Frequency Response of FIR Filters

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Background

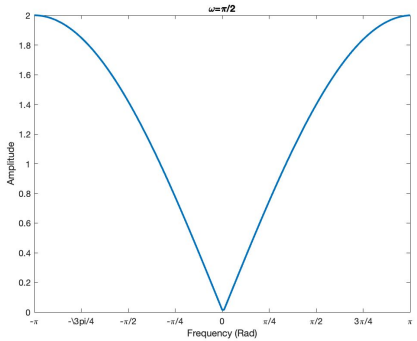
When sinusoidal signals pass through LTI systems the output may have a changed magnitude and phase but the frequencies remain the same. FIR filters can be used to pass or reject components of signals at specific frequencies.

We will be using selective frequency nullification to remove distortion from audio

Nulling Filters

$$y[n] = x[n] - 2\cos(\hat{\omega}_n)x[n-1] + x[n-2]$$

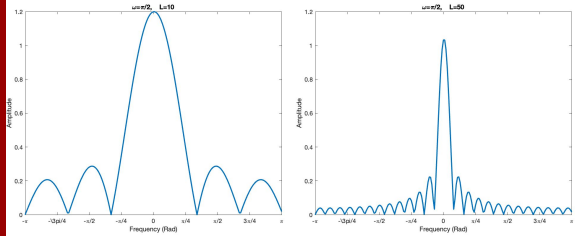
Reject a specific frequency $\hat{\omega}_n$



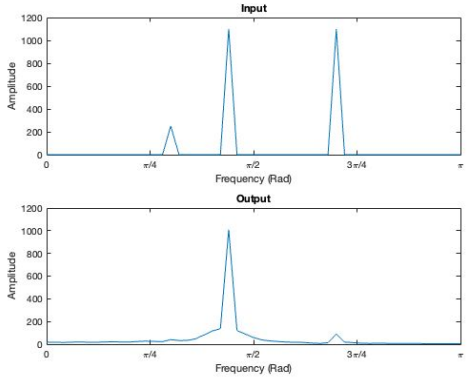
Bandpass Filters

$$h[n] = \frac{2}{L}\cos(\hat{\omega}_c n), \qquad 0 \le n < L$$

Passes frequencies in a window inversely proportional to L around $\hat{\omega}_c$



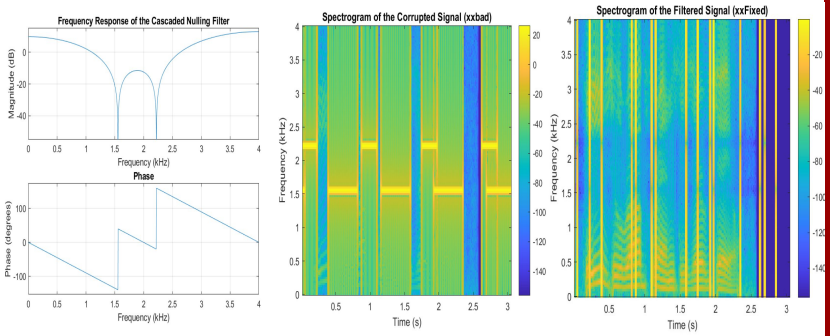
Passing a sum of sinusoids at 0.3π, 0.44π, 0.7π through a bandpass filter centered around 0.44π



Speech Interference

Problem Statement: Generate a nulling filter to remove sinusoidal interference at 1555 and 2222 Hz from an audio recording

Results:The absence of high intensity frequencies at 1555 and 2222 Hz in the spectrogram of the filtered signal indicates that the filter effectively nullified those frequencies. Additionally the filtered signal is intelligible.



Summary:

We were able to develop a filter which nulled out two frequencies that were masking our audio signal. After convolving the audio signal with the filter the audio signal was intelligible and it was determined to contain the massage “Thieves that rob friends deserve jail” which I suppose is fair enough.