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Quasi-Lumped Reactive Elements Based on Crystal-Like Discontinuities

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Abstract—The paper proposes an implementation of quasi-lumped reactive elements by using electromagnetocrystalline (EC) discontinuities. Characteristics of EC discontinuities and traditional microstrip structures are compared that illustrate a significant rise (by the factor of 1.5…4) of values of reactances caused by their implementation with EC discontinuities. The software package CST Microwave Studio has been used for simulation. Experimental characteristics for the proposed and traditional quasi-lumped inductances are presented. In addition, an error of quasi-lumped element parameter is analyzed and possible minimization of the error is shown.

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INTRODUCTION

Microstrip devices are widely used in radioelectronic systems for various applications. In recent times new development trends have been established in the field of microstrip technology that are based on new technological solutions and materials making it possible to materially reduce the device dimensions and enhance their selectivity [1].

One of these directions involves the use of artificial structures with specific characteristics [1, 2]. Such structures include crystal-like structures with zone properties similar to crystals [2]. Microstrip devices utilize the microstrip crystal-like structures representing electromagnetic crystals (EC) and also individual EC discontinuities. Traditional EC discontinuities are implemented as two-dimensional in the form of various shape holes or slits in the metallized area or in signal conductor [1, 3, 4].

Microstrip structures employ elements with low (Z_{low}) and high (Z_h) impedances [1, 5]. The boundary values of Z_{low} and Z_h are limited by the admissible width of signal conductor and equal to 20 and 120 Ω [6]. The traditional two-dimensional EC discontinuities by their nature are high-impedance with boundary value of $Z_h = 210\ \Omega$ [7].

Papers [8–10] propose the high- and low-impedance three-dimensional EC discontinuities that combine irregularities in metallized area, in dielectric and on the signal conductor surface with noticeably larger and smaller equivalent impedances. For example, EC discontinuity with $Z_h = 360\ \Omega$ was considered in [8], while that with $Z_{low} = 4\ \Omega$—in [9].

A material extension of the impedance range (up to 4–400 Ω) represents a key advantage of three-dimensional EC discontinuities. The wave impedance characterizes the reaction force of the structure on the wave disturbance and the efficiency of the structure impact on the wave. The ratio Z_h/Z_{low} increases from 6 to 100 as compare to the conventional microstrip structures. The selectivity of structures increases with the rise of Z_h/Z_{low} ratio [5].

The use of three-dimensional EC discontinuities as quasi-lumped reactive elements has been first proposed in the present paper. The propose elements feature significantly increased values of reactances as compare to the conventional microstrip structures.