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Design of Microstrip High Pass Filter using Optimum Distributed Technique for GSM Applications

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Abstract— in this paper, we propose a microstrip high pass filter using optimum distributed technique for GSM Applications. Here we designed 5th order High Pass Filter at 1.8 GHz and it is implement on FR4 substrate of relative permittivity 4.3, loss tangent 0.02 with a thickness of 1.6mm.The performance of HPF is improved by using Defected Ground Structure which is rectangular in shape. Two slots at Left hand side and two slots at right hand are of same size and symmetric in nature along with the middle slot of comparatively big size are chosen in parallel . All the dimensions of Microstrip HPF is calculated with the help of optimum distributed approach at 1.8 GHz resonant frequency. Emerging applications such as wireless communications continue to challenge RF/microwave filters with ever more stringent requirements like higher performance, smaller size, lighter weight, and lower cost. Results are simulated using computer simulation technology software (CST).

Keywords— High Pass Filter, Microstrip Filter, Optimum Distributed Filter, Chebyshev Filter, Quasilumped Elements Filter.

I. INTRODUCTION

Filters are mainly frequency selective elements. A network that is designed to attenuate certain frequencies but pass other frequencies without any loss is called a filter. The filtering behavior results frequency dependent reactance providing by inductors and capacitors. Typically frequency response include low-pass, high pass, band pass and band stop characteristics. A microwave filter is a two-port network which is 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 stopband of the filter. Depending on the requirements and specifications, RF/microwave filters may be designed using lumped element or distributed element circuits [1].Now days Microwave filter are widely used in industry and also fulfill the demand of advanced communication systems. To design compact and high performance 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 of DGS are available [2-3]. By using these different DGS structures filters, power divider, power amplifier etc. was implemented. 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 [4].

Microstrip could be a variety of electrical cable, which may be made-up victimization computer circuit board [PCB] technology and is employed to convey microwave-frequency signal. Stepped impedance consists of high and low impedance transmission lines in cascaded structure. The high-impedance lines act as series inductors and the low-impedance lines act as shunt capacitors. It consists of a conducting strip separated from a ground plane by dielectric layer known as the substrate [5-7].

Microstrip has many advantage over traditional waveguide like it is much less expensive, lighter in weight and more compact. For lowest value, microstrip devices could also be designed on a standard FR-4 (standard PCB) substrate victimization insertion loss technique. In this proposed work a rectangular shape of DGS is used to improve the parameters of the filters like return loss, transmission coefficient etc.

II. IMPLEMENTATION OF 5TH ORDER HIGH PASS FILTER

High pass filter can be easily designed based on a lumped-element low pass prototype [9-10].High pass filters can be constructed from distributed elements such as commensurate (equal electrical length) transmission-line elements is shown in Figure 1, which consists of a cascade of shunt shortcircuited stubs of electrical length θ_c at some specified frequency fc (usually the cutoff frequency of high pass), separated by connecting lines (unit elements) of electrical length $2\theta_c$. Although the filter consists of only n stubs, it has an insertion function of degree 2n – 1 in frequency so that it's high pass response has 2n – 1 ripples. The typical transmission characteristic of this type of filter, where f is the frequency variable and θ is the electrical length, which is proportional to f. [3]

$$\theta = \theta_c \frac{f}{f_c} \qquad (1)$$

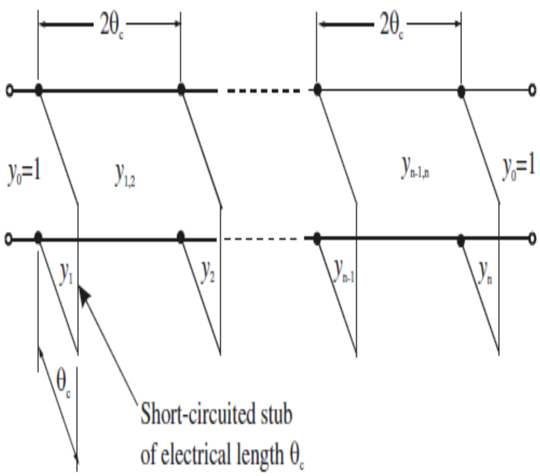


Figure 1: Optimum distributed high pass filter

To design high pass filter with the cut off frequency fc=1.8 GHz and 0.1dB Ripple in passband up to 7.8 GHz.
As in figure the electrical length Ɵc can be determined by equation (2): [4-5]

$$\left(\frac{\pi}{\theta_c} - 1\right) f_c = 7.8 \qquad (2)$$

By this, Ɵc =33.75° and for proposed 5th order high pass filter have element values given in table 1. For given terminating impedance Zo the associated impedance values can be determined by equation (3) and (4)

$$Z_i = Z_0/Y_i \qquad (3)$$

$$Z_{i,i+1} = Z_0/Y_{i,i+1} \qquad (4)$$

For i=1, 2......6
HPF was design at the cut off frequency of fc=1.8 GHz and formula which is used for the design of HPF is Synthesis of W/h

$$\frac{W}{h} = \frac{8\,e^{A}}{e^{2A} - 2} \qquad (5)$$

With

$$A = \frac{Z_c}{60}\left[\frac{\varepsilon_r + 1}{2}\right]^{0.5} + \frac{\varepsilon_r + 1}{\varepsilon_r + 1}\left[0.23 + \frac{0.11}{\varepsilon_r}\right] \qquad (6)$$

Where Zc= Zo = 50Ω and εr (dielectric constent) = 4.4, W= width, h= height of dielectric which is taken as 1.6mm. Effective dielectric constant of dielectric material given by equation (7) and (8)
For W/h ≤ 1:

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

For W/h>1

$$\varepsilon_{re} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[\left(1 + 12\frac{h}{w}\right)^{-0.5} + 0.04\left(1 - \frac{w}{h}\right)^2\right] \qquad (8)$$

Whereas guided wavelength is given by equation

$$\lambda_g = \frac{300}{f(\mathrm{GHz})\sqrt{\varepsilon_{re}}} \qquad (9)$$

εre = Effective dielectric constant , f= 1.8 GHz.
Lengths of the elements (l) were determined by equation (10)

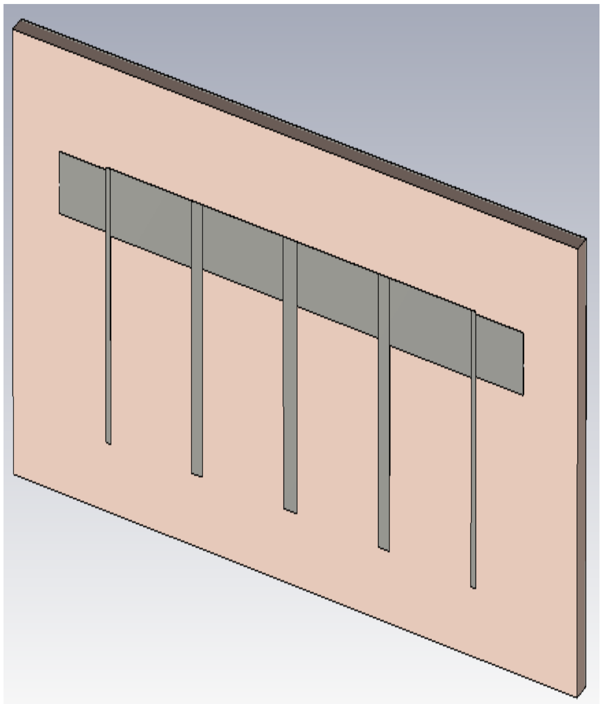
$$Ɵc = \beta * l \qquad (10)$$

Where β is the phase constant.

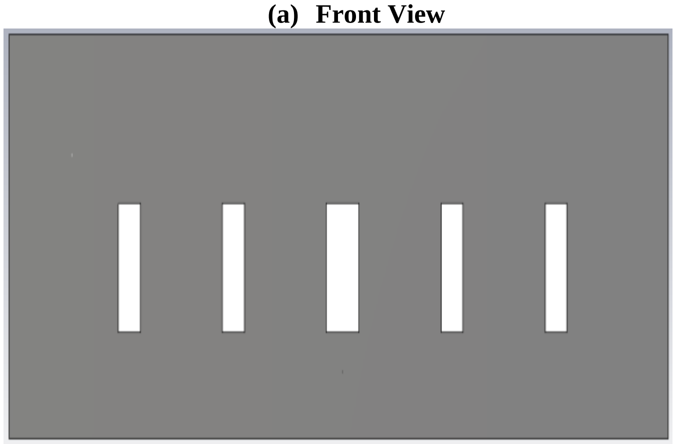
Table 1: Element values of the proposed configuration

Parameters	Unit Element (UE)	Short Circuit Stub (SC)
Admittance values (mho)	$Y_{1,2}$= 1.03872 $Y_{2,3}$=1.01187 $Y_{3,4}$=1.01187 $Y_{4,5}$=1.03872	Y_1=0.43734 Y_2=0.60563 Y_3=0.66389 Y_4=0.60563 Y_5=0.43734
Impedance values (ohm)	$Z_{1,2}$= 48.136 $Z_{2,3}$= 49.413 $Z_{3,4}$= 49.413 $Z_{4,5}$= 48.136	Z_1= 114.328 Z_2= 82.559 Z_3= 75.314 Z_4= 82.559 Z_5= 114.328
Length of the element (mm)	$l_{1,2}$= 8.62 $l_{2,3}$= 8.64 $l_{3,4}$= 8.64 $l_{4,5}$= 8.62	l_1= 9.10 l_2= 8.94 l_3= 8.88 l_4= 8.94 l_5= 9.10
Width of the element (mm)	$w_{1,2}$= 3.313 $w_{2,3}$= 3.172 $w_{3,4}$= 3.172 $w_{4,5}$= 3.313	w_1= 0.493 w_2= 1.18 w_3= 1.45 w_4= 1.18 w_5= 0.493

The proposed design of 5th order microstrip high pass filter shown in figure 2(a) and 2(b).



(a) Front View



(b) Back View

Figure 2 (a) Front view of the designed microstrip Optimum Distributed HPF (b) Back view of the designed microstrip HPF with rectangular slots.

The geometry of proposed 5th order high pass filter is symmetric like unit element 1-2 and 4-5, 2-3 and 3-4 are of same size. Also short circuit stubs like 1 and 5, and 2 and 4 are of same size.

In the ground plane, five rectangular shaped slots are created to enhance the performance of high pass filter. Like unit element & short circuit stub geometry, dimension of all rectangular slots except middle slot are of same size and symmetry.

The dimensions of all rectangular shaped slots in ground plane are shown in table 2.

Table 2: Dimension of Rectangular slots of ground plane

Rectangular Slots	Length	Width
Slot 1, 2, 4 and 5	2	2
Slot 3	3	7

The rectangular slots produce in a ground plane make a ground plane to be defected, called Defected Ground Structure (DGS).

III. Results Analysis and Discussion

The response of proposed 5th order HPF is obtained using CST Software [11] as shown in figure 3. From the figure it is clear that the cut-off frequency is found to be 1.8 GHz at -3dB. Hence proposed high pass filter using optimum distributed approach is capable of passing the frequency greater than 1.8 GHz & reject the frequency below 1.8 GHz.

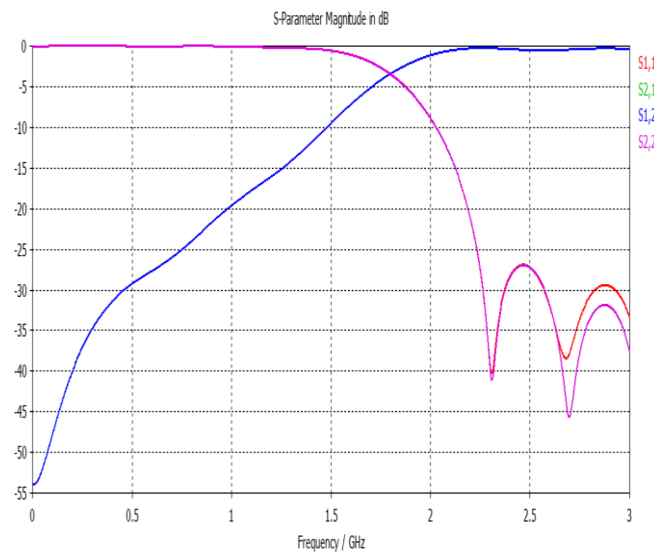


Figure 3: Simulated result of 5^{th} order high pass filter with DGS.

Table 3: Comparison of results of proposed work with Reference paper [12]

parameters	Makrariya's et.al (ref 12)	Proposed work
cut off frequency	fc=2.4hz	fc=1.8hz
Permittivity	4.4	4.3
Response	at -5db	at -3db
Ripple Passband	0.1db up to 10.44hz	01.db up to 7.8hz

From the above table, we can say that Makrariya's et.al (ref 12) proposed high pass filter which is designed at 2.4 GHz. The response of filter was obtained at -5dB return loss with many high order harmonic fluctuations. Hence as a suggested improved design, the response of filter is obtained at -3dB with less number of high order harmonic fluctuations. The elimination of high order fluctuations is removed with the help of Defected Ground Structure in our proposed design which is absent in Makrariya's et.al (ref 12).

IV. CONCLUSION

The proposed structure of 5th order high pass filter simulated using the CST Microwave Software. From simulated results we can conclude that propose work is more effective than Makrariya's et.al (ref 12) on basis of various parameters as shown in table 3.in the present work Fifth order Optimum Distributed High Pass Filter is design and simulate at the frequency of 1.8 GHz for GSM Applications using rectangular shaped ground defected structure to enhance the performance of high pass filter. This frequency of filter is widely used for GSM band applications.

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