International Symposium on Devices MEMS, Intelligent Systems & Communication (ISDMISC) 2011
Proceedings published by International Journal of Computer Applications® (IJCA)

Bandstop Filtering Characteristics of a New Spiral Defected Microstrip Structure (DMS)

Susanta Kumar Parui
Department of Electronics and Telecommunication Engineering
Bengal Engineering and Science University, Shibpur,
Howrah, India,

Somdotta Roy Choudhury
Department of Electronics and Telecommunication Engineering
Bengal Engineering and Science University, Shibpur,
Howrah, India,

A. Roy, L. Murmu, Santanu Das
Department of Electronics and Telecommunication Engineering
Bengal Engineering and Science University, Shibpur,
Howrah, India,

ABSTRACT

The defected structure in the signal plane of a microstrip line effectively disturbs the shield current distribution and added line inductances and capacitances to the line. These new brand of slow-wave structures are called defected microstrip structure (DMS). We have introduced here a new spiral shaped structure with improved filtering characteristics. The frequency characteristics of the proposed unit show one pole stopband response. The equivalent L C parameters are extracted using proposed equivalent LC model. Two such DMS units are cascaded onto High-Low impedance line to realize a bandstop filter having 20 dB rejection bandwidth of 34% and sharpness factor of 50 dB/GHz at both edges.

General Terms

Glassiproxy substrate, IE3D MoM simulated software.

Keywords

Defected structure, Slowwave structures, DMS, High-Low impedance line, Bandstop filter, spiral-shaped.

1. INTRODUCTION

The microstrip line acts as a good transmission line. The performance of the microstrip line can be improved if we etch geometry on signal plane and such structures are known as Defected Microstrip Structure (DMS). The slowwave factor of a DMS microstrip line is raised as discontinuities is introduced in the path of EM waves, which increases the impedance of line. This phenomenon can be used to reduce the size of passive planar circuits like microstrip line length, coupling lines, and microstrip antennas. Its improved filtering characteristics can help to meet the emerging application challenges.

There are many works specifying or diverse types of discontinuities applied in microstrip lines including electromagnetic band gap structures (EBG) and defected ground structures (DGS). A defect etched in the metallic ground plane of a microstrip line yields rejection band and slow-wave characteristics due to perturbation of the shield current distribution. Dumb-bell shaped DGS is explored first time by D. Ahn and applied to design a lowpass filter [1,2]. Unit cell was described as a one-pole Butterworth filter, where the capacitances come from the gap and the inductances from the loop only. It is well known that a filter with attenuation poles and attenuation zeros at finite frequencies shows higher selectivity compared to all pole filter. Such DGSs with quasi-elliptical response was proposed in recent time [3-4]. The radiation from the ground plane is the major constrain to design a DGS based circuit. But DMS provides same slowwave characteristics, keeping ground plane intact [5-7].

2. FREQUENCY CHARACTERISTICS

Fig. 1(a) shows the schematic diagram of the DMS unit consists of spiral shaped slot etched off over the microstrip line. The substrate with a dielectric constant of 4.4 and thickness of 1.57 mm is considered for the microstrip line. The width (w) of the microstrip line is obtained as 3 mm corresponding to 50 Ohm characteristics impedance. The different dimensions of spiral shaped DMS have been taken as a = 4.75 mm, b = 2 mm, c = 3 mm, d= 2.5 mm and e = 2 mm. The slots have width of 0.5 mm and 50 Ohm line have width of 3 mm. The cut out size of DMS unit is 4.75 X 2.5 mm.

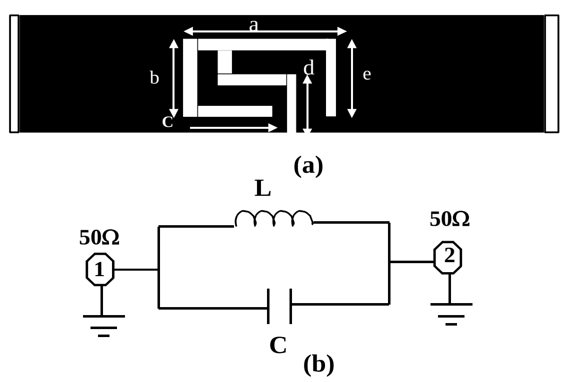
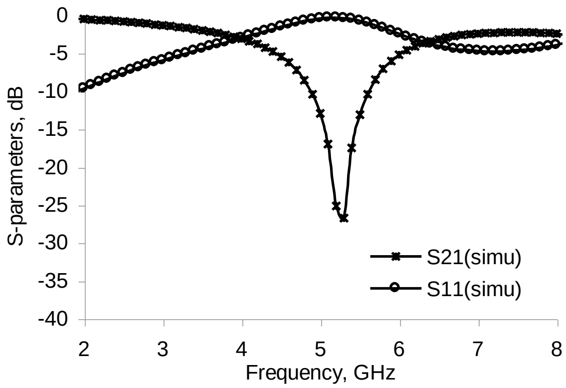
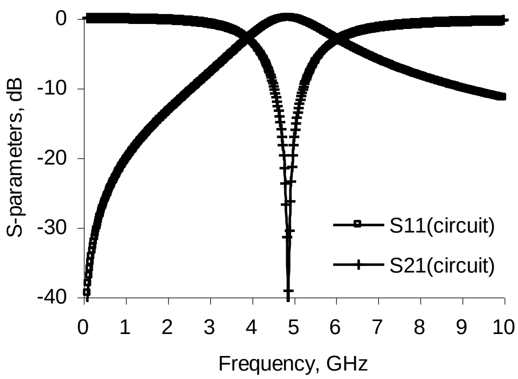


Figure 1 (a) Schematic diagram of spiral shaped DMS (b) Equivalent LC circuit

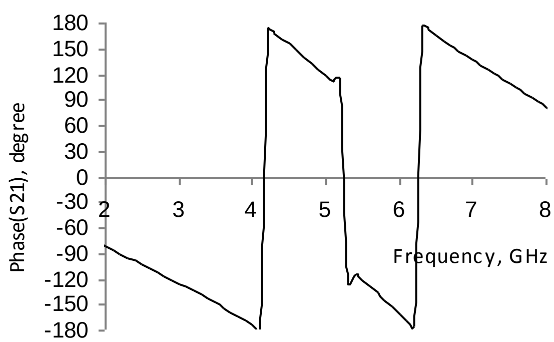
From the MoM based IE3D simulated S-parameters as shown in Fig. 2(a) and 2(b), it is observed that the investigated DMS unit provides a stopband with 3dB cutoff frequency at 4 GHz and center frequency at 5.3 GHz with stopband attenuation of 26.8 dB.



(a)



(b)



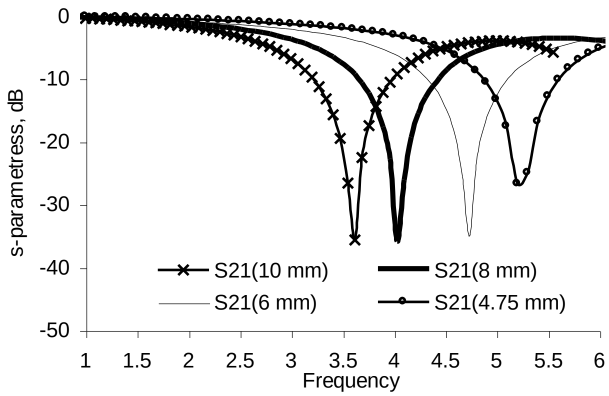
(c)

Figure 2 (a) s-parameters from EM-simulation (b) s-parameters from circuit model (c) Phase characteristics

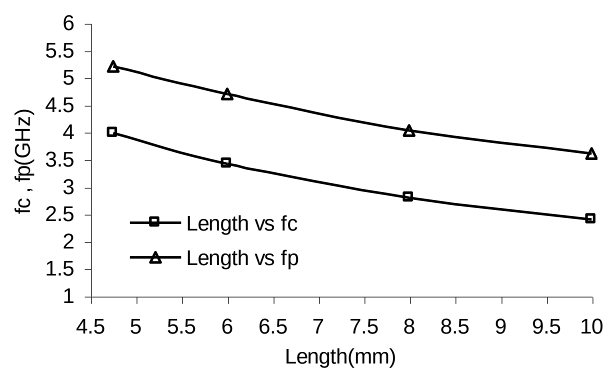
It observed that this DMS produces one pole bandstop filter response and thus, it may be described by a LC parallel resonant circuit. For the given dimension the extracted L=1.4 nH and C=0.758 pF as shown in Fig. 1(b). The simulated s-parameters from circuit model are plotted in Fig. 2(c).

3. FREQUENCY VARIATION WITH OVERALL DMS LENGTH

The cut off and pole frequencies of the proposed structure may be varied by simply changing its overall length, (l= e+a+b+c). The Fig. 3(a) shows that if the length of the proposed DMS increases its cut-off and pole frequencies decrease. So, a DMS structure can be designed in any frequency by simply adjusting its length, as illustrated in Fig 3(b).



(a)



(b)

Figure 3 (a) Plot of cut off / pole frequency with effective length of DMS. (b) Relation between the length and frequency

4. TWO-CELL DMS FILTER

Fig. 4(a) shows the schematic diagram of a DMS filter consists of two spiral slots cascaded onto a High-Low impedance line. The same FR-4 substrate and same dimension of earlier DMS is used. From the simulated S-parameters as shown in Fig. 4(c), it is observed that the investigated filter shows two pole bandstop response having cutoff frequency at 3.9 GHz and poles at 4.8 GHz and 5.8 GHz respectively. The 20 dB bandwidth is obtained as 1.8 GHz and center frequency at 5.3 GHz.

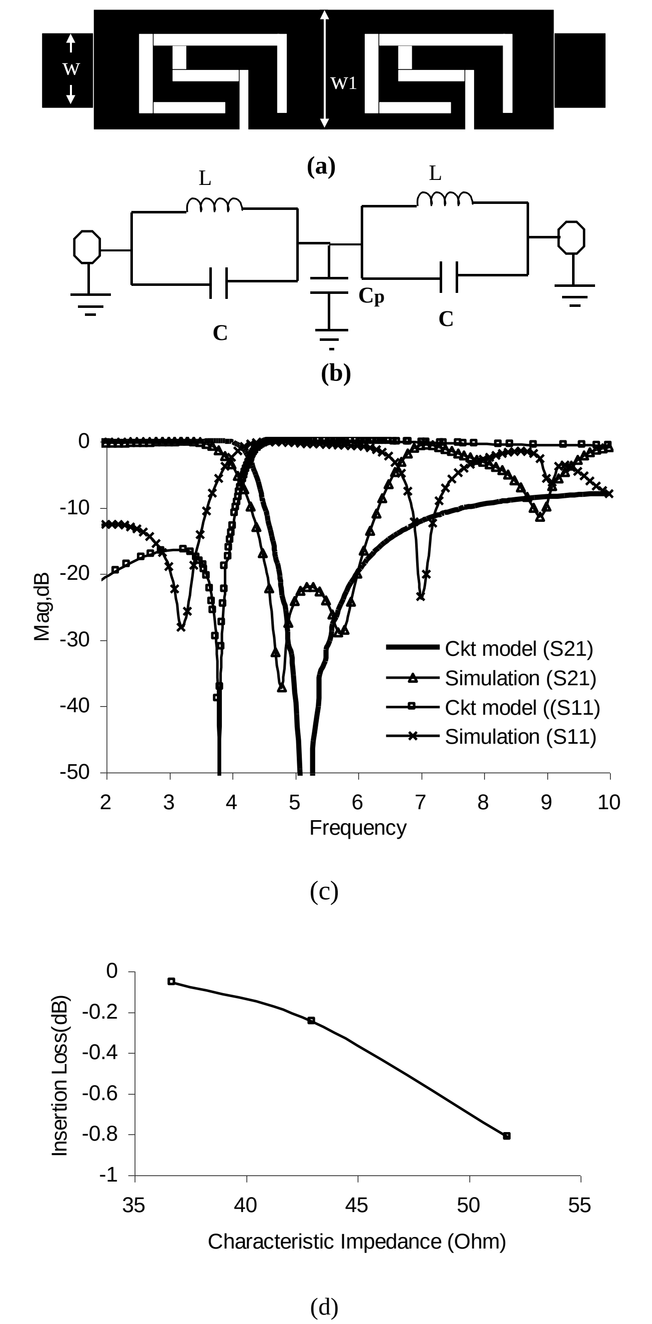


Figure 4 (a) Schematic diagram of 2 cell DMS underneath a HI-LO line (b) Equivalent circuit (c) s-parameters from EM simulation and circuit simulation (d) Insertion Loss vs. Characteristic impedance plot

The simulated s-parameters from circuit model as described in Fig. 4(b) is compared with EM-simulated results and good agreement is obtained as shown in Fig. 4(c). The passband insertion loss is reduced, when the impedance of the low impedance line decreases (i.e. increasing w_1). For w_1 = 4 mm, passband insertion loss is obtained as 0.4 dB. The fractional bandwidth of 34% and sharpness factor of 50 dB/GHz is observed as shown in Fig. 4(c). The insertion loss can furthue be reduced by increasing the width of the high-low line. The variation of insertion loss with changing line impedance is shown in the Fig 4(d). Thus, by reducing the impedance of the low-Impedance line, the insertion loss may be adjusted and bring down to nearly 0 dB.

5. CONCLUSION

The investigated spiral DMS structure exhibits one-pole bandstop response. It is modeled by LC parallel resonant circuit. The two such DMS units are cascaded under a high-low line to realize a bandstop filter. It offers high sharpness factor, low passband insertion loss, and wide bandwidth. The insertion loss in the passband of the filter is adjusted by width of the low-Impedance line. Such DMS based filters may be found suitable in different RF and microwave applications, as they need very less real estate.

6. ACKNOWLEDGMENTS

This work was funded by Council of Scientific and Industrial research (CSIR), India.

7. REFERENCES

[1] C.S.Kim, J.S.Park, D.Ahn and J.B. Lim, “A novel one dimensional periodc defected ground structure for planar circuits,” IEEE Microwave and Guided wave Letters, vol. 10, No. 4, pp.131-133, 2000

[2] D. Ahn, J.S.Park, C.S.Kim, J.Kim, Y Qian and T. Itoh, “A design of the lowpass filter using the novel microstrip defected ground structure,” IEEE Trans. on Microwave Theory and Techniques, vol. 49, no. 1, pp. 86-93, 2001

[3] Chen J.-X., Li J.-L., Wan K.-C. and Xue Q., “Compact quasi-elliptic function filter based on defected ground structure,” IEE Proc.-Microwave Antennas propagation, vol . 153, no. 4, pp. 320-324, Aug. 2006

[4] Susanta Kumar Parui, Santanu Das ‘An asymmetric defected ground structure with elliptical response and its application as a lowpass filter’ Int. J. Electron. Commun. (AEÜ) vol. 63, pp. 483 – 490, 2009

[5] A. Tirado-Mendez, H. Jardon-Aguilar, and R. Flores-Leal “Improving frequency response of microstrip filters using defected ground and defected microstrip structures” Progress In Electromagnetics Research C, Vol. 13, 77 - 90, 2010

[6] M. Kazerooni, N. P. Gandji, A. Cheldavi, and M. Kamarei, “A New Microwave Bandstop Filter Using Defected Microstrip Structure (DMS)”, Progress In Electromagnetics Research Symposium Proceedings, Moscow, Russia, August 18- 21, 2009

[7] M. Kazerooni, G. Rezai Rad, and A. Cheldavi "Behavior Study of Simultaneously Defected Microstrip and Ground Structure (DMGS) in planar circuits ", Progress In Electro-magnetics Research Symposium, Beijing, China, March 23-27, 2009