International Journal of Latest Engineering Research and Applications (IJLERA) ISSN: 2455-7137

Volume – 02, Issue – 06, June – 2017, PP – 37-42

Design and simulation of compact Hairpin Bandpass filter

[1]Mrs. Sudha Surwase,

Department of Electronics & Telecommunication SKNSCOE, Sinhgad college of engg. Korti, Pandharpur Solapur India,

[2]Miss.Suchita Salunkhe, [3]Miss.Prajakta Vhatkar, [4]Miss.Revati Mali

[2,3,4]Student, Electronics & Telecommunication Department ,SKNSCOE Sinhgad college of engineering Korti, Pandharpur, Solapur, India

Abstract: This paper presents design, measurement and analysis for size reduction of the tapped micro strip Hairpin band pass filters (MHBPF's).The shapes of the hairpin resonators are modified to suppress the unwanted spurious harmonic response by folding the arms of normal parallel coupled λ/2 resonators into U shape to reduce the size of filter. A hairpin band pass filter is designed to operate at center frequency of 2.4 GHz with a bandwidth of 100 MHZ. This frequency is furnished for various applications like GSM, GPS wireless LAN also operates in the ISM (Industrial, Scientific, Medical) band. Band pass filter is simulated using ADS 2014 software.

Keywords: Hairpin, GSM (Global System for Mobile communication), GPS (Global Positioning system), LAN (Local Area Network).

I. INTRODUCTION

Micro strip is one type of electrical transmission line which consists of conducting strip separated from ground plane by a dielectric layer. Main advantage of micro strip band pass filter is that it is lighter, compact and less expensive than waveguide.

A band pass filter is a filter which passes particular band of frequency and attenuate all other frequencies .For most of the wireless applications high quality and compact sized RF/microwave filters at low cost are required. This can be fulfilled by the use of planar filters. Amongst planar filters hairpin filters are of much use as they are available in much reduced size as compared to parallel couple line structure.

This paper is organized as follows. Section 2 Basics of Hairpin filter, section 3 describes Design of Hairpin filter, In section 4 presents Experimental simulation results, section 5 presents fabrication of Hairpin filter ,section 7 analyzes the final results with the help of that we state our conclusions in the this section .

II. BASICS OF HAIRPIN FILTER

There are different types of filter such as RF/Microwave filters, Chebyshev filter , RF amplifier filter , lowpass filter likewise and so on .Hair pin filter is similar to the parallel coupled filter which is folded into the U shape so that space is saved by folding resonator and due to its U shape it is called as hairpin. The FR-4 substrate is the backbone of hairpin filter in which thin layer of Cu foil is laminated on one or both side of FR-4 glass epoxy panel. Two types of input structure are in practice for Hairpin resonators. These are coupled input and tapped input structures. In couple line input, Input transmission line is directly attached onto the first coupling section. As shown in figure 1.This results in poor isolation which in turn affects the response characteristic. Tapped line input resonator are introduced due to poor response characteristics of the coupled line input resonators. As shown in figure 2. Microwave filter plays an important role in any RF front ends for suppression of out band signals .As the filters are reactive in nature that passes a desired band of frequency and attenuates all other band of frequency.

Fig.1 : Coupled input hairpin Filter

Fig.2: Tapped input hairpin Filter

III. DESIGN OF THE HAIRPIN BAND PASS FILTER

A] The design of band pass filter involves two main steps :

1) The first step is to select an appropriate low pass prototype.
2) The choice of type of response including pass band ripple, order of filter and number of reactive elements will depends on the required specifications.

B] Filter Design Specification:-

1) Center frequency:2.4GHZ
2) Insertion loss S_{21}<1.5dB
3) Return loss S_{11}>16dB
4) Attenuation =50dB
5) FR-4 Substrate permittivity =4.6
6) Thickness h=1.6mm
7) Metal thickness t=35um
8) Loss tangent δ=0.0022

C] Hairpin Filter Design :-

For the designing of hair pin filter the fractional bandwidth is of 0.08dB is used at the central frequency of 2.4GHZ.Theelement values are g0=g5=1.70,g2=g4=1.22,and g3=2.5408,g6=1.000.
This elements are used to determine design parameters of band pass filters such as coupling coefficient and external quality factor.The band pass filter parameters can be calculated by

$$Q_{e1}=\frac{g0\ g1}{FBW} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

$$Q_{en}=\frac{gn\,(gn+1)}{FBW} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(2)$$

Mutual coupling coefficient between adjacent resonators is calculated by

$$M_{i,i+1} = \frac{FBW}{\sqrt{gi\ (gi+1)}} \text{ for i= 1 to n-1} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.....(3)$$

Where $M_{i,i+1}$ are the coupling coefficients between the adjacent resonators and Qe1and Qen are the externalquality factors at the input and output side.
Spacing between the resonators can be calculated by using mutual coupling coefficient(M)

$M_{12}=M_{45}$ & $M_{23}=M_{34}$

Gives spacing of resonators as
$S_{12}=S_{45}$ & $S_{23}=S_{34}$

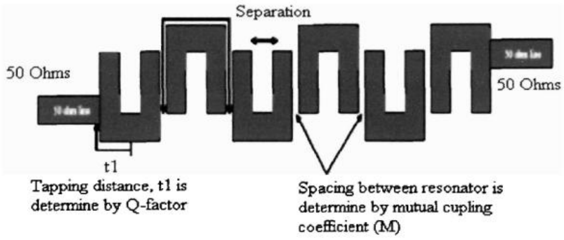

Fig.3:spacing between U shapes

D]. Even and Odd Mode Impedance Calculation
Even mode impedance can be calculated by

$Z_{0en}=Z_0\,[1+Z_{0jn}+(Z_{0jn})^2]$………………………………… (4)

Odd mode impedance can be calculated by

$Z_{0on}=Z_0[1-Z_{0jn}+(Z_{0jn})^2]$………………………………. (5)

After Z_0, $\frac{W}{d}$ ratio can be calculated as

$\frac{W}{d}=\frac{8e^A}{e^{2A}-2}$……………………………….... (6)

Where ,
$A=2\square*\frac{Z_0}{Z_1}\sqrt{\frac{\varepsilon_r+1}{2}}+\frac{\varepsilon_r-1}{\varepsilon_r+1}\left(0.23+\frac{0.11}{\varepsilon_r}\right)$

E] Effective Dielectric Constant and Characteristic Impedance
The effective dielectric constant for($\frac{w}{h}\geq 1$) of a micro strip line is approximately defined as

$\varepsilon_{re}=\frac{\varepsilon_r+1}{2}+\frac{\varepsilon_r-1}{2}\left(1+\frac{12h}{w}\right)^{-0.5}$……………………(7)

Where, ε_r is Relative dielectric constant of the substrate, h is the height of substrate and W is width of line.

F] Tapping Point:-
Tapped line input resonator are introduced due to poor response characteristics of the coupled line input resonators.
To approximate the tapping length, formula given below has been used in design

$t=\frac{2L}{\pi}\sin^{-1}\left(\sqrt{\frac{\pi}{2}*\frac{Z_0}{Z_{r*Q_e}}}\right)$………………………..(8)

IV. SIMULATION RESULTS

The simulated results of the filter is as shown in figure 4 is shown in figure 5,6,7,8. From this we can observe the response of band pass filter for different orders (n=3,5,7) .
The below graphs are plotted between gain (in dB) versus frequency (in GHZ).
Simulation of hairpin filter is as shown in the fig. by using ADS software

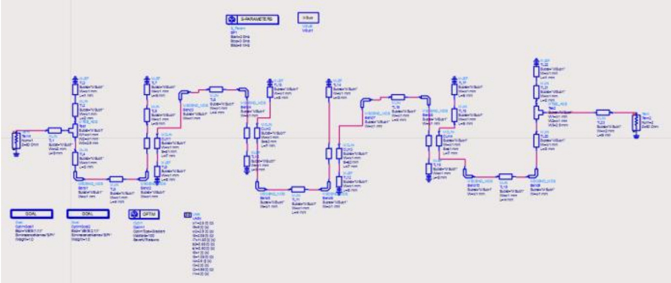

Fig.4:Simultion on ADS

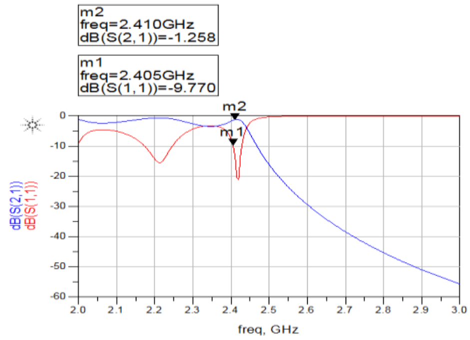

Fig.5: Graph of S_{11},S_{21} of Hairpin filter on ADS

V. FABRICATION OF HAIRPIN FILTER

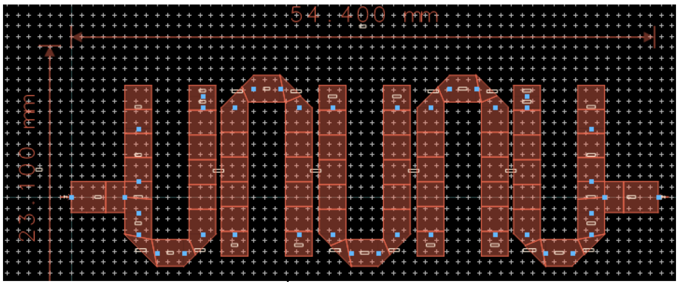

Fig.6: Layout of 5th order hairpin filter on ADS

With the help of above layout shown in figure 6 and parameters and specifications 5th order hairpin filter is fabricated as shown in figure 7 below

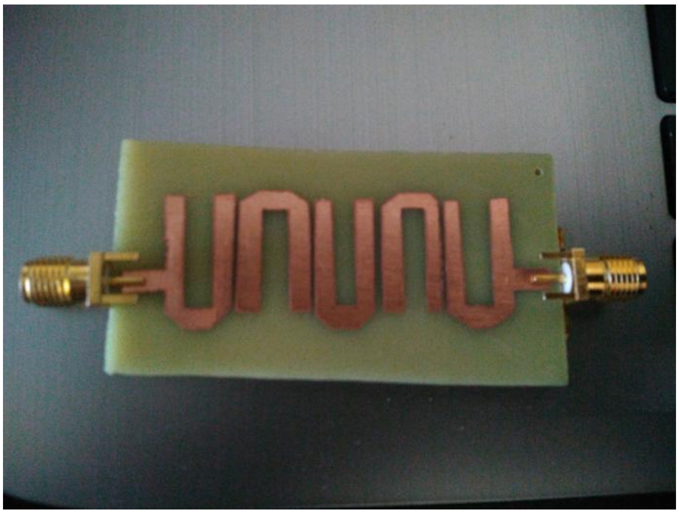

Fig.7: PCB of hairpin filter

During the fabrication of hairpin filter we have used FR-4 substrate having ε_r =4.6. This filter is fabricated in the laboratory.

VI. FINAL RESULTS OBSERVED ON VNA

After the fabrication of hairpin filter this filter is tested and its results are obtained on Vector Network Analyzer. The figure 8
shows the VSWR plot. Practically VSWR must be less than 2.

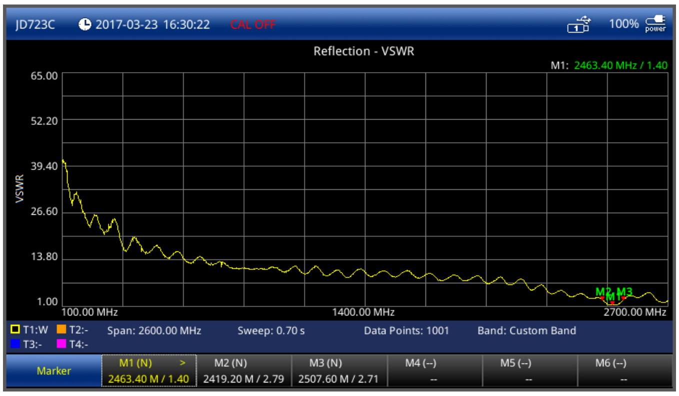

Fig.8: VSWR of hairpin filter

Figure 9 represents graph of return loss of hairpin filter which should be less than -10 dB shown by marker M1.

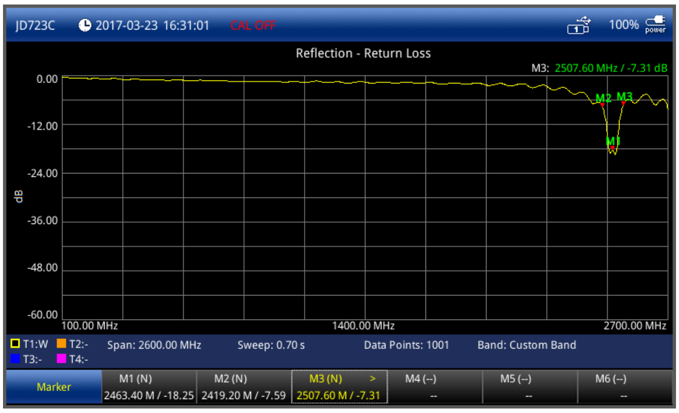

Fig.9: Plot for return loss

Plot of smith chart on VNA is shown in figure 10. Which is used for impedance matching .

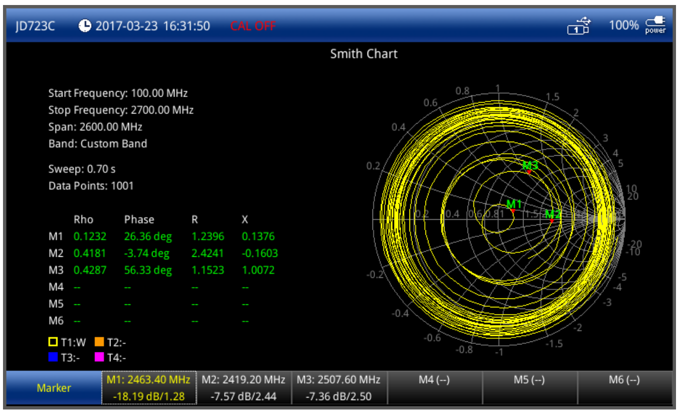

Fig.10: Plot of smith chart on VNA

VII. REFERENCES

[1]. Girraj Sharma, Prof. (Dr.) Sudhir kumar Sharma, Sandeep Bhullar, Nilesh Kumar, Saurabh Chauhan ,International Journal of Modern Communication Technologies & Research (IJMCTR) ISSN: 2321-0850, Volume-2, Issue-4, April 2014

[2]. K.Vidhya- Research Scholar, Sathyabama University, 2 T.Jayanthy-Principal, Panimalar Institute of Technology *2011 International Conference on Information and Electronics Engineering IPCSIT vol.6 (2011) © (2011) IACSIT Press, Singapore*

[3]. Jia-Sheng Hong and Michael J. Lancaster, "*Couplings of Micro strip Square Open-Loop Resonators cross coupled Planar Microwave Filters,*" IEEE Transaction on Microwave Theory and Techniques, Vol. 44, Nr. 12, Dec.,1996.

[4]. J. *S* . Park, J-S. Yun, and D Ahn, " A design of the novel coupled-line band pass filter using defected ground structure with wide stop band performance," *IEEE Trans. On Microwave Theory and Techniques*

[5]. David M. Pozar, "*Microwave and RF design of wireless systems,"* John Wiley & Sons, Inc., p-p 19-21.,

