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Comparative Study of RF/microwave IIR Filters by using the MATLAB

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Abstract— **In recent years, due to the magnificent development of Filter designs take attention in research area. RF/microwave Filters are used to separate or combine different frequencies. There are different types of filters are used for separation of frequency like Low pass, High pass, Band pass, Band stop. In this paper we used three band pass filters (Elliptic, chebyshev I, butterworth) for comparison. We design two parameters for comparison: transfer function and zero pole gain. We design 9th order filter, band pass ripple 0.33dB and stop band ripple is 75 dB, the normalized cutoff frequency is a number between 0 and 1 and it the two-element vector with pass band 2.41 MHz < ω < 28.7MHz. The results show magnitude response phase response and group delay. To simulate all filters we use MATLAB.**

Index Terms—**: microwave; microstrip; Low pass; High pass; Band pass; Band stop; Elliptic; chebyshev I; butterworth ; MATLAB.**

I. INTRODUCTION

Filters play a very important role in the field of Frequency separation. A microwave filter is a two port network used to control the frequency response at a certain point in a microwave system by providing transmission at frequencies within the pass band of the filter and attenuation in the stop band of the filter [1]. RF/microwave signals are selected or confine by the filter within the assigned spectral limits. RF/microwave filters challenge with ever more stringent requirements- higher performance, smaller size, lighter weight, and lower cost, Depending on the requirements and specifications [2]. The design of IIR filter is related to design analog filters. In this paper, the focus is on compare minimum order IIR filters to meet a set of specifications using MATLAB functions. Each result is accompanied by a plot of its transform function and zero pole gain. The responses of three IIR filters using MATLAB are compared with the same specifications. The main goal of this paper is to obtain an optimized filter response along with the filter coefficients.

IIR FILTERS

Basic prototype IIR filters are of four types. First is Butterworth filter, whose magnitude response is maximally flat from Ω= 0 to Ω= ∞. $|H(j\Omega)| = \sqrt{1/2}$ at Ω = 1. Second filter is chebyshev filter.This filter itself is of two types, Chebyshev I and Chebyshev II. The Chebyshev Type I filter minimizes the absolute difference between the ideal and actual frequency response over the entire pass band by incorporating an equal rippale of Rp dB in the pass band. Stop band response is maximally flat. The transition from pass band to stop band is more rapid then for the Butterworth filter. $|H(j\Omega)| = 10^{-Rp/20}$ at Ω = 1. The chebyshev Type II filter minimizes the absolute difference between the ideal and actual frequency response over the entire stop band by incorporating an equal rippale of Rs dB in the stop band. Pass band response is maximally flat. Elliptic filters are eqiripple in both the pass band and stop band. They generally meet filter requirements with the lowest order of any supported filter type. Given a filter order n, pass band ripple Rp indecible, and stop band ripple Rs in decibel elliptic filter minimize transition width. $|H(j\Omega)| = 10^{-Rp/20}$ at Ω = 1. Magnitude response of these classical IIR filter is shown in following figures 1,2,3,and 4 respectivly. The function of the filter is used to remove unwanted parts of the signal, such as random noise, or to extract useful parts of the signal in signal processing.

There are some considerable advantages of digital over analog filters which make digital filters unavoidable [4]. Some of these are as follows:

1. A digital filter is programmable, i.e. its operation is determined by a program stored in the processor's memory. This means the digital filter can easily be changed without affecting the circuitry (hardware).
2. Digital filters are easily designed, tested and implemented on a general-purpose computer or workstation
3. Unlike their analog counterparts, digital filters can handle low frequency signals accurately. As the speed of DSP technology continues to increase, digital filters are being applied to high frequency signals in the RF (radio frequency) domain, which in the past was the exclusive preserve of analog technology.

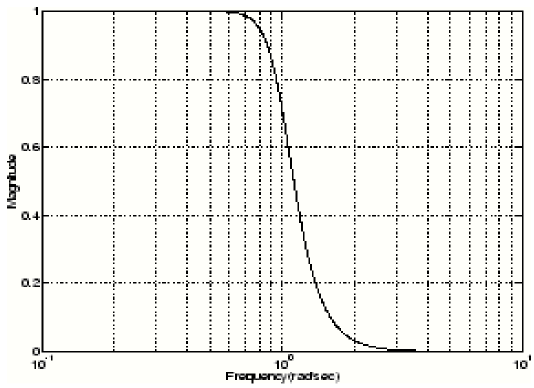

Figure 1 Magnitude response of Butterworth filte

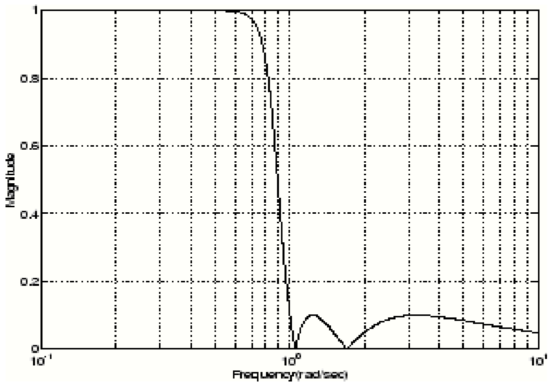

Figure 2 Magnitude response of Chebyshev I filter

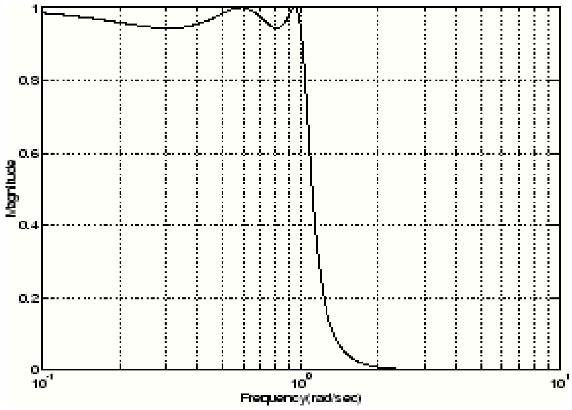

Figure 3 Magnitude response of Chebyshev II filte

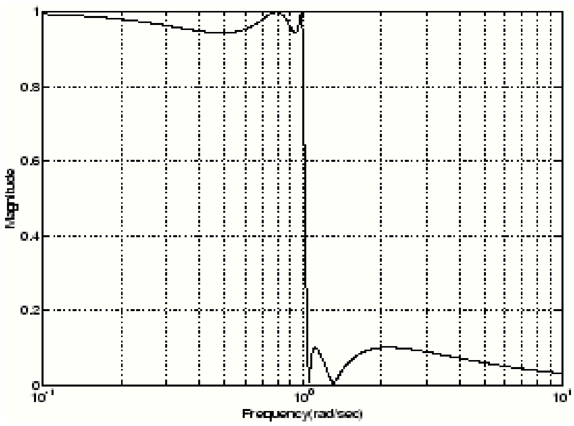

Figure 4 Magnitude response of Elliptic filter

BUTTERWORTH FILTER

Some characteristics are shown by the Butterworth filter

- It provides smooth response at all frequencies.
- Monotonic decrease from the specified cut-off frequencies
- Flatness is maximal with the ideal response of unity in the pass band and zero in the stop band.

The transfer function for Butterworth filter is given by-

$$B(\omega) = \frac{1}{[1+\left(\frac{\omega}{\omega_0}\right)^{2n}]^{1/2}}$$

Where n is the order of filter [4].

CHEBYSHEV FILTERS

Some characteristics are shown by the Chebyshev filters

- Peak error minimized in the pass band.
- It provides Equiripple magnitude response in the pass band.
- It provides monotonically decreasing magnitude response in the stop band.
- Sharper roll off than Butterworth filters.

The frequency response of the filter is given by-

$$|H(\Omega)|^2 = \left(1+\varepsilon^2 T_N^2\left(\frac{\Omega}{\Omega_p}\right)\right)^{-1}$$

Where ε a parameter of the filter is related to ripple present in the pass band and T (x) N is the Nth- order Chebyshev polynomial defined as

$$T_N = \cos(N\cos^{-1}x) \qquad |x| \le 1$$
$$\cos(N\cosh^{-1}x) \qquad |x| \ge 1$$

ELLIPTIC FILTERS

Some characteristics are shown by the Elliptic filters.

- It provides Minimization of peak error in the pass band and the stop band.
- It provides Equiripples in the pass band and the stop band.

The transfer function is given by

$$|H(\Omega)|^2 = \left(1+\varepsilon^2 U_N\left(\frac{\Omega}{\Omega_c}\right)\right)^{-1}$$

Where U (x) N the Jacobian is elliptic function of order N and ε is a constant related to pass band ripple. They provide a realization with the lowest order for a particular set of conditions.

DESIGN:

MATLAB empowers to build own solutions for scientific and engineering systems. It gives the flexibility to design and manipulates the predefined systems. We can simulates all the filters and also create different types of filters [5]. In this paper we use three digital IIR filters to simulate on some system specifications. We design transform function and zero pole gain models on parameters magnitude response, phase response, group delay and phase delay.

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System specification:

Filter type	-	Band pass
Order	-	9
Pass band ripple	-	0.33
Stop band ripple	-	75
Pass band frequency	-	2.41 MHz < ω < 28.7MHz

DESIGN OF TRANSFORM FUNCTION-

The transfer function of a two-port filter network is a mathematical description of network response characteristics, namely, a mathematical expression of S21. For linear, time-invariant networks, the transfer function may be defined as a rational function [2], that is

$$S_{21}(p) = \frac{N(p)}{D(p)}$$

Where N(p) and D(p) are polynomials in a complex frequency variable p =σ + jΩ
If a rational transfer function is available, the phase response of the filter can be found as

$$\emptyset_{21} = \text{Arg } S_{21}(j\Omega)$$

Then the group delay response of this network can be calculated by

$$\tau_d(\Omega) = \frac{d\emptyset_{21}(\Omega)}{-d\Omega} \quad \text{Seconds}$$

Where $\emptyset_{21}(\Omega)$ is in radians and Ω is in radians per second.
3.2 Zero pole gain model
Zero pole gain model are used to create a continuous-time zero-pole-gain model with zeros, poles and gain. The transfer function has the form [6]

$$H(s) = K\frac{Z(s)}{P(s)} = K\frac{(s-Z(1))(s-Z(2))\ldots(s-Z(m))}{(s-P(1))(s-P(2))\ldots(s-P(n))},$$

Where Z represents the zeros, P the poles, and K the gain of the transfer function.

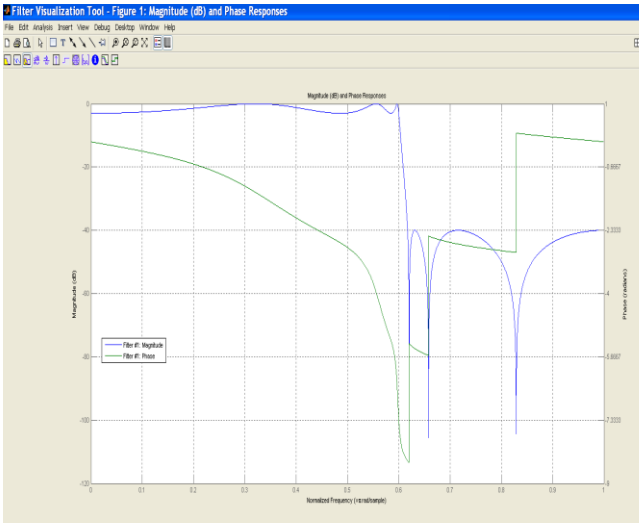
The number of poles must be greater than or equal to the number of zeros. If the poles and zeros are complex, they must be complex-conjugate pairs. For a multiple-output system, all transfer functions must have the same poles. The zeros can differ in value, but the number of zeros for each transfer function must be the same.

FDATOOL

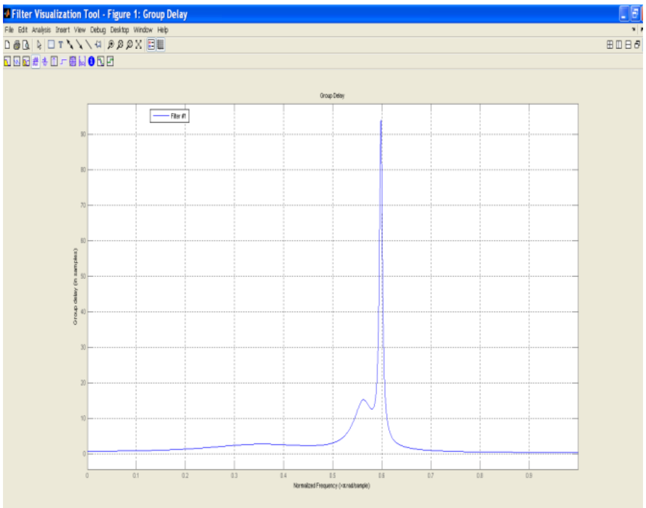
The Filter Design and Analysis Tool (FDATool) is a powerful user interface for designing and analyzingfilters quickly. FDATool enables you to design digital FIR or IIR filters by setting filter specifications, byimporting filters from your MATLAB workspace, or by adding, moving ordeleting poles and zeros. FDATool also provides tools for analyzing filters, such as magnitude and phase response and pole-zero plots. FDA tool is an inbuilt standard tool in MATLAB.

Tables and figures:

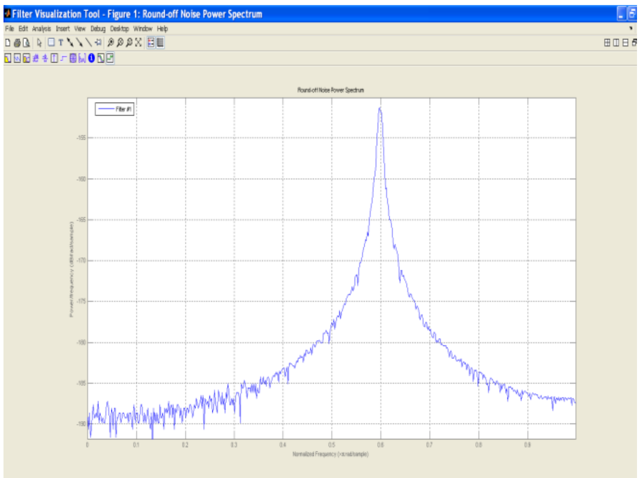
II. Procedure for Paper Submission



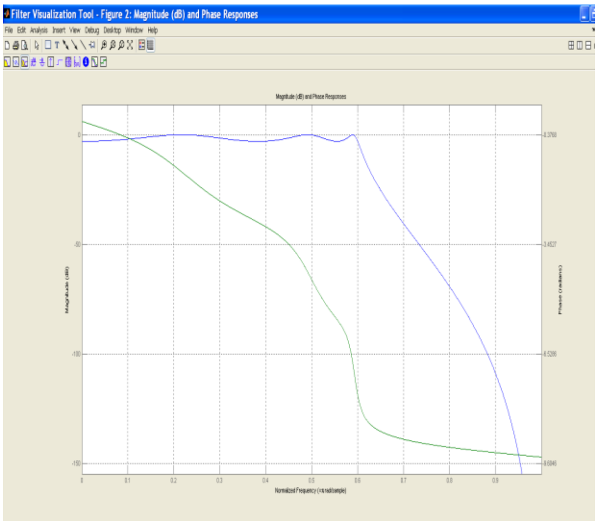
Magnitude and phase response



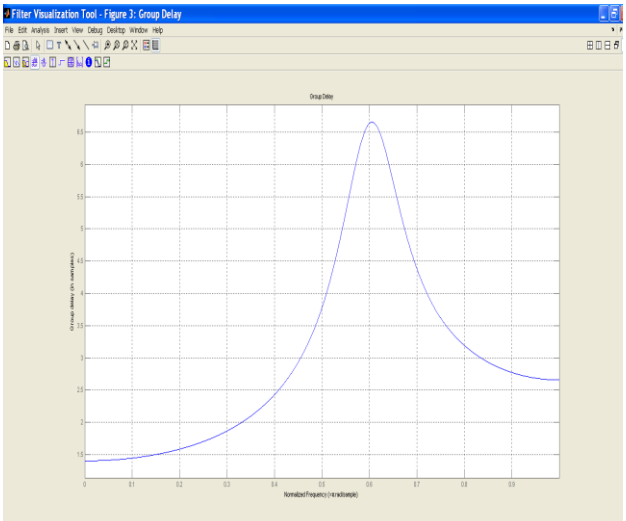
Group dely



Round of noise power spectrum



Magnitude and phase response



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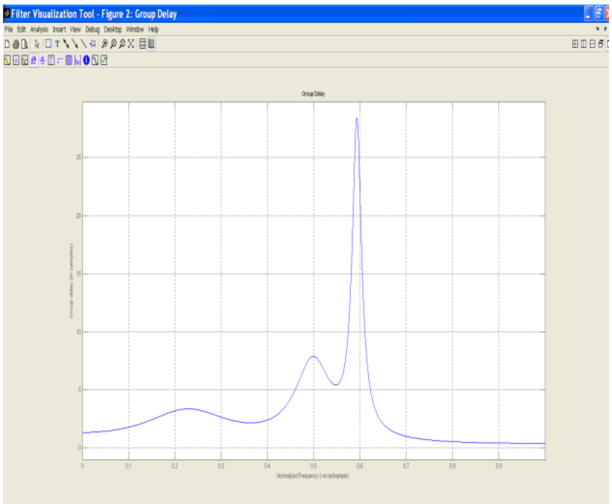

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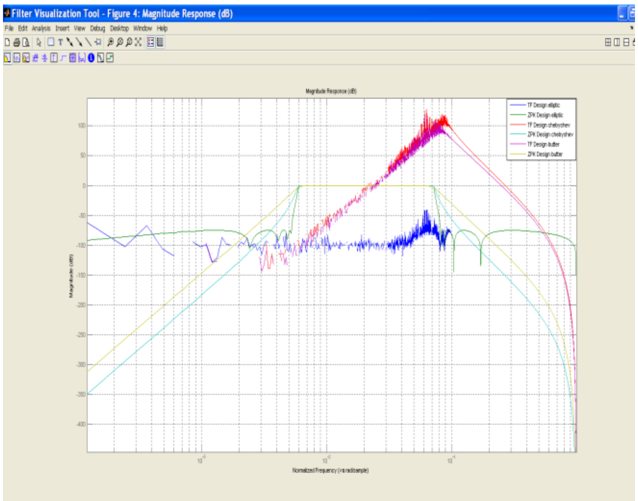
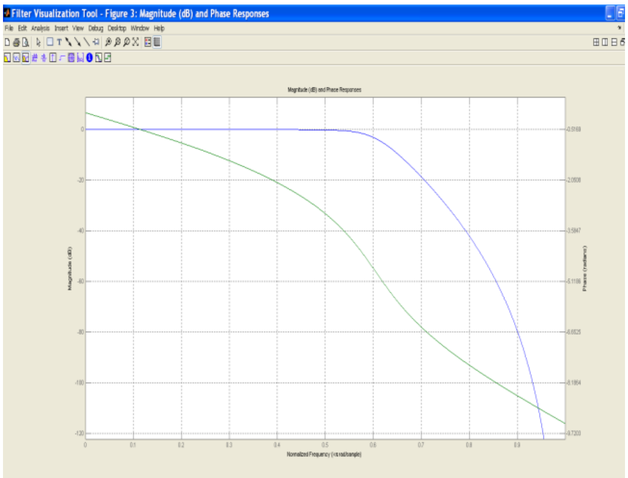
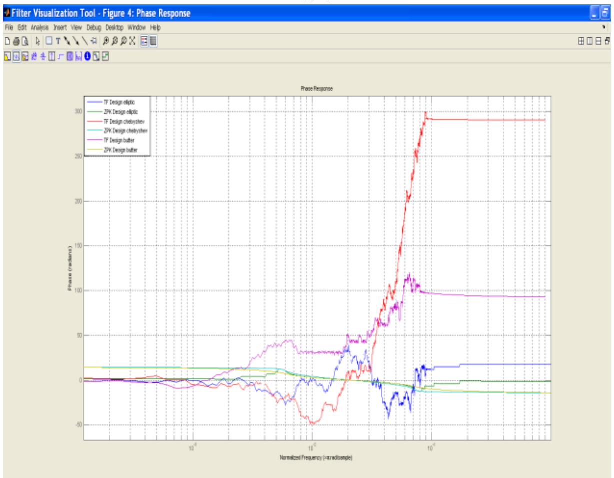


Magnitude Comperision of all lowpass filters



Magnitude and phase response



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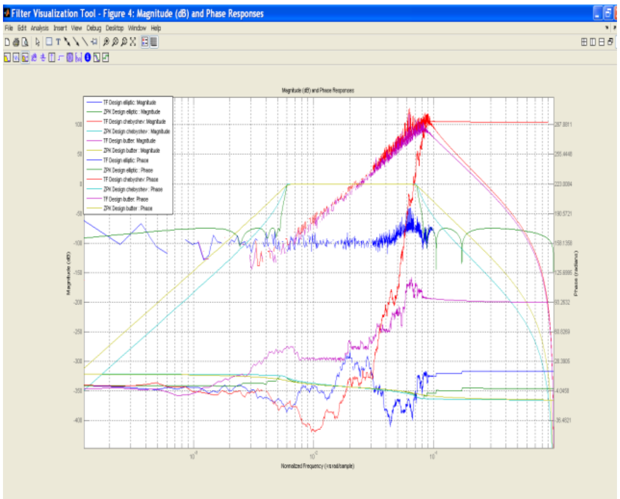
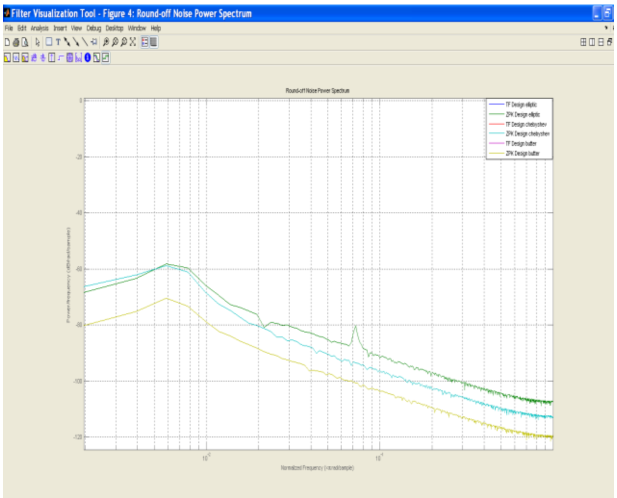
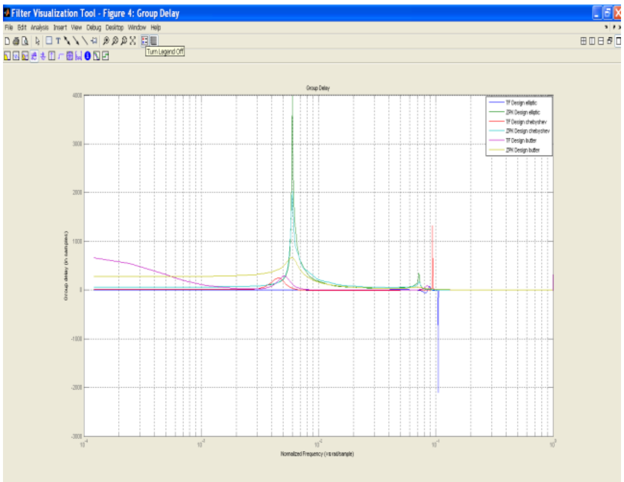
phase Comperision of all low pass filters



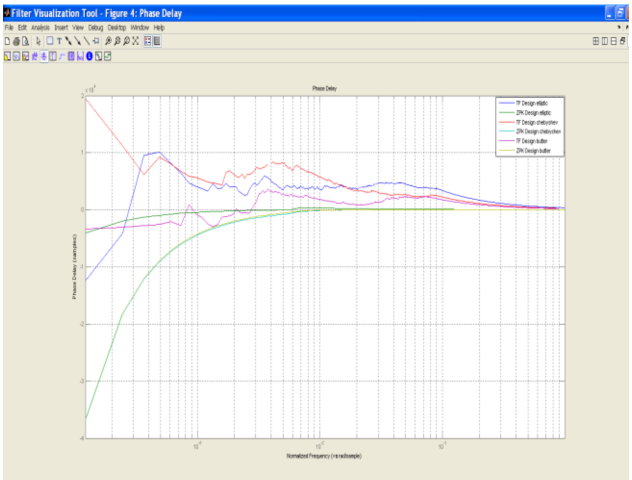
Comparison of Magnitude or phase response of all low pass filters



Comparision of round off noise power spectrum of all low pass filters



Comparision of group delay of all low pass filters



Comparision of phase delay of all low pass filters

CONCLUSION

Obtaining above spoken result from the constructed MATLAB program from the microwave microstrip low pass filteris an obvious development in MATLAB domain. The order of low pass filters is chosen is 9. Microsrip low pass filter system parameter can be the beginner's choice for research and design purposes. Clarification and analysis of each system parameteris available in detail for magnitiud response , phase response , group delay ,round off noise power spectrum design transfer function of all filters(TF design) , design zero-pole gain function of all the filter(ZPK design) and finally comparative study of these low pass filter with the help of MATLAB.

REFERENCES

[1] David M .Pozar "Microwave Engineering" –Third Edition -370.
[2] Anju "Design of Butterworth and Chebyshev1 Lowpass Filter for Equalized Group Delay" Volume 2, Issue 5, May 2012 ISSN: 2277 128X
[3]] Jia-Sheng Hong, M. J. Lancaster "Microstrip Filters for RF/Microwave Applications", Copyright © 2001 John Wiley & Sons, Inc. ISBNs: 0-471-38877-7 (Hardback); 0-471-22161-9 (Electronic)
[4] Jackson L. B., "Digital Filters and Signal Processing", 3rd ed., Kluwer Academic Publishers, 1996.
[5] Ricardo A. Losada "Digital Filters with MATLAB", MATLAB and Simulink are registered trademarks of The Math Works, Inc.
[6] Oppenheim, A.V., R.W. Schafer, "Discrete Time Signal Processing", 2nd ed., Pearson Education, 2005.
[7] Huelsman, L. P., Active and Passive Analog Filter Design; Mc Graw Hill, 1993.
[8] MATLAB The Language of Technical Computing, The Math Works Inc., Natick, MA., 1997.
[9] Alcántara, R., MFILTERS Design of analog and digital filters, Master´s thesis, (in Spanish), Universidad de las Américas, Puebla, 2000.
[10] Escalante, T., Passive and active filter realizations in MFILTERS 2.0, B.S. thesis, (in Spanish), Universidad de las Américas, Puebla, 2000.
[11] Romero, J. J., MFILTERS 2.0 FIR filter design using Remez algorithm, B.S. thesis, (in Spanish), Universidad de las Américas, Puebla, 2000.
[12] Alfonso Fernandez-Vazquez Gordana Jovanovic- Dolecek, IIR filter design based on compex Allpass filters, Mexico.
[13] "Mathworks manual"

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