ELECTRODYNAMIC ANALYSIS OF IRREGULAR WAVEGUIDES AND RESONATORS CONTAINING NONLINEAR MEDIA

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A computational algorithm has been proposed for solving diffraction problems for microwave waveguide devices containing nonlinear media. When the method of successive approximations is used, the original nonlinear boundary value problem for the Maxwell equations can be reduced to considering a series of linear boundary value problems which can be solved by the projection method. The stability of the computational algorithm has been considered for various iteration processes. The results of mathematical simulation have been presented for diffraction by a medium having a nonlinear electrical conductivity in a rectangular waveguide.

Domestic and foreign scientific works do not provide results on the electrodynamic level for the solution of problems involving diffraction by nonlinear media in microwave waveguide devices. A microwave waveguide device with nonlinear elements is treated as a certain waveguide transformer whose cavity contains nonlinear media. The Maxwell equation for a nonlinear medium has the form

$$\operatorname{rot} H = \frac{\partial D(E)}{\partial t} + J(E); \qquad \operatorname{rot} E = -\frac{\partial B(H)}{\partial t}, \tag{1}$$

where E, H are the electric and magnetic field intensities; D(E), B(H) are the electric and magnetic inductions; J(E) is the current density. The nonlinear dependences J(E), D(E), B(H) are represented in the form

$$\begin{gathered} J(E) = (a_1 + a_2|E| + a_3|E|^2 + \ldots)E; \qquad D(E) = \varepsilon_0(\varepsilon_1 + \varepsilon_2|E| + \\ + \varepsilon_3|E|^2 + \ldots)E; \qquad B(H) = \mu_0(\mu_1 + \mu_2|H| + \mu_3|H|^2 + \ldots)H, \end{gathered} \tag{2}$$

where ϵ_0, μ_0 are the absolute electric and magnetic constants; $|E|$, $|H|$ are the moduli of the electric and magnetic field vectors.

In the general case, each of the waveguide channels of the transformer contains incident normal waves having the frequencies $\omega_1, \omega_2, \ldots, \omega_t$. The medium is nonlinear, and consequently reflected waves having all possible frequencies appear in the waveguide channels:

$$\omega_m = \sum_{k=1}^{p} Z_{mk}\omega_k, \tag{3}$$

where Z_{mk} are the files of numbers from all possible combinations of the numbers ..., -2, -1, 0, 1, 2, ...; m is the number of the combination. The frequencies $\omega_1, \omega_2, \ldots, \omega_p$ of the incident normal waves shall be treated as particular cases of the combination frequencies (3).

The functions E(t), H(t) in Eqs. (1) are represented in the form of series in the combinational frequencies:

$$E(t) = \sum_{m=1}^{\infty} E(\omega_m)\cdot\exp(i\omega_m t), \quad H(t) = \sum_{m=1}^{\infty} H(\omega_m)\cdot\exp(i\omega_m t). \tag{4}$$

Inserting Eqs. (2) into Eqs. (1), we derive a system of coupled Maxwell equations with allowance for Eq. (4):

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