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DESIGN OF A MICROSTRIP FILTER FOR 5 GHZ BAND USING DIFFERENT NUMERICAL METHODS

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Проектування мікросмужкового фільтра діапазону 5 ГГц з використанням різних чисельних методів розрахунку

Описано підхід до проектування мікросмужкових НВЧ-фільтрів із застосуванням різних чисельних методів розрахунку і пов’язаних з ними систем автоматизованого проектування. Здійснено розрахунок та моделювання мікросмужкового фільтра зі смугою пропускання 4850…5150 МГц. Здійснено порівняння характеристик фільтра, отриманих методами моментів, скінченних елементів та розрахованих за значеннями S-матриць відрізків ліній передачі.

Rapid development of mobile communication systems and growth of the number of corresponding equipment increase the demand for small-size and high-performance microwave filters. At present, theory of filter design is well-studied part of microwave engineering, and there are a large number of filter types and design techniques that can be used for designing and fabrication of filters [1] – [3]. Nowadays, a filter design is usually an iterative procedure involving numerous simulations and optimization of the filter structure. The comparison of microstrip filter design using different numerical techniques was previously done in [4]. The comparison of the analytical model and the FEM simulation was done in [5] for the example of the 2.4 GHz patch antenna.

In this paper, the design of a microstrip filter was performed, the filter was firstly modelled using three numerical techniques and then fabricated. The simulation results and measured values of scattering parameters were then compared.

The research task implied designing a bandpass microstrip filter operating in the frequency band 4850 – 5150 MHz. The parameters of the filter were as follows: center frequency f_0 = 5GHz, passband BW = 300 MHz; ripple within the passband 0.1 dB. In order to provide small dimensions of the filter, the hairpin topology was chosen for microstrip realization.

For the realization of the filter, the RT/Duroid 5880 laminate was used. The parameters of the material are as follows: dielectric constant $\varepsilon_r = 2.2$; thickness $h = 0.508$ mm; thickness of strip $t = 0.017$ mm; dissipation is defined by $\tan\delta = 0.0009$; height of the top shield $H = 15$ mm.

The Chebyshev response was used. To meet the listed above demands, the filter should consist of 5 hairpin resonators. Using the parameters of low-pass prototype, the parameters of the transmission line segments for the edge-coupled structure can be calculated using the procedure given in [1]. The model of the filter was prepared using the Microwave Office software and is shown in Fig.1.

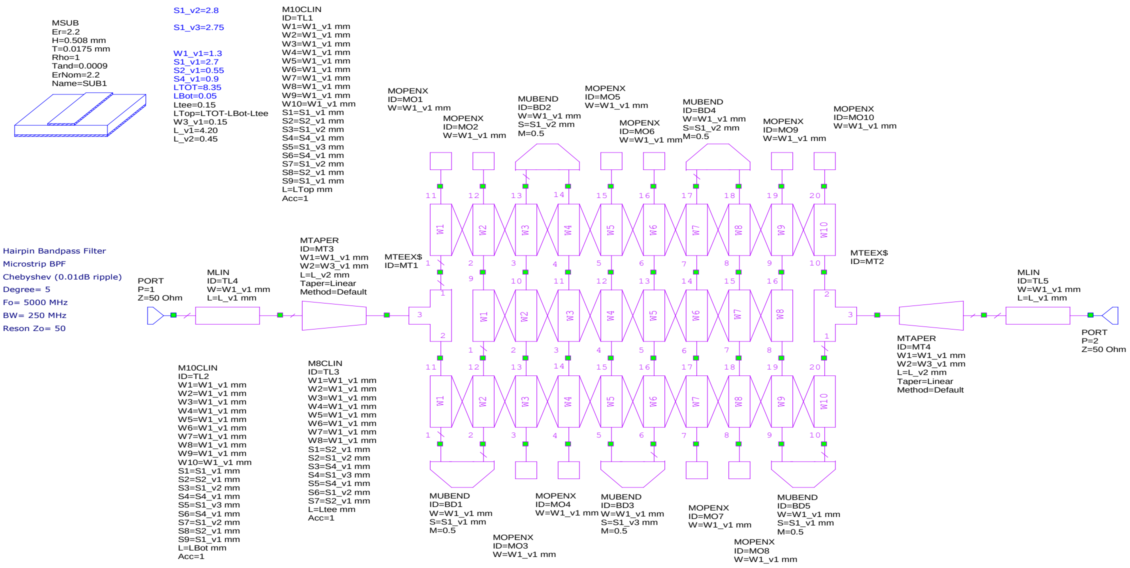
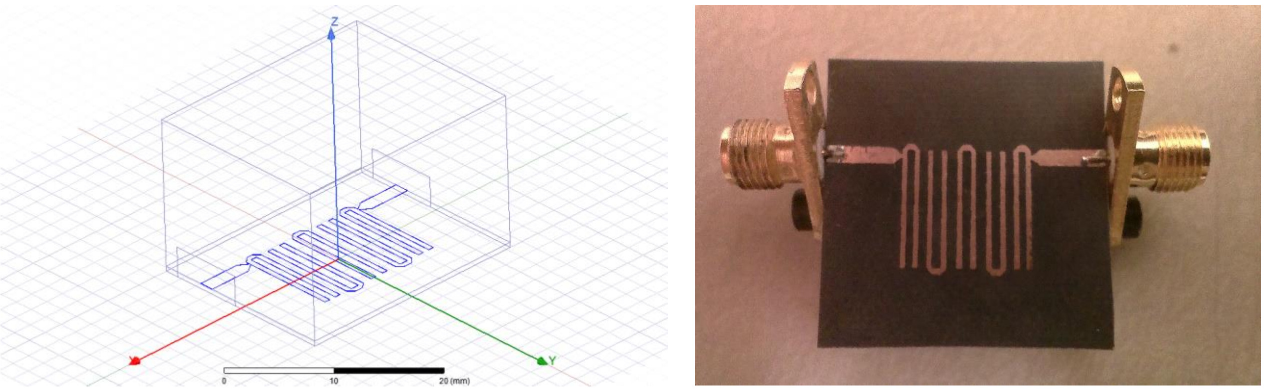


Fig.1. Model of the filter

Using this model, the topology of the filter was generated. It was then used for preparing the 3D model for the filter shown in Fig. 2(a). This model was used to perform FEM simulation with HFSS software. Using 3D model, the prototype of the filter was fabricated as shown in Fig. 2(b). The dimensions of the filter are 25x20 mm^2.

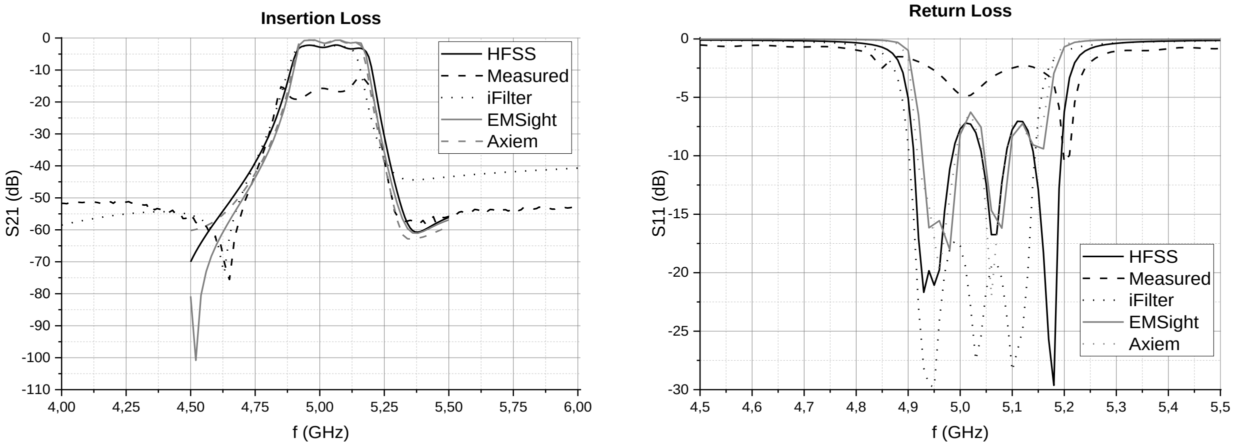


(a) (b)

Fig.2. Topology of the filter. (a) HFSS model. (b) Fabricated filter

In Fig.3, the simulated and measured results for the insertion loss (IL) and return loss (RL) frequency responses of the filter are shown. There are 5 curves for each characteristic: 3D FEM simulation (denoted as “HFSS”), the measured values of physical prototype (“Measured”), S-matrix calculation using the model shown in Fig. 1 (“iFilter”), MoM simulation using EMSight solver (“EMSight”) and MoM simulation using AXIEM solver (“Axiem”). It can be seen that there is a considerable difference in frequency responses for the three methods exists.

The method based on the S-matrix theory is based on lumped-element network representation of microwave structures and is then the least precise amongst the three compared methods. The MoM is 2.5D technique, which can be implemented only for planar structures, i.e. the structures consisting of a few layers. FEM is 3D technique, where the accuracy of the results can be increased by increasing the number of the cells (of tetrahedral shape). FEM method is the most precise among the three considered techniques.



(a)

(b)

Fig.3. Frequency responses of the filter calculated by different numerical techniques.
(a) Insertion loss. (b) Return loss.

As it can be seen from Fig. 3, the S-matrix method is the fastest among others, but showing the least accuracy. MoM and FEM simulations give more precise results. The measured characteristics of the fabricated filter prototype don’t show the best filter performance as given by simulations. This can be explained by the absence of the metal shield box and the shortcomings of the fabrication technique, which was insufficiently precise for the selected relatively high frequency band.

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