Low-Frequency Inverted-F Antenna on Hemispherical Ground Plane

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***Abstract* - Helmet antennas have been widely developed as wearable antennas for military and disaster prevention uses. To reduce the operational frequency band and overcome the gain reduction in proximity to human head, this paper presents the inverted-F antenna on the hemispherical metal ground plane. The arrangement of the antenna element and the feeding directions are examined in detail through electromagnetic simulation. As a result, the gain of −3.0 dBi is achieved in proximity to the human head.**

***Index Terms* — Helmet antennas, Inverted-F antennas, Hemispherical ground plane, Human head.**

I. Introduction

Helmet antennas have been widely developed as wearable antennas for military use [1]. From a practical point of view, the broadband and high gain antennas are required for the helmet antennas. One of the candidates for the helmet antennas is the microstrip antenna on the top of the helmet composed of the metal [2]. In this case, the lowest operational frequency becomes 1.35 GHz. To decrease the operational band for the disaster prevention, a curved folded dipole antenna operated at 150 MHz has been proposed [3]. When the antenna is installed on the human head, the gain decreases because the helmet consists of the dielectric material. To develop the 150 MHz antenna loaded on the human head, an inverted-L antenna on the metal helmet has been examined including the human head effect [4]. However, the maximum gain of the inverted-L antenna was −4 dBi. To overcome the gain reduction, this paper presents the inverted-F antenna on the hemispherical metal ground plane. The arrangement of the antenna element and the feeding directions are examined in detail through electromagnetic simulation.

II. Antenna Configuration

Figure 1 shows the simulation models of the proposed inverted-F antennas on a hemispherical ground plane. The Model-A is the parallel arrangement of the inverted-F antenna and ground plane as shown in Fig. 1(b). The antenna element is arranged along the edge of the hemispherical ground plane. The width of the antenna element is 3 mm. A radius of the hemispherical ground plane is 125 mm. The distance between the antenna element and the edge of ground plane is 10 mm. The inverted-F antenna of the Model-B is

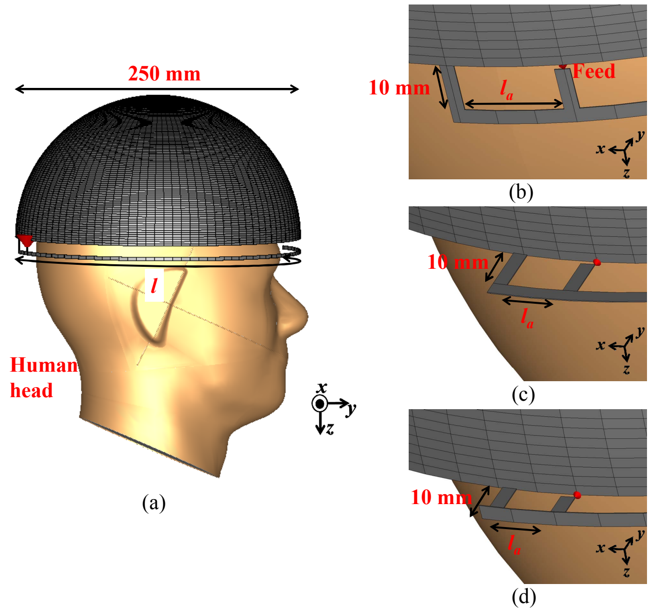

Fig. 1. (a) Configuration of inverted-F antenna on hemispherical ground plane loaded on human head. (b) Model-A. The inverted-F antenna is arranged parallel to the ground plane. (c) Model-B. The inverted-F antenna is arranged perpendicular to the ground plane. (d) Model-C. The antenna element is folded to *z* direction.

arranged perpendicularly to the ground plane as shown in Fig. 1(c). Furthermore, the feeding direction of the Model-C is the same as the Model-B as shown in Fig. 1(d). However, the antenna element is folded to *z* direction.

To achieve the impedance matching at 150 MHz, the length l of the antenna element in the Model-A, B, and C are 440 mm, 480 mm, and 460 mm, respectively. The length l_a between the feed and shot plates in the Model-A, B, and C are 20 mm, 12 mm, and 10 mm, respectively. The dielectric properties of the human head are relative permittivity of 52.3 and conductivity of 0.76 S/m. The CST microwave studio is used in this paper.

III. Antenna Characteristics

A. VSWR Characteristics

Figure 2 shows the simulated VSWR characteristics of the Model-A, B, and C. Fig. 2(a) shows the inverted-F antenna on the hemispherical ground plane in free space. The bandwidth of each model does not depend on the arrangement of the antenna element and the feeding direction.

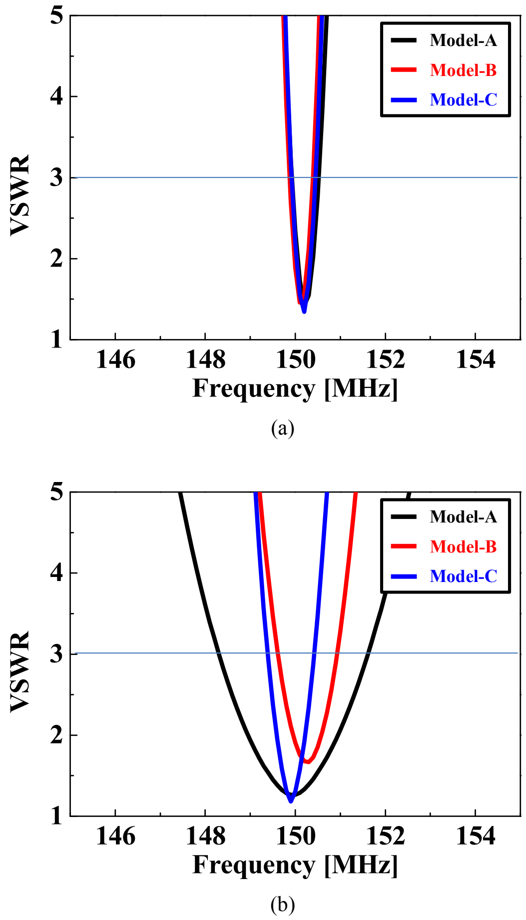

Fig. 2. VSWR characteristics of the inverted-F antenna on hemispherical ground plane (a) without human head, and (b) with human head.

The bandwidth at VSWR = 3 of the Model-A, B, and C are 0.4%, 0.5%, and 0.4%, respectively. Fig. 2(b) shows the antenna loaded on the human head. The bandwidth at VSWR = 3 of the Model-A, B and C are 2.0%, 0.9% and 0.8%, respectively. The bandwidth of the configuration of the Model-A becomes large due to the proximity to the lossy material.

B. Radiation Patterns

Figure 3 shows the simulated radiation patterns of the Model-A, B, and C. Fig. 3(a) and (b) show the inverted-F antenna on the hemispherical ground plane without/with human head. As shown in Fig. 3(a), the gain of the Model-A, B, and C are 0.0 dBi, −0.2 dBi, and −0.4 dBi, respectively. On the other hand, E_θ at *yz* plane is significantly reduced as shown in Fig. 3(b). The gain of the Model-A, B, and C are −18.5 dBi, −5.1 dBi, and −3.0 dBi, respectively.

IV. Conclusion

This paper presents the low-frequency inverted-F antenna on the hemispherical ground plane, and investigates the effect

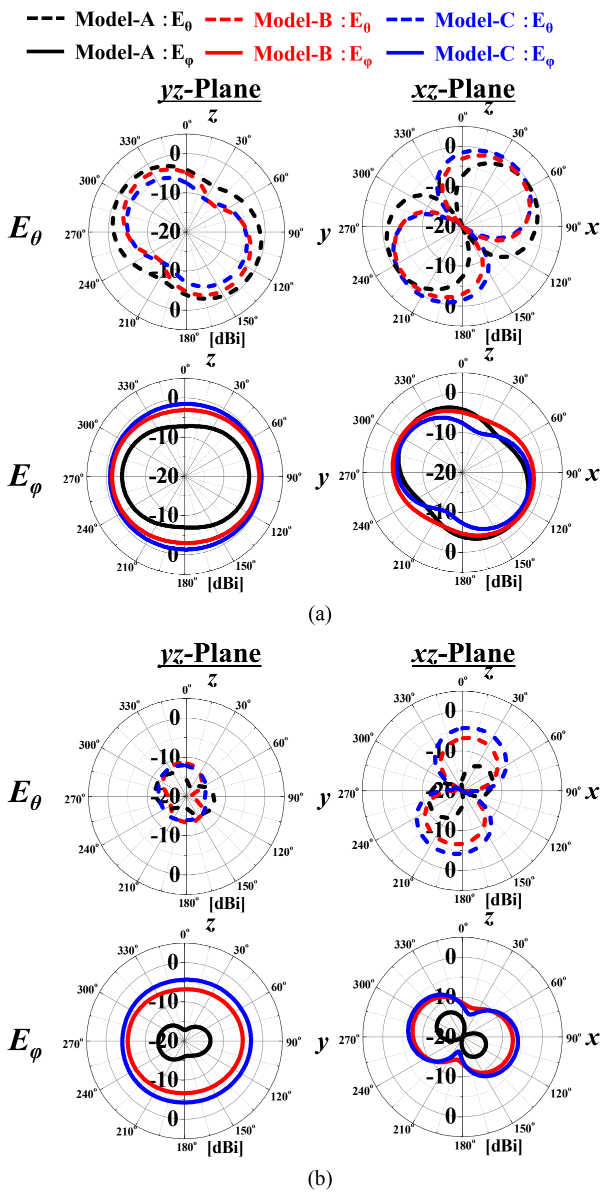

Fig. 3. Radiation patterns of the inverted-F antenna on hemispherical ground plane (a) without human head, and (b) with human head.

of the human head. When the antenna element is arranged perpendicularly to the ground plane, and folded to z direction, the bandwidth of 0.4% and gain of −3.0dBi are achieved.

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