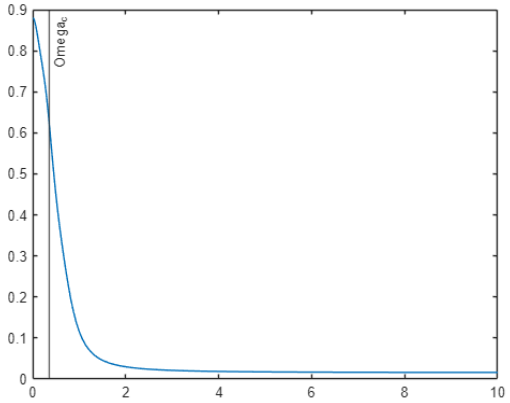
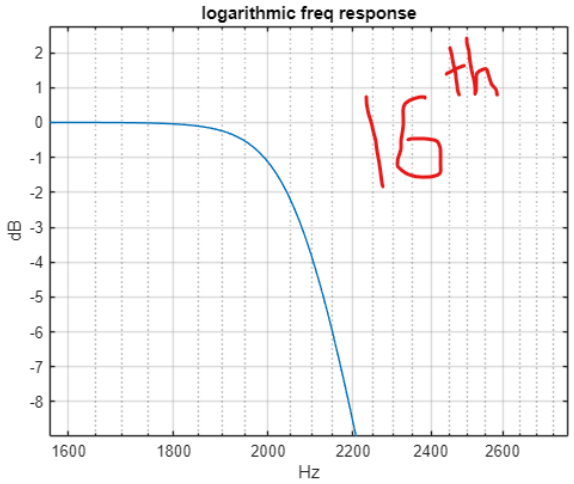
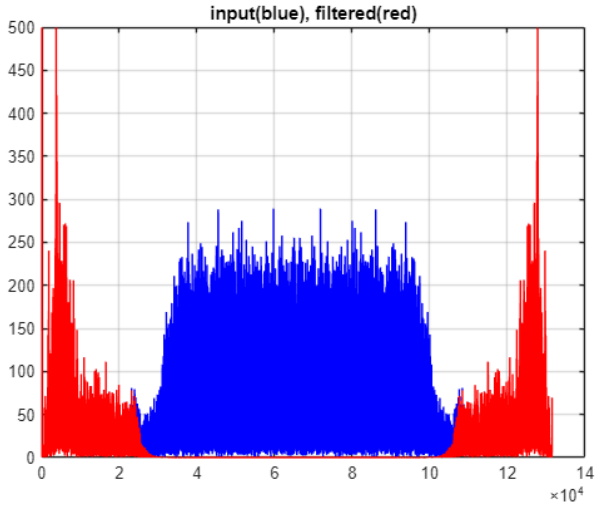
cse3313 - spring 2025 - filter design project - George Boone 1002055713

wStraight forward design of a low pass butterworth filter using the IIR method. Filter specifications were drafted from the requirements document and visual inspection of the audio's FT; then tuned experimentally. The resulting filter is a 16th order butterworth. Result wise - this works but I believe this to be an excessively high order, yet can't find any error in the program. An possible improvement aside from reducing the order would be using a band pass between ~500Hz and ~2kHz.

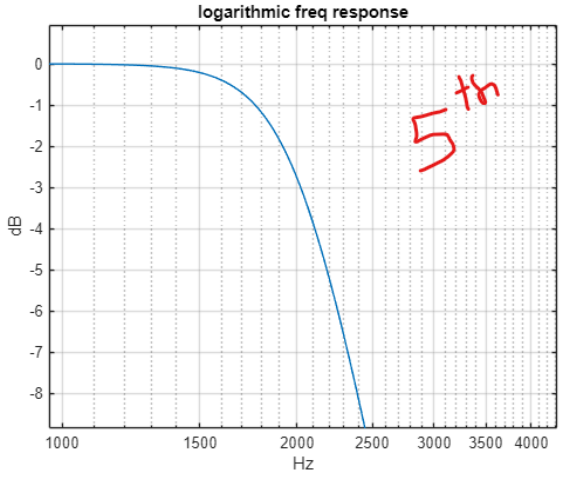


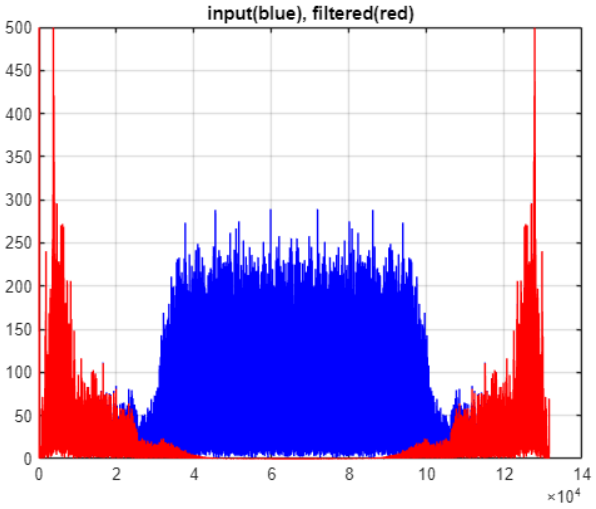
I found it necessary to prioritize stop band over pass band for noise reasons; a high order filter was necessary inorder to also meet the 1dB retention requirement for the pass band. The order was adjusted by tuning the stop band attenuation.





It's worth noting that we can get away with a 5th order implementation for this specific audio sample as the noise and attenuation share similar growth rates.





The matlab code also displays the difference equation, for the 5th order filter it is

```
y[n] = 0.015616*x[n] + 0.078080*x[n-1] + 0.156160*x[n-2] + 0.156160*x[n-3] +
0.078080*x[n-4] + 0.015616*x[n-5]
- -1.309974*y[n-1] - 1.236361*y[n-2] - -0.567955*y[n-3] - 0.159018*y[n-4] -
-0.017738*y[n-5]
```

And for the 16th order filter it is

```
y[n] = 0.000002*x[n] + 0.000040*x[n-1] + 0.000297*x[n-2] + 0.001387*x[n-3] +
0.004508*x[n-4] + 0.010819*x[n-5] + 0.019834*x[n-6] + 0.028335*x[n-7] +
0.031877*x[n-8] + 0.028335*x[n-9] + 0.019834*x[n-10] + 0.010819*x[n-11] +
0.004508*x[n-12] + 0.001387*x[n-13] + 0.000297*x[n-14] + 0.000040*x[n-15] +
0.000002*x[n-16]
- -3.934765*y[n-1] - 9.163560*y[n-2] - -14.704572*y[n-3] - 17.936699*y[n-4] -
-17.228558*y[n-5] - 13.365413*y[n-6] - -8.462049*y[n-7] - 4.395889*y[n-8] -
-1.870232*y[n-9] - 0.647236*y[n-10] - -0.179690*y[n-11] - 0.039136*y[n-12] -
-0.006449*y[n-13] - 0.000757*y[n-14] - -0.000056*y[n-15] - 0.000002*y[n-16]
```