The Ability to Minimize a New Type of Moderate-Bandwidth Microwave Filter

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***Abstract*—An example of minimizing the width of a microwave filter structure by bending the stubs and reducing the number of required via holes is presented in this paper. It is shown that the filter area can be reduced near 2 times after bending the stubs. EM model of minimized structure is presented and compared with common filter design.**

***Index Terms*—Microwave filter, Minimization, Microstrip.**

I. Introduction

WIDE bandpass filters (WBPFs) are important components found in microwave circuits [1-8]. Their purpose is to suppress DC components of the signal as well as low frequency signal components. This suppression is achieved by combing coupling and short-circuiting stubs [1-4] or by only short-circuiting stubs [5-8]. Also, the defective ground structure (DGS) or multilayers can be also used with the same purpose [1,4].

Fig. 1 shows an infinite periodical series of identical T-cells with a short-circuited stub and uniform lines implemented in microstrip technology. Here, Z and Z_s represent characteristic impedances of the base line θ and stub θ_s. θ is electrical length given as the phase for a given frequency or wavelength ($\theta=2\pi L/\lambda$). Central passband frequency f_c corresponds to $\theta_s = \pi/2$ i.e., $L = \lambda_c/4$. λ_c is wavelength for the frequency f_c.

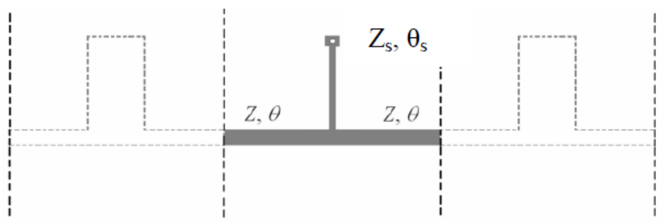

Fig. 1. Scheme of one cell within a filter in microstrip technology.

In [9, 10] relation $\theta_s = 2\theta$ was chosen to eliminate ripples in the stopband. For that relation optimized S_{11}-parameters are for $Z = 50\ \Omega$ for all values of Z_s. Calculated design curve of Z_s on the relative bandwidth (*RBW*) is presented in Fig. 2.

The film for fabrication (etching) for 4-cells filter with the dimensions is outlined in Fig. 3 [10]. Central frequency is 3 GHz while used substrate is FR-4 with $\varepsilon_r = 4.3$. *RBW* is 100% (1.00) for $Z_s = 60.5$ Ohms. The dimensions of the metallization (black surfaces in the Fig. 3) are 15 μm (0.015 mm) wider on both sides (2 x 15 μm) in order to compensate the lateral etching.

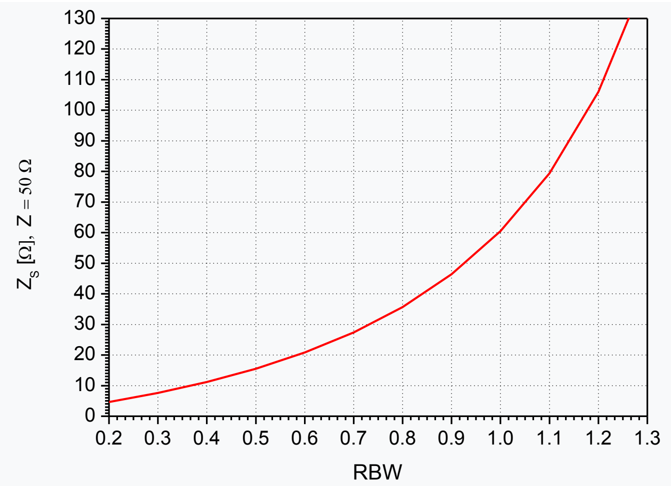

Fig. 2. Design curve of Z_s depending on *RBW* for Z = 50 Ω [9, 10].

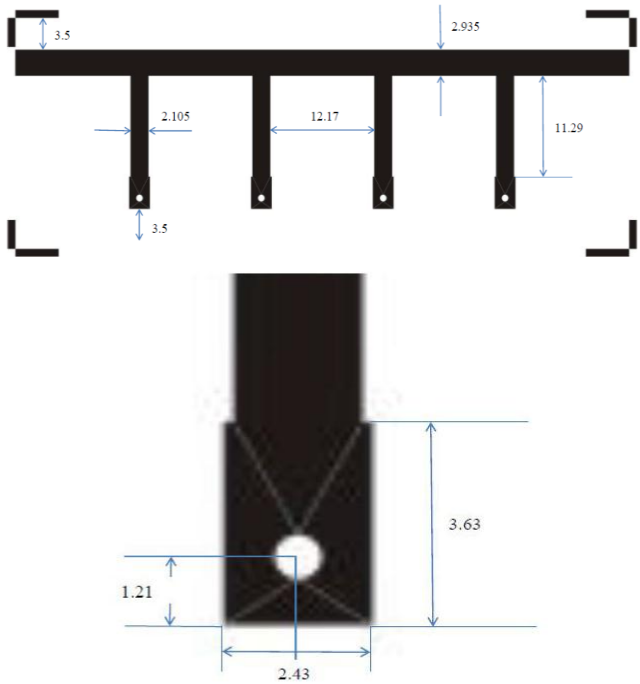

Fig. 3. Dimensions of the film used for etching in mm. Hole radius is equal to 0.385 mm (0.4 mm – 0.015 mm) [10].

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One of the problems with all structures, including filters, is minimization. Here, one cell has an area of about $\lambda_c^2/16$ (λ_c is wavelength for the central passband frequency f_c). The area can be reduced by bending the stubs and connecting the pair of stubs to one via [8].

II. Minimization

Bending the stubs and connecting a pair of stubs to one via is possible according to the relation $\theta_s = 2\theta$. Actually, the length of one stub is approximately the same as the length of a line between the stubs, see Fig. 3. The EM model of the commonly used filter (the model without bending stubs) and the model of the filter with bent stubs are all presented in the Fig. 4 in Program Package WIPL-D [11]. After bending, the area of the filter is reduced near 2 times. The comparison of calculated S-parameters is given in the Fig. 5. A good agreement between the results can be noted.

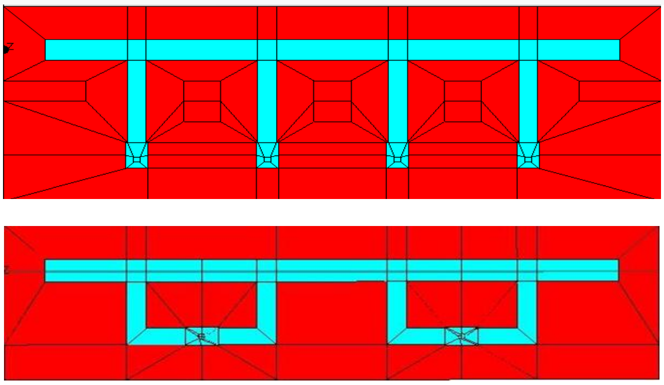

Fig. 4. Commonly used model and the model with bending of the stubs.

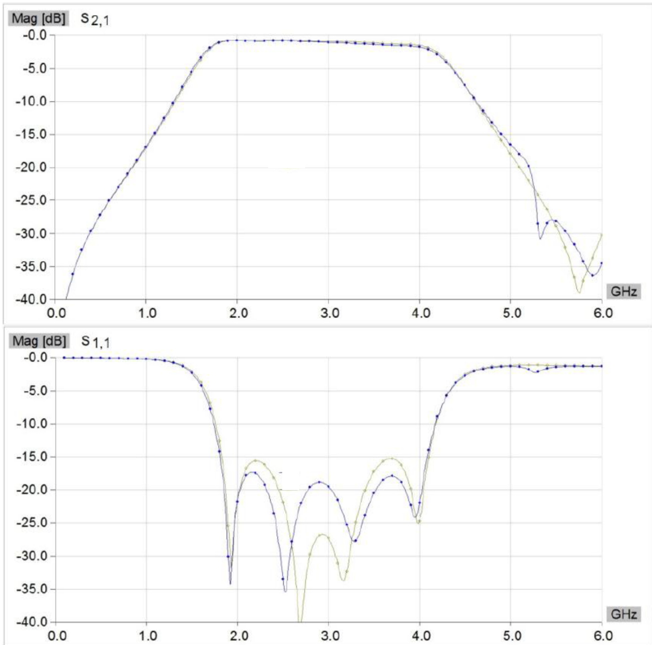

Fig. 5. The comparison between the S-parameters of the commonly used model and the model with bent stubs which are displayed in Fig. 4. No bending (yellow); Bending (blue).

The solution with low *Zs* values, i.e. implementation with wide microstrip stubs, can be realized as a parallel connection of branches with two times higher *Zs*. The EM model for 2 times lower *Zs* than the model presented in Fig. 4 ($Zs = 60.5\ \Omega / 2 = 30.25\ \Omega$) is outlined in Fig. 6 in Program Package WIPL-D [11]. That way the filter achieves relative bandwidth of about 75% (0.75) according to Fig. 2. It is accompanied by the model with bending stubs.

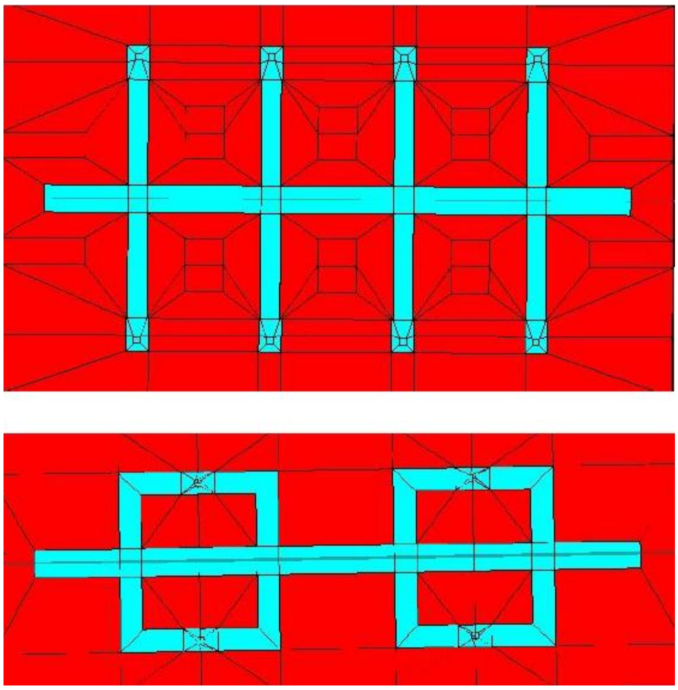

Fig. 6. EM model of the filter with parallel connection of stubs with twice higher Zs and the model with bent stubs.

The comparison between the S-parameters of the model without and the model with bending is shown in Fig. 7. It can be seen that, if the parameter S_{21} is observed, the model with stub bending gives a bit "worse", but still acceptable result in the higher frequency stop-band. The filter area is also reduced near 2 times.

III. Conclusion

An example of minimizing the width of the filter structure by bending the branches as well as reducing the number of required holes for vias was presented. A solution applying low impedances, i.e., wide microstrip lines of branches, was also given, as a parallel connection of branches with twice as large Z_s. It is accompanied with a model with bending of branches and minimization.

It can be seen that minimization of the filters was performed successfully and that responses of the filters after bending the stubs are almost the same as the response of the commonly designed filters.

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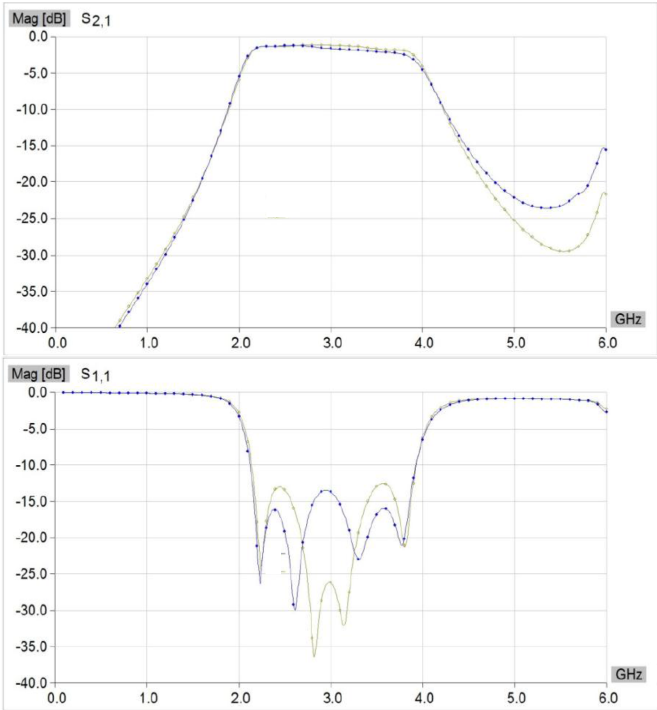

Fig. 7. The comparison of the S-parameters of the model without and with bending in Fig. 6. No bending (yellow); Bending (blue).

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