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Approximate Calculation of Eigenfrequencies of Biconical Microwave Cavities

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Abstract—Simplified expressions are obtained for the calculation of the eigenfrequencies of a biconical cavity with large apex angles with the use of two symmetrical points at the boundaries of overlapping partial regions in the form of a spherical sector. Using these expressions, the dependence of the cavity eigenfrequencies on the apex angles of the conical elements is studied, and the results are compared with those obtained by the classical finite-element method. The applicability range of the simplified expressions is identified, and recommendations on their use are given.

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INTRODUCTION

Biconical cavities (BC) find application in design of various kinds of sensors, filters, material parameter probes, for example, gases and liquids. In particular, due to the possibility of making relatively large holes in cone's vertex without significantly changing the resonant frequency [1] these resonators may be used for measuring material parameters in the flux.

Introduction in wide measurements application of the mentioned class of resonators is limited by the absence of relatively simple eigenfrequency estimation methods. During design of the corresponding elements based on BC it is important to quickly determined eigenfrequencies under different geometrical dimensions. The use of corresponding calculation packages requires not only significant time and qualification, but is also limited by their high cost. Simple precise or approximate analytical expressions for finding eigenfrequencies of BC with H_{01p} oscillations have not been mentioned in literature. More over there is no information on approximate methods for estimating eigenfrequencies of a BC.

The difficulty of determining eigenfrequencies of BC is caused by presence, in a general case, of degenerate oscillation types. As shown in [2], in cavities that contain conical surfaces, even under small apex angles, there exists a dependence between degeneration of E_{111} and H_{011} oscillation types on the values of these angles. More over one may observe a consistent trend of increasing mismatch between eigenfrequencies of these oscillation types with growing angle values. Hence in biconical cavities, especially under large angles, degeneration between E_{11p} and H_{01p} oscillation types is also eliminated. At the same time separation of the oscillation types may be sufficient for providing separate consideration of H_{01p} oscillation types apart from the other ones.

In practice symmetrical biconical cavities with large apex angles at vertexes are of greatest interest. This allows considering only H_{01p} oscillation types subject to eigenfrequency estimation.

PROBLEM DEFINITION

The paper aims to develop a relatively simple approximate method for estimating eigenfrequencies of biconical cavities with H_{01p} oscillations.

Consider a model of a biconical cavity (Fig. 1) whose internal volume is divided into two mutually overlapping partial regions in the shape of spherical sectors with equal radius R and R'.

Let's introduce a coordinate system in each partial region. Origins are located in vertexes of cones that make up the biconical cavity.

Coordinates of any point that lies inside a partial region may be described as follows: