THE RADIATION CHARACTERISTIC OF A $\lambda/4$–MONOPOLE ANTENNA MOUNTED ON A CONDUCTING BODY BY THE SPATIAL NETWORK METHOD

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1 INTRODUCTION

A monopole type antenna is suitable for a hand–held type telephone such as cordless telephones and portable telephones. But it is rather difficult to predict the radiation characteristics of such an antenna, because the high–frequency current on the conducting body affects the radiation from the antenna. A monopole antenna whose radiating element's length is nearly $\lambda/2$ used to be employed to reduce such influence. But this antenna is not suitable in minimizing hand–held telephones. Besides, the impedance of such an antenna is relatively high so that it requires a matching circuit. On the other hand, a $\lambda/4$–monopole antenna does not need a matching circuit. However, the influence of the current on the conducting body in this case may be larger than that of a $\lambda/2$–monopole antenna. Therefore, a method for reducing such an influence is indispensable.

In this paper, the authors first report the result of simulating the electromagnetic field around a portable telephone model with a $\lambda/4$–monopole antenna by SNM (Spatial Network Method[1]), a kind of TLM[2], compare this result with an experimental result to certify the validity of SNM for such a model and investigate the behavior of the current distribution on the conducting body. Secondly, a technique for improving such a current distribution will be presented for suiting the radiation characteristic to telecommunications, and the validity of this technique by a simulation and an experiment are discussed.

2 THE APPLICATION OF SNM TO AN ANTENNA ON A CONDUCTING BODY

In terms of improving the radiation characteristic of an antenna mounted on a conducting body, it is necessary to know not only the current distribution on the antenna but also that on the conducting body. However, it has been difficult to make these clear from experimental results and also from analytical results using the frequency domain method. On the other hand, the time–domain method[2][3] is recently becoming more and more useful with the improvement of computer performance. It is now possible to know such current distribution on a conducting body by using this method and a high performance computer.

An electromagnetic simulator for arbitrary shape models[4] was made on a super–computer employing SNM. First the electromagnetic field in the vicinity of the model was calculated by applying this simulator to an ordinary portable telephone model for the L band (Fig. 1). The region of the 3–dimensional lattice network was $80 \times 70 \times 90(\Delta d)$, Δd, where the unit length of the lattice, was $\lambda/40$. The far–field radiation pattern was calculated from the electromagnetic field on the surface of the closed–area over the model, as shown in Fig.2.

Figure 3 illustrates the normalized electrical field $|E\theta|$ patterns of the model in Fig. 1. There were beam separations at $\theta=60^\circ$ and 110°, contrary to the expectation from the characteristics of a $\lambda/4$–monopole antenna on an infinite grand plane, and the directivity at $\theta=90^\circ$ was weaker than that of the maximum value by 4(dB). It is usually suitable in terms of telecommunications that the directivity of an antenna have its maximum gain at $\theta=90^\circ$. So, there arises the necessity of improving such a radiation characteristic.

The experimental results are also plotted in Fig. 3. The experimental model had almost the same parameter as that of the simulation model, and measurements were made at 1.9(GHz). The experimental results agreed well with the results of simulation, so it shows that the accuracy of the simulation was sufficient.

On the other hand, the results of the magnitude and phase of the current distributions Ix and Iz on the x–z surface of the model is shown in Fig. 4. There was a relatively large standing wave of |Iz| from the vicinity of the feed point of the antenna to the bottom of the conducting body along the z–axis. And the phase of Iz at the 2nd peak ,the next peak of |Iz| at the feed point as shown in Fig.3, was contrary to the phase of Iz at the 1st peak ,the peak at the feed point. And it seems that the distribution of the current along the z–axis was rather close to that of the $3\lambda/2$–monopole antenna, so Iz on the conducting body can be considered as having a relatively large influence on the radiation characteristic.

3 THE CONDUCTING BODY WITH A NOTCH

A notch on the conducting body is proposed in order to improve the current distribution. The position of this notch is at about $\lambda/4$ from the feed point along the z–axis, and the length is about $\lambda/4$(see Fig. 5) and the width is Δd.

The results of the current distribution are shown in Fig. 6. In terms of the current Iz, the phase of the 2nd peak, as shown in Fig.6, was still contrary to the phase of Iz at the 1st peak in Fig.6, but its magnitude became lower so that the distribution of the current Iz was almost close to that of a $\lambda/2$–monopole antenna. And it is clear that the counter phase part of the current Iz changed to the current Ix along the notch.

Next, the $|E\theta|$ patterns by simulation and experiment are shown in Fig. 6. Both results are normalized by its maximum value In Fig. 3. Obviously, the value on the horizontal x–y plane increased, and the maximum directivity was almost close to θ=90° and the beam separation was reduced.

4 SUMMARY

This paper has described the radiation characteristic and the current distributions of a $\lambda/4$–monopole antenna mounted on a conducting body modeled as an ordinary portable telephone by simulation using SNM, and it has been shown that SNM was an effective measure for analyzing such a model by comparing the simulation result with an experimental result. Both results showed that the current on the conducting body gave an undesirable influence on the radiation of the antenna. A new method has also been proposed to prevent such an undesirable influence of the current by cutting a notch in the conducting body. And in terms of the radiation characteristic of the model with such a notch, the results of simulation and the experiment have indicated that good performance has been realized in terms of the radiation characteristic of the model with such a notch.

REFERENCES

[1]N.Yoshida and I.Fukai:" Transient analysis of a stripline having a corner in three–dimensional space," IEEE Trans. Microwave Theory and Tech.,MTT–32,No.5, pp.491–498,1984.

[2]P.B.Johns and R.L.Beurle:" Numerical solution of 2–dimensional scattering problems using a transmission–line matrix," Proc. of IEE,Vol.118,No.9 pp.1203–1208,1971.

[3]K.S.Yee:" Numerical solution of initial boundary value problems involving Maxwell's equations in isotropic media," IEEE Trans. Antennas & Propag.,AP–14, No.3,pp.302–307,1966.

[4]S.Sekine and T.Maeda:" An analysis of electromagnetic characteristics of antennas in the vicinity of a human–body model" 1991 Autumn Nat. Conv. Rec. IEICE. SB–1–6, Sept. 1991.

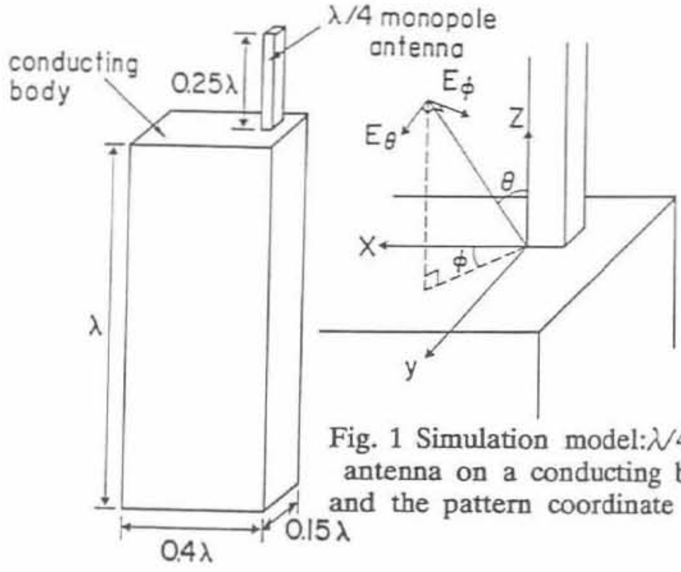

Fig. 1 Simulation model:λ/4–monopole antenna on a conducting body and the pattern coordinate system

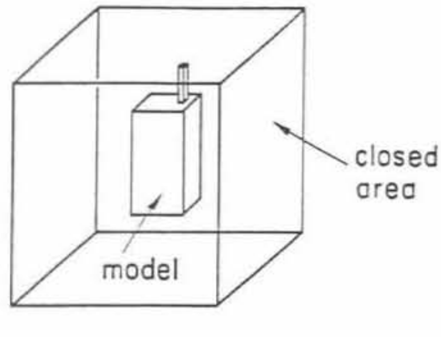

Fig. 2 Simulation model and closed area

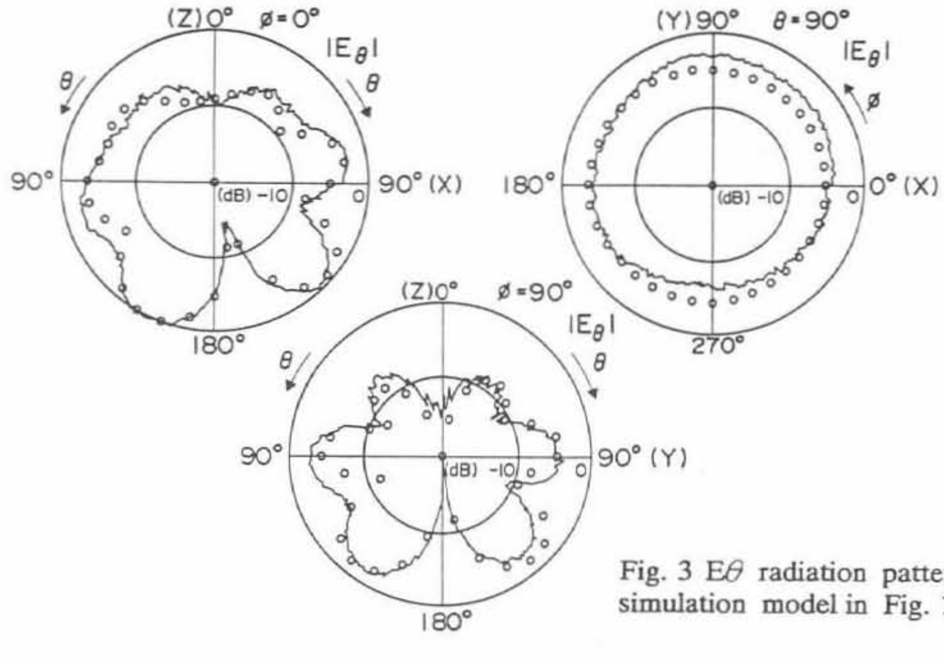

Fig. 3 Eθ radiation patterns of simulation model in Fig. 1

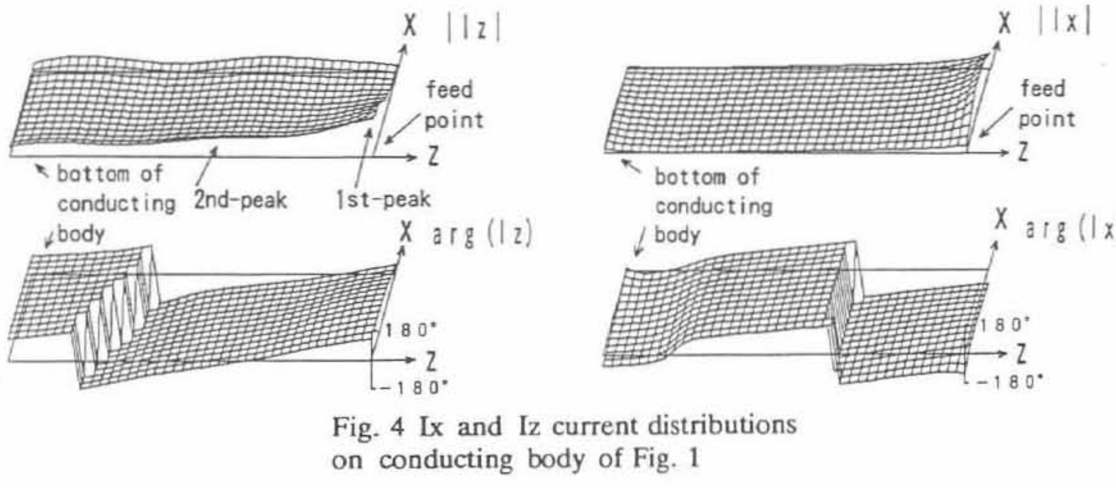

Fig. 4 Ix and Iz current distributions on conducting body of Fig. 1

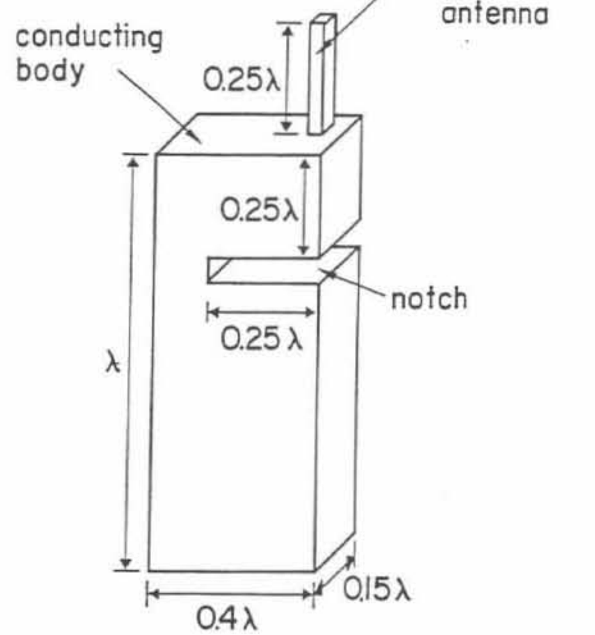

Fig. 5 Simulation model: λ/4–monopole antenna on a conducting body with a notch

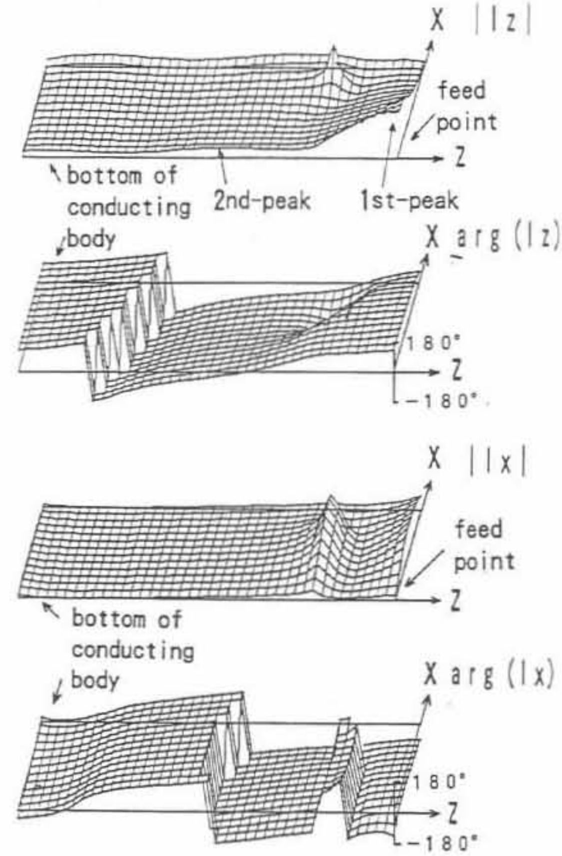

Fig. 6 Ix and Iz current distributions on conducting body of Fig. 5.

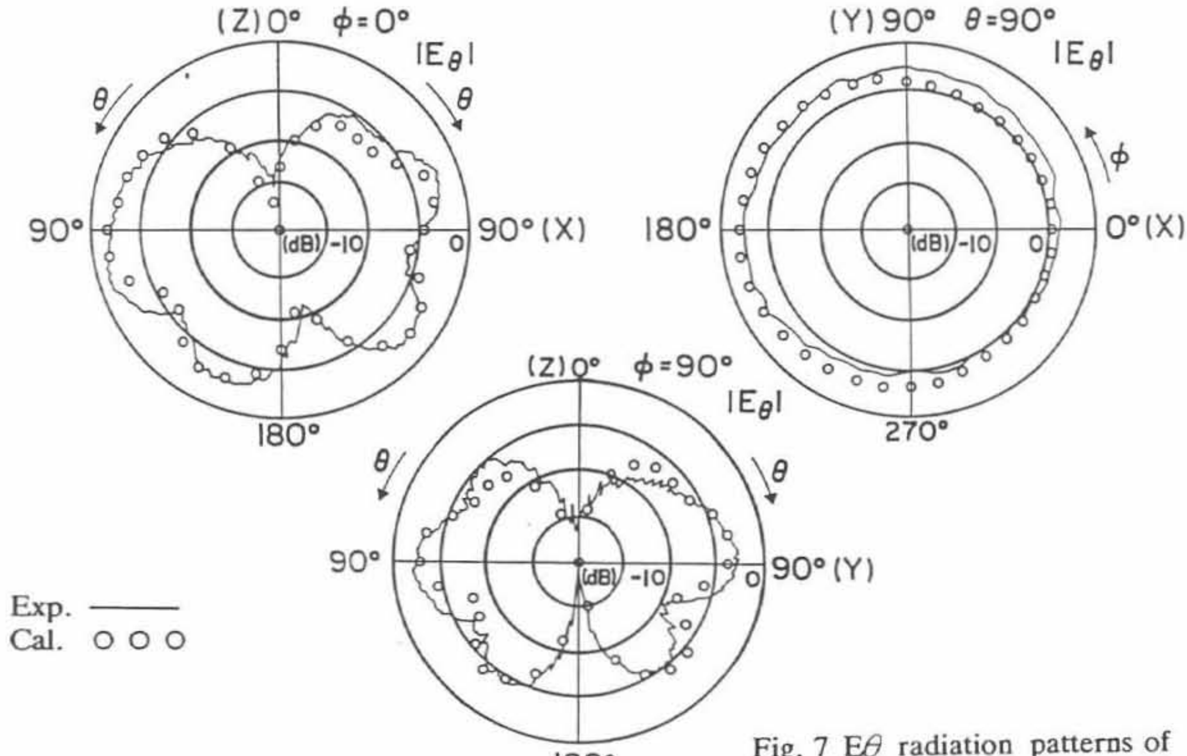

Fig. 7 Eθ radiation patterns of simulation model in Fig.5