CALCULATION OF THE FREQUENCY SPECTRUM OF THE NATURAL OSCILLATIONS OF A SCREENED DIELECTRIC RESONATOR

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Izvestiya VUZ. Radioelektronika,
Vol. 31, No. 1, pp. 75-77, 1988

UDC 621.372.413

The wide application of metal-dielectric resonators (MDR) in microwave techniques is due to their relatively small dimensions, good compatibility with other circuit components, etc. [1-3]. The trend towards increasing the Q of the resonance has given rise to the need to use oscillations with high indices as the operating oscillations, and to find optimum relations for the dimensions and the permittivities. In the centimeter band this usually leads to structures in which resonance occurs as a result of rereflection, not of one wave in the region of the dielectric element with maximum transmission, but of several waves of different modes in different regions of the resonator. All this leads to the need to construct accurate algorithms to describe metal-dielectric resonators and makes it inadvisable to use approximate formulas obtained using models with magnetic walls bounding the resonating element of volume.

In many cases, it is convenient to represent the construction of a metal-dielectric resonator as a multilayer system. This corresponds, primarily, to those structures in which the dielectric element, in order to increase the Q, is "isolated" from the metal screen, and also to certain versions of temperature-stabilized constructions and resonators with special tuning. In this paper we consider a metal cylindrical resonator with a nonuniform dielectric filling. The main dimensions and geometry of this construction are shown in Fig. 1. The internal space of the resonator $-t-d\leqslant z\leqslant b$ is divided by planes, parallel to the base $z=0$, $z=-t$, into three different layers. Each layer is divided into two parts by a common cylindrical surface $r = R_1$, coaxial with the external metal screen. The six internal regions found in this way can be filled with dielectric having different values of the permittivity ε_{kl}. The index $k = 1, 2$ denotes the number of the region, and the index $l = 0, 1, 2$ denotes the number of the layer. Different versions, for specific values of the dimensions and the permittivities, enable one to consider this structure as a model for many metal-dielectric resonator constructions.

The resonance frequencies of the model were calculated by finding the eigenvalues of a boundary value problem. The requirement that uniform boundary conditions should be satisfied is reduced to a finite system of linear algebraic equations. The electromagnetic field in the resonator is represented by the z-components of the electric Hertz vector $\varphi=\Pi_z^e(r,z,\xi)$ and the magnetic Hertz vector $\psi=\Pi_z^m(r,z,\xi)$. For each of the regions of $0\leqslant r\leqslant R_1$, $R_1\leqslant r\leqslant R_2$ the solution of the wave equation which satisfies the boundary conditions on the surface $z=b$, $z=-t-d$, $r=R_2$, and in the planes $z = 0$ and $z = -t$, is written in the form

$$\begin{gathered}
E_{rk}=\frac{\partial^2\varphi_k}{\partial r\partial z}+jk\frac{\rho}{r}\frac{\partial\varphi_k}{\partial\xi};\qquad H_{rk}=-j\frac{k}{\rho r}\frac{\partial\varphi_k}{\partial\xi}+\frac{\partial^2\psi_k}{\partial r\partial\xi};\\
E_{\xi k}=\frac{1}{r}\frac{\partial^2\varphi_k}{\partial\xi\partial z}-jk\rho\frac{\partial\psi_k}{\partial r};\qquad H_{\xi k}=j\frac{k}{\rho}\frac{\partial\varphi_k}{\partial r}+\frac{1}{r}\frac{\partial^2\varphi_k}{\partial z\partial\xi};\\
E_{zk}=k^2\varphi_k+\frac{\partial^2\varphi_k}{\partial z^2};\qquad H_{zk}=k^2\psi_k+\frac{\partial^2\psi_k}{\partial z^2},
\end{gathered}\tag{1}$$

where

$$\varphi_1=\sum\nolimits_{n=0}^{N}A_{1n}J_\nu(\beta_{1n}r)\,g_{1n}(z);\qquad \psi_1=\sum\nolimits_{n=1}^{N}B_{1n}J_\nu(\tau_{1n}r)\,p_{1n}(z);$$

$$\varphi_2=\sum\nolimits_{n=0}^{N}A_{2n}\left[J_\nu(\beta_{2n}r)\,Y_\nu(\beta_{2n}R_2)-J_\nu(\beta_{2n}R_2)\,Y_\nu(\beta_{2n}r)\right]g_{2n}(z);$$

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Revised 15 September 1986