DESIGN AND PERFORMANCE COMPARISON OF MICROSTRIP PASSIVE FILTERS

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Abstract: This project is about the development of microstrip passive filter using both Advanced Design Software (ADS) simulation and fabrication technique. The significance of this work is to design various micostrip passive filters and to compare its performance. The microstrip filters are used in variety of microwave systems, for example, satellite communication, measurement and test systems, radars etc. because of their advantages in price, selectivity and simple. This involves comparison of various characteristics like Q factor, insertion loss and so on.

Keywords: microstrip passive filter, Q factor, insertion loss.

I. INTRODUCTION

The communication system in the field of Telecommunication, plays most important role in exchanging of information. The components of it are transmitter, channel and receiver. There is a need to remove the unwanted signal during transmission. This could be performed with the help of Filters. The filters could be of Low pass, High Pass, Band Pass, Band Stop. This designed using Butterworth, Chebyshev, Elliptic or Bessel Thomson. The filters could be designed using lumped elements as well as distributed elements. In this project various microstrip filters are compared based on their Performance.

II. LITERATURE SURVEY

"Realization of Butterworth Low Pass Filter Design in Microstrip" by SalaiThillaiThilagam.J, M.Vittal, T.SarathBabu, B.Siva Reddy, K.Raju.[1]

The proposed technique involves the design of butterworth low pass filter with response obtained is -19.48 dB, attenuation at 4990 MHz. the cut off frequency occurred at 3dB at 2660 MHz and is shownin the S11, S21 characteristics.

"Design, Simulate Analyze the Performance of Parallel Coupled Micro Strip Band Pass Filter at 1.5 GHz" by ArjunKumar and M.V.Kartikeyan.[2]

In this paper, the parallel coupled Micro Strip Band Pass Filter is designed for GPS application. The designing process is done using FR-4 substrate stating that it is cost effective and easily available**.**

"Design, Simulation and Fabrication of a Microstrip Bandpass Filter" by Shreyasi Srivastava, R.K.Manjunath, Shanthi P.[3]

In this paper, it is observed that, the insertion loss is 1.5db higher than the simulated result. This may be due to anomalies during fabrication and this could be overcome by using Teflon board instead of FR-4.

"Designand Simulation of Band-Pass Filter using Micro-Strip Lines" by M.Taghizadeh, Gh.Moloudian, A.R.Rouzbeh. [4]

In this paper, it is observed that Band Pass Filter is designed using Micro Strip Lines, with the desired output obtained. In order to improve the work, they have drawn filter substitution map.

"Design and Analysis of Stepped Impedance Microstrip Low Pass Filter Using ADS Simulation Tool for Wireless Applications" byK.Rajasekaran, J.Jayalakshmi,T.Jayasankar.[5]

In this paper, a filter of designed based on the specification along with the output waveform. A stepped impedance micro strip filter whose harmonic suppression is -60db is obtained.

III. CHEBYSHEV FILTER

1. SPECIFICATIONS
1.ORDER

The order of the Chebyshev filter is equal to the number of the reactive components present in the circuit designed. The order of the filter for the designed filter is about **5**.

2. PASSBAND ATTENUATION

The passband attenuation is the amount of variation in the amplitude, within the designated passband of the filter. The passband attenuation (Ap) is about 0.1db.

3.STOPBAND ATTENUATION

The stopband attenuation is minimum attenuation level with the designated rejection band of the filter. The stopband attenuation (As) is about 40 db.

4.CUT OFF FREQUENCY

The designed frequency is about 2.5GHz. Since it is a low pass Chebyshev filter, it allows the frequency range within 2.5GHz alone. The passband frequency (fp) is about 2.5GHz and the stopband frequency (fs) is about 6 GHz.

2. DESIGN OF CHEBYSHEV FILTER (LUMPED COMPONENTS)

The design of the chebyshev filter with Inductor and Capacitor is as bellow. The following are the filter elements for the low pass Chebyshev filter with passband attenuation with 0.1db. For the designed Chebyshev filter with order 4. The values of g1, g2, g3, g4, g5, g6 are as follows. g1=g5=1.1468, g2=g4=1.3712, g3=1.9750, g6=1.0

The formula used for calculating Inductor(L) and Capacitor(C) are gi/Zo*2*pi*fc and gi*Zo/2*pi*fc respectively. With the above formula the value of Inductor and Capacitor is calculated and the filter is designed. The below diagram shows the schematic of the designed filter.

3.1Schematic view of Chebyshev Low pass filter

3.MICROSTRIP CHEBYSHEV LOW PASS FILTER

The designed Chebyshev low pass filter above with lumped components should be converted into distributed elements. This constitute the step of converting the lumped elements into microstrip one. The following is the schematic of the designed microstrip Chebyshev low pass filter.

3.2Schematic of microstrip Chebyshev low pass filter

4. GRAPH FOR LC AND MICROSTRIP DESIGN

The graph obtained for the design using lumped components and microstrip are compared.
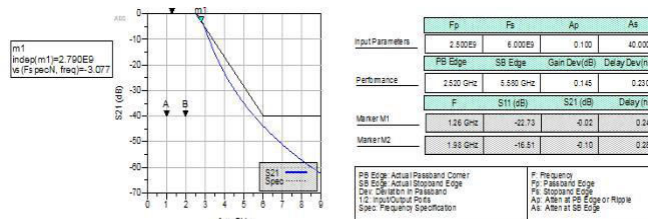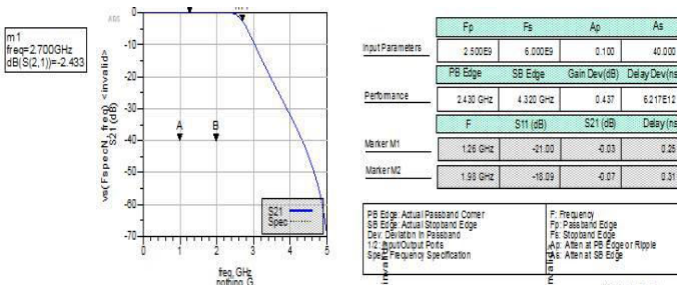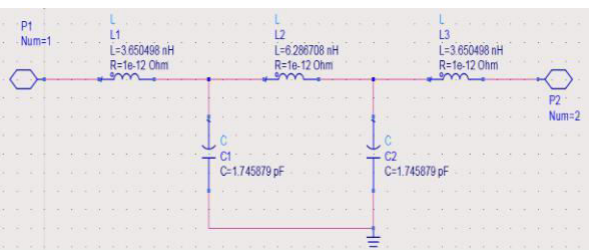

3.3.Graph for lumped component

The S11 represents the return loss which is to be above 20db and the S21 represents the insertion loss which is to be less than 1 db. Here in this graph the S11 is close to 20db and S21 is below 1db.
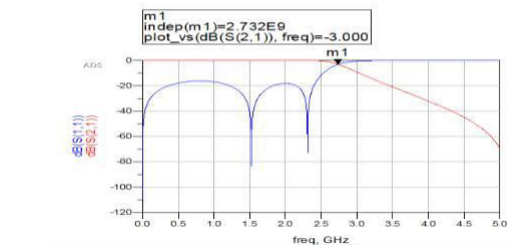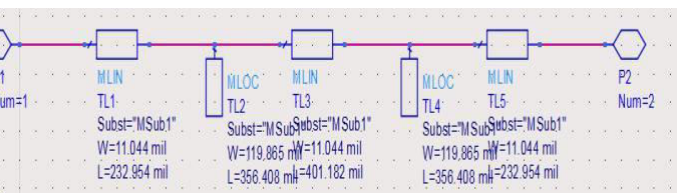

3.4.Graph for microstrip components

The S11 that represents the return loss is close to 20db and the S21 that represents the insertion loss is close to 0db.

5. SCATTERING PARAMETER

The Scattering parameter of the designed microstrip Chebyshev low pass filter is as below.

3.5 S parameter graph

The designed cut off frequency is about 2.5Ghz but the obtained frequency is about 2.732Ghz, which is demonstrated in the above graph.

6.LAYOUT

The layout for the above designed filter is then converterd into layout. The layout of the designed microstrip Chebyshev low pass filter is as below.

3.6.Layout of Chebyshev low pass filter

IV. BUTTERWORTH FILTER

1.SPECIFICATION

1. ORDER

The number of reactive component present in the circuit is same as the order of the Butterworth filter. The order of the filter for the designed filter is about 8.

2. PASSBAND ATTENUATION

The passband attenuation (Ap) is about 0.1db.The passband attenuation is the amount of variation in the amplitude, within the designated passband of the filter.

3. STOPBAND ATTENUATION

The stopband attenuation (As) is about 40db.The stopband attenuation is the minimum attenuation level with the designated rejection band of the filter.

4. CUT OFF FREQUENCY

The passband frequency (fp) is 2.5GHz and the stopband frequency (fs) is 6GHz.The designed frequency is about 2.5GHz. Since, The filter is a lowpass Butterworth filter, it allows the frequency range upto passband frequency.

2.DESIGN OF BUTTERWORTH FILTER (LUMPED COMPONENTS)

The design of Butterworth filter with Inductor and Capacitor is as below.
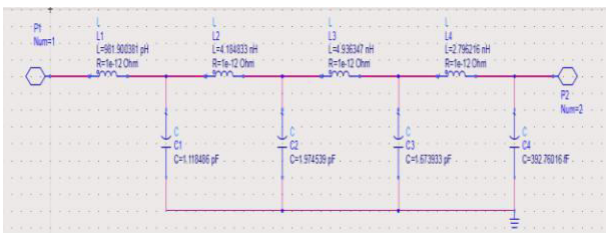

4.1Schematic view of Butterworth Low pass filter

The Capacitor and Inductor value shown above are calculated using the formulas above.

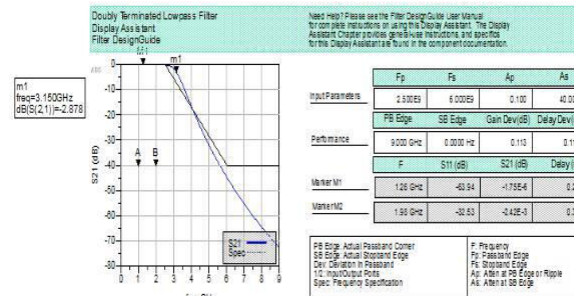### 3.MICROSTRIP BUTTERWORTH LOW PASS FILTER

The designed Butterworth low pass filter with lumped components is converted into distributed components. This involves the conversion of microstrip Butterworth low pass filter. The following schematic represents the Microstrip Butterworth low pass filter.
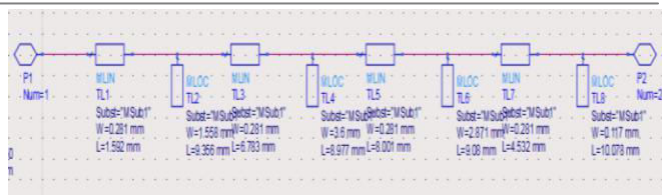
4.2.Schematic representation of microstrip Butterworth Filter

### 4.COMPARISON OF LC AND MICROSTRIP

The graph obtained for the design using lumped components and microstrip are compared. The graph below is one obtained from the designed Butterworth low-pass filter with lumped components.

4.3.Graph forButterworth filter using lumped components

The graph for the designed Butterworth filter has S11 is above 20dB and the parameter S21 is below 1dB.

The graph obtained for the design using distributed components is taken into account. The below graph which demonstrate the Butterworth Low pass filter with distributed component.
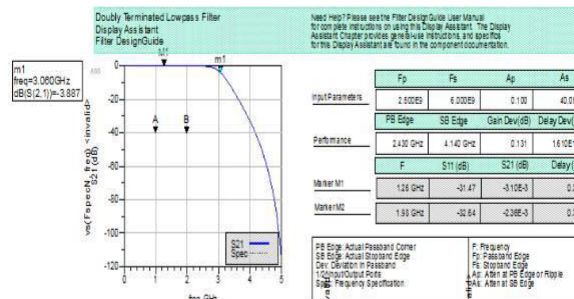

4.4.Graph for Butterworth filter using microstrip components

The S11 represents return loss which is close to 20dB and S21 represents the insertion loss which is close to 0dB.

5.SCATTERING PARAMETER

The Scattering parameter of designed microstrip Butterworth filter is below. The S11 and S21 parameters are represented in the graph below. S11 parameter is input port voltage reflection efficient. S21 represents the power transmitted from port2 to port1. GRA
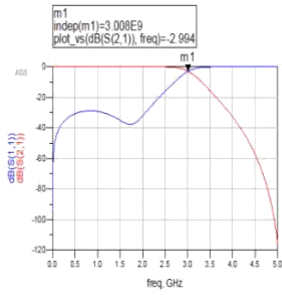
4.5.S- Parameter graph

6. LAYOUT

The layout for the designed Butterworth filter is converted into layout. The layout of designed Butterworth low pass filter is shown below,

4.6. Layout

The above layout is then converted to Gerber file, which could be fabricate with PCB technology.

V. MICROSTRIP BAND PASS FILTER

1. FILTER IN GPS APPLICATION

GP refers to Global Positioning System. GPS is a satellite-based radio navigation system. GPS satellite broadcast microwave signals to enable GPS receivers on or near Earth's surface to determine location and time and derive velocity. There are four signals available for civilian use,

1. L1 C/A
2. L2C
3. L5
4. L1

2.FREQUENCY PARAMETERS

The signal to travel from satellite to the receiver, must be modulated onto a carrier wave. In such a case two frequencies are utilized one at 1575.42MHz called L1 and second one at 1227.60MHz called as L2.

3. L2 BAND

L2C contains two distinct PRN code sequences to provide ranging information; the civil-moderate code (called CM), and the civil-long length code (called CL).

When compared to the L1 C/A signal, L2C has 2.7 dB greater data recovery and 0.7 dB greater carrier-tracking, although its transmission power is 2.3 dB weaker.

4. FLOW OF THE DESIGN

The first step is to calculate admittance interval, followed by calculation of odd and even impedance, then it is subjected to simulation and to plot bandpass filter, if the graph obtained is not accurate then further move to the step of calculating admittance interval. If the graph obtained is correct then the process of layout could be preceded.

5. CALCULATION

The admittance interval formulas required for the calculation of band pass filter are as follows.

5.1.Admittance interval formula

The following table helps us to calculate the odd and even impedance with the admittance interval calculated above.

5.2.Formula for odd and even impedance

With the help of admittance interval, odd and even impedance calculated above, the filter is designed. The following table gives the clear view about the various stages of the filter and the even and odd impedance.

STAGES OFTHE FILTER	ADMITTANCE INTERVAL	Zo (even)	Zo(odd)
1	0.1403	57.9992	43.9692
2	0.0237	51.2131	48.8431
3	0.0237	51.2131	48.8431
4	0.1403	57.9992	43.9692

5.3. Calculated result

The above obtained result is used for the design of the filter. With the help of these values the width , length of the filter is calculated, which helps us to design the required filter.
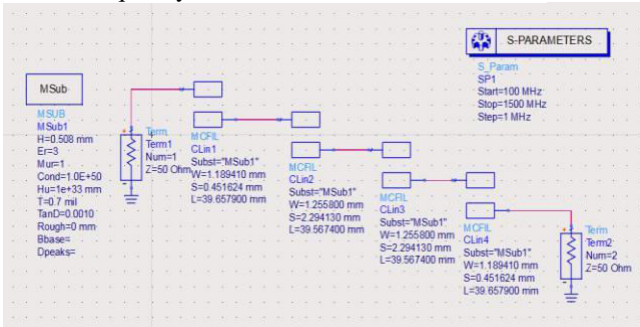
6. DESIGN OF THE FILTER

The specifications for the designed filter are as follows,
Substrate = Rogres RO3003,
Dielectric constant, εr=3,
loss tangent tan d =0.0010,
Substrate thickness, h =0.508mm,
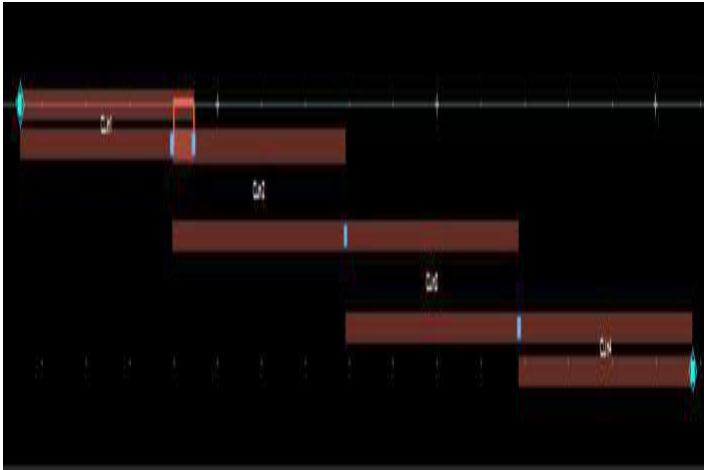
Center Frequency GPS L2 band is F= 1227.6 MHZ

5.4.Schematic view of the filter

7. SCATTERING PARAMETER

The scattering parameter graph help us to clearly view the insertion loss, return loss and the performance of our filter. The following is the graph the clearly view about the performance of the filter.

5.5.S-parameter graph

5.7.Layout of the filter

5.6.S- parameter graph for 1.235Ghz

The above mentioned two graphs clearly gives us a view of the various frequency for the various S-Parameter.

8.LAYOUT OF THE FILTER

The layout of the designed filter is below. The filter is obtained based on the calculated values as above.

VI. CONCLUSION

This paper clearly describes about the various steps starting from the design to fabrication of various microstrip passive filters. The filters designed include Chebyshev filter, Butterworth filter and a band pass filter for the L2 band of GPS application. From this we could also analyze the various important factors like insertion loss and return loss, which forms the important part of the filter designing process and its selection for various uses.

VII. INFERENCE

1."Realization of Butterworth Low Pass Filter Design in Microstrip" by Salai Thillai Thilagam.J, M.Vittal, T.Sarath Babu, B.Siva Reddy, International Journal of Innovative Technology and Exploring Engineering (IJITEE) ISSN: 2278-3075, Volume-8 Issue-4S2 March, 2019.

2. "Design, Simulate Analyze the Performance of Parallel Coupled Micro Strip Band Pass Filter at 1.5 GHz for GPS Application" by ArjunKumar and M.V.Kartikeyan, at

International Journal of Innovative Technology and Exploring Engineering (IJITEE) ISSN: 2278-3075, Volume-8 Issue-2S December, 2018.
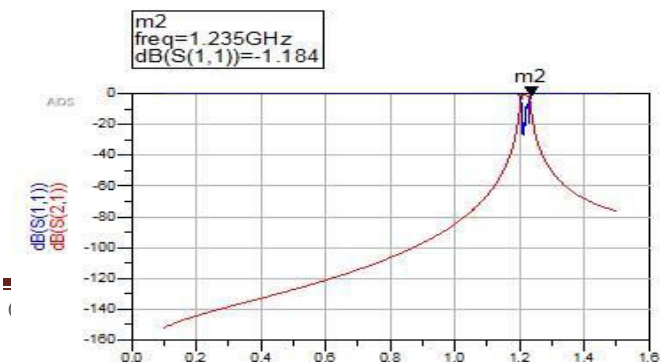
3.”Design, Simulation and Fabrication of a Microstrip Bandpass Filter” by Shreyasi Srivastava, R.K.Manjunath, Shanthi P, International Journal of Science and Engineering Applications Volume 3 Issue 5, 2018.

4.”Design and Simulation of Band-Pass Filter using Micro-Strip Lines” by M.Taghizadeh, Gh.Moloudian, A.R.Rouzbeh, International Journal of Computer Science and Mobile Computing, November 2018.

5.”Design and Analysis of Stepped Impedance Microstrip Low Pass Filter Using ADS Simulation Tool for Wireless Applications” by K.Rajasekaran, J.Jayalakshmi, T.Jayasankar, International Journal of Scientific and Research Publications, Volume 3, Issue 8, August 2018.