iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 3 **Issue:** V **Month of publication:** May 2015

DOI:

Volume 3 Issue V, May 2015
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

Design and Simulation of Sixth order parallel coupled line band pass Chebyshev filter

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Abstract: The aim of this paper is to simulate sixth order 16.5 Ghz parallel coupled line Chebyshev band pass filter with 0.1db ripple. Simple simulation study and calculation are presented with RT duroid 5880 substrate. Element values determination formulas are expressed in terms of microstrip line impedances. To study the simulation ADS software is used and both forward transmission |S11| and reflection coefficient |S21| are represented. The result shows that filter works well at operating frequency.
Keywords Band passes filter, Chebyshev, parallel coupled line.

I. INTRODUCTION

A filter is a frequency selective two port network which passes the desired frequency from a group of frequencies. Filter is an important component in RF and microwave application. Nonlinear circuits such as mixers and amplifier usually generate unwanted frequency components such as image signals, distortion etc. these signal degrade the system performance.

In recent communication there is a need for high performance, small size, light weight and low cost band pass filter. Parallel coupled microstrip line filter are widely used in RF front end of both microwave and wireless communication. This paper focuses on the performance of parallel coupled line microstrip band pass asymmetrical filter of quarter wavelength transmission line.

A. Filter Design

In this paper the filter is designed using Chebyshev low pass prototype. The element values for 0.1db ripple are taken from [1-5] after that these values are assigned to LC elements. Based on the desired attenuation i.e. 40db the value of n is selected which determines the order of filter.

g0	g1	g2	g3	g4	g5	g6	g7
1	1.1681	1.4040	2.0562	1.5171	1.9029	0.8618	1.3554

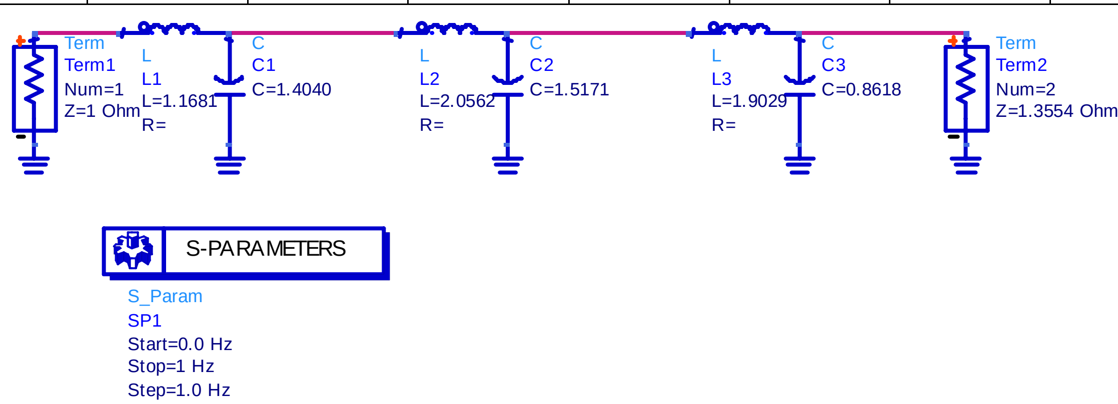

Fig 1: Low Pass Prototype

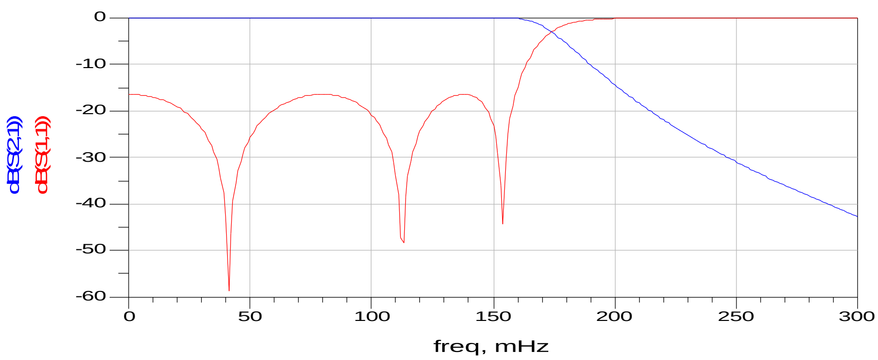

Fig 2: Simulated S21 and S11 of Low Pass Prototype

The next step is to find the lumped element values of LC section of band pass filter using frequency and impedance scaling. The frequency is scaled to the desired mid band frequency of 16.5Ghz and the source impedance is scaled to 50Ω.

$$Ls=\left(\frac{\Omega c}{BW}\right)\gamma 0 gi$$ where Ωc =cutoff frequency

BW =bandwidth

$\gamma 0$ =50 Ω

gi =corresponding element value

$$Cs=\frac{1}{\omega_0^2 L_s}$$ where $\omega_0^2 = 2\Pi f_1 * 2\Pi f_2$

Similarly,

$$Cp=\left(\frac{\Omega c}{BW*\gamma 0}\right)gi$$ and

$$Lp=\frac{1}{\omega_0^2 C_p}$$

After scaling the circuit diagram along with response is shown

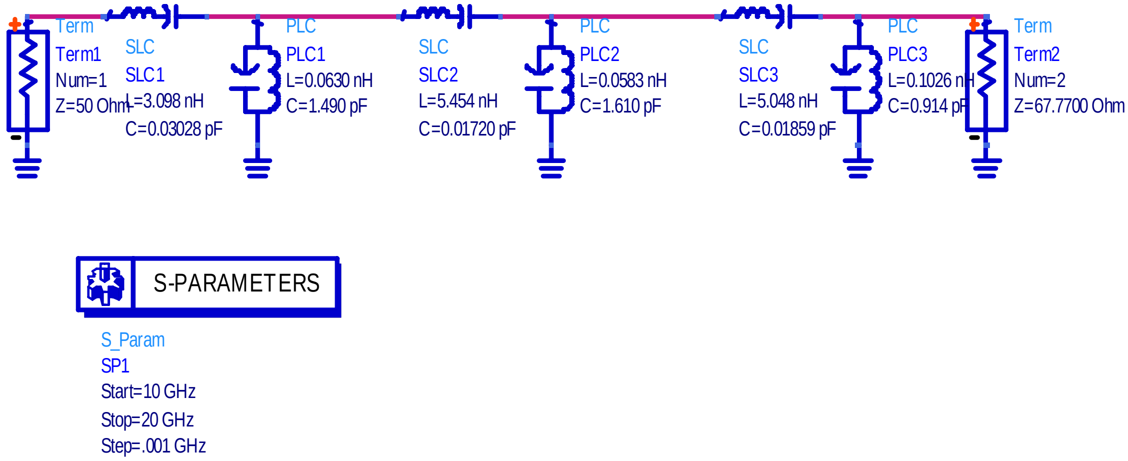

Fig 3 Converted version of LPP to BPF

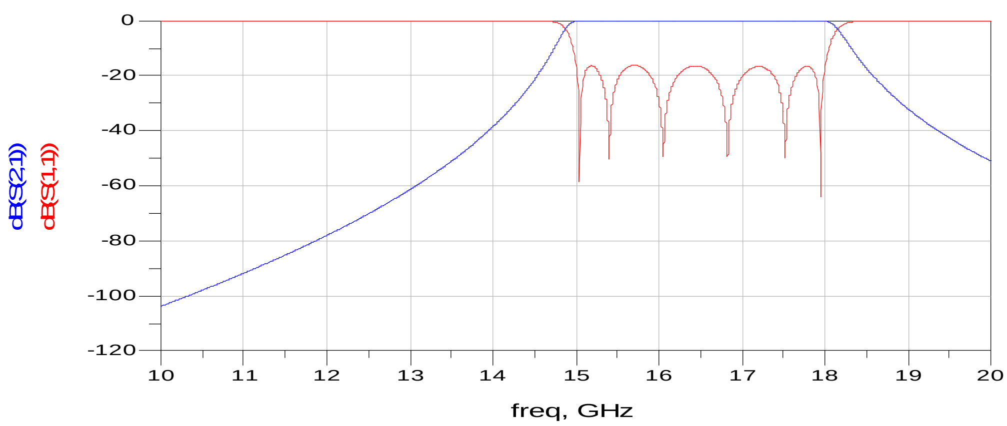

Fig 4 Simulated lossless response of Band pass filter

Since, at high frequency the dimension of the device becomes comparable to the wavelength of operation so there is a need to convert lumped circuit diagram into microstrip transmission line structure. To convert the circuit into corresponding transmission lines the even and odd impedances are determined using the admittance inverters. The design equations for this type of filter are given by

$$\frac{J_{o1}}{Y_o} = \sqrt{\frac{\pi \text{ FBW}}{2 \text{ g}_0 \text{ g}_1}}$$

$$\frac{J_{j,j+1}}{Y_o} = \frac{\pi \text{FBW}}{2} \sqrt{\frac{1}{\text{g}_0 \text{ g}_1}} \quad \text{for J=1 to n-1}$$

$$\frac{J_{n,\,n+1}}{Y_o} = \sqrt{\frac{\pi \ \mathrm{FBW}}{2\ g_n\ g_{n+1}}}$$

where *g0*, *g*1… *gn* are the element of a ladder-type low-pass prototype with a Normalized cutoff $\Omega c = 1$, and *FBW* is the fractional bandwidth of band-pass filter. $J\ j, j+1$ are the characteristic admittances of *J*-inverters and Y0 is the characteristic admittance of the terminating lines.

To realize the *J*-inverters obtained above, the even- and odd-mode characteristic impedances of the coupled microstrip line resonators are determined by

$$(Z_{oe})_{j,\,j+1} = \frac{1}{Y_0}\left[1 - \frac{J_{j,\,j+1}}{Y_0} + \left(\frac{J_{j,\,j+1}}{Y_0}\right)^2\right]$$

for j=0 to n

$$(Z_{0o})_{j,\,j+1} = \frac{1}{Y_0}\left[1 - \frac{J_{j,\,j+1}}{Y_0} + \left(\frac{J_{j,\,j+1}}{Y_0}\right)^2\right]$$

for j=0 to n

Using above design equations yield the design parameters, which are tabulated as follows:

Table 1

S.No	W(width)	L(length)	S(height)
1	3.011440	1.871460	0.049951
2	3.960950	1.839140	0.495784
3	4.144790	1.832760	0.874624
4	4.161480	1.832200	0.933172
5	4.144790	1.832760	0.874624
6	3.960950	1.839140	0.495784
7	3.011440	1.871460	0.049951

The dimensions of the parallel line for the filter are determined using the line calc tool in ADS also verified by equations. The correction factor of 0.165b, where b is the ground plane spacing is subtracted from the basic length L of quarter wavelength.

II. RESULT AND CONCLUSION

The simulated and optimised result of S parameter is studied. All formulas are first coded in Matlab. Wider bandwidth is achieved with less tightly coupled lines. The advantage of this filter over edge coupled filter is its smaller size and use of quarter wave resonators instead of half wavelength resonators.

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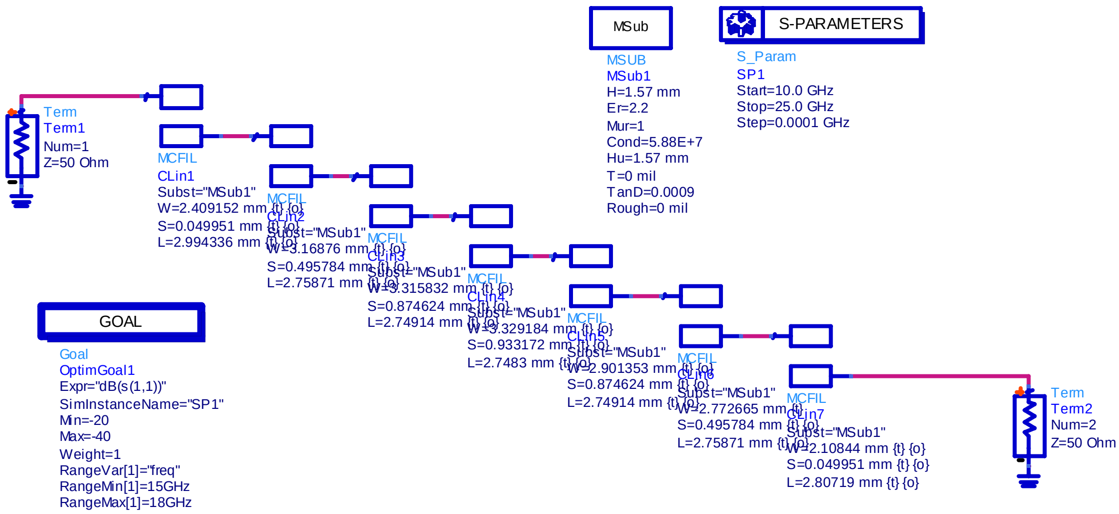

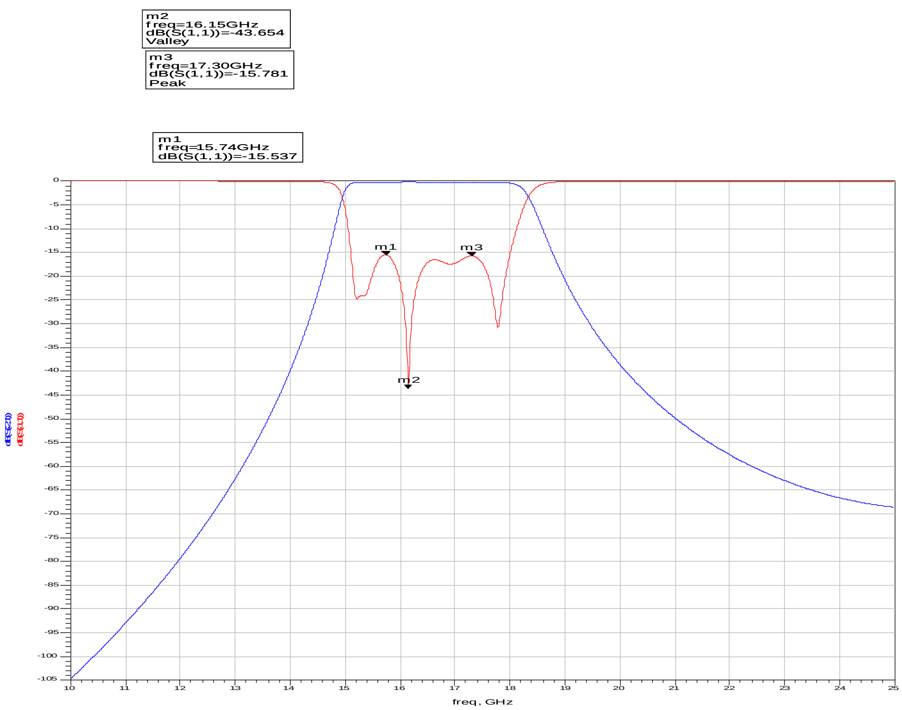

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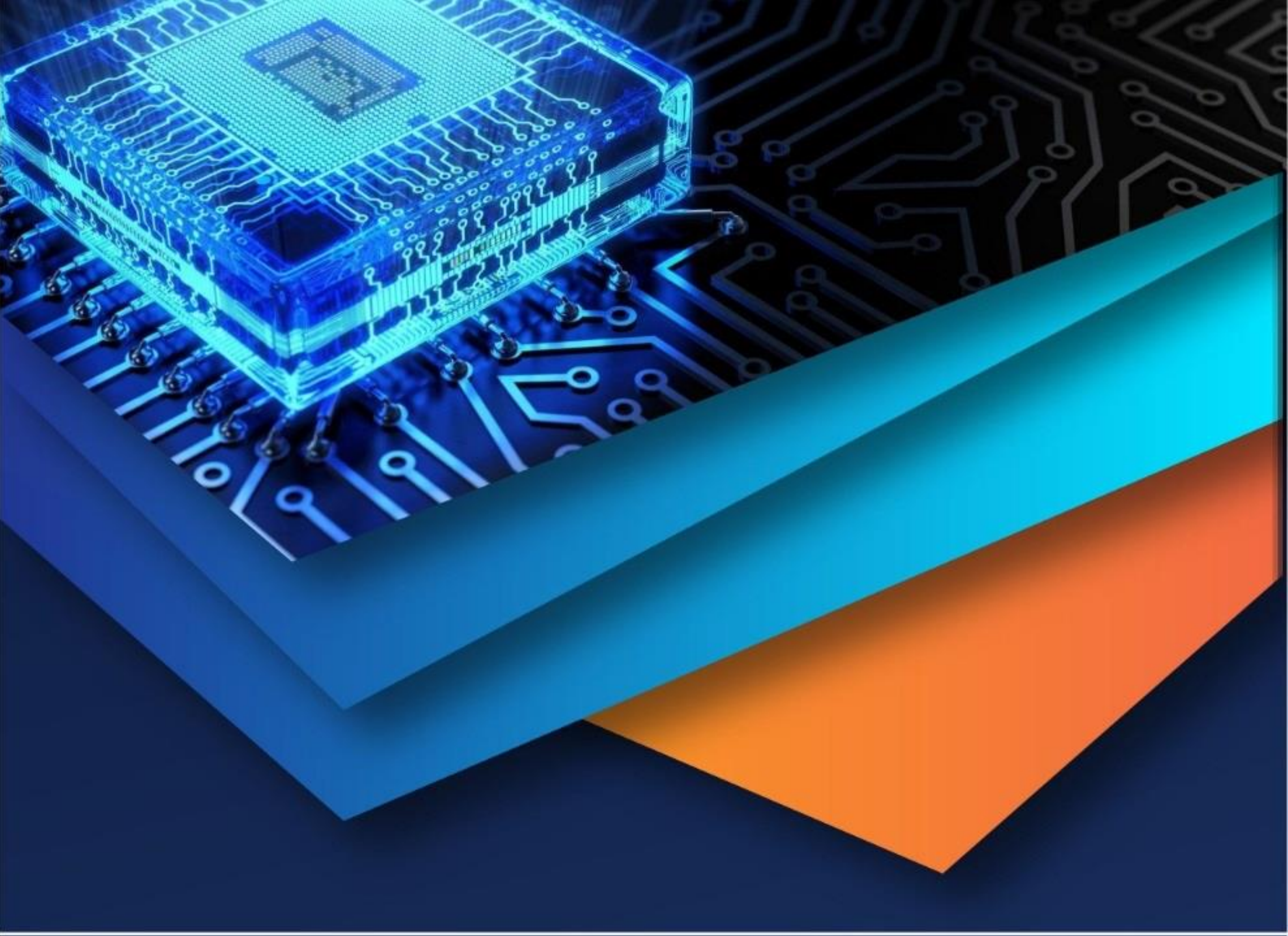

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