THE DESIGN OF DUAL BAND CHIP ANTENNA FOR GSM/DCS MOBILE PHONE HANDSET

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ABSTRACT

This paper proposes a dual band antenna of chip type that can be applied to actual portable phones. This antenna configuration has tuning capability when it is applied to practical phones. The minimization of the antenna was realized by using a helical and meander structure that has a loop antenna composed of vias and lines on FR-4 PCB of $\varepsilon_r = 4.4$. The antenna characteristic was analyzed depending on tuning components, the size of supporting dielectric portion and its permittivity by using the commercial software HFSS 3-D EM simulator.

1. INTRODUCTION

As the information technology has been developed rapidly today, wireless communication is getting more important. The wireless communication doesn't have the weakness of wire communication, the limitation of the distance, so the fast information exchange can happen anywhere. Therefore users of wireless communication are increasing and the manufacture technology needs to be 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. A whip antenna, a helical antenna and a monopole antenna are generally used in the wireless communication [1], [2].

These antennas have an advantage of the wide bandwidth. But it is hard to minimize their size and to install in the miniaturized mobile phone. To overcome these problems, the internal antennas [3] are being studied instead of the conventional external antenna such as a helical antenna and a monopole antenna. Among internal antennas, a PIFA (Planar Inverted-F Antenna) [4] and chip antenna [5], [6] is getting focused. But a chip antenna has to have the high permittivity dielectric to reduce its size, but 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 parasitic components and to mass-produce with printed circuit board technology. So the chip helical antenna that is mountable on practical cell-phone was designed. And this paper considered the problem that the frequency changes when the device is mounted.

2. ANTENNA DESIGN AND STRUCTURE

2.1. Dual band helical antenna structure and analysis

Conventionally, the helical antenna whose length is λ/4 is used as an external antenna. 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 as 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 meandered loop antenna can be approximated to the split-ring resonator. Figure 1 and 2 shows the split-ring resonator and its equivalent circuit. The input admittance of loop antenna is given by

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

$$= jY_S \cdot \frac{Y_S \sin\theta_T - 2\omega C_T (1-\cos\theta_T)}{Y_S \cos\theta_T - \omega C_T \sin\theta_T}$$

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

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

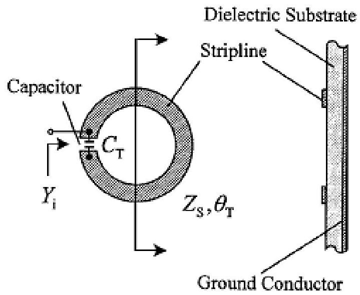

Fig. 1 Split-ring resonator structure

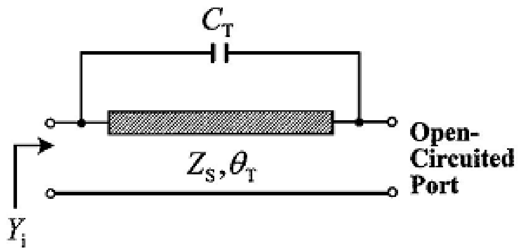

Fig. 2 Equivalent circuit for split-ring resonator

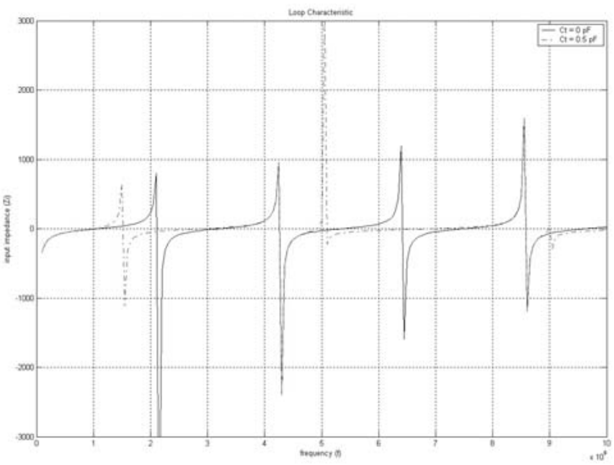

Fig. 3 Effect of inter coupling capacitance

The resonant frequency is determined by not only the transmission line but also inter coupling capacitance $\boldsymbol{C_T}$ in equation (1). The major reason why the helical structure can be miniaturized more than the conventional monopole antenna is the lowering of the anti-resonant frequency in Figure 3. The anti-resonant frequency is determined by inter-coupling capacitance [7]. In Figure 3, the solid line means the conventional monopole antenna and the dashed line means the meandered antenna.

If we choose proper line width of helical structure and control inter coupling capacitance value which varies as spacing among loops to tune GSM/DCS band, we can see

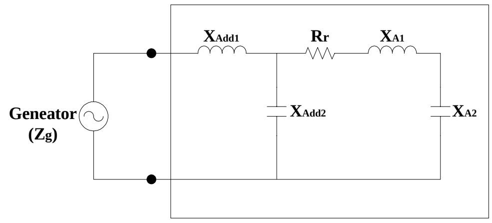

Fig. 4 Equivalent circuit

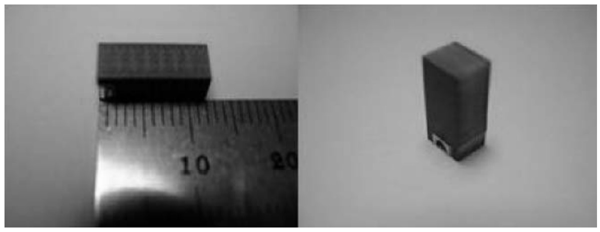

Fig. 5 A dual-band helical chip antenna

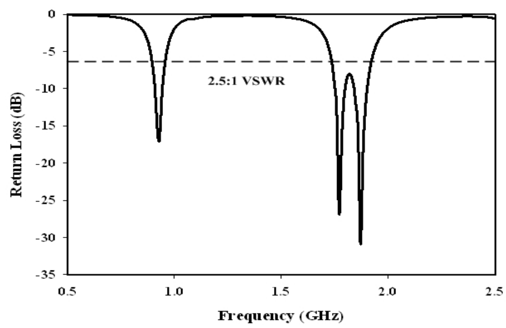

Fig. 6 Simulated return loss for dual-band helical chip antenna

that resonance is generated in a wanted frequency. We obtained a wide band characteristic by adding the parasitic patch.

In the basic helical antenna structure, input impedance looks more capacitive than inductive. 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 4.

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 the required reduced length of signal line is good for miniaturizing the antenna. As is stated above, we can see that the resonant characteristic and the bandwidth vary as parameters. The antenna designed in this paper is shown in Figure 5.

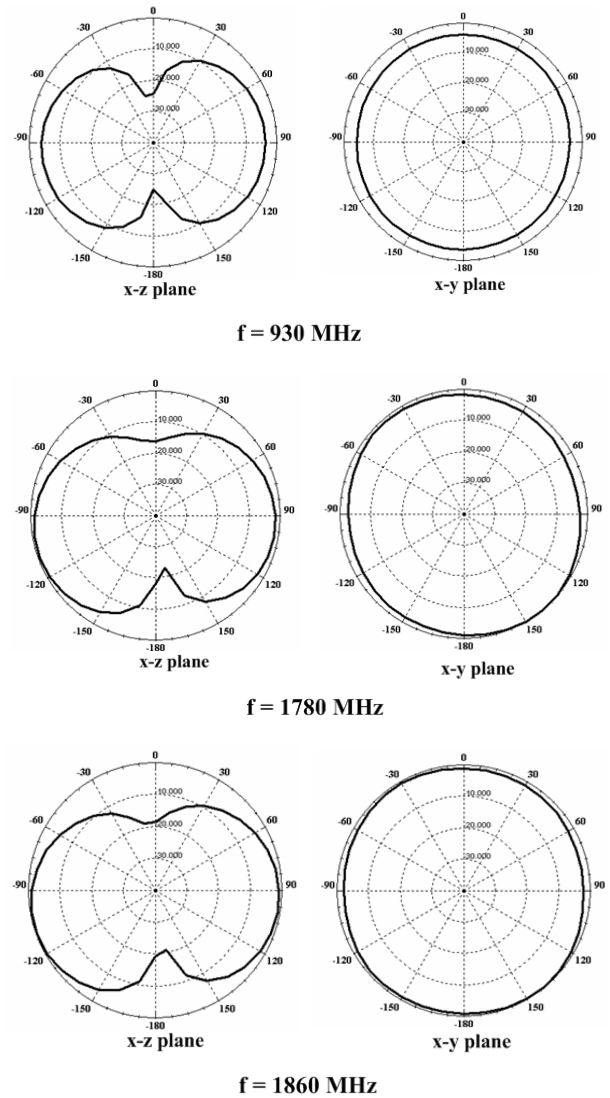

Fig. 7 Measured radiation pattern for dual-band helical chip antenna

Measured antenna return loss and radiation patterns are described in Figure 6 and 7, respectively.

3. CONCLUSION

In this paper the small chip antenna is suggested to miniaturize the cell-phone and to have a good performance. Physical size can be shortened by using both the printed circuit technology and the meandered antenna structure. In result, those methods enable the antenna to be embedded in the hand-set so that those lead to good space efficiency. Moreover, the chip type helical antenna has several design parameters that make the optimum condition to maximize bandwidth at GSM/DCS. In this antenna, the return losses (s11) in 930 MHz, 1780 MHz and 1860 MHz are measured -16.7, -19.1 and -17.4 dB, respectively.

We can verify that GSM bandwidth and DCS bandwidth are satisfied (VSWR < 2.5). The antenna that is proposed in this paper can be embedded in the bar-type cell-phone because it has a small size of 10mm height, 5.8 mm width and 4 mm thickness, and it was designed to be applied to many applications such as folder type cell-phone.

4. ACKNOWLEDGMENT

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