Analysis of Planar Sleeve Antenna

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Abstract

The planar sleeves antenna with two sleeves is numerically analyzed and its wideband characteristics are examined. The antenna is excited by the coplanar waveguide with characteristic impedance of 50Ω. The characteristics of the planar sleeve antenna are calculated by using the electromagnetic simulator IE3D based on Method of Moment. The design frequencies of this antenna are 3.5 GHz and 3.7 GHz. The calculated current distribution and radiation characteristics indicate that the sleeves work effectively at design frequencies. The return loss characteristics are improved by adjusting the length of radiating elements.

1. INTRODUCTION

The sleeve antenna is used as the base station antenna of mobile communication system. This is essentially a half-wave dipole antenna fed by a coaxial transmission line [1]. Authors have numerically and experimentally analyzed the sleeve antenna with two tubular sleeves [2]. The outer conductor of the coaxial transmission line and the hollow larger conductor form the lower sleeve and the inner conductor of transmission line and the hollow larger conductor form the upper sleeve. This antenna has the wideband return loss characteristics. However, the radiation characteristics of this antenna have not been discussed.
In this paper, a planar sleeve antenna exited by the coplanar waveguide (CPW) is numerically analyzed. This antenna is printed on the dielectric plate and two planar sleeves are located outside of the CPW [3]. In the numerical analysis, the electromagnetic simulator IE3D based on the Method of Moment is used [4]. From the calculated current distribution and the radiation pattern, the effect of sleeve is discussed.

2. ANALYTICAL MODEL

Figure 1 shows the structure of planar sleeve antenna fed by the CPW. This antenna is printed on the infinite dielectric plate. At first, the geometry of the CPW is designed by using the electromagnetic simulator TX-line calculator so that its characteristic impedance becomes 50 Ω [5]. Since the infinite width of side conductors are assumed in TX-line calculator, the characteristic impedance of the CPW is calculated by using IE3D in order to determine the exact width of the side conductors. The width of central and side conductors is 1.2 mm and 2.4 mm, respectively. The gap width between conductors is 0.2 mm. The thickness and the relative permittivity of dielectric plate are 3.6 mm and ε_r = 7.5, respectively. The thickness of metal conductor is 0.018 mm. This antenna has two sleeves outside of the CPW. The design frequency of sleeve is estimated from the frequency when the gap length becomes a quarter wavelength of calculated current distribution. The design frequencies of two sleeves are 3.5 GHz and 3.7 GHz.

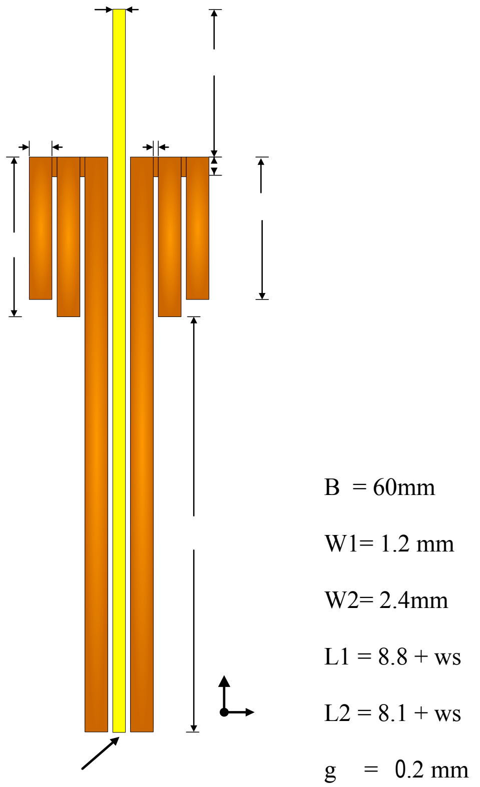


Figure 1 Structure of planar sleeve antenna

3. NUMERICAL RESULTS AND DISCUSSION

Figure 2 shows the current amplitude distributions on the sleeve antenna. On the CPW, the transmission line mode current from the input port to the radiator and the leakage current from sleeves flow. The transmission line mode current flows in the vicinity of gap between the central and side conductors of the CPW. Along the edge on the side conductor of CPW, the leakage current flows from the sleeves. The current amplitude at the open end of sleeve becomes small at frequencies from 3.3 GHz to 3.749 GHz.
Figure 3 shows the electric field radiation patterns in xz plane. The radiation patterns at the frequencies from 3.3 GHz to 3.749 GHz are almost same. At other frequencies, the radiation patterns are deformed. This may be the contribution from the leakage current on the CPW. At the frequency of 3.8 GHz, the current amplitude on the monopole element and sleeve becomes largest. However, the current amplitude is not small along the edge of CPW. Therefore the radiation pattern becomes deformed. Although the good return loss is obtained at the frequency of 4.0 GHz in the case of ws = 2.4 mm in Figure 4(a), the radiation pattern shown in Figure 3(k) is deformed. In this case, the current near the open end of sleeve is not negligible.
In order to discuss the relationship between the return loss characteristics and the antenna structure, the length of sleeve radiators L1, L2 and the length of the monopole element U extended the central conductor of the CPW are adjusted, while the gap length of sleeves are fixed. Figure 4(a) shows the return loss characteristics as the parameter of ws and Figure 4(b) shows the return loss characteristics for the different length of monopole element U. By increasing the length of ws or U, the higher and lower resonant frequency of 3.8 GHz become lower.
Figures 5 and 6 show the current distribution and the electric field radiation pattern at the resonant frequency of 3.904 GHz in the case of ws = 3.6mm, respectively. Figure 7 and 8 show the current distribution and the electric field radiation pattern at the resonant frequency of 3.824 GHz in the case of U = 8.8 mm. Since the current amplitude on the CPW is small in this case, the radiation pattern becomes almost symmetrical with respect to z axis.
Figure 9(a) and 9(b) shows the input impedance characteristics of the sleeve antenna.

4. CONCLUSION

The planar sleeve antenna printed on the dielectric plate has been analyzed numerically by using the electromagnetic simulator IE3D. From the calculated current distribution and the radiation pattern, it has been shown that the sleeve works most effectively at the design frequencies. The return loss characteristics are good at the design frequencies.
In the next step, the calculated characteristics of this antenna will be compared with the measured results.

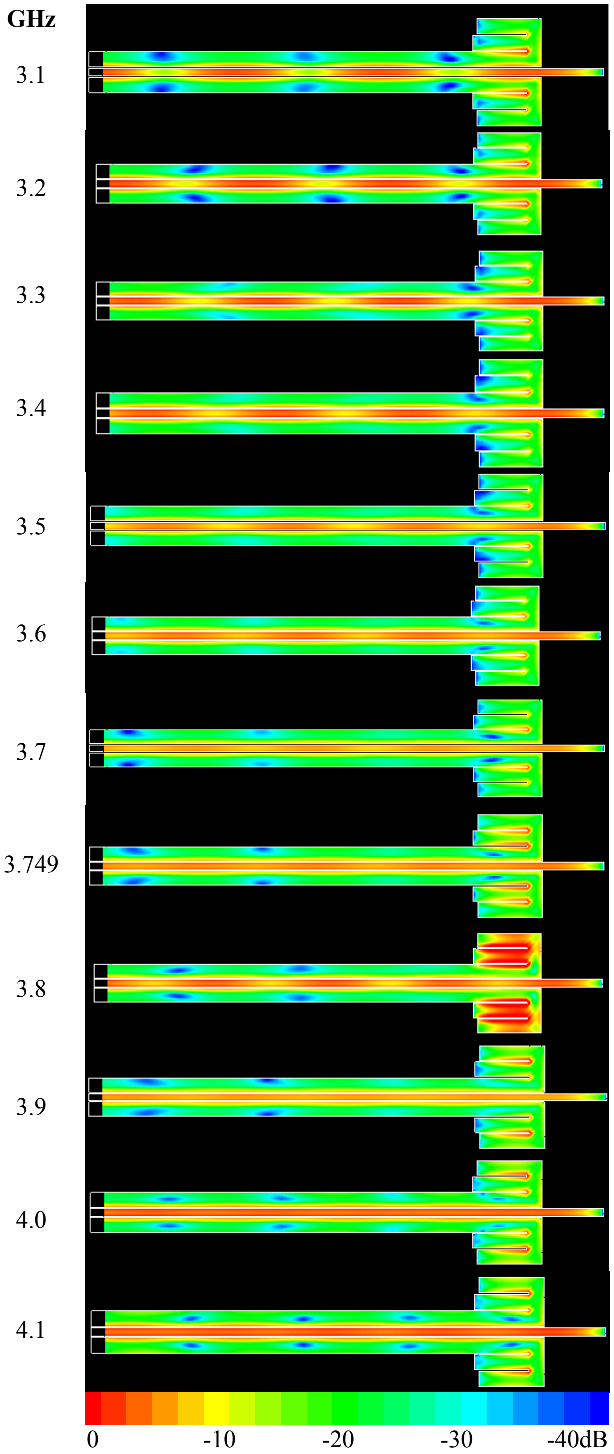
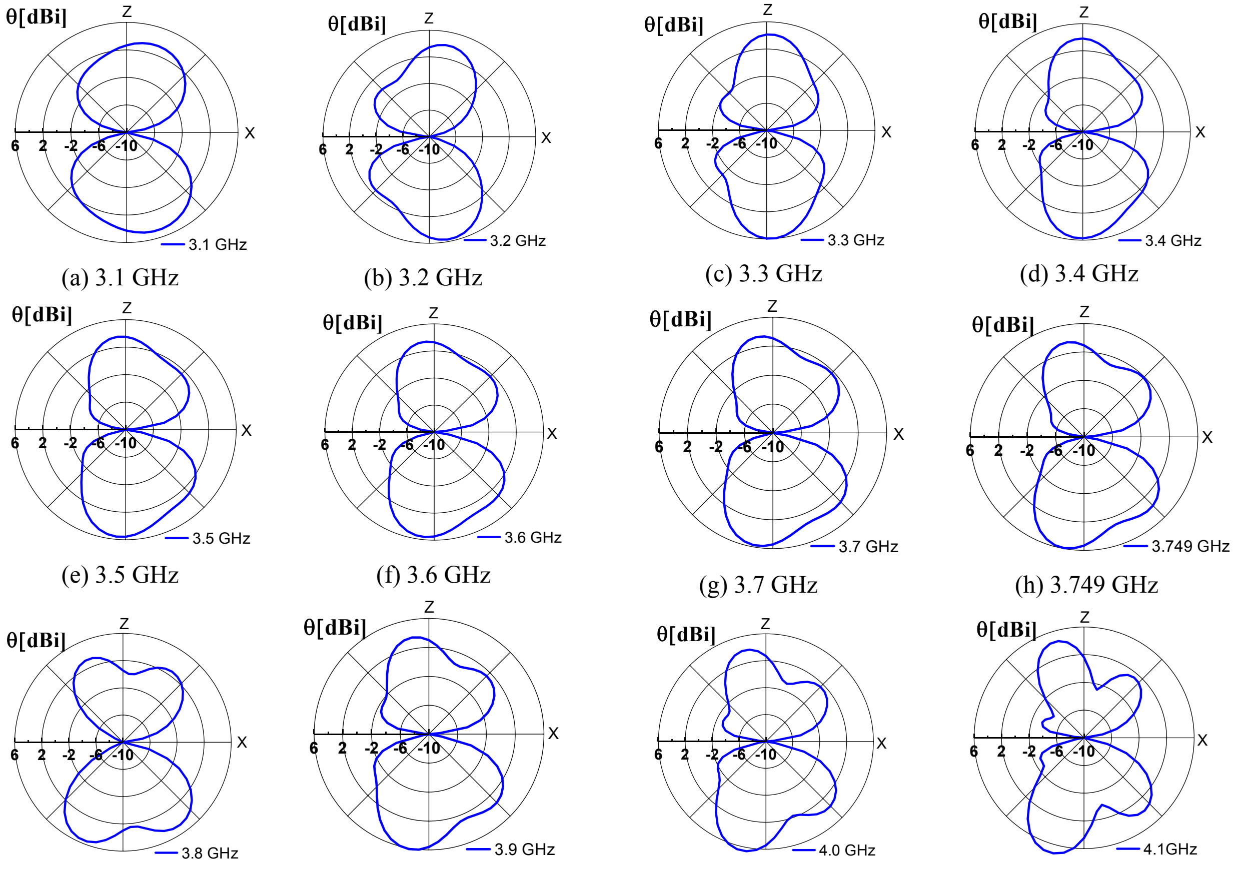


Figure 2 Current amplitude distribution
B = 60 mm, W1 = 1.2 mm, W2 = 2.4 mm, L1 = 11.2 mm, L2 = 10.5 mm, ws = 2.4 mm, g = 0.2 mm, U = 10 mm

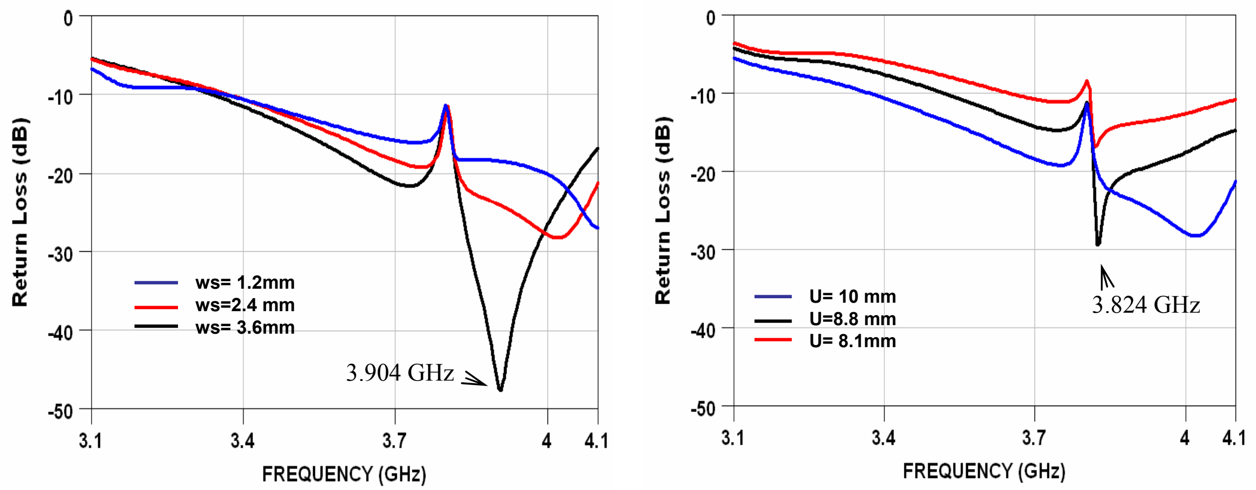


(a) 3.1 GHz (b) 3.2 GHz (c) 3.3 GHz (d) 3.4 GHz

(e) 3.5 GHz (f) 3.6 GHz (g) 3.7 GHz (h) 3.749 GHz

(i) 3.8 GHz (j) 3.9 GHz (k) 4.0 GHz (l) 4.1 GHz

Figure 3. The electric field radiation characteristics
B = 60 mm, W1 = 1.2 mm, W2 = 2.4 mm, L1 = 11.2 mm, L2 = 10.5 mm, ws = 2.4 mm, g = 0.2 mm, U = 10 mm



(a) U=10mm (b) ws = 2.4 mm

Figure 4. Return loss characteristics. B = 60 mm, W1 = 1.2 mm, W2 = 2.4 mm, g = 0.2 mm

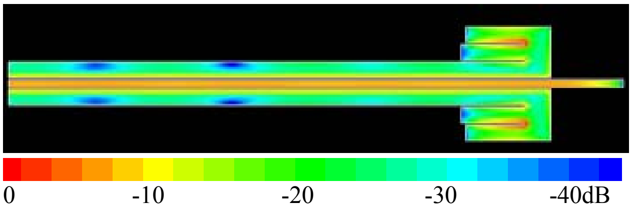


Figure 5 Current distribution at 3.904 GHz
B = 60 mm, W1 = 1.2 mm, W2 = 2.4 mm, L1 = 11.2 mm, L2 = 10.5 mm, ws = 3.6 mm, g = 0.2 mm, U = 10 mm

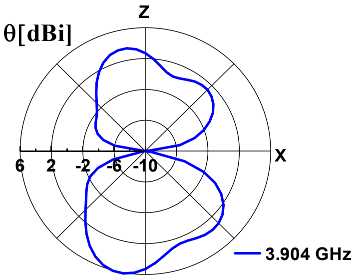


Figure 6 Electric field radiation characteristics at 3.904 GHz
B = 60 mm, W1 = 1.2 mm, W2 = 2.4 mm, L1 = 11.2 mm, L2 = 10.5 mm, ws = 3.6 mm, g = 0.2 mm, U = 10 mm.

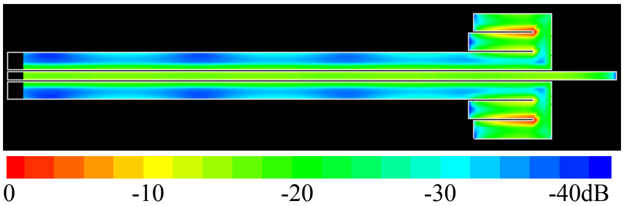


Figure 7 Current distribution at 3.824 GHz
B = 60 mm, W1 = 1.2 mm, W2 = 2.4 mm, L1 = 11.2 mm, L2 = 10.5 mm, ws = 3.6 mm, g = 0.2 mm, U = 8.8 mm

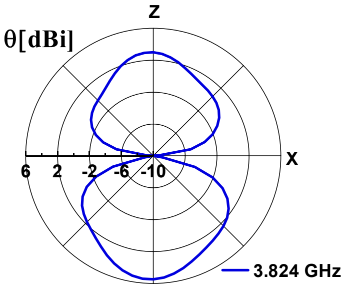
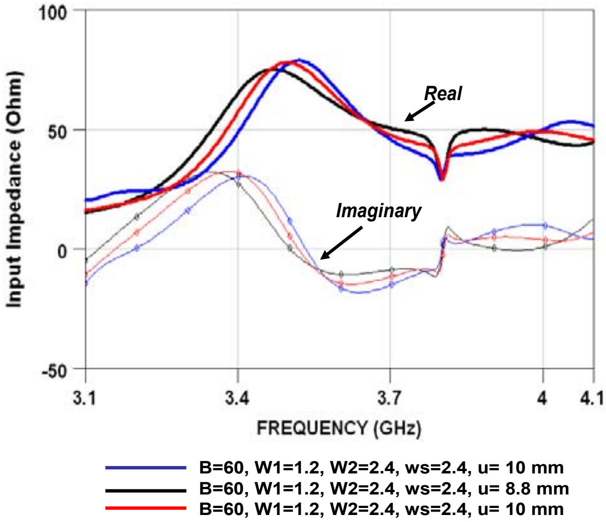
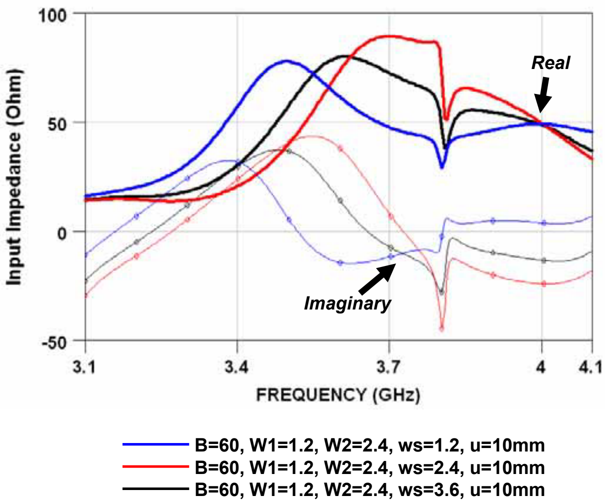


Figure 8 Electric field radiation characteristics at 3.824 GHz
B = 60mm, W1 = 1.2 mm, W2 = 2.4 mm, L1 = 11.2 mm, L2 = 10.5 mm, ws = 2.4 mm, g = 0.2 mm, U = 8.8 mm



(a) by adjusting U



(b) by adjusting ws
Figure 9 The Input Impedance Characteristics

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