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High Pass Filter Analysis using DGS

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Abstract- In this paper, performance of High Pass Filter (HPF) with and without Defected Ground Structure (DGS) has been analysed. The defected ground is in 'wrist watch' shape with two symmetrical circles on either side from centre. In this proposed paper, simulation has been done on both the designs separately and the results of both the designs have been compared. The cut- off frequency of filter is 1.5 GHz. The filter can be useful in various RF circuits where less fluctuations are required in pass band.

Keywords *–High Pass Filter (HPF), Computer Simulation Technology Software (CST), Defected Ground Structure (DGS).*

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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 passband 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 microstrip.

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. There are various different structures for implementing DGS [5]. By using these different DGS structures, filters, power divider, power amplifier etc were implemented [3-8]. PBG (photonic band gap) and EBG (electromagnetic band gap) structure are also a type of DGS, which is created by etching different periodic shapes in the ground plane. However, it is so difficult to use PBG structure for the design of the microwave or millimetre wave components due to the difficulties of the modulation and radiation from the periodic etched defects. So many etched shapes for the microstrip could be used as a unit DGS. An LC unit circuit can represent the unit DGS circuit.

They provide inductive and capacitive elements connected in series [1]. 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 in the case of BPF [7]. DGS has property of rejecting electromagnetic wave in certain frequency and direction, and most important function of these structures is the filtering of frequency bands, and harmonics of the filter in microwave circuit. 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

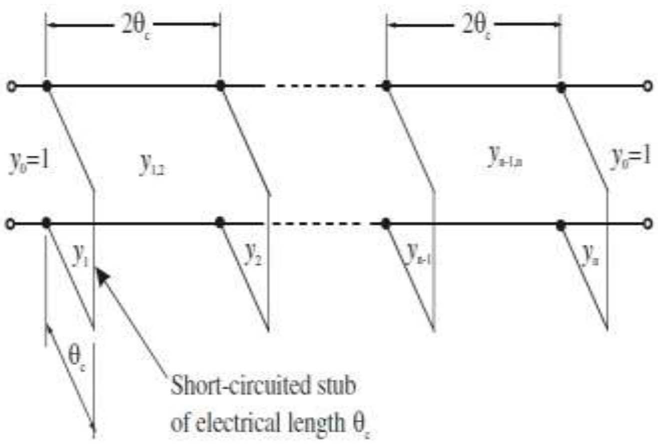

Figure 1: Optimum distributed high pass filter

The proposed high pass filter (HPF) consists of shunt short circuited stubs of electrical length ϴc at some specified frequency fc (usually the cut off frequency of HPF). These elements were separated by unit elements (UE) of length 2ϴc shown in the figure 1 [12]. In theory this type of filter has very wide band response for small ϴc 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 passband up to 5GHz. As in figure, the electrical length ϴc can be determined by equation (1) [12]:

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

With the help of Θ_c and order of high pass filter, element values of optimum distributed high pass filter with 0.1dB ripple was obtained. For given terminating impedance Z_0 the associated impedance values can be determined by equation (2) and (3) [12]

$$Z_i = Z_0/Y_i \quad (2)$$

$$Z_{i,i+1} = Z_0/Y_{i,i+1} \quad (3)$$

For i=1, 2….4

Synthesis of *W/h* [12]

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

With

$$A = \frac{Z_c}{60}\left[\frac{\varepsilon_r + 1}{2}\right]^{0.5} + \frac{\varepsilon_r + 1}{\varepsilon_r + 1}\left[0.23 + \frac{0.11}{\varepsilon_r}\right]$$

Where

Zc = Impedance (in Ohm) and ε_r (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) [12]

For W/h>1

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

For W/h>1

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

Whereas guided wavelength is given by equation (8)

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

ε_{re} = Effective dielectric constant , f= Cut off frequency

Lengths of the elements (l) were determined by equation (9) [12]

$$\Theta_c = \beta * l \quad (9)$$

Where β is the phase constant.

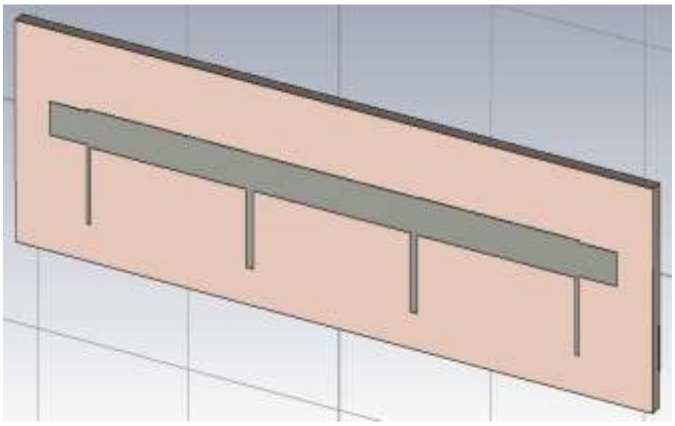
III. FILTER DESIGN

The dimensions of length and width of the elements was calculated using the microstrip design equation 1-7 for a resonant frequency fc = 1.5GHz. The dimensions of the element values for the 4th order of high pass filter at a cut off frequency fc 1.5GHz is shown in the table 1.

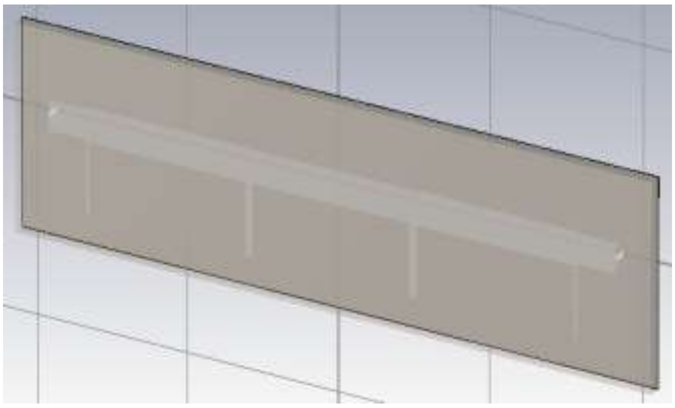
TABLE1. Element values of the proposed configuration

Element	Admittance Values (mho)	Impedance value(ohm)	Length of element (mm)	Width of element (mm)
Unit Element	$Y_{12}=Y_{34}$ =1.046	$Z_{12}=Z_{34}$ =47.76	$l_{12}=l_{34}$ =20.70	$W_{12}=W_{34}$ =3.37
	Y_{23}=1.027	Z_{23}=48.65	l_{23}=20.70	W_{23}=3.29
Short circuit Stub	$Y_1=Y_4$ =0.415	$Z_1=Z_4$ =120.25	$l_1=l_4$ =10.29	$W_1=W_4$ =0.41
	$Y_2=Y_3$	$Z_2=Z_3$=90.48	$l_2=l_3$ =10.33	$W_2=W_3$ =0.95

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 1.6 mm. with dimension of length 84mm and width 20mm.



A. Front View



B. Back View

Figure 2: Structure of Proposed 4th order HPF.

The another 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.

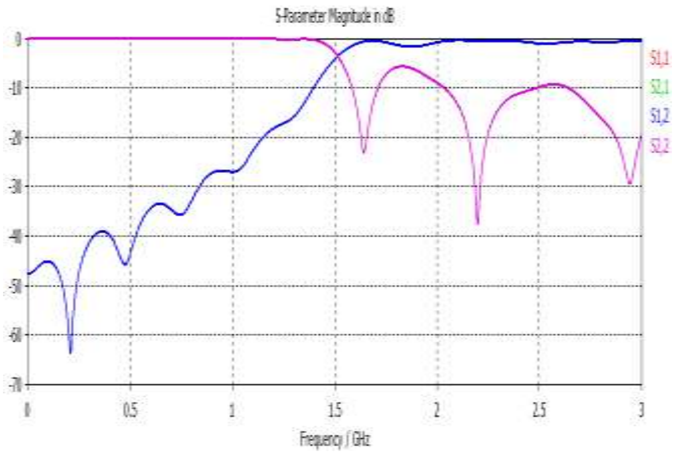


Figure 3: Simulated results of proposed HPF

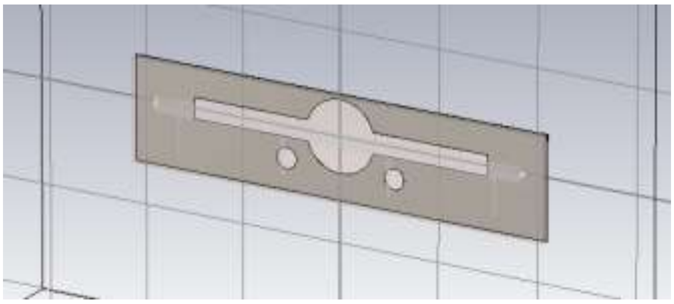


Figure 4: Back View of Proposed 4th order HPF using DGS.

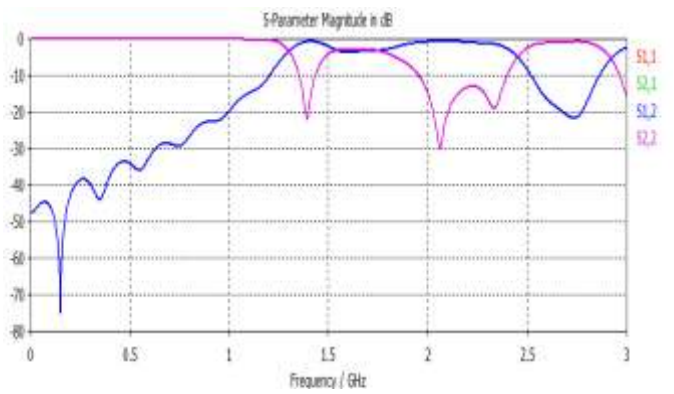


Figure 5: Simulated results of proposed HPF using DGS

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.

$S_{11} = S_{22}$, $S_{12} = S_{21}$

The graph shown in figure 3 shows that the cut off frequency is at 1.5GHz, means that the signals are allowed to pass above this frequency. An attenuation of - 63dB is provided below cut-off frequency . Return loss after 1.5 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 -30 dB above cut-off and attenuation below cut-off is -75 dB.

A configuration of printed microstrip high pass filter with and without using DGS shapes was proposed and analyzed at the centre frequency f_c=1.5GHz 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.

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REFERENCES

[1] David M. Pozar, “Microwave Engineering”, 3rd Ed., John Wiley & Sons Inc., New York, 2005.
[2] Shao Ying Huang, Yee Hui Lee “Compact U-Shaped Dual Planar EBG Microstrip Low-Pass Filter” IEEE Transactions on Microwave Theory and Techniques VOL.53, No.12, Dec-2005
[3] Atallah Balalem, Ali, Jan Machac “Quasi-Elliptic Microstrip Low-Pass Filters Using an Interdigital DGS”IEEE Microwave and Wireless Components letters 1531-1309 2007.
[4] H. Oraizi and m. S. Esfahlan “Miniaturization of Wilkinson Power Dividers by Using Defected Ground Structures” progress in Electromagnetics Research Letters, vol.4, 113-120, 2008
[5] Weng, L. H., Y. C. Gue, X. W. Shi, and X. Q. Chen, “An overview on defected ground structure,” Progress In Electromagnetics Research B, Vol. 7, 173–189, 2008.
[6] Kamaljeet Singh and K. Nagachenchaiah “Very Wideband, Compact Microstrip Bandstop filter Covering S-Band to Ku-Band”. International Journal of Microwave Science and Technology H.P.Corporation Volume 2010, Article ID 624849.
[7] Chang Chen, Weidong Chen, and Zhongxiang Zhang “ A. in Electromagnetics Research Symposium Proceedings, Marrakesh, Morocco, Mar. 20-23, 2011.
[8] A. Boutejdar, A. Omar, “Compensating For DGS Filter Loss”, Microwave & RF Journal [Design Features], Issue February. 2012, pp. 68-76.
[9] A.K. Verma, Ashwani kumar “Design Of Low Pass Filters Using Some Defected Ground Structure” Int. J. Electron. Commum. (AEU) 65 (2012) 864-872.
[10] J.-K.Xiao and Y.-F. Zhu “New U-Shaped DGS Bandstop Filters” progress in Electromagnetics Research C, vol.25, 179-191, 2012

ISSN: 2321-8169
3930 - 3933

[11] 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.

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

[13] CST (computer Simulation Technology) microwave software.

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