UDC 621.372.543

ATTENUATION POLES IN BAND-PASS FILTERS WITH EVEN END ODD MODES

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Полюса затухания в полосовых фильтрах с четными и нечетными модами

В докладе рассмотрены теоретические и экспериментальные характеристики полосового фильтра с полюсами затухания, образованного короткозамкнутым посредине полуволновым резонатором. Моделирование проведено с помощью программных продуктов Microwave Office и LabVIEW. Совпадение теоретических и экспериментальных результатов исследований свидетельствует об адекватности и эффективности выбранных моделей.

The report reviews the theoretical and experimental characteristics of a band-pass filter with attenuation poles formed by a half-wave resonator short-circuited in the middle. The simulation was carried out using the software products Microwave Office and LabVIEW. The matching of theoretical and experimental research results indicates the adequacy and effectiveness of the selected models.

A photograph of a microstrip filter, consisting of open circuit line and two parallel-connected resonators (short - "half-wave" and long - "wave") is shown in Fig. 1. Such a filter design with a controlled bandwidth was considered in [1].

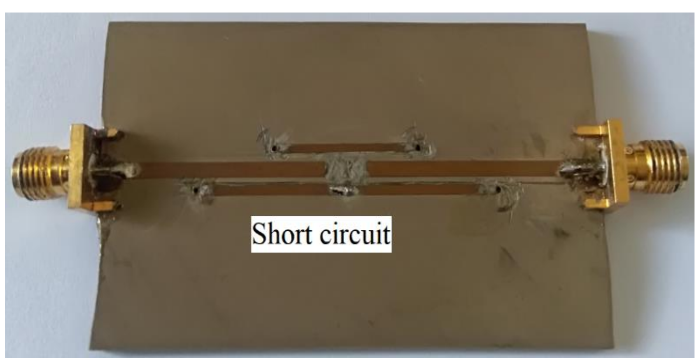
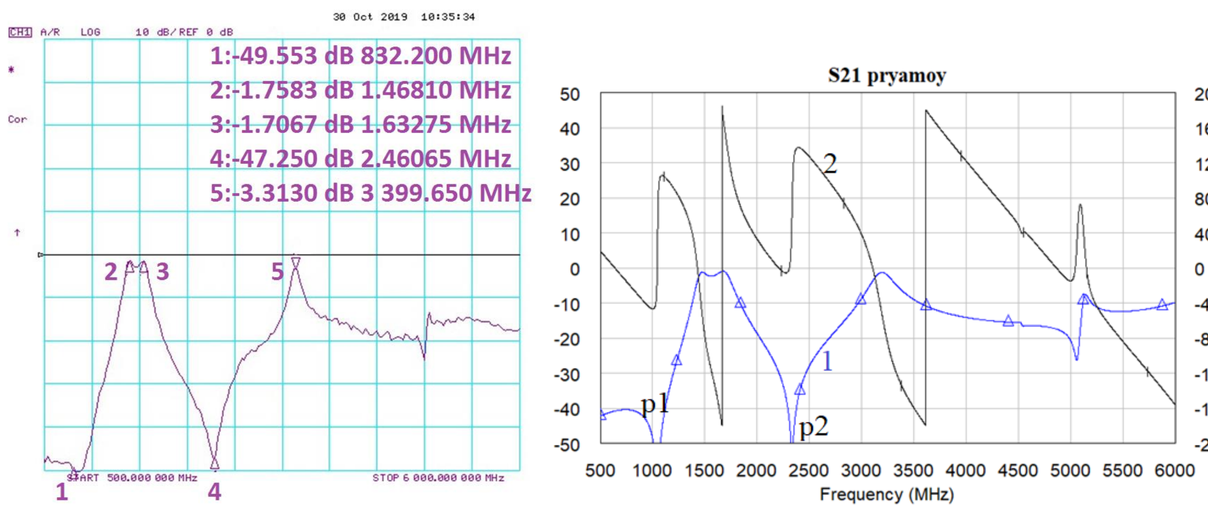


Fig. 1 Microstrip bandpass filter with two parallel resonators of different types. The long resonator is short-circuited with a 2 mm loop in the middle.

It is known [2] that if a short-circuit (SC) loop is set in the middle of a strip resonator, its characteristic becomes similar to a two resonators filter. In the design under consideration, a dielectric substrate with ε = 9.8 and a thickness of 2 mm was used; therefore, the SC at the operating frequencies of the resonator (of the order of 1.5 GHz) is an inductance that affects the resonant frequencies of the even and odd oscillation modes differently [3].

Figure 2 shows the experimental (Fig. 2 a) and calculated in the Microwave Office software (Fig. 2 b) filter characteristics in the frequency range from 0.5 to 6 GHz. The presence of attenuation poles (p1 and p2 in Fig. 2 b), which are absent in the filter with a short-circuited middle resonator from [2], is noteworthy.



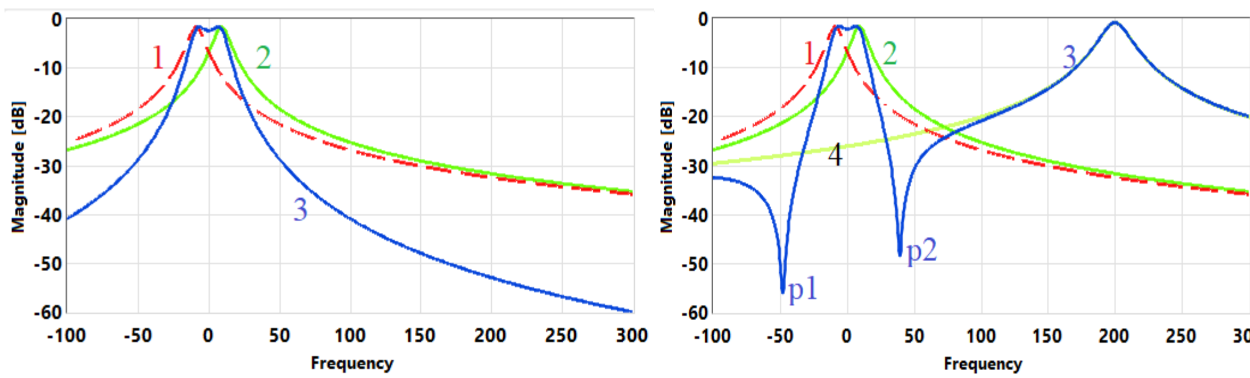
a) b)

Fig. 2. Experimental a) and calculated b) characteristics of the strip filter Fig. 1.
Curve 1 in Fig. 2 b) is the amplitude of the transmission coefficient S_{21},
curve 2 is the phase of the transmission coefficient S_{21}.

The reason for the presence of attenuation poles is a short “half-wave” resonator with a resonant frequency of the order of 3.4 GHz. Indeed, since the resonators in this construction are not coupled, but are connected in parallel, there are at least two independent channels of energy transfer and a bridge equivalent circuit can be used to model the S-parameters of the filter [4].

An algorithm was developed for modeling bridge filters in the LabVIEW software, which allows us to clearly demonstrate the amplitude and frequency characteristics of both individual arms and the quadrupole as a whole on a graph. In fig. 3 a) are depicted the frequency dependences of $|S_{21}|$ of even (curve 1) and odd (curve 2) oscillations; curve 3 is the total characteristic of the quadrupole transfer coefficient, equivalent to the short-circuited in the middle “long” resonator. The frequencies on the characteristics on Fig. 3 are presented in relative units.

If now an another oscillation is added, simulating the short resonator in Fig. 1 (its resonant frequency corresponds f_{rel}=200 in fig. 3 b), then, as follows from fig. 3 b), the attenuation poles are formed at frequencies in the regions p1 and p2. The reason for the formation of the poles is the different “signs” of the reactances of the “loops” of oscillations 1, 2, and 3 (we can also speak of the inductive and capacitive nature of the reactances and the “antiresonances” in the field of poles). An abrupt change in phase (curve 2 in Fig. 2. b) indicates a change in the sign of reactivity in the pole region (“antiresonance”).



a) b)

Fig. 3. Curves 1 and 2 in Fig. a) and b) are the characteristics of the in-phase and antiphase oscillations. Curve 3 is the characteristic of the filter as a whole.
Curve 4 - low-frequency slope of antiphase oscillation with a central frequency f_{rel}=200.

If the frequency of the second resonator is tuned, as was done, for example, in [1], then the position of the attenuation poles can be controlled.

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