ISSN 0735-2727, Radioelectronics and Communications Systems, 2014, Vol. 57, No. 6, pp. 254–261. © Allerton Press, Inc., 2014.
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# Eigenwaves of Periodic Rectangular Waveguide with Dielectric-Filled Dips on Broad Wall

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Received in final form May 14, 2014

**Abstract**—The paper presents a solution of the boundary problem for eigenwaves of periodic structure consisting of rectangular waveguide with dielectric-filled dips on broad wall obtained by Galerkin's method. The types of waves are analyzed with due regard for the symmetry of structure and field. The results of calculations of basic characteristics of eigenwaves in the baseband are also presented.

**DOI:** 10.3103/S073527271406003X

## INTRODUCTION

Special waveguides representing the right- and left-hand structures have been used due to the increased interest in metamaterials observed in recent time. The advantages of such waveguide structures as compared with the planar ones include the virtually loss-free radiation, the possibility of transition to smaller sizes and wavelengths, and also the robustness of characteristics with respect to external impacts.

The rectangular waveguide with dielectric-filled dips on the one or both broad walls can be used as a structure supporting the left-hand propagation [1, 2]. The dispersion characteristic and the gain of rectangular waveguide with dips on one of the broad walls were analyzed by using the method of equivalent circuits [3, 4].

The electrodynamic characteristics of rectangular waveguide with dielectric-filled dips on a broad wall were determined in this paper by solving a corresponding boundary problem. The left-hand propagation of waves in such structure was shown on the basis of calculation data. The calculation results are in good agreement with experimental data presented in available literature.

## STATEMENT OF THE PROBLEM

The geometry of the examined rectangular waveguide with dielectric-filled dips on a broad wall is presented in Fig. 1. The region over dips has parameters $\varepsilon_1$ and $\mu_1$. The length of dips satisfies condition $l \le a$, the width is $L_1$, the height is $t$, and the period is $L_2$. Dips are filled with material having parameters $\varepsilon_2$ and $\mu_2$.

For performing calculations let us divide the structure into two regions: region I ($y > 0$) and region II ($-t < y < 0$). Fields in region I satisfy the Floquet theorem:

$$E_x^{\mathrm{I}}(x,y,z) = \sum_{s=-\infty}^{+\infty} \sum_{n=0}^{\infty} \frac{\mathrm{i}\omega\mu_{\mathrm{a}1}}{k_1^2 - \beta_s^2} A_{ns}\gamma_{ns} \cos\left(\frac{n\pi x}{a}\right) \sin\left(\gamma_{ns}(y-b)\right) \mathrm{e}^{-\mathrm{i}\beta_s z}$$

$$- \sum_{s=-\infty}^{+\infty} \sum_{m=1}^{\infty} \frac{\mathrm{i}\beta_s}{k_1^2 - \beta_s^2} \frac{m\pi}{a} B_{ms} \cos\left(\frac{m\pi x}{a}\right) \sin\left(\gamma_{ms}(y-b)\right) \mathrm{e}^{-\mathrm{i}\beta_s z}, \quad (1)$$

$$E_z^{\mathrm{I}}(x,y,z) = \sum_{s=-\infty}^{+\infty} \sum_{m=1}^{\infty} B_{ms} \sin\left(\frac{m\pi x}{a}\right) \sin\left(\gamma_{ms}(y-b)\right) \mathrm{e}^{-\mathrm{i}\beta_s z}, \quad (2)$$