DIFFRACTION BY A DIELECTRIC WEDGE WITH DISTRIBUTED CORRECTION CURRENTS ON THE INTERFACES

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One of the fundamental problems in electromagnetic scattering is the diffraction by a dielectric wedge, which is canonical for the calculation of edge diffraction from dielectric objects. In spite of its simple geometry, a rigorous solution to this problem is not avaiable to date(1). Physical optics approximation with a multipole line source at the edge of the wedge yields an efficient calculation of asymptotic fields far from the edge for arbitrary relative dielectric constants and wedge angles(2,3). A new field representation valid not only in the far zone but also in the near zone of the edge is obtained by assuming distributed correction currents on the dielectric interfaces. These correction currents are forced to satisfy the edge condition of the static limit.

When a plane wave polarized in the edge direction is incident on a dielectric wedge, as shown in Fig. 1, the total field may be obtained by solving a dual integral equation in the spectral domain(2,3). Physical optics solution for the dielectric wedge may be obtained from the boundary fields of the geometric optical solution. Physical optics solution gives reflected, refracted, and transmitted fields from the dielectric interfaces and edge diffracted fields. A correction field may be defined such that physical optics approximation plus the correction field satisfy the original dual integral equation. It is shown that this correction field modifies only the edge diffracted field of the physical optics solution(2,3). One may choose arbitrary sheet currents along the dielectric interfaces as a correction source to give such correction fields. These currents may be expanded in a series of Bessel functions known as Neumann's expansion. For the static potential, closed form solution is known for this problem(4). The dynamic field behavior near the edge may be assumed to be the same as for the static limit. Therefore, one may choose the fractional orders for the Bessel functions in the Neumann's expansion to satisfy this static edge condition. Expansion coefficients of the correction currents may be obtained from the dual integral equation which provides the correction fields from the physical optics solution. Dual integral equation then yields a dual series equation for the expansion coefficients, which involves integrals yet to be evaluated in the near field region but is easily obtainable in the far field region. For the fast convergence of the expansion coefficients in the far region, however, another series equivalent to Neumann's expansion is obtained.

Electric and magnetic sheet currents are assumed on the two interfaces. About five series coefficients for each currents (total of 20) and the corresponding total fields are calculated. This result is compared with that of the multipole line source as shown in Fig. 2. Dotted curves represent the pattern function

of the edge diffraction of the physical optics solution. Real curves are calculated by solving a dual series equation and are supposed to coincide the dotted line in one region(inside the wedge) and yield a correction for the edge diffraction of the physical optics solution in the other region (outside the wedge). The result of Fig. 2(a) obtained from the multipole line source at the edge shows more deviation between two curves than that of Fig. 2 (b) obtained from the distributed currents. The total diffraction pattern including this correction of the edge diffrection, however, is less affected from these deviations and these two calculations give similar results.

Peferences

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(4) G.A. Greenberg, "On a method of solving the fundamental problem of electrostatics and allied problems," Zh. Exp. Teor. fiz. (Russian), Part. 1, Vol. 8, no. 3, pp. 221-252, Mar. 1938.

Figure Captions

Fig. 1. Geometry of dielectric wedge.

Fig. 2. Real parts of edge diffracted pattern function in case of wedge angle $\theta_0 = 45^\circ$, incident angle $\theta_i = 150^\circ$, relative dielectric constants $\epsilon = 2$, 10, and 100.

(a). Correction by multipole line source at tip of wedge

(b). Correction by distributed sheet currents on the interfaces.

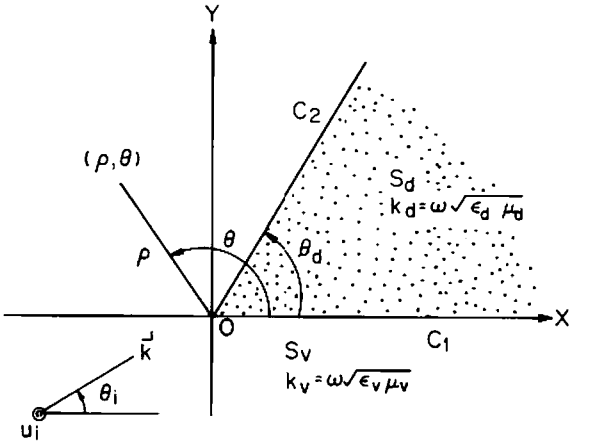
Y
C2
(ρ,θ)
Sd
kd=ω√εd μd
θ
ρ
θd
X
O
C1
k
Sv
kv=ω√εv μv
θi
ui

Fig. 1

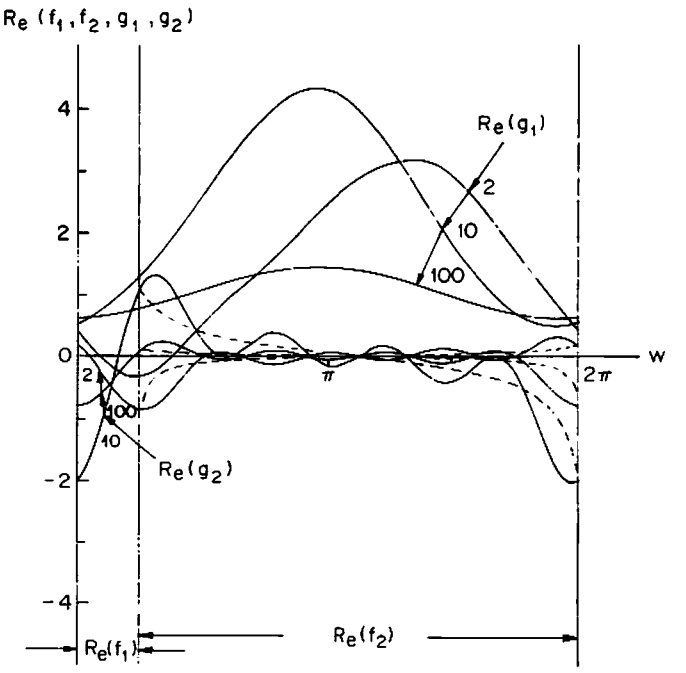
Re (f1, f2, g1, g2)
4
2
0
-2
-4
Re(g1)
2
10
100
w
π
2π
2
100
10
Re(g2)
Re(f1)
Re(f2)

Fig. 2.a

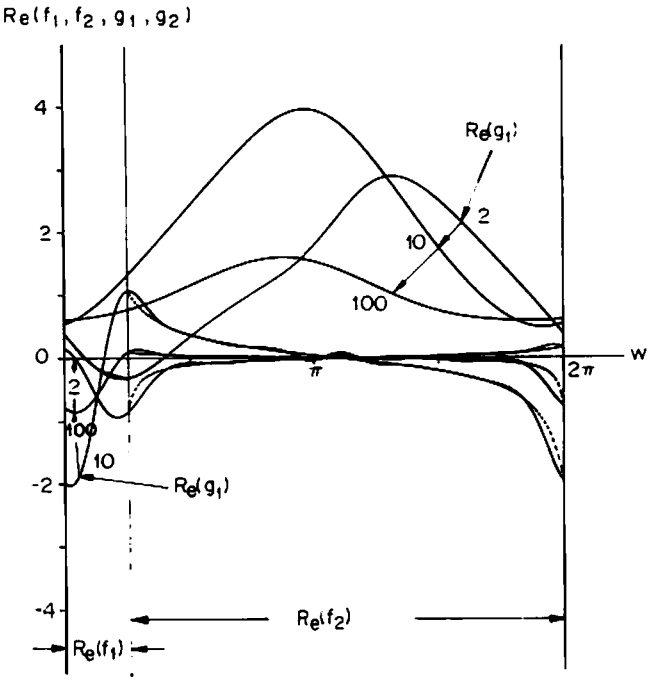

Fig. 2.b