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DESIGN OF LOW PASS FILTER USING CONCENTRIC SPLIT- RING DGS

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ABSTRACT

In this paper, a DGS consisting of two concentric split-rings defective pattern having different size, shape and inverse split direction is used to design a 3-pole LPF. The DGS unit is modeled by 3rd elliptic LPF filter and equivalent component values are extracted. By varying the length of unit cell, changes in cut-off frequency and pole frequency in the frequency characteristics of the proposed DGS unit is investigated. Three DGS units with different pole frequencies are then used to realize a LPF having excellent sharpness factor. FR-4 substrate is used to fabricate the prototype filter. The experimental results show good agreement with its simulated results

Keywords: Band stop filter, Defected Ground Structure, Elliptical Filter, Micro strip Line

1. INTRODUCTION

In order to achieve a finite pass band, finite rejection band and slow wave characteristics a defected structure etched in the metallic ground plane of a micro strip line is now-a- days a very popular method. D.Ahn proposed Dumbbell shaped defected ground structure and applied successfully to design a LPF [1]-[3]. Dumbbell DGSs with different head-slot were also proposed [4]-[5]. Butterworth low pass filter function were used to model such DGSs as their frequency characteristics indicated one-pole response. To obtain a sharp filtering response a large dumbbell DGSs are cascaded. A DGS filter with elliptic function response has attenuation poles and zeros at finite frequencies and show high selectivity characteristics. Recently, few DGS with quasi-elliptic responses have been reported [5]-[8].

In this paper, a DGS with two concentric split-ring defective patterns is proposed. Outer ring is rectangular in shape while inner one is circular. The frequency characteristics show close positioning of cut-off frequency and pole frequency thus giving sharp transition band. The frequency characteristics look like a 3rd order elliptic low pass filter response. By varying the length of the DGS the cut-off frequency and the pole frequency of the proposed DGS can be tuned easily. Now by cascading three DGS units with different pole frequencies are cascaded underneath a HI-LO micro strip line to realize a low pass filter with deep stop band and excellent sharpness factor.

2. FREQUENCY CHARACTERISTICS OF DGS UNIT

Figure 1(a) shows the proposed DGS cell etched off on the backside of metallic ground plane underneath a micro strip line.

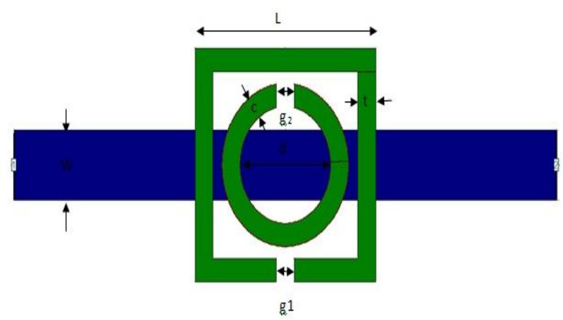

Figure 1(a) Proposed unit cell

Its frequency characteristics are investigated by simulating the unit cell in Mom based IE3D simulator as shown in Figure 1(b). The dimensions of the simulated cell are considered as: L= 10mm, t=1 mm, d=7mm, c=1mm, g_1=g_2=1mm. The cell is fabricated on FR-4 substrate having dielectric constant 4.4, loss tangent 0.02 and height of substrate 1.6mm. The width of micro-strip line is taken as W= 3mm (50 ohm).

The simulated attenuation zero frequency and the pole frequency are obtained at 2.07 GHz and 2.25 GHz, respectively. The maximum stop band attenuation and pass band insertion loss are found to be -32 dB and -0.32 dB, respectively. The sharpness factor at lower transition knee is obtained as 176 dB/GHz.

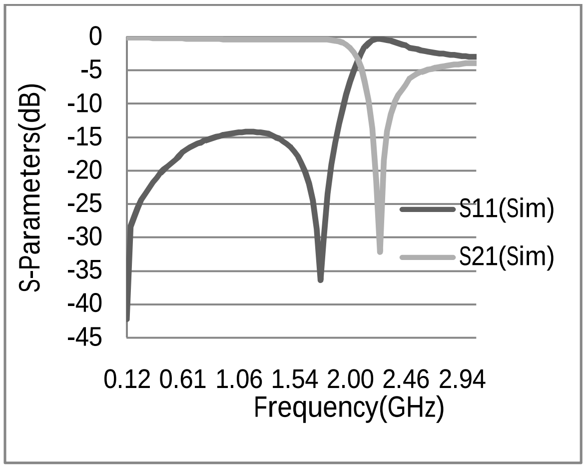

Figure 1(b) The S-parameters of unit cell

Thus, the investigated DGS unit exhibits both attenuation zero and pole at finite frequencies and they are close to each other. As a result, a sharp transition knee is achieved with deep stop band attenuation

3. MODELING OF DGS UNIT CELL

The frequency characteristics of the unit cell looks like a 3rd order elliptic low pass filter response. Figure 2(a) shows the proposed equivalent circuit model for the proposed Defected Ground Structure.

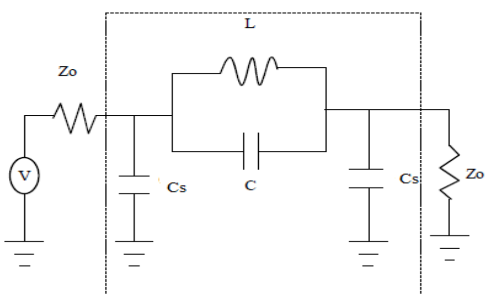

Figure. 2(a) The proposed model for DGS

The equivalent model consists of a parallel network comprising of inductance L and capacitance C and two parallel capacitances C_s. For given dimension of DGS unit, L-C parameters are extracted as L=1.0817 nH, C= 4.663pF and C_s= 3.0882 pF using NuHertz make Filtersim software. The S-parameters obtained from circuit simulation as shown in Figure 2(b) are in agreement with simulated response of the proposed DGS.

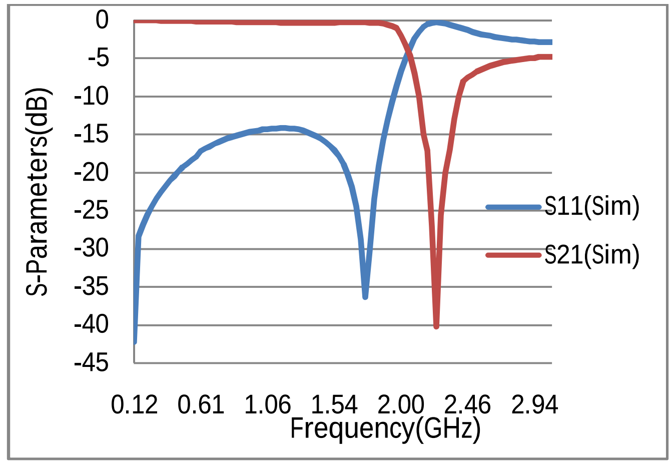

Figure. 2(b) S-parameters from the circuit model

4. INFLUENCE OF LENGTH OF DGS

By varying the length of the proposed DGS, a variation in the cut-off frequency and pole frequency of the proposed model is observed. Table 1 shows the variation in f_c and f_p values by changing the length L.

Table1 Variation in f_c and f_p by changing L

Length L (mm)	**Cut-off Frequency f_c (GHz)**	**Pole Frequency f_p (GHz)**
8	2.82	3.03
9	2.39	2.58
10	2.07	2.25
11	1.80	1.97
12	1.60	1.76

Figure 3 shows the variation of cut-off frequency and pole frequency with the changes in L

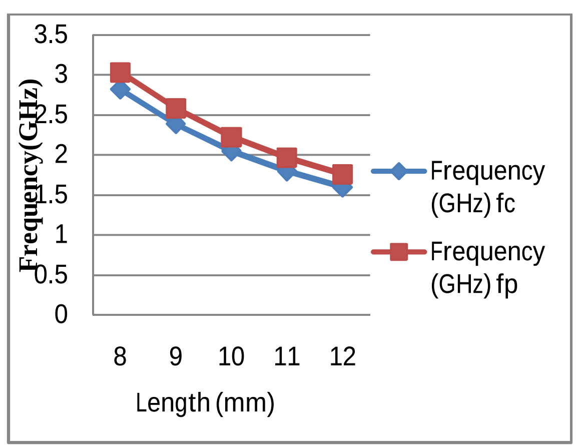

Figure 3 Variation in f_c and f_p with L

5. REALIZATION OF LOW PASS FILTER

Taking into account of above mentioned circuit model of DGS, a three pole low pass filter, using 3 DGS units cascaded is designed as shown in figure 4(a). The feed lines of the low pass filter in the design

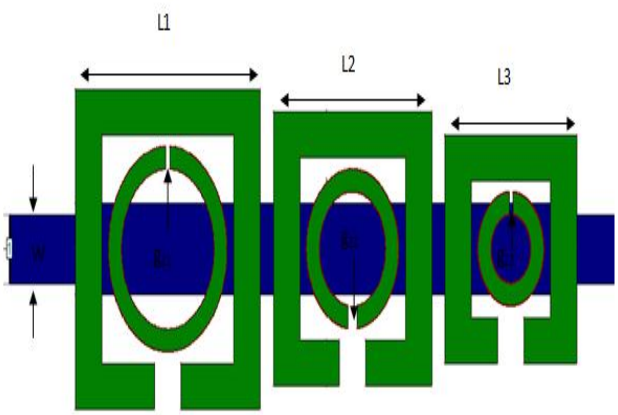

Figure. 4(a). Proposed Filter

are set to be 50Ω characteristics micro-strip lines with its width W= 3mm and length P=5mm for input/output matching. The pole frequency is varied by varying the length(l) of the DGS. The length og DGS units are taken as L_1= 14mm, L_2= 12mm and L_3=10mm. Other dimensions of the unit cell are same as before. The simulated result, as shown in Figure 4(b) shows that the realized filter has cut-off frequency f_c at 1.4 GHz and pole frequency f_p at 1.6GHz. The sharpness factor obtained in the case of simulated result is 185dB/GHz while in measured result, it is 168dB/GHz. The filter is facbricated on FR-4 substrate and measurements are carried out on E5061B ENA Series Network Analyzer. On comparing the Figure. 4(b) and Figure. 4(c), it is found that the experimental results show the good consistency with the simulated result

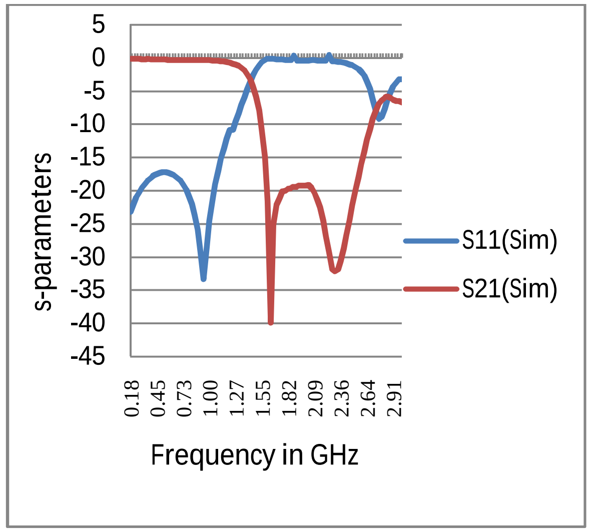

Figure 4(b) Simulated S-parameters of the Filter

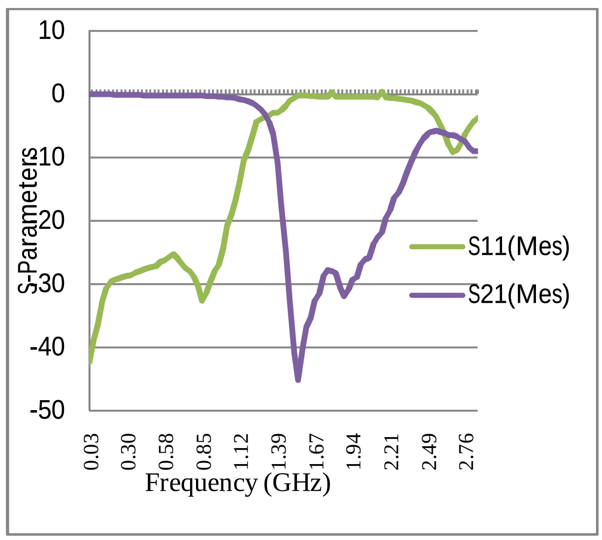

Figure 4(c) Measured S-parameters of the filter

6. CONCLUSION

This paper has proposed a new two concentric split-rings type DGS which is modeled by 3rd order elliptical low pass filter. Π-type LC network is used to represent the equivalent circuit. With the help of three DGS units having different pole frequencies, a low pass filter is designed. Proposed filter provides better sharpness and narrow bandwidth and thus it can be used in designing the wireless communication networks.

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