A Compact Microstrip Lowpass Filter Using Spiral Resonant Structure

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Abstract—**In this paper, a novel low-pass filter using spiral compact microstrip resonant structure for size reduction and broad pass-band is presented. The proposed low-pass filter is designed, fabricated and tested. The insertion loss of the filter is less than 0.1dB in the frequency range from DC to 3.5 GHz. The novel low-pass filter has the advantages of low insertion loss in the pass-band, high and wide rejection in the stop-band and compact size. The performances of the proposed filter are demonstrated by measured results, which are good agreement with the simulation ones.**

Keywords- Lowpass filter, microstrip, transmission lines, resonant structure, spiral

I. INTRODUCTION

Low-pass filters have been studied and exploited extensively as a key block in modern communication systems. A planar microwave filter is widely used in microwave systems because of its easy fabrication. Designing a traditional low-pass filter in microstrip circuits involves the use of shunt stubs or stepped-impedance lines. However, microwave low-pass filters with these structures usually require quite large sizes in order to obtain low cutoff frequency. This is because the physical size of one section of the filter structure is comparable to a half-wavelength of the design frequency [1–2]. Compact design, low insertion loss in the pass-band and high rejection in the stop-band are necessary. To meet these requirements, there has been much effort to develop a variety of compact low-pass filters. Sheen, J. et. al. [3] designed a compact semi-lumped low-pass filter which has the capability of harmonics and spurious suppression. In 2001, Hsieh, L. et. al. [4-9] proposed a low-pass filter using a single microstrip stepped impedance hairpin resonator with direct-connected feed lines.

In this letter, we proposed a novel compact microstrip low-pass filter with spiral resonant cell. The low-pass filter characteristics are analyzed by using high-frequency structure simulator, and the dimensions are optimized. The filter is fabricated and its scattering parameters are measured. The proposed low-pass filter has the advantages of compact size, low insertion loss, high rejection and wide stop-band frequency response. The measured results show that that the insertion loss from DC to 3.5 GHz is less than 0.1dB and the return loss is better than 10dB in the pass-band. The performances of the low-pass filter are demonstrated by the simulation and measurement results.

II. FILTER CONFIGURATION AND SIMULATION

The sketch of the proposed low-pass filter using spiral compact microstrip resonant and spiral resonant cell is shown in Fig.1. In our design, we assume that the structure is lossless and the width of the feeding lines is negligible. Two 50 Ω feedings are added at the filter input and output ports. As shown in Fig. 1, the proposed low-pass filter is made of five cascading spiral compact microstrip resonant cells.

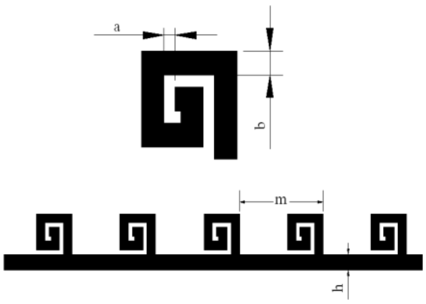

Fig. 1. Sketch of the proposed low-pass filter using spiral compact microstrip resonant and spiral resonant unit.

Here, we simulate the proposed low-pass filter using Ansoft's commercial software high-frequency structure simulator (HFSS9.1), and the simulated results are shown in Fig.2 (in dB). From the Fig.2, one sees that the insertion loss from DC to 3.5 GHz is less than 0.1dB, the return loss is better than 10dB in the pass-band for the low-pass filter with four cascading spiral resonant cells. No ripples exist because only one attention pole is at 2.25 GHz. The 20 dB stop-band width is 4.55 to 5 GHz. For the low-pass filter with five cascading spiral resonant cells, the insertion loss from DC to 3.5 GHz is less than 0.15dB, and the return loss is better than 10dB

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in the pass-band. Little ripples exist because two attention poles are at the frequencies 1.85 GHz and 3.3GHz. The low insertion loss in the pass-band, sharp and wide rejection in the stop-band and compact size is realized.

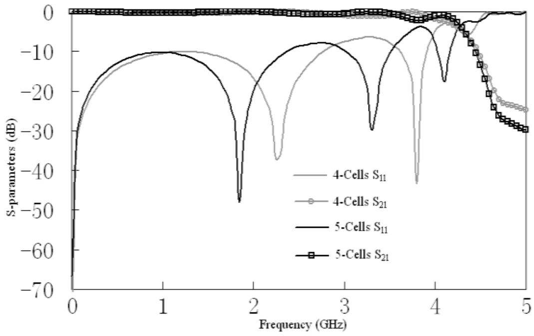

Fig. 2 Simulated results of the proposed lowpass filter

III. MEASUREMENT AND ANALYSIS

The dimensions of the low-pass filter are optimized according to the design requirements via simulation. An experimental low-pass filter was designed, and fabricated and tested. The filter was fabricated on substrate with a relative dielectric constant ε_r =2.65. The dimensions of the proposed low-pass filter are as follows: a=0.4mm, b=0.8mm, L=1.4mm, and P=8mm. Fig. 3 shows the photography of the fabricated band-stop filter based on five spiral compact microstrip resonant cells.

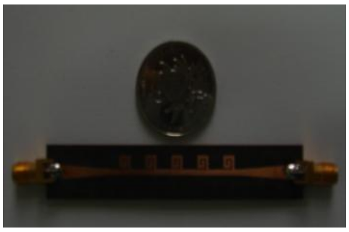

Fig. 3 Photograph of proposed lowpass filter

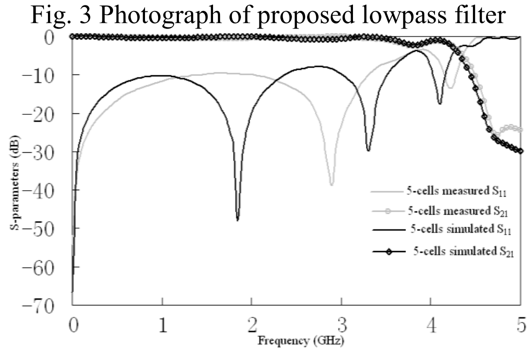

Fig. 4 Measured and simulated results of the proposed lowpass filter

Fig.4 shows the simulated and measured performances of the designed low-pass filter by using network analyzer. From the Figure, it can be noted that the insertion loss from DC to 3.5 GHz is less than 0.1dB, the return loss is better than 10dB in the pass-band. No ripples exist because only one attention pole is at 2.85 GHz. The 20 dB stop-band width is 4.55 to 5 GHz. As observed in the figures, there is a good agreement between simulations and the measurement within a relative error of 5%.

Being the influence of the transition between subminiature version A (SMA) connectors and microstrip, dielectric loss of substrate, and the technical errors of the material and fabrication process, the measurements results are a bit worse than the simulations results.

IV. CONCLUSION

A novel compact microstrip low-pass filter using spiral resonators is proposed. The measured results show that that the insertion loss from DC to 3.5 GHz is less than 0.1dB and the return loss is better than 10dB in the pass-band. The low-pass filter is not only of compact size, but has low insertion loss in the pass-band and high rejection in the stop-band. Its low insertion loss, sharp and wide rejection and compact size are desirable in communication systems. The novel device can be easily implemented in a hybrid microwave integrated circuit and a monolithic microwave integrated circuit. It is very suitable for future microwave communication systems.

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