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Low-Pass Filters Based on Crystal-Like Inhomogeneities[1]

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Abstract—The paper proposes microstrip low-pass filters (LPF) based on three-dimensional electromagnetocrystalline inhomogeneities (ECI). The calculated responses (AFRs) of quasi-lumped reactive elements based on traditional and ECI structures are compared. AFRs of quasi-lumped ECI-based reactive elements are noticeably close to AFRs of lumped elements. The frequency of the AFR first minimum of ECI-based LPF is three times as large as the similar frequency of LPF based on traditional structures. Combined ECI incorporating the inductive and capacitive elements are also proposed. LPF structures based on single and combined ECI are presented. The calculated and experimental parameters and AFRs of filters are presented that illustrate a significant size reduction and performance improvement in the suppression band as compared to the filter having the traditional structure. The amplitude-frequency characteristics have been calculated using the three-dimensional simulation in the environment of CST Microwave Studio software package.

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INTRODUCTION

Microstrip devices are widely applied in different radioelectronic systems. The modern development of microstrip facilities to a great degree is associated with the use of artificial materials, i.e. metamaterials, and also artificial structures with special characteristics [1, 2]. Such structures include the crystal-like structures with zonal properties similar to crystals. Microstrip crystal-like structures representing electromagnetic crystals (EC) and also individual EC inhomogeneities (ECI) in the form of two-dimensional inhomogeneities in microstrip conductor or in metallized surface [3–5] are used in designing of filters [6], antennas [7], and power dividers [8].

Traditional ECI are two-dimensional. The three-dimensional ECI were proposed in [9, 10]. They have an important advantage that consists in significant extension of the range of equivalent wave impedance as compared to the traditional microstrip structures and two-dimensional ECI. One of the consequences of such extension is the possible implementation of quasi-lumped reactive elements with reactance values (1.5–4) times as large as those of traditional structures with the same dimensions [11].

Quasi-lumped reactive elements are implemented by using short sections of transmission line (TL) as compared to the wavelength. The low-pass filters (LPF) are built on the basis of quasi-lumped reactive elements. Three-dimensional ECI have smaller sizes for the specified values of reactances. The reduced size of quasi-lumped reactive elements makes it possible to extend the frequency range of their implementation and reduce the sizes of filters.

The purpose of this study consists in comparative investigation of frequency characteristics of quasi-lumped reactive elements based on traditional microstrip structures and three-dimensional single ECI with the inductive or capacitive character of reactivity, the investigation of frequency characteristics of the proposed ECI combining the inductive and capacitive elements, and also in the investigation of ECI-based microstrip LPF.

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