Dual Band Small Chip antenna for GSM/DCS Mobile Phone Handset

Seunghyun Yun, Sangjae Yun, Nadan Kang, *Hyeongdong Kim
Dept. of Electronic Communication & Radio Science Eng., Hanyang University
***Dept. of Electrical & Computer Eng., Hanyang University**
17 Haengdang-Dong, Sungdong-gu SEOUL 133-791 KOREA
hdkim@hanyang.ac.kr

Abstract: The methods that can control the parameters of the dual band antenna were suggested in this paper. The minimization of the antenna was realized by using a helical structure that has loop antenna composed of via and lines on FR-4(ε_r= 4.4) PCB. The antenna characteristic was analyzed on parasitic components, the size of dielectric and the permittivity by using the commercial software HFSS 3-D EM simulator. The parameters that can control the active region of antenna were verified. And the principle of increasing bandwidth was verified, too. So the antenna was designed to have an optimal characteristic. At last the antenna based on simulation results has 10mm height, 5.8mm width, and 4mm thickness as internal printed antenna for GSM/DCS cell-phone. Its size was minimized so that it can be mounted inside of dual band cell-phone.

1. Introduction

As the information technology is being developed rapidly today, wireless communication is getting more important. Wireless communication doesn't have the weakness of wire communication, the limitation of the distance so the fast information exchange can happen. Therefore the users of wireless communication are increasing and the manufacture technology is being developed rapidly. And the size of cell-phone is getting smaller and its parts need to be smaller. The antenna which has comparatively large volume is being studied to miniaturize it. Now whip antenna, helical antenna, monopole antenna and a complex are popular in wireless antenna [1], [2].

These antennas have an advantage of the wide bandwidth. But it is hard to minimize their size and to be designed. To improve these problems, the internal antennas [3] are being studied instead of the conventional external antenna such as helical antenna and monopole antenna. Among the internal antennas, PIFA (Planar Inverted-F Antenna) [4] and chip antenna [5], [6] is getting focused. But chip antenna has to have the dielectric whose permittivity is so higher to reduce its size than PIFA that it results in narrow bandwidth. It's not suitable for various multi service bands.

Therefore, in this paper the rectangular helical antenna structure was applied to keep its size small, to perform in multi bands, to control the frequency easily by the parasitic components and to mass-produce with printed circuit board technology. So the chip helical antenna that is mountable on

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practical cell-phone was designed. And considering the problem that when the device is mounted, the frequency changes, it was produced and measured so.

2. Antenna design and structure

2.1 Dual band helical antenna structure and analysis

A kind of conventional external antenna generally used is the helical antenna whose length is λ/4. By applying printed circuit board technique to that helical antenna, the chip helical antenna which is small and mountable inside cell-phone was produced.

This chip helical antenna of this paper uses both sides of the board as patterns. And the upper pattern connects with the lower pattern through via. Because via connects patterns, via also acts a part of pattern. As the parameters that have an effect on antenna characteristics are changed, the variation of antenna characteristic is described with imaginary part of input impedance and return loss. The input admittance of loop antenna is given by

$$Y_i = \frac{-(1-\cos\theta_T)^2 + j\sin\theta_T \cdot (jZ_S \sin\theta_T + 1/j\omega C_T)/Z_S}{jZ_S \sin\theta_T + \cos\theta_T / j\omega C_T} = jY_S \cdot \frac{Y_S \sin\theta_T - 2\omega C_T (1-\cos\theta_T)}{Y_S \cos\theta_T - \omega C_T \sin\theta_T} \quad (1)$$

The resonance condition of a shunt-resonator can be expressed as $Y_i = 0$, and thus the following equation can be derived.

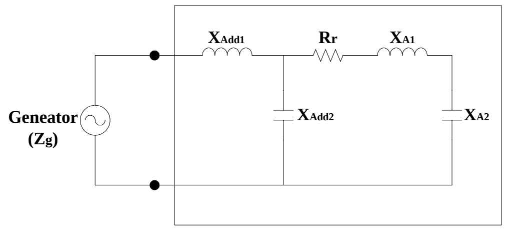
$$Y_S \sin\theta_T - 2\omega C_T (1-\cos\theta_T) = 0 \quad (2)$$

We know the resonant frequency is determined by not only the transmission line but also inter coupling capacitance C_T in equation (1). The major reason why the helical structure can be miniaturized more than the conventional monopole antenna is shift of the anti-resonant frequency. The anti-resonant frequency is determined by inter-coupling capacitance [7].

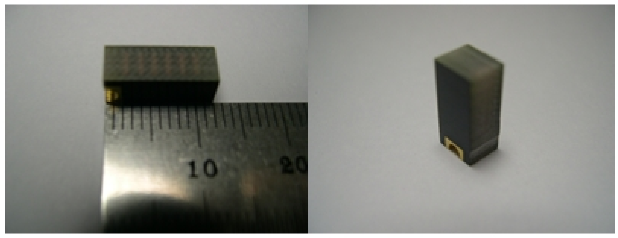
If we choose proper line width of helical structure and tune inter coupling capacitance value which varies as spacing among loops to select GSM/DCS band, we can see that resonance is generated in a wanted frequency. We verified wide band characteristic can be obtained by add the parasitic patch, because as parallel capacitance increases, the variation of the imaginary part of impedance for frequency decreases.

In the basic helical antenna structure, input impedance is capacitive. Thus in the bottom layer a helical line which has small pitch angle is mainly for achieving enhanced impedance matching, which works as an inductor. The equivalent circuit designed in this paper is shown in Figure 1.

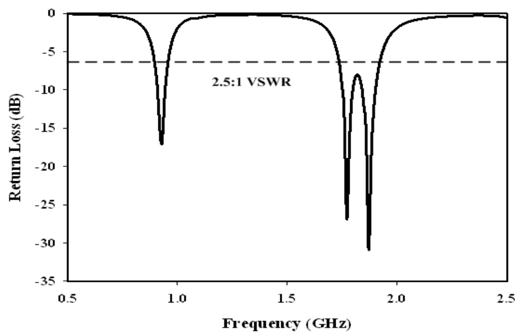
Also, Effective permittivity leads resonant frequency to go down by coating front side and back side with dielectric material in the basic helical antenna structure, so to reduce the required length of signal line is good for miniaturizing the antenna. As stated above, we can see resonant characteristic and bandwidth vary as the parameters. The antenna designed in this paper shown in Figure 2. Measured antenna return loss and radiation patterns are described in Figure 3 and 4 respectively.



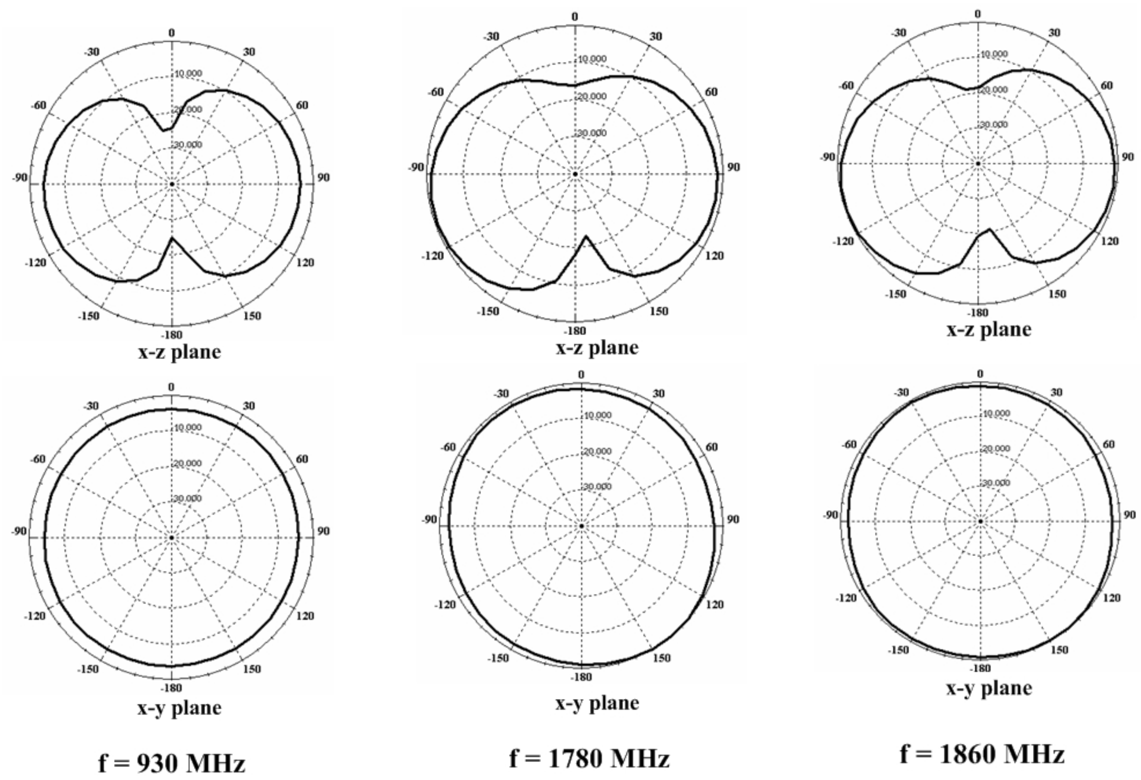
▪ Fig. 1 Equivalent circuit



▪ Fig. 2 A dual-band helical chip antenna



▪ Fig. 3 Simulated return loss for dual-band helical chip antenna



▪ Fig. 4 Measured radiation pattern for dual-band helical chip antenna

3. Conclusion

In this paper the small chip antenna was suggested to miniaturize the cell-phone and to have a good performance. Physical length can be shortening by using both the printed circuit technology and the helical antenna characteristic. In result, those methods enable the antenna to be embedded in the hand-set so that those lead room efficiency. Moreover, the conventional chip type helical antenna added on several design parameters makes the optimum condition to maximize bandwidth at GSM/DCS. In this antenna, the return losses (s11) in 930 MHz, 1780 MHz and 1860 MHz measured -16.7, -19.1 and -17.4 dB respectively.

We can verify GSM bandwidth and DCS bandwidth are satisfied (VSWR < 2.5). And it is observed that both of radiation patterns of GSM and DCS look similar and stable. The antenna that is suggested in this paper can be embedded in the bar-type cell-phone because it has 10mm height, 5.8 mm width and 4 mm thickness, and it was designed to be applicable in many application such as folder type cell-phone. And it needs to be studied further to widen the bandwidth for commercialization.

4. Acknowledgment

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