Design and simulation of Five Pole Hairpin Band Pass Filter using Square Shape Defected Ground Structure

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Abstract- The filter is an important part of the communication system its function is to select the desired signal and block the unwanted signal. The Good performance filter is always needed in a communication system. The Return loss and The Insertion loss are the two important parameters to analyze a microwave filter. This Paper presents the Design of Two different five Pole hairpin Bandpass filters. The first filter is Designed and Simulated without defected ground structure to operate at the center Frequency of 3.1 GHz on an FR-4 substrate with a Dielectric constant of 4.4 with a substrate height of 1.55mm and we obtained a Return loss of -44.15 dB and an insertion loss of -1.11dB. The Second filter is Designed and Simulated with Defected Ground Structure and we obtained a Return loss of -45.73 dB and an insertion loss of -1.26 dB. The simulation is carried out in High-Frequency Simulation Software (HFSS).

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Index Terms-Return loss, Insertion loss, Hairpin Bandpass Filter, HFSS software, Defected Ground Structure.

I. INTRODUCTION

The Defected ground structure (DGS) is a new area of research for different microwave band applications different types of microwave devices such as directional couplers, filters, and power dividers are fabricated by the DGS technique. low insertion loss, sharp cutoff, and high return loss are the basic need of an ideal microstrip bandpass filter.DGS along with the micro-strip line exhibits a resonant property. The dimensions and structure of the connecting slot depend upon its resonant frequency. various types of defective structures have been fabricated by using different shapes such as dumbbell, circular, and spiral type structures. DGS is the most interesting field for scientists and researchers in various wireless applications such as microwave imaging in a variety of microstrip antennas and filters. [1] High-performance filters are necessary to enhance the system's performance. Parallel coupled microstrip filters are commonly used in the RF front end of microwave and wireless communication systems for decades. The Main advantages of this filter involve its planar structure, insensitivity to fabrication tolerances, reproducibility, wide range of filter fractional bandwidth (FBW) (5% to 50%), and easy design. In the parallel coupled line filter λ/2 resonators are used to design a filter because this filter is large. To solve this problem a Hairpin Band pass filter is developed in which λ/2 resonators are folded into λ/4 resonators. [2] Line bandpass filters are the filter that has a systematic. structure. This filter has a concept concerning resonator folds, it is important to evaluate the reduction from the length of a coupled line which can decrease the coupling between the resonators. Similarly, if both of the Hairpin resonator's arms are calculated carefully, they worked as a set of coupled lines which has a good effect in coupling [3]. Ramdedovic et al. [4] proposed a Tight-coupled microstrip hairpin bandpass filter and also did a parametric analysis and compare their design with previous work and obtain good results. To further improve the performance of above mention filter we have proposed a design of five pole Filter with a dumbbell-defected ground structure.

II. METHODOLOGY

Chebyshev's response is chosen to design a filter with N = 5 order and pass ripple below 2dB with normalized cut-ofF frequency, ΩC =1, g0 = 1, g6 = 1, g1 = g5= 1.1468,g2 = g4 =1.3712, g3 =1.9750

$$Qe1= g0g1/FBW \ldots\ldots\ldots\ldots\ldots (I)$$

$$Qen= gngn+1/FBW \quad \ldots\ldots\ldots .(ii)$$

Where

Qe1, Qen are External quality factor of input and output resonator.

FBW is the fractional bandwidth.

Mutual coupling coefficient between resonators-

$$Mi,i+1 = \frac{FBW}{\sqrt{g_i g_{i+1}}} \ldots\ldots\ldots\ldots\ldots (iii)$$

$$\text{For } \frac{W}{h} < 2$$

$$\frac{W}{h} = \frac{8e^A}{e^{2A}-2} \quad \ldots\ldots\ldots\ldots\ldots (iv)$$

With

$$A = \frac{Z_c}{60}\sqrt{\frac{\varepsilon_r+1}{2}} + \frac{\varepsilon_r-1}{\varepsilon_r+1}\{ 0.23 + \frac{.11}{\varepsilon_r}\} \ \ldots\ldots\ldots (v)$$

Therefore, W = u x h

Where W is the width of the resonator

Width of Microstrip line

Effective Dielectric constant-

$$\varepsilon_{eff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2\sqrt{1+12(\frac{H}{W})}} \text{……………………(vi)}$$

Guided wavelength-

$$\lambda_g = \frac{300}{f_{GHz}\sqrt{\varepsilon_{eff}}} \text{ …………………………….. (vi)}$$

Length of resonator-

$$L_R = \frac{\lambda_g}{4} \text{ ………………………………….. (vi)}$$

The tapped position can be calculated by the following formula-

$$t = \frac{2LR}{\pi} sin^{-1}\left(\sqrt{\frac{\pi}{2} x \frac{z_0/z_T}{Q_{en}}}\right) \text{…………………..(vii)}$$

equations (i) to (vii) are used to calculate the filter dimension.

Table 1-

FILTER SPECIFICATION- Design 1

BANDPASS FILTER	VALUE
Start Frequency	2.6 GHz
Stop Frequency	3.6 GHz
Center Frequency	3.1 GHz
Fractional Bandwidth	0.32
Filter Order	5
Frequency Response	Chebyshev

TABLE 2-

SUBSTRATE SPECIFICATION-

SUBSTRATE	VALUE
Dielectric constant	4.4
Substrate height	1.55mm

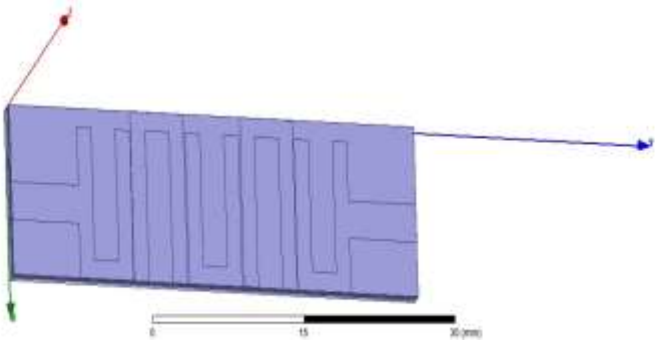

Figure 1- layout of design in HFSS

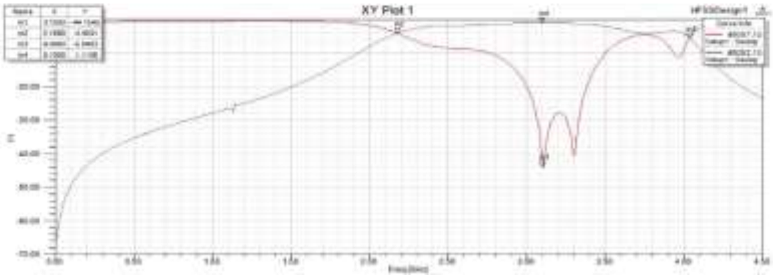

Figure 2- S parameter of Design 1

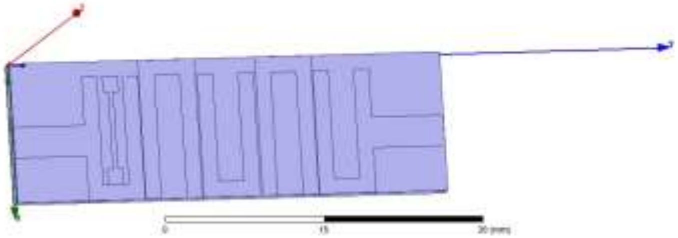

Figure 3- Layout of Filter with defected ground structure

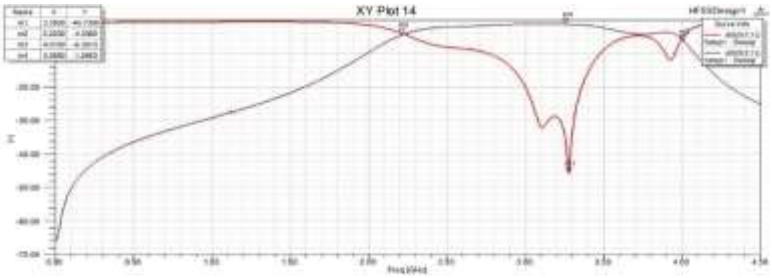

Figure 4- S- parameter of the filter with defective ground structure

III. RESULT

In this paper, we design two different filters in the first design we obtain -45.15dB Return loss, and in the second with the defective ground structure we obtain -45.17dB return loss. There is an improvement in Return loss.

IV. CONCLUSION

In this paper, we design two different filters in the first design we obtain -44.15dB Return loss, and in the second with the defective ground structure we obtain -45.73dB return loss. There is an improvement in Return loss. The proposed filter can be used in internet wireless communication. Now Filter is Ready to fabricate and testing.

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ACKNOWLEDGMENT

I would like thanks to my supervisor Dr. Uma Shankar Kurmi for their support.

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