ЗБОРНИК РАДОВА

65. годишња конференција за електронику, телекомуникације, рачунарство, аутоматику и нуклеарну технику

ЕТРАН 2021

и

8. интернационална конференција за електротехнику, електронику и рачунарство

ИцЕТРАН 2021

PROCEEDINGS

8th International Conference on Electrical, Electronic and Computing Engineering

IcETRAN 2021

and

65th National Conference on Electronics, Telecommunication, Computing, Automatic Control and Nuclear Engineering

ETRAN 2021

Етно село Станишићи, Република Српска, 8 - 10. септембра 2021. године
Ethno Village Stanišići, , Republic of Srpska, 8 - 10, September, 2021

ISBN 978-86-7466-894-8

Издавачи
Друштво за ЕТРАН, Београд
Академска мисао, Београд

Published by
ETRAN Society, Belgrade,
Academic Mind, Belgrade

ЗБОРНИК РАДОВА

65. годишња конференција за електронику, телекомуникације, рачунарство, аутоматику и нуклеарну технику

ЕТРАН 2021

и

8. интернационална конференција за електротехнику, електронику и рачунарство

ИцЕТРАН 2021

PROCEEDINGS

8th International Conference on Electrical, Electronic and Computing Engineering

IcETRAN 2021

and

65th National Conference on Electronics, Telecommunication, Computing, Automatic Control and Nuclear Engineering

ETRAN 2021

Зборник радова - 65. Конференција за електронику, телекомуникације, рачунарство, аутоматику и нуклеарну технику,
Етно село Станишићи, 08-10.09.2021. године

Proceedings of Papers – 8th International Conference on Electrical, Electronic and Computing Engineering, IcETRAN 2021,
Ethno willage Stanišići, Republic of Srpska, Bosnia and Herzegovina

Главни уредник / Editor in Charge
Слободан Вукосавић / Slobodan Vukosavić

Издавачи / **Друштво за ЕТРАН, Београд и Академска мисао, Београд**
Published by **/ ETRAN Society, Belgrade, Academic Mind, Belgrade**

Израда / Production
Академска мисао, Београд / Academic Mind, Belgrade

Место и година издања / Place and year of publication
Београд, 2021. / Belgrade, 2021.

Тираж / Circulation
200 примерака / 200 copies

ISBN 978-86-7466-894-8

ЕТРАН - Друштво за електронику, телекомуникације, рачунарство, аутоматику и нуклеарну технику

ETRAN – Society for electronics, telecommunication, computing, automatics and nuclear angineering

Кнеза Милоша 9/IV, 11000 Београд / Kneza Milosa 9/IV, 11000 Belgrade

Телефон / Phone: 011 3233 957

Е-пошта / E-mail: office@etran.rs

www.etran.rs

ОРГАНИЗАТОРИ - ORGANIZERS

Друштво за ЕТРАН, Београд / ETRAN Society, Belgrade

Универзитет у Бањој Луци - Електротехнички факултет / University of Banja Luka - Faculty of Electrical Engineering, Banja Luka, Republic of Srpska

Универзитет у Београду - Електротехнички факултет / University of Belgrade - School of Electrical Engineering

---

ПОДРШКА / SUPPORTED BY

IEEE – Institute of Electrical and Electronics Engineers, USA

Радови укључени у Зборник прихваћени су од стране рецензената и приказани на 65. годишњој конференцији Друштва за ЕТРАН (ЕТРАН 2021) и 8. Интернационалној конференцији (ИцЕТРАН 2021) које су одржане од 08. до 10. септембра 2021. године у Етно селу Станишићи, Република Српска.

Број пријављених радова за конференције ЕТРАН и ИцЕТРАН је 162. Рецензије радова обавило је укупно 266 рецензената. Просечан број рецензената по раду био је 2. Прихваћен је и на конференцији приказан 141 рад који су публиковани у овом зборнику.

Заједничка тематска сесија "Дигитална Србија и Република Српска" окупила је научнике, стручњаке, истраживаче, представнике високошколских установа и представнике државе који су изнели своје погледе на значај и развој информационих технологија и вештачке интелигенције, на њихову улогу у развоју привреде и на одговарајуће промене у образовном систему. Координатори сесије били су проф. др Бранко Докић и проф. др Мило Томашевић, док су активни учесници сесије били Мр Срђан Рајчевић, Министар за научнотехнолошки развој, високо образовање и информационо друштво у Влади Републике Српске, др Саша Стојановић, помоћник Министра за просвету, науку и технолошки развој Владе Србије, проф. др Мило Томашевић декан Електротехничког факултета Универзитета у Београду, проф. др Зоран Ђурић, декан Електротехничког факултета Универзитета у Бањој Луци и проф. др Божидар Поповић, декан Електротехничког факултета Универзитета у Источном Сарајеву.

Координатор специјалне седнице на секцији Метрологија, под насловом "Стохастичке методе у мерењима био је Владимир Вујичић. Координатор специјалне седнице на секцији Рачунарство и вештачка интелигенција, под насловом "Шта рачунари данас не могу" био је Бошко Николић. У оквиру секције за електроенергетику одржана је специјална седница "Електроенергетика у 21. веку" у организацији Одбора за енергетику САНУ.

Члан Председништва Предраг М. Петровић био је координатор заједничке тематске седнице организоване као омаж Милољубу Смиљанићу, Почасном члану Друштва за ЕТРАН и Генералном секретару Академије инжењерских наука. Уз поруку "Драги Мићо, дивљење и поштовање са захвалношћу" говорили су Предраг М. Петровић, Дејан Б. Поповић, Председник ЕТРАН-а.

Председник ЕТРАН-а, академик Дејан Б. Поповић био је координатор заједничке тематске седнице организоване као омаж академику Нинославу Стојадиновићу, бившем Председнику ЕТРАН-а, члану Председништва и Заслужном члану Друштва за ЕТРАН. Уз поруку "Остајемо да негујемо његове идеје" говорили су проф. др Данијел Данковић, Дејан Б. Поповић, Председник ЕТРАН-а и Братислав Миловановић, академик АИНС.

Посебно се захваљујемо организаторима из Републике Српске и домаћинима из Бијељине, који су допринели стварању услова за рад и плодну размену мишљења и критички осврт на резултате у оквиру свих секција.

Београд, 12.10.2021.

Академик Слободан Вукосавић

заменик председника ЕТРАН

The papers included in the Proceedings were selected in a peer review process and presented at the 65th annual conference of the ETRAN Society (ETRAN 2021) and at the 8th international Conference IcETRAN 2021, both held September 8 – 10, 2021 in Stanišići ethno-village, Republic of Srpska, Bosnia and Herzegovina.

The number of the submitted papers for the ETRAN and IcETRAN conferences was 162 in total. Peer reviewing was done by 266 reviewers. The average number of reviewers per paper was 2. A total of 141 papers was accepted, presented at the two conferences and published in full in these Proceedings.

The joint thematic session "Digital Serbia and Republic of Srpska" gathered scientists, experts, researchers, representatives of universities and governmental representatives who presented their opinions about the significance and development of information technologies and artificial intelligence, their role in the economic development and the corresponding changes in the educational system. Session coordinators were prof. dr. Branko Dokić and prof. dr. Milo Tomašević, while the active participants of the session were Mag. Sci Srdjan Rajčević, Minister of Scientific and Technological Development, Higher Education and Information Society in the government of the Republic of Srpska, dr. Saša Stojanović, Assistant Minister of Education, Science and Technological Development in the government of Republic of Serbia, prof. dr. Milo Tomašević, Dean of the School of Electrical Engineering, University of Belgrade, prof. dr. Zoran Djurić, Dean of the Faculty of Electrical Engineering, University of Banja Luka and prof. dr. Božidar Popović, Dean of the Faculty of Electrical Engineering, University of East Sarajevo.

The coordinator of the special session within the Metrology Section titled "Stochastic Methods in measurements" was Vladimir Vujičić. The coordinator of the special session within the Computers and Artificial Intelligence Section titled "What computers cannot do today" was Boško Nikolić. Within the Power Engineering Section a special session "Electric Power in 21st Century", organized by the Power Engineering Board of Serbian Academy of Sciences and Arts (SASA).

The member of the ETRAN Society Board Predrag M. Petrović was the coordinator of the plenary thematic session organized as a homage to late dr. Miloljub Smiljanić, Fellow of the ETRAN Society and Secretary General of the Serbian Academy of Engineering Sciences. With the message "Dear Mićo, admiration and respect with gratitude" the speakers were Predrag M. Petrović and academician Dejan B. Popović, ETRAN Society Chairman.

The ETRAN Society Chairman, academician Dejan B. Popović was the coordinator of the plenary thematic session organized as a homage to late academician Ninoslav Stojadinović, Member of ETRAN Society Board and a Fellow of ETRAN Society. With the message "We continue to forward his ideas" the speakers were prof. dr. Danijel Danković, academician Dejan B. Popović, ETRAN Society Chairman and Bratislav Milovanović, academician of Serbian Academy of Engineering Sciences.

We express our special gratitude to the organizers from the Republic of Srpska and our hosts from Bijeljina who contributed to creating working conditions and a fruitful interchange of opinions, as well as a critical review of the results within all sections.

Belgrade, October 12, 2021.
Academician Slobodan Vukosavić
Vice-Chairman of the ETRAN Society

Incorporating a Lowpass Filter into a Very Wide Bandpass Filter to Suppress Harmonics

Dušan Nešić, *Member, IEEE*

***Abstract*—This paper presents an algorithm for suppression of higher harmonics in response of the very wide bandpass filter (WBPF). Lowpass filter (LPF) is incorporated into the very wide bandpass filter to suppress harmonics. The LPF is consists of only three identical cells with uniform open stubs. At least two higher harmonics are suppressed.**

***Index Terms*— Microwaves, Suppression of higher harmonics for very wide bandpass filter, Ideal model.**

I. Introduction

ONE disadvantage of common bandpass filters is existing of higher harmonicas causing a narrow bandstop region on higher frequencies outside bandpass. This is specially a problem for the very wide bandpass filter (WBPF) like one presented in [1]. Common solution is incorporating lowpass filter (LPF) into the WBPF [2,3]. The solution intends not to significantly degrade bandpass characteristics but suppress higher harmonics. In the same time slow-wave characteristic of the lowpass filter shortens (minimizes) the structure. Problems can be nonuniform open stubs in [2] or too many different uniform open stubs like in [3].

Starting WBPF is from reference [1] with 150 % relative bandwidth. Ideal transmission structure and its response are presented in Fig. 1 and Fig. 2 in program package WIPL-D [4]. As can be seen in Fig. 2, bandstop region between the first bandpass and the next harmonic is narrow.

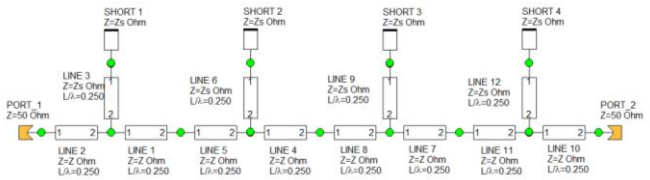


Fig. 1. Model of the ideal bandpass filter for relative bandwidth 150 %, presented in [1].

The aim is to suppress at least one higher harmonic. From Fig. 1 can be seen that transmission line segments between shorted stubs are λ/2 (2 x 0.250 λ), in phase π. To incorporate lowpass filter, the segment between the second and the third shorted stub is replaced with a lowpass filter. An example of a lowpass filter is chosen from [5]. It can be constructed of identical cells.

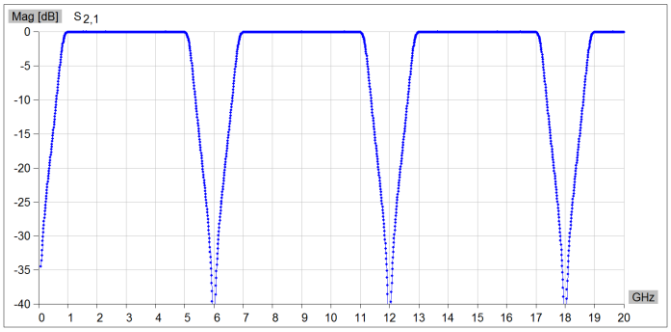


Fig. 2. S_{21} parameters for the filter around 3 GHz in the Fig. 1 with higher harmonica.

II. The Method

The method of incorporation of the lowpass filter is presented in Fig. 3. Instead of a transmission line segment π (λ/2 = 2 x 0.250 λ in upper Fig.3) between shorted stubs there are three equal cells of the lowpass filter, each with (*L1* + *L1*)* λ distance on the main line (3 x (*L1* + *L1*)* λ) in down Fig. 3). The phase difference π/3 is replaced with a cell presented in Fig. 4 with (*L1* + *L1*)* λ distance on the main line.

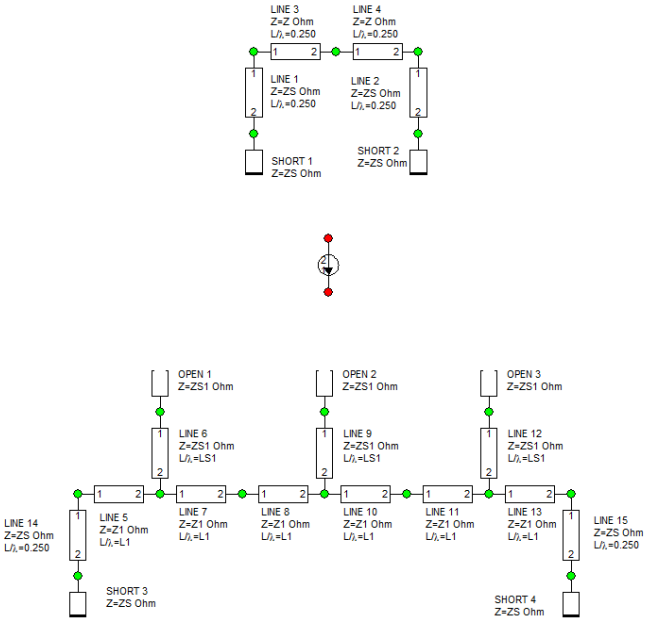


Fig. 3. Equivalence for incorporating low pass filter into bandpass filter.

Dušan Nešić is with Centre of Microelectronic Technologies, Institute of Chemistry, Technology and Metallurgy, University of Belgrade, Njegoševa 12, 11000 Belgrade, Serbia (E-mail: nesicad@nanosys.ihtm.bg.ac.rs).

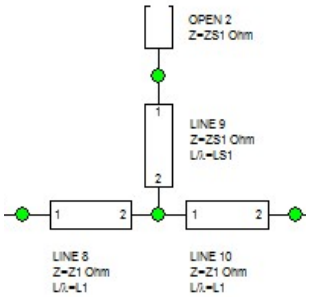


Fig. 4. One cell of the incorporated lowpass filter.

$A_cB_cC_cD_c$ matrix for the section $\pi/3$ of the primary filter with characteristic impedance *Z*, Fig. 1, is equaled on central frequency at 3 GHz with calculated ADCD matrix of the cell in Fig. 4. *L1* in Fig. 4 corresponds to phase difference *t1*, $L1 = t1/(2\pi)$. *Z1* is characteristic impedance of the main line and *ZS1* is characteristic impedance of the open stub. *LS1* corresponds to phase *tS1* of the open stub, $LS1 = tS1/(2\pi)$.

Calculation process is presented in Fig. 5 according to the reference [5], $Y = C_s/A_s$. Entering parameters are *Z*-characteristic impedance of the primary filter, *ZS*-characteristic impedance of the shorted stub of the primary filter (not in calculation, only in final results), *ZS1*-characteristic impedance of the open stub. *tS1*- phase length of the open stub was firstly treated as an entering parameter but later it is equaled with *t1* to get better response of the lowpass filter according to [5]. Output parameters are *t1* (*L1*) and *Z1*.

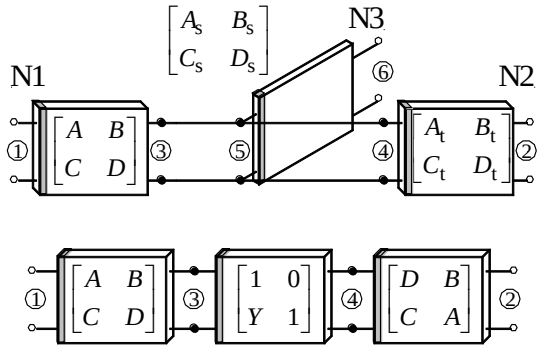


Fig. 5. Transformation of the cell in the Fig. 1 via ABCD matrix according to [4].

Equaled elements of matrix are presented in (1)-(3).

$$A_c(\pi/3) = \cos(\pi/3) = D_c(\pi/3) = AD + BC + BC_s\frac{D}{A_s} \quad (1)$$

$$B_c(\pi/3) = jZ\sin(\pi/3) = 2AB + C_s\frac{B^2}{A_s} \quad (2)$$

$$C_c(\pi/3) = j\sin(\pi/3)/Z = 2CD + C_s\frac{D^2}{A_s} \quad (3)$$

The corresponding ABCD-parameters for the cell in Fig. 4 are: $A = D = \cos(t1)$, $A_s = \cos(tS1)$, $B = \mathrm{j}Z1\sin(t1)$, $C = \mathrm{j}\sin(t1)/Z1$ and $C_s = \mathrm{j}\sin(tS1)/ZS1$.

Solution for *Z*1 from (1) and from (3) are (4) and (5) respectively

$$Z1 = \frac{ZS1\cdot(2\cos(2\cdot t1)-1)}{\sin(2\cdot t1)\cdot tg(tS1)} \quad (4)$$

$$Z1 = \frac{\sin(2\cdot t1)}{(\sqrt{3}/(2\cdot Z) - (\cos(t1))^2\cdot tg(tS1)/ZS1)} \quad (5)$$

Next, equal solutions from (4) and (5). After rearranging

$$(\cos(t1))^2 = 3\sqrt{3}/(4\sqrt{3} - 2Z(tg(tS1)/ZS1)) = C \quad (6)$$

$$t1 = a\cos(\sqrt{C}) \quad (7)$$

Return (5) to solution for *Z*1 and calculate *Z*1. Calculation in WIPL-D Microwave Pro v5.1 [4] is presented in Fig. 6. *Z*1 is firstly calculated via (6) and then checked via (5) (*PU*).

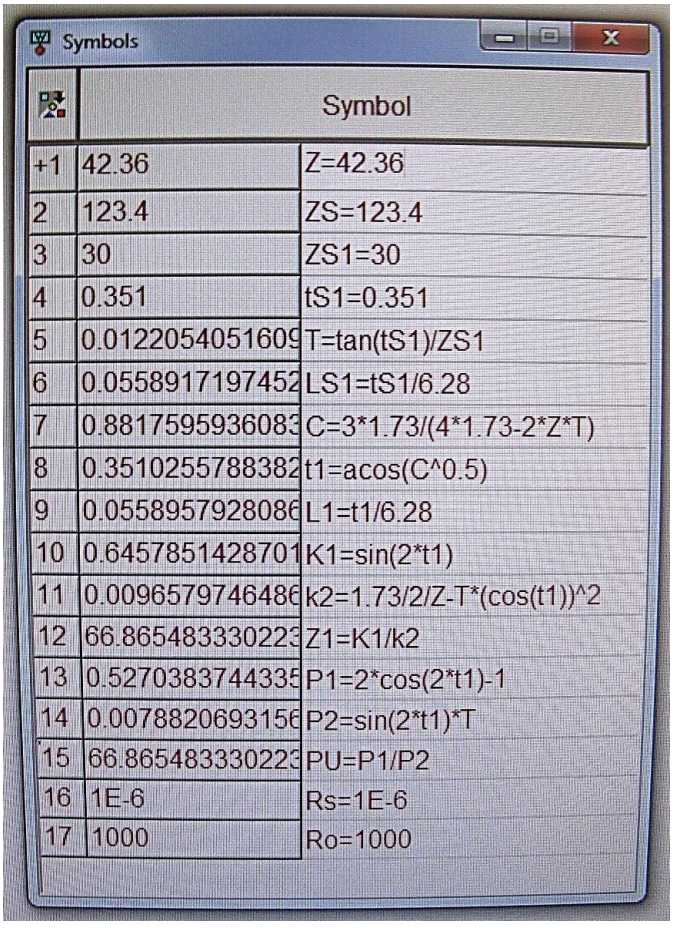


Fig. 6. Calculation of parameters in WIPL-D Microwave Pro v5.1. *T*=tg(*tS1*)/*ZS1*. PU only checks calculation.

III. Results

Entering values for *Z* and *ZS* are chosen according to [1] for the very wide bandpass filter with relative bandwidth of 150

% around 3 GHz. The value of characteristic impedance of the open stub, *ZS1*, is chosen to induce equality of *tS1* and *t1* for better characteristics of the lowpass filter [5].

The values from Fig. 6 are incorporated into models in Fig. 7. The final filter is symmetrical as can be seen in Fig. 7. Additional resistivity is incorporated to suppress numerical problems, Fig. 6. Results for S_{21} and S_{11} for the final structure with the incorporated lowpass filter are presented in Fig. 7. More than two higher harmonics are suppressed. S_{11} is below -15 dB in the bandpass.

IV. CONCLUSION

The algorithm for incorporating lowpass filter into bandpass is presented. For example, it is applied to a very wide bandpass (WBPF) filter of 150 %. Such WBPF has narrow bandstop and wide higher harmonic that make problems in circuits. More than two higher harmonics are suppressed with incorporated lowpass filter. The lowpass filter consists of only three identical cells with uniform arms in the middle of the WBPF structure. The algorithm is applicable to other bandpass filters. Further research will include simulation and fabrication in microstrip.

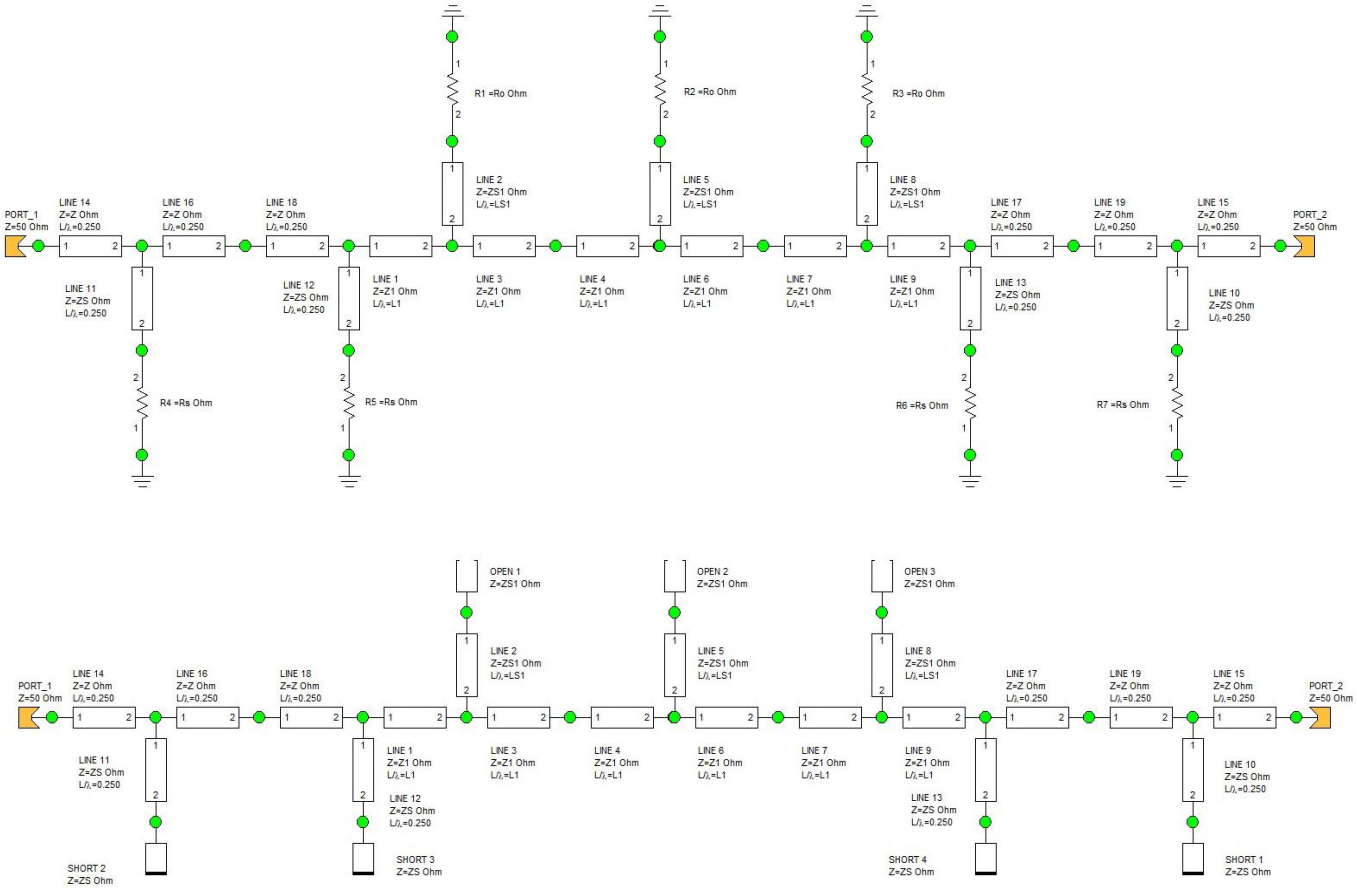
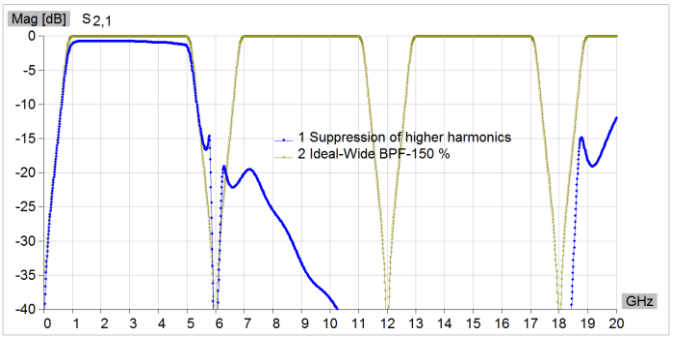


Fig. 7. Model of the lowpass filter incorporated into the bandpass filter, down model; the model with additional resistivity, upper model.



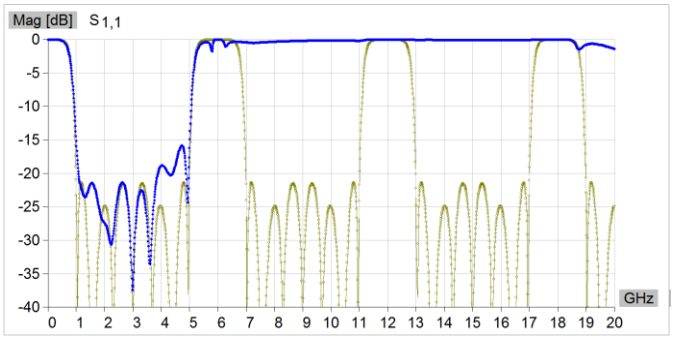


Fig. 8. S_{21} and S_{11} parameters for the resulting bandpass filter for *ZS1*-characteristic impedance of the open stub, equals 30 Ω.

ACKNOWLEDGMENT

This work was financially supported by Ministry of Education, Science and Technological Development of the Republic of Serbia (Grant No. 451-03-68/2020-14/200026).

REFERENCES

[1] D. Nesic, B. Kolundzija and T. Milosevic, "Simulation of wideband bandpass filters with arbitrary relative bandwidth," *7th International Conference on Electrical, Electronic and Computing Engineering, IcETRAN 2020*, API1.8 (MTI)

[2] J. García-García, J. Bonache, and F. Martín, Application of Electromagnetic Bandgaps to the Design of Ultra-Wide Bandpass Filters with Good Out-of-Band Performance, *IEEE Transactions on Microwave Theory and Techniques*, Vol. 54, No. 12, 2006, DOI 10.1109/TMTT.2006.886155, pp. 4136-4140

[3] K.-K. Ryu, Bandpass Filter Using Short Stubs and Step Impedances Lines for Ultra-Wideband Applications, *Microwave and Optical Technology Letters*, Vol. 53, No. 5, 2011, DOI 10.1002/mop, pp. 1062-1065

[4] *Program Package* WIPL-D Microwave Pro v5.1 (*WIPL-D d.o.o, Belgrade 2019*. www.wipl-d.com)

[5] D. A. Nesic, B. M. Kolundzija, D. V. Tosic and D. S. Jeremic, Low-pass filter with deep and wide stop band and controllable rejection bandwidth, *International Journal of Microwave and Wireless Technologies*, Vol. 7, Iss. 2, 2015, pp. 141-149