SAR inside Human Body Protected by Lossy Dielectric Shield

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INTRODUCTION

In immunity tests, experimenters have to operate test equipment directly in the test site during their experiments and are frequently exposed to strong EM waves.

Many studies about the biological effects are reported. But there are quite a few reports on protections of human bodies against EM waves.

In this paper, a protection method against EM waves is proposed by a semicircular arc shield made of lossy dielectric materials behind which the experimenters can safely work in the test site.

Under TM plane waves illumination, the reduction of SAR inside a cylindrical human model by the shield is calculated. A case that the average SAR is reduced to 1/5 is discussed as an example of the protection effects.

On the immunity tests, it is also important that scattered waves from the shield and the human body should not affect the test equipment. Directions where the EM waves scatter strongly are also calculated.

The calculated results show that the SAR and the scattering patterns are affected by the loss, thickness of the shield and positions of the human model.

SHIELD AND HUMAN MODEL

As shown in Fig.1, the cylindrical human model is located behind the lossy dielectric shield shaped into the semicircular arc. The human model (radius a_1=11.28[cm][1], complex permitivity ε_1: 2/3 muscle model[2]) and the shield (inner radius a_2=75.0[cm]) is infinitely long along the z-axis. The center of the human model is located at (x_0, y_0).

For the incident TM plane waves, the frequency and the power density are respectively f=300[MHz] and P=1[mW/cm^2].

CALCULATION OF FIELD

First, when the thickness d and the complex permitivity ε_2 of the shield are varied, the SAR and the scattering patterns are calculated.

Secondly, when the human model is moved behind the shield, the effects by the movement are discussed.

On the calculation of the EM fields, "Source and Radiation Field Solution"[3] proposed by Ito and Tokumaru is used.

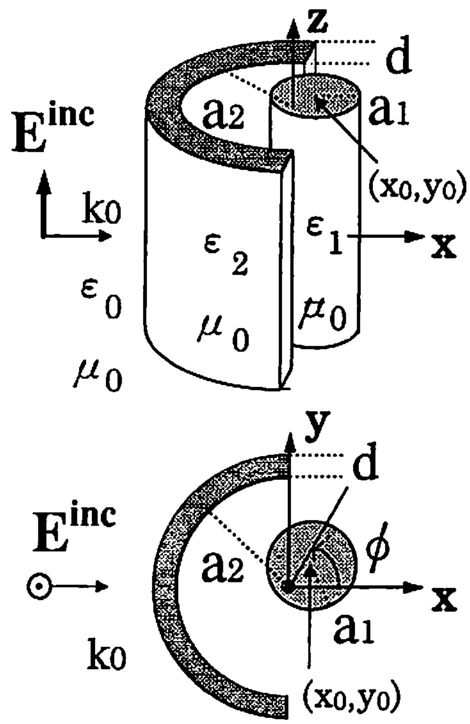


Fig.1 Lossy dielectric shield and cylindrical human model

The secondary source (polarization current) and the scattering pattern can be obtained simultaneously by this solution method. In two dimensional problems of scattering from a dielectric, the effectiveness of this method is verified[3].

Local SAR are calculated using electric fields (polarization currents) inside the human model obtained by this method. Average SAR is calculated using the local SAR

SAR AND SCATTERING PATTERNS

Effects by the Shield

The average SAR vs. thickness d in the case of the human model located inside the shield ($x_0=y_0=0$[cm]) is shown in Fig.2.

Since the absorption of the EM waves in the shield increases with the increase of d , the average SAR decreases. In the case of d=2[cm], $\varepsilon_2=(11.4-j20.2)\varepsilon_0$, the average SAR is reduced to about 20% of the case that the human model is without the shield. In the case of d=6[cm], the average SAR decrease to 5%. So, the thicker shield is much better concerning the SAR.

Fig.3 shows the scattering patterns in the cases of d=2[cm] and 6[cm]. When the shield is thicker, side lobes become larger. Therefore, to reduce scattered waves , the shield should be thinner.

Then, as an example, we choose the parameters as d=2[cm] and $\varepsilon_2=(11.4-j20.2)\varepsilon_0$ that can reduce the SAR to 20% and keep the side lobe level low.

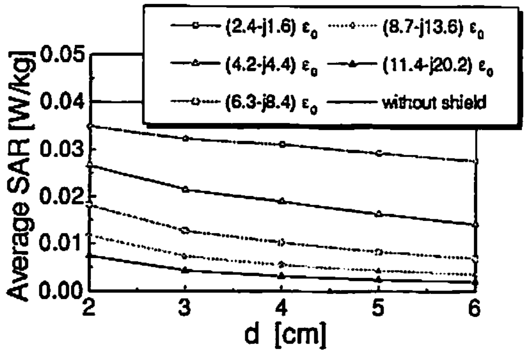
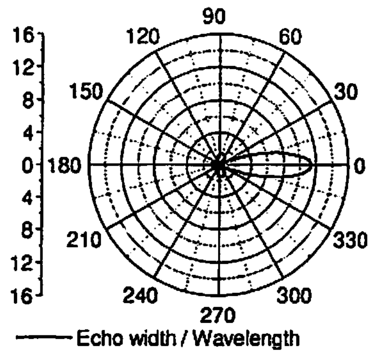
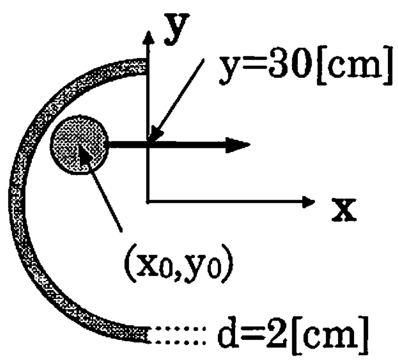


Fig.2 Average SAR vs. thickness

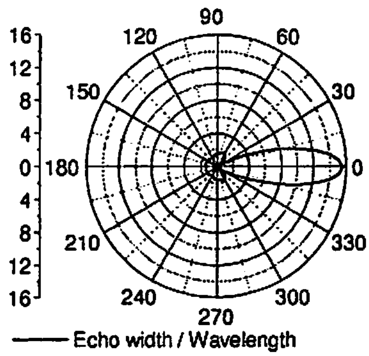


(a) d=2[cm]



$\varepsilon_2=(11.4-j20.2)\varepsilon$

Fig.4 Movement of human model



(b) d=6[cm]

Fig.3 Scattering patterns ($\varepsilon_2=(11.4\text{-}j20.2)\varepsilon_0$)

<u>Effects by the human model location</u>

When the human model moved behind the shield as shown in Fig.4, the SAR and the scattering patterns are calculated.

Fig.5 shows the local SAR on the surface of the human model where a peak SAR appears. In the case of $x_0=-30$[cm], the peak SAR is reduced to about 12% and appears at the point (ϕ=190[deg]) on the surface. When the human model is outside the semicircular region formed by the shield (x_0=30[cm]), the peak SAR appears at a point on the surface (ϕ=210[deg]) near the center of the shield (origin) . It is considered that the EM waves gather near the origin because of the so called lens effects.

Fig.6 shows the scattering pattern in the case of $x_0=-30$[cm] where the highest side lobe is in the direction of ϕ =300[deg]. In this case, the EM wave is not scattered to the direction of ϕ =330[deg]. For this kind of scattering pattern, the locations of equipment should be considered carefully.

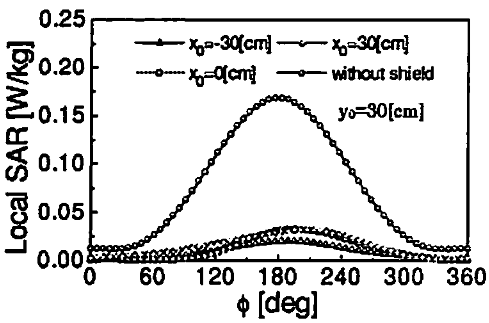


Fig.5 Local SAR on surface of human model

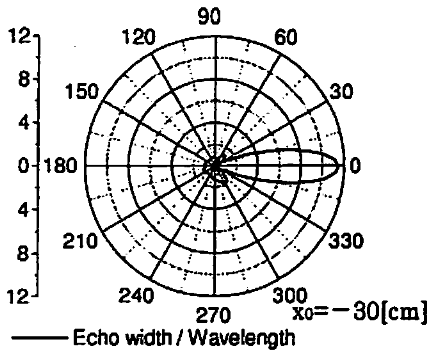


Fig.6 Scattering pattern (d=2[cm], $\varepsilon_2=(11.4-j20.2)\varepsilon_0$)

CONCLUSION

The reduction of the SAR inside the cylindrical human model by the lossy dielectric shield against TM plane waves were calculated. The scattering patterns from the shield and the human model were also calculated. As a result, we found parameters of the shield and the position of the human model behind the shield to reduce the SAR adequately and hold the side lobe level low. The protection effects for a human body by this shield are shown. However, the locations of the equipment should be chosen carefully not to receive high EM waves and can be found from the scattering patterns.

REFERENCES

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