

Modular Design of Bandpass Filter Utilizing a Novel Hybrid Structure

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Abstract:—This paper proposed implementation of Band pass filter. This new structure based on the combination of two different technologies: the waveguide and microstrip. This filter implement second and third order filtering with help of Transmission zeros. This paper represent the asymmetric and filtering function with complex pair of transmission zeros can be obtained easily. Several examples are presented to demonstrate the structure.

Index Terms—Bandpass filters, coupling matrices, resonator filters, synthesis techniques, transmission zeros, transversal filters.

I. INTRODUCTION

To reject unwanted signals in microwave filters implementation of transmission Zeros is necessary. For this purpose, different techniques have been developed. Implementation of both second and third-order filtering function of microwave filter with up to two or three transmission zeros is explained in (1). The introduction of cross-couplings between nonadjacent resonators in the coupling scheme of the filter has been the design method traditionally used to achieve this goal (2). Microwave resonator filter also proposed (3). This combine waveguide & microstrip in a combine to form a unique filter. Development of transversal microwave filters is focused here. Development of transversal microwave filters in hybrid waveguide-printed technology is focused in this paper. Here the example of the third-order structure are presented which show the capability of the structure to control the position of the two transmission zeros.

Finally, using the hybrid technology concept, a novel implementation of a third-order fully canonical transversal filter is proposed. For the first time, it is shown that, using the hybrid technology, a very compact structure can be used for

the implementation of third-order transversal filters. The third-order filter, which can be directly implemented with the new structure.

II. DESIGN AND STRUCTURE DESCRIPTION

The hybrid structure under study is able to implement either a second- or third-order filter. The open line microstrip resonator R_1 in the printed circuit behaves as resonator of the modified doublet, whereas a longitudinal section magnetic (LSM) mode excited in the partial filled waveguide behave as resonator R_2 in the hybrid structure. For the modified doublet one of the four couplings must be negative and the change in sign in the electric field is due to negative coupling as in (10). To implement the desired coupling terms can be obtained. First, we compute the $(N+2)$ transversal matrix associated with a fixed second-order filter. Then coupling terms of the $(N+2)$ coupling matrix, i.e., the impedance inverters (J_i), the prototype de-normalization process (see, e.g., [3]) is applied. By this process we calculate the values of the required resonant frequencies of each resonator in asynchronously tuned filters ($f_{0,K}; K=1,2$). The de-normalization process also leads to the values of the required external quality factors ($Q_{e,k}$) of each resonator. For the required frequency response of the resonant LSM mode we eliminate the printed line microstrip resonator, then adjust the port lengths L_{in} and L_{out} and the waveguide width (b) in order to achieve the required external quality factor and resonant frequency. To adjust the microstrip line resonator we modify the line length L_T and the coupling gaps ω_1 and ω_2 to obtain the required resonant frequency and external quality factor. The direct coupling term M_{SL} can be synthesized by varying the dimensions L_1 and L_2 (the dielectric thickness and height of the cavity), until the transmission zeros are placed at the right locations.

Here we apply same concepts for the synthesis of third-order fully canonical transversal filters using this hybrid waveguide–microstrip structure is represented in fig.1. It consist of input and output lines which are coupled in shunted configuration to three resonators at the same time.

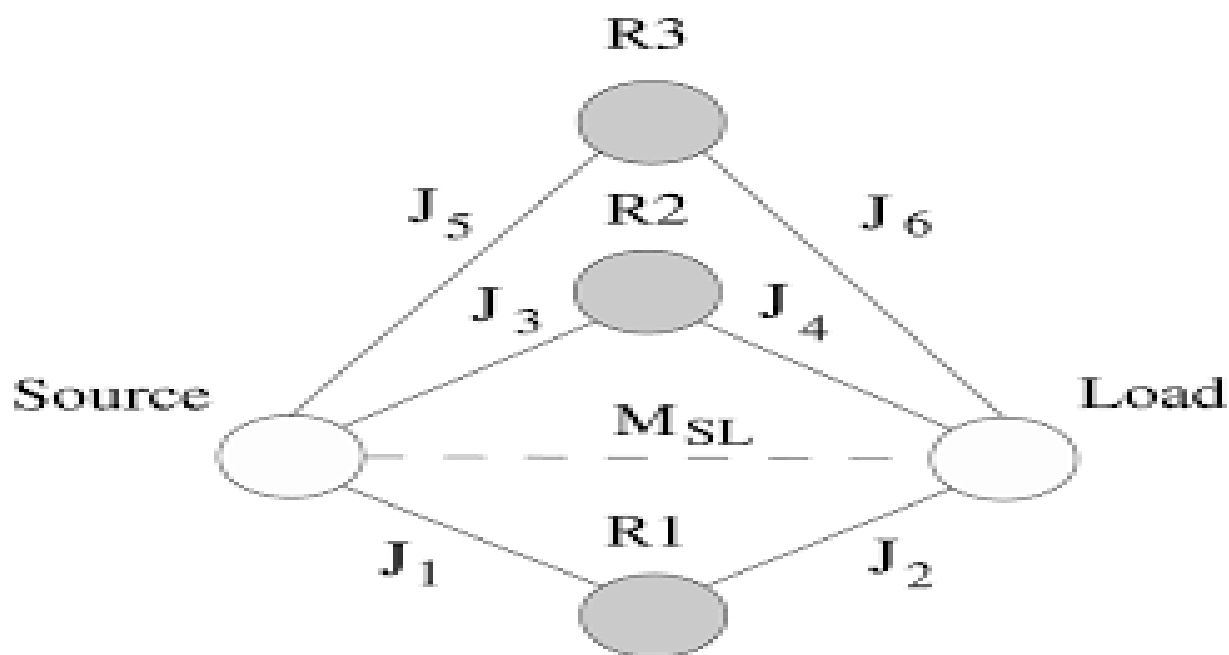


Fig. 1. Coupling scheme of a third-order fully canonical transversal filter. J–J represent the couplings between source S, load L, and the resonators. M represents direct coupling from source to load

The lateral and top view is shown in fig.2. In the hybrid structure R_1 , R_2 and R_3 are waveguide resonator. The $(N+2)$ by $(N+2)$ coupling matrix of a third-order fully canonical transversal filter, calculated with the technique extensively presented in [3]. In fig.1. J_1 , J_2 and J_3 represent the three input couplings, whereas J_2 , J_4 , and J_6 represent the output couplings. M_{SL} represents direct source–load coupling. Finally, the nonzero diagonal elements represent the self-couplings, i.e., the differences in the resonant frequencies of the three resonators, with respect to the center frequency of the filter. The diagonal elements are different from zero for asynchronously tuned filters and this is a typical characteristic of transversal configurations.

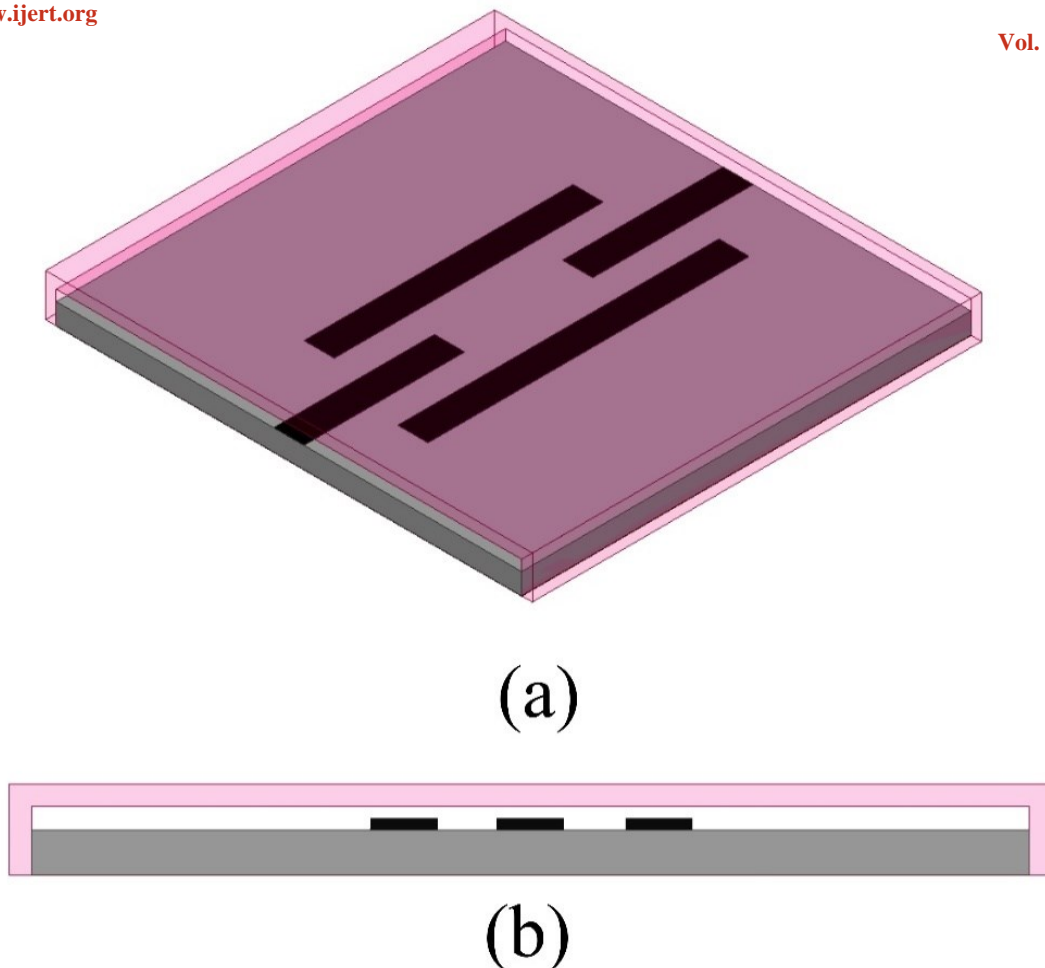


Fig.2. Proposed hybrid waveguide-microstrip structure for implementation of Third-order Transversal filter
(a) Top view (b) Lateral view

The x -component of electric field of the excited LSM mode is maximum at the input port and it is zero at the center of the waveguide cavity and the field then changes sign at the output port. This change in sign makes it possible to synthesize the negative coupling which is used to order transversal filter. The other two resonators are formed with half-wavelength printed lines so no further negative couplings are implemented. The self-coupling M_{33} is controlled by the lateral dimensions of the cavity (a and b) and other self-

couplings M_{11} and M_{22} are controlled by their respective line lengths (L_{r2} and L_{r3})

To determine the dimension of the structure first we compute the $(N+2)$ transversal matrix associated with a fixed second-order filter. Then by using the coupling terms of the above $(N+2)$ coupling matrix, i.e., the impedance inverters (J_i), the prototype de-normalization process is applied next. The value of the required resonant frequencies of each resonator in asynchronously tuned filters are obtained by this process.

IV. RESULT AND DISCUSSION

We demonstrate here how a third degree filtering function can be directly implemented with the proposed compact hybrid waveguide-microstrip technology. The third-order transversal structure will be able to generate up to three transmission zeros in the transfer function of the filter. As there will be a direct coupling different from zero ($M_{SL} \neq 0$). The positions of the transmission zeros can be implemented with the proposed structure. The limitation comes in the number of negative couplings that the hybrid structure, proposed in Figs. 2 and 3. Only One negative coupling can implement in this structure. The sign change of the x -component of the electric field associated to the LSM mode created negative coupling in the structure. Other two resonances are formed by two half-wavelength printed line resonators and, therefore, no sign change can be

implemented. Only matrices of the form are represented below. Result obtained with commercial software HFSS is used to design.

The prototype that implement in the proposed hybrid structure is a transfer function with three transmission zeros at finite frequencies, two below the passband and one above the passband. In this example, we have placed the transmission zeros at $f_1 = 3.75$.GHz, $f_2 = 3.91$ GHz, and $f_3 = 4.75$ GHz. The return loss of the filter is -17 dB and the center frequency is 4.25 GHz with a bandwidth of 65 MHz. Therefore, the normalized transmission zeros result to be $s = -j.10.5433$, $s = -j.5.5643$ and $s = j.2.1122$. Following the technique presented in [3], the following by coupling matrix is presented.

$$M = \begin{pmatrix} 0 & 0.5146 & 0.4142 & -0.7417 & 0.0081 \\ 0.5146 & 1.3171 & 0 & 0 & 0.5146 \\ 0.4142 & 0 & -1.2912 & 0 & 0.4142 \\ -0.7417 & 0 & 0 & -0.1553 & 0.7417 \\ 0.0081 & 0.5146 & 0.4142 & 0.7417 & 0 \end{pmatrix}$$

Here we see that only one sign change is required in the couplings of the three resonators ($J_1 = J_2$, $J_3 = J_4$ and $J_5 = -J_6$). The direct input/output coupling is also different from zero. In the hybrid structure the LSM model is in between the resonance of the two printed line resonators. By considering the design criteria the dimension of the structure are given below

TABLE
 Dimension of The Third-Degree Filter With Three Transmission Zeros in the Frequency Axis

Dimension	Value (in millimeters)
a	42
b	43.5
L ₁	1.95
L ₂	1
L _{in} =L _{out}	15
L _{r2}	25.12
L _{r3}	30
$\omega_1 = \omega_2$	2.8
ϵ_r	2

We noted here that filter with symmetric characteristics i.e. two transmission zeros one above and one below the passband cannot be obtained in the hybrid structure which we proposed.

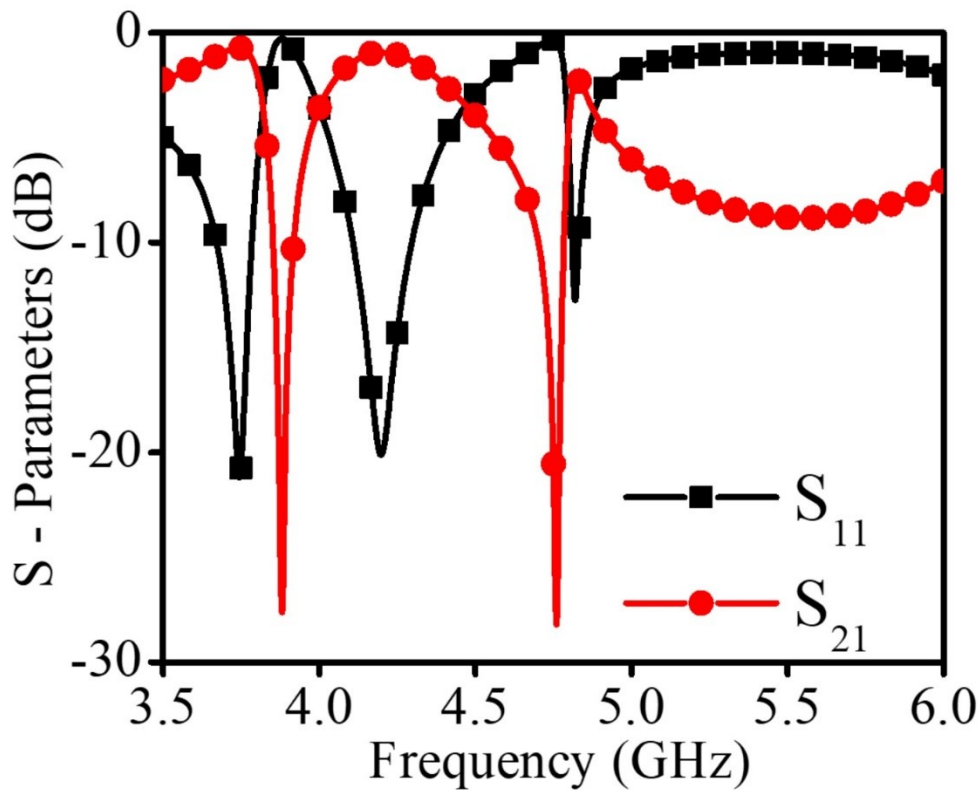


Fig.3.Simulated Result for the bandpass transversal filter with three transmission zeros

Therefore two sign changes implemented in the new structure the below graph shows two transmission zeros on one side of the passband. Therefore this design produce a pair of complex transmission zeros together with one transmission zero in the frequency axis.

V. CONCLUSION

This paper proposed a novel hybrid structure for implementation of third order filtering function using transversal topologies. This is a combination of two technologies i.e microstrip and waveguide The positions of the transmission zeros can be implemented with the proposed structure .Again a filter with a pair of transmission zeros placed in the complex plane has been designed.

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