DESIGN OF 4^{TH} ORDER MICROSTRIP HIGH PASS FILTER USING WRIST WATCH SHAPED DEFECTED GROUND STRUCTURE AT 2.5 GHZ

Abhishek Singh Bhadoriya[1], Sandeep Kumar Agrawal[2], Mahendra Kumar Pandey[3]
[1]PG Scholar, Department of Electronics, Rustamji Institute of Technology, BSF Academy, Tekanpur, Gwalior, India
[2] Asst. Prof., Department of Electronics, Rustamji Institute of Technology, BSF Academy, Tekanpur, Gwalior, India
[3]Asst. Prof., Department of Electronics, Rustamji Institute of Technology, BSF Academy, Tekanpur, Gwalior, India

Abstract-The performance of a high pass filter (HPF) with and without Defected ground structure has been analyzed. The Defected Ground Structure is in "wrist watch" Shape. Parameters of the proposed configuration were calculated at the centre frequency of 2.5 GHz with dielectric constant of 4.4, loss tangent of 0.02 and substrate height of 1.6mm. Results were simulated using computer simulation technology software (CST). The undesired sidebands and fluctuations of response are concentrated by using modified ground structure. Also the cutoff point of the high pass filter is shifted to a higher frequency and an enhancement in selectivity. The filter can be useful in various RF circuits where fewer fluctuations are required in pass band.

Keywords: High pass filter (HPF), Modified Ground Structure, DGS, Short Circuited Stub

I. INTRODUCTION

A microwave filter is a two-port network used to control the frequency response at certain point in a microwave system by providing transmission at frequencies within the pass band of the filter and attenuation in the stop band of the filter. Depending on the requirements and specifications, RF/microwave filters may be designed as lumped element or distributed element circuits; they may be realized in various transmission line structures, such as waveguide, coaxial line, and micro strip. [1]

For designing high performance and compact filters, a defected ground structure has been widely used. A Defect on ground can change the propagation properties of a transmission line by changing the current distribution and applied field between the ground plane and upper surface.

PBG and EBG structure are also a type of DGS, which is created by etching different periodic shapes in the ground plane. So many etched shapes for the micro strip could be used as a unit DGS. [8]

An LC unit circuit can represent the unit DGS circuit. They provide inductive and capacitive elements connected in series, which remove undesired output response fluctuations; move the high pass filter frequency limit to a higher value and the selectivity of a particular band is also improved [2][7].

In this proposed work an arbitrary shape of DGS is used to improve the parameters of the filters like return loss, transmission coefficient etc. And also the dimension of these different shapes varies to find efficient response. A lot of different shapes of DGS were tested and the more efficient one is introduces in this work.

II. IMPLEMENTATION OF 4TH ORDER HIGH PASS FILTER

The proposed high pass filter (HPF) consists of shunt short circuited stubs of electrical length Ɵc at some specified frequency fc (usually the cut off frequency of HPF). These elements were separated by unit elements (UE) of length 2 Ɵc

shown in the figure 1 [6]. This type of filter has very wide band response for small Ɵc but this requires a high value of impedance in the short circuited stub (SC-Stub). To design high pass filter let us consider the cut off frequency fc in GHz and 0.1dB Ripple in pass band up to 5GHz.

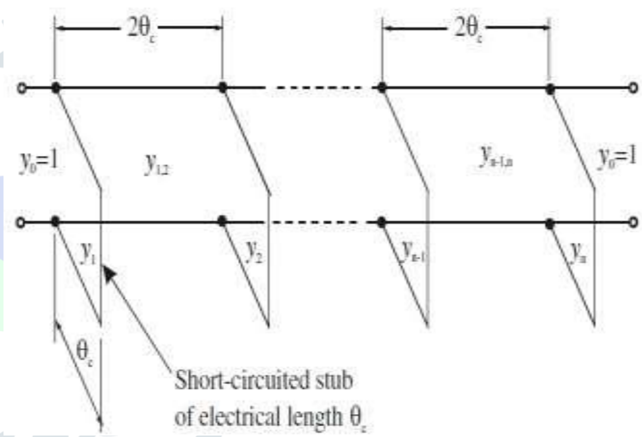


Figure 1: Optimum distributed high pass filter

As in figure, the electrical length Ɵc can be determined by equation (1) [3-6]:

$$\left(\frac{\pi}{\theta_c} - 1\right) f_c = 5 \quad (1)$$

With the help of Ɵc and order of high pass filter, element values of optimum distributed high pass filter with 0.1dB ripple was obtained. For given terminating impedance Z0 the associated impedance values can be determined by equation (2) and (3) [12]

Zi= Zo/Yi (2)

Zi,i+1= Zo/Yi,i+1 (3)

For i=1, 2......6

Synthesis of W/h [12]

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

With

$$A = \frac{Z_0}{60}\left[\frac{\varepsilon_r + 1}{2}\right]^{0.5} + \frac{\varepsilon_r + 1}{\varepsilon_r - 1}\left[0.23 + \frac{0.11}{\epsilon_r}\right]^{0.5} \quad (5)$$

Zc = Impedance (in Ohm) and εr (dielectric constant) = 4.4, W= width, h = height of dielectric which is taken as 1.6mm. Effective dielectric constant of dielectric material given by equation (6) and (7) [9]

For w/h≤1

$$\varepsilon_{re} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left(1+12\frac{w}{h}\right)^{-0.5} \quad (6)$$

For W/h>1

$$\varepsilon_{re} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left[\left(1+12\frac{w}{h}\right)^{-0.5} + 0.04\left(1-\frac{w}{h}\right)^2\right] \quad (7)$$

Whereas guided wavelength is given by equation (8).

$$\lambda_g = \frac{300}{f(GHz)\sqrt{\varepsilon_{re}}} \quad (8)$$

εe= Effective dielectric constant, f= 1.48 GHz Lengths of the elements (l) were determined by equation (9) [12].

$$\Theta c = \beta * l \quad (9)$$

Where β is the phase constant.

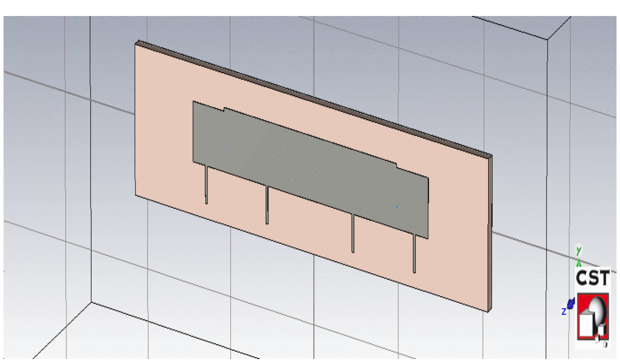
III. FILTER DESIGN

The dimensions of length and width of the elements was calculated using the Microstrip design equations for a resonant frequency fc = 2.5GHz. The dimensions of the element values for the 4th order of high pass filter at a cut off frequency fc 2.5GHz is shown in the table 1.

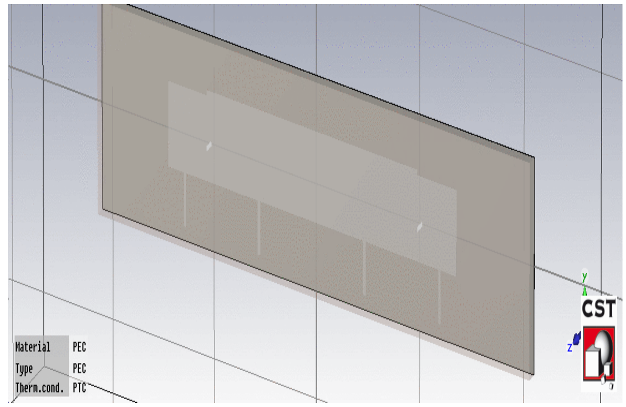
Element	Admittance Values (mho)	Impedance value(ohm)	Length of element (mm)	Width of element (mm)
Unit Element	$Y_{12}=Y_{34}$ =1.46	$Z_{12}=Z_{34}$ =45.75	$I_{12}=l_{34}$ =21.71	$W_{12}=W_{34}$ =3.037
	Y_{23}=1.025	Z_{23}=47.55	I_{23}=21.71	W_{23}=3.28
Short circuit Stub	$Y_1=Y_4$ =0.416	$Z^1=Z_4$ =121.26	$I_1=I_4$ =11.28	$W_1=W_4$ =0.42
	$Y_2=Y_3$	$Z_2=Z_3$=90 .45	$I_2=I_3$ =11.34	$W_2=W_3$ =0.96

TABLE1. Element values of the proposed configuration

The structure of proposed design for 4th order high pass filter is shown in figure 2. HPF is printed on the FR4 lossy substrate of dielectric constant 4.3, loss tangent 0.02 and thickness of 1.6mm. with dimension of length 80mm and width 25mm.



Front View



Back View

Figure2: Structure of Proposed 4th order HPF.

The DGS layout with wrist watch type shape and two circles has been considered. The other dimensions of proposed DGS are kept constant as in geometry without DGS. The DGS structure is shown in figure 4. The response of this proposed configuration after applying DGS is shown in figure 5. The radius of an etched circular ground structure is 5mm at the unit element which is placed at the exact middle portion of the proposed design and the radius of an etched circular ground structure is 2mm at the short circuit stubs which is nearer with the bigger circular structure of the ground plane.

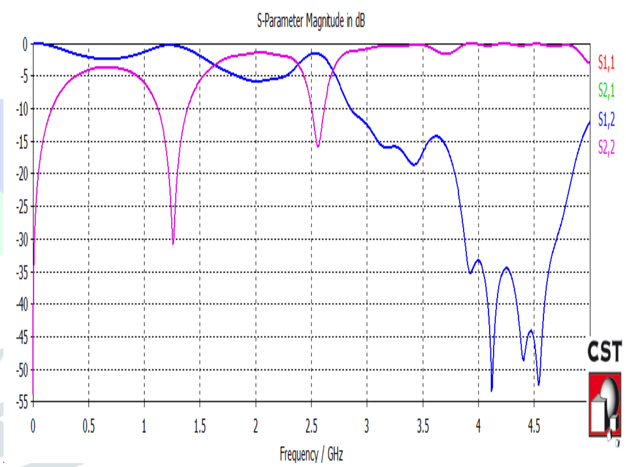


Figure 3: Simulated results of proposed HPF without DGS.

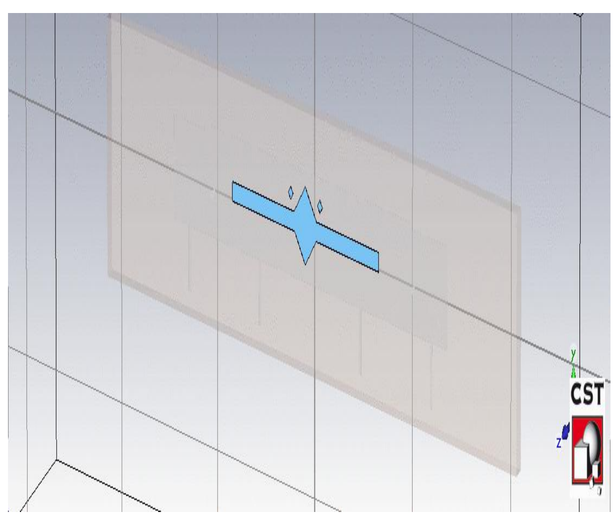


Figure 4: Back View of Proposed 4th order HPF using DGS.

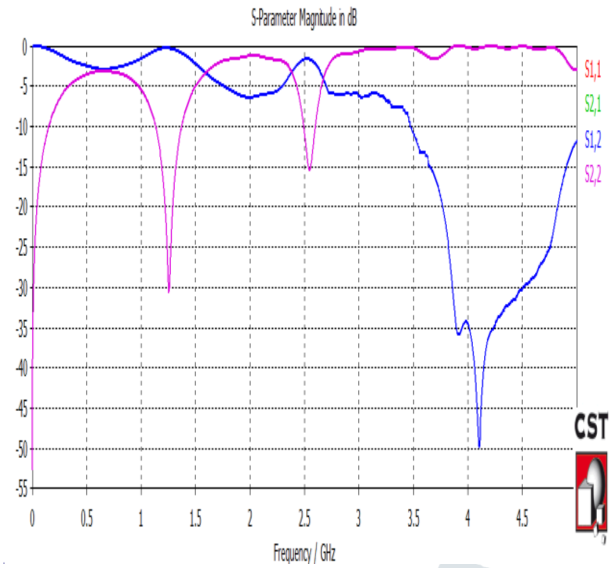


Figure 5: Simulated results of proposed HPF using DGS.

IV. RESULT AND DISCUSSION

The proposed structure of 4th order high pass filter was simulated using the CST Microwave Software. The simulated return loss of the proposed HPF is shown in the figure 3. With the use of SMA Connector of 50Ω at both the ports of filter, the response of the filter is symmetric at both the ports S11 = S22, S12 = S21. The graph shown in figure 3 shows that the cut off frequency is at 2.5GHz, means that the signals are allowed to pass above this frequency. An attenuation of - 55dB is provided below cut-off frequency. Return loss after 2.5 GHz is below -10 dB which shows perfect impedance matching for pass band. From the figure 5, it is clearly seen that the cut off frequency is same in both the designs. The return loss is about -26 dB above cut-off and attenuation below cut-off is -65 dB. A configuration of printed Microstrip high pass filter with and without using DGS shapes was proposed and analyzed at the centre frequency fc = 2.5GHz with the dielectric constant of 4.3 and at the height of 1.6mm. It has been found that results of HPF using DGS are better than the results of HPF where DGS is not applied. The sidebands fluctuations are reduced in this design.

REFERENCES

[1] Mukesh Kumar Khandelwal, Binod Kumar Kanaujia, SantanuDwari, Sachin Kumar, A.K. Gautam,,",Analysis and design of dual band compact stacked Microstrip patch antenna with defected ground structure for WLAN/WiMax applications" Journal of Electronics and Communications, Volume 69, Issue 1, Pages 39-47,January 2015.

[2] Ahmed Boutejdar, Mohamed Al Sharkawy and Abbas Omar, "A Simple Transformation of WLAN Band Pass to Low Pass Using Couple U-Defected Ground Structure (DGS) and Multilayer-Technique" Journal of Microwaves, Optoelectronics and Electromagnetic Applications, Volume 12, Issue 1, pp: 111-130, 2013.

[3] X.L. Guo, C. Xu, G.A. Zhang, Z.J. Zhang, H.H. Yin, Z.L. Wang "Tunable low-pass MEMS filter using defected ground structures (DGS)" Solid-State Electronics, Volume 94, Pages 28-31, April 2014.

[4] Dong-ming YUAN, Shu-wen ZHAO, Hong-xin ZHANG, Peng-fei HE ," Design and analysis of a structure-based micro strip band pass filter The Journal of China Universities of Posts and Telecommunications, Volume 21, Issue 4, Pages 64-67,95, August 2014.

[5] A.K. Verma, Ashwani kumar "Design Of Low Pass Filters Using Some Defected Ground Structure" Int. J. Electron. Commum. (AEU) 65, 2012. .

[6] Abhishek Singh Bhadoriya et.al. "Design and Performance Analysis of High Pass Filter with Modified Ground Structure for L Band" International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering, vol.06, issue 3 1791-1796, 2017.

[7] Jian-Kang Xiao, Yu-Feng Zhu "Multi-band bandstop filter using inner T-shaped defected microstrip structure (DMS)" - International Journal of Electronics and Communications, Volume 68, Issue 2, Pages 90-96,February 2014.

[8] Chang Chen, Weidong Chen, and Zhongxiang Zhang " A Novel Dual-Mode Bandpass Filter With DGS" progress in Electromagnetics Research Symposium Proceedings, Marrakesh, Morocco, Mar. 20-23, 2011.

[9] Jia-Sheng Hong, M. J. Lancaste "Microstrip filters for RF / Microwave Application" A Wiley-Interscience Publivation book.