Characteristics of a balance-fed L-type loop antenna system for handsets in the vicinity of human head

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1. Introduction

Conventional antennas for handset are mostly of the type having unbalanced terminals and being fed by unbalanced lines, so that in almost all cases radiation currents are induced on the conducting materials existing in the handset unit, as well as on the antenna element [1]. These currents on such conducting materials contribute to improvement of the antenna performance, particularly when the antenna element is very small. A design concept up to now has been to use these current positively. However, since these currents are varied by the influence of the operator's hand and/or head, it would cause significant variation that will result in degradation of the antenna performance. This implies that the antenna performance may be degraded sometimes seriously when placed at a talk position.

In the previous paper [2], a loop antenna system, which has the balance structure and is fed with the balanced line in order to reduce the effect of currents on the conducting box, has been introduced and it is shown that the reduction of the currents on the ground plane is remarkable by using balanced system. Since L-type loop antenna [3] produces both vertically and horizontally polarized components, it would be useful for handset operation in the multipath environment [4]. In the analysis, a simple model consisting of a small loop antenna mounted on a ground plane is used and antenna characteristics are analyzed both theoretically and experimentally.

In this paper, in order to confirm the effectiveness of using the balanced antenna and L-typed structure, the performance of the balance-fed and L-typed loop antenna system for handset under the influence of a human head is analyzed numerically and experimentally. As a human head model, COST (European Cooperation in the field of Scientific and Technical Research) 244 model [4], which has a spherical or cubic form, is used. The electromagnetic IE3D simulator by *Zeland Software* is used to obtain the antenna characteristics such as current distribution and radiation pattern.

2. Antenna structure

An antenna model is shown in Fig. 1, which illustrates a small rectangular loop on a rectangular ground plane and a feeding system of both unbalanced and balanced structures. The rectangular L-shaped loop is taken into consideration. The rectangular L-shaped loop has a perimeter of about a half wavelength and is placed very close to the rectangular ground plane, which has the perimeter of about two wavelengths. Both balanced and unbalanced types of feed are considered as shown in Fig.1 (a) and (b). The center frequency f_0 is 1860MHz.

Fig. 2 shows simulation models of the antenna placed near the human head. As the human head model, COST 244 model is used and is the one of the normative human head model for the international standard [3]. The models have a spherical form with a diameter of 200 mm and a cubic form with an edge of 200 mm. The head model has the dielectric properties of the relative permittivity of 43.37 and the conductivity of 1.204[S/m], which correspond to a brain tissue. The distance between the human head model and the antenna is h =15 mm for both type of unbalance-fed and balance-fed system.

3. Results

In calculation, both the antenna with the finite ground plane and the head model are analyzed by using IE3D simulator. A spherical model is approximated by a polyhedron with 72 faces.

Calculated current distributions on the ground plane obtained by IE3D simulator are shown in Fig. 3, where (a) and (c) show those without and with a head model in unbalanced system, respectively and (b) and (d) show those without and with a head model in balanced system, respectively. In the figure, dark color indicates small current and light color indicates large current. As can be seen in the figure, only small current flows are observed in the balanced system, on the other hand much current flows in the unbalanced system. Those results clearly show that the balanced system is very effective for reducing current on the ground plane regardless of the existence of a head model.

Fig.4 shows radiation patterns in *yz*- plane without and with a head model in both unbalanced and balanced systems. The radiation patterns are normalized with respect to their pattern maximum in each plane. Fig. 4(a) and (b) show the radiation pattern without human model in both systems. The calculated and measured results agree well for both unbalanced and balanced systems. It can be said that there is significant effect of the current distribution on the ground plane with respect to the radiation pattern and an L-type loop produces both vertically and horizontally polarized components in the balanced system. Fig. 4(c) and (d) show the radiation patterns with a cubic head model. As can be seen in the figure, a change in the radiation is small with a balanced system, even when the antenna system is placed in the vicinity of the human model. The radiation decreased toward the head model is seen in the balanced E_θ and E_ϕ pattern, while only a slight change is seen in the unbalanced E_θ and E_ϕ pattern. Although the radiation pattern in the other planes is not shown here, the effect of the head model is relatively small in balanced system. The calculated and measured results agree well for balanced system, on the other hand, they do not agree much for unbalanced system. This may be caused by the slight difference between the experimental setup and the simulation model. Fig. 4(e) and 4(f) show the radiation patterns with a spherical head model in both unbalanced and balanced systems. The similar tendency is observed as in the case of a cubic head model.

4. Conclusion

From the analysis shown here, it is found that the balanced system has not been very much affected by the human head model as compared with unbalanced system and an L-type loop produces two polarization components, which would be effective to be used in the multipath environment.

References

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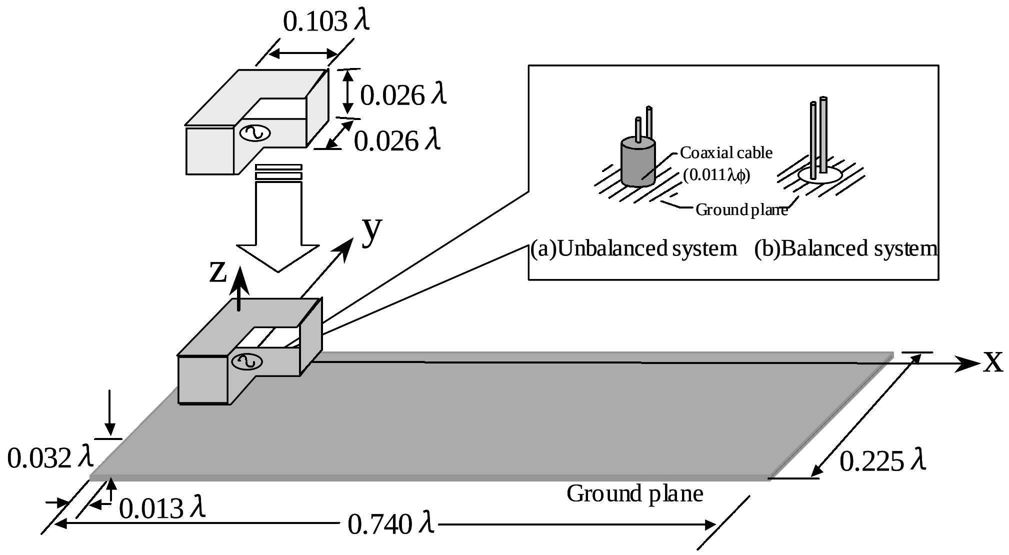
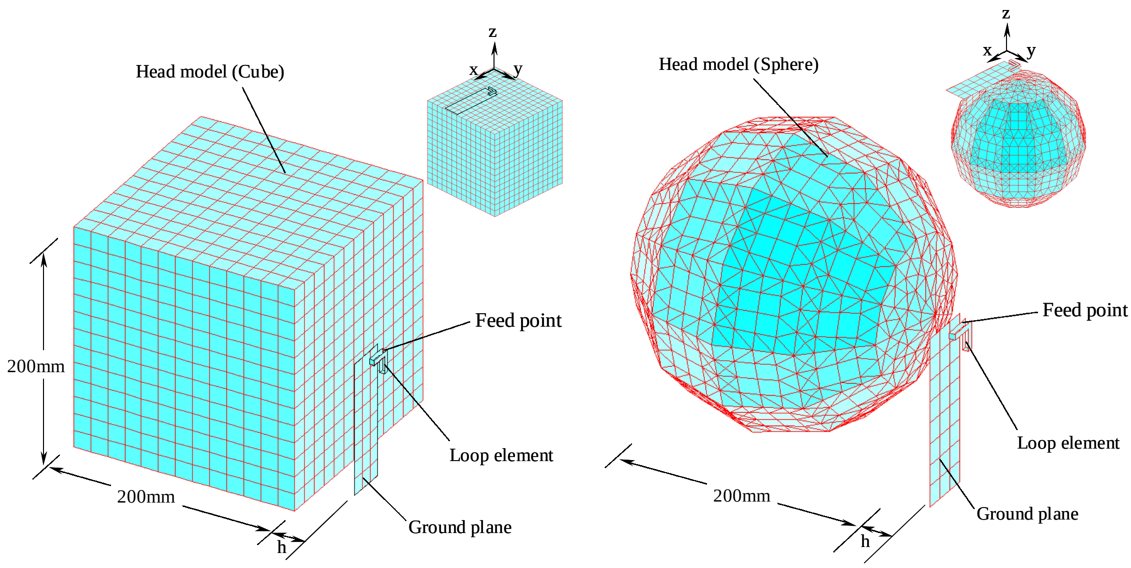


Fig.1 Antenna structure

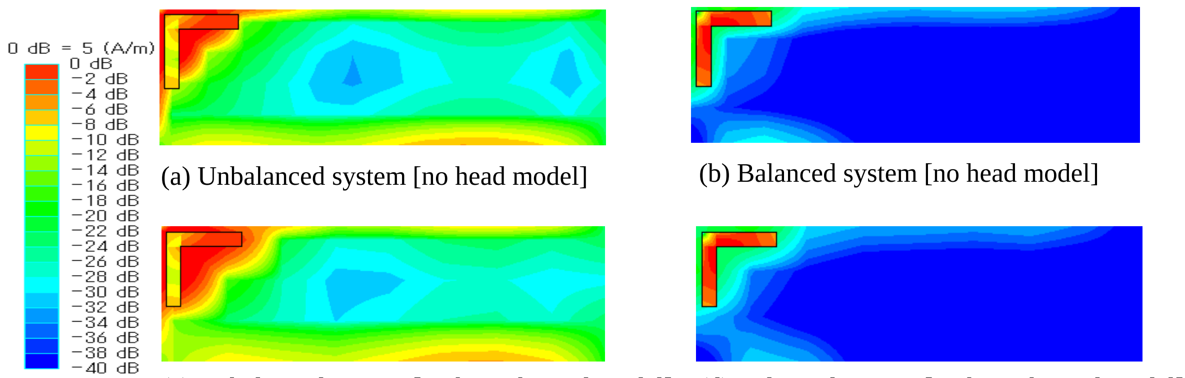


(a) Cubic model

(b) Spherical model

Fig.2 Antenna and human head model for simulation

ε r=43.37, σ [S/m]=1.204, h=15mm, f=1.86GHz



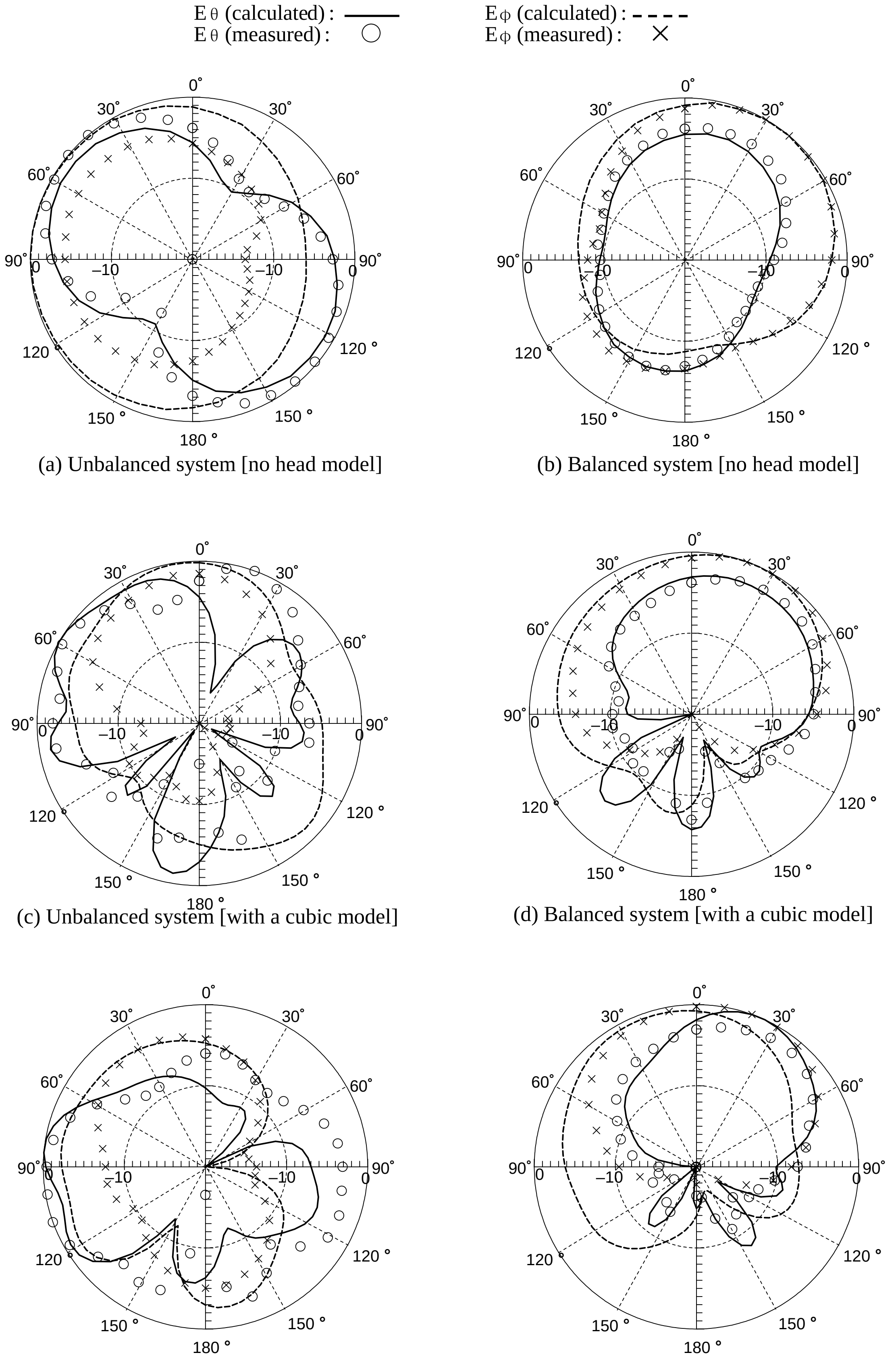
(a) Unbalanced system [no head model]

(b) Balanced system [no head model]

(c) Unbalanced system [with a spherical model]

(d) Balanced system [with a spherical model]

Fig.3 Current distributions



(a) Unbalanced system [no head model]

(b) Balanced system [no head model]

(c) Unbalanced system [with a cubic model]

(d) Balanced system [with a cubic model]

(e) Unbalanced system [with a spherical model]

(f) Balanced system [with a spherical model]

Fig.4 Radiation pattern in yz-plane