This paper is part of the following report:

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

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EIGENWAVES IN THE LAYERED MEDIUM OF BIPERIODIC STRIP ARRAYS

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Periodic layered structures are considered. Each layer of the structure is an array of plane metal strips of complex shape placed on a dielectric substrate. The frequency dependencies of eigenwave propagation constants have been obtained. The reflection coefficients from the half-space filled by such medium have been studied. The results for structures made of identical layers and for structures composed of pairs of different layers are presented.

1. Let each layer be constructed by using the plane C-shaped elements oriented in one direction (see Fig. 1a). In this case, on the array period small compared with the incident wavelength, the first or even the second current resonances are possible on the element. The periods of all layers along the OX and OY axes are identical. The layers are positioned perpendicularly to the OZ axis (see Fig. 1b). The field near this array may be presented as the sum of an incident field and the field reflected by the array. The reflected field may be presented as the sum of spatial harmonics (see [1]). We shall consider the case when only one spatial harmonic is propagating. Its propagation constant is equal to k .
The matrix elements of the reflection and transmission operators (r and t) for
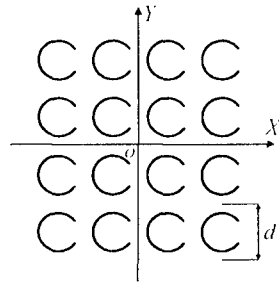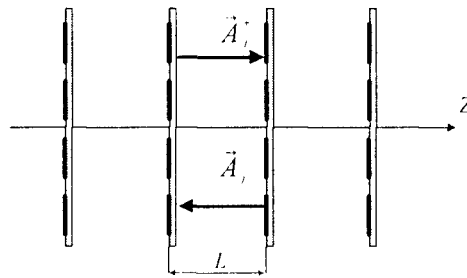

Fig. 1a.   Fig. 2a

one layer can be obtained by using the method of moments. As we take into account only a one harmonic and consider two orthogonal polarizations, the reflection and transmission operators look like square 2x2 matrixes. And as the chosen structure of the layer is symmetric, there will be no transformation of polarization of the reflected and transmitted field. Thus the matrixes r and t will be diagonal. The operator equations describing the eigen waves in such medium is possible to derive in the same manner as in [2]. They are:

$$(I - e^{-i\beta L} t^- e)\vec{A}_j^+ - r^- e\vec{A}_j^- = 0 \tag{1a}$$

$$r^+ e\vec{A}_j^+ - (I - e^{i\beta L} t^- e)\vec{A}_j^- = 0 \tag{1b}$$

where e is the operator describing change of a field propagated from any layer to the neighboring one; $\bar{A}_j^{\pm}$ are the amplitudes of eigenwave partial constituents in the interval between j and $j+1$ layers (hereinafter the "+" and "–" superscripts refer to propagation of the wave from left to right and from right to left, respectively); L is the period of the structure; β is the propagation constant of an eigenwave.
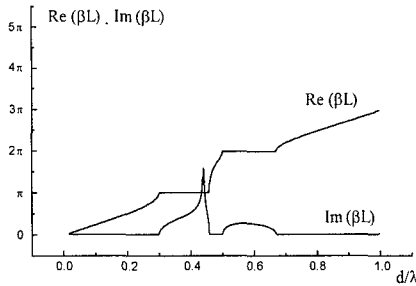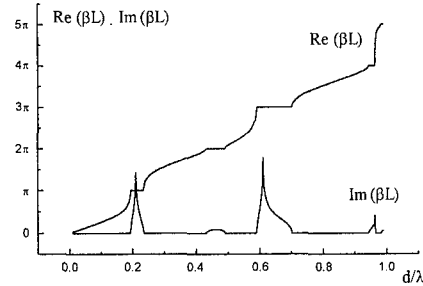

Fig. 2a.

Fig. 2b.

The dispersion dependencies for the eigenwaves propagation constants are solved numerically. They are presented in Fig. 2a (the eigenwave is polarized in the OX plane) and Fig. 2b (the eigenwave is polarized in the OY plane).

Consider semi-infinite structure of layers described above. The reflection operator for such a structure may be obtained in the same manner as in [3] as a solution of equation

$$R_\infty^+ = r^+ + t^- e R_\infty^+ e (I - r^- e R_\infty^+ e)^{-1} t^+ . \tag{2}$$

Equation (2) is solved numerically by an iterative method. As an initial approximation it is possible to take, for example, the reflection operator of a positive partial constituent of eigen wave for semi-infinite structure. This operator is possible to find from (1a) and (1b) in the form

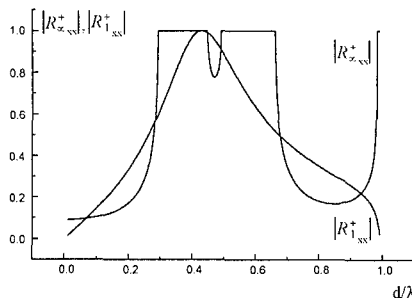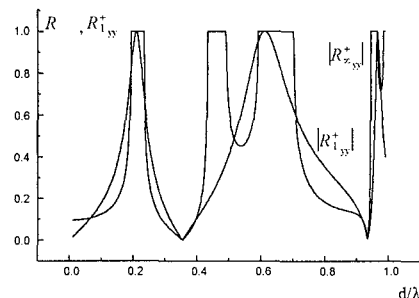$$R_e^+ = (I - t^- e e^{i\beta L})^{-1} r^+ . \tag{3}$$

Fig. 3a.

Fig. 3b.

Frequency dependencies of the matrix elements $R_{\infty\,xx}^+$ and $R_{\infty\,yy}^+$ are represented in Fig.3a and 3b. Curve I in both figures refers to the reflection coefficient for a semi-infinite structure, a curve II - for the reflection coefficient of one layer. Comparing dependencies in Fig. 2 and Fig. 3, we can see, that the zones of total reflection from this artificial medium refer to the cutoff zones for eigenwaves in this medium. It can be seen

that in those areas where the reflection factor for one layer is close to unity, a sharp increase is observed in the imaginary part value of the propagation constant. This increase can be explained by the total reflection of the incident field from each layer, and therefore the eigen wave cannot be excited as a propagating wave. Thus, the imaginary part of its wave number tends to infinity.

2. The difference between the reflection coefficients for different polarizations may be undesirable in creating of microwave devices. To avoid this strong polarization dependence, we shall rotate each second layer through 90^0 around the OZ axis. Consider a new layered medium constructed from pairs of layers, one of which is rotated through 90^0. Let the distance between layers in pair be equal to h, $h < L$. Reflection and transmission operators for a pair of layers (R and T) is possible to obtain in the same manner as in [4].

The 1 subscript refers to a layer oriented, as in Fig. 1a, and the subscript 2 to the layer rotated through 90^0. The equations governing the eigenwaves in this medium looks analogously to (1). And the equations (2) and (3) can be rewritten too.
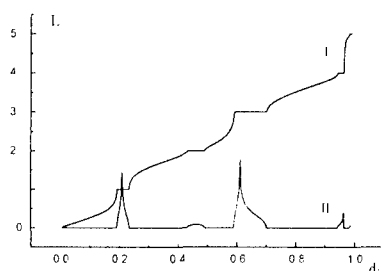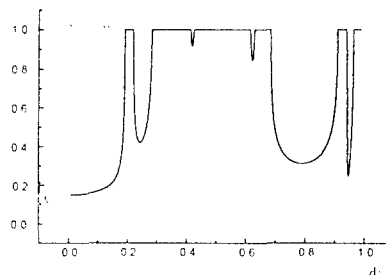

Fig. 4a   Fig. 4b

Now the solutions for the dispersion equation coincide for both polarizations. The reflection coefficient for this medium also will be identical to both polarizations. Its frequency dependence is presented in Fig. 4b.

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