Audio Signal Noise Reduction using Low Pass Filter

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Abstract—*This paper elucidates designing of filters to reduce noise from an audio or speech signal. Such kind of signal may contain random noise which can get added from surroundings while transmission. Various filters are used to remove different kinds of noise. A low pass filter (LPF) is used to remove high frequency noise from the signal and preserves the low frequency components in the signal. Whereas a high pass filter is used to remove low frequency noise and preserves the high pas components. A bandpass filter is used to allow only a range of frequencies by taking human threshold voice. In this paper, we are using a low pass IIR (Infinite Impulse Response) and FIR (Finite Impulse Response) filter to remove noise from an audio signal. This LPF is designed on Filter Design and Analysis Toolbox in MATLAB. Butterworth, Chebyshev type-II and Elliptic low-pass filters are used for noise reduction and results are compared using signal to noise ratio (SNR) and mean square error (MSE).*

Keywords- Noise, low-pass filter, elliptic filter, butterworth filter, Chebyshev filter

I. INTRODUCTION

Audio signals are most commonly used in music applications, acoustic detection, speech processing, sound recognition, synthesis and enhancement [1,2]. The processing of these signals requires pre-processing like amplifying, noise removal, etc. before further application processing. The pre-processing of the signal ensures the quality of the signal is appropriate enough so as to be process it further without deterioration. All audio signals are analog in nature. To process the signals on a digital computer, it is required to apply analog to digital conversion. For this, analog signal is uniformly sampled at a sampling rate, quantized and then encoded to get final digital signal[3]. It is at the time of transmission; the signal acquires some random noise which may be due to environment or during analog to digital conversion process. This noise generates errors in the information carried by signals and thereby distorts the quality of the signal. Thus, it becomes important to extract the original information from the noisy signal. The filters in digital signal processing are used to reduce the noise by extracting the desired information from the signal and improving the performance of the system. There are many different types of filters that are available for reducing the effects of noise. Like a low pass filter which passes the low frequency components and stops the high frequency components, high pass filter that allows high frequency to pass and stop lower frequency [4–6].

This paper aims to design the Butterworth, Chebyshev type-II and Elliptic low-pass filter for remove high frequency noise components from audio signal and then compare their performance.

Low pass filter eliminates high frequency noises. Noises are generally of random noise containing a little amplitude of each frequency. We will use three types of filters in this paper: Chebyshev type II, Butterworth and Elliptical Low-Pass filter. A low pass will eliminate high frequency. It is observed generally that elliptical filter provide better output rather than the other two. In this we seek to find which filter removes better high frequency noise by using same cut-off frequency and order[7,8].

Figure 1 represents the magnitude plot of chebyshev type II filter. In this filter cutoff frequency is 4KHz and sampling frequency of 44100khz. Figure 2 represents the magnitude response of butterworth low pass filter with a cutoff frequency of 4KHz and sampling rate as 44100KHz. Figure 3 shows magnitude response of elliptic filter. It has cutoff frequency of 4KHZ and sampling rate as 44100KHz.

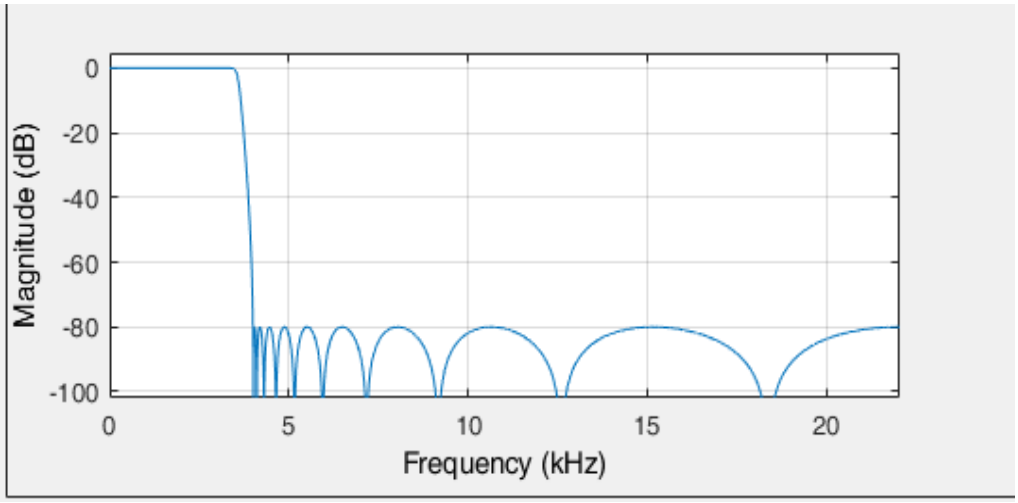

Figure 1. Magnitude response of Chebyshev type-II low-pass filter

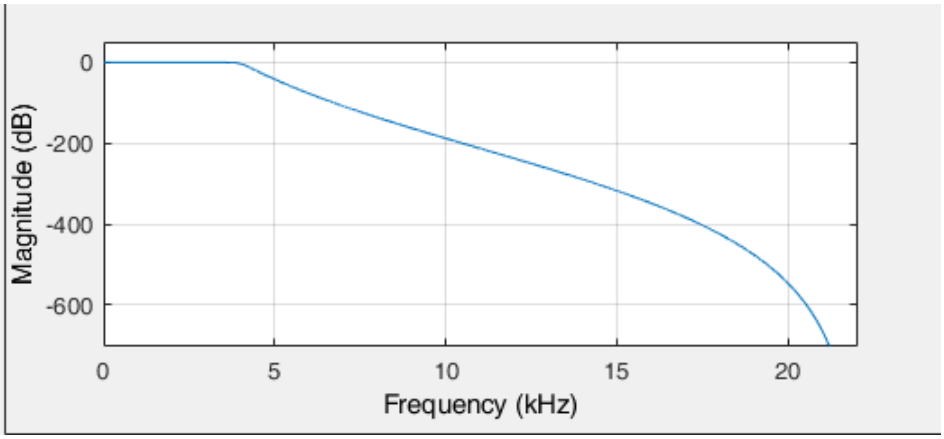

Figure 2. Magnitude response of Butterworth low pass filter

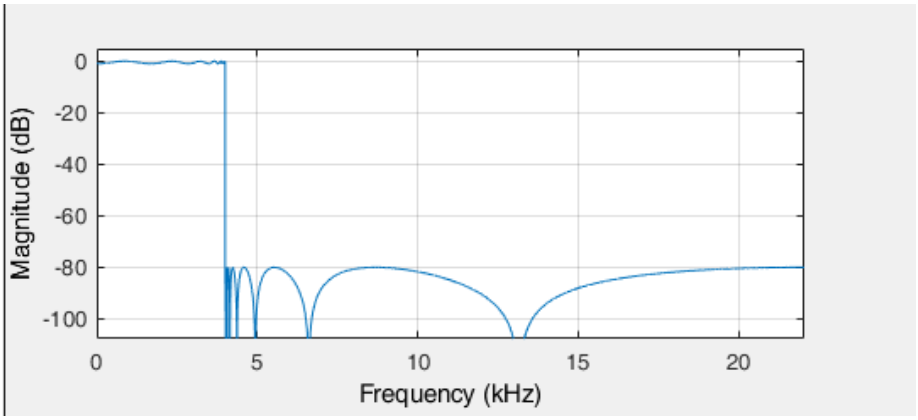

Figure 3. Magnitude response of Elliptic low pass filter.

The frequency range of human voice is of the order of 300 to 3300Hz. Hence any other frequency can be considered as noise. By using low pass Filter, we can eliminate all frequency higher than 4KHz [5].

II. PROPOSED ALGORITHM

A. Importing Audio file: Use "audioread" command to import the audio file from which noise has to be removed.

B. Sampling the Audio: Use [a, fs] = audioread ('name') to sample the audio file.

C. Plotting Raw Inputs: Use subplot and Plot to display the audio signal

D. Filter designing: Use Filter Designing Toolbox in MATLAB and set the type of filters, order and frequency.

E. Passing audio from Filter: Use output = filter (Hd,a); Where Hd is designed Filter.

F. Ploting and Playing output file: Use subplot and Plot commands to display the signals and Sound (output, fs) to play sound.

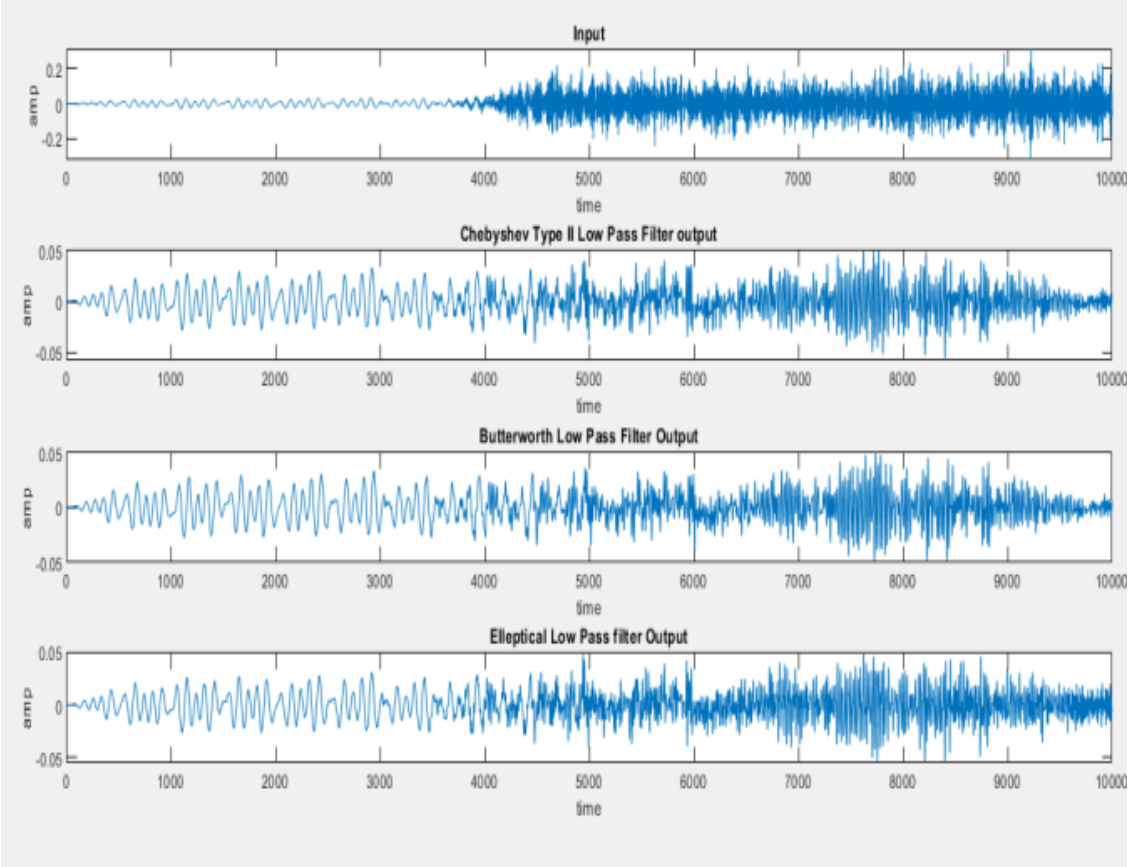

Figure 4. Simulation results (a – d; top to bottom)

III. RESULTS AND DISCUSSIONS

Figure 4 shows comparison of output signal when passed through different filters. Figure 4.a is the sample input audio signal. Figure 4.b is output when passed through Chebyshev type II filter, Figure 4.c is the output of Butterworth filter and Figure 4.d is the output of elliptic filter. For all these filters following two parameters namely signal to noise (SNR) ratio and mean square error (MSE) have also been calculated as given by Equation (1) and (2) respectively [6]. Table 1 represents the comparison of SNR and MSE for these three filters. It is observed from the parametric values that the elliptic filters work best for such type of signals.

$$SNR = \frac{Signal\ Power(dB)}{Noise\ Power(dB)} \quad (1)$$

$$MSE = \frac{1}{n}\sum_{i} x_i - y_i)^2 \quad (2)$$

TABLE I. COMPARISON OF SNR AND MSE FOR DIFFERENT FILTERS

Parameter	Chebyshec Type II	Butterworth	Elliptical
SNR	78.9840	42.3176	79.5959
MSE	0.0015	0.0015	0.0013

IV. CONCLUSIONS

In this paper, three types of low pass filters are designed to reduce the noise from an audio signal. Butterworth, Chebyshev type II and Elliptic low pass filters have been used for this purpose. It is observed that Elliptical low pass-filter has best noise removal capabilities among Butterworth, Chebyshev type II and Elliptic low pass filter. Elliptical low pass filter has minimum mean square error. Also FIR digital filter outperforms IIR low-pass filters.

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