

Stacked LTCC Band-Pass Filter for IEEE 802.11a WLAN

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1. Introduction

New communication environments demand smaller and lighter devices for the multi-band and multi-function services. Low Temperature Co-fired Ceramic (LTCC) technology is widely used in the fabrication of miniaturized multi-functional communication components such as SoP (System on Package). The band-pass filter applications using parallel-coupled shorted strip lines have been found useful in terms of their compact size and low cost.^[1~4] In this paper, a stacked band pass filter using LTCC multi-layer technology is proposed for IEEE 802.11a WLAN coupled strip lines for IEEE 802.11a WLAN. The proposed band-pass filter achieving improved miniaturization, available insertion loss, good skirt characteristic and group delay.

2. Filter Design

The figure 1(a) shows the equivalent circuit of filter using L-C resonator. In order to extrude 2-stage band-pass equivalent circuit, band-pass and J-inverter transform theory applied to Chebyshev low-pass prototype filter. The figure 1(b) shows the equivalent circuit of filter using shorted $\lambda/4$ resonator. Because parallel L-C resonator is complicate and hard to control the inductor characteristics in high frequency, the shorted quarter wavelength transmission line structure is selected for the resonator structure. The figure 2 shows the frequency response of filter, this synthesis is verified through circuit simulation tool ADS(Advanced Design System).

The capacitive element is designed by parallel plate structure and each port is located on the different layer, this method is very suitable for using the LTCC multi-layer technology. In order to reduce the passive elements, parallel L-C coupled element between resonators is replaced electromagnetic coupling phenomenon. The passive elements located in the different layers are connected by conventional via structure and isolated by inner ground, respectively. The permittivity and tangential loss of substrate material is 7.8 and 0.005 respectively, and thickness is $100\mu\text{m}$. Diameter of via is $140\mu\text{m}$ and that of through hole is $400\mu\text{m}$. Conductor thickness is $10\mu\text{m}$.

The figure 3 shows the 3-Dimensional structure of the proposed filter. For the low volume and high

integration, many filter structures are non-reciprocal, but the proposed band-pass filter is designed by the reciprocal structure, and each ground is connected by printing the side walls. Capacitive element is fabricated between $550\mu\text{m} \times 525\mu\text{m}$ electrode. The resonator has length of 4.51mm and width of $200\mu\text{m}$. Each resonator is folded in order to control the resonant frequency of the filter, and truncated structure is selected to suppress the spurious radiation. To improve the defect of the mis-aligned via, every connected area including resonators has extended structure, catch pad. But resonance frequency is lower than normal structure, so it is necessary to control the length of resonator.

The important parameters of band pass filter, such as position of attenuation pole and coupling coefficient of resonators, is discussed using even-odd mode analysis and tuned by distance of resonators. These EM characteristics are verified through the CST Microwave Studio.

3. Experimental results

The figure 4 shows the photo of fabricated filter. The proposed band-pass filter is fabricated by LTCC technology. The substrate material is DP-951 Green sheet of Dupont. The dimension of fabricated stacked band-pass filter which is composed of six layers, is $2.5 \times 2.27 \times 1.02\text{mm}^3$. The measured filter characteristics show the center frequency of 5.28GHz , insertion loss of -2.25dB , bandwidth of 220MHz , attenuation at 5.7GHz of -33.2dB and group delay of 0.9ns at 5.25GHz , center frequency. These results are contains evaluation board characteristics.

The figure 5 shows simulated and measured characteristics of the filter. The center frequency is increased by about 60MHz from the simulated center frequency of 5.22GHz because the conductor shrinkage rate error brings shorter length of resonators. Due to the frequency depended quality factor of dielectric material and several via misalign, insertion loss is increased compared with simulated value of -0.8dB . The other characteristic is similar to the simulated data.

4. Conclusion

Passive components integrated in a dense LTCC-multilayer can be used to reduce the circuit sizes. In this paper, in order to achieve compact size and good skirt characteristics of the filter, coupled strip line resonators and two in/out coupling capacitors are used in multi-layer LTCC substrates. The fabricated filter size is $2.5 \times 2.27 \times 1.02\text{mm}^3$. The resonance frequency is 5.29GHz , and half-power bandwidth is 220MHz , insertion loss of pass-band is -2.25dB , rejection at 5.7GHz is -32.25dB . For more sophisticated designs, it is necessary to research about characteristic of material, such as variation of loss at high frequency.

5. Reference

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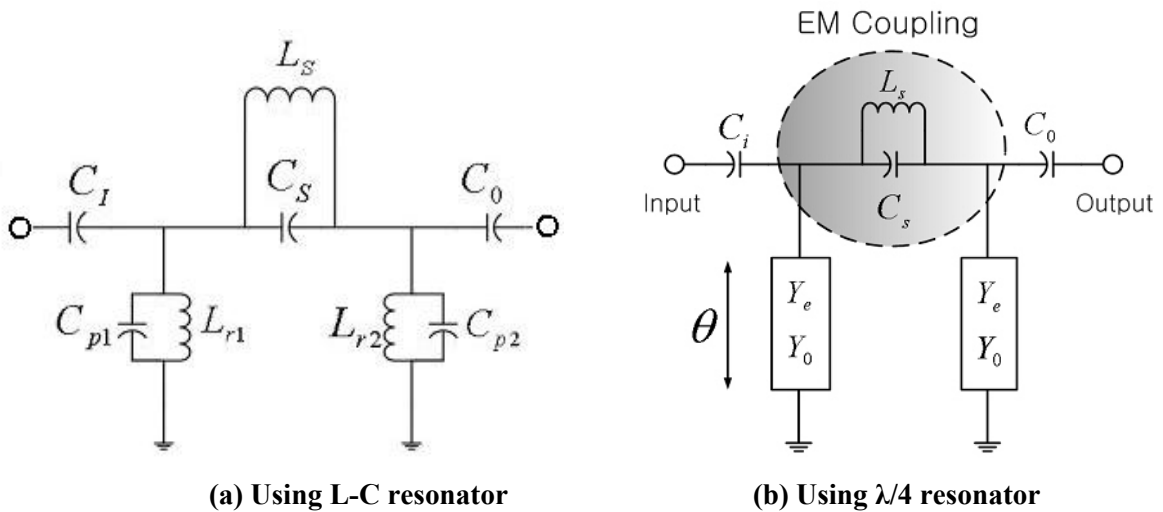


Fig 1. The equivalent circuit of band-pass filter

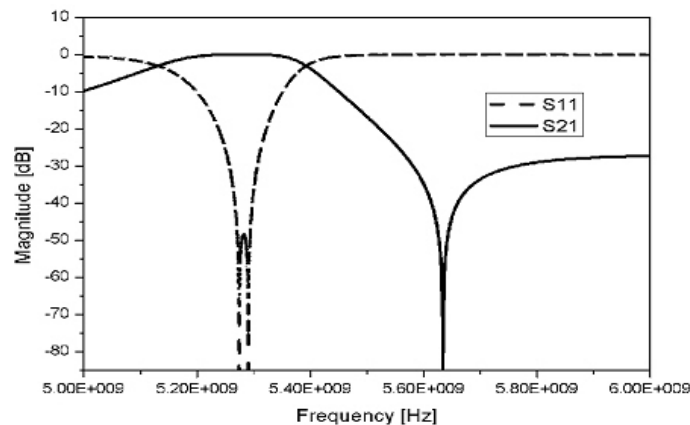


Fig 2. The simulated result of the equivalent circuit using $\lambda/4$ resonator.

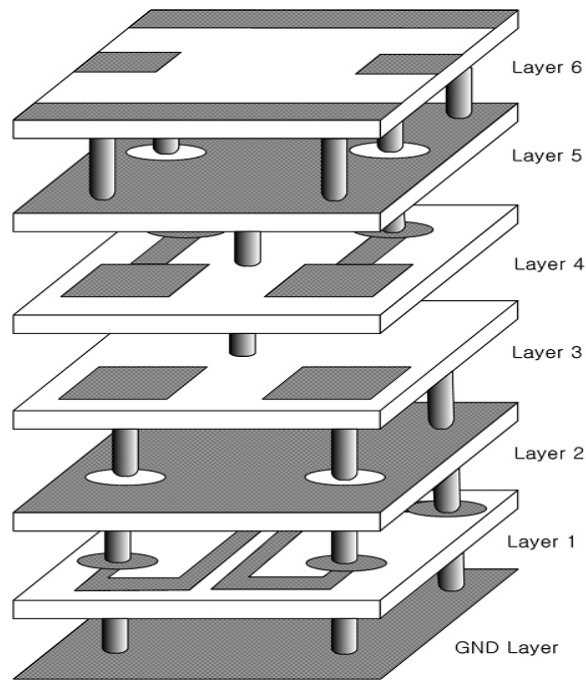


Fig 3. 3D structure of proposed band-pass filter

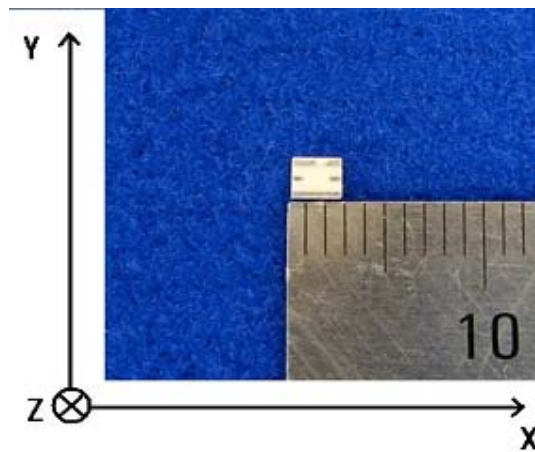
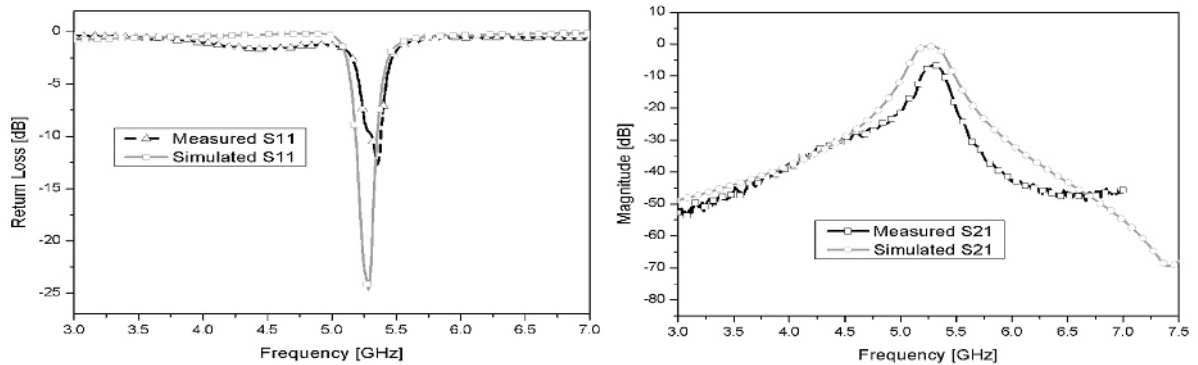


Fig 4. The fabricated LTCC filter



(a) Return loss

(b) transmission

Fig 5. The simulated and measured characteristics of band-pass filter