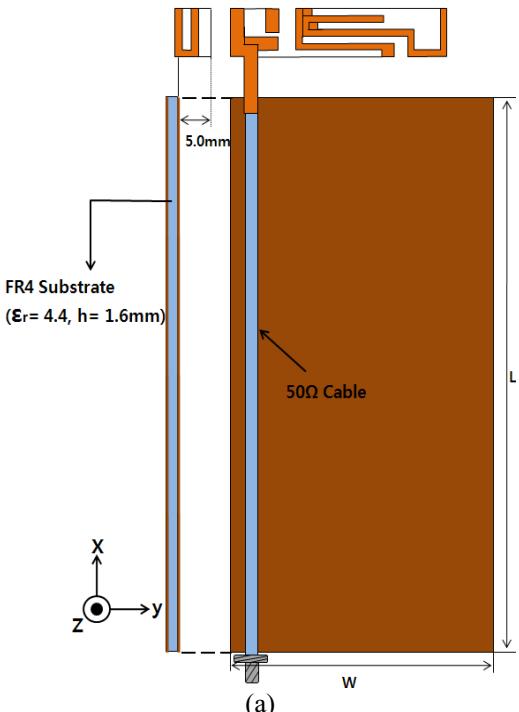
Many techniques of the folded monopole antenna have been developed to meet the needs for multi-band

operations for the third generation mobile system[6-9]. Folded Monopole Antenna (FMA) and Planar Inverted-F Antenna (PIFA) are widely used for mobile station applications. Especially monopole antennas have found widespread applications in wireless mobile communications systems[10].

In this paper, we propose a multi-band internal folded monopole antenna for mobile station. The proposed antenna covers Global System for Mobile Communications (GSM900: 880~960 MHz), Digital Communications System (DCS: 1710~1880 MHz), US-Personal Communications Service (US-PCS: 1850~1990 MHz), Bluetooth(2400~2484 MHz), WiMAX(3400~3600 MHz), and Wireless Local Area Network (WLAN: 5150~5350 MHz, 5725~5875 MHz) frequency bands.

## II. PROPOSED ANTENNA

The geometry of the proposed internal multi-band folded monopole antenna for operating at GSM900/DCS/US-PCS/Bluetooth/WiMAX/WLAN frequency bands is shown in Fig. 1.



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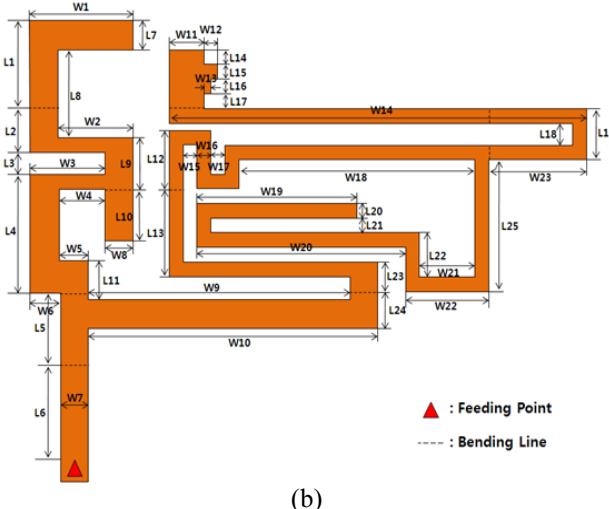


Fig. 1. Geometry of the proposed antenna. (a) Top and side view. (b) Detail dimensions of the proposed antenna.

The size of the proposed antenna is  $33.0 \times 7.0 \times 5.0$  mm<sup>3</sup>. And the ground plane is  $40(W) \times 80(L)$  mm<sup>2</sup> and a FR4 substrate with the thickness of 1.6 mm and relative permittivity of 4.4 is used.

Table 1 shows the design parameters of the proposed antenna.

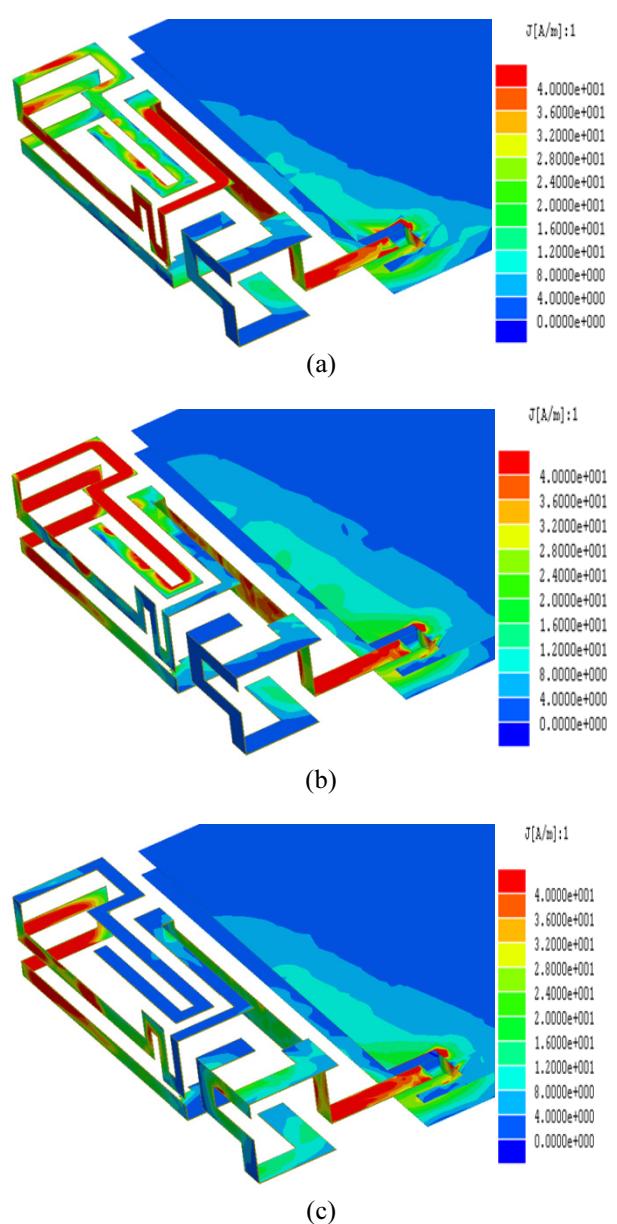
TABLE I  
DESIGN PARAMETERS OF THE PROPOSED  
ANTENNA

Parameter	Length (mm)	Parameter	Length (mm)
W	40.00	L	80.00
W1	7.40	L1	6.00
W2	5.40	L2	3.00
W3	5.40	L3	1.50
W4	3.30	L4	7.00
W5	2.10	L5	5.00
W6	2.20	L6	8.00
W7	2.00	L7	2.00
W8	2.00	L8	6.00
W9	18.80	L9	3.50
W10	20.80	L10	5.54
W11	2.50	L11	2.65
W12	1.00	L12	4.00
W13	0.50	L13	6.00
W14	27.50	L14	1.00
W15	1.00	L15	1.00
W16	1.00	L16	1.00
W17	1.00	L17	1.00
W18	17.00	L18	6.00
W19	11.50	L19	3.47
W20	15.00	L20	1.00
W21	4.00	L21	1.00
W22	6.00	L22	3.00
W23	7.00	L23	2.00
		L24	2.54
		L25	7.00

### III. SIMULATION AND MEASUREMENT

The commercial program High Frequency Structure Simulator (HFSS) from Ansoft based on the Finite Element Method (FEM) is used to obtain suitable values of parameters and analyze the behavior of the proposed antenna. And the measurement of electrical characteristics such as radiation patterns and return loss of the implemented antenna were conducted in an anechoic chamber equipped with a HP8510C network analyzer and far field measurement system.

Fig. 2 shows the excited surface current distributions obtained from the HFSS simulation on the radiation element of the proposed antenna at 920 MHz, 1795 MHz, 1920 MHz, 2442 MHz, 3500 MHz, and 5250 MHz.



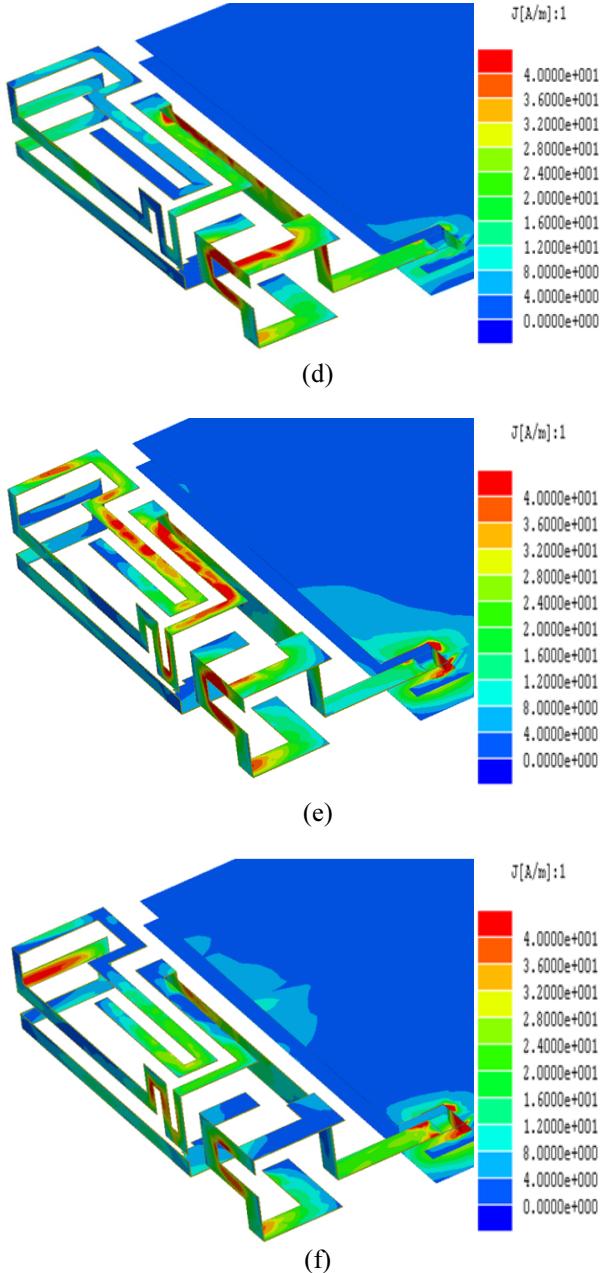


Fig. 2. Current distribution of the proposed antenna. (a) at 920MHz. (b) at 1795MHz. (c) at 1920MHz. (d) at 2442MHz. (e) at 3500MHz. (f) at 5250MHz.

From the Fig. 2, we can see the corresponding major radiation element for each frequency bands. There are three branches. For low frequency band, long branch plays a major roll. And short branch operates for high frequency band.

Fig. 3 shows measurement and simulation results on the return loss of the proposed antenna. Reasonable agreement between measurement and simulation is observed, and demonstrates that the proposed antenna covers GSM900/DCS/US-PCS/Bluetooth/WiMAX/WLAN frequency bands for Voltage Standing Wave Ratio (VSWR)  $\leq 3$ .

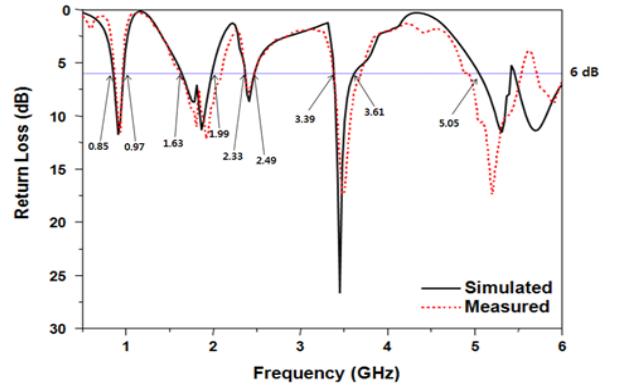
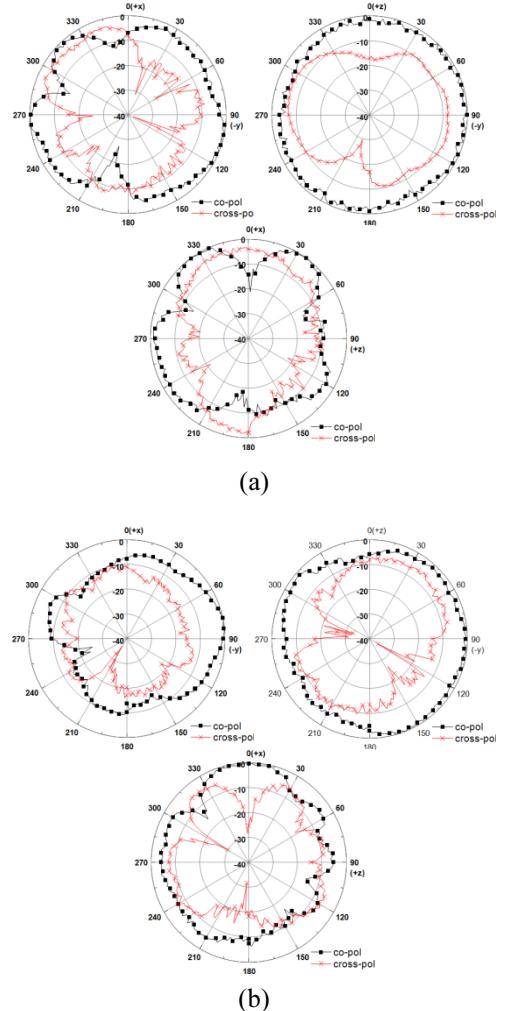


Fig. 3. Simulation and measurement result on the return loss of the proposed antenna.

Fig. 4 shows the measured co-polarization and cross-polarization radiation patterns in the x-y plane (elevation plane), y-z plane(azimuth plane) and z-x plane(elevation plane) for the proposed antenna at 920 MHz, 1795 MHz, 1920 MHz, 2442 MHz, 3550 MHz, and 5250 MHz. At all the frequencies, radiation patterns are nearly omni-directional in the y-z plane.



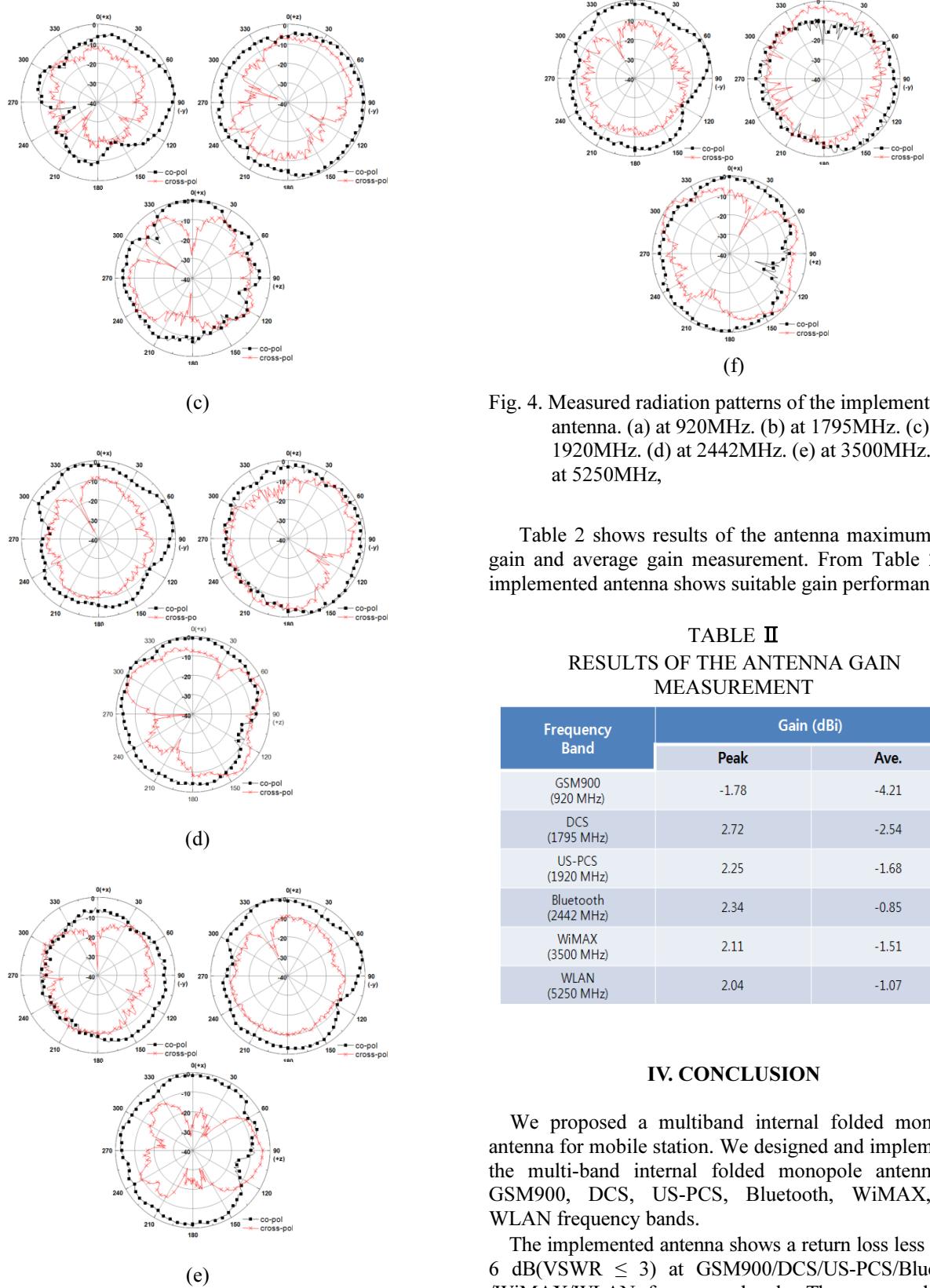


Fig. 4. Measured radiation patterns of the implemented antenna. (a) at 920MHz. (b) at 1795MHz. (c) at 1920MHz. (d) at 2442MHz. (e) at 3500MHz. (f) at 5250MHz,

Table 2 shows results of the antenna maximum peak gain and average gain measurement. From Table 2, the implemented antenna shows suitable gain performances.

TABLE II  
RESULTS OF THE ANTENNA GAIN  
MEASUREMENT

Frequency Band	Gain (dBi)	
	Peak	Ave.
GSM900 (920 MHz)	-1.78	-4.21
DCS (1795 MHz)	2.72	-2.54
US-PCS (1920 MHz)	2.25	-1.68
Bluetooth (2442 MHz)	2.34	-0.85
WiMAX (3500 MHz)	2.11	-1.51
WLAN (5250 MHz)	2.04	-1.07

#### IV. CONCLUSION

We proposed a multiband internal folded monopole antenna for mobile station. We designed and implemented the multi-band internal folded monopole antenna for GSM900, DCS, US-PCS, Bluetooth, WiMAX, and WLAN frequency bands.

The implemented antenna shows a return loss less than -6 dB(VSWR  $\leq$  3) at GSM900/DCS/US-PCS/Bluetooth /WiMAX/WLAN frequency bands. The measured peak gains are -1.78dBi at 920MHz, 2.72dBi at 1795MHz, 2.25dBi at 1920MHz, 2.34dBi at 2442MHz, 2.11 dBi at 3550MHz, and 2.04 dBi at 5250MHz. The proposed

multiband internal folded monopole antenna has good radiation patterns characteristics.

We expect that the implemented antenna can be used for GSM900/DCS/US-PCS/Bluetooth/WiMAX/WLAN application.

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