Design, Simulate Analyze the Performance of Parallel Coupled Micro Strip Band Pass Filter at 1.5 GHz for GPS Applications

Ramprakash K, Loshni T, Aparna A P

Abstract: ***In this trending generation, world is mainly focusing on system miniaturization, without affecting the performance. GPS(Global Positioning System) is a satellite navigation system, used to determine the ground position. Radio Frequency (RF) filters used in this GPS receiver should be in compact size. One of the RF transmission line structure is micro strip line structure, and it is the most preferable one because of its low cost, compact size, less weight etc. In this work , a small sized parallel coupled microstrip band pass filter was designed with the frequency of 1.5GHz lies in the L band and 200MHz frequency band. The simulation was carried out by using the software, Advanced Design System 2016 (ADS). Easily available and cost effective Fire Retardant 4 substrate with the dielectric constant of 4.4 was used to design the filter. The designed filter meets the required insertion and return loss values.***

Key Words: Parallel coupled microstrip line structure, Band pass filter, GPS, FR4, ADS 2010.

I. INTRODUCTION

In telecommunication, communication system plays an important role in exchanging information and it consists of transmitter, channel, additive noise and receiver. RF Filters are used to remove the unwanted noise signal from the desired frequency components and normally their operating frequency ranges from few Mega Hertz (MHz) to several hundred Giga Hertz (GHz). Band Pass Filter (BPF) is one of the significant component in Radio Frequency communications. It only allows the range of frequency signals that is already specified, called as passband and it will reject the signals other than the specified bandwidth called as stopband. BPF can be used at both transmitter and receiver side of the RF communication system as interference canceller. These filters can be designed by using lumped (like Resisters, Capacitors, Inductors etc.) or distributive components (Transmission line theory is used here). For the frequencies above 500MHz, distributive circuit will be preferred compared to lumped circuit. Because above the mentioned frequency, in lumped circuit the dimensions of the component will become comparable with the wavelength of the signal. In distributive type, there are number of RF transmission line structures such as coaxial cable, microstrip line and stripline. From these, Microstrip line structure is commonly preferred because of its low cost, less weight, compact size,easy fabrication etc. This structure consists of a conducting strip of width(W) and thickness(t) separated from a ground plane by a dielectric layer called substrate with thickness(h) as shown in Fig. 1.RF filters can be designed by using Butterworth, Chebyshev, or Elliptic (Cauer filter) filter coefficients. For microstrip BPF chebyshev type is commonly preferred because of its equal ripples in either passband or stopband. There are number of structures available in designing BPF like parallel coupled line, capacitive gap, interdigital, stub based, hairpin, comblineetc.The simulation study can be performed by using ADS, CST, CADFEKO, HFSS, IE3D EM Simulator, [18] Microwave office etc.

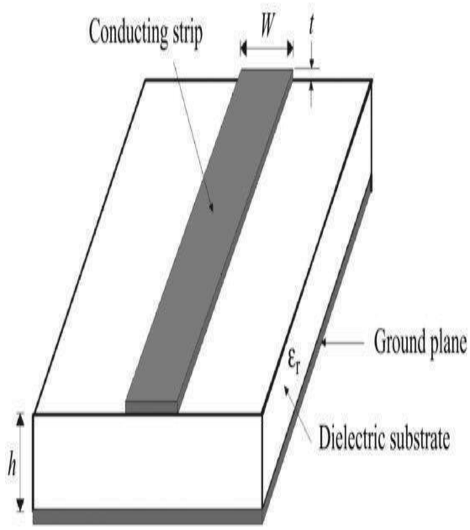

Fig. 1. General Microstrip Structure

In this paper, the L band center frequency, chebyshev coefficients, parallel coupled microstrip line structure, FR4 substrate and ADS simulation tool were used to design the filter.A basic band pass filter consists of a single strip with different lengths and widths for different cut off frequencies[16]

A. Filter Design Calculation and Layout Generation

Parallel coupled line filter structure consists of parallel half wavelength resonators coupling over neighboring quarter wavelength resonators, also known as odd and even mode impedances. The Zs , Z_L impedances (Z0=50ohms) of the filter should be matched to reduce the losses. The structure of this filter is shown in

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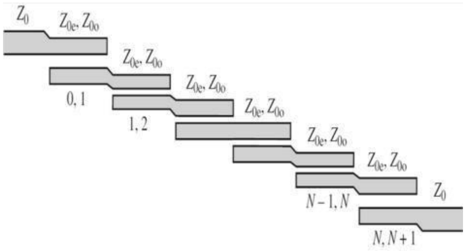

Fig. 2.Where Zoe and Zoo refers to even and odd mode impedances.

Fig. 2.Parallel Coupled Line Structure

In this paper, band pass filter was simulated with the specifications as shown in Table. 1.

S NO	FEATURES	VALUES
1	Centre frequency	1.5 GHz
2	Bandwidth	200MHz
3	Order of the filter	3,5
4	Ripples in pass band	0.5dB
5	Substrate	FR4
6	Dielectric constant	4.4
7	Substrate thickness	1.56mm
8	Conductor thickness	0.035mm
9	Loss tangent	0.0025

Table. 1. Filter Specifications

The fractional bandwidth (Δ) for the desired frequencies is calculated by using the equations given below

$Zoo = Z0 [1 - JZ0 + (JZ0)^2]$

In order to design the filter low pass chebyshev prototype coefficients are necessary. Here 0.5dB ripple chebyshev prototype is used as shown in Table. 2.

N	g1	g2	g3	g4	g5	g6
3	1.5963	1.0967	1.5963	1.0000		
5	1.7058	1.2296	2.5408	1.2296	1.705 8	1.000 0

Table. 2. Low pass Chebyshev Filter Coefficients for 0.5dB Ripple

The calculated even and odd mode impedance values for the both 3rd and 5th order Chebyshev filter by using above mentioned equations are tabulated in Table. 3. And Table. 4.

n	J_nZ_0	Z_{oe}	Z_{oo}
1	0.3622	74.6694	38.4494
2	0.1583	59.1679	43.3379
3	0.1583	59.1679	43.3379
4	0.3622	74.6694	38.4494

Table. 3. Even and Odd Mode Impedance Values for 3rdOrder Chebyshev Filter

n	JnZ0	Zoe	Zoo
1	0.3504	73.6590	38.6190
2	0.1446	58.2756	43.8155
3	0.1185	56.6271	44.7771
4	0.1185	56.6271	44.7771
5	0.1446	58.2756	43.8155
6	0.3504	73.6590	38.6190

Table. 4. Even and Odd Mode Impedance Values for 5th OrderChebyshev Filter

$\omega 1 = 2\pi f1$ $\omega 2 = 2\pi f2$

$\omega 0=(\omega 1\omega 2)1/2$

$\Delta=(\omega 2-\omega 1)/\omega 0$

Where, f1 and f2 are the upper and lower cutoff frequencies

The admittance interval Jn is calculated by using the equations given below

$ZoJ1=\sqrt{\pi\Delta/2g1}$

$Z0JN = \Delta\pi/2\sqrt{gN-1gN}$

$ZoJN+1 = \sqrt{\Delta\pi}/\sqrt{2gNgN+1}$

Where, g0, g1, g2 …gn are the normalized chebyshev coefficient values

The even and odd mode impedances, Zoe and zoo for the filter with specified features are calculated by using the equations

$Zoe = Z0 [1 + JZ0 + (JZ0)^2]$

Calculated width, length and spacing values for both third and fifth order filters by using "linecalc" function in ADS are shown in Table. 5 and Table. 6.

Table. 5. Calculated Width, Length, Spacing Values for Third Order Filter

Transmission line (TL n)	Width (W) in mm	Length (L) in mm	Space (S) in mm
TL 1	1.811	28.067	0.28
TL 2	2.74	27.6	1.266
TL 3	2.74	27.6	1.266
TL 4	1.811	28.067	0.28

Table. 6. Calculated Width, Length, Spacing Values for Fifth Order Filter

Transmission line (TL n)	Width (W) in mm	Length (L) in mm	Space (S) in mm
TL 1	1.747	28.633	0.39728
TL 2	2.919	28	1.44153
TL 3	2.829	27.46	1.747
TL 4	2.829	27.46	1.747
TL 5	2.919	28	1.44153
TL 6	1.747	28.633	0.39728

The layout diagram of these third and fifth order chebyshev 0.5dB ripple filters were generated with the help of ADS simulation tool by using the cost effective substrate FR4 with 4.4 dielectric constant and 1.56mm substrate thickness as shown in Fig. 3 and Fig. 4.

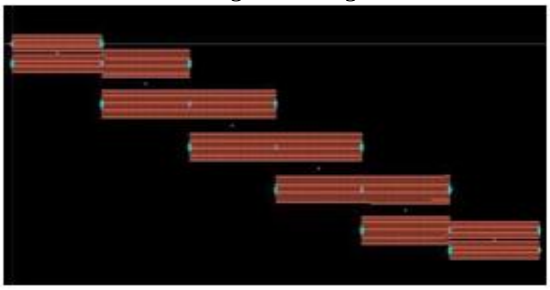

Fig. 3. Layout Diagram of Third Order Filter

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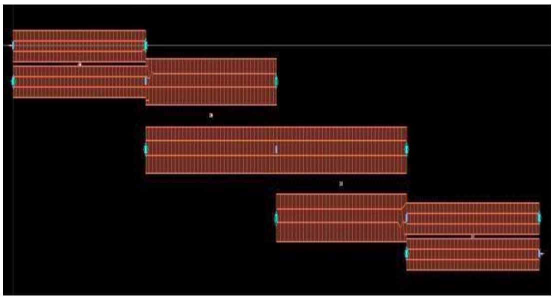

Fig. 4. Layout Diagram of Fifth Order Filter

II. RESULTS AND DISCUSSIONS

The different scattering parameters were simulated. The simulated results of the 3rd and 5th order designed parallel coupled microstripbandpass filter, operating at 1.5GHz frequency is shown in Fig. 5 and Fig. 6.

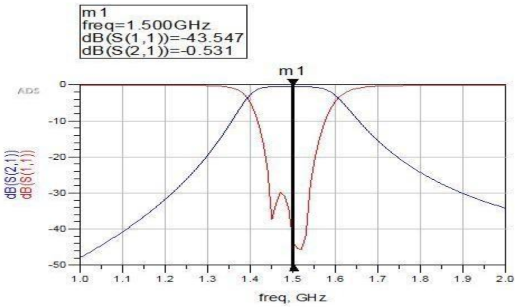

Fig. 5. Simulated S11 and S21 Values for Third Order Filter

Simulated Scattering parameter S21 and S11 values for the third order filter were -0.531 and - 43.547 as shown in Fig. 5. With consideration of - 10dB value, the bandwidth achieved is about 200 MHz. The lower and upper passband (f1 and f2) frequencies are approximately 1.4GHz and 1.6GHz respectively.These filters can also be used along with fractal antennas in the receivers[17]

Simulated S21 and S11 values for the fifth order filter were -1.081 and -35.178 as shown in Fig. 6. With consideration of -10dB value, the bandwidth achieved is about 200 MHz. The lower and upper passband (f1 and f2) frequencies are approximately 1.4GHz and 1.6GHz respectively.

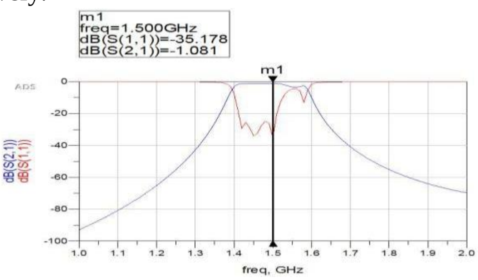

Fig. 6. Simulated S11 and S21 Values for Fifth Order Filter

III. CONCLUSION

Thus the third and fifth order parallel coupled microstrip bandpass filter at 1.5GHz operating frequency with 0.5dB ripple chebyshev coefficient was designed, simulated and their performance is also analyzed.Simulated insertion and return loss values for both the designed filter are met the desired specifications. FR4 substrate is used in the designing process, which is cost effective and easily available worldwide. Since the designed filters are operating at the center frequency of 1.5GHz, both will be used for GPS applications with the required specifications.

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