Design of a High-pass Filter Based on a Paired-strips Transmission Line

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Abstract

A 5th order pseudo high-pass filter based on a balanced paired-strips transmission line is proposed. In this case the width of the dielectric layer of the transmission line is equal to the widths of the conducting strips. Microstrip baluns were part of the designed filter. Both simulation and measurement show similar high performance results.

1. INTRODUCTION

Microstrip filters are very popular in RF circuits [1], [2]. However, these filters have some disadvantages: the difficulty in realizing thin lines especially in the high order filters, due to high characteristic impedances of the microstrip transmission line sections, and the need to include an expensive dielectric material when high performance is required. Here we use a paired-strips transmission line for which the width of the dielectric layer is the same as the widths of the conducting strips, hence the amount of the dielectric material needed is greatly reduced in comparison to a similar microstrip filter. Moreover, the range of characteristic impedances needed for the various transmission line sections in the paired-strips transmission line is greater than that of a microstrip line, for a given mechanical accuracy. Hence the proposed filter is suitable for high order configurations.

The pseudo high-pass filter described here is based on a similar microstrip filter prototype describes in [3], having equal electrical lengths shorted stubs. The filter was simulated by the CST - Microwave Studio software. The filter had been produced on a Rogers RO4003C dielectric layer, and its scattering parameters were measured. Simple microstrip baluns were connected to the two ports of the filter during the measurement.

The structure of the paper is as follows: In section 2 we present the geometry of the filter and the baluns. Section 3 describes the simulation results, while section 4 describes the measurements. Finally, conclusions are founded in section 5.

2. GEOMETRY

A picture of the filter is shown in figure 1. Its length including the baluns is approximately 16 cm.

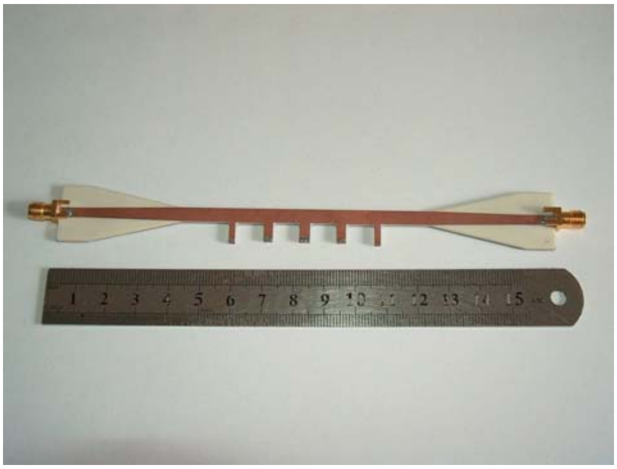

Fig.. 1: A picture of the pseudo high-pass filter, connected to microstrip baluns at its ends.

A transverse cut of the paired-strips transmission line is shown in figure 2. The dielectric layer is a Rogers RO4003C type having thickness 1.524 mm, $\varepsilon_r = 3.38 \pm 0.05$ and $\tan\delta =$ 0.0021. The thickness of the conducting strips is about 0.017 mm. The width of the dielectric layer is the same as the widths of the conducting strips.

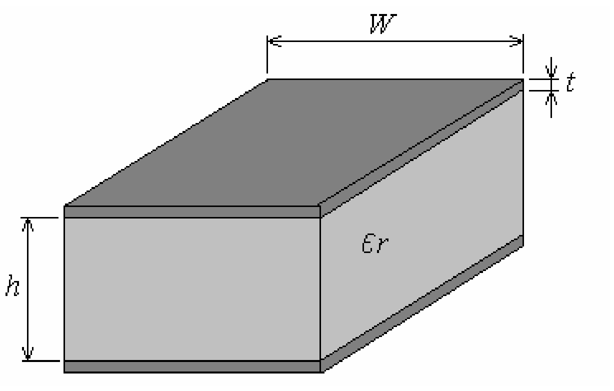

Fig. 2: A cross section of the paired-strips transmission line used to produce the pseudo high-pass filter. The thickness h equal to 1.524 mm, ε = 3.38 ± 0.05 and tan δ = 0.0021. The thickness of the conducting strips t is about 0.017 mm. The width W of the line is determined by the needed characteristic impedance.

The detailed geometry of the filter is presented in figure 3. Numbering of the 5 stubs is from left to right, the structure of the filter has centre symmetry - stub pairs 1 and 5, 2 and 4 are symmetric around stub 3. The length of stub 1 is 6.8 mm and its width is 1.9 mm. The length of stub 2 is 6.32 mm and its width is 2.92 mm. The length of stub 3 is 6.24 mm and its width is 3.3 mm. The characteristic impedances of stubs 1, 2, and 3 are 106.6 Ω, 75.65 Ω and 69.04 Ω respectively. The length of the section between stub 1 and stub 2 is 9.43 mm, its width is 5 mm and its characteristic impedance is 48.64 Ω. The length of the section between stub 2 and stub 3 is 8.79 mm, its width is 4.83 mm and its characteristic impedance is 50.06 Ω.

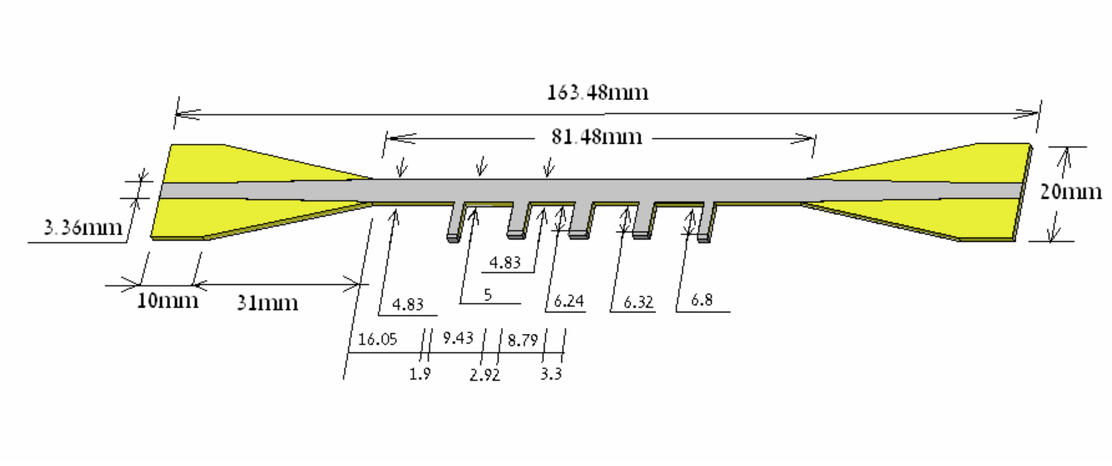

Fig. 3: Detailed geometrical structure of the filter.

3. SIMULATION

The CST - Microwave Studio software had been used for the simulation. At first we found the geometry, characteristic impedances and effective wavelengths related to the transmission line sections and stubs, and later the complete filter was simulated. The simulations included the baluns. The return loss of the filter is shown in figure 4. It is shown that the return loss of the filter is less than - 10 dB for the complete range of frequencies, except a minor range of frequencies for which the return loss value is less than - 9 dB.

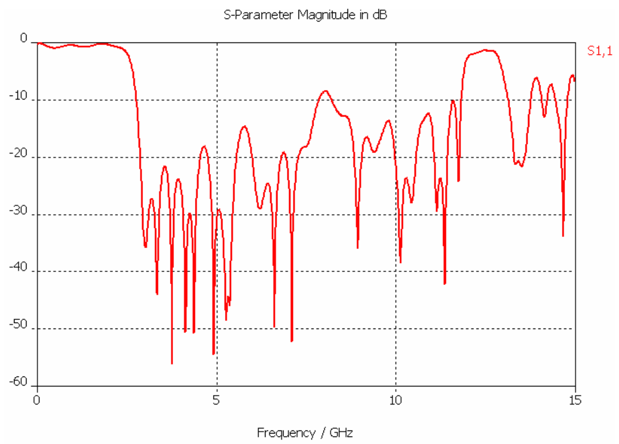

Fig. 4: Simulated return loss of the filter.

The simulated insertion loss of the filter is shown in figure 5. The pass-band range is between 2.6 GHz to 11.45 GHz, showing low pass-band ripple.

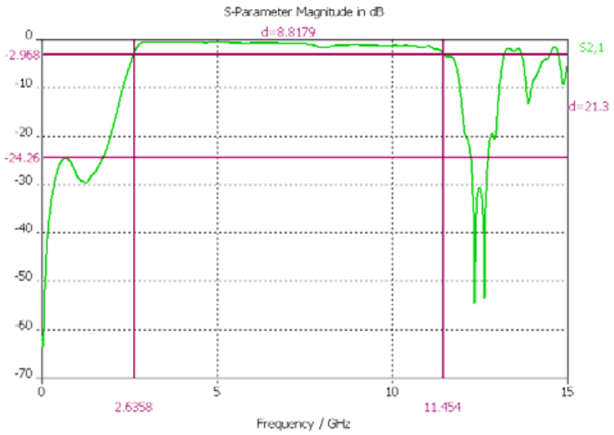

Fig. 5: Simulated insertion loss of the filter.

4. MEASUREMENTS

The measured return loss of the filter is presented in figure 6, and is shown to be a little bit higher than the simulated one.

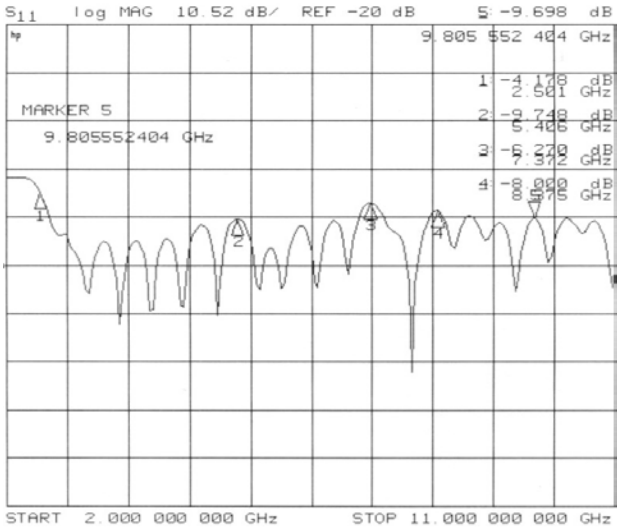

Fig. 6: Measured return loss of the filter.

The measured insertion loss of the filter is presented in figure 7. The pass-band range is between 2.5 GHz and 10.9 GHz, in good agreement with the simulation.

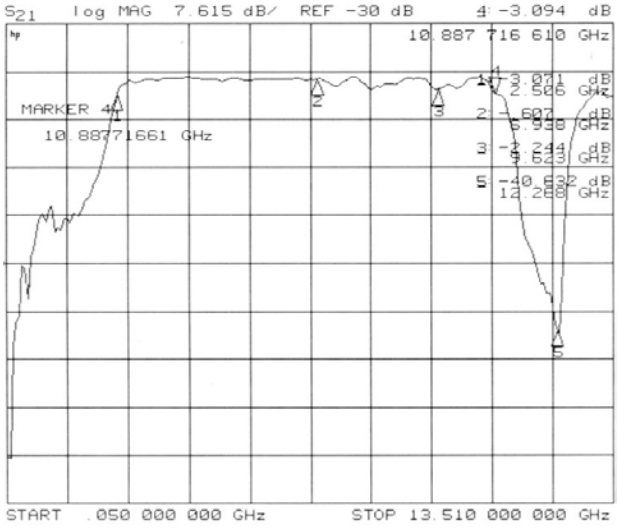

Fig. 7: Measured insertion loss of the filter.

5. CONCLUSIONS

A pseudo high-pass filter based on a paired-strips transmission line for which the width of the dielectric layer equals to the widths of the conducting strips was presented. The simulated results are in good agreement with the measured results. This type of filter can be easily designed also for higher orders.

REFERENCES

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