International Journal of Engineering Science Invention (IJESI)
ISSN (Online): 2319 – 6734, ISSN (Print): 2319 – 6726
www.ijesi.org ||Volume 7 Issue 8 Ver V || Aug 2018 || PP 24-27

Narrowband Passband Microstrip Filter Using Octagonal Ring Resonator with DGS Technique

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Abstract: *In this paper, a narrowband passband filter is proposed with 9.2 GHz resonance frequency and 4 % bandwidth. In the proposed design, one single octagonal ring resonator and two defected ground structures (DGS) for perturbing symmetry are used to obtain sharp cutoff frequency and high insertion loss in the rejection band. Unlike previous works, in the proposed design, suppression of higher order modes is obtained only by utilizing single ring resonator. Moreover,by optimizing filter's dimensions, high compactness and minimum insertion loss in the passband of the proposed design can be achieved.*

Keywords–*Narrowband passband filter,Octagonal ring resonator, Defected ground structures (DGS)*

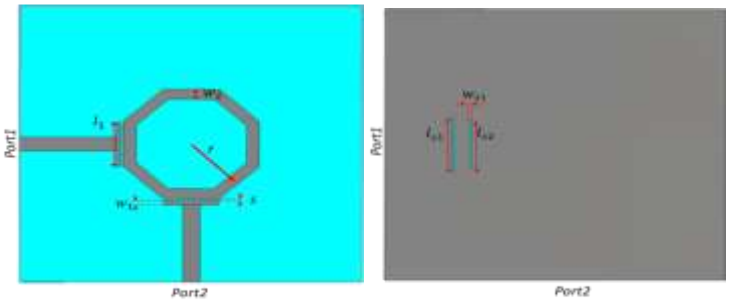
Date of Submission: 17-08-2018 Date of acceptance: 31-08-2018

I. INTRODUCTION

In recent years, demands to minimize the size and weight of filters increases especially in applications such as communication like [1] and imaging systems demonstrated in [2]. In that way, microstrip filters are desirable compare with waveguide filters due to their compatibility to be compact by optimizing filter's design as discussed in[3]. Beside size reduction, low insertion loss in pass band and high insertion loss in rejection band are significant considerations that should be account especially in narrow band passband filter design as mentioned in [3]. In many works, parallel coupled microstrip filters are utilized because of their wide range of bandwidth as discussed in [1]. However, the drawback of this type of the filter is large size of the filter because parallel coupled lines resonates when their lengths are half wavelength. To minimize filter size, instead of parallel coupled lines, microstrip ring resonators, which are coupled through a gap to the feed line like [1], is utilized in some works such as [4]. Beside small size of microstrip ring resonators, this type of filter has narrow bandwidth and by optimizing ring's dimensions and coupling gap, desired resonance frequencies can be selected. In this work, similar to [1], octagonal resonator is used instead of circular ring resonator to obtain sharp cut off frequency response. In addition, as discussed in [5], defected ground structures (DGS) is used for more compactness and suppression of undesired periodicity effect in the rejection band. Hence, by optimizing pattern and dimension of DGS, higher order of the resonance frequency can be suppressed in the rejection band. Here, ring resonator and DGS are optimized to work at 9.2 GHz with 4% bandwidth (BW) and for optimization, CST Microwave Studio simulator is utilized.

II. DESIGN OF OCTAGONAL RESONATOR WITH DGS

The proposed octagonal resonator is depicted in Fig. 1(a) and two DGS are designed in the ground plane (Fig. 1(b)) for improve filter's performance in the rejection band. For designing narrowband filter, RO3010^{TM} with 20 mil thickness is used to compress resonator due to high permittivity of the RO3010^{TM} substrate. In the proposed narrowband filter to have resonance at 9.2 GHz with minimum insertion loss in the passband, optimized dimensions are: r = 3.9 mm, l_1 = 3.2 mm, l_{s1} = 4 mm, l_{s2} = 3.5 mm, w_{s1} = 0.1 mm,s = 0.2 mm, w_1 = 0.3 mm and w_2 = 0.8 mm. These optimized dimensions are achieved based on simulation results that are shown and discussed in follow.



(a) (b)

Figure 1. (a) Top view and (b) bottom view of the proposed narrowband passband filter.

First, simulation results are prepared to compare frequency response of the circular and octagonal ring resonators with same radius (r = 3.9 mmobtained from [6]). As seen in Fig. 2, insertion loss of octagonal ring resonator in the passband is around 1 dB, while for circular ring resonator is 4.3 dB.In addition, $|S_{11}|$ at the resonance frequency in the octagonal ring resonator is achieved to -11 dB but for circular one is -8.6 dB.Hence, rest of simulations are prepared with octagonal ring resonator.

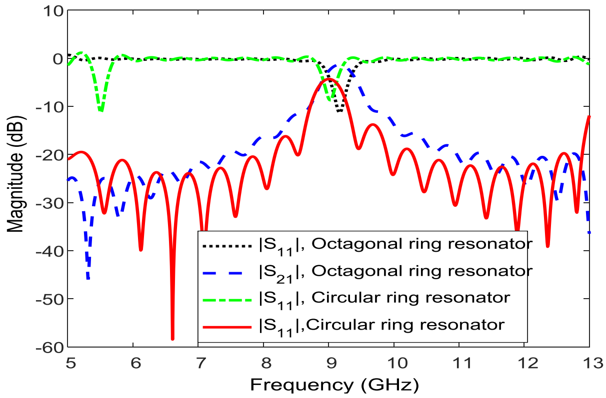


Figure 2. S-parameters of octagonal and circular ring resonators with same radius.

Next, as seen in Fig. 1(a), port 1 and 2 are orthogonal to each other. As discussed in [3], when feedlines are orthogonal to each other, there is not coupling between them and they do not affect each other but by perturbing the symmetry of the orthogonal design, electric field distribution of these field lines are not orthogonal to each other and they can couple electric field to each other and creates two couple modes which acts like two poles. These poles creates sharper cut off frequency and higher insertion loss in rejection band. In the proposed design, to perturbing the symmetry of the design, two rectangular DGS are used in the side of port 1. Hence, it is expected frequency response of the proposed design with orthogonal feed lines and DGC perturbation near port 1 has less rejection band level compare with symmetric (without DGS) ring resonator where feedlines are in the same direction. To prove this simulations are prepared for both of these design and results are shown in Fig. 3. As shown in Fig. 3, insertion loss in the rejection band is less when feedlines are orthogonal to each other and this is the result of poles in the rejection band as expected.

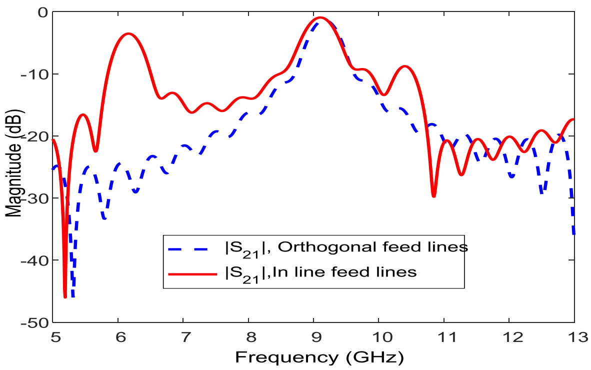


Figure 3. Insertion loss of octagonal ring resonator for different port's location.

Next, simulation results are prepared for different s values (gap between resonator ring and feed line) and results are shown in Fig. 4. Results show that for less gap distance, beside variation of resonance frequency for different s, return loss is less but BW increases. In this work, s = 0.2 mm is optimized gap to have 4% BW for the proposed filter.

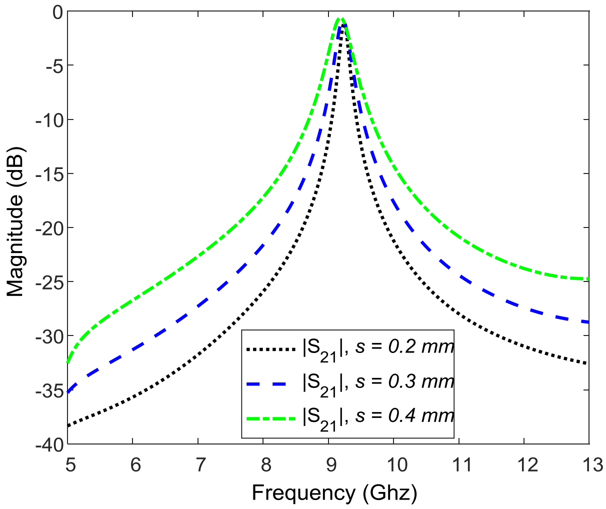


Figure 4. Insertion loss of the proposed filter for different gap values.

Finally, simulations are prepared for different DGS lengths. Similar to [7], Poles in the frequency response of microstrip structures is determined by slot's length. Hence, it is expected by optimizing DGS length (rectangular slot in the ground plane), high suppression in the rejection band (higher order mode's suppression) is obtained. As seen in Fig. 5, for w_{s2} = 3 mm, suppression of higher order modes (around 18.4 GHz) is more compare with 0.5 and 1.75 mm.

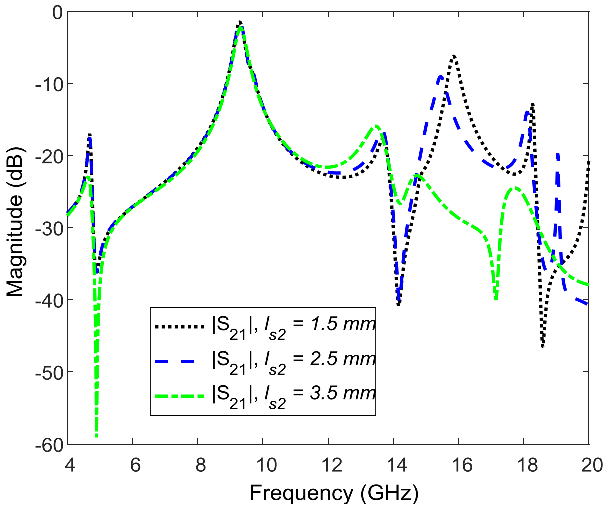


Figure 5. Insertion loss of the proposed filter for different DGs length.

III. Conclusion

In this work, the narrowband passband filter at 9.2 GHz with 4% BW is proposed and the frequency response has rejection band less than -20 dB up to 20 GHz. In this compact design, unlike other works, with two rectangular DGS near one of the feedlines, desired perturbation for generating coupling between feedlines is created and as a consequence, two poles in the rejection band are appeared to suppress higher order modes.

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Zahra Manzoor "Narrowband Passband Microstrip Filter Using Octagonal Ring Resonator with DGS Technique "International Journal of Engineering Science Invention(IJESI), vol. 7, no. 8, 2018, pp. 24-27