Frequency Reconfigurable PIFA for Cell-Phone Application

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Abstract

In this paper, a frequency reconfigurable planar inverted-F antenna (PIFA) for cell-phone application has been proposed. The resonant frequency of the proposed antenna is changed by capacitance of the varactor diodes on the stubs. To simulate the tunable response and compact size, on behalf of varactor diodes, two capacitors are apply in each two stubs.

Keywords: PIFA Tunable antenna

1. Introduction

Recently, due to the various developments in the communication systems, one device performs the many functions. For this reason, the broadband and small size of the antenna is become more important. Many researches about the planar inverted-F antenna (PIFA) have been conducted because of its compactness and easy fabrication [1-3]. However, since the bandwidth of the PIFA is narrow, it has the drawbacks for reducing the size and improving bandwidth of the antenna. To overcome that, the many techniques for the multi resonances are reported [4], [5]. Even so, there is a trade-off between antenna size and operating bandwidth because the physical size is increased in order to create the additional resonance. Reconfigurable antennas are attractive structure due to its frequency extensible without extra resonator of the antenna [6], [7].

In this paper, a frequency reconfigurable PIFA using varactor diodes is proposed. Basically, the proposed PIFA has the dual-band operation which is made by two microstrip line paths and capacitance. The frequency response of both bands can be tuned over a wide frequency range by changing the capacitance of the varactor diodes. To verify the tenability of the designed antenna, the varactor diode is replaced by lumped capacitance. So, in this paper, the simulation is conducted as changing the value of capacitances where are located on stubs. The simulation results, the proposed antenna covers the code division multiple access (CDMA: 824 MHz ~ 894 MHz), the global system for mobile communication (GSM: 880 MHz ~ 960 MHz), the digital cellular system (DCS: 1710 MHz ~ 1880 MHz), the personal communication system (PCS: 1850 MHz ~ 1990 MHz), and the universal mobile telecommunication system (UMTS: 1920 MHz ~ 2170 MHz) based on -10 dB of reflection coefficient, and peak gain is 3.4 dBi.

2. Antenna Design

The geometry of the proposed antenna is depicted in Fig. 1. In Fig. 1, the proposed antenna is designed on a 1.574 mm thick substrate with dielectric constant of 2.2, and overall ground size is 90 mm × 40 mm (g_w × g_l). The distance from the shorting pin of S_1 is 18.4 mm and S_2 is 14.9 mm. The gap distance, g, between the shorting pin and feed is 0.1 mm, and the width of the strip line is 1.2 mm. The length of the stub directly connected ground plane, L_2, is 8 mm, and the other stub, L_1, length is 3 mm. The length of the radiating strip line which decides the antenna width, S_1, is 26 mm. C_1 is capacitor of stub where is placed S_1 from the shorting pin, and C_2 is capacitor of the stub where is placed S_2 from the shorting pin. These two capacitors apply to achieve the tunable frequency response. By changing the value of C_1 and C_2, required resonant frequencies can be obtained without physical modification of the antenna.
3. Simulation Results

The simulation and optimization have been carried out using the commercial software HFSS based on the finite element method (FEM). The simulated reflection coefficients as changing the capacitance from 0.5 pF to 0.9 pF are shown in Fig. 2. As presented in Fig. 2, the higher and lower resonant frequencies are decreased as increasing the capacitance value of $C_1, C_2$, and the lower resonant frequency is more affected by $C_1$, in contrast, the higher resonant frequency is more affected by $C_2$. Fig. 3 shows the electric field distributions of the proposed antenna. In this figure, when the antenna resonates at the lower frequency, the electric field is concentrated around $C_1$. However, when the electric field is concentrated around $C_2$, the antenna resonates at the higher frequency. Fig. 4 is the simulated reflection coefficient of the prototype antenna as variation of the capacitance. According to the simulation result of reflection coefficient below -10 dB, the proposed antenna covers the GSM, CDMA, PCS, UMTS, WCDMA bands as the capacitance is increased from 0.4 pF to 1.1 pF.

The simulated radiation patterns at 900 MHz and 2050 MHz are depicted in Fig. 5. The radiation pattern of 900 MHz shows the omni-directional pattern, and the pattern is tilted at the 2050 MHz, because the radiation is generated around $S_2$ and $C_2$. Fig. 6 is the gain of the antenna. The gain is increased from 2.1 dBi to 3.4 dBi.

4. Conclusion

In this paper, a frequency reconfigurable PIFA for cell-phone application has been designed and simulated. In simulation results, the proposed antenna covers the required band of the wireless communications service in Korea. The lumped capacitor is used in simulation, replacing the varactor diode. Though actual results may vary from parasitic elements, frequency tunability as changing the capacitance is verified.

5. Figures

Figure 1. (a) Detail view, (b) top, and (c) bottom view of the proposed antenna.
Figure 2. Simulated reflection coefficients as variation of (a) $C_1$ and (b) $C_2$.

Figure 3. Simulated electric field distributions at (a) lower and (b) higher resonant frequencies.

Figure 4. Simulated reflection coefficients of the optimized antenna as variation of the capacitance.
Figure 5. Simulated radiation patterns in the (a) xy-plane (900 MHz), (b) zx-plane (900 MHz), (c) zy-plane (900 MHz), (d) xy-plane (2050 MHz), (e) zx-plane (2050 MHz), and (f) zy-plane (2050 MHz).

Figure 6. Simulated gain of the antenna.

References


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