AN APPROXIMATE METHOD OF THE BACKSCATTERING FROM POLYHEDRON STRUCTURES

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Introduction

Study of electromagnetic backscattering from arbitrary shaped bodies have been reported by various authors. Approximate methods of backscattering have been given for a few simple geometrical bodies. Recently, the equivalent current concept for the backscattering from flat plates was reported by Sikta et al. [1]. In this concept, the flat plate is represented by a series of strips, where the width of the strips approaches zero. So, the backscattering is calculated by using only the components of the currents perpendicular to the incidence plane.

In this paper, the equivalent current concept [1] is extended and it's concept is applied to the calculation of the backscattering from polyhedron structures. In the case of the backscattering from flat plates, this approximate method reduces to that of Sikta et al. [1]. The calculated backscattering of a finite rectangular cylinder shows good agreement with the experimental results [2].

Approximate method

Equivalent currents on the wedge are obtained by using the diffraction field given by the geometrical theory of diffraction(GTD). When the plane wave is perpendicularly incident to the wedge, the equivalent currents in the usual form are given by [3].

$$I^e = j\,\frac{2(E^i\cdot\hat{\beta}')}{kZ}\,G_s \tag{1}$$

$$I^m = j\,\frac{2(E^i\cdot\hat{\phi}')}{k}\,G_h \tag{2}$$

$$G_{h}^{s} = \frac{\sin\pi/n}{n}\left(\frac{1}{\cos\pi/n - \cos\{(\phi-\phi')/n\}} \mp \frac{1}{\cos\pi/n - \cos\{(\phi+\phi')/n\}}\right) \tag{3}$$

Where ϕ' and ϕ are the incident and diffraction angles, respectively, and $(2-n)\pi$ is the wedge angle as shown in Fig. 1. The unit vectors $\hat{\beta}'$ and $\hat{\phi}'$ are vectors showing the increasing direction of β_0 and ϕ' on the incident wave side as shown in Fig. 1. E^i is the incident field at the wedge. Z is the intrinsic impedance of the medium. G_s (G_h) is the soft (hard) scalar diffraction coefficient [4] given by GTD. These equivalent currents become infinite when the observation point is at either a shadow ($\phi-\phi'=\pi$) or reflection ($\phi+\phi'=\pi$) boundary. In the case of flat plates, the strip model was introduced by Sikta et al. [1], and this problem was solved.

Now, the backscattering from polyhedron structures is considered, the diffraction coefficient (3) is arranged and the equivalent currents (1) and (2) are rewritten as follows:

$$I^e = \sum_{i=1}^{2} I_i^e = \frac{j}{kZ}\sum_{i=1}^{2}(E^i\cdot\hat{\beta}_i')\,G_s^i \tag{4}$$

$$I^m = \sum_{i=1}^{2} I_i^m = \frac{j}{k}\sum_{i=1}^{2}(E^i\cdot\hat{\phi}_i')\,G_h^i \tag{5}$$

$$G_{\substack{s\\h}}^i = -\frac{1}{2}\,\frac{1}{n}\left(\frac{\cos\dfrac{\pi-(\phi_i-\phi_i')}{2n}}{\sin\dfrac{\pi-(\phi_i-\phi_i')}{2n}} \mp \frac{\cos\dfrac{\pi-(\phi_i+\phi_i')}{2n}}{\sin\dfrac{\pi-(\phi_i+\phi_i')}{2n}}\right) \tag{6}$$

Where ϕ_i' and ϕ_i are the incident and diffraction angles from the plane i (i=1,2) which are shown in Fig. 2, respectively. Similarly, $\hat{\beta}_i'$ and $\hat{\phi}_i'$ are vectors in relation to the plane i as shown in Fig. 2. The equations (4) and (5) show that the equivalent currents I^e and I^m on a wedge are the sum of the currents I_1^e and I_1^m determined by angles ϕ_1' and ϕ_1 from the plane 1 and the currents I_2^e and I_2^m determined by angles ϕ_2' and ϕ_2 from the plane 2. For the backscattering calculation ($\phi_i = \phi_i'$), the contribution given by the currents I_1^e and I_1^m is dominant in the region where the incident wave is in the plane 1 side and the contribution given by the currents I_2^e and I_2^m is dominant in the plane 2 side. Therefore, it is considered that the currents of a wedge can be expressed by the sum of I_1^e, I_1^m in plane 1 and I_2^e, I_2^m in plane 2.

For the backscattering from polyhedron structures, the equivalent currents on the wedge are given by I^e, I^m which are the sum of I_1^e, I_1^m in plane 1 and I_2^e, I_2^m in the plane 2 as shown in Fig. 3. In Fig. 3, the strip model by Sikta et al. [1] is applied in each plane. Now, the backscattering from polyhedron structures can be calculated by using the equations (4) - (6) without special treatment of the singularity in the diffraction coefficient.

Numerical results

The backscattering from a finite rectangular cylinder has been computed. The calculated results are shown in Fig. 4 with the experimental results [2]. It can be seen that the agreement is very good.

Conclusions

The backscattering from polyhedron structures has been calculated by the equivalent currents. This method has no difficulty in any observation direction. For the flat plates, this method reduces to that by Sikta et al. [1]. Numerical examples are compared with experimental results. The agreement is very good, and the validity of the present method is comfirmed.

References

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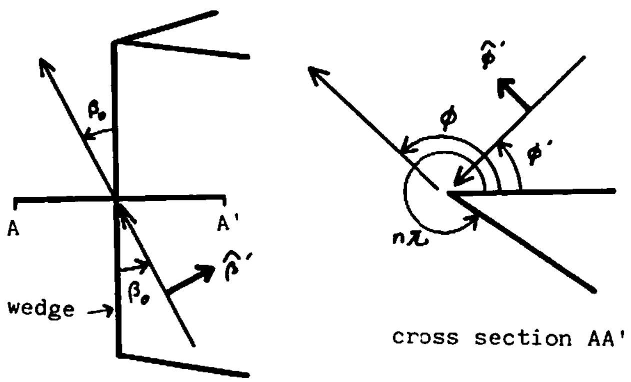


Fig. 1 Wedge geometrical

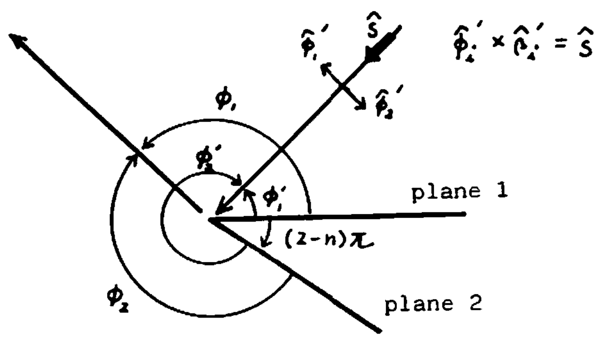
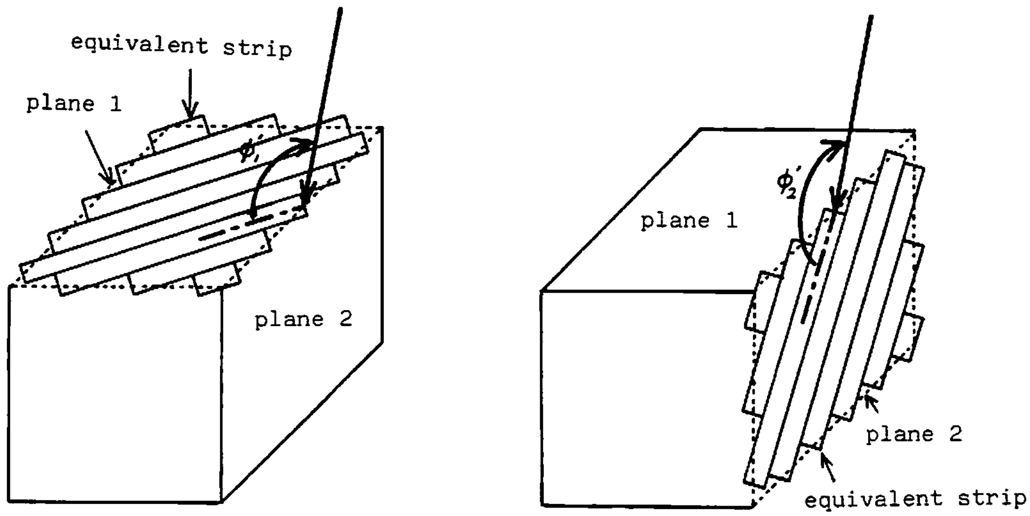
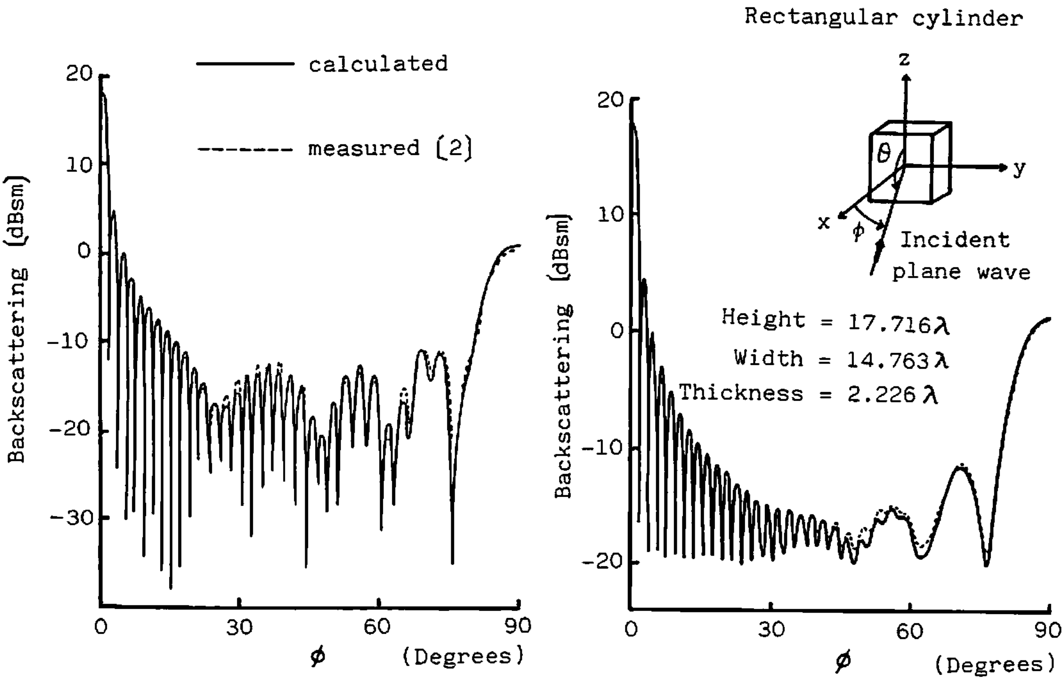


Fig. 2 Difinitions of ϕ_1', ϕ_1, ϕ_2' and ϕ_2



(a) strip model in plane 1 (b) strip model in plane 2

Fig. 3 Strip models of polyhedron structure



(a) Horizontal polarization (b) Vertical polarization

Fig. 4 Backscattering ($\theta=90^\circ$) from a rectangular cylinder at 35.34GHz