Development of Compactness of Reconfigurable LPF/BSF Using a Simple Technique for Radar Applications

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Abstract. In this paper a new compact reconfigurable low pass/band stop filter using a miniature omega resonator placed in a small DGS in the ground. The reconfiguration in frequency response can be achieved with the same topology and the same dimensions by changing just the position of channel slot which connect the omega resonator to the metallic ground without any other requirements. Several advantages obtained with this structure based on the use of one omega resonator cell such as simplicity of fabrication, very low insertion loss in the pass bands, a high rejection in the stop band with a sharp transition. This filter is suited for many areas of modern communication applications and microwave technology since it shows a simple frequency reconfiguration with a several benefits such a good wide rejection of out of bands signals, high selectivity, compactness and small losses and seize, with total area of 9.08×10mm^2.

1 Introduction

Reconfigurable and compactness filters have received significant attention for their applications in wireless communications, electronic surveillance and countermeasures by adapting their properties to achieve selectivity in frequency and bandwidth to obtained more surface and improving performance to replace the standard filters, [1]. These filters can only furnish a progressive transition from pass-band to stop-band with narrow bands and large size [2]. Such as stepped-impedance [3-5], semi-lumped element filters [6], open-circuited stubs [7], [8] and others. Many effort has gone to overcome this problem into designs of compactness and simple structure of filters using micro-strip ground structure (DMS) [9-11], electromagnetic band gap (EBG) and defected ground structure (DGS) [12-14], periodic and non-periodic DGS [15], [16], cascaded resonators [17-20], Though all these previous techniques, structures have confines on the minimization of the effective size reduction of circuits, because their resonators based absolutely on the half-wavelength resonance [21],[22].

In other, complementary cell resonators with high quality factor have gotten much interest for their simple integration with planar topology, low-cost and easy fabrication. Parallel to this previous device, a complementary split ring resonator formed omega topology is better than the conventional microwave shaped resonators, since it has very high-quality factor, and it can resonate with very small size, which offers low radiation losses, [1].

The basic structure is an omega complementary resonator with Ω-topology, as shown in Fig. 1. A circuit model has been extracted to characterize the proposed structure, [1]. All the dimensions of the proposed Ω-omega resonator are depicted in Table 1.)

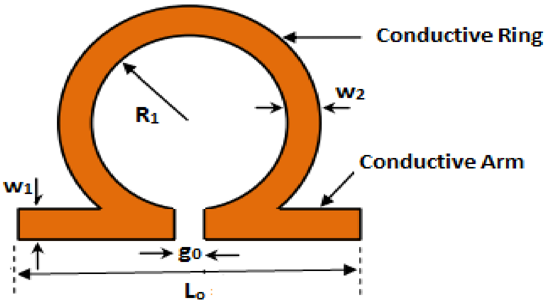

Fig. 1. Layout of the Ω-omega shaped resonator.

Table 1. Dimensions of resonator with omega Ω-topology.

Parameters of Ω-unit	L0	g0	W1	W2	R1
Values (mm)	2.781	0.0785	0.2	0.266	20

2 Design of the proposed low pass filter

The present structure is a new coplanar waveguide (CPW) low pass filter (LPF) as schematic shown in Fig. 2. The basic unit of the proposed LPF layout is a single omega resonator which is inserted in a small DGS in the metallic ground plane of coplanar line and connected vertically to the ground plane via slot-channel (Sc=0.2x0.05mm^2) between the top arm heads of omega resonator and the ground of structure. While the omega resonator speared horizontally with a disconnecting gap (g=0.05x0.2mm^2) between the two arms and the ground

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plane. The new low pass filter has been simulated on a FR4 substrate with a relative dielectric constant of εr = 4.4 and a thickness of 0.635 mm.

The input-output characteristic impedance of the CPW transmission line is 50Ω, with a signal line width of W=0.83 mm and the gap of G=0.125 mm. While the width of the rectangular DGS in the ground is 0.696 mm and length of 2.881 mm. The surface area of the whole structure is 9.08 mm in width and length of 10 mm (9.08×10mm^2). The design procedure is optimized and validated by using Momentum based on moments method.

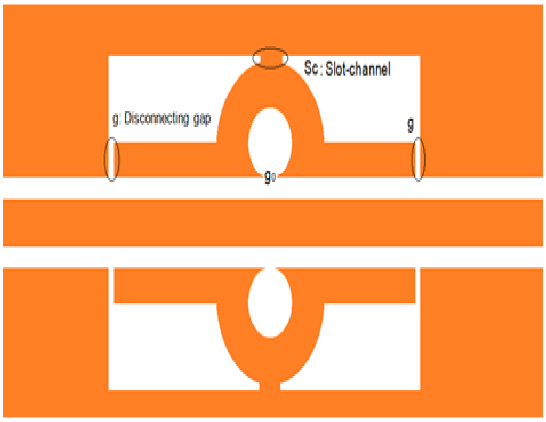
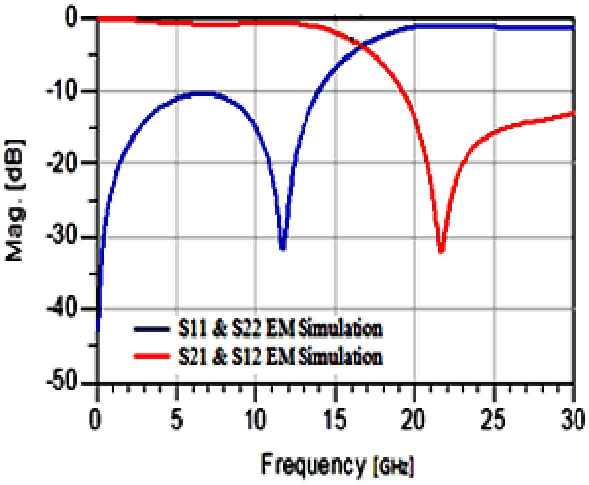
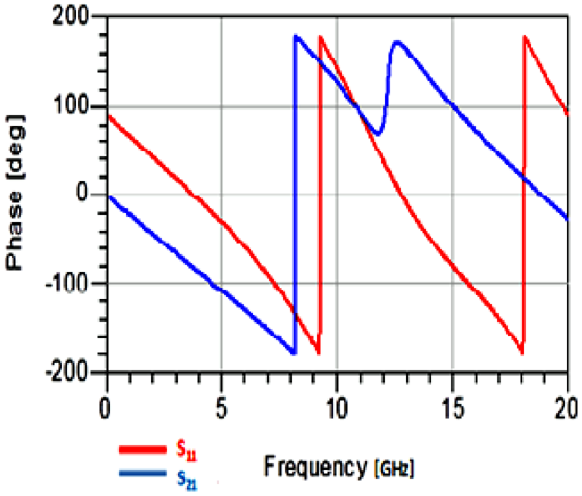


Fig. 2. The schematic of the proposed LPF.

The proposed structure has been designed, optimized and simulated. The results of EM simulation are shown in Fig. 3(a). The proposed LPF have a cut off frequency at 16.02 GHz. The first attenuation pole at 11.5 GHz with level more than -30dB. The insertion loss in the passband around 0.5dB. While the suppression level is greater than -20 dB from 20 GHz up to 30 GHz. Thus, the filter exhibit sharp roll-off at transition knee of 32 dB/GHz. While the stopband bandwidth is equal to 14 GHz. Fig. 3(b), depicts the phase simulation in term of return loss (S11) and insertion loss (S21) of the proposed LPF, which is accepted as a linear for wide band such as here from 0.1 GHz up to 30 GHz.



(a)



(b)

Fig. 3. EM-Simulation results of the proposed CPW LPF (a), and its simulation phase responses (b).

3 EM-field distribution of the proposed LPF filter

To demonstrate the level accord between the EM-simulation results and the current distribution of this proposed structure, we propose the study of surface energies as depicts in Figs. 4(a), and 4(b). The topology characteristic was revaluned in two different frequencies, at 10 GHz and 25 GHz, which corresponds to pass- and stop-bands state, respectively.

Firstly, at frequency 10 GHz, as observed in the results of the Fig 6(a), it is clearly that the current energies distributed from the input to the output along the filter, which confirms the passband state of structure. Secondly, in the Fig 4(b) at frequency of 25 GHz, we can see clearly that the energy distribution remains blocked in the first part of the filter and mainly concentrated around the omega resonator, hence no current energies at the output port, which signifies that the structure is in the stopband response. Finally, a good agreement between EM-Simulation results and EM-Field distribution.

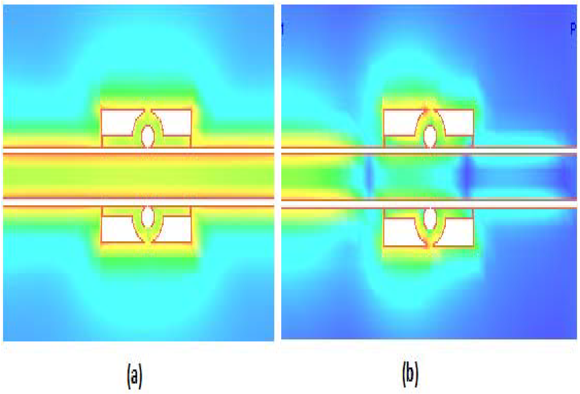
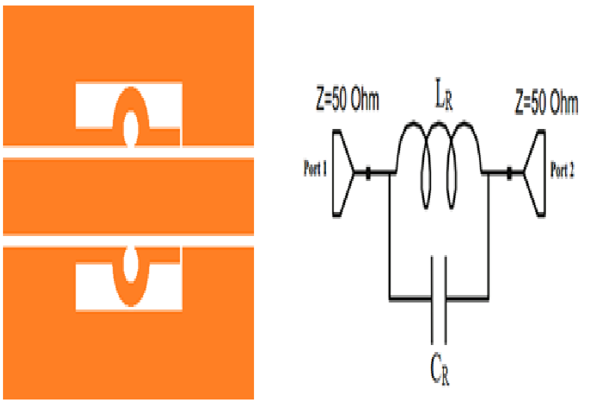

(a) (b)

Fig. 4. The current distribution of the simulated structure: (a) at 10 GHz & (b) at 25 GHz.

4 Reconfiguration of low pass (LPF) to band stop filter (BSF) based on switches technique

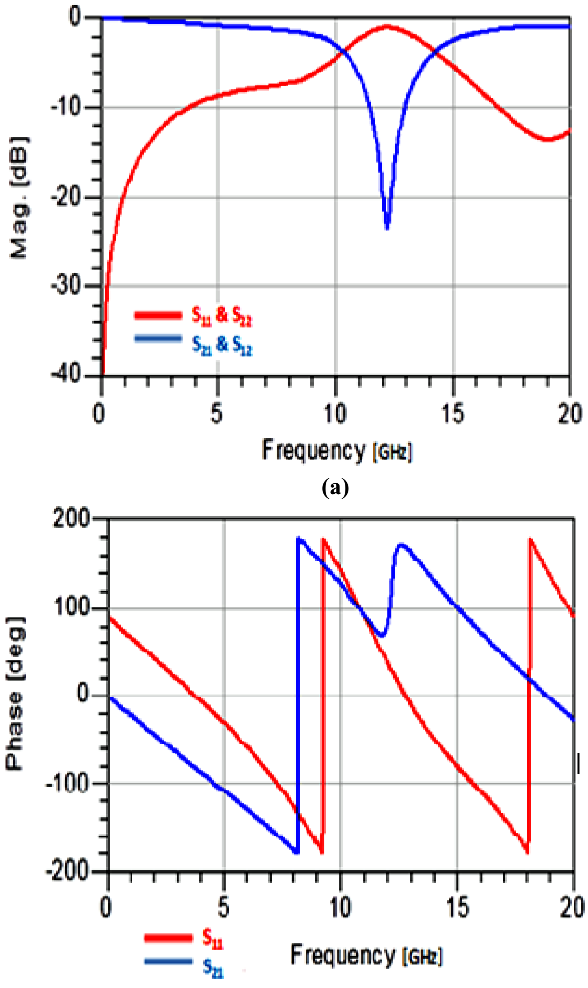
The goal of this study is to reconfigure the proposed low pass filter to the band stop filter, in order to save the same dimensions of the global structure with the same topology, as shown in Fig.5(a). Consequently, limiting the occupied volume on the surface area of this structure then minimize the level of complexity of the proposed filter in the transformation bands. However, the trick in this work is a sample technique based on switches mechanism, compared to the conventional transformation and other complicated method that is need to change the topology and adding other parameters which occupied an overall volume of structure. The band stop filter is composed of a single omega resonator that is placed in DGS in the metallic ground plane and directly connected with the left arm heads to the ground of coplanar line with a small slot channel with of 0.05x0.2mm^2. The extracted circuit of the proposed filter is compatible to the layout structure as shown in Fig.5(b).



(a) (b)

Fig. 5. The schematic of the BSF (a) & Its equivalent circuit (b).

The EM and phase simulation results of the reconfigurable BSF filter, are shown in Fig. 6(a) and (b), respectively. As can be seen from the results, the band stop filter has resonance frequency, lower and higher cut-off frequencies of f0=12.1GHz, fl=9.9 GHz and fh=14.6 GHz, respectively. The stop band rejection level is extended over −20 dB, while it is greater than -15 dB from 11 GHz to 13 GHz. Thus, the stop band filter exhibits a sharp cutoff within a range of 2 GHz, from -3 dB to - 23 dB. The insertion loss is less than -1dB, the return loss is more than -23 dB in the stop band. While the stop band bandwidth is equal to 4.6 GHz. While the phase is accepted as a linear in term of return loss (S11) and insertion loss (S21) for the BSF for wide band from 0.1 GHz to 20 GHz.



(a)

(b)

Fig. 6. Simulation results of the reconfigurable SBF (a), and its simulation phase responses (b).

5 Conclusion

This paper presents, a novel design and development of a compact coplanar wave guide low pass filter and band stop filter with good performances as sharp-rejections, low loss and high rejection using a single omega resonator cell has been designed. The reconfiguration of frequency response can be achieved easily by using four switches. Parallel to this previous several advantages, a small size and wide rejection band of reconfigurable LPF/BSF is highly demanded in modern microwave communication systems, especially in radar applications in attempt to suppress spurious and harmonics signals. There are several general requirements for a LPF, such as low loss.

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