Mohammed Ali-Khan

1001722553

Maa2553

28 November 2025

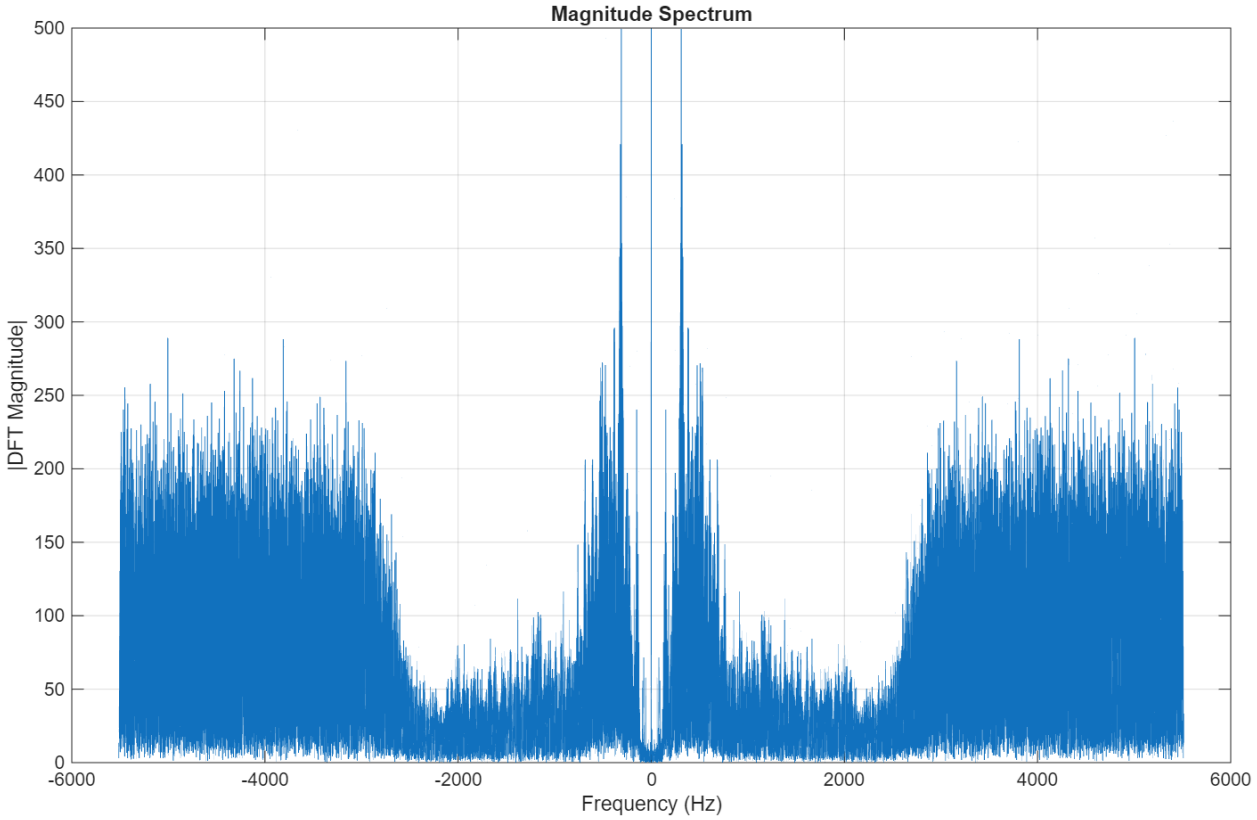
CSE 5366 INTRO TO SIGNAL PROCESSING

Fall Semester 2025

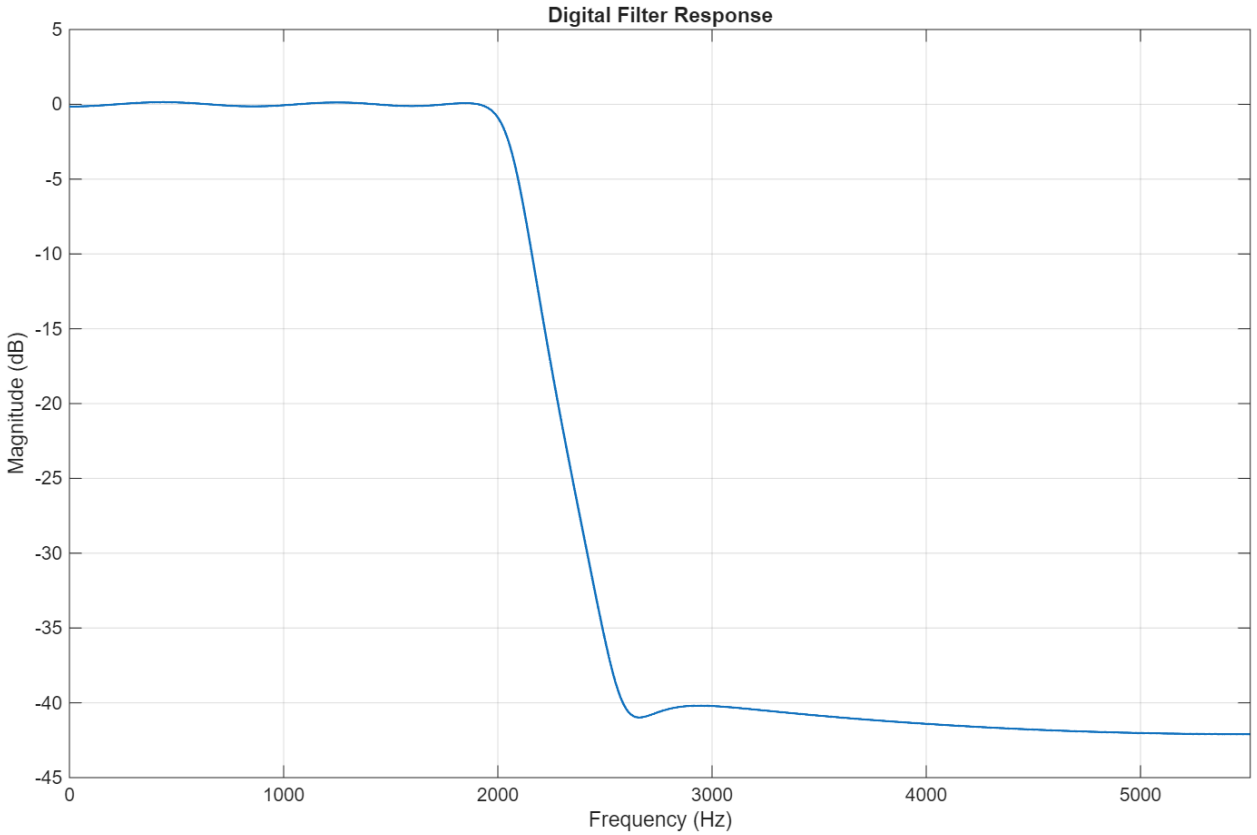
Final Project

IIR Filter Design

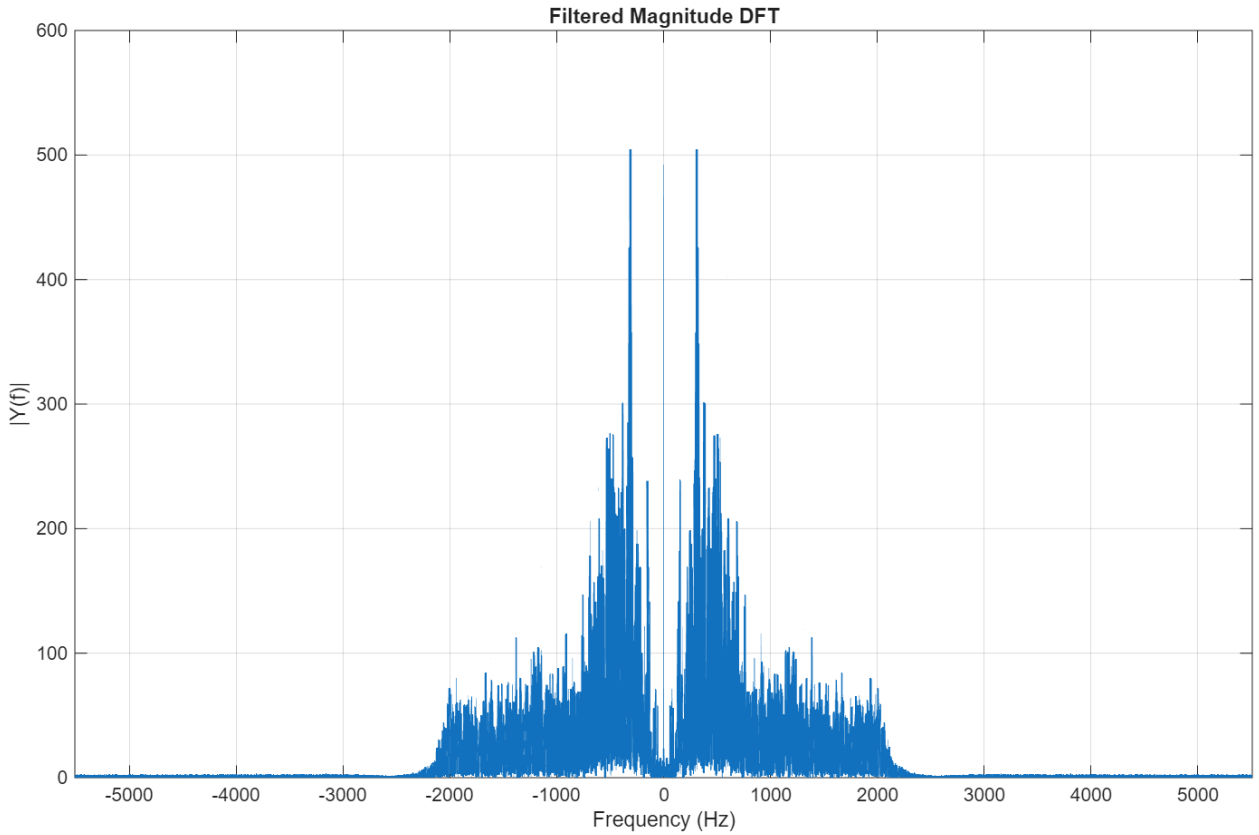
Report

1. Audio Frequency Analysis
    a. The sampling frequency Fs is 11025, indicating that 11,025 samples were taken from the audio every second.
    b. 

        i. The plot above shows the magnitude of audio signal.
    c. The voice from the audio is seen to be from 100 Hz to 2000 Hz, with abundant noise from 2500 Hz to 5500 Hz. This noise needs to be removed to get a clear voice audio.
2. Filter Design
    a. The digital frequencies
        i. Omega_p = 2*pi*fp = 2 * pi * 2000 = 1.2566 * 10^4
        ii. Omega_s = 2*pi*fsb = 2 * pi * 2500 = 1.57 * 10^4
    b. Dp and Ds values are determined. 1 dB of attenuation is kept for the passband, and 40 dB is kept for the stopband.
        i. Ap = 1 dB
        ii. As = 40 dB
    c. The filter order N is calculated to be 24. Omega C is calculated.
    d. Omega c, the cutoff frequency is
        i. Wc = 12965.45 rad/s

3. Filter Implementation
    a. Butter() command is used to apply a digital filter. The filter is first and analog filter given N and Wc parameters, and is then converted to digital using an impulse invariance command.
        i. Wn = 4127.03
    b. 

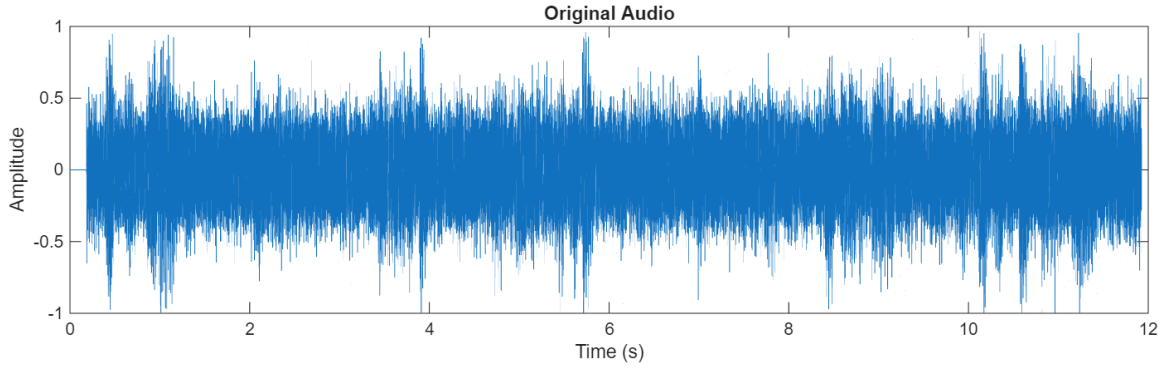
        i. Plot of the logarithmic gain of the digital filter using butter() coefficients.
    c. Audio is then filtered using the butter digital filter coefficients.



d.

i. The plot above shows the magnitude of the filtered audio signal

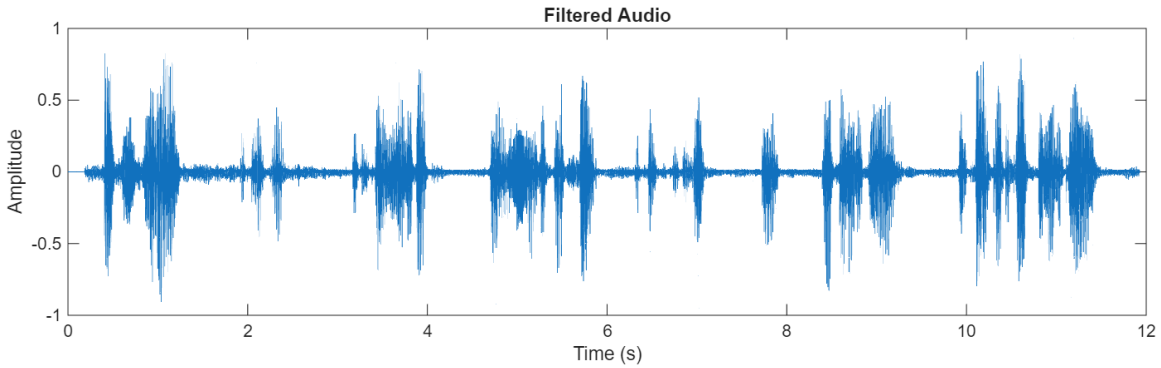
e. The filter reduced the amplitudes of the unwanted frequencies. This eliminates the noise of the original audio signal, only showing the voice of the audio.



i.

1. Original Audio Graph. Shown to be very noisy

ii.



1. Filtered Audio Graph. Much cleaner. Can now see the individual voice lines.

f. Using the sound filter, the audio becomes much more comprehendible. The whizzing sound of the noise is almost completely gone.

g. Audio is saved as a separate audio file, using the same sampling frequency of the original audio.