A Planar Antenna for Three Frequencies printed on Dielectric Substrate

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Abstract **A planar antenna for three frequencies printed on dielectric substrate is proposed. It is analyzed by using FDTD method. The characteristics of the antenna such as return loss, current density and far field patterns are shown in figures. This antenna is useful for three kinds of applications in mobile communication.**

1. Introduction

Recently, wireless communication technologies have been developed rapidly, and used in every field. Especially, the utilization of mobile communication has been expanded, and wireless mobile multimedia communication systems will be used to access to network service increasing. In these systems, there are many demands for antennas such as small size, low cost, and high reliability and so on.

In conventional antenna technology, an antenna is prepared for respective frequency band. Hence several type antennas must be installed in order to design systems in wireless mobile communication.

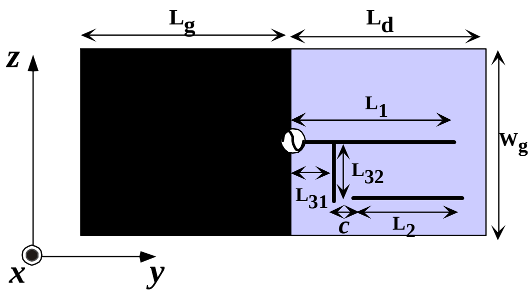
In this paper, a new type of planar antenna is proposed which has three resonance frequencies. This antenna is analyzed by using FDTD method, and characteristics of return loss, far field patterns and so on are obtained. Those results are shown in figures. From the results, it is clear that this planar antenna is useful for mobile communication system.

2. Structure of antenna

Fig.1 shows a structure of the three frequencies planar antenna which is proposed for mobile communication.

This antenna has a copper foil for ground conductor and three elements on dielectric substrate. This dielectric substrate is glass(ε_r =6.68). And it has a length Lg+L_d, a width Wg and a thickness h.

The ground conductor has a length Lg and a width Wg. The ground conductor is necessary for impedance matching at the first frequency. And so the length Lg is about a quarter of a wavelength at the first frequency in vacuum.



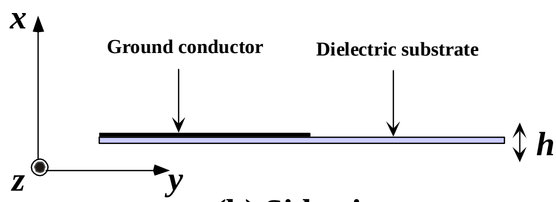


Fig.1 Three frequencies strip antenna

The element 1 has a length L_1. The L_1 is influenced by the element3. L_1 needs to be longer than a quarter of a wavelength at the first resonance frequency. The element 3 has a length $L_{31}+L_{32}(=L_3)$. It is decided by the quarter of a wavelength at the third frequency. There is the gap c between element 3 and element 2. The element2 has a length L_2. It is decided by half of a wavelength at the second frequency.

3. FDTD analysis

The planar antenna is analyzed by the FDTD method. In this analysis, the cell size is $dx = dy = dz = 1$[mm]. The analytical region consists of 41x 89 x 63 cells. Fig.2 shows the analytical region. The input pulse is a gaussian pulse. PML (Perfect Matched Layer) is used as the absorbing boundary in order to improve accuracy. Time step *dt* is decided by the following Courant stability condition:

$$dt \le \frac{1}{c\sqrt{(\frac{1}{dx})^2 + (\frac{1}{dy})^2 + (\frac{1}{dz})^2}}$$

where c is the velocity of wave propagation in vacuum.

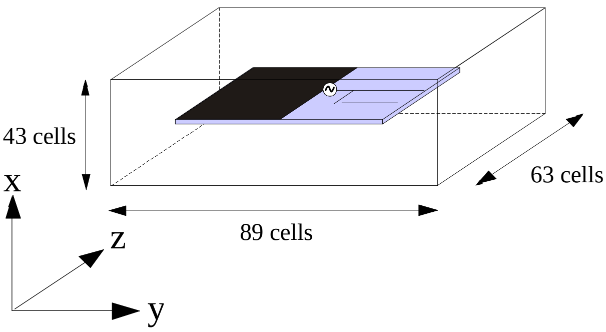


Fig.2 The analytical region

The L_1 of element 1 is 21[mm]. The L_2 of element 2 is 14[mm]. L_{31} and L_{32} of element 3 are 3[mm] and 4[mm], respectively. The gap c is 1[mm]. L_g and W_g of ground conductor are 27[mm] and 23[mm], respectively. W_g and h of dielectric substrate are 22[mm] and 1[mm], respectively.

4. Analytical result

Characteristics of return loss, current distributions and far field pattern which were obtained by FDTD method are described. A characteristic of return loss is shown in Fig.3.

This planar antenna has three resonance frequencies 2.39[GHz], 5.12[GHz] and 6.04[GHz]. Value of return loss and bandwidth are -24.9[dB] and 250[MHz](at -15[dB]) at 2.39[GHz], respectively. At 5.12[GHz], those values are –24.1[dB] and 500[dB], respectively. At 6.04[GHz], those values are -28.7[dB] and 700[MHz], respectively.

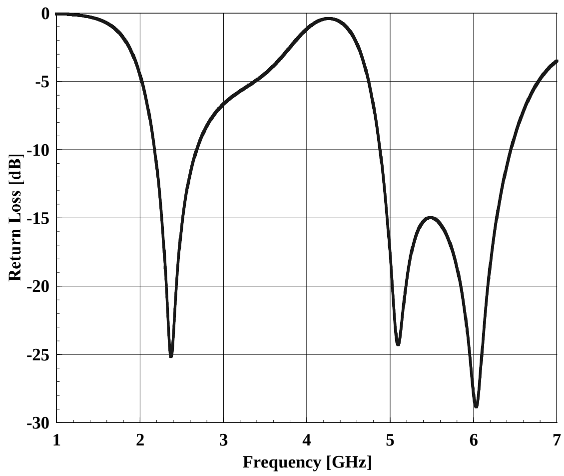


Fig.3 Characteristics of return loss

Figs.4, 5 and 6 show characteristics of current distributions on the antenna. In order to confirm the difference between three frequencies, the results are compared. Current density at the first resonance frequency is large on the element 1. The first frequency also has an influence due to the length Lg of ground conductor. Current density at the second resonance frequency is distributed on element 2 and element 3 as shown in Fig.5. However, if they compared, the current distributed over the element 2 is the larger than that of element 3. Therefore the second resonance frequency depends on the length L_2. Current density at the third resonance frequency distributed on element2 and element3 as shown in Fig.6. However the current distributed over the element3 is the larger than that of element 2. Therefore the third frequency depends on the length L_3.

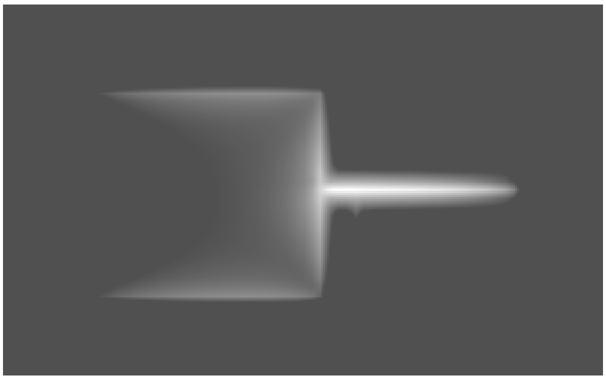


Fig.4 Current density of the first frequency

Fig.5 Current density of the second frequency

Fig.6 Current density of the third frequency

Far field patterns are shown in Figs.7, 8 and 9. Fig.7 shows far field patterns on the XY plane. The directivity at first frequency exists in the directions of 183 and 356 degrees, and the maximum value of an antenna gain is 2.18[dBi] at 356 degrees. Also the directivity at second frequency exists in directions of 208 and 334 degrees, and the maximum value of the gain is 3.39[dBi] at 334 degrees. But, the radiation at 20 and 160 degrees is weak. Similarly, the directivity at third frequency exists 15 and 163 degrees. The maximum value of the gain is 2.31[dBi] at 15 degrees.

Fig.8 shows far field patterns on the XZ plane. They have almost omni directional characteristic. But, the radiation at 270 degrees is weak at the third frequency.

Fig.9 shows far field patterns on the ZY plane. The directivity at first frequency exists in the directions of 183 and 354 degrees, and the maximum value of an antenna gain is 1.84[dBi] at 354 degrees. The directivity at second frequency exists in the directions of 225 and 341 degrees, and the maximum value of an antenna gain is 2.89[dBi] at 341 degrees. Also the directivity at third frequency exists in directions of 31 and 180 degrees. The maximum value of the gain is 3.18 at 180 degrees.

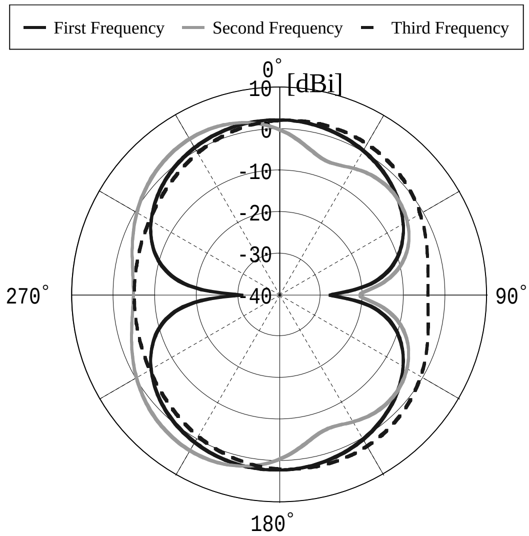


Fig.7 Far field patterns (XY plane)

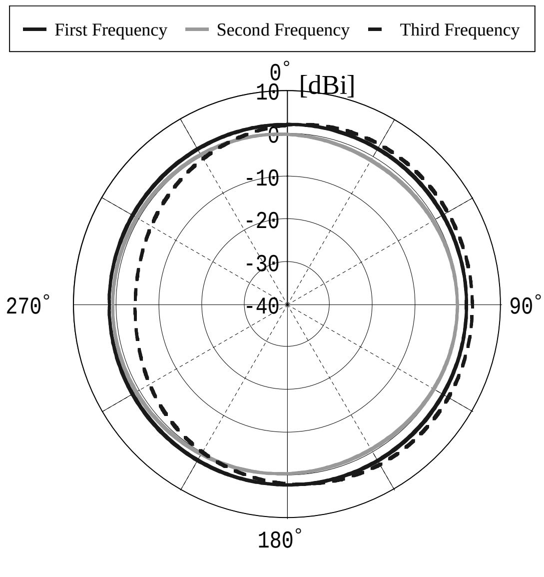


Fig.8 Far field patterns (XZ plane)

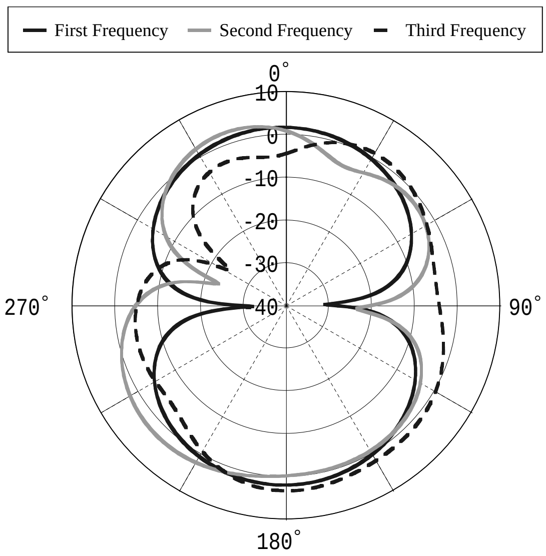


Fig.9 Far field patterns (ZY plane)

5. Conclusion

We proposed the planar antenna for three frequencies printed on dielectric substrate and analyzed it by using FDTD method. The first, second and third frequencies are decided by lengths of L_1, L_2 and L_3, respectively. From the results, it is clear that each resonance has a frequency band over 250[MHz], and the maximum value of antenna gain is about 2[dBi]. This antenna is useful for wireless and mobile communication.

As a future issue, resonance frequency is controlled in more depth, and a radiation pattern is improved.

Reference

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[2] Y.Ukawa, N.Yoshida, H.Matsui, and T.Wakabayashi, "Screen Antennas Printed on Dielectric Substrate with Conductor frame", PIERS2001, pp.426(18-22 July 2001)