DIFFRACTION GRATING PROFILE RECONSTRUCTION: SIMPLE APPROACHES TO SOLVING APPLIED PROBLEMS

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ABSTRACT

R.J.Wombell and J.A.De Santo have presented in their paper (Wombell and De Santo, 1991) the computational scheme which implementation made possible sufficiently good reconstruction of one-dimensional rough-surface profile with small roughness when a single frequency and a single viewing angle are used. The basic idea of the method (quasilinearization of integral relations of potential theory) turns out to be reasonably universal with respect to numerically solvable inverse boundary value problems and can give rise a large body of simple algorithms being efficient both in long wavelength and resonance frequency regions. Certain of these potentialities are analyzed in our paper. Reflecting grating with an arbitrary profile (a classical object in wave scattering theory) has been chosen as a model structure.

1. DIRECT PROBLEM OF THE DIFFRACTION GRATING

Consider a grating (see Fig.1, the structure is uniform in x-direction) placed in the field of a plane E-polarized electromagnetic wave $U^i(y,z)=E_x^i=\exp[i(\Phi_0 y-\Gamma_0 z)]$, $E_y=E_z=H_x=0$. The direct diffraction problem is reduced to determination in the region $Q=\{\{y,z\}:-\infty<y<\infty;\ f(y)<z<\infty\}$ of twice continuously differentiable function $U(y,z)=E_x=U^i+U^s$ (the total field) which is the solution of the homogeneous Helmholtz equation

$$\left(\frac{\partial^2}{\partial y^2}+\frac{\partial^2}{\partial z^2}+k^2\right)U(y,z)=0,\qquad \{y,z\}\in Q, \tag{1}$$

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with boundary conditions

$$\left\{U, \frac{\partial U}{\partial y}\right\}(y+2\pi, z) = e^{i2\pi\Phi_0}\left\{U, \frac{\partial U}{\partial y}\right\}(y, z); \quad U(y, f(y)) = 0 \tag{2}$$

and radiation conditions

$$U(y,z) = U^i(y,z) + \sum_{n=-\infty}^{\infty} a_n e^{i(\Phi_n y + \Gamma_n z)}, \qquad z \geq 0. \tag{3}$$

$E_{(\ldots)}$ and $H_{(\ldots)}$ are the components of electric and magnetic field strength vectors; $\Gamma_n = \sqrt{k^2 - \Phi_n^2}$, $\mathrm{Im,Re}\Gamma_n \geq 0$; $\Phi_n = n + \Phi_0$, $n = 0, \pm 1, \ldots$; $\Phi_0 = k \sin\alpha$; $k = 2\pi/\lambda$ is a frequency parameter; λ and α are wavelength and angle of incidence of a plane wave; $f(y)$ is 2π-periodic real function. The problem is considered in the dimensionless space-time coordinates, in which the period of the structure is 2π and the time dependence is defined by the factor $\exp(-ikt)$.

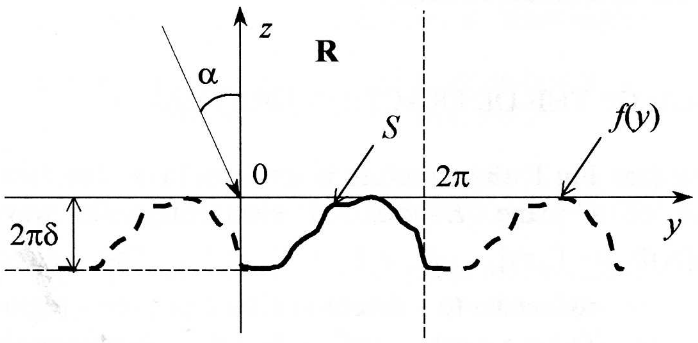

FIGURE 1. Perfectly conducting grating.

The problem (1)-(3) is uniquely resolvable for all real k except a countable set of k that may has accumulation points only at infinity (Shestopalov and Sirenko, 1989). It is known (Shestopalov and Sirenko, 1989, Colton and Kress, 1983) that its solution everywhere in $\mathrm{R} \setminus S$