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A MATHEMATICAL MODEL OF ELECTROMAGNETIC WAVE SCATTERING BY AN IMPEDANCE CIRCULAR CYLINDER

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The paper gives relationships for calculating the scattering characteristics of a radar object in the shape of a circular cylinder whose surface is coated with a material with impedance properties. The scattering matrix coefficients are obtained with the use of impedance boundary conditions. Results of investigation of the surface impedance impact on the scattering characteristics of a circular cylinder are presented.

The design and effectiveness estimation of radar systems are impossible without a priori knowledge of the scattering characteristics of objects of various shapes. Particularly, an object under observation may represent a circular cylinder whose surface is covered with some radio absorbing material or coating to modify the scattering characteristics. The most efficient way to obtain the main quantitative index characterizing the scattering fields (the effective scattering area (ESA) σ of target) is simulation of electromagnetic interaction of radio waves with the object under investigation based on a strict electrodynamic model [1, 2]. Imperfection of the known models of electromagnetic wave scattering by impedance bodies [3–4] points to actuality of this line of inquiry.

The purpose of this paper is to set up a mathematical model of the electromagnetic field scattering from an anisotropic impedance circular cylinder, and to investigate the impact of the impedance parameters on the scattering characteristics.

When constructing the new mathematical model, the following assumptions were made at the formalization stage: the process is stationary; the body in its generatrix direction is homogeneous and has a size (the length L) exceeding substantially the wavelength λ of the radiation field ($L >> \lambda$), i.e., is protracted in this direction (for such objects the impact of the end faces of the cylinder of radius a for a certain spatial sector is negligible [2]); the cylinder radius is commensurable with the wavelength; the incident wave in the point of the object location is planar (monochromatic) and has a definite polarization; the amplitude of the reflected wave is measured at an infinitely large distance from the scattering object.

Depending on the required accuracy of calculations, the marginal distance to the object, when we may neglect the wave sphericity (in the diffraction problem this distance corresponds to the remote zone), is defined by the condition

$$r_{\min} \geq bL_{\max}^2 / \lambda \qquad (1)$$

where $b = 1,..., 4$; and $L_{\max}$ is the largest size of the object in the direction transversal to the wave propagation.

With regard for the above assumptions and simplifications, the matrix of ESA per unit length, in the polarization linearly orthogonal basis and quasistationary approximation, is defined by the formula [5]

$$\sigma = \begin{bmatrix} \sigma_{\theta\theta} \sigma_{\theta\varphi} \\ \sigma_{\varphi\theta} \sigma_{\varphi\varphi} \end{bmatrix}. \qquad (2)$$

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