An Ultra Wideband Bandpass Filter using Interdigital Structure and DGS

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Abstract - This paper presents methods and simulations of designing a bandpass filter to support Ultra Wideband communication systems(UWB).The UWB bandpass filter operating in the 3.1 GHz to 10.6 GHz frequency band is targeted to comply with the Federal Communications Committee(FCC) spectral mask for UWB systems. Here, we have designed a microstrip bandpass filter to operate within the ultra wideband passband of 7.5 GHz. The filter is designed on FR4 substrate of thickness 1mm with dielectric constant of 4.4 using ZEALAND IE3D Simulation Software v14.0.

Key Words: Bandpass Filters, Defected Ground Structure, Insertion Loss, Interdigital Resonator, Microstrip line, Return Loss, Ultra wide band.

1. INTRODUCTION

Filters are two port networks used to control the frequency response in a system by allowing transmission of wanted signal frequencies while rejecting the unwanted frequencies.

Band pass filter is a passive component capable of selecting a signal inside a specific bandwidth with a certain centre frequency known as pass band and reject signals in another frequency region, especially in frequency regions, known as stop band [1].

Microwave filter design has been remained persistent and productive field for investigation for researchers since the Federal Communications Committee(FCC) have authorized the unlicensed use of the ultra wideband (UWB) frequency spectrum which is from 3.1 GHz to 10.6 GHz for short range and high speed wireless communication in 2002 [2]. Presently UWB is widely used in wireless communication because or various advantages [3]-[4]. Presently, the demands of high data rate in wireless communications require higher system bandwidth. The Ultra-Wideband system can overcome such problem. It utilizes very large bandwidth for more than20% of its centre frequency or at least 500 MHz [5].

For the design of microstrip bandpass filters, various techniques exist and most of proposed novel filters with advanced characteristics are based on these several structures [6].

Microstrip lines are one of the most commonly used and popular type of planner transmission lines because it provides easy connection to active devices like transistors or diodes, low cost of fabrication and has simple structure. It allows for greater flexibility and compactness of design [7].The demand for highly accurate design of microstrip filters is increasing as it has many advantages such as small size, low cost, no cut off frequency and good reproducibility [8]. In this paper microstrip band pass filter is designed with varying number of Defected Ground Structures (DGS). The purpose of this work is to obtain a passband covering the entire ultra wideband that is from 3.1 GHz to 10.6 GHz as well as a wide stopband response. The proposed filter is to be designed on a low cost microstrip substrate FR4 with dielectric constant 4.4 and thickness 1mm.

2. FILTER DESIGN AND STRUCTURE

In our presented work, we designed a microstrip BPF and implemented it using an interdigital resonator with two shunt stubs with rectangular pads [9]. Interdigital resonator has high degree of coupling and we get better return loss [10]-[12]. Shunt stubs with square pads are used for achieving better lower passband. It is designed on FR-4 substrate of thickness 1mm with dielectric constant 4.4 and is then simulated using Zealand IE3D simulation software v14.0.

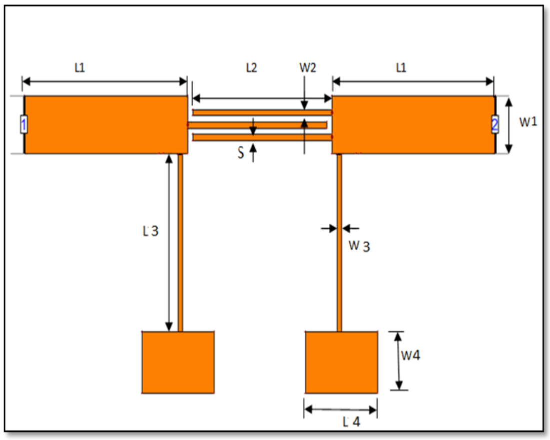
In the presented work, three designs of the filter structure have been developed to analyze the effect of variation in the number of Defected Ground Structures (DGS). The DGS is a deliberately etched periodic or non- periodic cascaded configuration (defect) in the ground plane of a planar transmission line [13]. It is used for achieving better performance of microstrip filters by etching slots in ground plane.

It disturbs the current distribution in the ground plane which changes the characteristics of a transmission line such as line capacitance and line inductance. Fig -1 shows all the three proposed structures of the proposed filter designs.

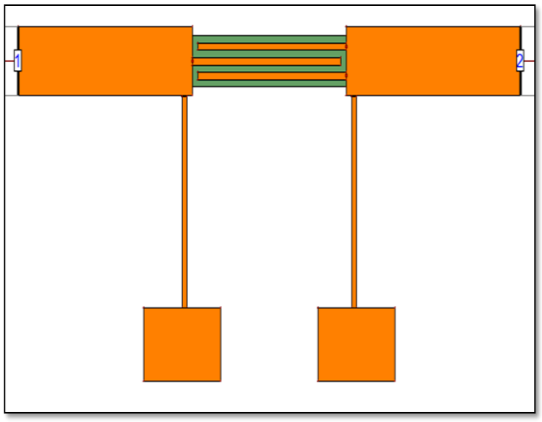
The constructional parameters of these designs have been detailed in Table -1.

Table -1: Constructional Parameters of Proposed Filter Structures

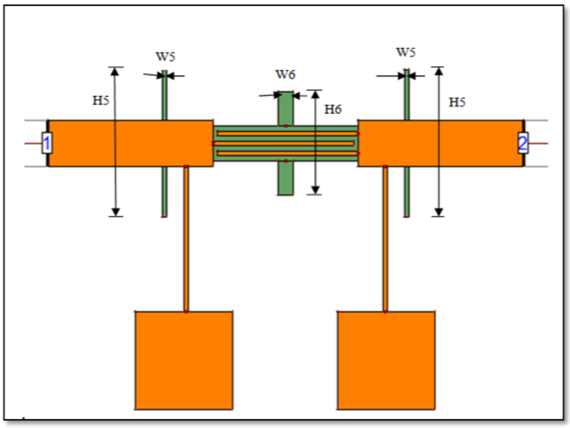
Parameters	Values(mm)
L1(Length of input & output microstrip lines)	6.8
W1(Width of input & output microstrip lines)	1.9
L2(Length of all the three coupled lines forming Interdigital resonator)	5.8
W2(Width of all the three coupled lines forming Interdigital resonator)	0.2
L3(Length of the two Stubs)	5.8
W3(Width of the two Stubs)	0.2
L4(Length of the two rectangular pads)	3
W4(Width of the two rectangular pads)	2
S(Spacing between the coupled lines)	0.2
Length and Width of Square pads (Design-2 & Design-3)	4
Length of DGS Structure below resonator (Design-2 & Design-3)	6
Width of DGS Structure below resonator (Design-2 & Design-3)	1.4
H5 (Height of two DGS Structures of feeding lines in Design-3)	6
W5 (Width of two DGS Structures of feeding lines in Design-3)	0.2
H6(Height of the middle DGS Structure in Design-3)	4
W6(Width of the middle DGS Structure in Design-3)	0.4



(a)



(b)



(c)

Fig - 1: Proposed structure of filter (a) with no DGS (b) with single DGS (c) with four DGS strips.

3. RESULT & DISCUSSION

The proposed filter structures have been simulated using electromagnetic simulation software ZEALAND IE3D.

S_{11} and S_{21} parameters for the first microstrip BPF structure using an interdigital resonator with two shunt stubs and rectangular pads are plotted as a function of frequency to characterize return loss and insertion loss as depicted in Fig-2.

Fig-3 shows the simulation results of the second structure using single DGS (Defected Ground Structure) and with square pads to enhance the performance of the filter. It has been observed that by using DGS, the return loss, insertion loss and the fractional bandwidth of the filter improved.

Further, another rectangular DGS structure was merged vertically with the existing DGS and two more thin rectangular DGS structures were placed on two sides of the filter and obtained the result which has been shown in Fig- 4. Here it is observed that the passband of the filter covers the entire ultra wideband from 3.2 GHz to 11.1 GHz with a bandwidth of 7.9GHz at -10dB. A fractional bandwidth of 110% is obtained.

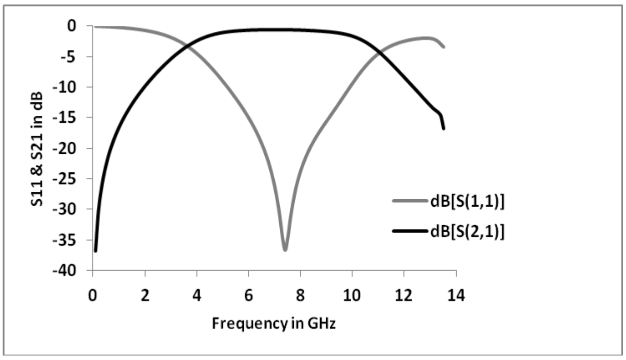


Fig - 2: Simulated S[11] and S[21] parameters of proposed filter without DGS.

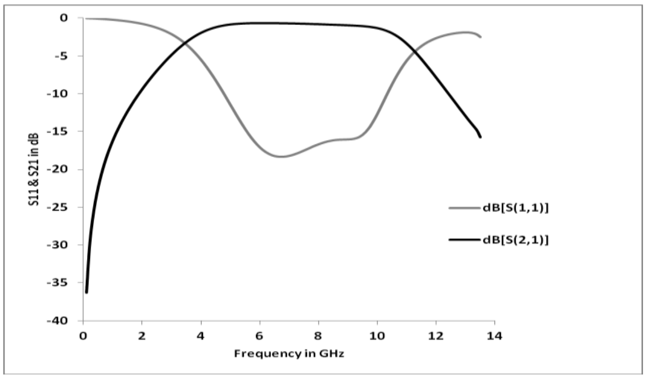


Fig-3: Simulated S[11] and S[21] parameters of proposed filter with single DGS.

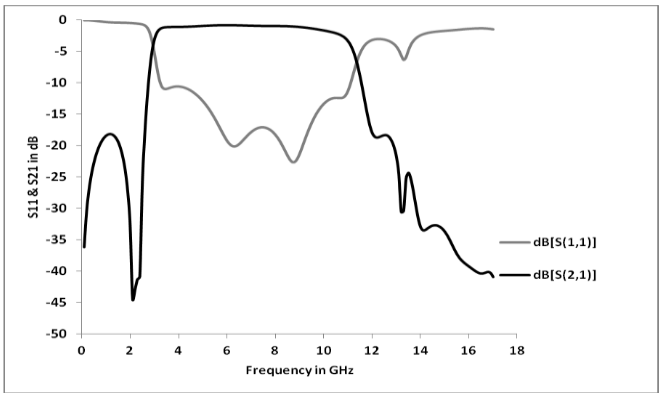


Fig-4: Simulated S[11] and S[21] parameters of proposed filter with four DGS.

4. CONCLUSION

This paper presents design and analysis of a microstrip band-pass filter that has been modeled using FR-4 substrate. The simulative analysis is performed with the help of IE3D EM software. From the analysis it has been noticed that the proposed filter is working within the frequency range for UWB. The Fractional Bandwidth achieved for this filter is 110%. Also a wide stopband is obtained. At -10dB, lower cutoff frequency is 3.2 GHz and upper cutoff frequency is 11.1GHz. Also Insertion loss is approximately flat over the passband. The stopband is extended beyond 18 GHz and it has a value of -40dB at 18GHz which is quite good.

5. FUTURE SCOPE

There are few sections in this paper which can lead to further investigations which are as follows:

The material used here for designing filter is FR4, which is considered a lossy material. Therefore the filter performance can be improved by using expensive less lossy material.

The DGS Structure which we have used in our design is the rectangular one without head, various other structures like rectangular slot with square head, circular head etc are also available which can be used to improve the response.

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