

Parametric studies on effects of defected ground structure (DGS) for dual band bandstop microstrip filter

Farah Shazuani Mahmud, Muhammad Shahrazel Razalli, Hasliza A Rahim, Wee Fwen Hoon and Mohd Zaizu Ilyas

Bioelectromagnetics Research Group (BioEM), School of Computer and Communication Engineering, Universiti Malaysia Perlis (UniMAP), 02600 Arau, Perlis, Malaysia.

Abstract. A dual-band bandstop microstrip filter is proposed and designed by using microstrip resonator with Defected Ground Structure (DGS). The DGS are placed in the ground plane to obtain high attenuation of the bandstop filter response. The proposed is designed by using R04003C printed circuit board with dimension of 38 mm x 20 mm. Simulated result shows an insertion loss of -12.31 dB, a return loss at -1.75 dB for center frequency at 2.4 GHz and insertion loss of -22.93 dB, a return loss of -0.78 dB for center frequency at 5.8 GHz. The results of simulated in different parameters of DGS is analysed and discussed.

1 Introduction

Recently, many applications such as microwave or wireless communication systems are widely used bandstop filters. Bandstop filters used to block a band of frequencies which is determined by the upper and lower cutoff frequencies and allows all other frequencies. To understanding the bandstop filter, there are numerous approaches and designs have been determined [1]. The proposed bandstop filter in [2] using a simple layout configuration with high attenuation performances. The size of configuration is reduced by using method of dual band filter [3-4]. In the recent past, the researchers have been utilized several kinds of design and method of dual band bandstop filter [5-7].

Defected Ground Structure (DGS) was popular in bandstop filter to accomplish the S-parameter performances and smaller size [8-9]. DGS has affected the ground plane structures periodic or non-periodic cascaded. The shield current distribution in the ground plane is disturbed cause of the DGS. The disturbance will produce the additional inductance and capacitance to create resonant at some frequency. The DGS in the microstrip line applied in the ground planes and it gives a band rejection feature from the resonant characteristics. Meanwhile, in order to enhance the stop band characteristics, the DGS is recently used. Since it have band-rejection properties.

There are several types of DGS geometries that have been used for filter such as L-shaped, U-shaped, V-shaped, I-shaped hairpin DGS, square, rectangular, circular, square, dumbbell, spiral, hexagonal, cross shaped and interdigital [10-11]. Depending on the DGS shape and dimensions in the ground plane, the disturbed

resulting in a controlled excitation and propagation of the electromagnetic waves through the substrate layer [12]. In this paper, the design of dual band bandstop microstrip filter is developed by placed the slot DGS in the ground plane. A rectangular shaped DGS is varying the dimension of width and length are analyzed and discussed in this paper. The dual band bandstop filter is simulated by using Electromagnetic Wave simulator.

2 Bandstop DGS filter

The configuration of dual band bandstop microstrip filter is illustrated in Figure 1. Figure 1 show the dual-band bandstop microstrip resonator filter without DGS. The ground plane is etched in rectangular pattern. The slot DGS pattern consists of length, l and width, w , as illustrated in Figure 2. Figure 3 shows the dual band bandstop filter with DGS. The configuration is designed by using R04003C printed circuit board with dielectric constant of 3.38 and a thickness of 0.508mm. The specifications of bandstop filter are shown in Table 1.

Table 1. Bandstop filter specifications

Physical Parameter	Specifications
Center Frequency, f_0	2.4 GHz and 5.8 GHz
Insertion loss, S_{21}	≤ -10 dB
Return loss, S_{11}	≥ -1 dB

*Corresponding author: farahshazuani@ymail.com

Based on the orientation or configuration from Figure 1, the layout is combined both resonators in one single transmission line to obtain dual band bandstop filter. In obtaining an easy layout, miniature and compact size, [13] the layout is designed as illustrated in Figure 1.

The slot defected ground structure (DGS) as shown in Figure 2 are added to the design layout in Figure 3. The insertion loss (S_{21}) and return loss (S_{11}) of the bandstop filter are improved the performances by using DGS [14].

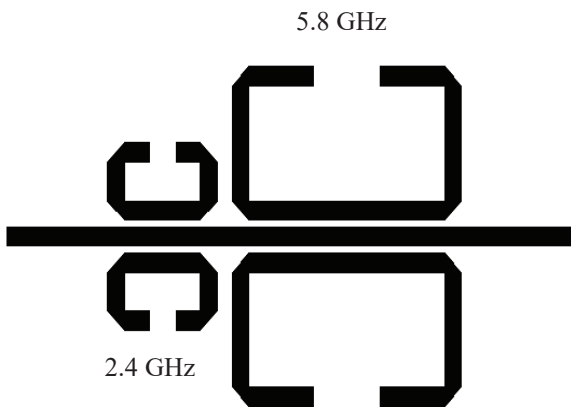


Fig. 1. Dual band bandstop microstrip filter without DGS



Fig. 2. Rectangular shaped DGS pattern

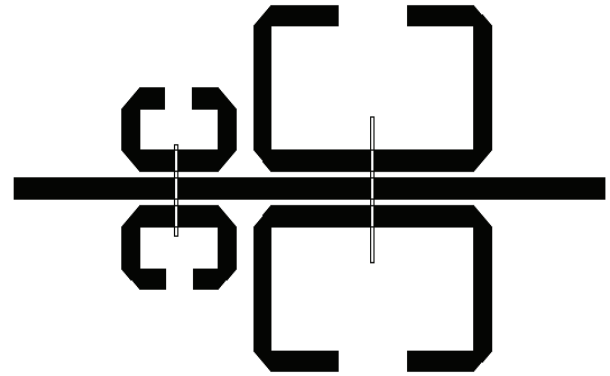


Fig. 3. Dual band bandstop microstrip filter with DGS

3 Results and Discussion

Based on the structure in Figure 1, the simulation result shows in Figure 4. There are two center frequencies of bandstop filter. The first resonant frequency is at 2.40 GHz and the second resonant frequency delivers at 5.80 GHz. The insertion loss, S_{21} in the stop bands are -8.45 dB and -10.42 dB. The return loss, S_{11} shows at -3.23 dB and -3.11 dB on it.

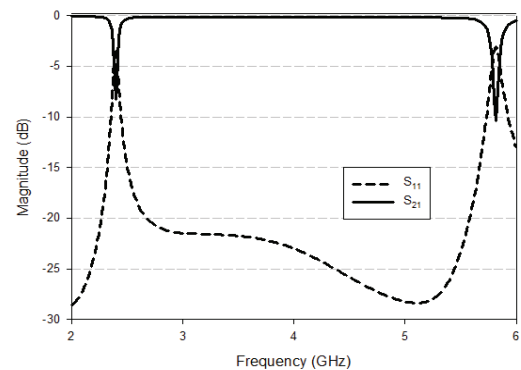


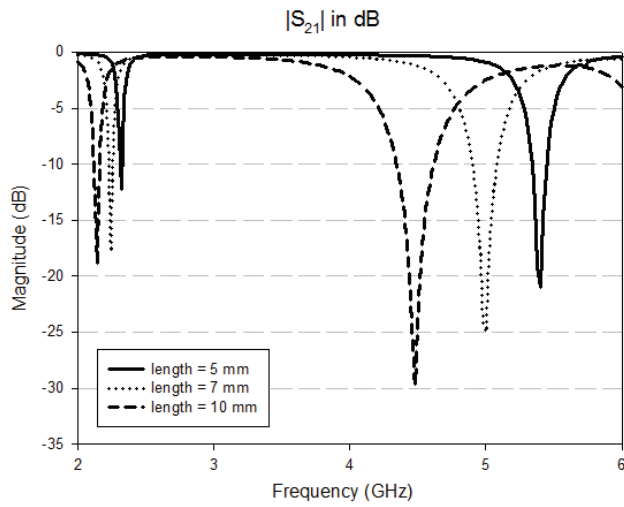
Fig. 4. Simulation result for dual band bandstop microstrip filter without DGS

However, the resonant frequency is affected and varied due to the improper length and width of the slot DGS in the ground structure. The center frequency are shifted when applied the slot DGS in the ground structure.

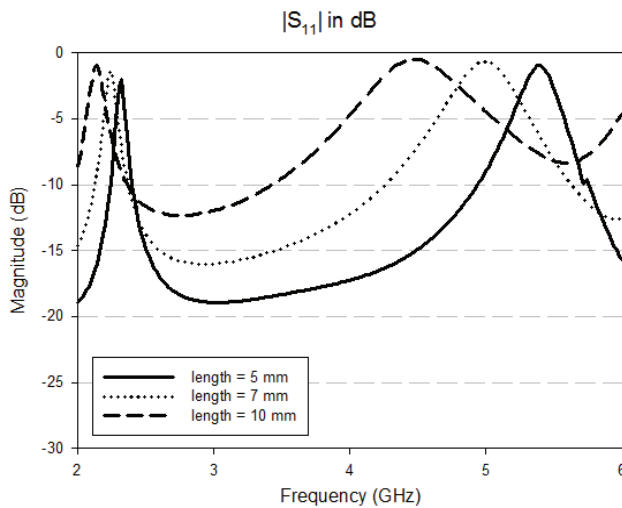
From the studies, the DGS width is found slightly or less impact to the variation of the resonant frequencies. This is due to the lack of tightness of the current density in the DGS width direction [15]. However, the DGS length is significantly and gives a huge impact to the resonant frequencies. Moreover, the DGS length controlled the resonant frequency and the DGS width has little impact on it. Figure 4 and Figure 5 shows the simulation S-parameter results of DGS length and width.

Initially, both DGS widths are set at 0.3 mm for both resonators and the DGS length are varying with

different length that are 5mm, 7mm and 10mm. Referring to Figure 4(a) and (b) shows the simulation result for insertion loss, S_{21} and return loss, S_{11} by using different length of DGS.



(a)



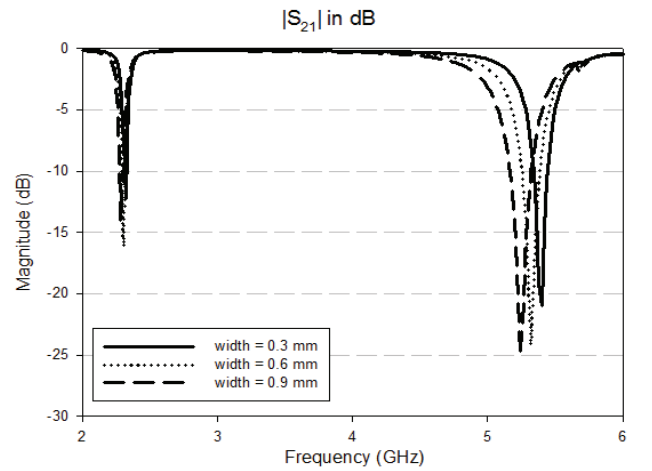
(b)

Fig. 4. DGS with different length (a) Insertion loss, S_{21} (b) Return loss, S_{11}

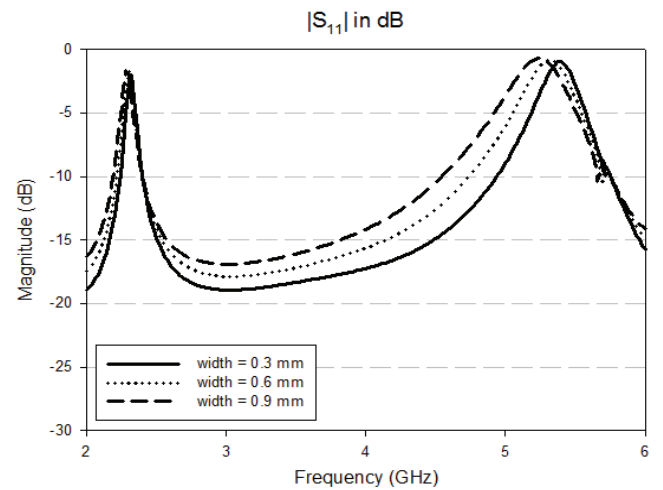
Analysing the simulated results in Figure 4, it is realized that if the length increased the center frequency decreased. Hence, the best DGS length for both resonators are 5 mm since it can deliver the nearest target resonant frequencies which at 2.32 GHz and 5.4 GHz. To improve the S-parameters and resonant frequencies, the proper DGS width is needed to be analysed.

Figure 5 shows the effects of the DGS width on S-parameters and resonant frequencies. The simulated

DGS widths are 0.3 mm, 0.6 mm, 0.9 mm and the DGS length is permanently set at 5 mm.



(a)



(b)

Fig. 5. DGS with different width (a) Insertion loss, S_{21} (b) Return loss, S_{11}

The simulated results are tabulated in the Table 2. As a conclusion, from the simulated results as shown in Figure 4 and 5, the best width and length of the DGS are 0.3 mm and 5 mm. At these DGS dimension values, it delivers 2.32 GHz ($S_{21} = -12.31$ dB) and 5.4 GHz ($S_{21} = -22.93$ dB) that are nearest results to the resonant frequency at 2.4 GHz and 5.8 GHz.

Table 2. Result for varying dimension of length and width of DGS

		Resonance Frequency (GHz)		Insertion loss, S_{21} (dB)		Return loss, S_{11} (dB)	
		$f_1=2.4$	$f_2=5.8$	$f_1=2.4$	$f_2=5.8$	$f_1=2.4$	$f_2=5.8$
Length of DGS (mm)	5	2.32	5.40	-12.31	-22.93	-1.75	-0.78
	7	2.24	5.00	-17.69	-25.00	-1.31	-0.43
	10	2.14	4.48	-19.03	-29.94	-0.77	-0.34
Width of DGS (mm)	0.3	2.32	5.40	-12.31	-22.93	-1.75	-0.78
	0.6	2.30	5.30	-18.19	-23.00	-1.75	-0.69
	0.9	2.28	5.20	-19.12	-24.86	-1.57	-0.60

The comparison results between dual band bandstop microstrip filter with and without DGS are shown as in Figure 6. From the Table 3, it is shown that the resonant frequencies slightly change when the design is added with slot DGS. It changes from 2.4 GHz to 2.32 GHz and 5.8 GHz to 5.4 GHz.

It is due to the etched area in the ground plane that modifies the characteristics of the transmission line. It will produce the effective capacitance and inductance. The path of the ground current will increase when the etched area of DGS increases, hence increasing the inductance. Thus, the capacitance will decrease since the distance between the ground and the signal line has increased.

As the inductance increases, the resonance frequency will decrease to a lower cut-off frequency. With the result that it indicates that the etched area in the ground plane provides an impact on the cut-off frequency, whether it shifts up or down. Therefore, to obtain the target frequencies (at 2.4 GHz and 5.8 GHz) both resonators will be optimized by varying the dimensions of the width and length.

However, the resonant frequency shifts, the S-parameters of insertion loss (S_{21}) and return loss (S_{11}) are improved to high performance. The slot DGS increases the slow wave factor that enhances the coupling between lines. As a result, it is shown that the defected ground structure (DGS) can increase the rejection level of S-parameters performance.

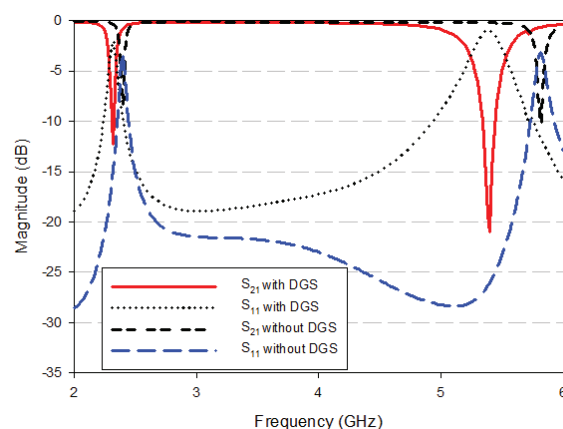


Fig. 6. Comparison between dual band bandstop filter with and without DGS

Table 3. Comparison results between dual band bandstop microstrip filter without and with DGS

	Without DGS	With DGS
Center Frequency	2.4 GHz 5.8 GHz	2.32 GHz 5.4 GHz
Insertion loss, S_{21}	-8.45 dB -10.42 dB	-12.31 dB -22.93 dB
Return loss, S_{11}	-3.23 dB -3.11 dB	-1.75 dB -0.78 dB

4 Conclusions

In this paper, dual band bandstop microstrip filters are designed by applying the rectangular shaped defected ground structure (DGS). The dimensions of width and

length of DGS is analyzed by varying with different parameters. By varying the parameter, it is tuning the resonant frequency and the S-parameters. Moreover, the comparisons between dual band bandstop microstrip filter with and without DGS are shown in this paper.

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