

PAPER • OPEN ACCESS

Investigation of frequency-selective properties of microwave wideband bandpass filters

To cite this article: S A Khodenkov and N M Boev 2017 *J. Phys.: Conf. Ser.* **929** 012025

View the [article online](#) for updates and enhancements.

Related content

- [Microstrip filters based on 2D electromagnetic crystal](#)
S A Khodenkov and B A Belyaev
- [Multimode filter composed of single-mode surface acoustic wave/bulk acoustic wave resonators](#)
Yulin Huang, Jingfu Bao, Gongbin Tang et al.
- [IM3 measurements of HTS microstrip bandpass filters](#)
H Sato, K Cho, J Kurian et al.



IOP | ebooks™

Bringing together innovative digital publishing with leading authors from the global scientific community.

Start exploring the collection—download the first chapter of every title for free.

Investigation of frequency-selective properties of microwave wideband bandpass filters

S A Khodenkov¹ and N M Boev²

¹ Physics Department, Reshetnev Siberian State Aerospace University, 31 Krasnoyarskiy Rabochiy pr., Krasnoyarsk 660037, Russia

² Laboratory of electrodynamics and microwave electronics, Kirensky Institute of Physics, 50/38 Akademgorodok, Krasnoyarsk 660036, Russia

E-mail: hsa-sibsau@mail.ru

Abstract. A new approach allowing to improve frequency-selective properties for a fixed order of N filter is suggested. In all the studies, conducted with the help of numerical electrodynamic analysis of 3D models of microstrip filters based on a multimode resonator, the same substrate with dielectric constant $\varepsilon=2.8$ and thickness $h=2$ mm (material - FLAN) was used in calculations. The central bandpass frequency of microwave structures $f_0 \approx 1.4$ GHz was registered and as well as relative bandwidth $\Delta f/f_0 \approx 80\%$. The strip conductor of central multimode resonator in six studied filters of the sixth and eighth orders has the shape of an irregular meander being electromagnetically connected with four single-mode resonators, a pair of which is located to the left of it, and the other pair is to the right. It is shown that in single-mode quarter-wave resonators building-up the number of portions of identical parallel strip conductors, connected to a screen at one end and connected with each other by a strip conductor jumper, can increase the power of suppression at low-frequency stop band by more than 15 dB, as well as near high-frequency slope of passband by more than 10 dB. Therefore, the level of maximums of return losses in the passband of wideband bandpass filter ranges within a few dB.

1. Introduction

During the process of development and study of new frequency-selective devices, including microstrip filters, developers traditionally make an attempt to increase their frequency-selective properties, to enhance the manufacturability and to reduce the size and cost of the finished product [1-5].

While constructing a broadband microstrip filter [6, 7], multimode resonator with strip conductors in the shape of an irregular meander [8] proved themselves. The use of such resonator in microwave structure as central electromagnetically associated with multiple single-mode resonators at the input and the output, two of which are connected to a screen, allows to observe among the amplitude-frequency characteristics (AFCs) plurality of attenuation poles, a pair of which is on the left, and a pair - on the right near passband [8]. As a result, frequency-selective properties of such filter are improved significantly. Besides the increase of number of periods in «irregular meander» allows to add one resonance into the passband of wideband filter based on multimode resonator. Moreover, the increase of number of single-mode resonators in microstrip construction allows to increase N filter order. Such complexity of the structure is accompanied by additional improvements of its frequency-selective properties. In this connection, if the research is carried out by means of numerical electrodynamic analysis of 3D models, the obtained data coincide with measurements made on constructed layouts.



However, in fact, a substantial building-up of resonances' number, forming passband of filter is accompanied by strong complexification of «manual» parametric synthesis of the latter with set characteristics, especially while using multimode resonator with the number of working oscillation modes exceeding four in number.

Therefore, in the present paper a new approach that will improve the frequency-selective properties of the wideband filter without increasing its N order is suggested.

2. The study of frequency-selective properties of wideband bandpass filters

For objective comparison of amplitude-frequency characteristics of all the investigated broadband filters the same substrate with dielectric constant $\epsilon=2.8$ and $h=2$ mm thickness (material - FLAN) were used in calculations. Also, center bandpass frequency was recorded as $f_0 \approx 1.4$ GHz and the relative bandwidth was $\Delta f/f_0 \approx 80\%$. All the data stated in the publication are obtained by electrodynamic numerical analysis of 3D model structures. In this case all strip conductors of the considered filters have axial symmetry.

Figure 1a shows the original bandpass filter of the sixth order $N=6$ [5]. In such microstrip structure central resonator with three joined portions of strip conductors 3, 4, as it was mentioned above, is a multimode or rather – two-mode one. It is electromagnetically connected with four single-mode resonators having extended rectangular strip conductors 1, 2, while conductors 2 are connected to a screen at one end.

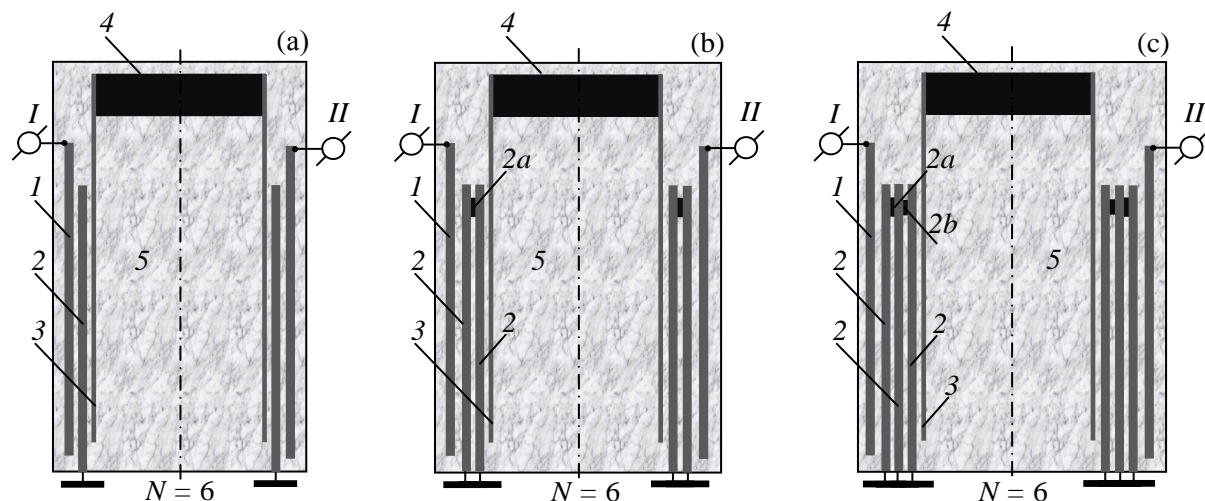


Figure 1. Wideband bandpass filters of the sixth order: original filter (a), filter with four portions of strip conductors connected to a screen (b), filter with six portions of strip conductors connected to a screen (c). Regular portions of conductors are designated by numbers (1-4) and located on the dielectric substrate 5. I, II – ports of the filters.

In such filter the internal quarter-wave single-mode resonators (figure 1b and figure 1c) can be transformed, increasing the number of, connected to a screen, identical portions of the strip conductors 2, connected with each other by strip conductor jumper 2a. It is necessary to note that the dimensions of the strip conductor 1 and portions 3, 4 of the strip conductor structure were not changed, while the bridge dimensions, its location and width of the conductors' portions 2 were chosen in order to enhance power suppression in stop bands of broadband filter (figure 2).

Moreover, two- or three-times increase of the number of strip conductors of such portions increases capacity suppression by 10.8 dB (11.7 dB) at frequencies of low-pass stop band and by 10.1 dB (11.6 dB) near high-pass slope of the passband.

It should be noted that the level of maximums of return loss $R(f)$ in the passband structure ranges in its turn within several dB, so such change of single-mode resonators, in fact, does not make the wideband filter's setting more complicated.

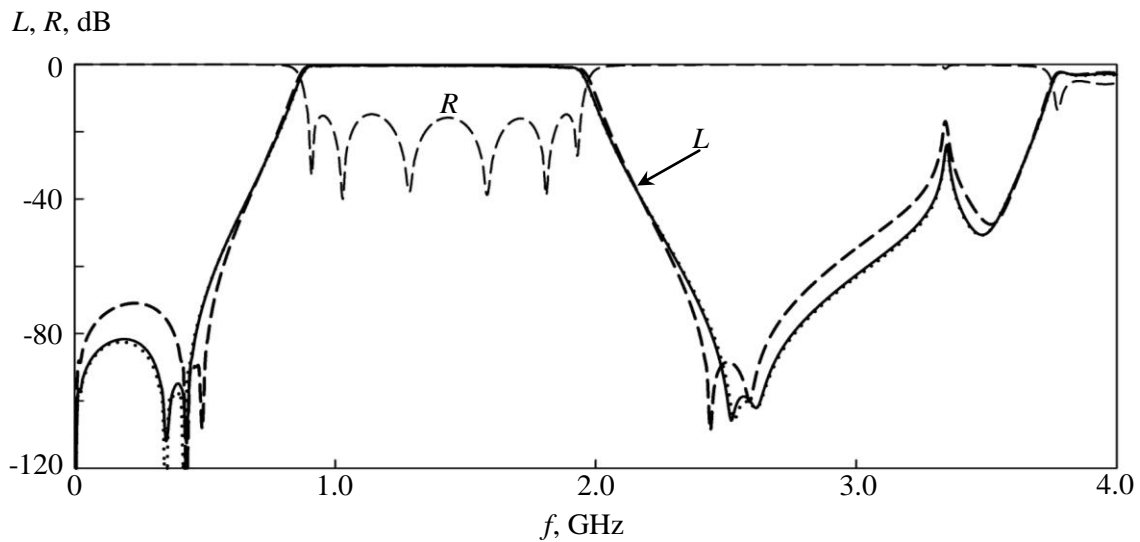


Figure 2. Amplitude-frequency characteristics of filters of the sixth order: AFCs of filter shown in figure 1a (dashed lines), AFCs of filter shown in figure 1b (line), AFCs of filter shown in figure 1c (points). $L(f)$ – frequency dependence of direct losses, $R(f)$ – frequency dependence of losses in reflection.

It is necessary to mention that the proposed approach aimed at improving the frequency-selective properties of wideband constructions can be applied dealing with higher order of N filter. It is shown by the example of bandpass filter of the eighth order that has already been implemented at four-mode resonator (figure 3).

In such resonator the portions of strip conductors 3-6 are joined in the form of irregular meander with a large number of foldings.

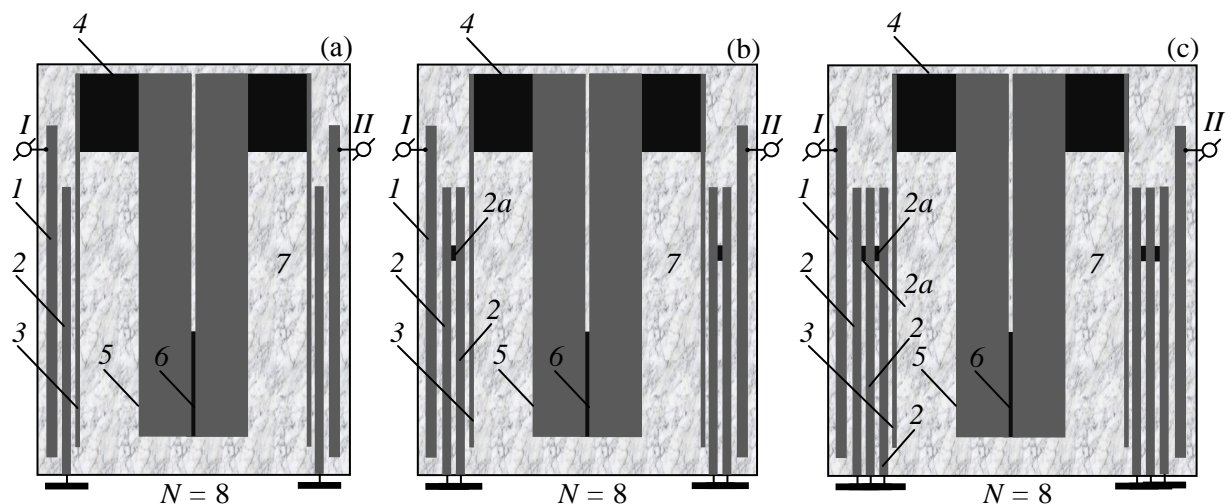


Figure 3. Wideband bandpass filters of the eighth order: original filter (a), filter with four portions of strip conductors connected to a screen (b), filter with six portions of strip conductors connected to a screen (c). Regular portions of conductors are designated by numbers (1-6) and located on the dielectric substrate 7. I, II – ports of the filters.

For objective comparison of construction characteristics, the same number of additional portions of strip conductors was used. Moreover, two-times increase of the number of portions in the strip

conductors 2 (figure 3) increases power attenuation by 12.3 dB (16.2 dB) at frequencies of low-pass stop band and by 5.7 dB (10.1 dB) near the high-pass slope of passband (figure 4).

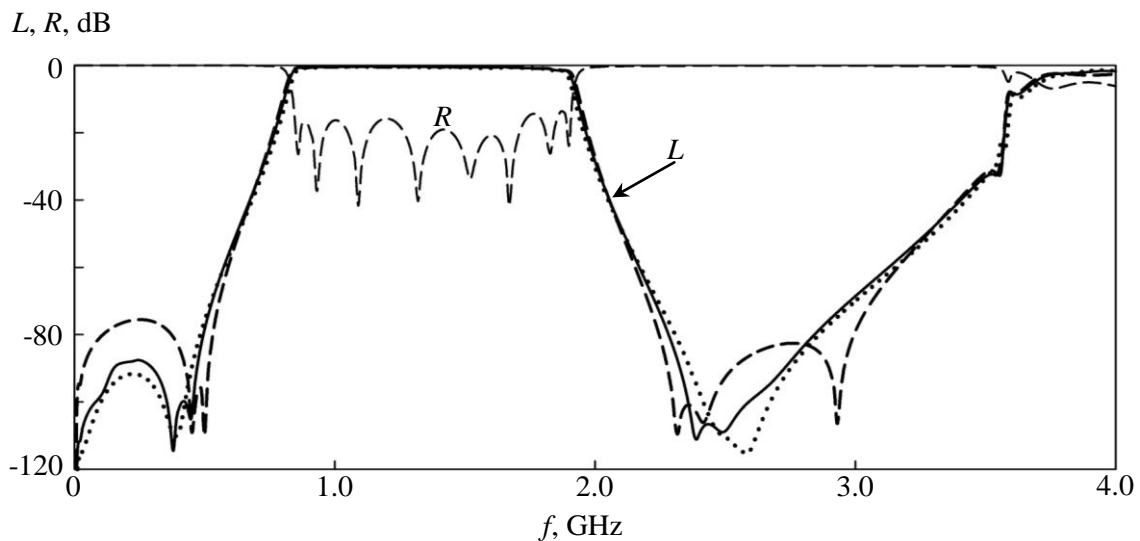


Figure 4. Amplitude-frequency characteristics of filters of the eighth order: AFCs of filter shown in figure 3a (dashed lines), AFCs of filter shown in figure 3b (line), AFCs of filter shown in figure 3c (points). $L(f)$ – frequency dependence of direct losses, $R(f)$ – frequency dependence of losses in reflection.

Dimensions of strip conductors in resonator as well as the gaps between them for all six studied structures are presented in table 1.

Table 1. Dimensions of filters conductors.

Figure with appropriate for filter conductors	Position of strip conductor or portions in figure	The area of strip conductor or portions (mm^2)	The gaps between strip conductors or portions (mm)
figure 1a, figure 1b, figure 1c	1	38.70×0.80	1 and 2 – 0.25
figure 1a, figure 1b, figure 1c	3	45.70×0.70	2 and 3 – 0.35
figure 1a, figure 1b, figure 1c	4	19.90×5.60	
figure 1a	2	35.90×0.75	
figure 1b	2	35.90×0.60	
figure 1b	2a	1.30×0.05	
figure 1c	2	35.90×0.40	
figure 1c	2a	0.90×0.05	
figure 1c	2b	0.70×0.05	
figure 3a, figure 3b, figure 3c	1	42.90×1.00	1 and 2 – 0.20
figure 3a, figure 3b, figure 3c	3	48.40×0.30	2 and 3 – 0.40
figure 3a, figure 3b, figure 3c	4	10.20×7.90	
figure 3a, figure 3b, figure 3c	5	47.10×6.70	
figure 3a, figure 3b, figure 3c	6	13.60×0.20	
figure 3a	2	37.40×0.70	
figure 3b	2	37.40×0.55	
figure 3b	2a	0.70×0.15	
figure 3c	2	37.40×0.45	
figure 3c	2a	0.70×0.15	

3. Conclusions

Consequently, it is shown that the improvement of frequency-selective properties of microstrip wideband bandpass filters based on resonator with strip conductors in the shape of irregular meander is observed not only while increasing the number of rollup of the strip conductor multimode resonator as well as while increasing the number of single-mode resonators in constructions, but also while building-up the number of connected to a screen portions of strip conductors in single-mode resonators.

Acknowledgments

This study was supported by the Ministry of Education and Science of the Russian Federation, grant MK-9119.2016.8 of the President of the Russian Federation for State Support of Young Russian Scientists.

References

- [1] Pursiainen O L J and Baumberg J J 2005 *Appl. Phys. Lett.* **87** 101902-1
- [2] Belyaev B A, Voloshin A S and Shabanov V F 2005 *Dokl. Phys.* **50** 337
- [3] Tyurnev V V and Serzhantov A M 2011 *Progress in Electromagnetics Research C* **23** 151
- [4] Belyaev B A, Khodenkov S A and Shabanov V F 2016 *Dokl. Phys.* **61** 155
- [5] Hejazi Z M, Omar A A, Scardelletti M C, Van Keuls F W and Al-Zayed A 2008 *Progress In Electromagnetics Research* **85** 261
- [6] Dovbysh I A and Tyurnev V V 2010 *Progress In Electromagnetics Research M* **12** 17
- [7] Yao C, Zhang W, Han L and Ma R 2007 *Int J Infrared Milli Waves* **28** 859
- [8] Belyaev B A, Khodenkov S A, Galeev R G and Shabanov V F 2015 *Dokl. Phys.* **60** 95