METHOD OF ANALYZING THE PASSAGE OF PULSES THROUGH FILMS WITH NONLINEAR PARAMETERS IN WAVEGUIDE STRUCTURES

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Passage of electromagnetic waves through interfaces has been studied well in a linear approximation. At the same time, nonlinear properties of materials, which are finding ever greater use in superhigh- and extremely-high-frequency equipment, must be taken into account already at power levels usual for communication and information processing systems. Owing to the difficulty of analysis, reflection from interfaces with nonlinear media was examined mainly when analyzing the generation of harmonics and frequency interactions of monochromatic signals. In the present work a method of calculating the parameters of pulses during their passage through the interface of media in free space or in a waveguide with a nonlinear film oriented perpendicular to it axis is examined. It was established that in the case of interactions in the form of step functions, an approximate analytic solution of integrodifferential nonlinear equations describing passage of pulses through a film with nonlinear parameters is possible.

For simplicity let us examine a plane model of a structure (Fig. 1) modeling well the dominant types of waves of strip, coaxial, etc., lines up to frequencies ~10 GHz, which is sufficient when analyzing video pulses. The wave equations in regions of the structure with linear parameters 1 and 2 have the form

$$(\nabla^2 - \varepsilon_{1,2}\mu_{1,2}\omega^2 / c^2)\,\mathrm{E}(x, y, t) = 0. \tag{1}$$

The boundary conditions in the plane of the interface of the media

$$\mathrm{E}_{1\tau}(y = 0-) - \mathrm{E}_{2\tau}(y = 0+) = 0, \tag{2}$$

$$\mathrm{H}_{1\tau}(y = 0-) - \mathrm{H}_{2\tau}(y = 0+) = -\frac{\partial}{\partial t}(\mathrm{n} \times \mathrm{P}_N(\mathrm{E})), \tag{3}$$

where the vector of nonlinear polarization is represented in the form

$$\mathrm{P}_N(\mathrm{E}) = \sum_{n=2}^{\infty} \kappa_n \mathrm{E}_n^n.$$

For definiteness we will examine $H(H_x, H_y, E_z)$ of the wave ($\partial/\partial z = 0$). The solution of (1) is sought in the form of expansions

$$E_{0,R,T}(x, y, t) = \int_{-\infty}^{\infty} \frac{d\omega}{2\pi}\varphi(x)\,E_{0,R,T}(\omega)\exp[i(\omega t \mp k_{1,2}y)], \tag{4}$$

where the subscripts 0, R, T correspond to an incident pulse, reflected pulse, and pulse that passed through the interface of the media. Substitution of (4) into (2) gives the relations between the spectral components, and substitution into (3), after multiplication by the function of the transverse distribution of the field $\varphi^*(x)$ and integration over the transverse section of the structure, gives an equation which reduces to a nonlinear integrodifferential equation for the distribution function of the field with a nonlinear function figuring in the differential operator. For the dominant waves of a stripline and coaxial line $\varphi(x) \approx 1$. In the case of small dispersion of the media in regions 1 and 2, determined by functions $\varepsilon_i(\omega)$, $\mu_i(\omega)$ for the dominant wave, we obtain a nonlinear ordinary differential equation

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