EE386 Digital Signal Processing Lab	Jul-Dec 2021

6: Experiment

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1 Solution

Wherever relevant, $\alpha = 1 + mod(x, 3)$ where x is the last three digits of registration number. Since $x = 161$,

$$\alpha = 1 + mod(162, 3)$$
$$\therefore \alpha = 1$$

Problem 1

Given: The maximum bandpass ripple of $-1dB$, and the edge frequency of 10 Hz. The filter has a maximum stopband attenuation of -40 dB from a stopband edge frequency of 20 Hz.Sampling frequency of 720 samples/sec.

(Subproblem 1) Find the transfer function of the filter

(Solution) Variables Initiated-

- omegaP = 700 Hz
- omegaS = 20
- rhoP = -1
- rhoS = -40

Calculating Passband gain, Stopband gain, epsilon

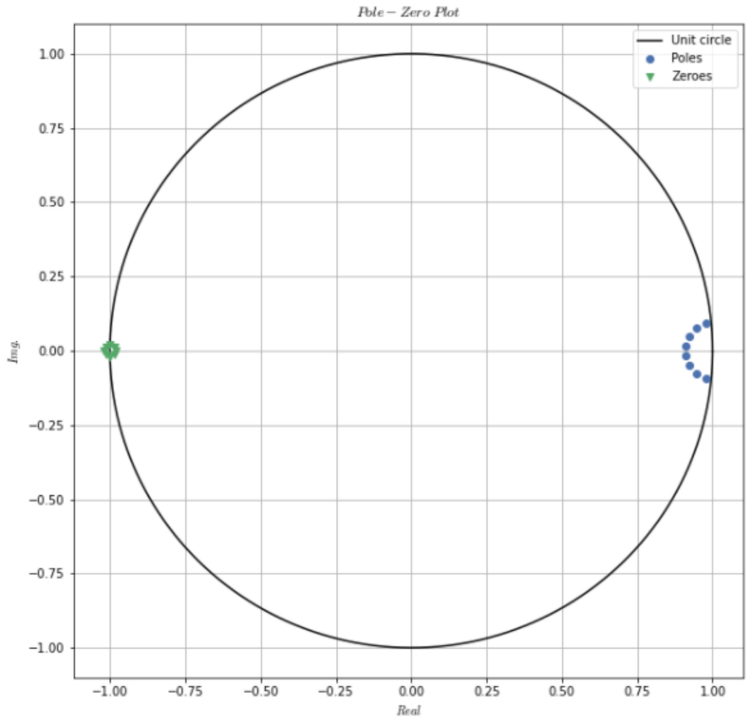
- Passband Gain(δ_p) =$10^(- 1/20)$
- Stopband Gain(δ_s) =$10^(- 40/20)$
- epsilon(ϵ) = $\sqrt{\frac{1-\delta_p^2}{\delta_p^2}}$

$\implies \delta_p = 0.89$
$\implies \delta_s = 0.01$
$\implies \epsilon = \sqrt{\frac{1-\delta_p^2}{\delta_p^2}}$
$\implies \epsilon = 0.5088$

Transfer function of the filter:- Since the order of the filter is 2,

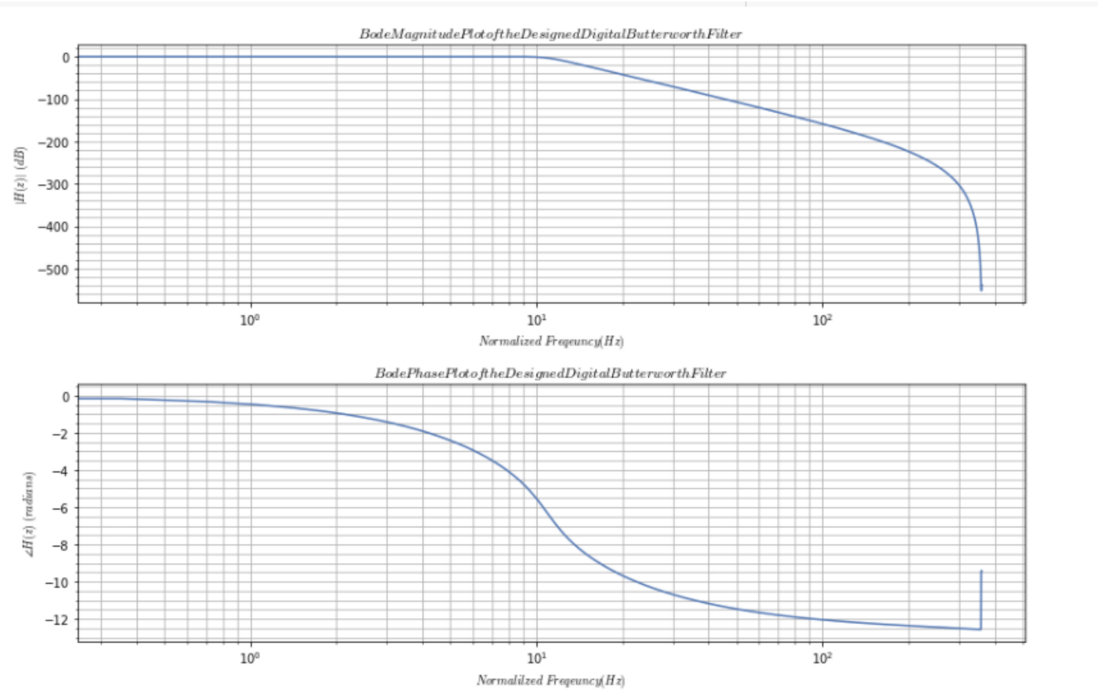
$H(s) = \frac{k}{1+1.414s+s^2}$, where $k = \frac{\delta_p}{\delta_s} = 89$
$\implies H(s) = \frac{89}{1+1.414s+s^2}$

(Subproblem 2) Pole zero plot:

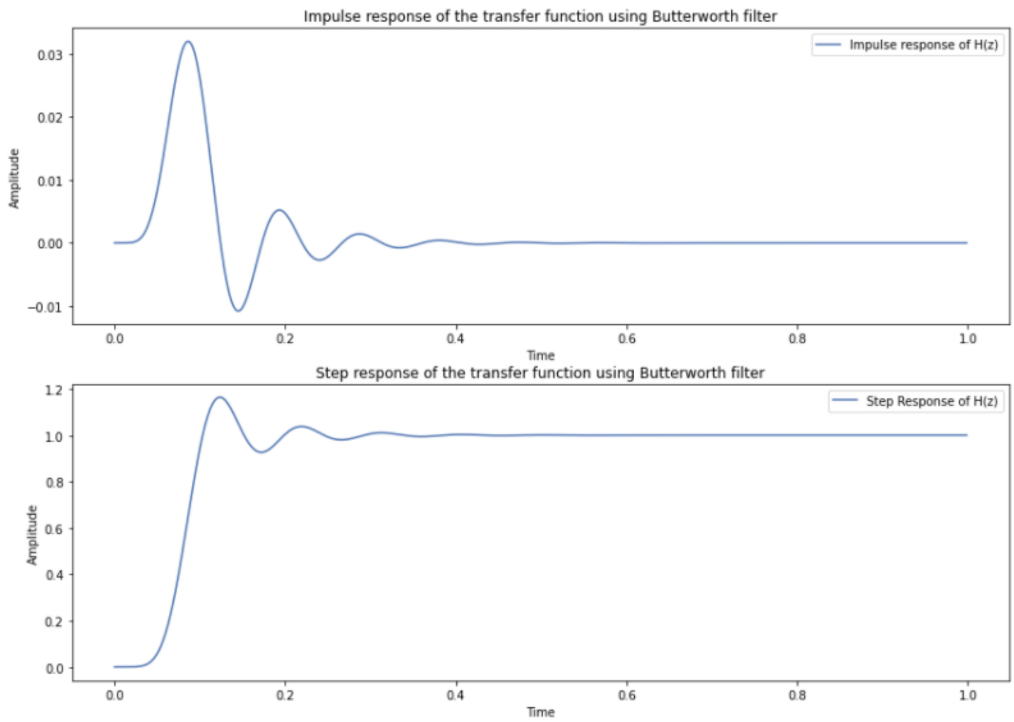


All the poles lies inside of the circle and hence, the system is stable.

(Subproblem 3) Bode plot of designed Butterworth filter:

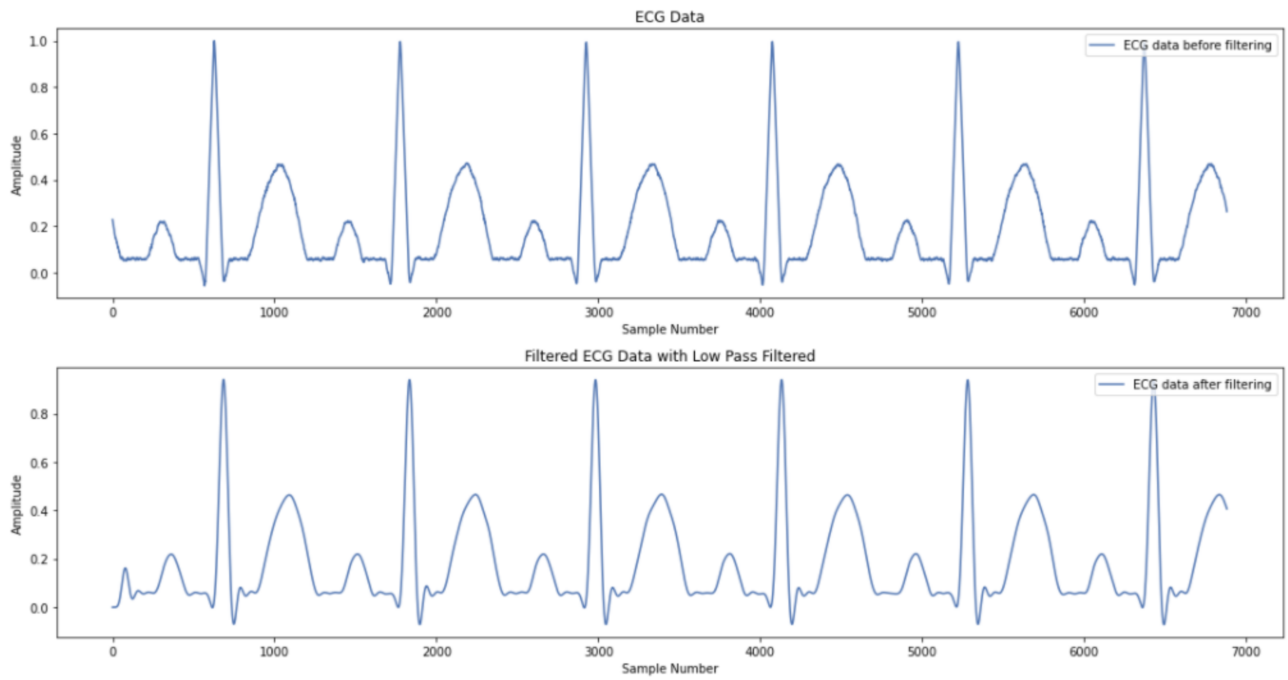


Impulse response and step response of filters

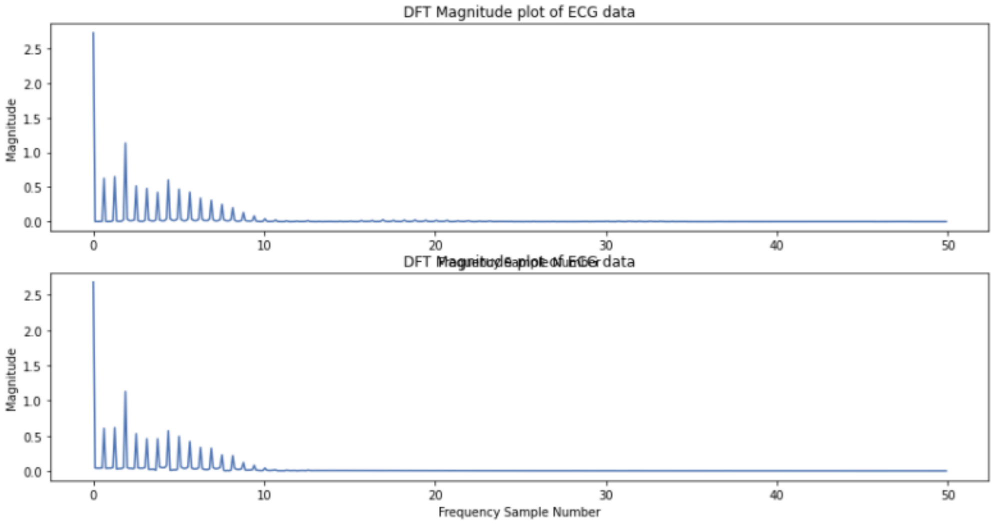


Problem 2

By using Butterworth filter, filter the ECG data stored in the text file.

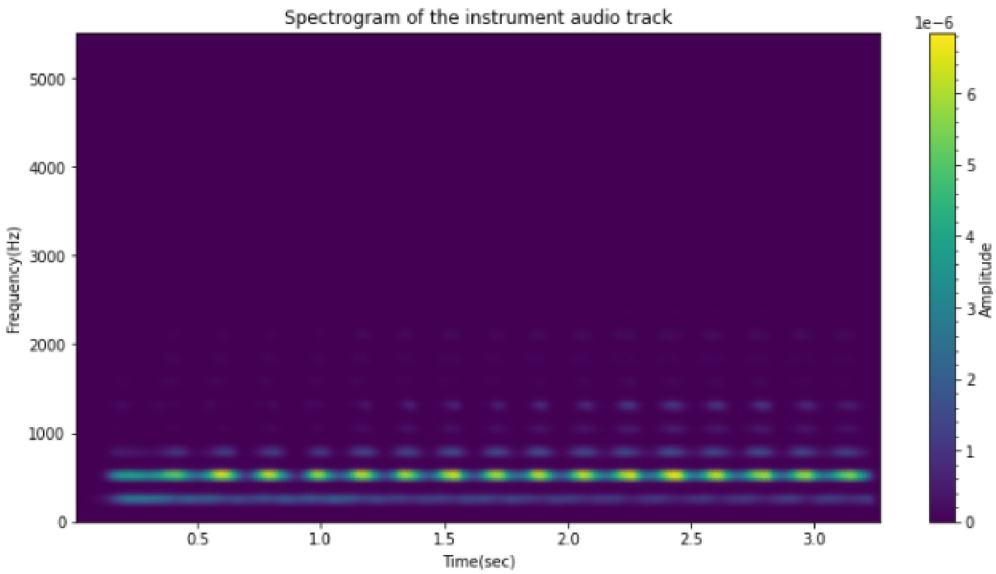


It can be observed that DFT magnitude plot has clear peaks from the figures below which indicates that the nosie has been removed from the signal using the butterworth filter. Hence, we can conclude that the filter is effective in removal of noise.

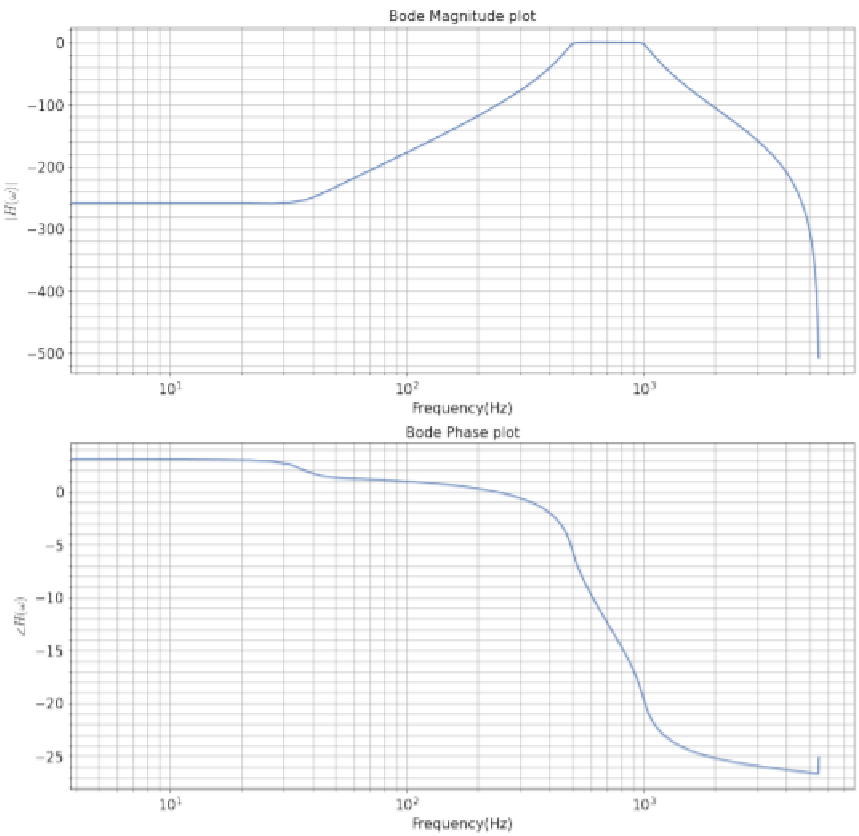


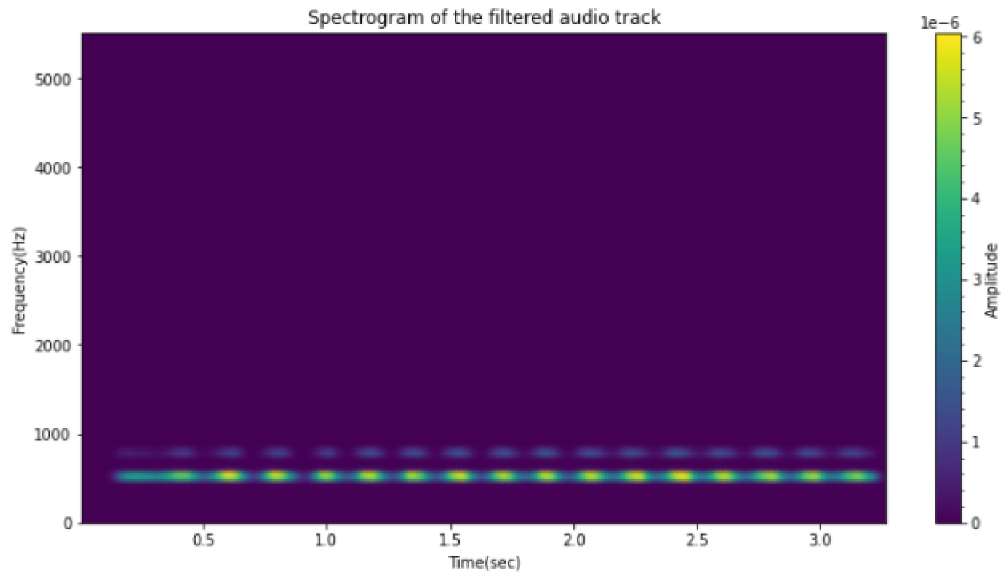
Problem 3

Spectogram of instru1.wav(aplha=1):



From the spectrogram we can see that the fundamental frequency of the audio track is 275.625. So in order to remove the noise (all other frequency), we'll be using a bandpass filter. Now in order to design a Butterworth filter capable of extracting/filtering out the fundamental peak we choose the specifications of the filter to be as follows: F(fundamental) = 250Hz approx, need to cut out 500Hz, so 3dB at 300Hz and 40dB attenuation at 400 Hz.





Spectrogram above is of the different vowels and consonants.This as a refrence,it is observed similar patterns of a, n, d in the spectrogram of voice.

Problem 4

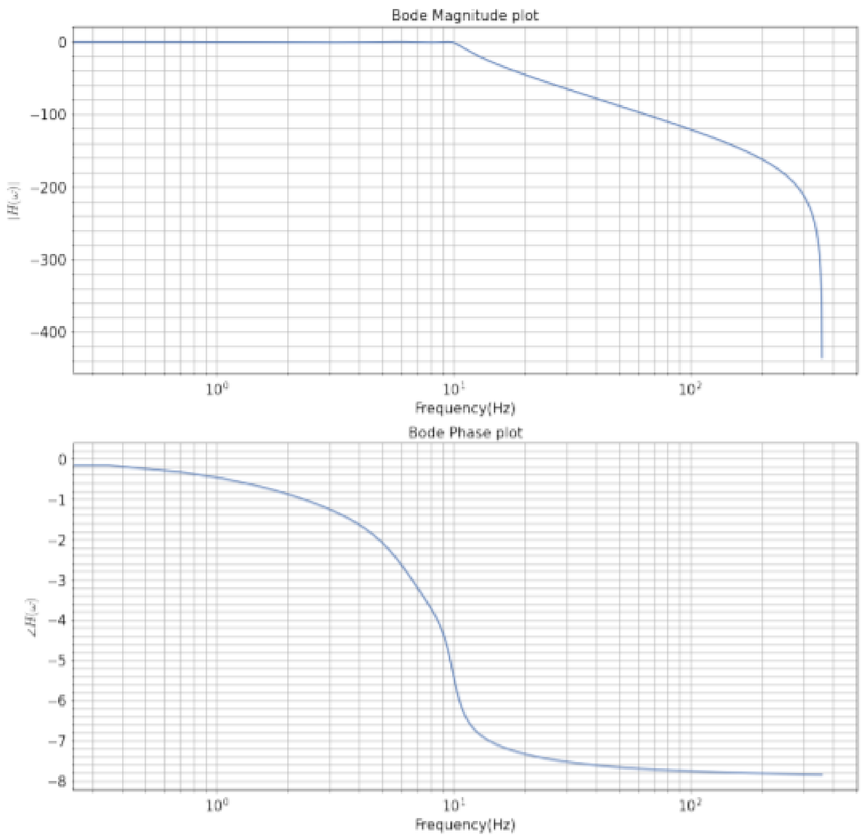
Designing Chebyshev Filter

$$\delta_p = 0.89$$
$$\delta_s = 0.01$$
$$N = \frac{cosh^{-1}(\frac{1}{\epsilon}\sqrt{\frac{1-\delta_s^2}{\delta_s^2}})}{cosh^{-1}(\frac{\Omega_s}{\Omega_p})} = 5$$
$$\implies N = 5$$

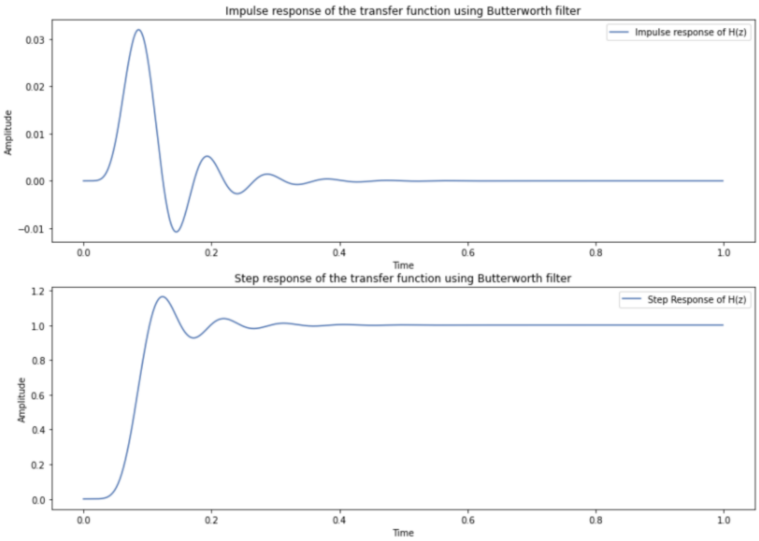
Transfer function for Chebyshev filter

$$H(z) = \frac{1.207 * 10^8}{z^5 + 58.9z^4 + 6676z^3 + 2.422 * 10^5 z^2 + 9.071 * 10^6 z + 1.207 * 10^8}$$

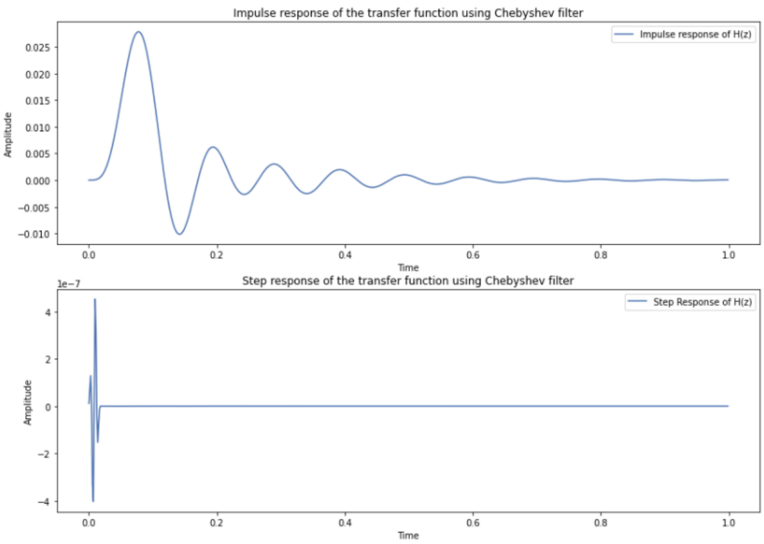
Bode plot:



Impulse response and step response for butterworth filter



Impulse response and step response for Chebyshev filter



On comparing the Chebyshev and Butterworth filter, Butterworth has higher order

A Code Repositories

Refrain from including any or all code in this document. Upload codes to your repository and include the links to executed nbviewer files here as – The codes to reproduce the results can be found in the GitHub repository `https://github.com/TanmayRanaware/Digital-Signal-Processing-La`