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ADP013938

TITLE: Influence of Defects on Electrodynamic Properties of a Semi-Infinite Periodic Sequence of the Metal-Dielectric Scatterers

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TITLE: 2002 International Conference on Mathematical Methods in Electromagnetic Theory [MMET 02]. Volume 2

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INFLUENCE OF DEFECTS ON ELECTRODYNAMIC PROPERTIES OF A SEMI-INFINITE PERIODIC SEQUENCE OF THE METAL-DIELECTRIC SCATTERERS

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ABSTRACT

A semi-infinite periodic sequence of the metal-dielectric scatterers with defect in N basic element is investigated. The analysis of the dynamic of electromagnetic properties of investigated structure was carried out for different polarization of the exciting field and degree of the electrodynamic connection between resonance volume.

OBJECT OF RESEARCH

The dynamic of the monochromatic ($\exp(-i\omega t)$) fields of the scattering of the symmetric TE_{0n}–, TM_{0n}– waves of the circular waveguide on a semi-infinite periodic sequence of the metal-dielectric scatterers, if the geometric and electric parameters of the N basic element are changing, is investigated. The structure and the coordinate system is depicted schematically in Fig. 1. The base element, which has length L (period), consist of the two dielectric layers, which characterized by the thickness' d_j, the wave conductivities Y_j, permitivities ε_j and permeabilities μ_j ($j = 1, 2$). Between the layers is placed the resistive film (it has conductivity Y_σ) (fig. 1.a) or the ring

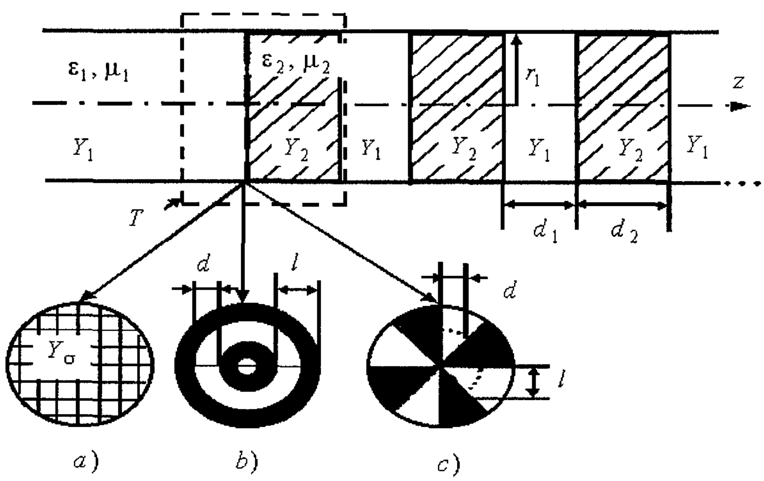


Fig. 1. Geometry of studding structure

(fig. 1.b) or radial (fig. 1.c) diaphragms. The diaphragms are infinitely thin and perfectly conducting and have a period l and a separation between conducting tape d

($u = \cos(\pi d / l)$ is the filling parameter of diaphragm). The characteristic dimension of the diaphragms is supposed to be significantly smaller than the wave length ($\kappa = l / \lambda << 1$), therefore the phenomena of the transformation of the wave types are absence. In this approaching the transfer matrix of the basic elements (T) was defined in [1].

The reflection coefficient (R_∞) from the perfect semi-infinite periodic sequence can be defined as the root of equation

$$t_{12} R_\infty^2 + (t_{11} - t_{22}) R_\infty - t_{21} = 0, \tag{1}$$

which less then 1 ($|R_\infty| \le 1$). t_{ij} is the elements of transfer matrix of basic elements.

The reflection coefficient R from the defect semi-infinite periodic sequence (the parameters of the N basic element is changed) can be found from operator equation:

$$\begin{pmatrix} A_0 \\ RA_0 \end{pmatrix} = T^{N-1} T' \begin{pmatrix} A_{N+1} \\ R_\infty A_{N+1} \end{pmatrix}. \tag{2}$$

Where T' is transfer matrix of defect basic element, the elements of the degree of the transfer matrix (T^{N-1}) were presented in [1] by the analytical formulas through the Mauguin polynomials $P_{N-1}(X)$, where $X = (t_{11} + t_{22}) / 2$.

RESULTS

There are a two type zones on the dependencies of the reflection coefficient of perfectly semi-infinite sequence of diaphragms on the frequency (fig. 2-3). The one of them has a relatively high value of reflection coefficient (stop band) and the second has a relatively small value of R_∞ (pass band). The value of the R_∞ in pass band depends on degree of electromagnetic connection between the basic elements. For the low degree connection

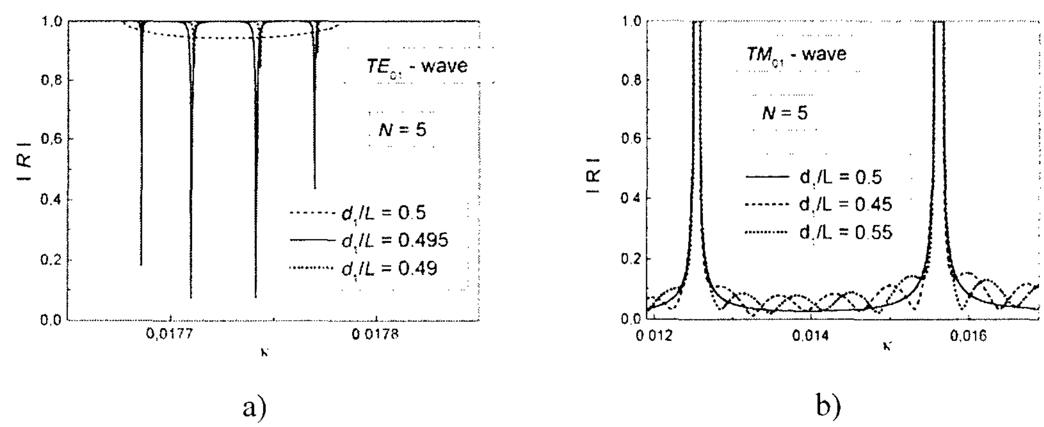
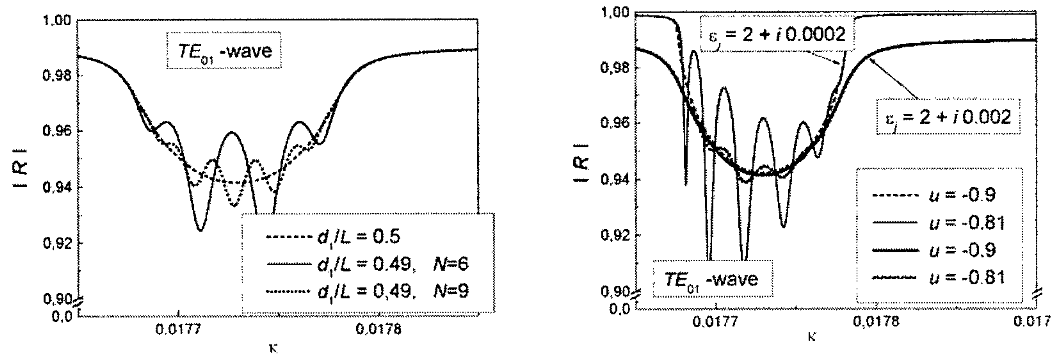


Fig. 2. The dependencies of the reflection coefficient from sequence of ring diaphragms on frequency. $\varepsilon_j = 2$, $\mu_j = 1$, $L/l = 100$, $r_1/l = 40$, $d_1/L = 0.5$.
a) $u = -0.9$; b) $u = 0,9$

(TE_{01}-wave for ring and TM_{01}-wave for radial diaphragms) the value $R_\infty \sim 1$, in other case $R_\infty \sim 0$.

The resistive film is the active local conductivity. As its volume Y_σ is much less of the wave conductivity of the waveguide channels, then the changes of the relative volume $\Delta Y_\sigma / Y_\sigma$ on the 10% or less result to the minor change of the average level of the reflection coefficient in the pass band. These changes does not depend from the type of the exciting field and position of the defect.



a) b)

Fig. 3. The dependencies of R from the semi-infinite sequence of ring diaphragms on frequency. $\mu_j = 1$, $L/l = 100$, $r_1/l = 40$, $u = -0.9$, $d_1/L = 0.5$. a) $\varepsilon_j = 2 + i0.002$; b) $N = 7$.

The reactivity of the diaphragms and the thickness of the layer determine the phase properties of the system. The changes one of these parameters in the N basic element result in the appearance of the high frequency oscillations in the pass bands (fig. 2). This fact is explained by exciting eigen oscillations of the set from $N-1$ identical elements loaded by the defect. The amplitude and number of high frequency oscillations is depended to the value of the defect and its number (N) (fig. 2-3).

The system with low electromagnetic connection between the basic elements is very sensitive to the phase defect (fig 2.a). The degree of influence of the defects can be decreased by the using in such system of the dielectric with low dissipative loses (fig. 3). The degree of the influense is decreased if the disipative loses or number of defect elements increasing.

CONCLUSIONS

The dynamic of the dependencies amplitude characteristics on the frequency with the change of the composition or geometric and material parameters in one of the base elements was determined in long wave region. The analysis of this dynamic was carried out for different polarization of the exciting field and degree of the electrodynamic connection between resonance volume.

REFERENCE

[1]. Kazanskiy V.B., Podlozny V.V., Khardikov V.V. // Electromagnetic Waves and Electronic System, 1999, V. 4, № 3.