THE INTERACTIONS BETWEEN A DIPOLE ANTENNA AND THE SPHEROIDAL MAN MODEL

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I INTRODUCTION Due to the recent rapid progress in portable/mobile communications, considerable attention has been paid to the possible interactions between antennas and the human being. These questions include, e.g., the effects of the radiated energy from antennas on a human body and the effects of the presence of a human body on antenna characteristics. The early works on these interactions have been carried out using planar, spherical and cylindrical models for the human body. In this paper, we use the more realistic spheroidal model and develop a theoretical analysis for the interaction between a nearby dipole antenna and the realistic human model.

II THEORETICAL ANALYSIS The geometry for the man model and the dipole antenna is shown in Fig.1. The spheroidal man model has the major axis 2a and the minor axis 2b. The electrical constants of the man model are assumed to be homogeneous and represented by relative dielectric constants ε_r, conductivity σ and free space permeability μ_0. The dipole antenna with length 2l and radius r is located at a distance of d from the surface of the spheroidal man model. The simultaneous integral equations with respect to the antenna current and the induced equivalent surface electric and magnetic currents are deduced from the boundary conditions on the antenna and the spheroidal man model surfaces. When the radius of curvature of the spheroidal surface is large enough in comparison with the skin depth, the magnetic currents can be related to the electric currents by using the surface impedance.[2] The integral equations are solved by the moment method[3] with respect to the

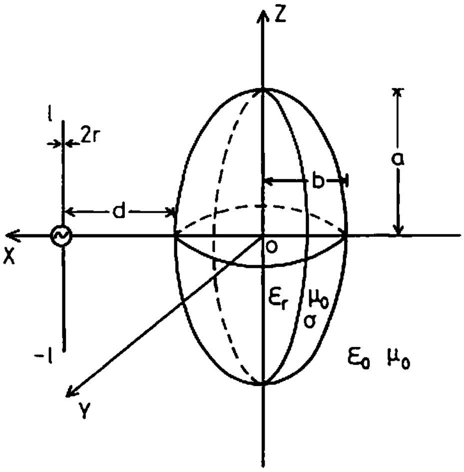


Fig.1 Geometry of the problem

unknown currents. As the spheroidal model shown in Fig.1 is rotationally symmetric, the unknown surface electric current on the model can be expanded into Fourier series with respect to the azimuthal angle. We use the sine waves for the antenna current and the triangle functions for the man model surface current, respectively as the basis functions.

III NUMERICAL RESULTS

The above method was applied to determine the current distributions on the antenna and the spheroidal man model surface. Numerical results calculated by using these currents are shown below. The size of the spheroidal man model are a=0.85m and b=0.15m. The man model is assumed to consist from tissues of high water content.[1]

a) Input impedance

The input impedance of the $\lambda/2$ dipole antenna at 150MHz was calculated. At this frequency the skin depth of the spheroidal model is 5.4cm. In Fig.2, the input impedance is shown versus d, the distance from the surface of the spheroidal model. It is observed that when the distance d becomes less than about $\lambda/20$ the input impedance increases very rapidly, and changes periodically as d increases to about one wavelength. As the distance d exceeds one wave length, the input impedance is very close to the value in free space.

b) Radiation Pattern

In Fig.3(a),(b), the radiation patterns are shown for the distances d=2cm, 20cm and 1m, at 150MHz. Fig.4(a),(b) show the radiation patterns for varying frequency. The shadowing effects of the body is indicated in these figures.

c) Absorbed Power

The absorbed power by into a human body W_a is calculated by

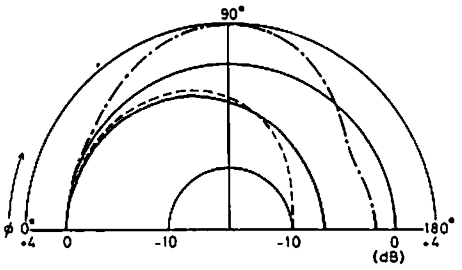
$$W_a = W_{in} - W_r \quad , \qquad (1)$$

where W_{in} is an input power of the antenna which is calculated from the antenna input current and the input resistance, and W_r is the radiated power which is calculated from the far radiated field. The average SAR (Specific Absorption Rate) of the whole body is given by

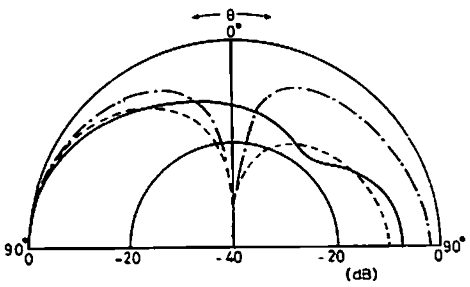
$$\text{Average SAR} = W_a / v_0 * 10^{-3} \quad [\text{W/kg}] \ , \qquad (2)$$

where v_0 is the volume of the spheroidal man model whose specific weight is assumed as unity. Average SAR calculated by (2) are shown in Fig.5 for W_{in}=1w. It is observed that when the antenna - body spacing is $\lambda/20$, more than 80 percent of the input power is absorbed into the body. In Fig.6, the average SAR in the whole body is plotted versus the frequency for the case where the $\lambda/2$ dipole antenna is located at the distance of 0.1m from the body. The absorbed power becomes maximum at about 88MHz which corresponds to the half-wave resonance frequency of the body. The SAR decreases rather rapidly in high frequency range above 500MHz.

IV CONCLUSION The interactions between a dipole antenna and a nearby human body have been analyzed theoretically by using the surface impedance method and the moment method. As a result the effects of the body on the antenna characteristics, the absorbed power into the body are clarified. For example, a considerable portion of the input power is absorbed in the body near a resonance frequency.



(a) H-Plane



(b) E-Plane

Freq.=150MHz a=0.85m —— 0.02 m
ε_r= 62.0 b=0.15 m --- 0.2 m
σ = 0.98 S/m l=0.25λ —·— 1.0 m

Fig.3 Radiation pattern of the $\lambda/2$ dipole antenna near the human body at 150MHz with d= 2cm, 20cm and 1m.

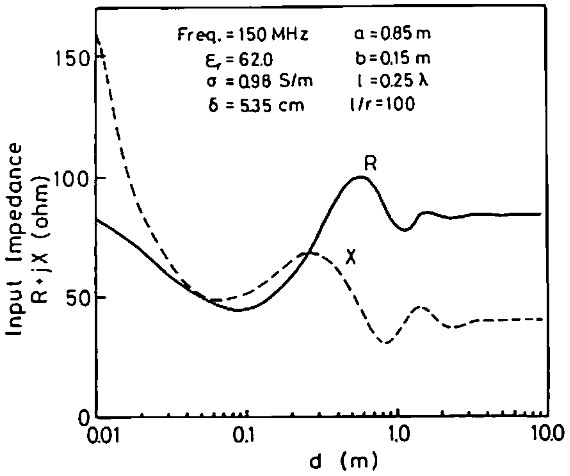
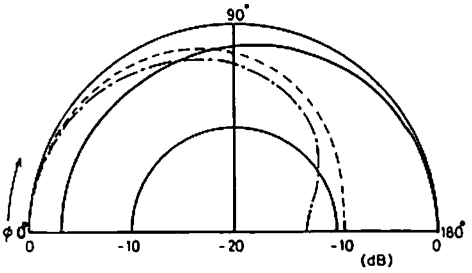
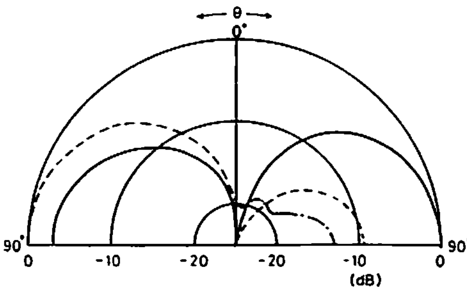


Fig.2 Input impedance of the $\lambda/2$ dipole antenna vs. the distance d at 150MHz.



(a) H-Plane



(b) E-Plane

a=0.85 m ———— 80 MHz
b=0.15 m ---- 150 MHz
l=0.25 λ —·—·- 300 MHz

Fig.4 Radiation pattern of the $\lambda/2$ dipole antenna near the human body at d=0.1m with frequency 80, 150 and 300MHz.

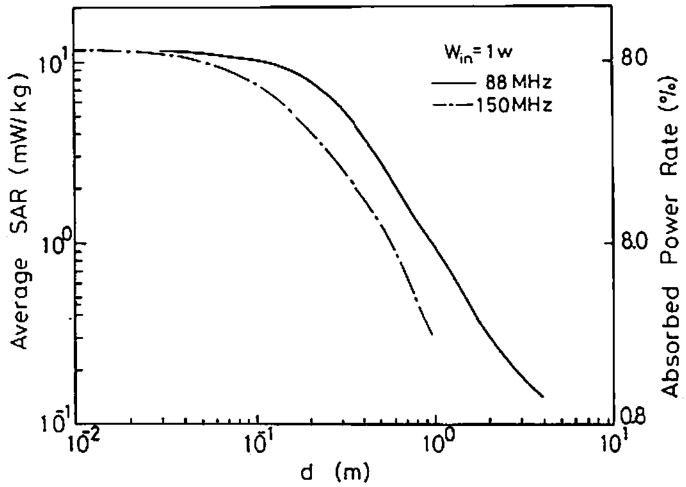


Fig.5 Average SAR of the whole body vs. the distance d at 88MHz and 150MHz.

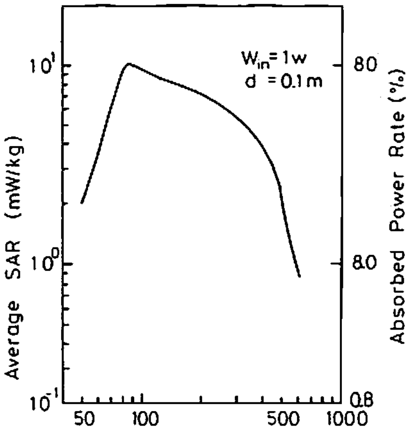


Fig.6 Average SAR of the whole body vs. the frequency with d= 10cm.

References

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[3] R. Mittra ed.;"Computer techniques for electromagnetics", PERGAMON PRESS, New York (1973)