



Photonic band gap structure for improve the Performance of Band stop filters

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ABSTRACT

In this paper we have designed two new compact Photonic Band Gap Structures, shows the properties of Band stop filters. Photonic Band gap filters are designed on central frequencies 1.7GHz and 2.2GHz. These Photonic filters are stable and observable. Also used photonic band gap structure on the filter surfaces, have been provided information about the increasing bandwidth up to 30% of band stop filters. To use of the PBG filters, the broad stop band has been obtained, slow wave factor increased, com-pensate for fabrication of tolerance has been improved and the unit elements of the band stop filter with open-circuited stub has been redundant and more compact configuration obtained.

Keywords: *PBG (Photonic Band Gap), Band Stop Filter (BSF), Printed Circuit Board (PCB), Defected Ground Structure (DGS), Computer Simulation Technology Software (CST) and Spectrum Analyzer.*

1 INTRODUCTION

The photonic band-gap (PBG) [Yu chen et al., 2008] structures are effective in microwave applications that provide an effective control of electromagnetic (EM) waves along specific direction and performance. Photonic band gap structures for microstrip line have been topic of research in recent year. The term PBG is introduced as a structure which influence or even changes the electromagnetic properties of materials. The periodic structure created in materials such as substrate or metals [yang et al. 1999]. The PBG structure provides a certain frequency bands which cannot propagate. PBG structures are most widely used in various applications like microwave filters, antenna and other devices. The different structures LPF, BSF, power divider, power amplifier etc. may be implemented [Oraizi et al.2008]. In addition to DGS (defected ground plane) and EBG (electromagnetic band gap) structure, PBG have been created by etching different shapes in ground plane, which increase the inductance and capacitance values of microstrip line. The above technique used for eliminate undesired output

response and sharp stop band for LPF [Shao, 2005; Atallah ali, 2007].

Dr. D’Orazio [1998] has been fabricated the PBG filter for wavelength division multiplexing (WDM) [1] & Villar [1999] has been analyzed the PBG structure with a liquid crystal defect for the purpose of fiber optic filters [M. S. Esfahlan, 2008].

The basic phenomena behind the proposed photonic band gap filter are forbidden gap in materials by electrons movement [Lancaste, book]. Recently a Photonic band gap structure consisting of small metal pads with grounding via which used to improve the performance of a patch antenna [Y. D. Chen, 2008; Yongxi Qian,1999]. The most important function of PBG structures is the filtering of frequency bands, and harmonics of the filter in microwave circuit.

2 BAND STOP FILTER DESIGN

Design-a narrow-band Band stop filter with L-resonators. Five order microstrip band stop filter in Chebyshev prototype having pass band ripple of 0.1 db. The desired band-edge frequencies to equal-ripple points are $f_1 = 4.5$ GHz and $f_2 = 5.5$ GHz.

Choosing $Z_0 = 50$ ohm, $g_0=1.1468$, $g_2=1.3712$, $g_3=1.9750$, $g_4=1.3712$, $g_5=1.1468$, $g_6=1$. Length of L-resonators $l_h = 8.9$ mm and $l_v = 8.9$ mm half guided wavelength Spacing of main line and resonators $s_1=s_5=0.292$ mm, $s_2=0.292$ mm, $s_3=0.292$ mm & $s_4=.292$ mm.

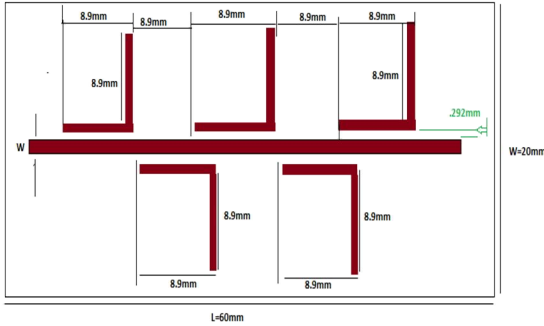


Fig. 1. (a) L-resonator narrowband Band stop filter

Design- an optimum microstrip band stop filter with three open-circuited stubs and $FBW = 1.0$ at a mid-band frequency $f_0 = 2.5$ GHz. Now assuming a pass band return loss of -20 dB, which corresponds to a ripple constant $\epsilon = 0.1005$ and Choosing $Z_0 = 50$ ohm. The optimum band stop filter is synthesized using optimum transfer function Chebyshev functions of first kinds order n

$$T_n(x) = \cos(n \cos^{-1} x)$$

Chebyshev functions of second kinds order n

$$U_n(x) = \sin(n \cos^{-1} x)$$

And calculation of parameters made by given equations:

$$Z_a = Z_b = Z_0$$

$$Z_i = Z_0 / g_i$$

$$Z_{i,t+1} = Z_0 / J_{i,t+1}$$

$$t = j \tan \left(\frac{\pi f}{2 f_0} \right)$$

Table 1: Parameters Calculation for Filter Design

Impedance (ohm)	Width(mm)	Length(mm)
$Z_a=Z_b=50$	1.85	5.475
$Z_1=Z_3=52.74$	1.7	14.32
$Z_2=29.88$	4.25	13.73
$Z_{12}=Z_{23}=93.97$.528	14.89

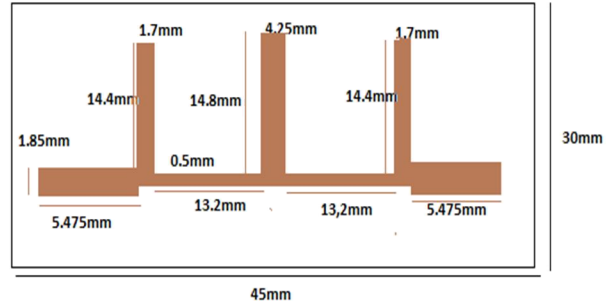


Fig. 2. (a) Layout of L-resonator band stop filter

The microstrip filters have been designed on a substrate which has thickness of 1.6 mm and a dielectric constant of 4.4. The open-end and T-junction effects should also be taken into account for determining the final filter dimensions. The optimum design demonstrates substantially improved performance with a steeper stop band response.

Design- Fig 3(a) have been designed for improve the response of L-resonator band stop filter. It designed for a three order microstrip Band stop filter in Chebyshev prototype with Passband ripple of 0.05 db. The desired band-edge frequencies to equal ripple points are $f_1 = 1.25$ GHz and $f_2 = 3.75$ GHz and $Z_0 = 50$ ohm.

Equations for designing Band stop filter with open circuit stub are Calculation for cutoff frequency:

$$f_0 = \frac{f_1 + f_2}{2}$$

Calculation for Fractional Band Width

$$FBW = \frac{f_2 - f_1}{f_0}$$

g-values of the prototype filter

$$g_0 = g_4 = 1.0, g_1 = g_3 = 0.8794$$

$$g_2 = 1.1132, z_a = z_b = 50$$

Calculation for impedences

$$Z_1 = Z_a \left(1 + \frac{1}{\alpha g_0 g_1} \right)$$

$$Z_2 = \frac{Z_a g_0}{\alpha g_2}$$

$$Z_3 = \frac{Z_a g_0}{g_4} \left(1 + \frac{1}{\alpha g_3 g_4} \right)$$

$$Z_{12} = Z_a (1 + \alpha g_0 g_1)$$

$$Z_{23} = \frac{Z_a g_0}{g_4} (1 + \alpha g_3 g_4)$$

$$\alpha = \cot \left[\frac{\pi}{2} \left(1 - \frac{FBW}{2} \right) \right]$$

Table 2: Parameters Calculation for Filter Design

Impedance(ohm)	Width(mm)	Length(mm)
$Z_a=Z_b=50$	1.85	5.475
$Z_1=Z_3=106.85$	0.3	15.15
$Z_2=44.92$	2.3	14.85
$Z_{12}=Z_{23}=93.97$.45	14.05

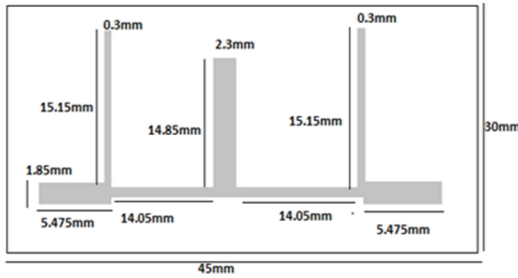


Fig. 3. (a) Open circuit Microstrip Band Stop Filter

2 DESIGN OF PBG STRUCTURE

PBG structures have been designed for unaltered the frequencies band for particular response of the filters. It has been designed back surface of the PCBs. Few photonic band gap (PBG) structures have been demonstrated on FR-4 substrate Pcb's with thickness of 1.6mm and ϵ_r is 4.4 and $\mu-1$.

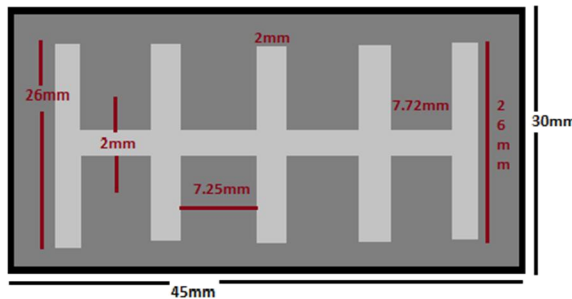


Fig. 4. (a) E- Shapes Photonic Band Gap Structure

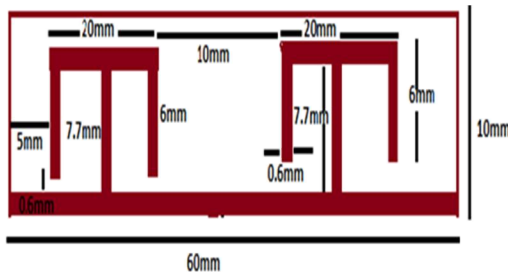


Fig. 5. (a) T Shape Photonic Band Gap Structure

3 SIMULATED RESULT

The simulated results of band stops filters with and without PBG structure are shown in Fig 1(b), 2(b), 3(b). Fig 1(b) at central frequency 5GHz provide very small band gap 0.7GHz, which is approximate 14% of central frequency.

To improve the performance of L-resonator filter we used optimum band stop filter for wide stop band. Optimum filter response provide wide band gap 1.69GHz at central frequency 3GHz. The band gap is 56.33% of central frequency as shown in Fig 2(b).

To reduced the side band fluctuation we designed open circuit band stop filter. Open circuit filters have very simple calculation for designing, the central frequency is 3.05GHz and band gap 1.815GHz which exactly 59.50% of central frequency shown Fig 3(b).

Now Fig 4(b) shows the response of photonic band gap filter provide two band gaps at central frequencies 2.2GHz & 4.8GHz. and Fig 5(b) shows another photonic band gap result at 1.7GHz and provide wide band gap 1.5GHz. these photonic band gap filters are simpler than the open circuit band stop filter and easily designed.

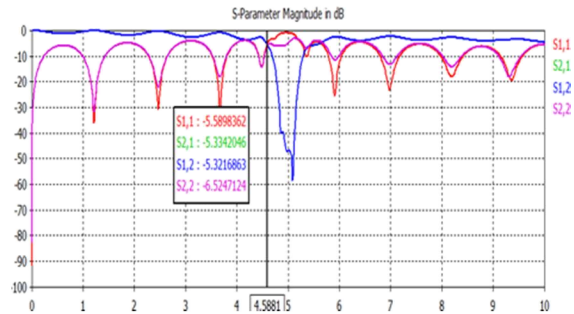


Fig. 1. (b) response of L-resonator band stop filter

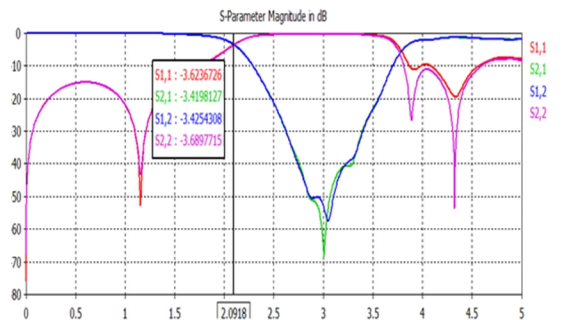


Fig. 2. (b) response of optimum band stop filter

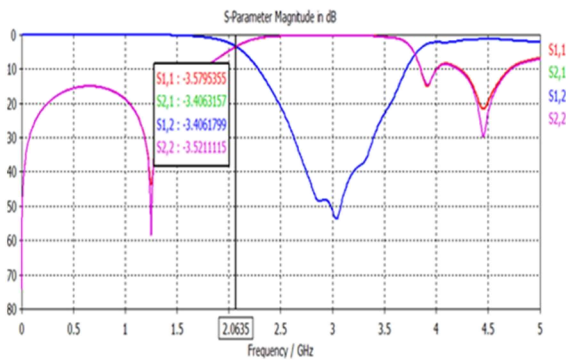


Fig. 3. (b) response of open circuited band stop filter

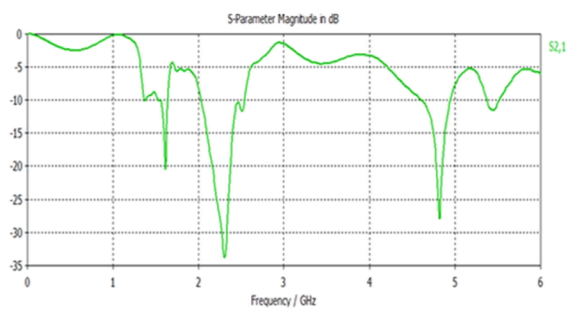


Fig. 4. (b) response of photonic band gap filter

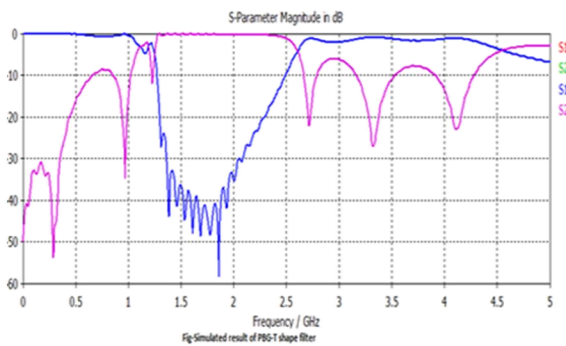


Fig. 5. (b) response of photonic band gap filter

Fig 6 shows the input output ports signals for each photonic band gap filters.

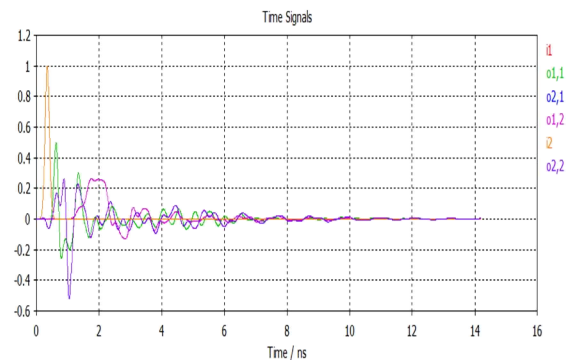


Fig. 6. I/O ports signals

Now smith charts for these PBG filter shown in fig 6(a) and Fig 6(b) for return loss nad insertion loss, provide the great stability for the filters. At 5GHz the total impedance is (14.8, 1.07)ohm and (19.8, 68.6)ohm.

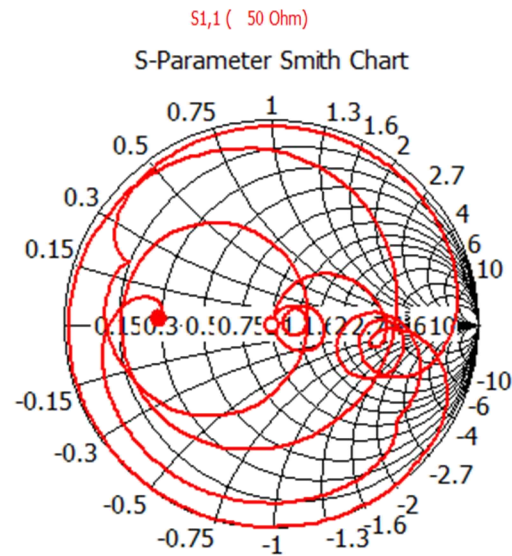


Fig. 6. (a) Smith chart for the proposed PBG Filter

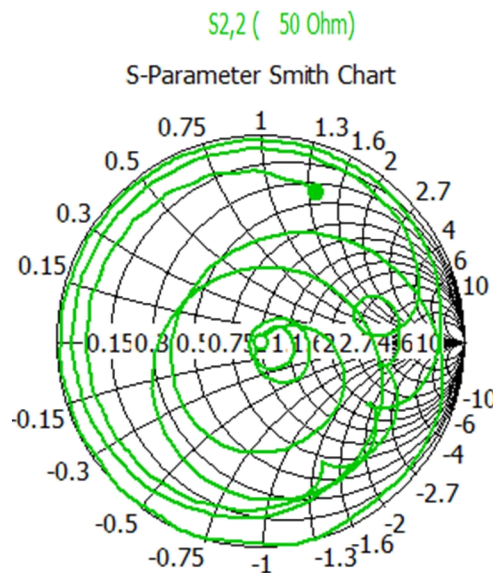


Fig. 6. (f) Smith chart for the proposed PBG Filter

4 CONCLUSION

Conclusion are made by the various responses obtained in fig 1(b) for L-resonator, fig 2(b) for optimum band stop filter& fig 3(b) for open circuit band stop filter& fig 3(b) for open circuit band stop filter and various PBG structure response shown in fig4(b) and fig5(b) which have been designed for different cut off frequencies. These novel PBG structures have wide stop band and

compact size, which can be easily incorporated into the ground planes of Pcb's or any other planer structures. The PBGs structures designing are very simpler than the design of band stop filters.

Results are simulated using computer simulation technology software (CST). The undesired sidebands and fluctuations of response are reduced by using PBG and improvement in bandwidth is achieved in case of band stop filter (BSF). This PBG structures should find wide applications for high-performance in microwave circuits.

5 REFERENCES

- [1] Cheng-Hung Lin, Guan-Yu Chen, Jwo-Shiun Sun, Kwong-Kau Tiong¹, and Y. D. Chen "The PBG Filter Design" PIERS Proceedings, Hangzhou, China, March 24-28, 2008
- [2] J.-K.Xiao and Y.-F. Zhu "New U-Shaped DGS Bandstop Filters" progress in Electromagnetics Research C, vol.25, 179-191, 2012
- [3] Fei-Ran Yang, Kuang-Ping Ma, Yongxi Qian "A Unipolar Compact Photonic Bandgap Structure And Its Applications For Microwave Circuits" IEEE Transactions on microwave theory and techniques, vol 47, no. 8, august 1999.
- [4] H. Oraizi and m. S. Esfahlan "Miniaturization of Wilkinson Power Dividers by Using Defected Ground Structures" progress in Electromagnetics Research Letters, vol.4, 113-120, 2008.
- [5] Shao Ying Huang, Yee Hui Lee "Compact U-Shaped Dual Planar EBG Microstrip Low-Pass Filter" IEEE Transactions on Microwave Theory and Techniques VOL.53, No.12, Dec-2005.
- [6] Atallah Balalem, Ali, Jan Machac " Quasi-Elliptic Microstrip Low-Pass Filters Using an Interdigital DGS"IEEE Microwave and Wireless Components letters 1531-1309 2007.
- [7] Jia-Sheng Hong, M. J. Lancaster "Microstrip filters for RF / Microwave Application" A Wiley-Interscience Publivation book.
- [8] Lakhan Singh and P. K. Singhal "Design And Comparision Of Band Pass Trisection Microstrip Filter" International Journal of Engineering Research & Technology (IJERT),Vol. 2 Issue 2, February- 2013, ISSN: 2278-0181.
- [9] CST (computer Simulation Technology) software microwave studio 2010.