Design and Fabrication of 2.45G Miniaturized Band Pass Filter by LTCC Technology

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Abstract

With the rapid development of wireless communication systems and personal consumer electronics, it is intensely necessary for RF-products to be more and more multifunctional and miniaturized. The low-temperature co-fired ceramics (LTCC) technology which has 3-D integration capabilities and low cost is usually used to fabricate miniaturized multilayer RF passive components. As one of the most important passive components in RF wireless transceiver system, the band pass filter (BPF) has attracted significant interest in 3-D miniaturized design. [1, 2].As we known，an excellent BPF must have low pass-band insertion loss and large out-of-band rejection. In this paper, a 2.45G miniaturized band pass filter, which incorporates a feedback capacitor between input and output to realize two finite transmission zero has been optimized by Ansoft HFSS. After the physical model and inner structure of the BPF are established, the samples are fabricated by LTCC technology. Testing results show that the insertion loss is less than 5.2dB and return loss is less than -13dB at the center frequency of 2.6GHz, which agree basically with the simulation results.

Introduction

With the current the explosive growth of communication, it is necessary to develop the devices which possess higher integration, multifunctionality and smaller size. Recently, the low temperature co-fired ceramic (LTCC) technology has been widely used in RF circuit design due to its high performance, high integration density and high reliability. LTCC is a multilayer ceramic technology that the active devices can be mounted on the surface layer while different types of passive components can be embedded in the inner layers to form very compact RF module at relatively low cost. Up to now, many RF devices have been sucessfully fabricated by LTCC technology.[1-3]

As one of the most important componentsin in the RF front-end , the bandpass filter is widely investigated.[4-5] The function of band pass filter is to suppress out of band signals that can interfere with the proper functioning of the receiver. As we known, an excellent BPF must have low pass-band insertion loss and large out-of-band rejection. To meet the requirements, the source-loaded coupling capacitor and the grounded coupling inductor between two resonators are implemented. In this paper, a new S band LTCC BPF, which incorporates a feedback capacitor between input and output to realize two finite transmission zero was designed and fabricated by LTCC technology.

This paper is organized as follows. In Section I, circuit design and physical model are optimized. The fabrication progress and samples are provided in Section II. Finally, testing results are given in the Section III.

Circuit design and physical model

A. Circuit design

Fig.1 shows a second-order filter circuit prototype with two finite transmission zero.[2] It can be seen that a feedback capacitor is introduced to form a pair of finite transmission zeros to improve the filter selectivity. This circuit prototype offers relatively low insertion loss in the pass-band, morever, it provids acceptably high attenuation out of band, too. The corresponding component values is caculated based on the second-order low-pass filter's normalized parameters. The component

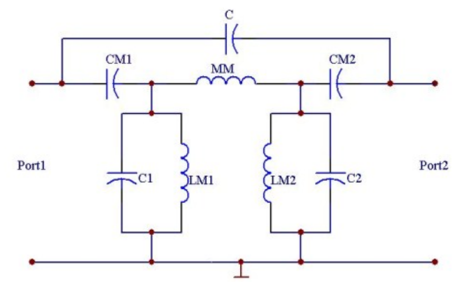

Fig. 1. The circuit prototype of BPF

values is shown as follow: CM1=CM2=0.79pF, LM1=LM2=1.55nH,C1=C2=2.48pF, MM=9.27nH.

B. Physical model

The circuit prototype has been established, the next work is to optimize physical structure of BPF . A three-dimensional electromagnetic simulator (Ansoft HFSS) was used to deal with the three-dimensional electro-magnetic fields' stimulation.

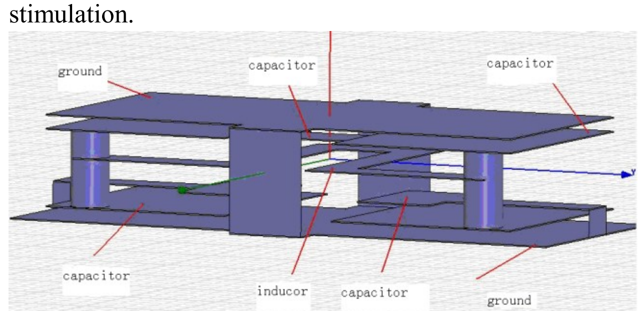

Fig.2.The physical prototype of BPF

The Ansoft HFSS is based on Finite element method(FEM) which is a numerical methods of differential equations based on boundary-value problems, so that it has higher calculating accuracy. In this physical prototype, some tuning of component values have to be done in HFSS simulation so that it can deal with the problem such as the generation of imagine signal between ground and via, the misalignment by the thick film print process, the coupling effects between elements, and the parasitic effects in high

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frequency. After optimizing, the physical structure of BPF is established and is shown in Fig.2.

After simulation and careful tuning, the optimized result is shown in fig.3. The simulation results show the center frequency is 2.59 GHz, the insertion loss less than 2dB , the return loss about -20dB and two transmission zeros located in about 1.01GHz and 3.20GHz, respectively.

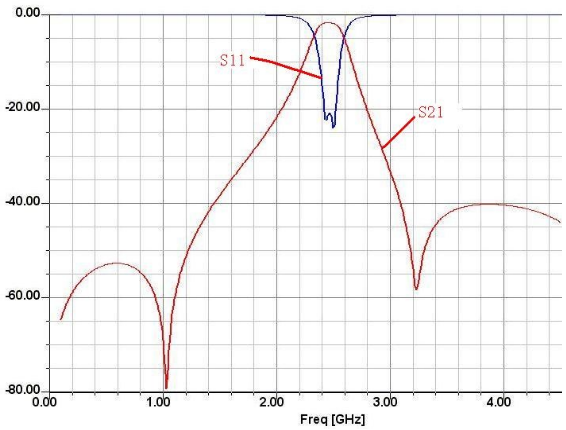


Fig. 3. The simulated results of BPF

Experimental and results

The substrate of Ferro ULF140 is employed for the three-dimensional(3-D) broadband filter and its dielectric constant and loss tangent are 14 and 0.0015, respectively. And the thickness of each layer was 40um. The BPFs was fabricated by the conventional low-temperature co-fired ceramic (LTCC) technology.The progress is shown in Fig.4.

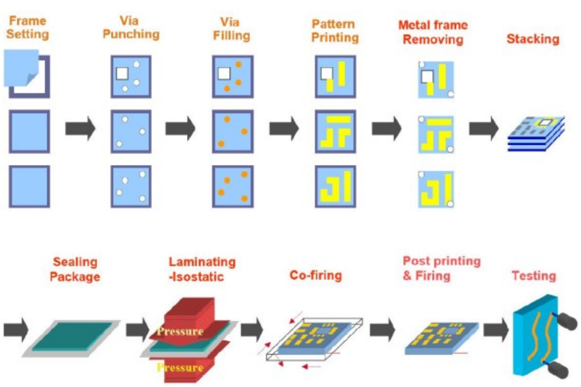


Fig.4. The progress of LTCC technology

The samples with the outline dimension of 3.0mm×1.5mm×1.0mm are shown in Fig.5.

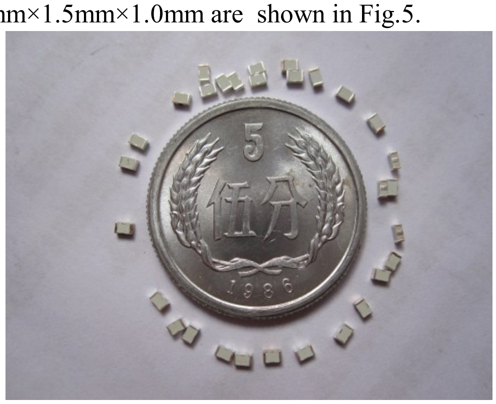
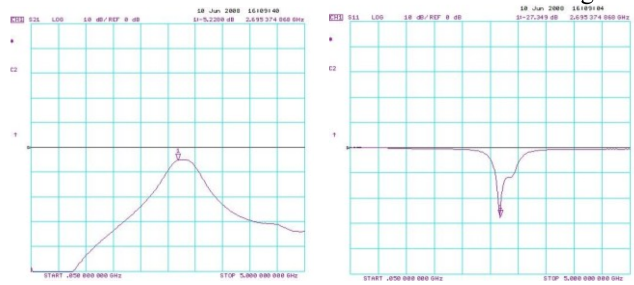


Fig.5 The samples of BPF

The measurements were carried on by Agilent 8722ES. A the thru-reflect line (TRL) calibration has been used in the range of 0.5 to 5GHz. The measured results are shown in Fig. 6.



(a)S_{21} (b) S_{11}

Fig.6 The testing results of sample

It can be seen from the measurement results:

(1) The BPF's center frequency is 2.6 GHz , which has a little displacement with the designed frequency,it is attributed to the effect of the additional

inductive and capacitive parasitic. The fabrication progress is another factor to center frequency.[6]

(2) The 1dB pass band width is larger than 1GHz, which agree basically well with the EM simulation results.

(3) The insertion loss is less than 5.2dB and return loss is less than -13dB.

Conclusions

In this paper, a compact S band BPF with has small size (3.0mm×1.5mm×1.0mm) has been fabricated by LTCC technology. The design 、 simulation and optimization procedure has been given in detail. The test result show that the insertion loss is less than 5.2dB and return loss is less than -13dB at the center frequency of 2.6GHz, which agree basically with the simulation results. It showt that these BPFs has excellent properties compared with other type filters while have more compact size.

Acknowledgments

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