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REFLECTIVE PROPERTIES OF GRID STRUCTURES WITH DIELECTRIC COATING

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ABSTRACT

The based on the solution of an integral equation method for calculating electrodynamic characteristics of a half-wave dipole located above the grid screen with dielectric coating is considered in the article. The acquired analysis results allow to estimate the influence of geometric parameters of the screen and dielectric parameters on radiation characteristics.

Grid screens are widely used in antenna techniques. They are used in various devices for electromagnetic protection, as reflectors of mirror and dipole antennas, as screens of passive retranslation. Depending on the function of antenna system application of a grid screen allows to solve such problems as mass reduction, wind impact reduction etc. While exploiting these systems quite possible is the formation of different kinds of thin coating, ice for instance, that can be approximated to an ideal dielectric. That is the practical importance of the research work concerned with modeling of electrodynamic properties of grid structures.

Usually the reflective properties of grid screens are considered using the results of solving the task of a plane electromagnetic wave incident on the grid of infinite dimensions [1]. But in practice we deal with systems of finite dimensions.

The purpose of this work is to model the radiation characteristics of half-wave dipole located above the grid screen covered with dielectric and to determine the dependence of these characteristics on dielectric permittivity and dielectric layer thickness.

The solution of this task was found within the limits of thin-wire aproximation usig an integral equation which is an analogue of Pocklington's equation for thin ideal conductors [2]:

$$\int_L I(s')K(s,s')ds' = i\omega\varepsilon_0 E_\tau^i \quad (1)$$

$$K(s,s') = -k^2\overline{ss}'G_a(s,s') + \frac{1}{\varepsilon_r}\frac{\partial^2}{\partial s\partial s'}G_a(s,s') + \frac{\varepsilon_r - 1}{\varepsilon_r}\frac{\partial^2}{\partial s\partial s'}G_b(s,s') \quad (2)$$

$$G_{a,b} = \frac{e^{-ikr_{a,b}}}{2\pi r_{a,b}},\ r_a = \sqrt{\sum_{i=1}^{3}(x_i - x_i')^2 + a^2},\ r_b = \sqrt{\sum_{i=1}^{3}(x_i - x_i')^2 + b^2};$$

where s, s' - the curvilinear coordinates counted along the conductor, x_i, x_i' - cartesian coordinates of observation and source points, ε_r - relative dielectric permittivity of the layer, k - wave number, ω- cyclic frequency, $2a$ – conductor diameter, $d=b-a$ - thickness of the dielectric layer, L - general length of the vibrator and all conductors of the grid,

$I(s)$ – the sought function of current distribution, E^i_τ - tangential component of an electric fields.

The solution of IE (1) is found by the method of moments transforming it to a matrix equation, choosing step-function as the basis function and delta-function as the weight function [3, 4].

$$E_m = \sum_{n=1}^{N} K_{mn} I_n \ , K_{mn} = \int_{\Delta s_m} K\left(s_n, s'\right) ds' \quad m,n = 1 \ldots N \tag{3}$$

To provide solution convergence it is necessary to choose the optimal length of segments of conductor fragmentation, the side of the cell should be covered with an integer number of segments [5]. The choice of wavelength is determined by the IE core behaviour. In this connection the analysis of IE core dependence on dielectric parameters for thin-wire structures of different configuration covered with a layer of dielectric was carried out. It is found out that the optimal fragmentation for electrically long rectilinear structures is $\Delta s/\lambda = 0.04...0.05$.

The calculation of amplitude-phase current distribution for dielectric permittivity $\varepsilon = 2\ldots9$ and the thickness of conductor dielectric coating $d/\lambda = 0.05\ldots0.4$ was made. By the known current distribution the radiation field in far zone in 2 mutually perpendicular planes ***E*** and ***H*** was calculated. Using the results of calculation of orientation characteristic the width of the main lobe of half-power, the level of back radiation were determined. That allows to estimate the reflective properties of grid screens. The square screen was considered, its geometric parameters varied within the following limitations: side length $L_s/\lambda = 0.8\ldots2.4$, square cell dimensions $l/\lambda = 0.08\ldots0.3$, conductor radius $a/\lambda = 0.005;0.01$. The half-wave dipole was located at the height $h/\lambda = 0.25$ in parallel with grid plane.

Calculation results for the grid screen with parameters $L_s/\lambda = 2.4$, $l/\lambda = 0.15$, $a/\lambda = 0.005$ are shown on fig. 1- fig. 4.

On fig. 1 as an example the dependence of maximal level of back lobe (MLBL) **p** in planes ***H*** (curve ***a***)and ***E*** (curve ***b***) on dielectric permittivity ε is shown. MLBL is normalized on the radiation maximum of the main lobe. On fig. 1 also shown is the the dependence of mean level of back lobe (mean LBL) in planes ***H*** (curve ***c***) and ***E***(curve ***d***) on dielectric permittivity ε. (mean LBL – the ratio of rear lobe area and the main lobe area). On fig. 2 the dependence of MLBL and mean LBL on dielectric layer thickness **d/λ** is shown. On fig. 3 – 4 the change of the main lobe width of half power $\mathbf{2\theta_{0.5}}$ in planes ***H*** (curve ***a***) and ***E*** (curve ***b***) from dielectric permittivity (fig. 3) and dielectric layer thickness (fig. 4) is shown.

The numerical investigation allows to make the conclusion that for a grid screen of finite dimensions the increase of dielectric permittivity and dielectric layer thickness leads to decrease of shielding effect. This is found to be in good agreement with similar structures of infinite dimensions [1].

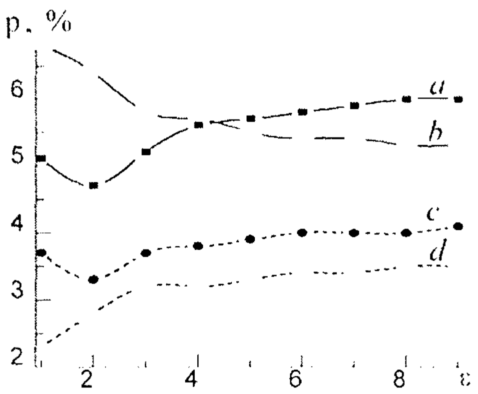

Fig. 1.

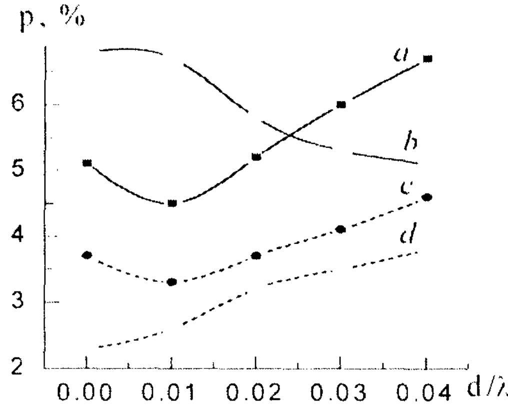

Fig. 2.

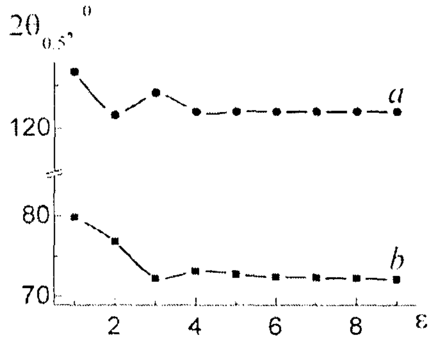

Fig. 3.

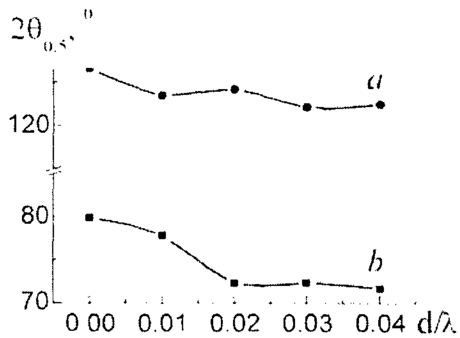

Fig. 4.

The offered methods allow to estimate reflective properties of a grid screen of finite dimensions covered with dielectric in dependence on geometric parameters, dielectric permittivity and dielectric layer thickness.

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