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Performance Improvement of Hairpin Bandpass Filter using Square Shape Slot Defected Ground Structure

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Abstract— ***This paper presents the design and simulation of a Microstrip hairpin Bandpass filter using a square shape slot defected ground structure. First, we designed a Hairpin Band pass filter to operate at the center frequency of 2.22 GHz with a fractional bandwidth of 0.2 on substrate FR-4 high permittivity material with substrate height is 1.6mm and Return loss(s11) -27.33dB is obtained and second hairpin Band pass filter is designed using square shape defected ground structure and -38.08 dB Return loss (s11) is Obtained It is observed that the return loss of the filter is improved in second filter design. Return loss indicates the performance of the filter. The simulation is carried out in high-frequency structural software (HFSS).***

Keywords- Hairpin Band pass filter, Rogers RT/Duroid 6006, and Square Slot defected ground structure, Return Loss (s11).

I. INTRODUCTION

The filter is an important component of the communication system it is used in communication on both sides that is transmitting and receiving sides. [4] it is used in wireless communication, global positioning system, and microwave communication, [3] an Ideal Microstrip Bandpass Filter require high return loss, Minimum insertion loss, and high return loss [8] The Band pass filter should have low insertion loss and low return loss. Microstrip Bandpass filter has many advantages such as small size, low cost, and ease of integration with other components [4]. The Hairpin Band pass filter is the modified form of a parallel coupled line Filter. The hairpin filter is one of the most popular microwave frequency filters because it is compact, simple and relatively eases to fabricate. [7] The types of filters used in telecommunication systems include the low pass filter (LPF), the high pass filter (HPF), the Band-pass filter (BPF), and the band stop filter (BSF). The hairpin filter is one of the most popular microwave filters because it is compact, simple and relatively eases to fabricate. The types of filters used in telecommunication systems include the low pass filter (LPF), the high pass Band-pass filter (BPF), and the band stop filter (BSF) [7] Different types of research have been conducted on Micro-strip Band-pass filters to improve its performance [3] out of which defected ground is popular. The defective ground structure is a pattern sketched in the ground plane. DGS along with the micro-strip line exhibits a resonant property .it improves the filter performance and reduces the size of the filter. Different types of defective structures have been fabricated by using different shapes such as, dumbbell, circular and spiral type structure Two Uniform U-shape defected ground structures have also been proposed for micro strip low-pass filter design with wide rejection band [3]. stubs DGS [7]. In this paper a square groove is added in the first resonator is added to improve the return loss of the filter.

II. MATERIALS AND METHOD

A. Materials

To Design a Filter in a HFSS software the following material are required – HFSS software, ground, substrate, patch, input port, output port, Radiation box. The following steps are taken to design a filter in HFSS software.

1. Open the HFSS software.
2. Insert new Design.
3. Create ground of specified length and Width and assign perfect electric to ground.
4. Create substrate of specified dimension and select the material on which you want to design.
5. On the top of substrate cerate filter of specified dimension and assign perfect electric to filter geometry.
6. Create input and output port.
7. Now create a radiation box and assign material air to radiation box.
8. Add solution frequency
9. Add sweep that is frequency range in which you want to see the result.
10. Validate the design and run the simulation.
11. Create model data report.

Methods

1. Chebyshev low pass filter is designed with the following specification pass Band ripple =0.1 Db, the filter N=3, Fractional Bandwidth =20%, Frequency Fr =2.22GHz,

   $g0 = 1, g4 = 1 , g1 = 1.0316 ,g3 = 1.0316 , g2 = 1.1474$

2. Now LPF is converted into BPF prototype

Qe1= g0g1/FBW……………. (1)

Qen= gngn+1/FBW ……….. (2)

Where

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

FBW is the fractional bandwidth.

Mutual coupling coefficient between resonators-

$$M_{i,i+1} = \frac{FBW}{\sqrt{g_i g_{i+1}}} \ldots\ldots\ldots\ldots\ldots \quad (3)$$

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

$$\frac{W}{h} = \frac{8e^A}{e^{2A}-2} \quad \ldots\ldots\ldots\ldots\ldots \quad (4)$$

With

$$A = \frac{Z_c}{60}\sqrt{\frac{\varepsilon_r+1}{2}} + \frac{\varepsilon_r-1}{\varepsilon_r+1}\{0.23 + \frac{.11}{\varepsilon_r}\} \ . \quad (5)$$

Therefore, W = u x h

Where W is the width of resonator

Width of Micro strip line

Effective Dielectric constant-

$$\varepsilon_{eff} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2\sqrt{1+12(\frac{H}{W})}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (6)$$

Guided wavelength-

$$\lambda_g = \frac{300}{f_{GHz}\sqrt{\varepsilon_{eff}}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (7)$$

Length of resonator-

$$L_R = \frac{\lambda_g}{4} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (8)$$

The tapped position can be calculated by the following formula-

$$t = \frac{2LR}{\pi} sin^{-1}\left(\sqrt{\frac{\pi}{2} x \frac{z_0/z_T}{Q_{en}}}\right) \ldots\ldots\ldots\ldots\ldots\ldots \quad (9)$$

equation (1) to (9) are used to calculate the filter dimension.

Table 1- Filter Specification

BANDPASS FILTER	VALUE
Start Frequency	1.85 GHz
Stop Frequency	2.6 GHz
Center Frequency	2.21GHz
Return loss	-27.33dB
3-dB bandwidth	750MHz
Filter Order	3
Frequency Response	Chebyshev

Table 2 Substrate Specification -

Substrate	FR-4
Dielectric effective constant	4.4
Height of the substrate	1.6mm

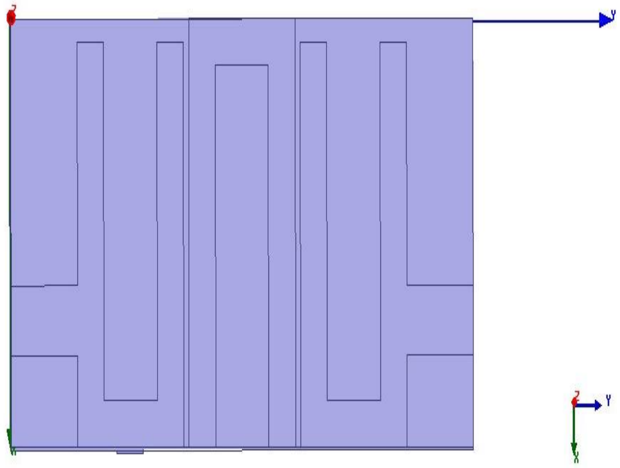

Figure 2- Layout of Hairpin Bandpass filter design 1

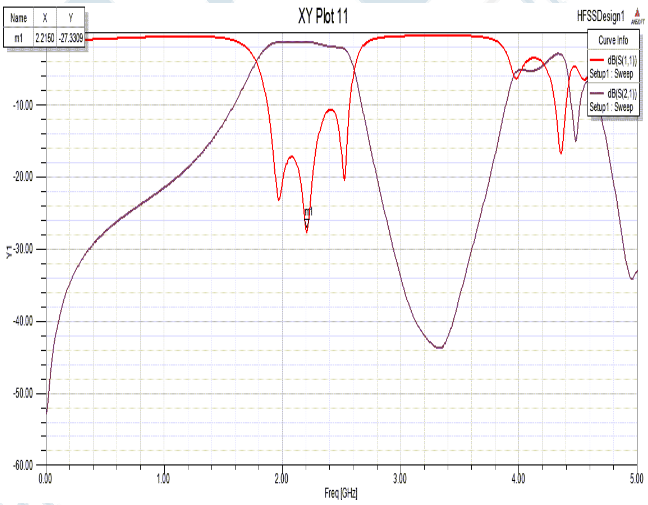

Figure 3 - Return Loss (S11) Of 3- pole hairpin Band pass filter Design without square slot.

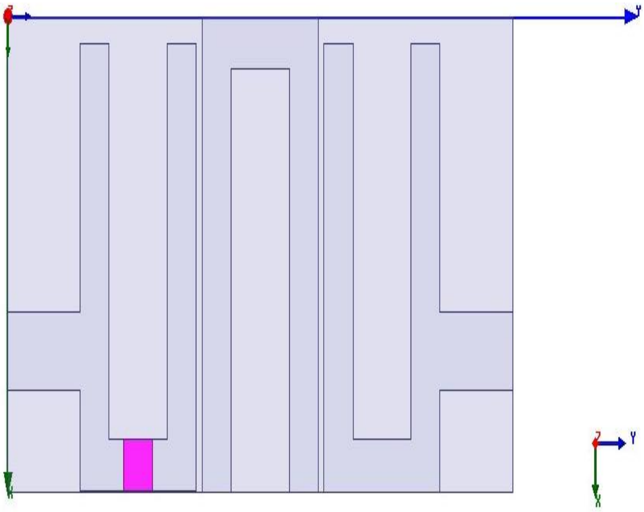

Figure 4- Layout of Hairpin Band pass filter design with square slot defected ground structure

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Table 3 Filter Specification- Design 2

BAND PASS FILTER	VALUE
Start Frequency	1.85 GHz
Stop Frequency	2.6 GHz
Center Frequency	2.15GHz
Return loss	-38.08dB
3-dB bandwidth	750MHz
Filter Order	3
Frequency Response	Chebyshev

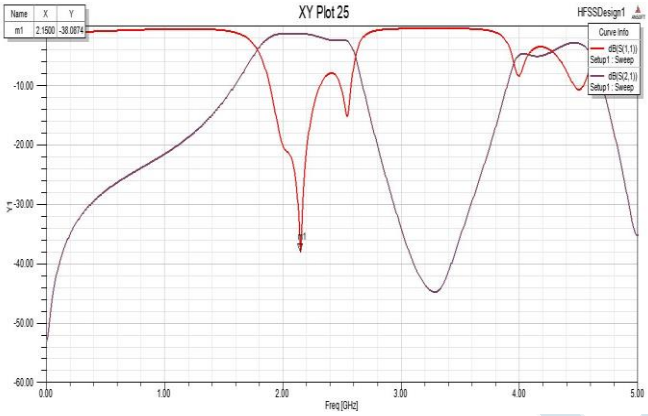

Figure1 - Return Loss (S11) Of 3- pole hairpin Bandpass filter with square sldefectiveted ground structure

III. RESULTS AND DISCUSSION

In This paper presents we design and simulate a Micro strip hairpin Band-pass filter using a square Slot defected ground structure and improve the Return loss(s11) of the Filter from -22.24dB to -38.08 dB Return loss (s11) which indicate improvement in the performance of the filter that is very important to analyze the performance of the filter.

Different sizes of the slot are created and simulation is carried out but we have not received a favorable result so finally, a square slot is taken that gives the desired result that increases the effective inductance because of this a slight variation in resonance frequency.

Now the filter is ready to fabricate and test for the next research

IV. ACKNOWLEDGMENTS

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