Characteristic Mode Analysis of Hemispherical Shell for Helmet Antenna Design

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Abstract **– This paper presents the characteristic mode analysis of the helmet, which is double hemispherical conductor shell, in order to achieve the omni-directional pattern in the horizontal plane. By deleting the weak part of the electric current on the double hemispherical conductor shell, the shape of the folded dipole is obtained with low resonant frequency.**

Index Terms **— helmet antennas, characteristic mode analysis, hemispherical shell.**

1. Introduction

A folded dipole antenna and an inverted-F antenna have been proposed as a helmet antenna for disaster prevention [1], [2]. To achieve the helmet antenna for low frequency operation, low-profile and small antennas are required to install in the helmet with the radius of 125 mm. The characteristics mode analysis has been considered as the systematic design of the antenna shape [3], [4]. This paper presents the characteristic mode analysis of the helmet, which is double hemispherical conductor shell, in order to achieve the omni-directional pattern in the horizontal plane. To analyze the characteristic mode, FEKO suite 7.0 is used.

2. Double hemispherical conductor shell

The helmet antenna has been required to achieve not only the low-profile and small configuration but also the suppression of the radiation toward a human head. Therefore, the double hemispherical conductor shell is the platform for the helmet antenna. Figure 1 shows the simulation models of the double hemispherical conductor shell. The inner shell is located in 17 mm inside the outer shell of the radius of 125 mm.

Figure 2 shows the modal significance characteristics of the double hemispherical conductor shell. The resonant frequency of J_1 and J_2 are 560 MHz. The eigenvalue of J_1 becomes 0.02. Figure 3 shows the radiation patterns of J_1 at 560 MHz. As shown in Fig. 3(a), the radiation patterns of each polarization on xy plane is shaped as a figure eight.

3. Surface current distributions

Figure 4 shows the electric current distribution of J_1. Fig. 4(a) shows the double hemispherical conductor shell. The strong electric current is distributed at the edge of the outer shell. The contour length of the edge of the shell

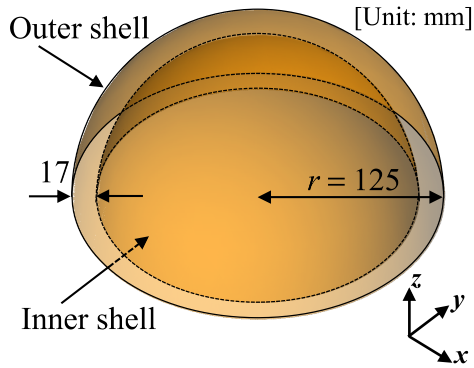

Fig. 1. Configuration of double hemispherical conductor shell.

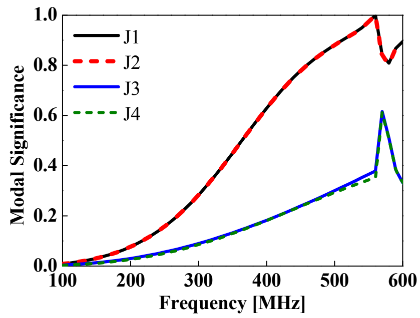

Fig. 2.Modal significance.

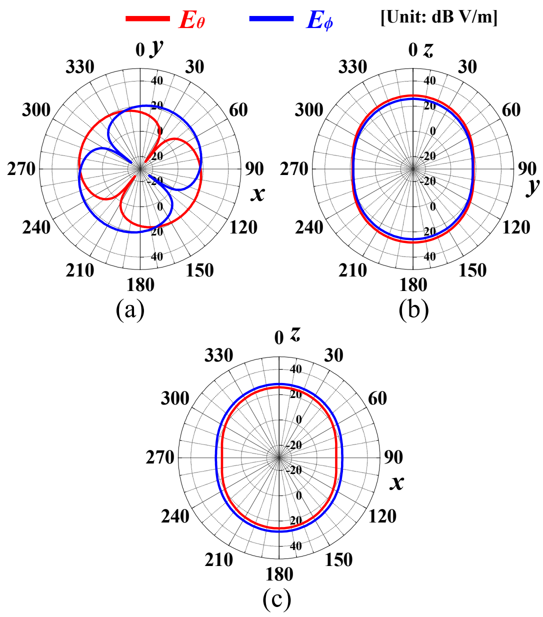

Fig. 3.Radiation patterns of J_1 on (a) xy plane, (b) yz plane, and (c) zx plane.

corresponds to one wavelength loop. The current intensity in the upper part of the outer shell becomes weak.

Therefore, the upper part of the outer conductor is deleted as shown in Fig. 4(b). The current flows widely on the outer conductor due to the narrow conductor. The upper part of the inner conductor also becomes weak. As shown in Fig. 4(c), the current on the inner shell flows in the direction opposite to the outer shell.

To change the characteristic modes from the one wavelength loop to the half wavelength loop, the outer conductor is split as shown in Fig.4 (d). The slit with 10 mm width is arranged at the weak part of the electric current on the outer shell in Fig.4 (c). As a result, the electric current on both inner and outer conductors become strong, and the current flows in one direction.

Finally, the weak part of the current on the outer shell is deleted as shown in Fig. 4(e). The current intensity of two strip on the outer shell becomes very strong. As a result, the configuration of the outer shell becomes the shape of the folded dipole.

4. Modal Significance and radiation patterns

Figure 5 shows the modal significance characteristics of each model as shown in Fig. 4. The resonant frequencies in the model 1 and 2 shift from 560 MHz to 420 MHz. And resonant frequency of 190 MHz is confirmed by arranging the slit on the outer shell in the model 3 and 4.

Figure 6 shows radiation patterns on xy plane of each model. In comparison with Fig. 3(a), the E_θ components of model 1 and 2 become low as shown in Fig. 6(a) and (b). The radiation patterns with the slit on the outer shell become omni-directional on xy plane. The deviation in the xy plane is 2.91 dB in the model 4.

5. Conclusion

This paper presents the characteristic mode of the helmet. By deleting the weak part of the electric current on the double hemispherical conductor shell, the shape of the folded dipole was obtained with low resonant frequency. The omni-directional pattern can be achieved in the horizontal plane.

Acknowledgement

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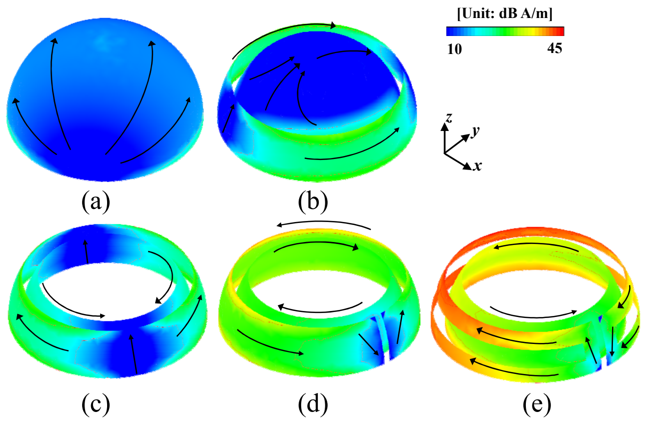

Fig. 4. Current distributions of J_1 of (a) hemispherical shell, (b) model 1 (upper half of outer shell is deleted, (c) model 2 (upper half of inner shell is deleted), (d) model 3 (slit is arranged), and (e) model 4 (middle part of outer shell is deleted).

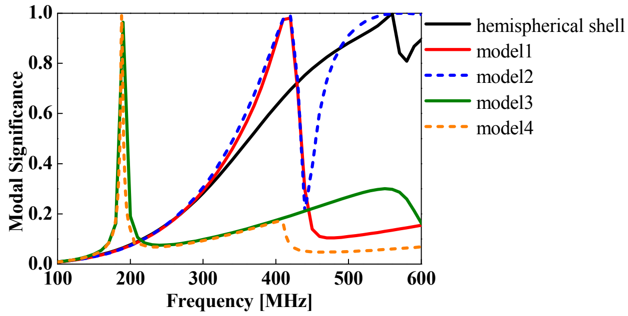

Fig. 5. Modal Significance of J_1.

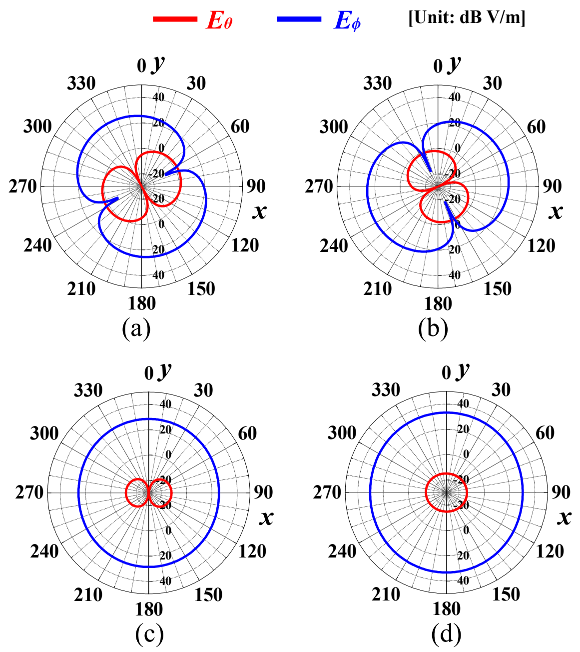

Fig. 6. Radiation patterns on xy plane of (a) model 1, (b) model 2, (c) model 3, and (d) model 4.