8-order filter based on 2-D photonic crystal with dual-mode microstrip resonators

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8-order filter based on 2-D photonic crystal with dual-mode microstrip resonators

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Abstract. The design of 8-order band-pass filter based on 2-D photonic crystal is suggested. Strip conductors in all dual-mode resonators are in the form of «irregular» rectangular frame with a gap and are connected at certain points with the ground. At optimal placement of such resonators on a substrate attenuation pole is observed on the amplitude-frequency characteristic of the filter, near low and high bandwidth slope that significantly improves its frequency-selective properties. The change of gap between input and output resonators allows to control the frequency of these poles.

1. Introduction

It is known that photonic crystals are artificial periodic structures, the irregularities in the dimensions of which are comparable to the wavelength of the electromagnetic wave [1, 2]. Currently, on the basis of one-dimensional and two-dimensional (2-D) crystals various perspective frequency-selective devices, including microwave ones are developed and studied [3, 4].

This paper presents the investigation results of microstrip band-pass filter of a new design constructed on the basis of two-dimensional photonic crystal. Its amplitude-frequency characteristics calculated by means of electrodynamic numerical analysis of 3-D models are in good agreement with the experiment, in this regard theoretical study of such 2-D structures can be considered reliable. Filter tune is performed by «manual» parametric synthesis, for this reason the substrate with high dielectric constant $\varepsilon = 80$, $h = 1$ mm thickness (material – TBNS ceramics) was used.

2. Modelling results

The topology of strip conductors of the proposed microstrip filter is shown in figure 1(a). At the same time four dual-mode resonators *I* - *IV* of a structure represent two-dimensional (with inhomogeneity along the *x*-axis and along the *y*-axis) microstrip photonic crystal structure. The strip conductor of each resonator is in form of «irregular» rectangular frame with a gap and has a connection with the ground near the centre (see figure 1(a)). Such grounding can be realized by through hole in the dielectric substrate of 0.2×0.2 mm^2 filled with conductive material. So, in fact, each of these dual-mode resonators of band-pass filter is a pair of connected quarter-wave resonators that allows to miniaturize frequency-selective device significantly.

As it has been shown by the example of 2-D structure with single-mode irregular microstrip resonators [5], there are several options for the location of resonators on a substrate, in this connection, as it should be expected, filters have significantly different frequency-selective properties. Therefore, having optimum clearances between the strip conductors, the signal is transmitted sequentially from the input *I* resonator to the *II*, *III* and finally to the output *IV* resonator.

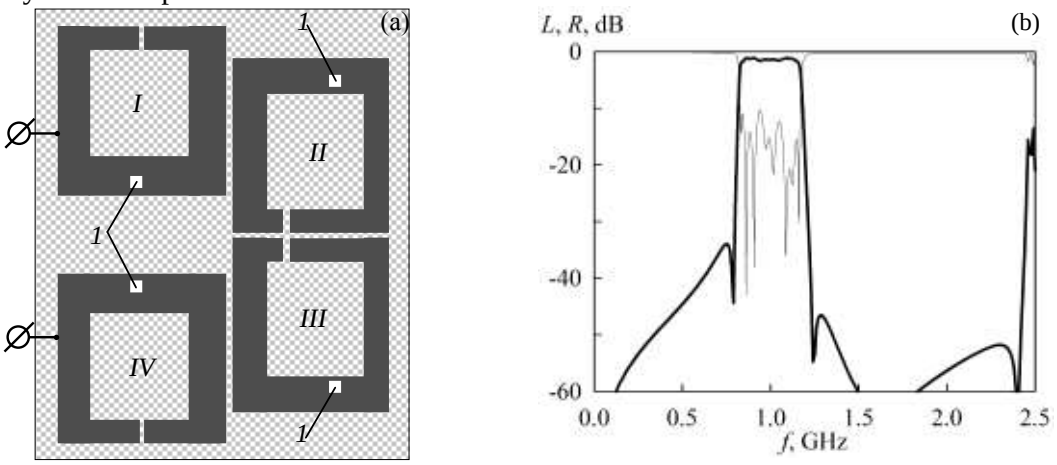

Figure 1. (a) The topology of strip conductors of 8-order filter; **(b)** Amplitude-frequency characteristics of 8-order filter. *1* – conductors' connection points with the ground

As it is shown in figure 1(b), on the amplitude-frequency characteristics of the filter near the low and high slopes of bandwidth the attenuation pole is observed that increases the steepness of the slopes greatly. Minimum power loss in the bandwidth does not exceed -1.1 dB at its relative width of ~ 34%.

It is worth noting that increasing of clearance between the conductors of *I* and *IV* resonators can simultaneously increase power suppression both in low-frequency and high frequency stopbands, but it is accompanied by the decrease of steepness of passband both slopes.

Therefore, the proposed microstrip 8-order band-pass filter based on 2-D photonic crystal has high frequency-selective properties.

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