

Design of 3rdOrder Coupled Line Bandpass Filter for Wireless Application using Agilent ADS

S.Srinath

B.Tech Alumnus, School of Electronics Engineering, Vellore Institute of Technology, Vellore, Tamil Nadu, India.

ABSTRACT:Design of a parallel-coupled microstrip bandpass filter is presented in this paper. The aim of this paper is to present the design technique, parameter analysis, real prototype fabrication and measurement results at a simulation frequency of 5.85GHz. Half wavelength long resonators and admittance inverters are used to design the filter. The filter is simulated using **Agilent ADS (Advanced Design System) 2011**.

KEYWORDS:Bandpass filter; Microstrip; 5.85 GHz; Parallel Coupled Line; Microwave Engineering; Agilent ADS simulator.

I. INTRODUCTION

Filters are an essential part of telecommunications and radar systems. Of its low-cost fabrication, easy integration and simple designing procedure, the parallel coupled-line/edge-coupled filters are widely used in microwave microstrip circuits with a required bandwidth up to 20 % of central frequency.

The parallel coupled transmission lines can be used to construct many types of filters. Fabrication of multi-section bandpass or bandstop coupled line filters is particularly easy in microstrip or stripline form for bandwidths less than about 20%. Wider bandwidth filters generally require very tightly coupled lines, which are difficult to fabricate. A two-port network can be formed from a coupled line section by terminating two of the four ports with either open or short circuits, or by connecting two ends.

A bandpass filter only passes the frequencies within a certain desired band and attenuates other signals whose frequencies are either below a lower cutoff frequency or above an upper cut-off frequency. The range of frequencies that a bandpass filter lets pass through is referred to as passband. A typical bandpass filter can be obtained by combining a low-pass filter and a high-pass filter or applying conventional low-pass to bandpass transformation. The architecture demonstrated here is a coupled line type filter, since this is among the most practical and common filter types which can meet the stated specifications.

The filter response will be based on the Chebyshev transfer function. Chebyshev type filters are popular for their high selectivity, i.e., they have a relatively fast signal cut off between pass and stop band.

II. RELATED WORK

This paper presents the design of a parallel-coupled microstrip bandpass. The design is based on the use of half wavelength resonators and admittance inverters. The center frequency of 5.85 GHz is selected, the bandwidth (BW) is about 200MHz, the minimum attenuation amounts to -20 dB and the pass-band ripple is obtained equal to 0.5 dB. The design technique, parameter analysis, real prototype fabrication and measurement results of a 3rd order coupled line bandpass filter at a simulation frequency of 5.85GHz is presented in this paper.

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III. THEORY

A general layout of a parallel coupled microstrip bandpass is shown in figure 1. The filter structure consists of open-circuited coupled microstrip lines. These coupled lines are quarter wavelength, ($\lambda/4$) long and are equivalent to shunt resonant circuits. The coupling gaps correspond to the admittance inverters in the low-pass prototype circuit. Even- and odd- mode characteristic impedances of parallel-coupled half-wave resonators are computed using admittance inverters. These even- and odd- mode impedances are then used to compute physical dimensions of the filter. Now consider a bandpass filter composed of a cascade of $N + 1$ coupled line sections, as shown in Figure 1. The sections are numbered from left to right, with the load on the right, but the filter can be reversed without affecting the response. Since each coupled line section has an equivalent circuit of the form, the equivalent circuit of the cascade is as shown in figure 2.

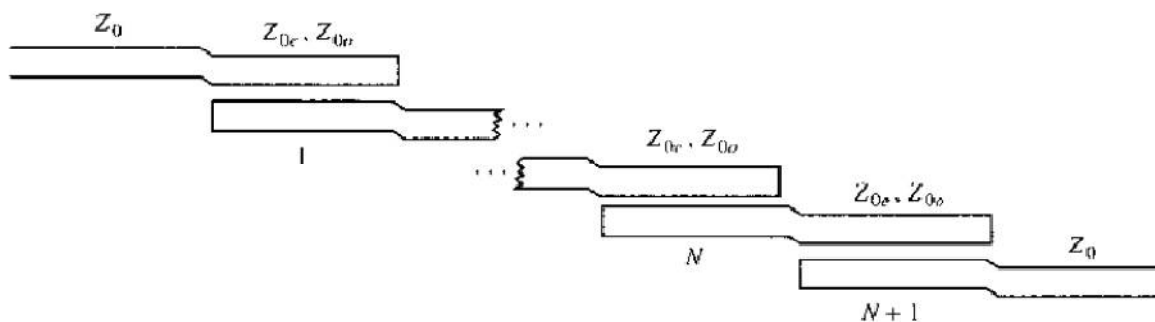


Figure 1. : Layout of an (N + 1)-section coupled line bandpass filter.

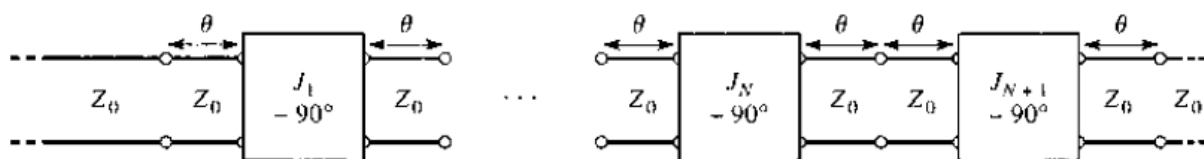


Figure 2. : Using the equivalent circuit of Figure 1. for each coupled line section.

IV. IMMITTANCE INVERTER

Immittance inverters play a very important role in filter design. They are used to transform a filter circuit into an equivalent form that can be easily implemented using various microwave structures. Immittance inverters are either impedance or admittance inverters. Making use of the properties of immittance inverters, bandpass filters may be realized by series (L-C) resonant circuits separated by impedance inverters (K) or shunt (L-C) parallel resonant circuits separated by admittance inverters (J). To design a bandpass filter, first of all a low-pass prototype circuit is modified to include immittance inverters. These low pass structures are then converted to bandpass circuits by applying conventional low-pass to bandpass transformation.

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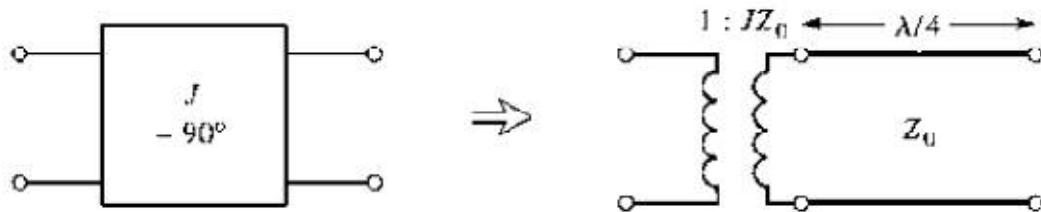


Figure 3. : Equivalent circuit of the admittance inverters.

V. SIMULATION MODELLING AND DISCUSSION

The order of the filter was calculated assuming an equi-ripple (Chebyshev type1) response with an attenuation of 20dB at the center frequency of 5.85 GHz and the pass band ripple amplitude (G) of 0.5dB. Hence the upper and lower cutoff frequencies of the passband are 6.5 GHz and 5.3 GHz respectively. Based on the filter application in system design, the fractional bandwidth (FBW) is calculated using equation below:

$$FBW = \{(\omega_2 - \omega_1) / \omega_0\}$$

where, ω_1 and ω_2 denote the edges of the passband frequency.

$$FBW = (6.5\text{GHz} - 5.3\text{GHz}) / 5.85\text{GHz} = 205\text{MHz}$$

Using the standard Chebyshev model:

$$n = \cosh^{-1} \frac{\sqrt{\left(10^{\frac{L}{10}} - 1\right) \left(10^{\frac{G}{10}} - 1\right)}}{\cosh^{-1} \left(\frac{f}{f_c}\right)}$$

This gives us $n=3$. Now, we get the low pass prototype values from the standard Chebyshev table:

$g_0 = 1$
$g_2 = 1.5963$
$g_2 = 1.0967$
$g_3 = 1.5963$
$g_4 = 1$

Now, we use the following design equations to get the inverter constants for a coupled line filter with $N+1$ sections:

$$Z_0 J_1 = \frac{\sqrt{(\pi \Delta)}}{\sqrt{(2g_1)}}$$

$$Z_0 J_n = \frac{\pi \Delta}{2\sqrt{(g_{n-1} g_n)}} \quad ; n = 2, 3, 4, \dots, N$$

$$Z_0 J_{n+1} = \sqrt{\left(\frac{\pi \Delta}{2g_n g_{n+1}}\right)}$$

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Now, the even and odd mode impedances can be calculated as follows:

$$Z_{oe} = Z_0[1 + JZ_0 + (JZ_0)^2]$$

$$Z_{oo} = Z_0[1 + JZ_0 + (JZ_0)^2]$$

The results of these calculations are tabulated below:

N	Admittance inverters	Even mode impedance $Z_{oe}(\Omega)$	Even mode impedance $Z_{oo}(\Omega)$
1	0.1805	60.655	42.605
2	0.0394	52.045	48.105
3	0.0394	52.045	48.105
4	0.1805	60.055	42.605

Using an Agilent ADS coupled line calculator, the width, length and line spacing for each coupled line was calculated. The width of the coupled lines 1 & 4 was calculated to be 1.0858mm, the length was calculated to be 7.702mm and the gap was calculated to be 0.3083mm.

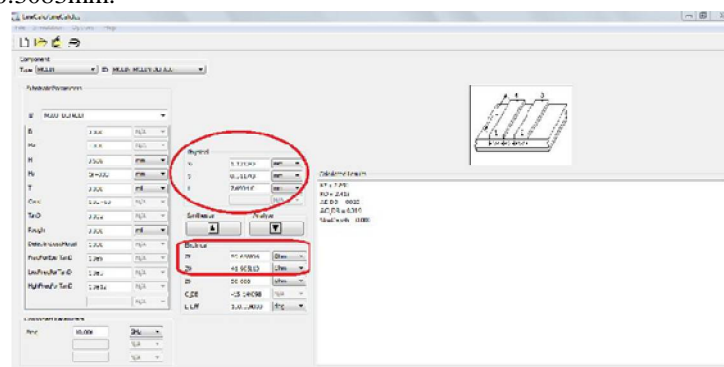


Figure 4. : Agilent Line Calc for coupled lines 1 & 4

Similarly, we use Agilent ADS coupled line calculator to calculate the width, length and line spacing for coupled lines 2 & 3. The width of the coupled lines 2 & 3 was calculated to be 1.1758mm, the length was calculated to be 7.6372mm and the gap was calculated to be 1.4395mm.

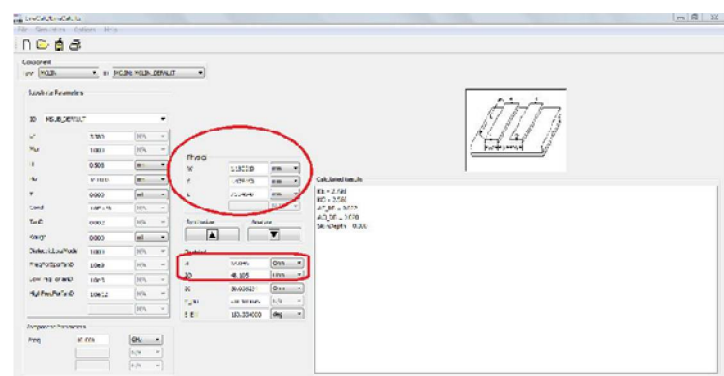


Figure 5. : Agilent Line Calc for coupled lines 2 & 3

The summarized results calculated from Agilent Line Calc are tabulated below. This includes 50Ω Line, coupled lines 1, 2, 3 & 4.

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Line Description	Width(mm)	Length(mm)	Gap(mm)
50 Ω Line	1.1763	7.604	-
Coupled Lines (1, 4)	1.0858	7.702	0.3083
Coupled Lines (2, 3)	1.1758	7.6372	1.4395

Based on the above values and taking standard port impedances Z_0 as = 50 Ω , the design was simulated.

VI. SIMULATION DESIGN, RESULTS & DISCUSSION

The design was simulated using Agilent ADS 2011 and a response was generated. The standard port impedance Z_0 was taken as 50 Ω . The values calculated using Agilent Line Calc and tabulated above are fed in the coupled lines simulation design.

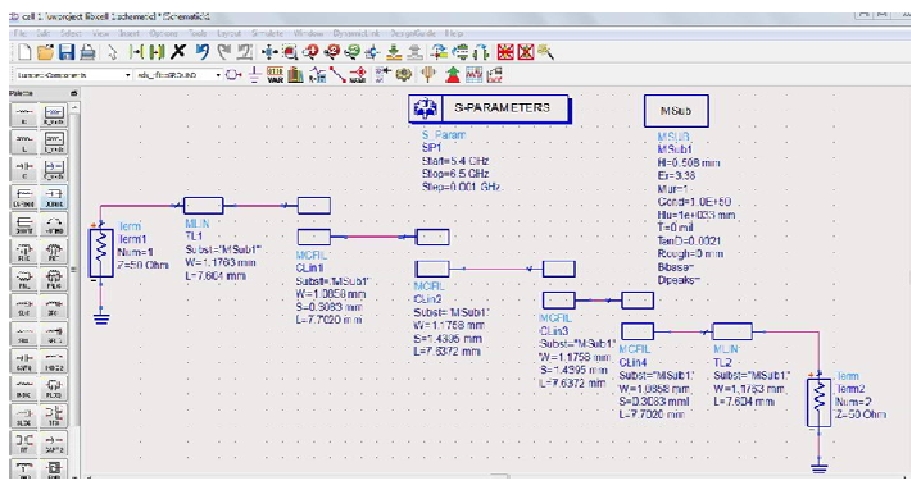


Figure 6. : Layout of the coupled line bandpass filter in Agilent ADS 2011

The simulation output is shown below. The center frequency is 5.85 GHz, the bandwidth is 200MHz, the minimum attenuation amounts to -20 dB and the pass-band ripple is obtained equal to 0.5 dB.

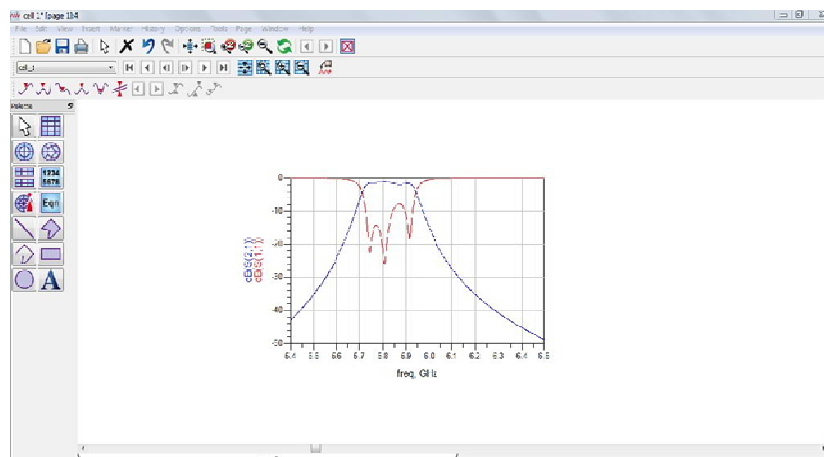


Figure 7.: Coupled Line Bandpass Filter at a frequency of 5.85 Ghz result

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Here, the parameter S_{11} (dB) represents the insertion loss at port 1 and the parameter S_{21} (dB) represents the insertion loss from port 1 to port 2.

VII. CONCLUSION

On a substrate with a dielectric constant of 3.38, the centerfrequency of 5.85 GHz was selected, the bandwidth is 200MHz, the minimum attenuation amounts to -20 dB and thepass-band ripple is obtained equal to 0.5 dB. Thus the design technique, parameter analysis, real prototype fabrication and measurement results at a simulation frequency of 5.85 GHz of a 3rd order coupled line bandpass filter was presented in this paper.

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BIOGRAPHY



S.Srinath passed 10th C.B.S.E. Board with a mark of 475/500(95%) in 2009 and 12th C.B.S.E. Board from D.A.V. Boys Senior Secondary School, Gopalpuram, Chennai, India with a mark of 458/500(91.6%) in 2011 .He graduated with B.Tech, ECE, from School of Electronics Engineering in Vellore Institute of Technology, Vellore, India with a C.G.P.A. of 8.39/10 in May 2015.