REVIEW OF VARIOUS FILTER DESIGNS AND THEIR COMPARISON

Gundeep kaur[1],Butta Singh[2]
ECE Dept., GNDU,RC-Jalandhar
Email: [1]gun2305@gmail.com, [2]bsl.khanna@gmail.com

Abstract: - This paper describes review on various types of designing of filter. For this study and discussion some papers based on filter design methods are reviewed and analyzed. For this first we will discuss about filters and then analysis of their types and later review on various filter designs. Filters discussed in this paper are chebyshev filter, butterworth filter and comb filter.

Keywords- Filter, Butterworth filter, Chebyshev filter, comb filter, analog digital

1. Introduction

A filter is basically a device used for frequency selection. Filter passes some frequencies through it and some are even blocked by it. Some signal frequencies are called pass band frequencies which are passed through the filter and those frequencies whichare stopped by the filter are called stop band frequencies. In case of pass band frequencies, the magnitude of system function is very large and is ideally constant whereas in case of stop band frequencies, the magnitude of system frequencies is very small and is also ideally zero. Filters are also used to remove unwanted frequency components from the signal, to enhance wanted ones. It is also useful in removing the noise component from the signal without any loss in meaningful part. Basically filters are of two types:-

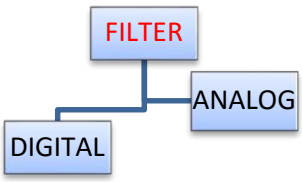

FIG. 1 Description of filters

Analog filters have simple implementation as they require few electrical components like capacitors, resistors and inductors whereas in case of digital filters implementation we first need to convert analog signal to digital signal by taking sampled values of analog signal and then we will implement the digital signal with the help of digital logic components. If we need to change the characteristics of analog filter, then we need to make major modification in thecircuit but there is no requirement of major modification in case of digital filters. In case of digital filters, noise component can be easily removed as in case of analog filters.

I. Types of filters

There are many different types of filters, but some of them are discussed in this paper and compares on the basis of their design and some of these are:-

a) Chebyshev filter

b) Butterworth filter

c) Comb filter

1.1 Chebyshev filter

The magnitude response of chebyshev low pass filter is given by:-

$$|H(j\Omega)| = A/[1 + \varepsilon^2 C_N{}^2(\Omega/\Omega_C)]^{0.5}$$

Where A is the filter gain ,ε is a constant and Ω_c is the 3 dB cut off frequency.

1.1.1 Designing method

Lopez and Fernandez paper he gave aimproved the delay response of chebyshev filter.Histechniques consist of how to shift frequencies nearest to origin without changing cutoff frequency.Swady. paper introduced a new chebyshev filter used for approximation for analog filters. Bhooshanand Kumar paper, he proposed a designing a 2-dimensional chebyshev filter.

1.1.2 Comparison table

Paper no	Objective	Pros	Cons
1.	To shift frequencies nearest to origin without changing cut off freq.	Delay response is improved	This can only be used for even order filter
2.	In this paper conversion of low pass filter tochebyshev filter magnitude response	In case of pass band frequencies, magnitude response is much more flat in this.	This type can only be used for odd order chebyshev filter
3.	In this paper , we will convert 1D chebyshev polynomial into 2D polynomial	Complexity is very less	

1.2 Butterworth filter

A butterworth low pass filter has a magnitude response given by:-

$$|H(j)| = \frac{A}{\left[1 + (\frac{\Omega}{\Omega_C})^{2N}\right]^{0.5}}$$

Where A is the filter gain and Ω_c is the 3dB cutoff frequency and N is the order of filter. The magnitude response has a maximally flat passband and stopband. It can be seen by increasing the filter order N, the butterworth response approximates the ideal response. However, the phase response of the butterworth filter becomes more non linear with increasing.

1.2.1 Designing method

Butterworth filter has one more feature of removing some noise components from the signal. Ping designed Butterworth filter with the use of symbolic codes by taking help of topology structure namely sallen key topology structure. Fleming and gilbertdesigned by outlining a high order of Butterworth filter with utilizing either series arrangement or parallel arrangement or blend of both arrangement. They plan a filter by utilizing twofold exactness system to beat the numerical precision instead of an immediate strategy.

1.2.2 Comparison table

Paper no.	Objective	Pros	Cons
1.	In this paper designing of filter is done by making use of symbolic codes.	By this method filter becomes more reliable and functional. This technique is also fast to analyse and verify.	Process of designing is slow.
3.	In this paper we will design a filter bydouble precision method to beat the numerical precision instead of an immediate strategy	By this method, economy and simplicity of programming will be easier.	This method can only be applied to denominator in case of transfer function.

1.3 COMB FILTER

In signal processing, a comb filter adds a delayed version of a signal to itself, causing constructive and destructive interference. The frequency response of a comb filter consists of a series of regularly spaced spikes, giving the appearance of a comb. Comb filters are produced when a signal is time delayed and added back to itself. Some frequencies will cancel and others will be reinforced, which can dramatically change the tonal color of the sound.

Frequency response is given by:-

$$H(w) = \frac{e^{-jw\frac{M}{2}}}{M+1} \frac{\sin w(\frac{M+1}{2})}{\sin(\frac{w}{2})}$$

1.3.1 DESIGNING METHOD

In this paper which is presented by Odda and Makarov the second order COMB filter comprise of two traditional COMB filter in cascade. The aim of this paper is to sucha filter by using (DM) technique which gives the realization cost efficient, simple and aproductive result progressively preparing. Another paper presented by Rasmussen says that utilization of the COMB filter is to remove the basic sinusoidal signal and its harmonics from signal of interest (SOI). So in such a case, it is not attainable to utilize straightforward IIR or FIR filter to remove these signals without noteworthy degradation of SOI. For this situation, we can utilize the FFT COMB filter to remove these intrupting signals yet the FFT system has not frequently utilized on account of its computational many-sided quality. In this paper they show another detailing of the FFT COMB filter that dispenses with all constraint of the FFT system and gives points of advantageover the IIR or FIR COMB channel.

1.3.2 COMPARISON TABLE

Paper no.	Objective	Pros	Cons
1.	In this method, stimulation of 2nd order COMB filter by the use of DM technique.	simple, cost efficient and a proficient result progressively preparing	

2.	Utilizing FFT and IFFT matrix duplication procedure to plan a COMB filter	Computational complexity is decreased and there is no limitation that a radix 2 value for the extent of the FFT must be utilized.	N/M must be an integer, so itis prerequisite that all N tests must be gathered before the output can be acquired and the time included may be too large for quite a time Division Multiple Access or network frameworks.

II. Conclusion

Filter can be designing can be done in many methods. In this paper we discussed the Chebyshev filter, Butterworth filter, andComb filter and there design methods and compared them.In Chebyshev filter,3 papers are discussed based on shifting of frequencies nearest to origin by not changing the cut-off frequency, using magnitude response of low pass filter and Convertion 1D Chebyshev polynomial into 2D. In Butterworth filter, 2 papers are discussed based upon the Sallen-key topology and double precision method. In Comb filter, 2 papers are discussed out of which one is based on upon delta modulation and other on matrix multiplication. The pros and cons of respective methods will be discussed. Further work will be done on algorithms based on designing of these filters.

References

1. **Jimenez-Fernanadez and Baez-Lopez, "***Modified Chebyshev filter design"* IEEE, 2000.
2. **Swady, L. Hisham "***Generalized Chebyshev-like for Low-pass Filter"* IEEE, 2010.
3. **Kumar, V and Bhooshan, S. "***Design of linear phase Chebyshev FIR filters."* IEEE, 2008.
4. **Ling-jaun, Miao, Hui, Ding and Guo-Ping "***Butterworth filter efficient design based on symbolic calculus."* IEEE, 2010
5. **Fleming, J. and Gilbert, N., "***Butterworth low-pass filterDirect form expansion transfer function."* IEEE, 1982.
6. **Makarov, Sergey B. "***comb filter based on delta modulation."*
7. **Rasmussen, J.L. "***New method of FIR comb filtering."* IEEE, 2012.

8. **S. Salivahan, A Vallabraj, C Gnanapriya, "**Digital Signal Processing" ; McGraw Hill education pvt limited, 2010.
9. *Digital Signal Processing.***Proakis, John G. and Manolakis, Dimitris G.** s.l. : Dorling Kindersley (India) Pvt. Ltd, 2007.
10. **SoontomOraintara and Truong Q. Nguyen, "** A new method in FIR filter design"
11. **Yassin M. Hasan, Lina J. Karam, Matt Falkinburg, Art Helwig, and Matt Ronning, "**Canonic Signed Digit Chebyshev FIR Filter Design" IEEE 2001
12. **AmanjeetPanghal, NitinMittal,Devender Pal Singh R.S. Chauhan,SandeepK.Arya.** **"**Comparison of various optimization techniques for design fir digital filters"
13. **R. Kaur, M. S. Patterh and J. S. Dhillon,** "Real Coded Genetic Algorithm for Design of IIR Digital Filter with Conflicting Objectives," *International Journal of Applied Mathematics and Information Sciences*, vol. 8, no. 5, pp. 2635-2644, 2014**.**
14. **R. Kaur, M. S. Patterh and J. S. Dhillon,** " Heuristic Search Method for the Design of IIR filter,*WSEAS Transactions on Signal Processing*, vol. 8, pp. 121-134, 2012.
15. **D. Singh and J. S. Dhillon,** " Design of Optimal IIR Digital Filter using Teaching-Learning based Optimization Technique, *WSEAS Transactions on Advances in Engineering Education*, vol. 12, pp. 9-18, 2015.