International Journal of Computational Intelligence Research
ISSN 0973-1873 Volume 13, Number 2 (2017), pp. 313-319

http://www.ripublication.com

Design of Closed Loop Dual Band Bandpass Filter Using Two Different Size Cascaded Open Loop Triangular Ring Resonator

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Abstract

This paper presents a dual band bandpass microstrip filter using different size cascaded conventional open loop triangular ring resonator for various application in microwave communication at 7.2 GHz and 13.8 GHz. The filter is less complex since no via or defected ground structures are used. The rejection performance is improved due to the introduction of cascade method in design of filter. Stop band has several attenuation poles to improve the selectivity of the proposed bandpass filter. The two passband is separated by wide stop band. A wide upper stop band is also obtained. The proposed filter is designed and simulated in Agilent ADS.

Keywords: Open Loop Triangular Ring Resonator Cascaded Structure, Dual Band Bandpass Filter and Selectivity.

1. INTRODUCTION

Wireless communication systems are influenced extensively by microstrip filters from last few years due to size, cost, weight, and fabrication advantages with various applications [1]. The dual band filters mostly have high quality narrow-band BPFs with features preferable in microwave communication such as small size, low loss, and low mass. In practical application of dual band filters strong attenuation is required for which many new structures is proposed such as stepped impedance resonators (SIRs) [2], parallel coupling [3] and equal-length coupled-serial-shunted lines [4, 5]. All the structure shows large size, more complexity, high insertion loss and absence of transmission zero in the stop band, due to which selectivity was not satisfactory and an additional matching network is needed as a solution. For low insertion loss and compact size a dual band filter using patch, triangular structure or stacked loop structure is proposed [6, 10]. Recently open loop ring structures are used to improve the rejection performance of the filter [11-15]. Since miniaturization, low cost and good rejection performance of filter is the main constraint area of interest and research is going on to achieve it.

The paper describes the close loop dual band filter using two cascaded open loop triangular ring resonator of different size. The dielectric material used for designing the proposed filter is Rogers RT Duroid 6010 with thickness 1.27 mm having dielectric constant 10.2.

2. DESIGN OF DUAL BAND BPF

Triangular open loop resonator has compact size and low insertion loss compared to other resonators. Electric coupling and magnetic coupling is necessary for low insertion loss and better coupling to occur. Coupling effect can reduce or increase the stored energy of the filter by splitting the resonant mode underlying in the configuration. This coupling effect does not only depend upon the length and width of the microstrip line of the filter but also on the type of dielectric and its thickness.

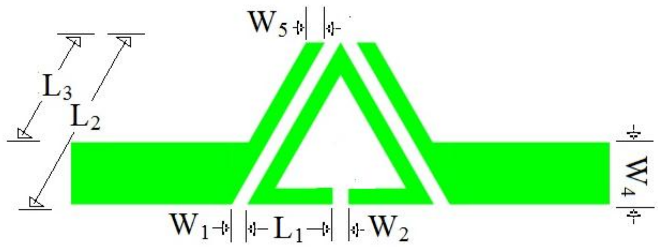

Figure 1. Structure of open loop triangular ring resonator coupled in series with transmission line with loaded stub.

The proposed filter has an open loop triangular ring resonator coupled with transmission line with an extended stub coupled with the sides of open loop resonator see fig. 1. The structure shows the electrical coupling and magnetic coupling. The magnetic coupling lie at the open loop area of ring resonator whereas electric coupling lies at the sides of ring resonator coupled with stub. Due to these coupling change in electric field is introduced and two passband is obtained one is the resonant frequency of the structure and the other is due to the degeneration of modes that generates the attenuation pole due to cross coupling with a shift of resonant frequency of higher harmonics. A two passband is obtained separated by wide stopband centered at 7.5 GHz and 13.7 GHz, see fig. 2. The first passband has insertion loss as 0.38 dB and return loss as 35 dB where as second passband has 2.6 dB and 13.6 dB. A good upper stopband is also achieved extending from 15.05 GHz to 20 GHz with return loss less than 3 dB and maximum value of insertion loss as 23 dB.

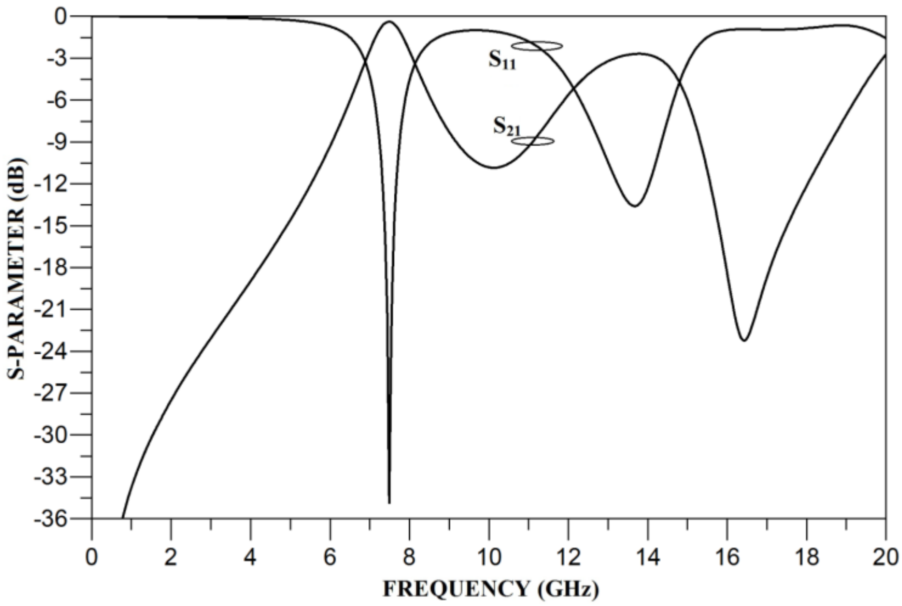

Figure 2. Frequency response of open loop triangular ring resonator coupled in series with transmission line with loaded stub.

To obtain the work condition of dual band bandpass filter the two passband and stop band is to be improved. To improve the passband and stop band coupled resonator theory is taken in to consideration. An open loop triangular ring resonator of small size is cascaded in parallel to the structure such that the resonator forms a close loop, see fig. 3. The field associated with open loop resonator is disturb when the small size open loop resonator is cascaded inspiring degenerate modes which further generates attenuation poles thus improving the selectivity of the filter with the creation of transmission zeros at the edges of the passband which improves the rejection performance of the filter with a shift of passbands towards the lower frequency side, see fig. 4. The first passband is centered at 7.2 GHz with insertion loss as 0.8 dB and return loss as 27 dB. The second passband is centered at 13.75 GHz with insertion loss as 2.1 dB and return loss as 16 dB. The two passband is separated by wide stop band that extends from 7.5 GHz to 12.86 GHz with minimum return loss as 0.34 dB and maximum insertion loss as 38.3 dB. A good upper stopband is achieved extends from 15.22 GHz with return loss less than 3 dB and maximum insertion loss as 50 dB, see fig. 5.

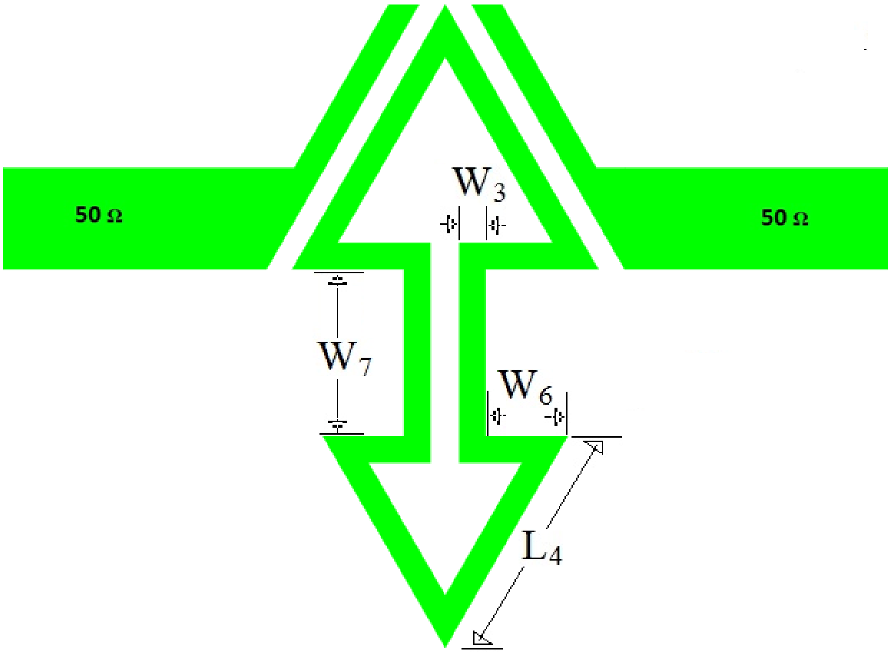

Figure3. Structure of the proposed Filter.

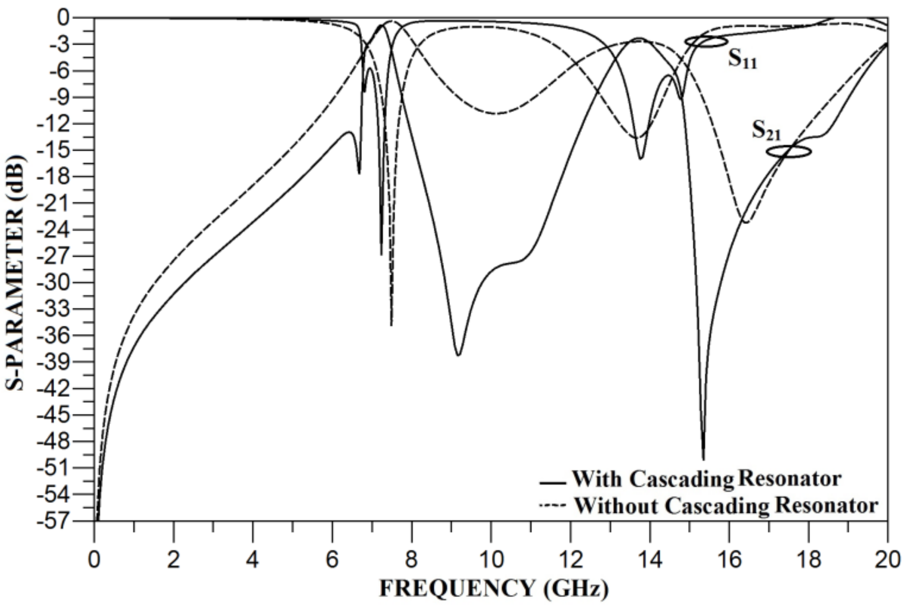

Figure 4. Frequency response of with and without cascaded open loop triangular ring resonator.

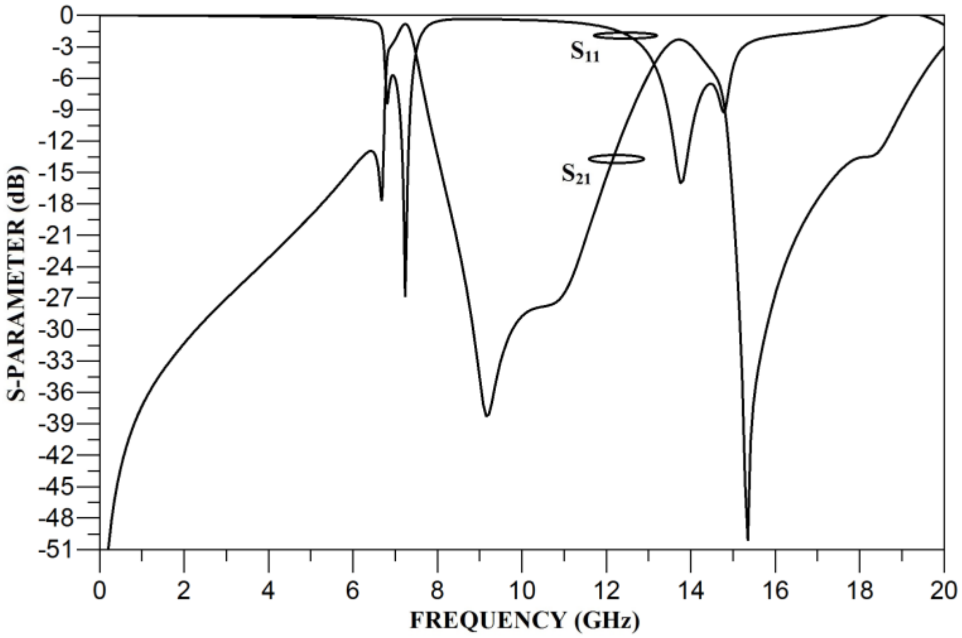

Figure5. Frequency response of proposed filter.

3. RESULTS AND MEASUREMENT

The designed parameters of the proposed filter are as follows: L_1 = 1.6 mm, L_2 = 3.5 mm, L_3 = 2.16 mm, L_4 = 2.8 mm, W_1 = 0.3 mm, W_2 = 0.2 mm, W_3 = 0.3mm, W_4 = 1.16 mm, W_5 = 0.35, W_6 = 0.94 mm, W_7 = 1.91 mm. the simulated frequency response of proposed filter has two passband. The two passband is centered at 7.2 GHz and 13.75 GHz with 3 dB fractional bandwidth as 8.4% and 6 %. The 3 dB rejection fractional bandwidth of the stop band separating the two passband is 52.2 %, see fig. 5. The overall size of the filter is 7.36 mm x 3.5 mm.

4. CONCLUSIONS

A compact and planar close loop dual band bandpass filter is proposed using two cascaded open loop triangular ring resonator of different size. The filter has a good upper stop band performance over a wide range of frequency. Frequency response of proposed filters shows good rejection performance and low insertion loss making it applicable in various microwave communication system.

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