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# MODELING OF TRIPLEXERS FOR OPTICAL COMMUNICATION SYSTEMS

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# МОДЕЛЮВАННЯ ТРИПЛЕКСЕРІВ ДЛЯ ОПТИЧНИХ СИСТЕМ ЗВ'ЯЗКУ

Досліджено нові структури триплексерів, побудованих на системах відомих Ad-drop фільтрів з резонаторами шепочучої галереї оптичного діапазону довжин хвиль. Побудовані електродинамічні моделі триплексерів. Розраховано частотні характеристики S-матриці. Показано можливість досягнення прийнятних параметрів розсіювання.

Add-drop filters based on microcavities with whispering gallery oscillations attract close attention of researchers and developers for constructing multiplexers of various types of optical communication systems [1 - 6]. The main difficulty in describing the processes of wave scattering in Add-drop filters is the presence of a doubled number of coupled oscillations due to their degeneracy. At the same time, the indicated degeneracy of natural oscillations leads to specific scattering effects, which makes it possible to build new types of filters and multiplexers based on them. This report presents the results of studies of new types of compact triplexers for integrated circuits of optical communication systems.

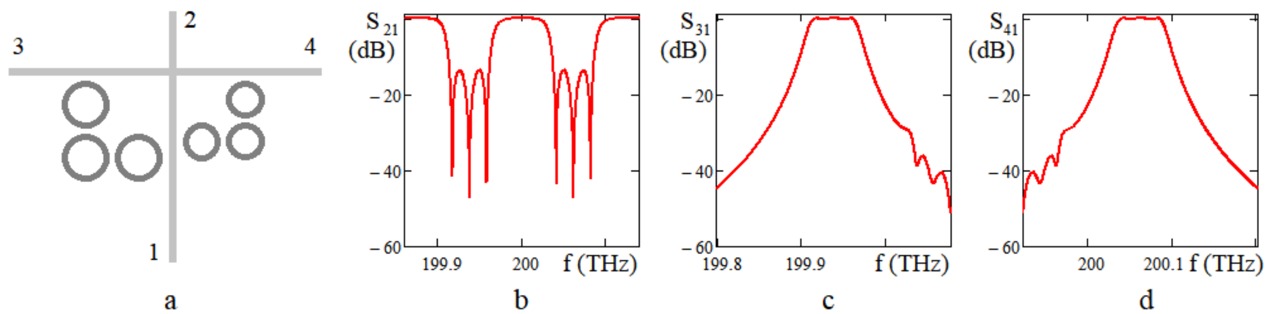


Fig. 1. The structure of the triplexer built on crossed optical waveguides and 3+3 microcavities (a). Frequency characteristic of the S-matrix (b - d) of the triplexer (a).

As follows from [7], the smallest pulse distortion occurs in filters with a sequential placement of microresonators. On the basis of the developed theory of electromagnetic modeling of Add-drop filters [8, 9], new structures of coupled microcavities for the construction of integrated triplexers are considered.

In Fig. 1 *a* shows the structure of the triplexer built on crossed optical waveguides. This triplexer consists of two Add-drop filters, each of which has an odd number of microcavities. The first bandwidth of the triplexer between ports 1-2 is formed due to the side slopes of the frequency response of the filters (Fig. 1, b). The second and third bandwidths are formed between ports 1-3 and 1-4 and determined by the Add-drop filters themselves. Coupling coefficients between resonators with even types of oscillations; $k^e_{s,s+1} = 2 \cdot 10^{-4}$ with odd oscillations $k^o_{s,s+1} = -2 \cdot 10^{-4}$. Coupling coefficients of microresonators with lines of resonators with even types of oscillations $\tilde{k}^e = 2 \cdot 10^{-4}$; for odd types of oscillations $\tilde{k}^o = 1{,}9 \cdot 10^{-4}$. Q-factor of dielectric of resonators $Q_D = 10^6$; coupling coefficients with open space $\tilde{k}_{OS} = 10^{-7}$. "Center frequency" $f_0 = 200\,\text{THz}$; band between center frequencies of the filters $\Delta f = 0{,}124\,\text{THz}$. The frequency characteristics of the triplexer are shown in Fig. 1, b - d.

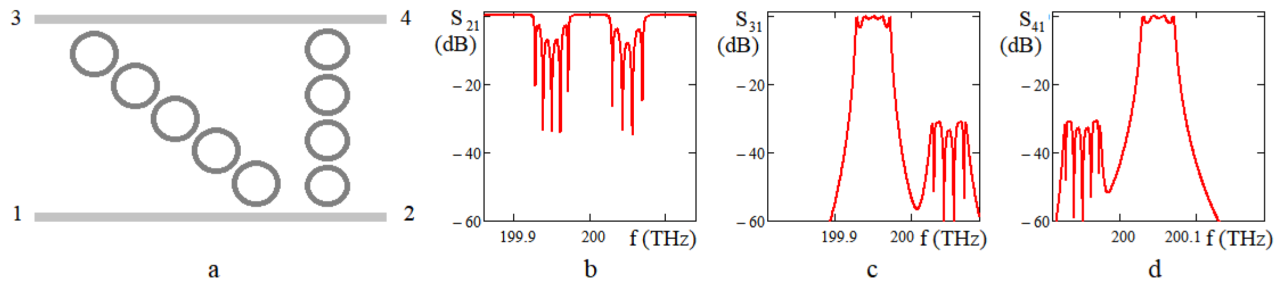


Fig. 2. The structure of the triplexer built on parallel optical waveguides. and 9 microcavities (a). Frequency characteristic of the scattering (b - d).

In Fig. 2 *a* shows the structure of the triplexer of the second type, performed on parallel optical integrated waveguides 1-2, 3-4. It is proposed to build this type of triplexers from two Ad-drop filters containing the number of microcavities of different parity. The transmission bands of such a triplexer for 5 and 4 microcavities are shown in Fig. 2, b-d. In the simulation, it was assumed that the coefficients of mutual coupling of Add-drop filters between resonators with even types of oscillations $k^e_{s,s+1} = 1{,}3 \cdot 10^{-4}$; with odd fluctuations $k^o_{s,s+1} = -1{,}3 \cdot 10^{-4}$. Coupling coefficients of microresonators with lines for even types of oscillations $\tilde{k}^e = 9 \cdot 10^{-5}$; for odd types of oscillations $\tilde{k}^o = 8 \cdot 10^{-5}$. Q-factor of dielectric of resonators $Q_D = 10^6$; coupling coefficients of microcavities with open space $\tilde{k}_{OS} = 10^{-7}$."Center frequency" $f_0 = 200\,\text{THz}$; approximate bandwidth between center frequencies of THz filters $\Delta f = 0{,}1\,\text{THz}$.

The electromagnetic modeling of triplexers, carried out on the basis of the theory [8], showed an acceptable amount of isolation between the channels.

The bandwidths and barriers of both types of triplexers are adjusted independently of each other with a sufficiently large detuning of the bandwidth of the outer channels. The main difficulty in tuning is to achieve an acceptable crosstalk between channels. As follows from the results of the performed optimization, the frequency response of the crosstalk between channels 1-3, 1-4 of the first type triplexer (fig. 1, a) exceeds 40 dB, and the crosstalk attenuation of the second type triplexer (fig. 2, a) is about 30 dB.

A new structure of triplexers based on crossed and parallel optical waveguides is proposed. Triplexers of the first type are built on filters with an odd number of microcavities. Triplexers of the second type are built on filters with a number of microresonators of different parity. The constructed electromagnetic models of triplexers make it possible to determine in advance the number of microcavities, as well as the dimensions of the structure according to the required scattering characteristics. The proposed structures are characterized by more compact dimensions in comparison with structures of the type: one channel - one filter.

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