Electromagnetic field analysis of the wire antenna in the presence of a dielectric with three-dimensional shape

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1.Introduction

In the design of the radio frequency antenna for magnetic resonance imaging, the electromagnetic field analysis is useful to determine the size and structure of the antenna. But, because human body is a lossy dielectric, the computation method which can analyze the wire antenna in the presence of a lossy dielectric has to be developed. In this paper, we propose a method which is combined the moment method, which deals with wire antenna,[1] with the boundary element method, which deals with three-dimensional shapes of dielectrics and magnetic materials.[2] For the verification of the proposed method, a helical antenna in which a dielectric cylinder is inserted was chosen as a computation model and the computation results were compared with the experimental results.

2. Formulation

The boundary element method and the moment method are combined by using the following equations.

$$\nabla \cdot \vec{J} + j\omega\rho = 0 \quad (1), \qquad \vec{J} \cdot (\vec{\ell}/\ell) S = I \quad (2), \qquad \vec{E} \cdot \vec{\ell} = V \quad (3)$$

where $\vec{\ell}$ is the vector along the wire axis, S is the area of the wire cross section, I is the current of the segment on the axis of thin wire, and V is the impressed voltage between the two ends of the segment.

The final simultaneous equations of the proposed method are obtained as follows:

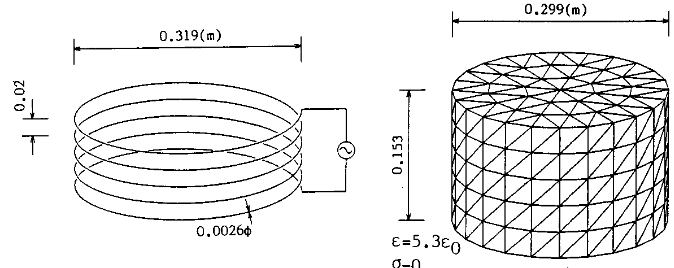
$$\begin{bmatrix} [CB] & [CI] \\ [CE] & [CM] \end{bmatrix} \begin{Bmatrix} \begin{Bmatrix} \vec{E} \\ \vec{B} \end{Bmatrix} \\ \{ I \} \end{Bmatrix} = \begin{Bmatrix} \begin{Bmatrix} 0 \\ 0 \end{Bmatrix} \\ \{ V \} \end{Bmatrix} \quad (4)$$

where [CB], [CI] and [CE] are the coefficient matrices given by the formulation of the boundary element method, and [CM] is the coefficient matrix given by the formulation of the moment method.

3.Computation Results

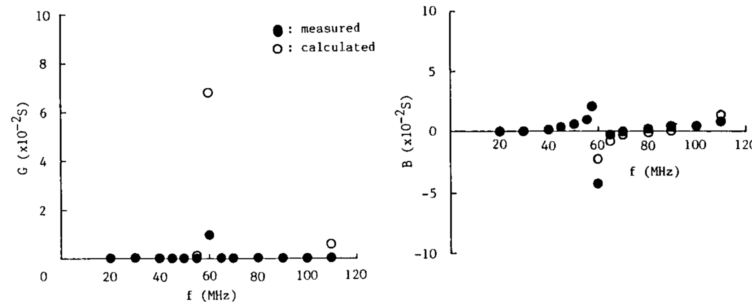
A helical antenna model is shown in Fig. 1(a), and a dielectric cylinder which is inserted in the helical antenna is shown in Fig. 1(b). The number of segments on the wire axis of the antenna and elements on the dielectric surface are 108 and 384, respectively.

The computation results of the helical antenna model are shown in Fig. 2. The computation results agree with the experimental results. The computation results of the antenna in the presence of a lossy dielectric will be presented in final paper.



(a) (b)

Fig. 1 A helical antenna model, (a)helical antenna, (b)dielectric.



(a) (b)

Fig. 2 Computation results of input admittance, (a)conductance G, (b)susceptance B.

References

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