ISSN 0735-2727, Radioelectronics and Communications Systems, 2012, Vol. 55, No. 5, pp. 214–222. © Allerton Press, Inc., 2012.
Original Russian Text © Yu.V. Rassokhina, V.G. Krizhanovski, 2012, published in Izv. Vyssh. Uchebn. Zaved., Radioelektron., 2012, Vol. 55, No. 5, pp. 29–39.

Analysis of Coupled Slot Resonators of Complex Shape in Metalization Plane of a Micro-Strip Transmission Line Using the Transversal Resonance Techniques

Yu. V. Rassokhina and V. G. Krizhanovski
Donetsk National University, Donetsk, Ukraine
Received in final form April 12, 2012

Abstract—The transverse resonance techniques is developed for analyzing three-layer planar structures based on micro-strip transmission line with slot resonators of complex shape in the grounding plane. Development of the techniques consists in considering higher space harmonics of current density in the strip line and mutual coupling between the slots in the grounding plane when numerically solving the boundary problem. In order to verify the techniques we conduct analysis of structures that consist of two coupled U- and symmetrical H-shaped slot resonators in the grounding plane of the micro-strip transmission line.

DOI: 10.3103/S0735272712050032

INTRODUCTION

The transverse resonance techniques (TRT) [1] was initially developed for analyzing waveguides that possess simple analytical solution of the boundary problem by adding a heterogeneity in the transversal cross-section. A typical example of TRT application is calculation of critical and eigen frequencies for waveguides of complex shape (L-, U- and H-shaped waveguides) and analysis of waveguide heterogeneities such as dielectric inserts or metal E-plane inserts/irises in a rectangular waveguide [2]. Further TRT was developed for analyzing planar transmission lines [3, 4], and when combined with the emittance techniques in the spectral domain [5, 6] and mode matching techniques/long transmission lines theory [7, 8] it was adopted for analyzing heterogeneities in them (i.e. for solving three-dimensional boundary problems). When applied to three-dimensional structures the techniques is called the generalized transverse resonance techniques.

The idea of a generalized TRT consists in the following. In homogeneous transmission line standing waves are created by superposition of two waves with equal amplitude propagating in opposite directions. This is equivalent to introducing perfect electric or magnetic planes for obtaining current or voltage zero that limit the resonator. When inserting heterogeneities into the waveguide the standing wave is created by a superposition of transmitted and reflected waves, but in this case with different amplitudes and phases that depend on the heterogeneity itself. In this case parameters of the resonator itself change as well.

Such methodology is applicable for analyzing both 1-port networks (for example, short circuit in the slot transmission line), 2-port and 4-port networks that contain coupled and placed on the opposite sides of the dielectric substrate strip transmission lines [9] or complex transmission lines that contain combinations of elementary ones, for example, a strip-to-slot transmission line transition [10].

In contrast to direct numerical techniques (for the method of moments refer to [11] and references in it) that are used for analyzing multi-layer planar structures including those used in commercial software, when calculating the characteristic matrix using TRT we use resonant frequencies obtained by solving the boundary problem for a resonator with heterogeneity. The spectrum of resonator's eigen frequencies provide more complete information on physical processes and wave modes transforms in the resonant structure.

Algebraic formalization of boundary problems in planar structures is conducted using the Galerkin techniques, when the electromagnetic field in the waveguide transmission line and in the heterogeneity is represented by a expansion into series with respect to some basis. For example, in [9] when solving the boundary problem for a resonator with a heterogeneity in the form of two crossing and placed on the opposite sides of the dielectric substrate strip lines the current density components are represented by a dual