A METHOD OF DESIGNING WAVEGUIDE FILTERS WITH LONGITUDINAL METAL INSERTS

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Waveguide filters, based on the use of metal inserts in the E-plane of a rectangular waveguide, have become widely used in the centimeter and millimeter band because they are easy to manufacture and have good electrodynamic characteristics. The structure of such a filter usually employed is shown in Fig. 1a. Symmetrical structures with a number of resonant gaps from 2 to 5 are usually used.

A number of methods of designing such structures exist. The method described in [1] is based on an analysis of the currents flowing in the partitions, and enables the parameters of the equivalent circuit of the metal insert to be calculated quite rapidly. However, it does not take into account the thickness of the metal insert and the losses due to the conductance of the metal. A procedure based on the matching method is described in [2,3] and enables one to construct an accurate model of the system, but it requires a considerable amount of calculation on a computer. The conductance of the metal is also ignored.

The method proposed here for designing such filters is based on the method described in [2], but the amount of computer time required for a numerical analysis is reduced considerably, and unlike [2], the losses in the metal are taken into account.

We will consider a metal insert in a rectangular waveguide parallel to its narrow wall, and we will divide the elementary cell of the filter (Fig. 1a) into partial regions 1-3, as shown in Fig. 1b. In each of the regions, the fields E and H can be represented in the form $H = \Delta \Pi$, $E = -i\omega\mu[\nabla \times \Pi]$, where Π is the magnetic Hertz vector in each of the regions, $\Pi = A^{\pm} e_z e^{\mp i\gamma_j z} \sin(\pi x/p_j)$; $A^{\pm}$ are unknown coefficients, p_j, γ_j are determined by the dimensions of each region

$$p_j = \begin{Bmatrix} a & j=1 \\ c & j=2 \\ a-d & j=3 \end{Bmatrix}; \qquad \begin{aligned} &\gamma_j^2 = k^2 - (\hat{m}\pi/p_j)^2 - (\hat{n}\pi/b)^2; \\ &k = (2\pi/\lambda_0) = (\omega/c); \end{aligned}$$

$\hat{m}$, $\hat{n}$ are parameters which depend on the conductance of the metal (they will be obtained later), e_z is the unit vector in the direction of the z axis, and λ_0 is the wavelength. Using the method of partial regions in the form given in [2], one can obtain the following expressions for the elements of the scattering matrix $\hat{S}$, which connects the amplitudes of the incident waves A^+, B^+ and the reflected waves A^-, B^-

$$\begin{pmatrix} A^- \\ B^+ \end{pmatrix} = \hat{S} \begin{pmatrix} A^+ \\ B^- \end{pmatrix}; \quad \hat{S} = \begin{Vmatrix} S_{11} & S_{12} \\ S_{21} & S_{22} \end{Vmatrix};$$

$$S_{11} = S_{22} = \frac{(1-\psi)(1+\psi)+\varphi^2}{(1+\psi)^2-\varphi^2}; \quad S_{12} = S_{21} = \frac{2\varphi}{(1+\psi)^2-\varphi^2};$$

$$\psi = \theta \operatorname{ctg} \gamma_2 l; \quad \theta = -i(4\gamma_1/ac\gamma_2)(I_2^2 + I_3^2); \quad \varphi = \theta/\sin \gamma_2 l$$

(here we have assumed that $a-d=c$, $\gamma_2=\gamma_3$), and

$$I_2 = \int_0^c \sin(\pi x/a)\sin(\pi x/c)\,dx; \quad I_3 = \int_d^a \sin(\pi x/a)\sin[\pi(a-x)/(a-d)]\,dx.$$

Hence, we can calculate the scattering matrix of a metal insert of finite length.

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