ISSN: 2277-9655
Scientific Journal Impact Factor: 3.449
(ISRA), Impact Factor: 1.852

IJESRT
INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

Design and Analysis of 5th Order Chebyshev Low Pass Filter

Annu [1], Gaganpreet [2]
Department of Electronics and communication, Ganga Technical Campus, India
annu.beniwal12@gmail.com

Abstract

The design of a 5th order Chebyshev low pass filter in this paper presented. This paper discuss the different design digital IIR filter mostly Chebyshev. Results obtained are provides the magnitude resonance, phase response, impulse response and pole-zero for each type filter. Digital IIR filters have been derived from the analog filters i.e. Chebyshev. Parameters required designing IIR filters are sampling frequency, pass band edge frequency, stop band edge frequency, pass band and stop band ripples.

Keywords: Chebyshev filter, low pass filter, pass band, stop band.

Introduction

With the advancements in scientific research and user friendly software, a user friendly graphical user interface was developed using MATLAB graphical user interface for the design and analysis of digital filters like FIR and IIR. This GUI will overcome the complexities in Developing a Chebyshev type-II and help the user to analyze the different order in an efficient manner. In this thesis we develop Chebyshev type-II and Type I with low pass filter consideration [1-3]. Digital filters are more versatile filters in their characteristics to handle both low as well as high frequency signals and the hardware relatively simple and compact. In real world signals are analog in nature[2]. A simple signal flow for the signal processing is shown in figure 1.

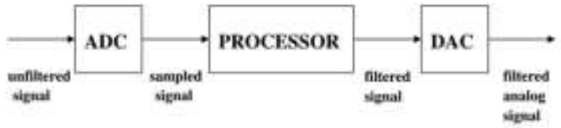

Figure 1 signal flow diagram

Analog to digital enables digital processor to interact with real world signals. The input to the processor sampled and quantized. Sampling and quantization restrict the amount of information a digital signal contain. In the figure1 an interface is provided between analog signal and the digital signal processor called analog to digital converter (ADC). The output from ADC is input to the processor. In applications output from the processor is given to user in analog form such as speech. This interface is called digital to analog converter (DAC). The processor can be anywhere from a large programmable digital computer to a small microprocessor which contains digital filters [4].

Two types of digital filters are based on their impulse response; finite impulse response (FIR) and infinite impulse response (IIR) filters [5]. FIR filters have same time, insensitive to quantization and always stable [6]. FIR filters can be designed in different ways, the window technique is most conventional method for designing FIR filters.

Chebyshev Filter

Chebyshev filters are analog or digital filters having a steeper roll-off and more passband ripple (type I) or stopband ripple (type II) than Butterworth filters. Chebyshev filters have the property that they minimize the error between the idealized and the actual filter characteristic over the range of the filter, but with ripples in the passband. This type of filter is named in honor of Pafnuty Chebyshev because their mathematical characteristics are derived from Chebyshev polynomials [7].

Chebyshev filters are of two types:

(i) Chebyshev type I
(ii) Chebyshev type II

The Chebyshev Type I filters are all pole filters which are equiripple in the pass band and are monotonic in the stop band. These minimize the absolute difference between the ideal and actual frequency response over

ISSN: 2277-9655
Scientific Journal Impact Factor: 3.449
(ISRA), Impact Factor: 1.852

the entire pass band by incorporating an equal ripple of R_p dB in the pass band. Stop band response is maximally flat. The transition from pass band to stop band is more rapid, poorer transient response. It features superior attenuation in the stop band, at the expense of ripple in the pass band. A ripple depth of between 0.1 dB and 3 dB. The Chebyshev Type II filter contains both poles and zeros exhibiting a the passband and equi ripple of R_S dB in the stopband and minimizes difference between the ideal and actual frequency response and passband response is maximally flat. The stopband does not approach zero as quickly as the type I filter.

Type I Chebyshev filters

The order of a Chebyshev filter is equal to the number of reactive components, inductors needed to realize the filter using analog electronics.The ripple is often given in dB:

Ripple in dB = $20\log_{10}\sqrt{1+\varepsilon^2}$

so that a ripple amplitude of 3 dB results from $\varepsilon = 1.$

Type II Chebyshev filters

Also known as inverse Chebyshev, does not roll off as fast as type I, and requires more components, no ripple in the passband, but does have equiripple in the stopband. The gain is:

$$G_n(\omega,\omega_0) = \frac{1}{\sqrt{1+\frac{1}{\varepsilon^2 T_n^2(\omega_0/\omega)}}}. \quad ...(2)$$

1. SIMULATION RESULT

In order to demonstrate the versatility of using active inductor in filters, a fifth-order Chebyshev type low pass filter has been designed. The Chebyshev filter has an equal-ripple frequency response in the pass band

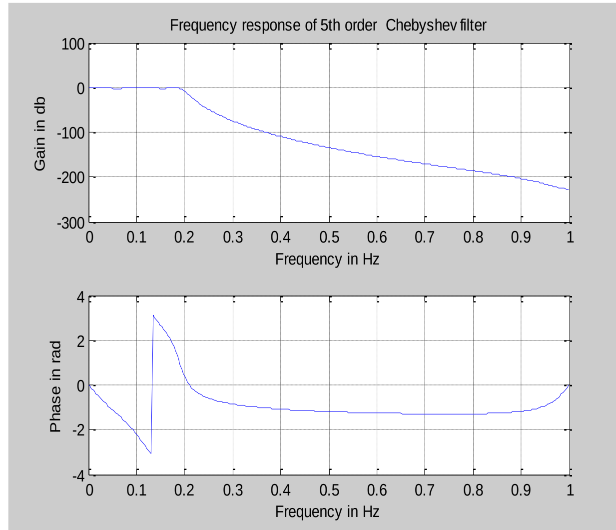

Figure 2 Frequency response of 5th order chebyshev filter

Result using signal processing tool box
For 5th order Chebyshev filter:-

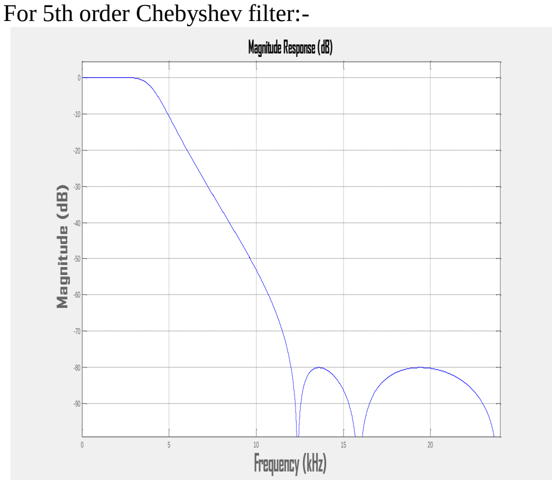

Figure 3 Magnitude plot for 5th order Chebyshev filter

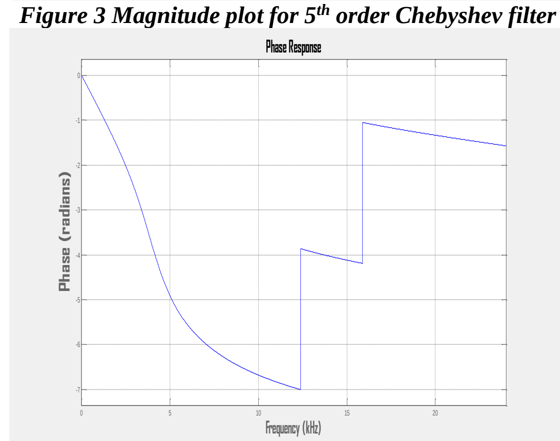

Figure 4 Phase response of chebyshev 5th order filter

ISSN: 2277-9655
Scientific Journal Impact Factor: 3.449
(ISRA), Impact Factor: 1.852

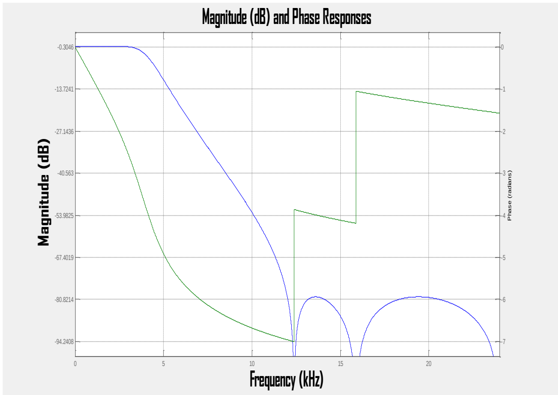

Figure 5 Magnitude & phase response of Chebyshev 5th order filter

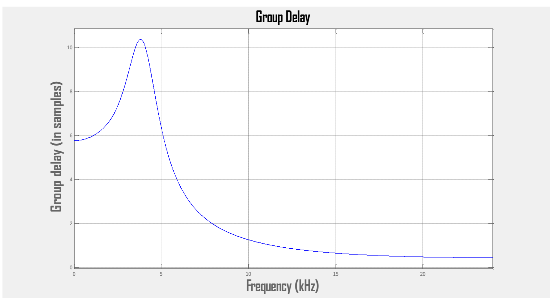

Figure 6 Group delay of Chebyshev 5th order filter

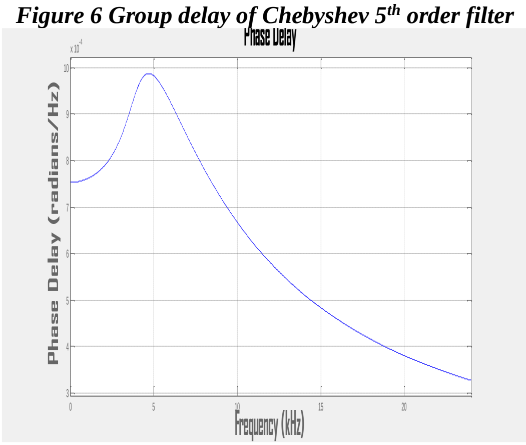

Figure 7 Phase delay of Chebyshev 5th order filter

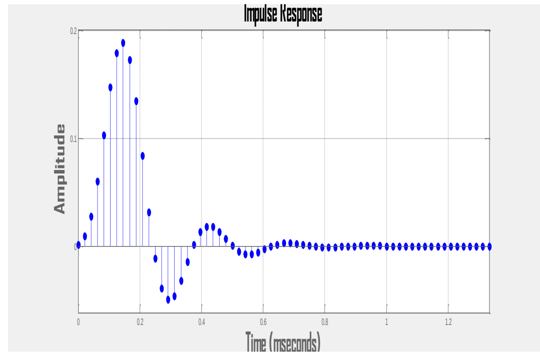

Figure 8 Impulse response of Chebyshev 5th order filter

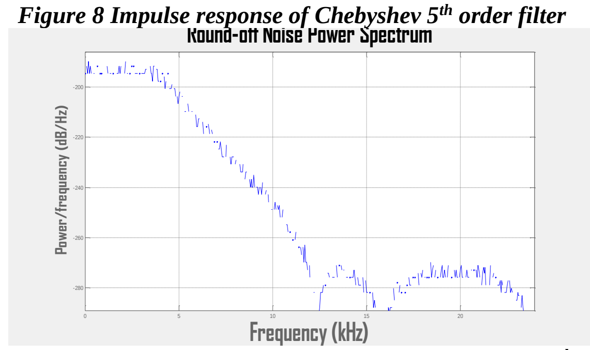

Figure 9 Round off Noise power spectrum Chebyshev 5th order filter

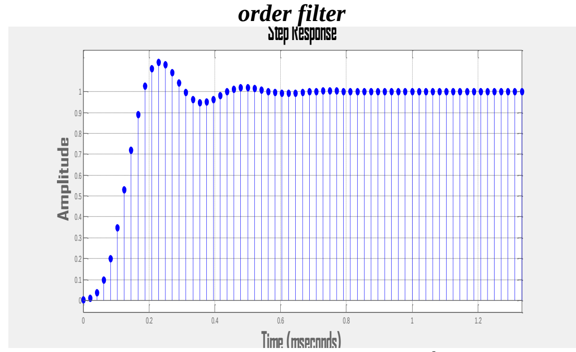

Figure 10 Step response of Chebyshev 5th order filter

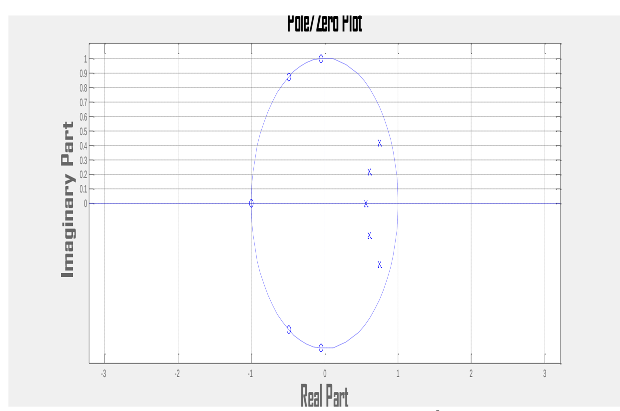

Figure 11 Pole- zero plot of Chebyshev 5th order filter

ISSN: 2277-9655
Scientific Journal Impact Factor: 3.449
(ISRA), Impact Factor: 1.852

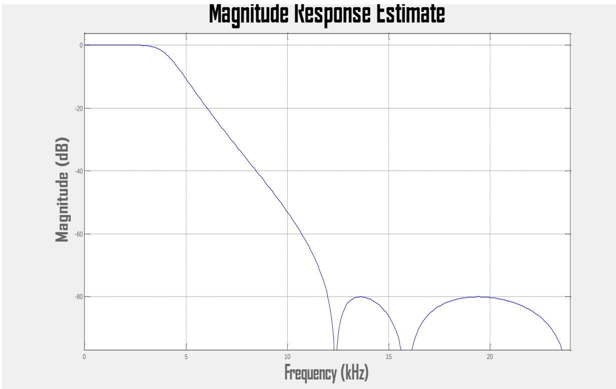

Figure 12 Magnitude estimate of Chebyshev 5th order filter

Conclusion

A 5th order Chebyshev low pass filter is designed here in this work. The designed has been found to provide the good accuracy and also promisingly applicable to low pass filter. Simulation results are showing the basic performance of the filter. The chebyshev filter shows better performance over other conventional fiters in terms of frequency, mangnitude, pole zero reponse.

References

[1]. Riewruja, V., “Simple square-rooting circuit using OTAs”, *Electron. Lett*., 2008, Vol. 44 No.17, pp. 1000-1002.

[2]. P. Soni, B. P. Singh, and M. Bhardwaj, “Design of Enhanced Performance Folded Cascode Operational Transconductance Amplifier”, American Institute of Physics Conference Proceedings, Volume 1324, pp. 360-364, December 2010, ISBN-978-0-7354-0879-1, ISSN-0094-243X.

[3]. Koomagaew C, Petchmaneelumka W, Riewruja V, “OTA based Floating Inductance Simulator”, *ICCAS-SICE*, pp 857-860, Aug.. 2009.

[4]. W. Kiranon and P. Pawarangkoon, “Floating inductance simulation based on current conveyors,” *Electron. Lett*., vol. 33, no. 21, 1997, pp. 1748-1749.

[5]. G. Ferri, N.C. Guerrini, and M. Diqual, “CCII-based floating inductance simulator with compensated series resistance,” *Electron. Lett*., vol. 39, no. 22, 2003, pp. 1560-1562.

[6]. P.R. Kinget, "Device Mismatch and Tradeoffs in the Design of Analog Circuits", *"IEEE Journal of Solid State Circuits,"* vol. 40, no. 6, IEEE, pp. 1212-1224, 2005.

[7]. R.Unbehauen, “Recursive Digital Low-Pass Filters with Predetermined Phase or Group Delay and Chebyshev Stopband Attenuation”, 1EEE Circuits Sys, vol.CAS-28, pp.965 912, Sept.1981.