Design, Simulation and size Reduction of Hairpin Band Pass Filter

Anoop kumar Bundela[*], Uma Shankar Kurmi[**]

[*] Electronics and Telecommunication,
Govt.Women's Polytechnic college
Bhoapl, Madhaya Pradesh
[**] LNCT University
Bhopal, Madhya Pradesh

Abstract

In this paper we presented Design and simulation of two hairpin Band pass filter. The first filter is designed to operate at center frequency of 2.22 GHz with a fractional Bandwidth of 20% and Return loss of -22.24 dB obtained using FR4 substrate and Second Hairpin Band pass filter is designed to operate at 2.22Ghz with a fractional Bandwidth of 20% using Rogers RT/duroid 6006 substrate and in the second case Return loss is Improved and filter size is Reduced.

Keywords- Hairpin Band Pass Filter, Return loss, FR-4 substrate and Rogers RT/duroid 6006 substrate

INTRODUCTION-

Filter is an important device of any signal processing device or communication [1] Filters Application can be easily found in wireless communication, global positioning system and microwave communication, , [1] Communication Technology needed High performance Band pass filter such as wireless technology at Microwave frequency[4] . Different types of microwave devices such as patch antennas, directional couplers, power amplifier,Microwave Filter and power dividers are fabricated using DGS technique. Ideal micro strip band pass require high return loss, Minimum insertion loss, sharp cutoff [8] The Band pass filter should have low insertion loss and low return loss. Micro strip band pass filter has many advantage such as small size, low cost and easy to integrated with other component [4].The Hairpin Band pass filter is the modified form of parallel coupled line Filter. Different research have been conducted on Micro strip Band pass filter to improve the performance such as low temperature co-fired Ferrite, low temperature co-fired Ceramic and defected ground structure. Therefore in this paper First a three pole filter is designed on FR-4 substrate and return loss is -22.5dB is obtained and To reduce the size of first filter a second hairpin filter is designed using a high permittivity substrate Rogers RT/duroid 6006 with the same specification and return loss and filter performance is improved ..

BASIC THEORY-

Different type of Microwave Filter is available such as Inter digital Filter parallel coupled line filter ,Comb line Filter etc .Out of these hair Pin Filter is Popular because of its ,compact size ,and low cost.

Hair pin Filter designing is same as parallel couple line filter. The concept of designing hairpin filter is same as that of parallel coupled half wavelength resonator filters to design Hairpin Filter parallel couple line filter is folded in to U shape to save the space.

The main parameter to analyze any Microwave Filter is Insertion Loss Return loss and VSWR.

Return loss is the Ratio of reflected power to Incident Power and Insertion loss is Ratio of Transmitted Power to Incident Power .The ratio of maximum to Minimum voltage is known as VSWR or Voltage Standing Wave Ratio. it select the desired frequency and reject the unwanted frequency .Basically four type of Filter that is low pass Filter, High pass Filter, Band pass Filter, and Band stop Filter .Low pass Filter pass the Frequency below a Cut the of Frequency .High pass Filter Pass Filter pass the Frequency above the cut off Frequency .Band Pass

Filter passes a Particular Band of Frequency and Band stop Filter Reject a particular Band of Frequency. At Higher frequency discrete component is replaced by Micro strip line .This paper describe design of two Microwave Filter Hair pin Band pass Filter using Two different substrate-

FILTER DESIGN PROCEDURE-

Filter order is set according to Chebyshev approach.

Order of the filter N=3

Pass band ripple =0.1dB

Fractional Bandwidth = 0.2

The value of prototype element is obtained as follows-

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

Qe1= g0g1/FBW…….(I)

Qen= gngn+1/FBW …….(ii)

Where

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

FBW is the fractional bandwidth.

Mutual coupling coefficient between resonators-

$$M_{i,i+1} = \frac{FBW}{\sqrt{g_i g_{i+1}}} \text{……(iii)}$$

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

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

With

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

Therefore width of resonator W = uxh

Width of Micro strip line

Effective Dielectric constant-

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

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-

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

DESIGN METHODOLOGY-

Simulation is carried out in High frequency structural simulation software(HFSS) equation (i) to (vii) are used to calculate the dimension of filter the obtained result and filter layout is shown in figure.

Design 1- Filter Design Specification-

Filter Specification-

BAND PASS FILTER	**VALUE**
Start Frequency	**1.71 GHz**
Stop Frequency	**2.39 GHz**
Center Frequency	**2.22GHz**
Return loss	**-22.24dB**
Filter Order	**3**
Frequency Response	**Chebyshev**

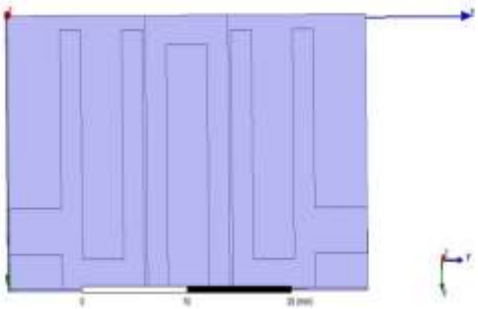
Table 1- Filter Specification

SUBSTRATE SPECIFICATION-

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

Table 2 - Substrate Specification

Filter layout-



Filter-1 Design layout of three pole Hairpin Band pass filter

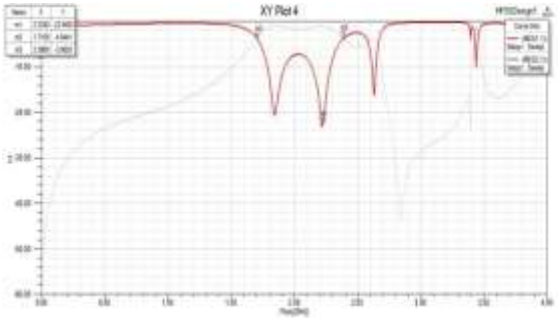


Figure 2- S-Parameter of three pole hair pin Band pass filter

Design 2- Filter Design Specification

Filter Specification-

BAND PASS FILTER	**VALUE**
Start Frequency	**1.85 GHz**
Stop Frequency	**2.85GHz**
Center Ferquency	**2.25GHz**
Return loss	**-26.29dB**
Filter Order	**3**
Frequency Response	**Chebyshev**

Table 3- Filter Specification

SUBSTRATE SPECIFICATION-

Substrate	Rogers RT/duroid 6006
Dielectric effective constant	6.15
Height of the substrate	1.27mm

Table 4 - Substrate Specification

Filter layout-

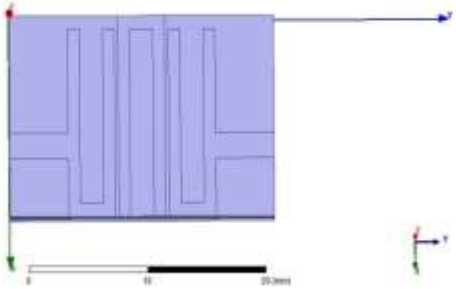


Figure –3 layout of three pole hairpin Band pass Filter

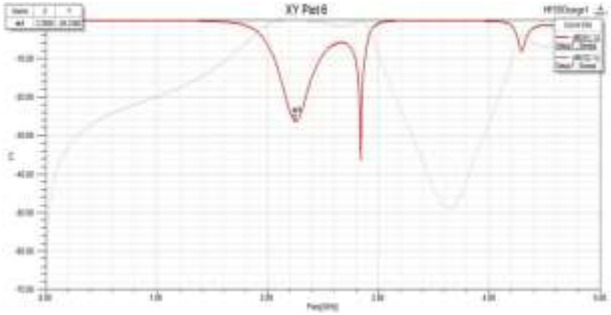


Figure –4 S-Parameter of three pole hair pin Band pass filter

From figure 2 the obtained return loss is -26.29dB that indicate the filter performance of a filter good.

Comparison between design 1 and 2

Design	parameter	Filter size
Design 1	S_{11} = -22.24 dB	34.8mmx22.2mm
Design 2	S_{11} = -26.29dB	22.6mmX15mm

Table 5 - Comparison

CONCLUSION-

In this paper we designed two Hair pin Band Pass filter to operate at 2.2 GHz. The Size of first filter is34.8mmx22.2mm and return loss is -22.24dB and the size of the second filter is 22.6mmX15mm and return loss is -26.29dB.From the graph and comparison table it is clear that design 2 have the better result in term of s parameter and 43% filter

size is reduced. Now filter is ready to fabricate and testing for next research.

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