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Characteristics of Eigen Waves of an Open Comb

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Abstract—Solution of a boundary problem for eigen waves of an open comb with combs of finite thickness is reduced to solving one of the two homogeneous systems of linear algebraic equations of the second kind. Advantages of one of them are determined. Optimal algorithm for calculating the power of eigen waves is found. To improve precision and to shorten the calculation time it is suggested to average power at the half of the comb's thickness. Calculations of all main characteristics of eigen waves in the primary passband of the comb are given, including the generalized connection resistance having not to be mentioned in literature before. Calculation results for the group velocity are verified using two approaches: the dispersion curve and the ratio of the pointing vector to energy density. All the calculated characteristics satisfy the known theorems.

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INTRODUCTION

An open comb, a comb with a cover or a twin is usually referenced by the term "comb". In the latter one the combs may be placed against each other of shifted.

In millimeter, sub-millimeter and optical ranges an open comb is considered as a reflecting array [1–3] and is used as an element of antenna and measurement systems in nuclear physics, acoustics (interference measurers, polarization converters, phase shifters, wavelength measurers, etc.). A comb with a cover is an electrodynamic system of orothron [4], a generator of diffraction radiation [3].

The first attemps to study the properties of eigen waves in an open comb were undertaken in [5–10]. A comb with infinitely thin combs was studied. The dispersion of eigen waves represented the main interest. The simplest dispersion equation was obtained which is based on accounting for the main harmonic in the interaction space and the main oscillation in the resonator.

The contents o works directed at spreading the developed theory to combs with finite thickness is accumulated in [6–9]. Only dispersion equations are given which are obtained assuming the electric field in the gap is constant. Formulas for the connection resistance are given in [7–9] and account only for the main harmonic.

Dispersion properties of the comb with infinitely thin combs are rather fully studied in [11]. The factorization method is used, which does not provide the final solution for this problem, but essentially leads only to reformulation of the problem with respect to another system of linear algebraic equations (SLAE) possessing perfect convergence. The results of calculating dispersion using the second order SLAE are provided. Spreading of the theory to the comb with impedance infinitely thin combs is studied in [12].

The parameters of periodic structures introduced in [13] broaden our knowledge of characteristics of eigen waves. In contrast to the usually used ones these parameters are limited in the passband and on its boundaries, satisfy some conditions, are more appropriate in theory of electronic devices and allow controlling the calculation results.

Knowledge of the comb's characteristics allows using them to calculate complex periodic structures, for example, a chain of connected resonators, quasi-periodic or non-periodic structures, to synthesize systems of capturing electrons' energy [14]. Under certain conditions the properties of waves in the open comb determine the properties of the waves in the open U-waveguide. The calculation results may be used in antenna technique as well.