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Designing a Microstrip coupled line bandpass filter

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Abstract

Bandpass filters play a significant role in wireless communication systems. Transmitted and received signals have to be filtered at a certain center frequency with a specific bandwidth, in this paper, a coupled-line bandpass Filter at the center frequency 6 GHz with the wide bandwidth of 2 GHz. this type of filter can be used in WLAN and other applications for the frequency range of 5-7 GHz.

Keywords: ***BANDPASS FILTERS, COUPLED LINE, CST 2011, WLAN***

1 Introduction

The broadband wireless access (BWA) is an important issue in current developments of the modern wireless communication system. To meet this trend, the bandpass filters with relatively wide bandwidth are frequently required in the RF front ends. In microwave communication systems, the bandpass filter is an essential component, which is usually used in both receivers and transmitters [1].In this work we would like to give a way to design a bandpass filter for the WLAN application at the frequency 6 GHz with parallel-coupled Microstrip.
The design goals and parameters have been shown in the Table 1.

Table 1: Design Goals of the Filter

Ordre of the Filtre	3
Frequency	6 GHz
ε_r, FR4	4.3
Height of the Substrate	1.56 mm
Thickness of the conducting	0.035 mm
Loss tangent	0.025
Fractional Bandwidth	33% at 6 GHz
Bandwidth	>1GHz

2 Parallel Coupled lines Bandpass Filter

Fig.1 gives the circuit implementation of the filter by means of concentrated components like inductors (L) and capacitors (C), for the even and odd filter degree (n).

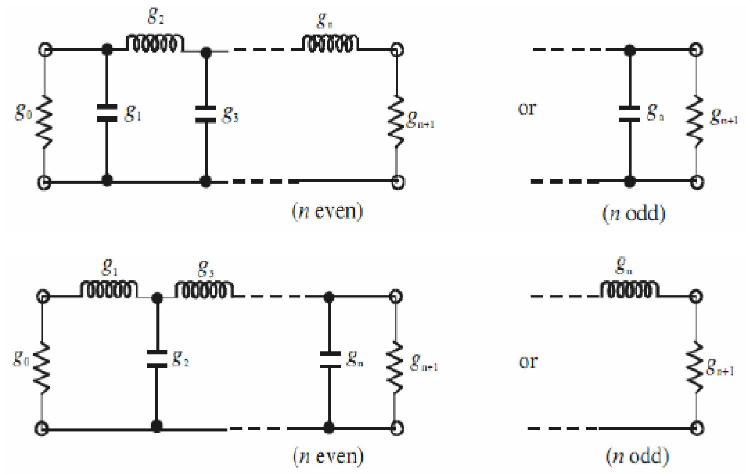

Fig.1: Realization of filter using LC components.

The component values can be calculated with the following rules:

$$g_0 = 1 \tag{1}$$

$$g_1 = \frac{2}{\gamma}\sin\left(\frac{\pi}{2n}\right) \tag{2}$$

$$g_i = \frac{1}{g_{i-1}}\left(\frac{4\sin\left(\frac{(2i-1)\pi}{2n}\right)\sin\left(\frac{(2i-3)\pi}{2n}\right)}{\gamma^2 + \sin^2\left(\frac{(i-1)\pi}{n}\right)}\sin\left(\frac{(2i-1)\pi}{2n}\right)\right) \tag{3}$$

for i=2 to n

$$g_{n+1} = \left\{\frac{1 \qquad \text{for odd} \quad n}{\cot^2\left(\frac{\beta}{4}\right) \qquad \text{for even } n}\right\} \tag{4}$$

Where $$\beta = \mathrm{Ln}\left[\cot^2\left(\frac{L_{A,r}}{17.37}\right)\right] \quad \text{and } \gamma = \sin^{-1}\left(\frac{\beta}{2n}\right) \tag{5}$$

2.1 Designing bandpass filter

Figure 2 shows the filter structure observed in this work. This filter type is known as parallel-coupled filter. The strips are arranged parallel close to each other, so that they are coupled with certain coupling factors. We use the following equations for designing the parallel-coupled filter [2].

$$\frac{J_{0,1}}{Y_0} = \sqrt{\left[\frac{\pi FBW}{2g_0g_1}\right]} \tag{6}$$

$$\frac{J_{j;j+1}}{Y_0} = \frac{[\pi FBW]}{[2\sqrt{g_jg_{j+1}}]} \tag{7}$$

For j=1 to n=1

$$\frac{J_{n,n+1}}{Y_0} = \sqrt{\left[\frac{\pi FBW}{2g_ng_{n+1}}\right]} \tag{8}$$

FBW is the relative bandwidth as explained before, $J_{j;j+1}$ is the characteristic admittance of J inverter and Y_0 is the characteristic admittance of the connecting transmission line.

With the data of characteristic admittance of the inverter, we can calculate the characteristic impedances of even-mode and odd-mode of the parallel-coupled Microstrip transmission line, as follows [2, 3].

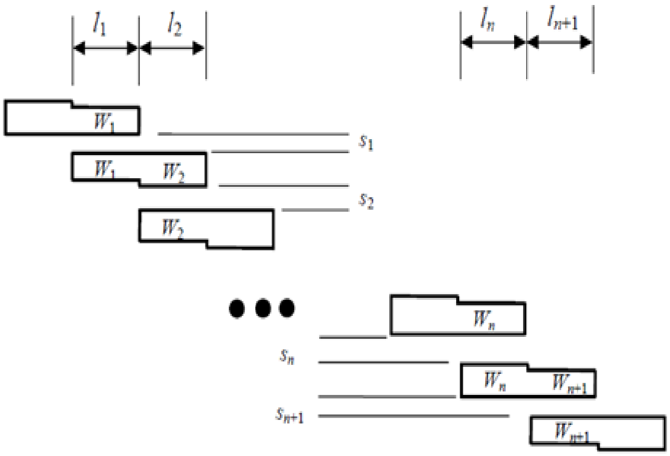

Fig 2: Parallel Bandpass Filter

for j = 0 to n
and

$$(Z_{oe})_{j,j+1} = \left(\frac{1}{Y_0}\right)\left[1 + \left(\frac{J_{j;j+1}}{Y_0}\right) + \left(\frac{J_{j;j+1}}{Y_0}\right)^2\right] \tag{9}$$

for j = 0 to n

$$(Z_{o0})_{j,j+1} = \left(\frac{1}{Y_0}\right)\left[1 - \left(\frac{J_{j;j+1}}{Y_0}\right) + \left(\frac{J_{j;j+1}}{Y_0}\right)^2\right] \tag{10}$$

From these values, width, length and spacing of the parallel coupled line are calculated and are shown in Table-2,

Table 2: Specifications of Parallel coupled Microstrip Lines

n	g_n	$Z_0 J_n$	$Z_{oe}(\Omega)$	$Z_{oo}(\Omega)$	W(mm)	L(mm)	S(mm)
1	0.6292	0.63	101.5	38.5	1.4	6	0.2
2	0.9703	0.32	71	39	2.4	6	0.2
3	0.6292	0.32	71	39	2.4	6	0.2
4	1.0	0.63	101.5	38.5	1.4	6	0.2

3 Design configuration and simulated results

3.1 Geometry on simulator

In this proposed design the height of the substrate is 1.5 mm and relative permittivity 4.3 and the conductor thickness 0.035 mm and loss tangent is 0.025, figure 3 shows the 3-dimensional view of proposed bandpass filter. Proposed design is simulated in CST microwave studio 2011 [5].

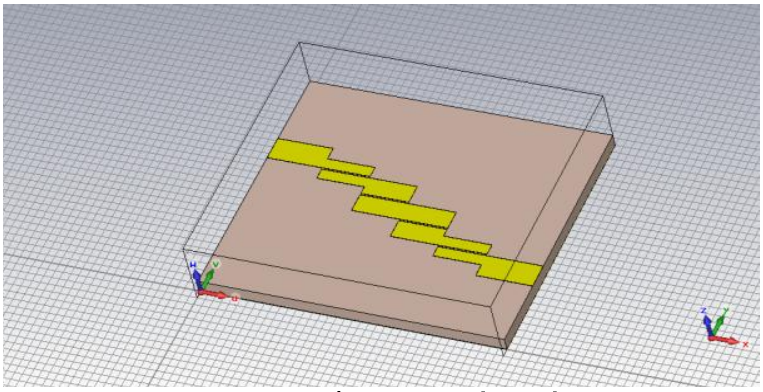

Fig 3: Geometry of Microstrip Band Pass Filter

3.2 Simulation result

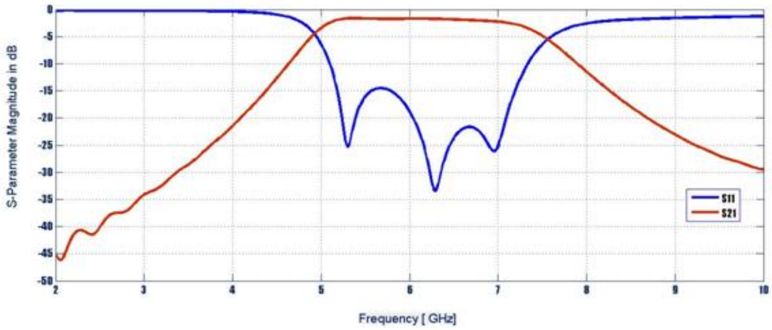

Fig 4: Simulation S-parameters of parallel coupled line bandpass filter at 6 GHz

Fig.4 shows the simulation response of conventional parallel-coupled microstrip line bandpass filter with centre frequency 6 GHz.

4 Conclusion

Designing of bandpass filter with Chebyshev approach in combination with concentrated components, i.e. inductors and capacitors and its computational verification in form of parallel coupled microstrip lines with the CST give very good filter characteristics at the center frequency 6 GHz with frequency bandwidth of about 2 GHz as required at the specification stage. At the center frequency the insertion loss and reflection factor has the values about -2 dB and better than -15 dB, respectively.

References

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