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Wave diffraction by the junction between resistive and soft-hard half-screens

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ABSTRACT

The scattering process of planes waves by a junction between resistive and soft/hard half-planes is investigated. First of all, the initial and total geometrical optics fields are determined by considering the related geometries. The scattered geometrical optics wave is obtained by subtracting the initial field from the total geometrical optics wave. The diffracted fields are derived by taking into account the behaviour of the geometrical optics wave at the reflection and shadow boundaries. The uniform expressions of the diffracted waves are constructed with the aid of the uniform theory of diffraction. The total field expressions are examined numerically.

1. Introduction

The scattering problem of electromagnetic waves by a junction between two half-planes, which have different boundary conditions, is an important problem that have application in wave propagation over terrain with different electromagnetic properties, land-sea transitions and aircrafts that include various material parts. In 1988, Rojas studied the diffraction of waves by a sheet junction between two half-planes with different face impedances with the aid of Wiener-Hopf factorization [1]. Later he obtained the solution of the same configuration as a special case of the impedance wedge problem [2]. Uzgoren et al. derived the high-frequency diffraction fields of the scattering scenario of plane waves by the junction between resistive and impedance half-screens [3,4]. Their results were also confirmed by Senior [5,6], who solved the same problem with the plane wave spectrum approach of Clemmow [7]. Another problem type is the diffraction of light by a nonplanar junction between perfectly conducting and resistive or resistive-resistive half-planes [8,9]. This geometry can be thought as a wedge with wide inner angle. We also studied the scattering problem of waves by a circular contour between two impedance surfaces by the method of boundary diffraction wave [10].

The aim of this paper is to investigate the diffraction of electromagnetic waves by a planar junction between resistive and soft-hard half-planes. A resistive surface is a thin layer of dielectric and is modelled mathematically by the jump boundary conditions [11]. A half-plane with soft and hard boundary conditions on its upper and lower surfaces is introduced artificially in the literature [12,13]. The soft and hard surfaces can be obtained by making the impedance of a surface very large and zero respectively. A similar scenario, which was consisting of transmissive and soft-hard half-planes, was investigated by Buyukaksoy et al. with the method of Wiener-Hopf factorization for acoustic waves [14]. They obtained two separate expressions for the diffracted wave in the lower and upper regions of the problem. Also the uniform diffracted fields were not obtained in that study. We will propose a new approach in the solution of the problem. First of all, the initial fields which are only geometrical optics (GO) wave for the case of a whole resistive sheet. Then the total GO fields will be determined when

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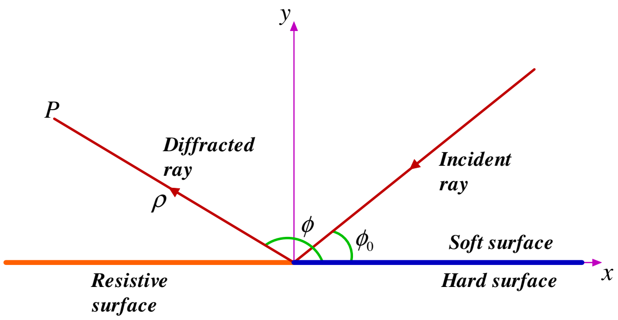

Fig. 1. The geometry of the diffraction problem.

the sheet junction exists. The scattered GO waves will be obtained by subtracting the initial fields from the total GO waves. The diffracted field expression will be constructed from the behaviour of the scattered GO wave at the transition boundaries. The uniform expressions of the diffracted fields will be derived by the uniform theory of diffraction. The behaviour of the total waves will be examined numerically.

A time factor of $\exp(j\omega t)$ will be suppressed throughout the paper. ω is the angular frequency.

2. The definition of the problem

Two half-screens, laying at the plane of $y = 0$, intersect along the z axis. On the half-plane, located at $x > 0$, the z component of the electric field intensity satisfies the Dirichlet (total field is equal to zero) and Neumann (normal derivative of the total field is equal to zero) boundary conditions at $y = 0^+$ and $y = 0^-$ respectively. The half-screen, at $x < 0$, is resistive with a surface resistivity, defined by R_E. The electric field intensity of the incident plane wave is given by

$$\vec{E}_i = \vec{e}_z E_0 e^{jk\rho\cos(\phi-\phi_0)} \tag{1}$$

where E_0 is the complex amplitude and Φ_0 angle of incidence. k is the wave-number. The cylindrical coordinates are shown by (ρ, Φ, z). The geometry of the problem is given in Fig. 1. P is the observation point.

The z component of the total electric field intensity satisfies the boundary conditions

$$E_{Tz}\big|_{\substack{x>0\\ y=0^+}} = 0 \quad , \tag{2}$$

$$\frac{\partial E_{Tz}}{\partial y}\Big|_{\substack{x>0\\ y=0^-}} = 0 \ , \tag{3}$$

$$E_{Tz}\big|_{\substack{x<0\\ y=0^+}} = E_{Tz}\big|_{\substack{x<0\\ y=0^-}} \tag{4}$$

and

$$E_{Tz}\big|_{\substack{x<0\\ y=0^+}} = \frac{1}{j2k\sin\theta}\left(\frac{\partial E_{Tz}}{\partial y}\Big|_{\substack{x<0\\ y=0^+}} - \frac{\partial E_{Tz}}{\partial y}\Big|_{\substack{x<0\\ y=0^-}}\right) \tag{5}$$

on the surfaces of the half-screens [15]. Note that the total field is the sum of the incident and scattered waves. $\sin\theta$ is $Z_0/2R_E$. Z_0 and R_E are the impedance of free space and resistivity of the surface respectively. The problem is the determination of the diffracted wave that is excited when the incident field, given in Eq. (1), illuminates the configuration.

3. Solution of the problem

The first step in the determination of the diffracted waves is the evaluation of the scattered GO field. The total electric field intensity can be written as

$$E_T = E_{in} + E_S \tag{6}$$

for E_S is the scattered wave and put forts the effect of the obstacle on the wave propagation [16]. From now on, we will omit the subscript z because of the symmetry in the fields according to the z axis. E_{in} shows the initial fields, which occur when