Development of GPS antenna mounted on shoes for human's position observation

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***Abstract* – Recently, the increase in aged wanderers or the infant abduction is becoming the serious social problem. The practical use of the GPS function loadings shoes is advanced to prevent such incident occurring. The dual-band antenna corresponding to GPS and WI-FI band which can be installed on shoes is proposed in this report.**

***Index Terms* — wearable antenna, dual-band antenna, GPS**

1. Introduction

Recently, the increase in aged wanderers or the infant abduction is becoming the serious social problem. Especially, the development of a preventive technology of such an incident is strongly hoped for in the east asian region where low birth rate and longevity progress rapidly. The technology that continuously observes elderlies or child's positions is practicable as a preventive technique of such an incident. The practical use of the GPS function loadings shoes is advanced to continuously observe the target person's position [1]. The antenna element is often stored in sole though the radiation efficiency decreases with user's foot in the existing GPS function loadings shoes. Moreover, the antenna that transmits measured positional information to the smart phone's network is also equipped into the sole. However, the development of the dual-band antenna and the investigation of antenna loading position become important problems in achievement of the antenna properties and shoe's comfortableness. Therefore, the development of the novel dual-band antenna (corresponding to GPS and WI-FI band) that can be loaded on the tiptoe of shoes is described in this report.

2. Antenna design

This study applied a method of wearable antenna, it makes the antenna design. Specifically the dual-band antenna corresponding to GPS band (1.575 GHz) and WI-FI or Bluetooth band (2.4 GHz) is proposed. In addition, it is assumed to load the antenna in shoes that will always be worn when the person goes out. The configuration of the proposal antenna is shown in Figure 1. A basic concept of the proposal antenna derives from inverse-F antenna. However, the shorting point and the feed point are set up around the center of antenna element. The right hand side element as viewed from the feed point contributes to GPS-band and other side element contributes to Wi-Fi-band. Moreover, a parasitic element as the director is set up above the antenna element because of the GPS signal receiving.

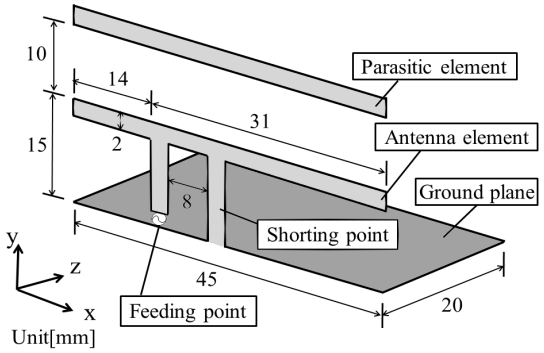


Fig. 1. Dual-band Inverse-F antenna.

3. Foot and ground effect simulation for antenna

Because the wearable antenna is used near the human body, it is necessary to simulate the body effect for the antenna design [2]. Concretely, because the proposal antenna will be loaded in the shoes's tiptoe, it is necessary to simulate foot influence. The electric constant of the foot model is determined from the body tissue dielectric parameters database of the Federal Communications Commission [3]. Because the share of the bone in the tiptoe part is considerably higher than that of the muscle, the foot is modeled with the homogeneous bone dielectric property. The foot below is modeled with the dielectric property of asphalt.

The antenna element is sandwiched between the silicone rubber sheets having a thickness of 3 mm to increase the durability. Positional relationship of the antenna and the foot model is shown in Figure2. Dielectric properties of the foot, antenna cover and ground are listed in TABLE 1.

The Finite Difference Time Domain (FDTD) method is used for antenna parameters analysis [4].

TABLE 1
Electric constant

	σ[S/m]	εr
Foot model	0.58	15.0
Silicone rubber	0.01	2.0
Asphalt	0.10	2.7

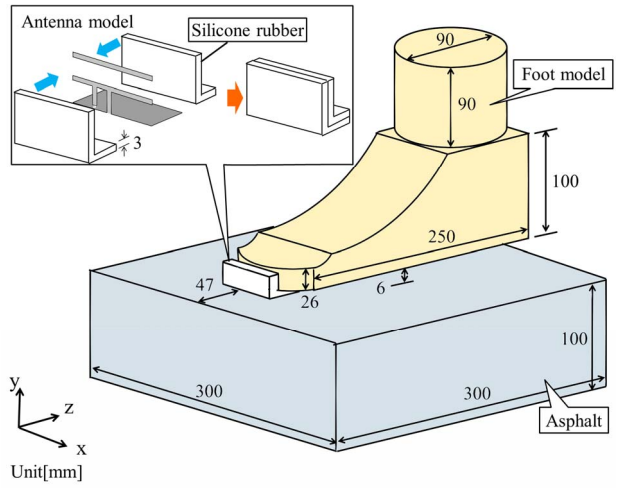


Fig. 2. Loading situation of the actual antenna.

4. Simulated Result

Figure 3 shows an analysis result of antenna input properties under the situation in Fig. 2. As a result, it is proven that the proposal antenna has excellent input properties in target frequency bands.

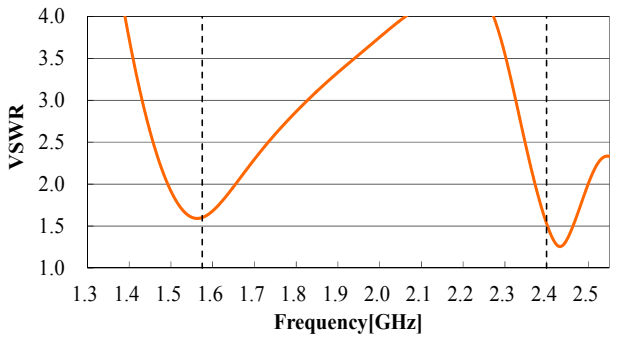


Fig. 3. Antenna input property as a function of frequency.

Analysis results of the current distribution on antenna elements at each target frequency are shown in Figure 4. It can be confirmed that the current is concentrated on the right hand side region from the feed point in GPS-band. On the other hand, it seems that the proposal antenna works as not inverse-F antenna but 'T' type dipole antenna in Wi-Fi-band. Additionally, it is confirmed that a parasitic element actively operates as the director.

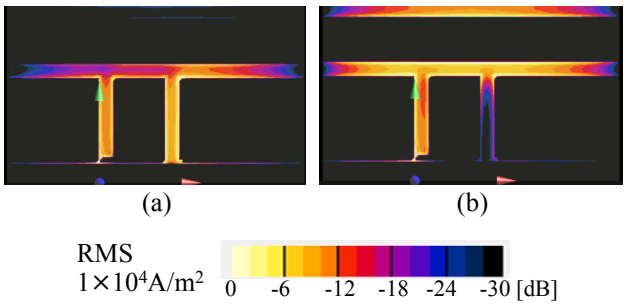
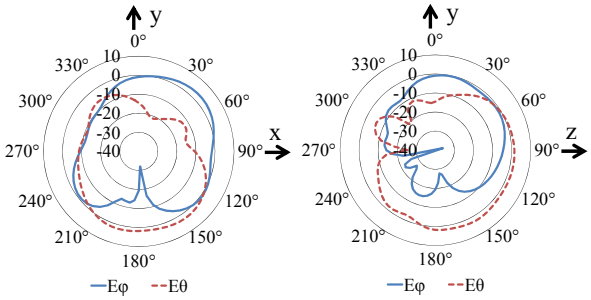


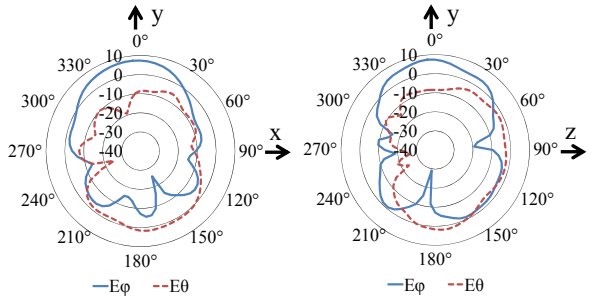
Fig. 4. Frequency dependency of the current distribution. (a) @ 1.575 GHz, (b) @ 2.4 GHz

Figure 5 shows analysis results of radiation properties in GPS-band under the situation of Fig. 2. Figure 6 shows analysis results of radiation properties in Wi-Fi-band under the same situation. The maximum radiation gain reaches 3.3 dBi though the tendency that the beam tilts toward the foot is shown in Fig. 5. As a result of Fig.6, because the director operates enough, the beam tilts toward the zenith and the maximum gain reaches 7.3 dBi.



(a)x-y plane (b)y-z plane

Fig. 5. Radiation patterns @ 1.575 GHz.



(a)x-y plane (b)y-z plane

Fig. 6. Radiation patterns @ 2.4 GHz.

Also in 2.4 GHz, flowing through the elements at both ends from the feeding point no flow through the shorting point. Each can be confirmed that running the length of a quarter wavelength.

5. Conclusion

We proposed the dual-band inverse-F antenna is confirmed that the VSWR is less than 2 at the target frequency band (1.575 GHz, 2.4 GHz). Radiation pattern was confirmed to satisfy the above 3 dBi in a certain range. As a future study, the experiment evaluation near foot with the prototype antenna will be carried out.

References

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