UDC 621.372.543

MICROSTRIP 4-RESONATOR FILTERS WITH ATTENUATION POLES

Galitskiy I., Kamarali R., Shevtsov K., Kirilyuk V.
National Technical University of Ukraine "
Igor Sikorsky Kyiv Polytechnic Institute"
Educational and Research Institute of Telecommunication systems
E-mail: ilyagal26@ukr.net, r.kamarali@kpi.ua,
shewtsov.kostya@gmail.com, kuruval1999@gmail.com

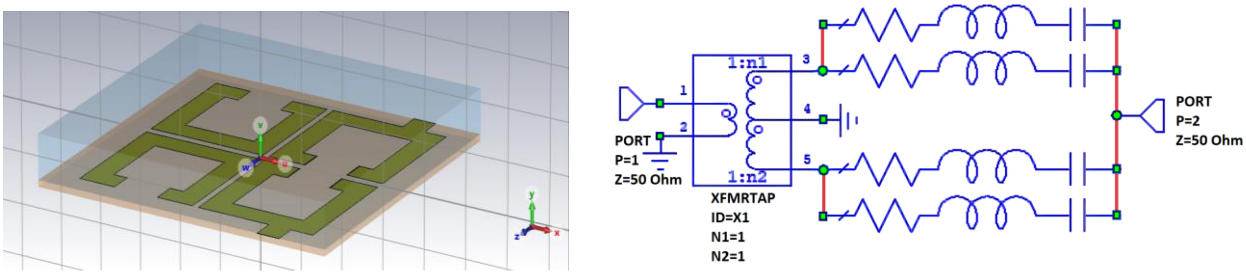
МІКРОСМУЖКОВІ 4-РЕЗОНАТОРНІ ФІЛЬТРИ З ПОЛЮСАМИ ЗАГАСАННЯ

У статті наводяться результати моделювання чотирьохрезонаторних фільтрів методами електродинаміки та теорії кіл.

The article presents the results of modeling four-resonator filters using the electrodynamics method and bridge circuits.

Resonators can be implemented using a variety of technologies, including microstrip lines, which are popular due to their planar structure and ease of integration with printed circuit boards [1]. These filters can also be reproduced on focused elements.

The filter pictured below was modeled by CST Studio Suite. Dielectric permeability ε=2.8, substrate thickness – 2 mm, strip thickness – 5.3 mm, tanδ– 0.001.



(a) (b)

Fig. 1. (a) Topology of the CST Studio Suite four-resonator filter. (b) AWR equivalent circuit.

In fig. 2 (a) the gain of S_{21} where Fano resonance has formed, exhibiting anomalously high attenuation of about -45dB and -30dB at the peaks and a narrow resonant characteristic around f = 0.82 GHz.

Metamaterials are usually diagrams of equivalent chain models. Figure 1 (b) shows the equivalent circuit modeled in the AWR Microwave Office software. In this case, a series RLC circuit is connected to the two arms of the transformer [2]. The simulation helped to build a microstrip filter not only with microstrips, but also with a bridge filter circuit. Figure 2 shows the result of the scheme. Bandwidth from 780 to 860 MHz. Attenuation is up to -40dB at peaks. The poles are formed because there are two paths of energy propagation that "intervene" in the region of zero transmission and create a "quasi-trapped" mode or "trapped" mode [3].

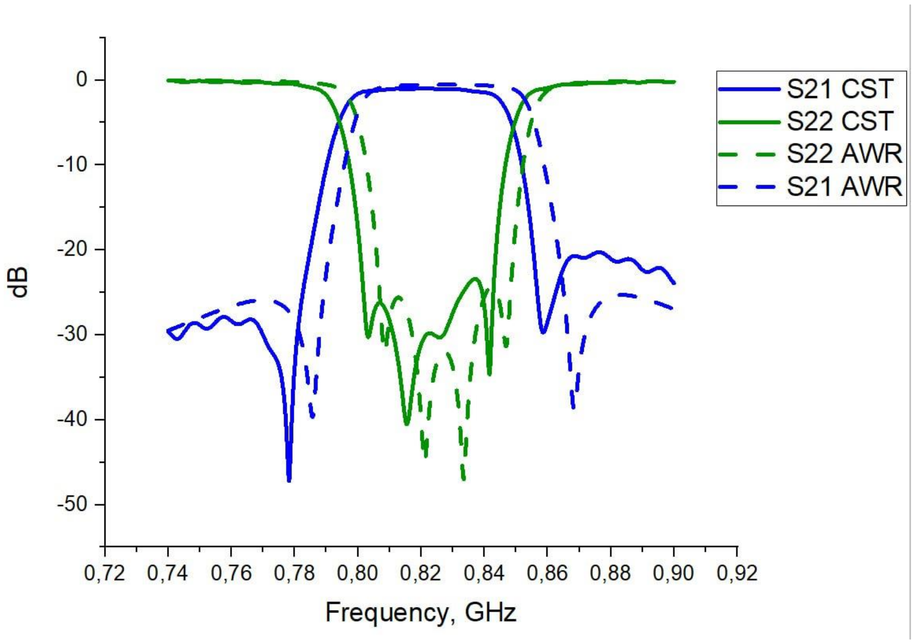


Fig. 2. Characteristic of the four-resonator filter in CST Studio Suite and AWR.

After studying the obtained results, we can come to the conclusion that the reflection coefficient does not change sharply in the regions of the poles. Therefore, a sharp decrease in the transmission coefficient can be explained only by the fact that trapped modes appear inside the structure in the region of such frequencies. The energy of these modes is not radiated outward, but "circulates" along the closed path 1-2-3-4-1, as shown in Fig. 3. Such poles can be reached with the help of additional connections between resonators, which makes it possible to create conditions for the formation and maintenance of these trapped modes.

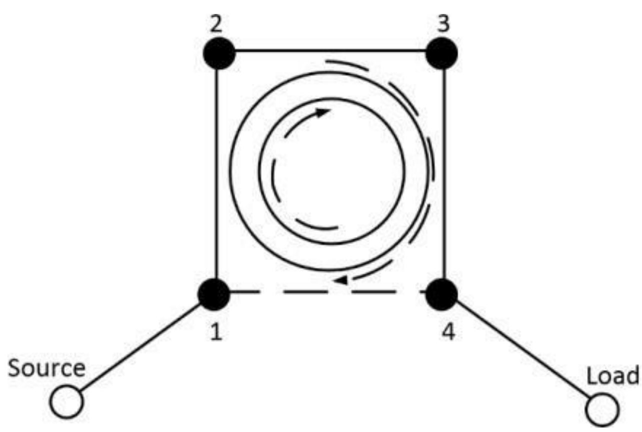


Fig. 3. Trajectory of propagation of trapped modes in a four-resonator filter.

The introduction of additional connections between resonators not only contributes to the formation of trapped modes, but also allows to control their properties. By changing the characteristics of these connections, it is possible to change the frequency characteristics of the trapped modes, which opens up wide opportunities for adjusting the properties of the structure. Thus, the study of the interaction between resonators and their influence on the formation of trapped modes is key to the development of new devices with improved characteristics [4].

Conclusion. Therefore, trapped modes appear in the form of extinction poles (interference of even and odd oscillations). A sign of this is the presence of two independent energy paths along which interfering oscillations propagate. With correctly selected parameters (resonator coupling coefficients, resonance frequencies) at a certain frequency, a complete exchange of resonator energies occurs in the direction perpendicular to the direction of energy propagation from the input to the output.

All 3 modeling methods gave a similar, even almost identical result, which testifies to the variety of variations in the performance of the investigated filters.

Acknowledgement. This work was supported by NATO SPS G6002 “3D metamaterials for energy harvesting and electromagnetic sensing”.

References

1. USSR Inventor’s Certificate 1529321.
2. Ільченко М. Й., Живков О. П., Камаралі Р. В. та ін. "Моделювання електромагнітно індукованої прозорості за допомогою RLC-схем і метаматеріальної комірки". Національний технічний університет України «Київський політехнічний інститут імені Ігоря Сікорського».
3. Zhivkov, O., Stoianov, I., Tychynskyi-Martyniuk, V., Galitskiy, I., Shevtsov, K., & Kamarali, R. (2023). Modeling of Microwave and Terahertz Trapped Modes by Circuit Theory Methods. 2023 IEEE 6th International Conference on Information and Telecommunication Technologies and Radio Electronics, UkrMiCo 2023. Presented at the 6th IEEE International Conference on Information and Telecommunication Technologies and Radio Electronics, UkrMiCo 2023, Kyiv, Ukraine, Nov 13 2023 - Nov 18 2023. https://doi.org/10.1109/UkrMiCo61577.2023.10380329.
4. Cameron, R. J., Kudsia, C. M., & Mansour, R. R. (2018). Microwave Filters for Communication Systems. doi:10.1002/9781119292371.