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CALCULATION PARAMETERS OF ADD-DROP FILTERS ON OPTICAL MICRORESONATORS

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РОЗРАХУНОК ПАРАМЕТРІВ ADD-DROP ФІЛЬТРІВ НА ОПТИЧНИХ МІКРОРЕЗОНАТОРАХ

Розроблена електродинамічна теорія розрахунку параметрів матриці розсіювання add-drop фільтрів, побудованих на діелектричних мікрорезонаторах з хвилями шепочучей галереї.

The use of microresonators in the filters will allow us create optical communication and computation devices with channel separation by wavelength in the integral design, therefore the development of add-drop filters is an actual technical task. Today, the development of such filters relies on modeling based on the use of equivalent circuits, and in the case of using whispering gallery modes (WGM), on the theory of connected lines [1-8].

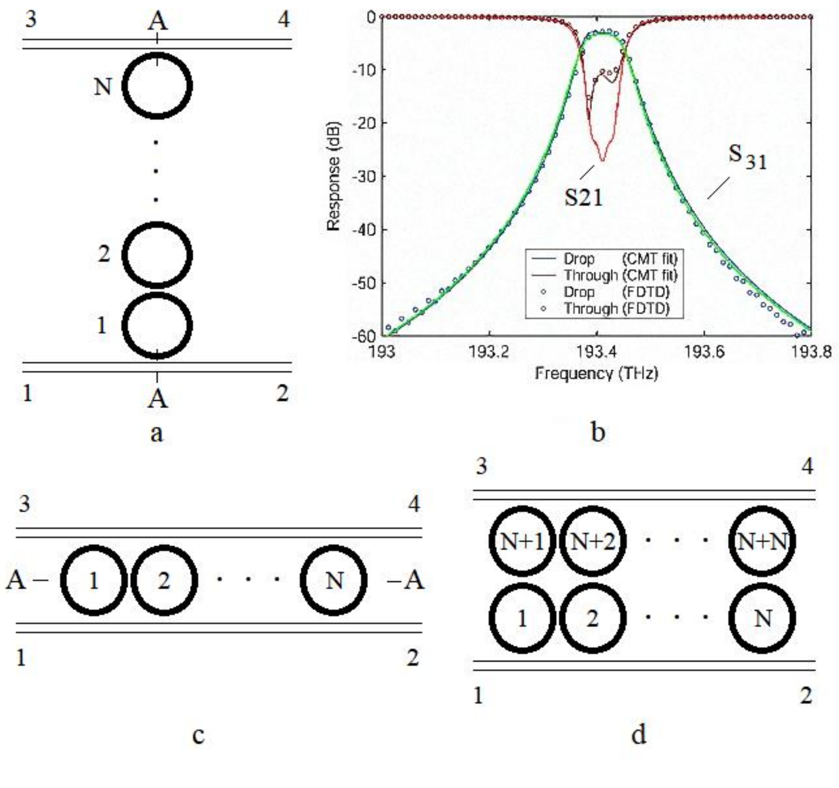

Fig. 1. Different add-drop filters (a, c, d) on microresonators. Comparison of S-matrix of the 3-microresonator filter from [4]; calculated by theory [9]: S_{21} - red; S_{31} - green curve

The purpose of this work is to apply the methods of electrodynamic modeling of scattering processes on systems of optical microresonators based on the results of work [9].

To build an electrodynamic models of the filters, the following assumptions were made. It was assumed that a pair of degenerate orthogonal WGM, characterized by a given parity relative to the plane of symmetry A – A of the structure (Fig.1, a, c), is excited in each microresonator. Such even and odd modes are not coupled.

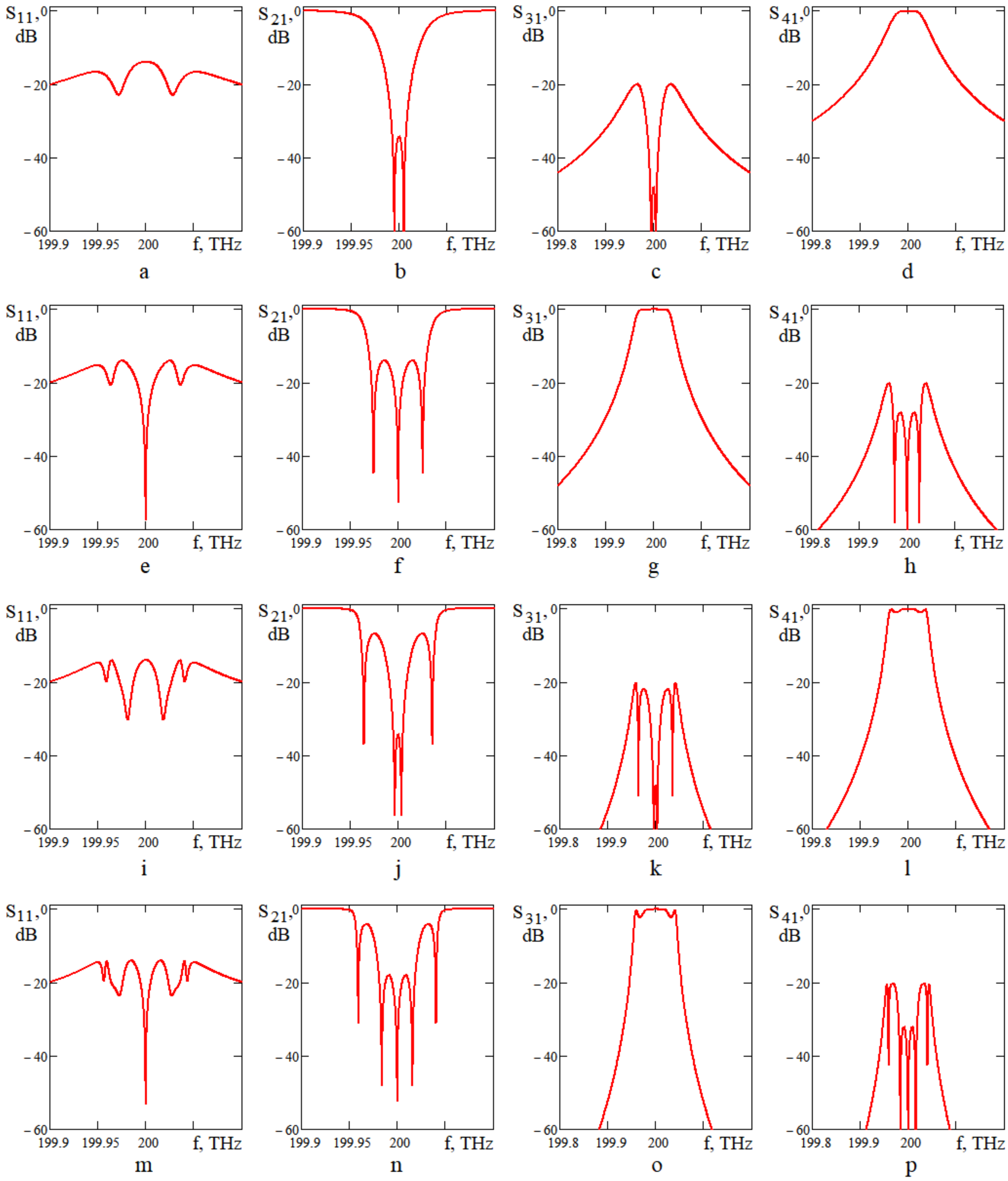

Fig. 2. Example of calculated dependences of scattering matrices of the Add-Drop Filters, shown in fig. 1, a, on 2 (a - d); 3 (e - h); 4 (i - l); 5 (m - p) microresonators.

All microresonators are coupled only with neighboring ones as well as can also radiate to an open space.

The results of the calculation of the dependence of S_{21} and S_{31} according to [9] as compared with the calculation data taken from [4] for 3 microresonator filter are shown in Fig. 1, b. Here the filter input port is 1; throughput port is 2; the drop port is 3 and the add port is 4.

The results of the calculation of the dependence of the scattering matrix on the frequency by the method [9] for 2 - 5 resonator add-drop filters are shown in Fig. 2. Where $f_0 = 200$ THz - is the natural oscillation frequency of isolated microresonators; open space microresonator coupling coefficient $\tilde{k}_{OS} = 10^{-7}$. The coupling coefficient of the 1-st and N-th microresonators with optical transmission lines for even oscillations $\tilde{k}^e = 3 \cdot 10^{-4}$; for odd oscillations $\tilde{k}^o = 2 \cdot 10^{-4}$. The coupling coefficient between adjacent microresonators for even oscillations $k_{12}^e = 2{,}5 \cdot 10^{-4}$; for odd oscillations $k_{12}^o = -2{,}5 \cdot 10^{-4}$.

Similar S-matrix dependencies were also calculated for filters that shown on fig. 1, c, d.

As can be seen from the data obtained, filters of different orders give frequency dependences that are in good agreement with the observed scattering patterns without additional assumptions regarding the distribution of the field in the structure.

The optical filter model, based on the results of the electrodynamic theory of coupled resonators, allows us obtain results that are close in values compared with the data of numerical calculations and traveling wave approximations.

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