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# DESIGN OF STEPPED IMPEDANCE LOW PASS FILTER AT 2.4GHz

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## ABSTRACT

In this era, life can't be envisioned without wireless communication. The microwave filter is a component which gives frequency selectivity in mobile, radar, satellite communication systems working at microwave frequency. Microwave low pass filter attenuates the unwanted signal above cut off frequency. For stepped impedance filter design high and low impedance lines are used. This paper describes designing of Chebyshev approximated stepped impedance low pass filter at 2.4 GHz with the permittivity of value 4.2 and the height/thickness of the substrate is 1.6mm for the order n=3. Designed filter is simulated using Computer Simulation Technology.

**KEYWORDS**: Low Pass Filter, Stepped Impedance, FR4 Substrate, Computer Simulation Tool.

## INTRODUCTION

A filter is a two-port system used to control the frequency response at one point in an RF or microwave system by giving transmission at frequencies inside the pass band of the filter and constriction in the stop band of the filter [1]. General structure of the stepped-impedance low pass filter utilize a cascaded structure of alternating high- and low impedance transmission lines, such filters are normally alluded to as stepped-impedance, or hi-*Z*, low-*Z* filters [2]. A low-pass filter has numerous helpful properties like simple fabrication, compact size, and very low insertion loss. Henceforth, it has expanded applications in cellular mobile communication and microwave circuits [2]. In present days neural system models are utilized broadly for wireless communication engineering, which disposes of the complex and tedious scientific methods [3].This paper exhibits the design of third order stepped impedance low pass filter at frequency 2.4Ghz utilizing CST software [4].

## FILTER DESIGN METHOD

The design of low pass filters includes two principle steps. The first one is to choose a suitable low pass model. the type of response, including pass band ripple and the number of reactive elements (order of the filter) will rely on upon the required details. the cutoff frequency $\Omega_c$=1.0 having normalized element values $g_o = g_4 = 1$, $g_1= g_3$=1.0316 and $g_2$=1.1474. The normalized element are then changed to L-C components for the craved cut off frequency $f_c$ and normally 50Ω source impedance is use for microstrip filter [1]. In this paper cutoff frequency of 2.4Ghz , the FR4 (lossy) substrate having 4.2 dielectric constant with 1.6mm thickness has been utilized. The filter design steps are as follows:

Determine the number of sections from the specification characteristics for micro strip parameters.
Filter Specifications:
Relative Dielectric Constant $\varepsilon_r$ =4.2
Cutoff frequency=2.4GHz
Height of substrate, h=1.6mm
The filter impedance Z0 =50Ω
The loss tangent tanδ=0.02
The highest line impedance $Z_H=ZO_L$=120Ω
The lowest line impedance $Z_L=ZO_C$=20Ω
$\Omega_C$=1

2. We have taken the element value for low pass filters from Table 3.2 [2] for n=3.

3. To calculate the width of capacitor and inductor we use the following formula [1].

For $\frac{W}{h} < 2$

$$\frac{W}{h} = \frac{8\exp(A)}{(\exp(2A)-2)} \qquad (1)$$

Where, $A = \frac{Z_c}{60}\sqrt{\frac{\varepsilon_r+1}{2}} + \frac{\varepsilon_r-1}{\varepsilon_r+1}\left(0.23 + \frac{0.11}{\varepsilon_r}\right) \quad (2)$

Where $z_c = \frac{\eta}{2\pi}\sqrt{\varepsilon_{re}}[\ln(\frac{8h}{w} + 0.25\frac{w}{h})] \quad (3)$

Where $\eta = 120\pi$ ohms is the wave impedance in free space.

For $\frac{W}{h} > 2$

$$\frac{W}{h} = \frac{2}{\pi}\left[B - 1 - \ln(2B-1) + \frac{\varepsilon_r - 1}{2\varepsilon_r}\left\{\ln(B-1) + 0.39 - \frac{0.61}{\varepsilon_r}\right\}\right] \qquad (4)$$

The effective dielectric constant can be found by the following formula [7]

$$\varepsilon_{re} = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_r-1}{2}\left[1 + 12\frac{h}{w}\right]^{-0.5} \qquad (5)$$

Effective wavelength is also found as [2]

$$\lambda_{ge} = \frac{\lambda}{\sqrt{\varepsilon_{re}}} \qquad (6)$$

4. The electrical lengths of inductors and capacitors areas of the transmission line are acquired by following equations

$\beta l = Z_o L / Z_{high}$

$\beta l = C Z_{low} / Z_0$

## DIMENSION OF THE FILTER

***Table 1: Dimensions of the Stepped Impedance Low Pass Filter (For N=3)***

| Section | $Z_l$ or $Z_H$ | Width in mm | Length in mm |
|---|---|---|---|
| 1 | 125 | 0.36 | 10.4 |
| 2 | 25 | 7.8 | 4.6 |
| 3 | 125 | 0.36 | 10.4 |

## SIMULATION RESULT

For simulation of third order stepped impedance low pass filter we have used CST software. The Layout of LPF is Shown in Fig.1 and Simulated result of LPF is shown in Fig.2

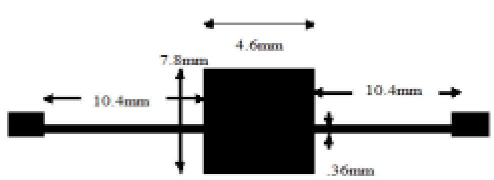


***Fig-1:The designed LPF***

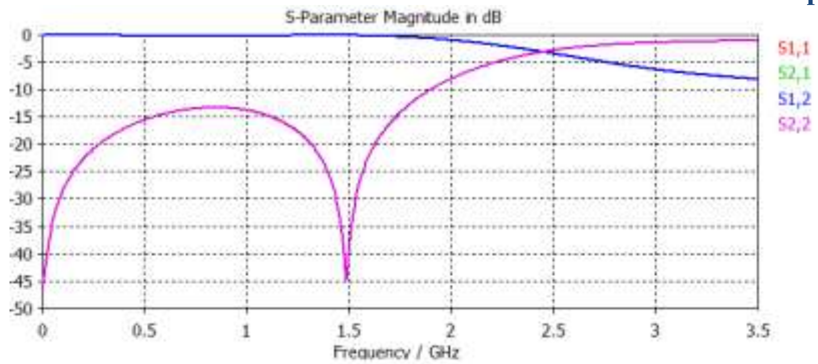


***Fig.2 CST performance of LPF***

## RESULT & ANALYSIS

The Simulated filter as shown in Figure 1 and 2 shows the geometry & response of low pass filters for n=3.The graph is plotted by taking gain (dB) on the Y-axis and frequency in GHz on the X-axis. From the graph it is clear that the cut-off frequency is found to be 2.4 GHz for stepped-impedance low pass filter. Hence the stepped impedance low pass filter is capable of passing the frequency less than 2.4 GHz & rejects the frequency after 2.4GHz for the thickness of the substrate 1.6mm and also has the return loss performance up to -39 dB and insertion loss -3 dB.

## CONCLUSION

The filters are one of the primary and necessary components of a microwave system and they are the very essential part of the microwave system, not only in microwave are they very important in communication field. In conclusion, the authors believe that the design can be archived compact filter design. The conventional geometry of the stepped-impedance low pass filter, shown in fig1 and the simulated response of the conventional geometry shown in fig2. The proposed filter has the return loss performance up to -39 dB and insertion loss -3 dB.

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