ISSN : 2348-9065 (Online)
ISSN : 2349-3143 (Print)
Vol. 1 Issue 1 Jan-March 2014
International Journal of Research in Electronics and Communication Technology (IJRECT 2014)

Performance of Photonic Filter and Its Applications for Microwave Circuits

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Abstract

In this paper we presented a newly photonic band gap (PBG) structures for microwave applications. This new type PBG structure is a two dimensional square lattice with each element consisting of a metal pad and four connecting branches. Experimental evidence is provided of the implementation of filter with wide band gap at higher cut off frequency (7 GHz) for six cell lattice pbg structure and insertion loss S12 is -80.9dB. a new compact E-type PBG structure provided wide band gap at cut off frequency (3GHz)& transmission coefficient S12 -52dB that shows excellent agreement with results predicted by the theory. This paper represents the design and simulation of wideband bandstop photonic filter using microstrip which is designed to have a center frequency of 1.5,3 & 7GHz. The filters are designed on a FR-4 substrate having dielectric constant ε_r=4.4 and thickness h=1.6mm. The design and simulation are performed using computer simulation technology software.

Keywords

E-cell lattice structure, Photonic Band Gap structure (PBGS), square lattice cell, Computer Simulation Technology Software (CST), Printed Circuit Board (PCB), and Spectrum Analyzer.

I. Introduction

Defected ground structure for microstrip line was most common topic for research at recent year. They are giving a lot of different structure for implementing DGS [1]. By using these different structures LPF [2], BSF [3], power divider [4], power amplifier etc. is implemented. In addition to EBG (electromagnetic band gap) structure, DGS and PBG structure was created by etching different shapes in ground plane. Which increase the inductance and capacitance values of microstrip line, so undesired output response fluctuations will be eliminated and the output is sharp stop band in case of LPF [5] and increased bandwidth in case of BSF [6]. PBGS has property of rejecting electromagnetic wave in certain frequency and direction, and most important function of these structures is the filtering of frequency bands. Few newly designed PBG structures are presented in this paper for microwave applications.

II. Design Of Photonic Band Gap Structure

The two dimensional square lattice PBG structure with 46mm×30 mm is shown in the figure 1. FR-4 lossy material with dielectric constant εr=4.4, substrate height h=1.6mm and loss tangent 0.02 used for the PBG design. The result shows a wide rejection band in case of square lattice cell.And another new E-type compact photonic band gap structureof dimension 120mm × 30mmis employing in figure-2.Four cell PBG structure exhibits band rejection characteristics at center frequency 3GHz.

Cut off frequency can be calculated by:

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

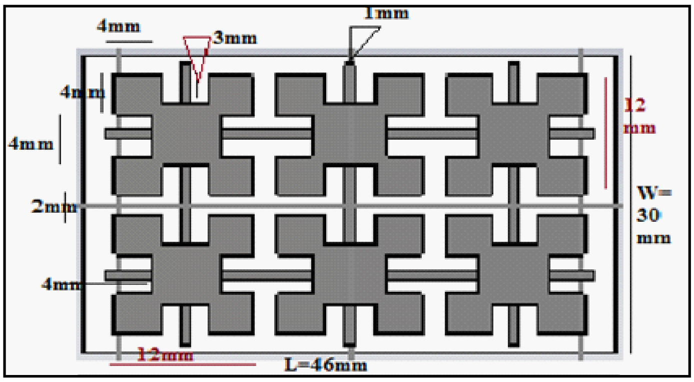

Fig. 1: Layout of six square lattice cell PBG Filter

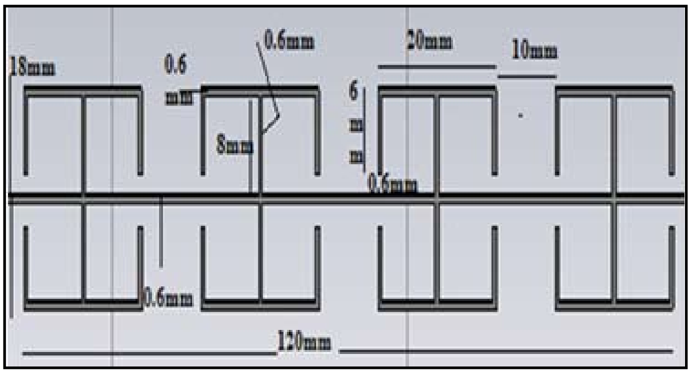

Fig. 2: Layout of Eight E-cell PBG Filter

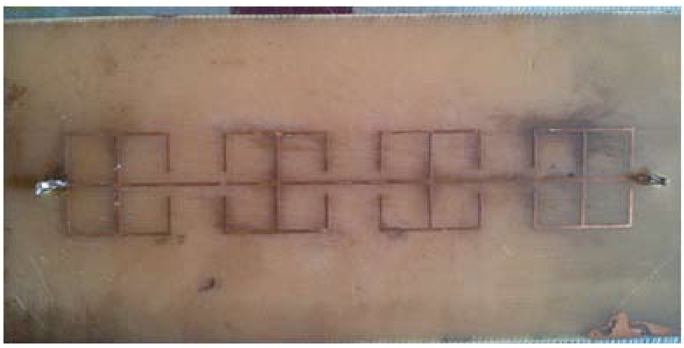

Fig. : 3fabricatedstructure of eight E-cell type PBG filter on PCB

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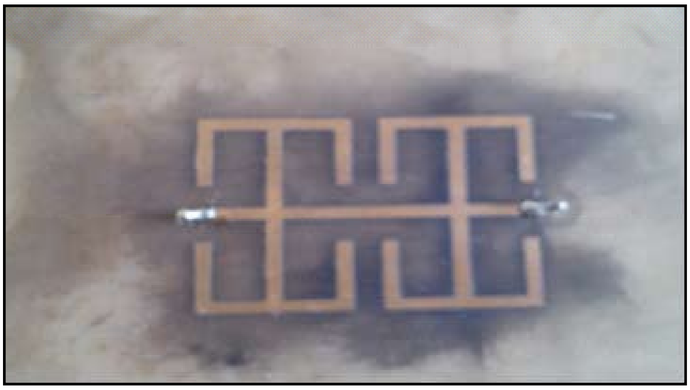

Fig. 4 : Fabricated structure of four E-cell type PBG filter on PCB.

III. Result

Result between S-parameters in dB and frequency in GHz,are analyzed on CST and measured on function analyzer. Figure-5 shows that the center frequency for six cell PBG filter is f_c=7 GHz and band gap frequencies are f_1=5 GHz & f_2=9.5 GHz and the observed bandwidth 4.5 GHz which is nearly 64.28% of center frequency.

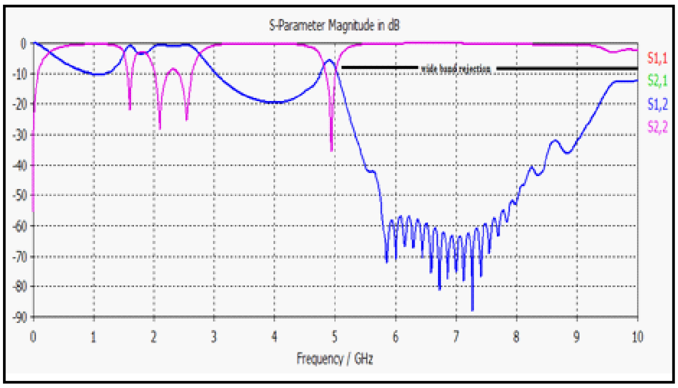

Fig. 5: Response of six cell two dimensional lattice PBG filter

For four cell E-type PBG filter response shows center frequency f_c=3 GHz at S_{12} -52 dB and corner frequencies f_1=1 GHz & f_2=2 GHz from figure-6. The obtaining bandwidth is 1 GHz, which is nearly 35% of center frequency.

Whennumber of cell increased figure-3than we obtained wide band gap at center frequency 1.5GHz from figure-7 and transmission coefficient S_{21}-60dB. The obtaining bandwidth is 1.6GHz which is approximately 106.667% of center frequency.

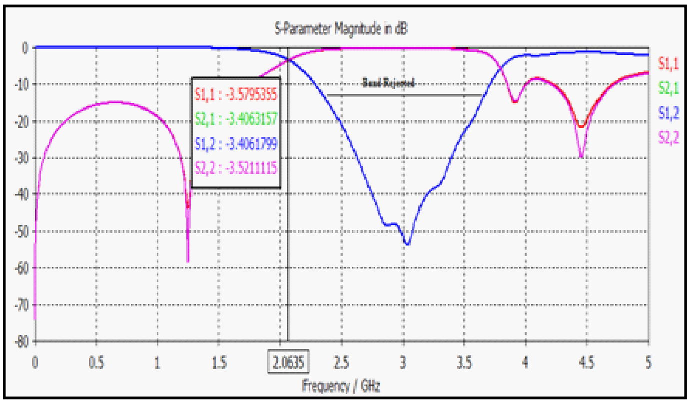

Fig. 6: Response of four cell E-Type PBG filter

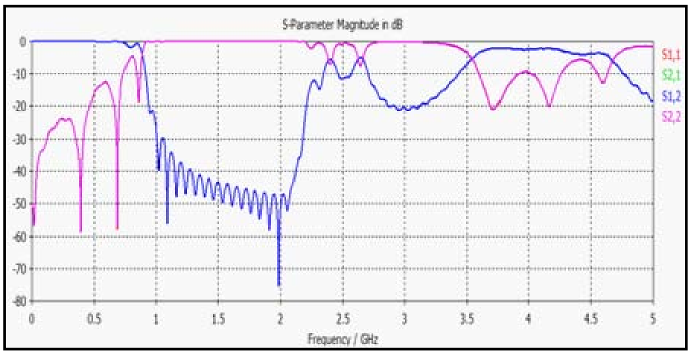

Fig.7: Response of Eight cells E-type microstrip cell PBG structure

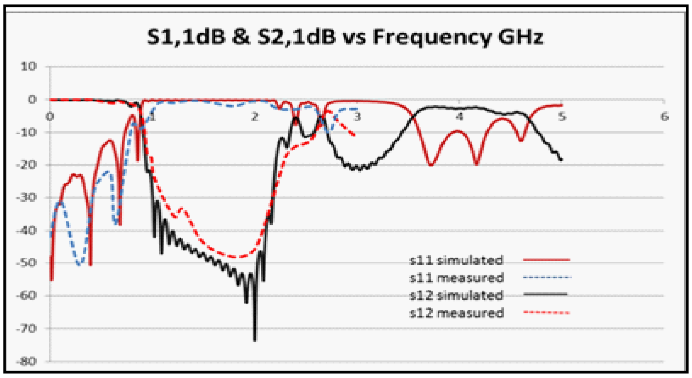

Fig. 8: Comparison b/w simulated and measured result for eight E-cell type PBG filter

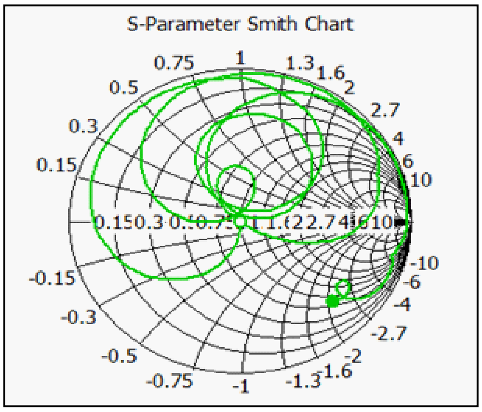

Fig. 9: Smith chart for six cell two dimensional PBG filter

In Fig. 6: showssmith chart for six cell PBG filter, represent the stability of filter at the 10 frequency/GHz (45,-106) Ω.

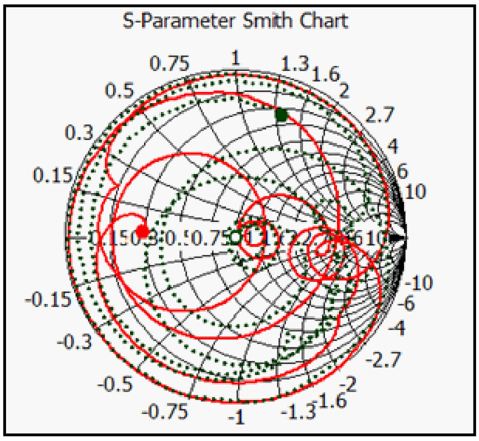

Fig.10 :Smith chart for Eight E-type microstrip cell PBG

structure

Smith chart for Eight E-type cell PBG filter figure-10, represent the stability of filter for S_{11} at the 0 frequency/GHz(50, -5.21e^{-18}) Ω and 5 frequency/GHz (14.8, 1.07) Ω and for S_{12} (50,-1.53e^{-17}) Ω & (19.8, 68.6)Ω.

IV. Conclusion

Microwave photonic filter are photonic subsystem designed with the aim of carrying equivalent tasks to those of an ordinary microwave filter. Photonic filter bringing supplementary advantages such as high bandwidth, low loss, immunity to electromagnetic interference and re-configurability.

Form figure-8, It has been found that the measured results are in good agreement with the simulated value. Measured result obtained by 3GHz function generatorwhich provide insertion loss S12 -49db and center frequency fc 1.59 GHz at bandwidth 1.62GHz. In case of four cells E-Type PBG filter, a sharp ratecut offwithout sideband fluctuation response has been achieved. In future PBG's Filter can be used as wide band stop filters. These novel structures have wide stopband and compact size, uniplanar configuration, which can be easily incorporated into the ground planes of any other planar structures.

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