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Microwave Band Pass Filter Using Embedded Electromagnetic Band Gap Structures

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ABSTRACT:In this proposed microwave filter design, unique compact slotted dumbbell shaped EBG structures is designed and its results are analyzed. Embedded dumbbell shaped structures are placed on the transmission lines supported by open ended stubs at the either ends. The filter supports the operating over the ultra wide band frequency range of 3.1GHz-10.6GHz, which can be used for various prerequisite applications such as WLAN,WiMAX,etc. The bandpass filters have improved roll off frequency ,with enhanced return loss of lower than 10dB throughout the passband. A comparison is made between Embedded EBG structures with existing models.

KEYWORDS: Electromagnetic Band Gap Structures(EBG),Embedded EBG, Ultra Wide-Band

I. INTRODUCTION

Microwave frequency are the frequencies in the range (300MHz to 300GHz) with certain appealing features as larger bandwidth, enhanced directivity as well reliable consuming low power. As the frequency increases, the wavelength decrease, hence the size of the filter must be comparable to the wavelength .So there is a necessity to design a compact structure that satisfies its typical application in Ultra Wide-band frequency. To solve this issue a compact ,low cost fabrication structure is EBG. Electromagnetic Band Gap(EBG) are typical periodic structures that deter or allow. EM waves only at particular frequency but at all incident angles and stopbands at Bragg's frequencies. EBG structures derive their properties from PBG. The origin for the work of EBG started off with Photonic Band Gapstructures that involves periodic structures operate over varying Photonic Bang Gaps[2].Based on the structure's periodicity and ability for the structure to resist the wave in any particular direction the EBG structures can be classified into three dimensional EBG, two dimensional EBG and One dimensional EBG. Other two types of EBG structures are available of which it can be differentiated based on presence and absence of vias. The type of EBG structure with vias are called Mushroom type EBG .The type of EBG structure with absence of vias are called as Planar filter. Hence EBG structure provide miniaturization of circuits and provide a higher impedance surface.

In the proposed work, entirely new compact slotted dumbbell shaped EBG structure is designed and simulated results are compared with existing conventional EBG structures. Size reduction is carried out such that entire dimension of the filter has been reduce, hence making the filter compatible to work under Ultra wide-band frequency as well as satisfying its desired S-parameter criteria.

II. RELATED WORK

EBG structures[6] have unit cell size 0.1 λ_g and has achieved a possible miniaturization. Mushroom type EBG structures [5] are constructed both in DGS and EBG structures. In Ref[5] the EBG structure is found to be more compact and the results were found to be good comparable with DGS type filter. In addition to this, Uniplanar Compact Structure [4] is found to be more compact by involving slow wave structures in the filter. Since slow wave structure tends to decrease size of the electrically large elements, in turn cost of the circuit also tends to reduce. In ref[2] a new technique of using UC-EBG with interdigital capacitor has been done, the results show improved wider relative bandwidth.

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III. DESIGN OF EBG STRUCTURES

In general, a filter is a two port structure used to control the frequency response at RF system, providing transmission of frequency within the passband of the filter as well as attenuation stopband of the filter can be designed using a number of methods of which most modern procedure involves insertion loss method. The periodic structures in filter can be represented using equivalent L and C components. Hence these Land C components for the mushroom EBG can be given by,

$$L = \mu_0 h \quad (1)$$

$$C = w\varepsilon_0 \frac{(1+\varepsilon_r)}{\pi} \cosh^{-1} \frac{w+g}{g} \quad (2)$$

Where w indicates the patch width, g denotes the gap width and h indicates the substrate thickness
The bandwidth of the filter can be given as

$$BW = \frac{1}{\eta}\sqrt{\frac{L}{C}} \quad (3)$$

The impedance at the input can be given as

$$Z_S = \frac{j\omega L}{1-\omega^2 LC} \quad (4)$$

Figure 1 indicates the layout design of 'dumbbell' shaped EBG structures. The filter construction consists of slotted dumbbell shaped structures placed periodically over the transmission lines, open ended stubs at the end. The parallel lines placed on the either side of the stubs are called interdigital coupled lines, they help to improve the coupling factor. The guided wavelength of the structure can be given by,

$$\lambda_g = \frac{c}{f_0\sqrt{\varepsilon_{eff}}} \quad (5)$$

Since the size of the filter must be comparable to the wavelength, the overall size of the filter can be indicated by the value'd' which can be given by,

$$d = \frac{\lambda}{4} \quad (6)$$

The above filter parameters help to construct a ideal filter theoretically. For the practical analysis of the filter, the design and analysis can be done on Advanced design system software platform.

The practical design and analysis of filter involves first designing the desired structure, then proceeding with the S-parameter results. S-pararmeters that are needed to be calculated for the filter is insertion loss and return loss. In addition to this group delay of the filter can also be calculated.

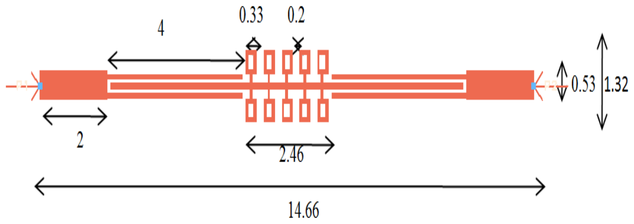

Figure 1-Layout design of slotted dumbbell shaped EBG structures

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The dimension of the filter is 14.66mmx1.32mm.The size of the unit cell is about 2.46mm which is comparatively smaller in size when compared to conventional MMR structure. The size of the slot width is 0.1mm and gap width is 0.1mm.The periodic dumbbell shaped structures are placed equally with distance of about 0.2mm.This proposed filter produce improvised results making the filter very much efficient.

IV. SIMULATION RESULTS

The proposed Embedded dumbbell shaped filter is simulated on Rogers 6010 substrate with thickness h=0.635mm, permittivity 10.2 and loss tangent 0.0023 on Advanced Design System(ADS) software .The Simulated results in Figure 3 exhibit an ultra wide-band passband from 3.1GHz to 10.6GHz.The S-Parameter results show that there is improved return loss characteristics less than 10dB and insertion loss lower than 1dB,which indicates that there is a improvement in the coupling factor.

Table 1-Comparison of Results

	Insertion loss	Return loss
Dumbbell shaped EBG	Less than 1dB	Lower than 10dB
Ref[4]	Less than 1dB	Lower than 10dB

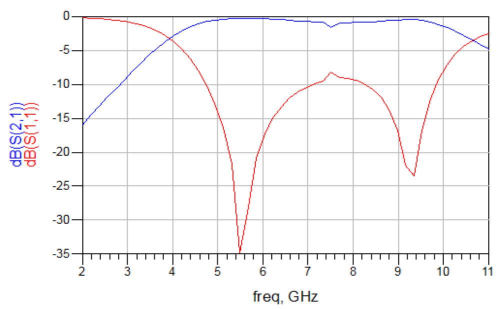

Figure 2-Simulation results of slotted dumbbell shaped EBG

V. CONCLUSION

The proposed filter shows that there is a improvement in the S-parameters, thereby making the filter more efficient. On the other hand the filter is also compact with reduced unit cell. Hence this compact filter can be used for many vital applications. This typical filter can be also included in various satellites, telephones and antennas to filter out the frequency in ultra wide band range.

VI. FUTURE WORK

This work attempts introduce a new novel band pass filter with better insertion and return loss. Still methods are to be introduced to minimize the ripples in passband thereby improving the overall performance of the filter and finding its suitable application in various fields. Inclusion of notched band studies can be made with novel modified structures with minimized ripples and possibly finding its application in wireless, satellite applications, WLAN, Wi-max etc.

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