A DESIGN OF MINIATURIZED BUILT-IN PENTA-BAND CHIP ANTENNA FOR GSM850/GSM900/DCS/USPCS/WCDMA MOBILE HANDSET

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ABSTRACT

The novel internal monopole chip antenna of penta-band operation for GSM850/GSM900/DCS/USPCS/WCDMA bands for mobile phones is proposed. This antenna occupies a small volume 8×3.2×20 mm^3 and is suitable to be embedded in a mobile phone as an internal antenna. Also, this antenna is designed to be installed at the newest mobile handset whose size is 40×93 mm^2. The minimization of this antenna was realized by using spiral line structure and meander line structure on FR-4 of dielectric permittivity ε_r = 4.4. The proposed antenna is SMD type to be easily installed in the practical mobile handset. Also we use PCB technology which can allow this antenna to be produced massively with low cost. We can get the wideband operation in the upper band by overlapping high order resonances. The measured bandwidth of this antenna (VSWR >3) is 150 MHz (1030 – 1180 MHz) in the lower band and 650 MHz (1760 – 2410 MHz) in higher band. The antenna has been designed by a commercial software HFSS.

1. INTRODUCTION

Recently competition of the mobile handset market has become hotter. Mobile phone companies make their efforts to get better designs. So they have installed antenna inside of mobile handset instead of outside of it. Accordingly, miniaturization research of antenna has been pursued for many years. As a result of it, many internal type antennas have been studied [1]. Because the mobile phone business is in active in export as well as domestic demand, interest in the development of the global roaming phone which can be sold in several countries by one development is rapidly growing. For the global roaming phone development the company needs the technology of multi-band antenna that can accommodate the bands more than quad-band.

Most antennas studied now are PIFA type antenna that can accommodate bands more than quad-band. But these antennas can work properly under the limited condition that they should be installed high from the ground of mobile phone [2, 3]. Because this PIFA type antenna can not be applied to cell phone of thin slices shape, it is hard for mobile handset using PIFA type antenna to lead the fashion. There were attempts to manufacture small antenna that take advantage of chip type antenna technology to solve this problem. Until now small dual-band antennas that use structure such as meander line or spiral line on dielectric substance have been studied much [4, 5]. This paper proposes the small dual wide-band antenna to be built in global roaming phone using dual-band chip antenna technology.

Because this antenna uses Printing Circuit Board (PCB) technology, this can reduce production cost and manufacturing time. Because this antenna is manufactured as SMD type, it can be easily installed in mobile handset. This antenna used FR-4 dielectric substance. And the structure of this antenna is constructed with meander line and spiral line. The size of this antenna is 8×3.2×20 mm^3 and it of test board is 40×93 mm^2. Although the larger ground plane helps to get the wider bandwidth, in this paper the size of test board is limited to it of common mobile handset. The measured bandwidth (VSWR 3:1) of the proposed antenna is 150MHz (1030 – 1180 MHz) at low frequency range and 650MHz (1760 - 2410 MHz) at high frequency range.

2. MAIN DISCOURSE

2.1. Design of antenna

This proposed penta-band chip antenna is designed to act in 824 - 960 MHz (GSM850/GSM900) and 1710 – 2170 MHz (DCS/USPCS/WCDMA). The resonance frequency given in test jig generally falls by permittivity of phone case when the antenna is installed in a real mobile phone. So we designed resonance frequency of this antenna a little higher.

The proposed antenna is manufactured by taking advantage of PCB technology. In making a small size antenna by using this PCB technology, meander line structure is more effective [4, 7]. But decrease of bandwidth of antenna is happened if use very many meander sections in limited height. Also we cannot expect linear falling of resonance frequency. Therefore one must decide the height of meander antenna through trade off process. The proposed antenna's height is decided 20mm considering commercial value and performance of it. The geometry of designed antenna is illustrated in Fig. 1.

The branch structure that consists of two meander line to get multi-band is affected by distance between two structures [4]. Therefore it is difficult to design the antenna under the condition that mobile phone's thickness is fixed. In addition to the capacitance between branch structure makes bandwidth at low frequency narrow [8]. So, in this paper we manufacture the branch structure antenna using meander line and spiral line. Fig.1 shows the entire antenna structure whose two patterns are connected by via. We did simulation changing a cylindrical via into equivalent model [7].

We actually manufactured antenna adjusting properly the length and width of meander line and spiral line to overlap the harmonic resonance components made by each structure. The characteristic of overlapping resonance components is observed at Fig.2.

As seeing in Fig. 3, there is an advantage that we can reduce product development time because instantly we can product many models which have various resonance frequencies when we take advantage of PCB technology. We can see the proposed antenna that is attached by SMD Type to test jig to measure with network analyzer in Fig.4. The test board whole size is 40×93 mm^2 and the area of ground on it is 3220 mm^2 as seen in Fig. 5. This dimension is reasonable as comparing the size of the newest cell phones.

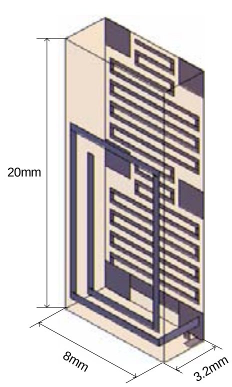
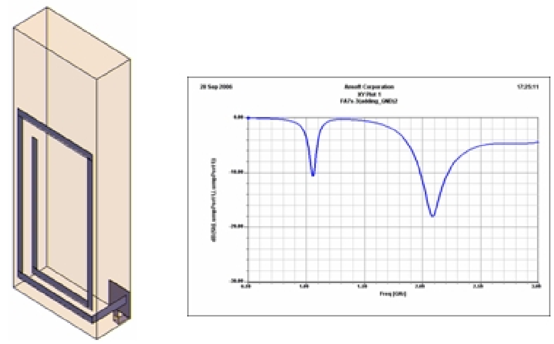
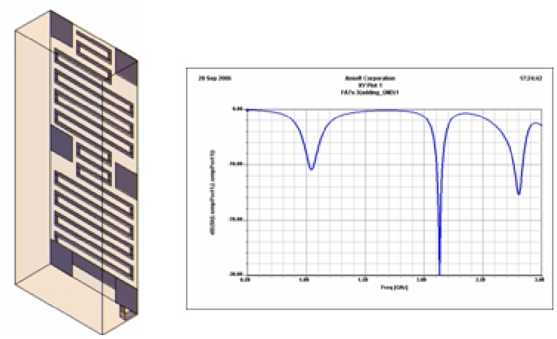


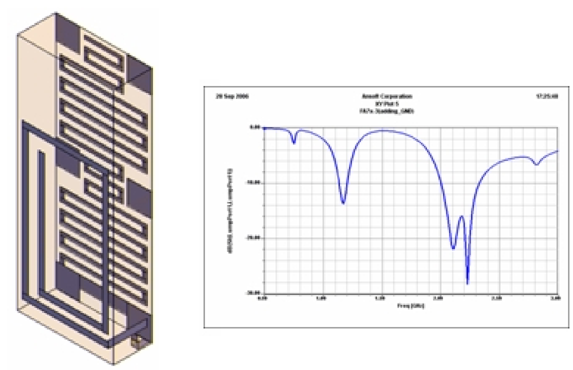
Fig.1. The designed antenna.



(a)



(b)



(c)

Fig. 2. The geometry and the return loss of each structure.
(a) Spiral structure, (b)Meander structure, (c) Spiral and meander structure.

Fig.3. Antennas manufactured by PCB technology.

Fig.4. The installation of antenna to test jig.

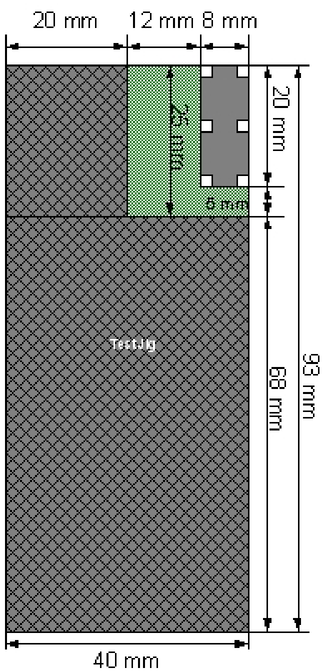


Fig.5. The geometry of test jig.

2.2. Antenna manufactured and results measured

We manufactured and measured the designed antenna. We displayed manufactured antenna to Fig. 6.

In Fig. 7 we compared VSWR value of this antenna in simulation with it in actual state. With Fig.7, we can confirm that tendency of measured value and simulated value is agreeable. The measurement of VSWR was achieved by using Agilent E8361 network analyzer.

Table 1 is expressed the measured radiation efficiency in VSWR 3:1 bandwidth of each resonance. These values were measured in A PLUS tech CTIA OTA test chamber. Table 1 illustrates that the radiation efficiency within (VSWR 3:1) bandwidth is over 50%.

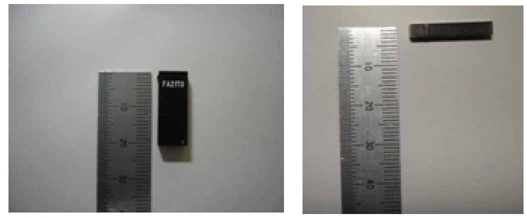


Fig.6. The manufactured antenna.

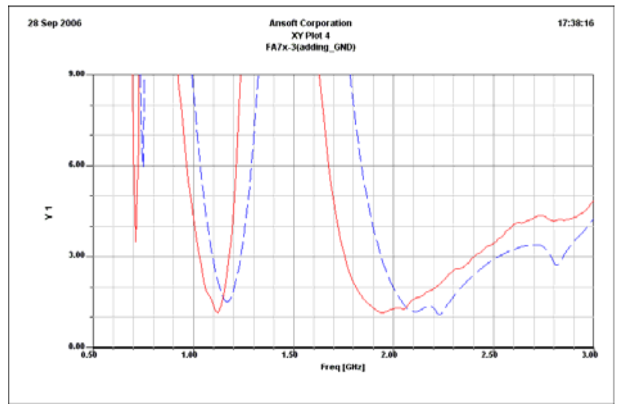


Fig.7. The measured(solid line) and simulated(dashed line) VSWR of the proposed antenna.

Table 1. The radiation efficiency of the proposed antenna
(a) at low frequency range, (b) at high frequency range.

	Start	Center	Stop
Frequency (MHz)	1030	1105	1180
Efficiency (dB)	-2.98	-1.91	-2.54
Efficiency (%)	50.37	64.42	55.74

(a)

	Start	Center	Stop
Frequency (MHz)	1760	2085	2410
Efficiency (dB)	-1.56	-1.33	-2.45
Efficiency (%)	69.75	73.58	56.85

(b)

3. CONCLUSIONS

In this research, we manufactured the dual wide-band monopole antenna of branch structure that use both meander line and rectangular spiral line. We improved productivity taking advantage of PCB method. And we could achieve broadband characteristic by using dual resonances in high frequency band. The high frequency bandwidth of the proposed antenna is wider bandwidth than the necessary band of DCS/USPCS/WCDMA. Also, the low frequency bandwidth of the proposed antenna can cover GSM850/GSM900 band. In conclusion, this proposed antenna is expected to be efficiently used for the global roaming phone in many corporations.

ACKNOWLEDGEMENT

This work was supported by HY-SDR Research Center at Hanyang University, Seoul, Korea, the ITRC program of MIC, Korea.

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