Society for Science and Education United Kingdom
TMLAI Transactions on Machine Learning and Artificial Intelligence
Volume 5 No 4, 2017
ISSN 2054-7390

A Novel Compact CPW Multi-StopBand Filter with DGS Integrating Circular Ring Resonator

Elmahjouby Sghir[1], Ahmed Errkik[1], Jamal Zbitou[1], A.Tajmouati[1], Larbi El Abdellaoui[1],
[1]*LMEET Laboratory FST of Hassan 1st University, Settat, Morocco*
[2]Mohamed Latrach
[2]*Microwave group ESEO, Angers, France*
elmahjouby.sghir@gmail.com

ABSTRACT

A novel and compact multi-band stop filter with good selectivity and wide upper pass band performance with good rejection based on defected ground structure (DGS) integrating a circular ring resonator to suppress undesired spurious bands frequency or harmonics in microwave and millimeter wave circuits is proposed.

The presented filter has a compact size because the circular ring resonator is integrated in DGS, the both of them are etching in the ground plane.

Index Terms— Defected ground structure (DGS), coplanar line, stopband filter, multi-stop stopband.

1 Introduction

The microwave circuits such as filters design is one of many application domain of DGS structure, which should give excellent performance in terms of response as bandwidth, quality factor and the parasite rejection, also the level of integration as the size, the development and integration of other components and their interconnection, [1-2].

The concept of the defected ground structure (DGS) has been derived from the idea of photonic bandgap structure (PBGs).[3-4].

However, the DGS structure is applied to design many microwave circuits type, such as microstrip antenna [5], dividers [6], couplers, amplifiers, oscillators, [7]. and microwave filters. Although, The most reported structures of filters on DGSs are designed for single-band (Pass or Stop) or used DGS for improving applications [8-9-10], or integrating a periodic cells for extend wide stopbands, [11].

Recently, there are some works and papers about dual-band bandstop filter presented DGS technique, [12–13]. Now, the multi stopband filter is one of the important microwave and millimeter components are highly applied in modern microwave systems because of their ability to suppress no desired bands signals and harmonics, [14-15]. For that a coplanar wave guide structure with DGS technique, and DGS integrating circular ring resonator, are a good condidate to build these kinds of filters with compact size and high performance, to answer the demands of modern communication systems.

DOI: 10.14738/tmlai.54.3331
Publication Date: 15th August, 2017
URL: http://dx.doi.org/10.14738/tmlai.54.3331

In this paper, we have developed a new design concept of multi-band stopband filter BSF using circular defected ground structure (DGS) with shaped coplanar line is investigated for compact single stopband filter (SBF) structure with the response of single resonant element in 20 GHz exhibits the stopband function, and the circular DGS integrating a circular ring resonator (CRR) for tri-band stopbands with compact size for practical microwave and millimeter applications operating between 1 GHz to 100 GHz frequency.

2 Single Band of Initial Dgs Stopband Filter Design

A Stopband filter with DGS circular structure is designed, Figure 1 depicts the schematic of the proposed structure. It consists of a **50Ω** conventional coplanar transmission line, with a signal line width of W=108µm and the gap width, G=60µm.The substrate is with dielectric permittivity of er=11.9 and thickness of H=200 µm, [16].

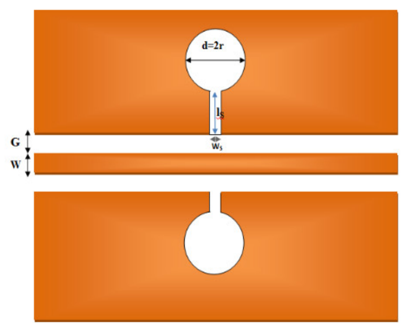

Figure. 1. CPW line with Circular DGS structure

The DGS configuration in this structure is a circular slot etched in the ground plane with a diameter d. This circular DGS is connected to the line gap by a rectangle transverse slot with length of $\mathbf{l_s}$ and width of $\mathbf{w_s}$. The Momentum (an EM solver integrated in ADS Agilent) is used for deriving and studying the filter's electrical performances.

3 Responce of Initial Circular DGS Filter

It is widely known that the DGS circular slot etched plays the role of resonator element and its frequency resonance depend on circular geometry parameters. Figure 2 depicts the response of the CPW DGS Filter.

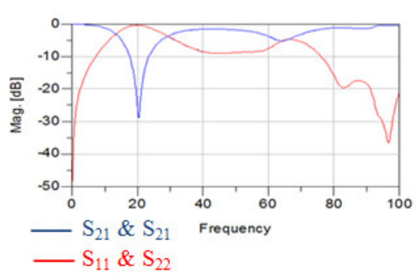

Figure. 2 Simulated S-parameters for the CPW DGS Circular structure

As noted from the S-parameter studies, we have a stop band behavior of the circuit with a good bandstop around 20 GHz.

Moreover, we analyzed the dependence of the rectangle slot on the S-parameters response, the ray of circular etched is kept constant at r = 600µm, also the width of the rectangle slot is fixed at w_s = 60µm.

The length $\mathbf{l_s}$ was optimized for two different value of l_s = 400µm and 500µm. The simulation results obtained with l_s = 500µm are shown in Figure. 3.

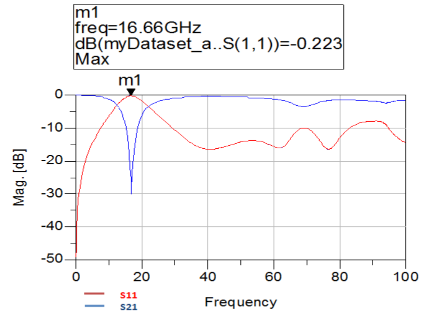

Figure. 3. Simulated S-parameters for the CPW

As a result, there is a significant difference in S-parameter between the initial response structure and this later with the new length ls. We see that the problem is resolved and insertion loss (S21) and return loss (S11) are affecting in the passband, S_{21} is better than −10dB and S_{11} is better than −3 dB in stopband with the new configuration.

4 Modelling of the Circular DGS Stopband Filter

Circular DGS combined with coplanar line causes a resonant response of the structure transmission, and the resonant frequency dependants by circular etched parameters and size of the slot. Its RLC-equivalent circuit of the cell is proposed, and the different parameters can be extracted as follows [17]:

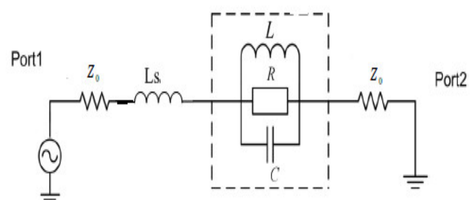

Figure. 4. RLC-equivalent circuit for CPW DGS Filter

$$C = \frac{w_c}{2Z_0(w_0^2 - w_C^2)} \tag{1}$$

$$L = \frac{1}{4(\pi f_0)^2 C} \tag{2}$$

$$R = \frac{2Z_0}{\sqrt{\frac{1}{|S_{11}(w_0)|^2} - (2Z_0\left(w_0 C - \frac{1}{w_0 L}\right))^2 - 1}} \tag{3}$$

Where, Z_0 is the characteristic impedance of the coplanar wave guide line, w_0 is the angular resonance frequency, w_c is the -3dB cutoff angular frequency, and $S_{11}(w)$ is the input reflection coefficient of the equivalent circuit, which can be obtained from EM simulation results.

5 Design of Multi-Band Stopband Filter

Based on the above design and analysis of circular DGS-SBF, tri-bands BSF response was designed on the same first structure.

The initial DGS Stopband Filter design is modified by introducing a circular ring resonator (CRR) with O-configuration to create the tri-bands stopband and to generate the second and third stopband performance, thereby maintaining the compact seize and easy fabrication of structure.

The parameters of the DGS StopBand filter are kept unchanged while dimensions of the circular ring resonator (CRR) are introduced, as shown in Fig. 5.

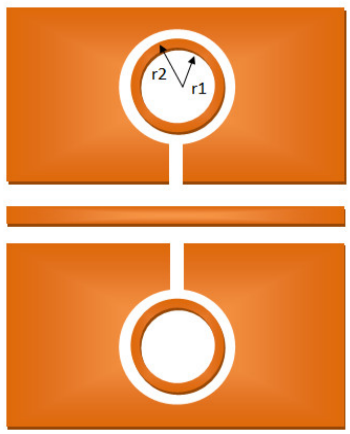

Figure. 5. The proposed device of tri-band stopband filter with O-CRR

The dimensions of the O-configuration of the circular ring resonator (CRR) are as first radium (r_1=409µm), and the second radium (r_2=470µm).

Figure 6 shows the simulated S-parameters of the proposed device of tri-bands stopband filter with O-stub in the circular DGS.

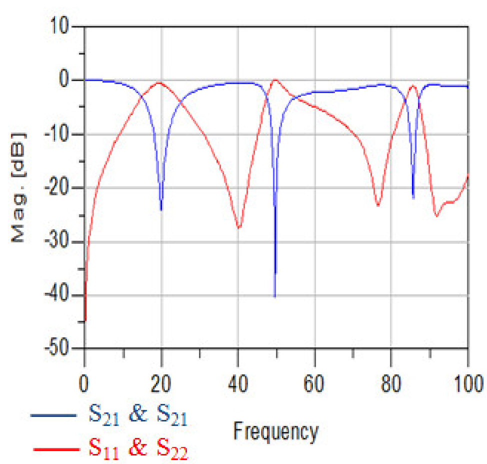

Figure. 6. Simulated S-parameter of the proposed device with O-CRR

As a result, the first stopband resonance is always around of f_{01}=20 GHz, it is approximately centered between 16 GHz and 23 GHz. The three resonance frequencies are measured at f_{01}=20 GHz and f_{02}=50 GHz ($f_{02}=2.5 \times f_{01}$) and f_{03}=86 GHz ($f_{03}=2.5 \times f_{02}$), with respective rejection levels of 25 dB, 40 dB and 22.30 dB.

Similarly, their three return loss S_{11} is better than −3 dB in stopband and offering a drastically improved response performance of stopband filter. So the O-Stub inserted in the DGS of a CPW structure can modify the insertion loss (S21) and return loss (S11) behavior, to get a multiple band stopband after the first one of the circular DGS. Also, the tuning resonance of the second and the third stopband can be achieved by varying the radius of the O-stub in the circular DGS.

6 Conclusion

In this paper a new compact and simple structure using one circular DGS integrating a circular ring resonator with O-configuration have been successfully simulated and applied to the design of compact multi-bands stopband filter in coplanar wave guide technology for many millimeter wave applications, with excellent suppressed, sharp rejection slope and wide stopband rejection. The O-CRR radiuses play a key role in adjusting and tuning the resonance of the second and third stopband center frequency for another different frequencies.

ACKNOWLEDGMENT

We thank Mr. Mhamed Latrach from ESEO Angers in France, for allowing us to use and to perform simulations by using electromagnetic solvers and measurement instruments.

REFERENCES

[1] Jia-Sheng Hong, and Bindu M Karyamapudi, " A General circuit model for defected ground structure in planar transmission lines," IEEE Microwave Wireless Comp. Lett., Vol.10, No.10, pp. 706-708, Oct. 2005.

[2] H A. T. Mendez, H. J. Aguilar, and R.F. Leal, et. al, "Improving frequency response of Microstrip filters using defected ground and defected microstrip structures," Progress in Electromagnetic Research C, Vol.13, pp. 77-90,

[3] 2010.L. H. Weng, Y. C. Guo, X. W. Shi, et al., "An overview on defencted ground structure," Progress in Electromag- netics Research B, Vol. 7, pp. 173-189, 2008.

[4] V. Radisic, Y. Qian, R. Coccioli and T. Itoh, "A novel 2-D photonic bandgap Structure for microstrip lines," IEEE Trans. Microwave and Guided Wave Lett., vol. 8, no. 2, pp. 69–71, Feb. 1998.

[5] J. P. Thakur and P. Jun-Seok, "A new design approach for circular polarize antenna with DGS under the unbalanced feed-lines," 36th European Microwave Conference, pp. 1483-1485, 2006.

[6] J.-J. Koo, S.-M. Oh, M.-S. Hwang, *et al*., "A new DGS unequal power divider," European Microwave Conference, pp. 556-559, 2007.

[7] A.A. Alsanousi, A. Ashoka, W.Jeberson**.** "A Compact Microstrip Low Pass Filter Based on DGS with Shaped Microstrip Line" International Journal of Engineering and Technology Volume 3 No. 6, June, 2013.

[8] Al Sharkawy, M. H., D. Abd El Aziz, and E. Galal, "A miniaturized lowpass/bandpass filter using double arrow head defected ground structure with centered etched ellipse,".

[9] Rehman, S. U., A. F. Sheta, and M. Alkanhal, "Compact bandstop filter using defected ground structure (DGS)," Saudi International Electronics, Communications and Photonics Conference, SIECPC, 2011.

[10] Woo, D.-J., T.-K. Lee, J.-W. Lee, et al, "Novel U-Slot and V-Slot DGSs for bandstop filter with improved Q factor," IEEE Trans. on Microwave Theory and Techniques, Vol. 54, No. 6, 2840–2847, 2006.

[11] Xiao, J.-K., Y.-F. Zhu, and S. F. Jeffrey "DGS lowpass filters extend wide stopbands," Microwaves & RF, Vol. 50, No. 3, 66– 76, 2011.

[12] Jun Wang1, Huansheng Ning1, Qingxu Xiong1, "A novel miniaturized dual-band bandstop filter using dual-plane defected structuree" Progress In Electromagnetics Research, Vol. 134, 397{417, 2013.

[13] Che, W. Q., W. J. Feng, and K. Deng, "Microstrip dualband bandstop filter of defected ground structure and stepped impedance resonators," International Journal of Electronics, Vol. 97, No. 11, 1351–1359, 2010.

[14] Y. Horii and M. Tsutsumi, "Harmonic control by photonic bandgap on microstrip patch antenna," IEEE Microw. Guided Wave Lett., vol. 9, no. 1, pp. 13–15, Jan. 1999.

[15] H. Liu, Z. Li, X. Sun, and J. Mao, "Harmonic suppression with photonic bandgap and defected ground structure for a microstrip patch antenna," IEEE Microw. Compon. Lett., vol. 15, no. 2, pp. 55–56, Feb. 2005.

[16] M. F. Karim, A.-Q. Liu, A. Alphones, X.J. Zhang and A.B. Yu. "CPW band-stop filter using unloaded and loaded EBG structures" IEE Proc.-Microw. Antennas Propag., Vol. 152, No. 6, December 2005.

[17] Ahn,D.,J. S. Park,C. S. Kim,J. Kim,Y. X. Qian,and T. Itoh, "A design of the low-pass filter using the novel microstrip defected ground structure," IEEE Trans. Microw. Theory Tech., Vol. 49, No. 1,86–93,2001. Progress In Electromagnetics Research Letters, Vol. 24, 99–107, 2011