Design and Analysis of High Pass Filter with Modified Ground T-Shape Structure for L Band Telecommunication User for 1800-1900 MHz

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***Abstract*— The performance of a high pass filter (HPF) with and without modified T shape ground structure for L Band telecommunication user for 1800-1900 MHz is analyzed in this specific work. The modified ground structure includes T etched shape in ground plane. Calculation and comparison of the response of both shape filters was done separately. Parameters of the proposed configuration were calculated at the center frequency of 1.48 GHz and also proposed designs 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 reduced by using modified ground structure. Also the cutoff point of the high pass filer is shifted to a higher frequency and an improvement in selectivity.**

Keywords*— High pass filter (HPF), Modified Ground Structure, and Computer Simulation Technology Software (CST)

1. INTRODUCTION

For designing high performance and compact filters, a modified ground structure has been widely used. A modification on ground can change the propagation properties of a transmission line by changing current distribution and applied field between the ground plane and upper surface. There are various different structures for implementing DGS [1]. By using these different DGS structures filters, power divider, power amplifier etc. was implemented [2]-[9]. 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 so difficult to use PBG structure for the design of the microwave or millimeter wave components due to the difficulties of the modulating and radiation from the periodic etched defects.

So many etched shapes for the micro strip 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 [10]. Which remove undesired output response fluctuations; move the high pass filer frequency limit to a higher value and the selectivity of a particular band. 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.

2. IMPLEMENTATION OF 5TH ORDER 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).

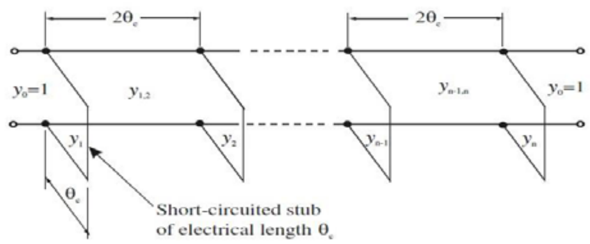

Figure 1: Optimum distributed high pass filter [12].

To design high pass filter let us consider the cut off frequency fc=1.48GHz and 0.1dB Ripple in pass band up to 3GHz. As in figure the electrical length ϴc can be determined by equation (1) [12]:

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

By this, ϴc =300 and for proposed 5th order filter shown in figure 2 have element values given in table 1. For given terminating impedance Z0 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......6

Synthesis of *W*/*h* [12]

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

With

$$A = \frac{z_0}{60}\left[\frac{\varepsilon_r+1}{2}\right]^{0.5} + \frac{\varepsilon_r+1}{\varepsilon_r-1}\left[0.23 + \frac{0.11}{\varepsilon_r}\right]^{0.5} \quad (5)$$

Where

Zc = Zo = 50Ω 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

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

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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)

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

εre = 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. For designing HPF T rectangular shape DGS were proposed. Length and width of rectangle is taken as 28, 11 and 7, 2 mm respectively.

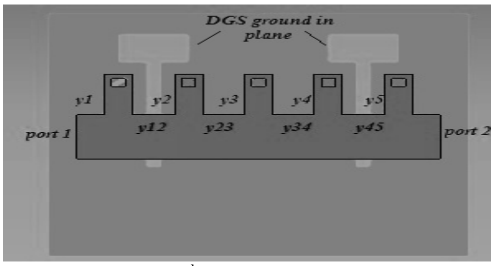


Figure 2: proposed 5th order high pass filter with DGS

The element value of the proposed configuration is y1 =y2 =10mm y3 =y4=y5=10mm and y12=y23=y34=y45=6mm. And also the length between y12 and y23 is taken as 4 mm. And the rectangular hole of 2×2mm to connect PEC to the ground structure.

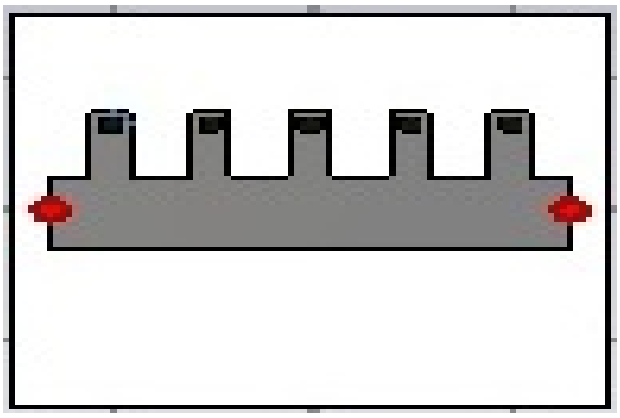


Figure 3: (a) front view of the high pass filter.

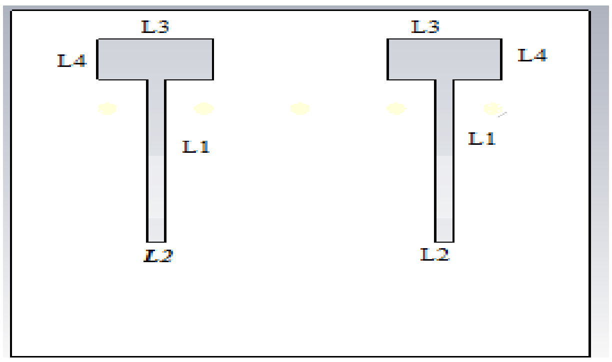


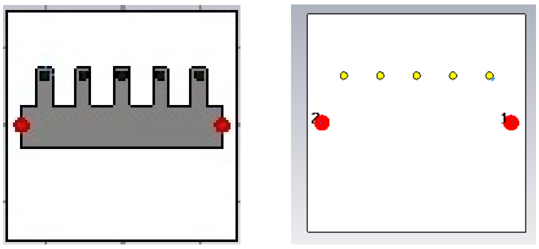
Figure 3: (b) bottom view of the high pass filter.

The proposed DGS unit has the dimensions of L1=28mm, L2=2mm, L3=11mm and L4=7mm.

3. RESULT

5^{TH} order high pass filter

The simulation of 5^{th} order high pass filter is shown in fig 4. FR4 lossy material with dielectric constant 4.4, loss tangent .02 and height of substrate 1.6mm are used in design. The graphs obtain after the simulation (CST software [13]) of high pass filter without defected ground structure are shown in fig5. CST software for electromagnetic analysis design in high frequency range. The most useful toll is transient solver, which is used to simulate any design. In this proposed work the result is calculated in 0-3GHz frequency range only for calculating the response of high pass filter without DGS structure of L band telecommunication user for 1800-1900 MHz.



(a) **(b)**

Figure 4: (a) Top view of HPF (b) bottom view of HPF

The graph show in figure 5 shows the cut off frequency at 1.48GHz means that the signals were passing after this frequency. Also before 1.48GHz the signal shows attenuation of 30 to -70 db means perfect stop band. Return loss after the 1.48GHz signal shows perfect impedance matching after this frequency.

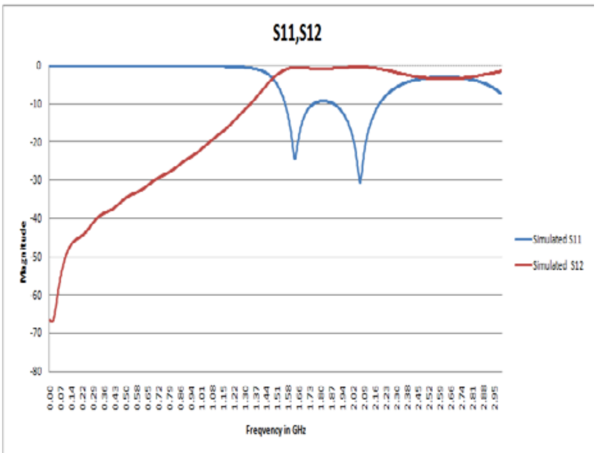


Figure 5: Graph of HPF without DGS

Another simulated result of using DGS (etched T shape on ground plane) is shown in figure 6. The graph shown in figure 6 after applying the DGS the cutoff point is shifted the 1.68GHz, which shows that the above 1.68GHz has were passes with negligible attenuation and signals below 1.68GHz is attenuation by up to 40 dB. By comparing both the results (figure 5 and figure 6), it has been found that the cutoff point changes after applying DGS and also reduced sidebands and fluctuation of the output is achieved. So for the application of L band telecommunication user for 1800-1900 MHz where we require increasing in passband using same size filter the use of DGS is advantageous. It shows that further improvement in the cut off point will be achieved by using DGS in this design of high pass filter.

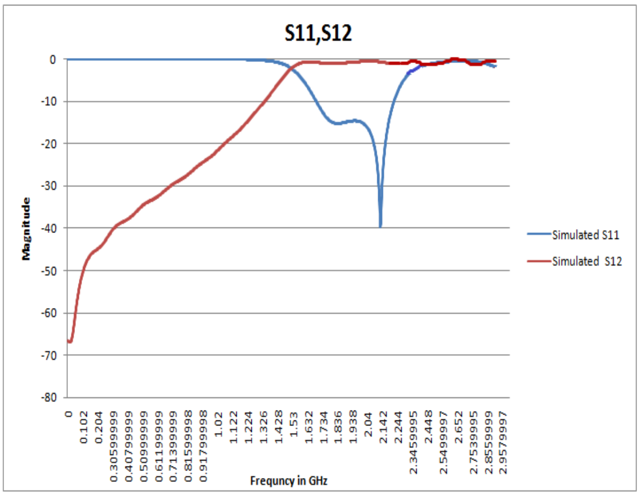


Figure 6: graph of HPF with DGS

4 CONCLUSION

The proposed design was implemented and analyzed at the centre frequency fc=1.48GHz for HPF. It has been found that measured results are in good agreement with the simulated value. In the case of the HPF the cutoff point has been shifted to a higher frequency and sideband fluctuation was removed and also the return loss is minimized -35 to -40db. So for the application for the L band telecommunication user for 1800-1900 MHz where shifting of cut off, reduced level of fluctuation of response of HPF then use of DGS for designing filter should be proposed.

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