Eigenmodes of Sectoral Coaxial Ridged Waveguides

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Received in final form June 11, 2012

Abstract—The results of numerical investigation of sectoral coaxial ridged waveguides eigenmodes of two configurations (with a ridge on inner or outer wall) for different cross-section dimensions are presented. In particular, dependences of cutoff wave numbers on geometrical dimensions ratios for first four modes are investigated, electric field components distributions for these modes have been obtained and the optimization of sectoral coaxial ridged waveguides has been carried out to provide maximal single-mode operation frequency band. Two optimal configurations of waveguides with single-mode operation bandwidth ratio 5.6:1 are obtained. It is shown that smaller cross-section dimensions at the fixed single-mode operation frequency band has the waveguide with the ridge at the inner round wall. The size of the gap between the ridge and the round wall of optimal waveguide is identical for both configurations and is determined by the required ratio of cutoff frequencies of two lower TE modes. Calculations are conducted utilizing the mathematical model obtained in [1] by the integral equation technique with the correct account of singular behavior of the field at the ridge.

DOI: 10.3103/S0735272712060015

INTRODUCTION

Ridged structures are widely used in filters [2–4], polarizers [5–7], waveguides [8–11], antennas [12–14], orthomode transducers [15–17], lasers [18–20], resonators [21, 22] and other devices. For the development of devices based on ridged structures it is necessary to know the modal characteristics of ridged waveguides, namely, modes cutoff frequencies (or cutoff wave numbers) and field distributions. The characteristics of ridged waveguides eigenmodes of coaxial [9], square [10], elliptical [11], circular [24], and rectangular [23, 24] cross-sections have been analyzed. In [1] the authors have solved the electrodynamics boundary problem for sectoral coaxial ridged waveguides (SCRW) by the integral equation technique. In this paper let us investigate the eigenmodes of SCRW using the mathematical model developed in [1] and the software based on it. Besides, let us carry out the optimization of SCRW to provide maximal single-mode operation frequency band.

Configurations of hollow infinite SCRW considered and designations of their cross-section dimensions are shown in Fig. 1. The SCRW with a ridge on inner and on outer wall are shown in Fig. 1a, b, respectively (subscripts “in” and “out” in a future). We will analyze only the modes, for which the symmetry plane of SCRW is a magnetic wall.

CUTOFF WAVE NUMBERS

First of all, let us investigate cutoff wave numbers and electric field distributions for several modes of SCRW of both configurations (Fig. 1) with fixed aperture angle $\alpha = 86^\circ$ at the change of relative ridge height $h$ for different angular ridge sizes $\gamma$ and inner-to-outer radii ratios. The results of cutoff wave numbers ($k_c$) multiplied by outer radius of SCRW with a ridge on inner ($k_{cin}b$) and outer ($k_{cout}a$) wall, obtained by the integral equation technique [1] (which is implemented in our own software) and by the finite integration technique (which is implemented in CST Microwave Studio software), are shown in Figs. 2–7. The deviation between the results for cutoff wave numbers obtained by these two techniques is less than 0.3%.

In Figs. 2–7 the results obtained using the integral equation technique are shown by lines, and the ones obtained using the finite integration technique—by symbols. The results for the first $TE$ mode are shown by solid lines and circles, for the second $TE$ mode—by dashed lines and triangles, for the third $TE$ mode—by dash-dotted lines and squares, for the first $TM$ mode—by dotted lines and diagonal crosses. The results for SCRW with a ridge on an inner wall are shown in Figs. 2–4, and for SCRW with a ridge on an outer wall—in Figs. 5–7. The dependences of cutoff wave numbers on relative height $h = (d - a) / b$ at $\gamma = 10, 30, 50^\circ$ and...