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Digital Signal Processing

Homework 4

December 5, 2021

Signal Analysis

The N point DFT of signal was taken with $N = 2097152$. The Magnitude response is shown in figure 1

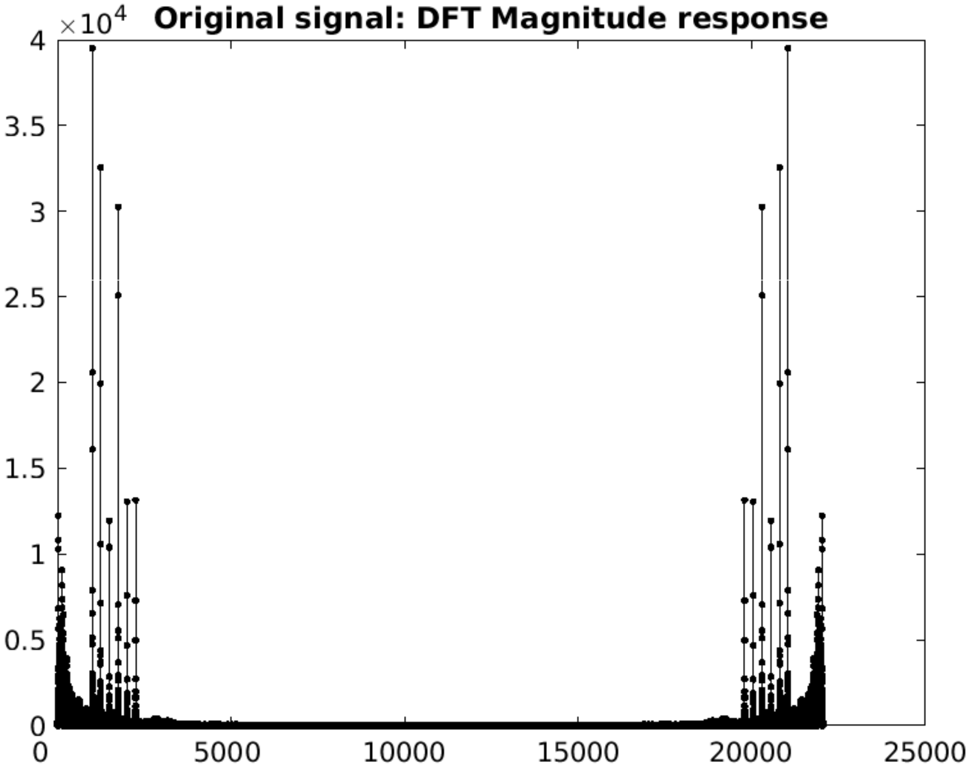

Figure 1: DFT of original signal

Filter Design

We know that our ears are indifferent to phase shifts, so an IIR filter can be used for efficiency. Using MATLAB DSP system toolbox's filter designer, we select a band stop filter with the following Frequency characteristics:

1. $F_{pass1} = 1920Hz$
2. $F_{stop1} = 1990Hz$
3. $F_{stop2} = 5000Hz$

4. $F_{pass2} = 5500Hz$
5. Design Method: IIR Elliptic
6. Order = 18

The order The magnitude response and PZ plot of the filter is given in figure 2 and 3 respectively.

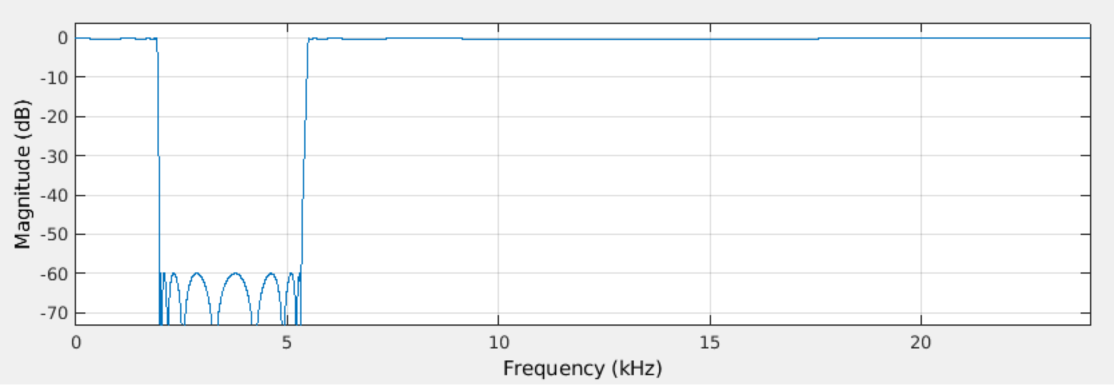

Figure 2: Filter Magnitude response

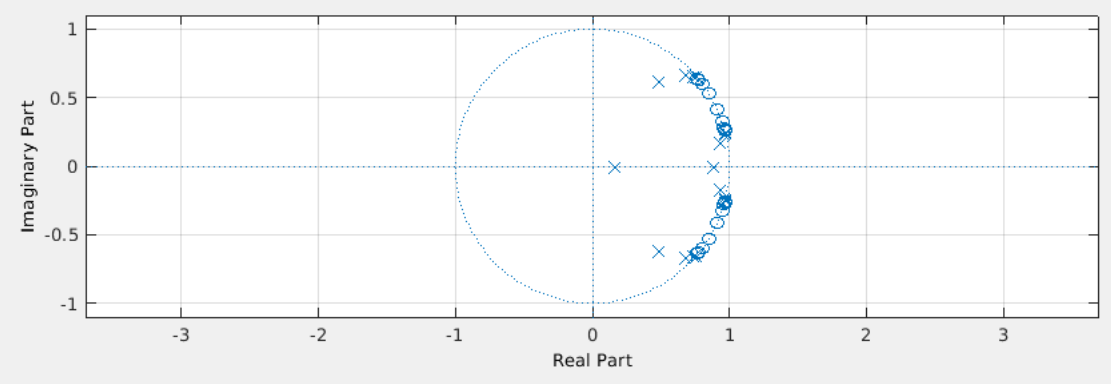

Figure 3: Filter PZ plot

Filtered Signal

Passing the signal through the above designed filter, we get the resulting signal's frequency response as shown in figure 4.

If we play back the filtered .wav (attached), it can observed that all noises have been eliminated.

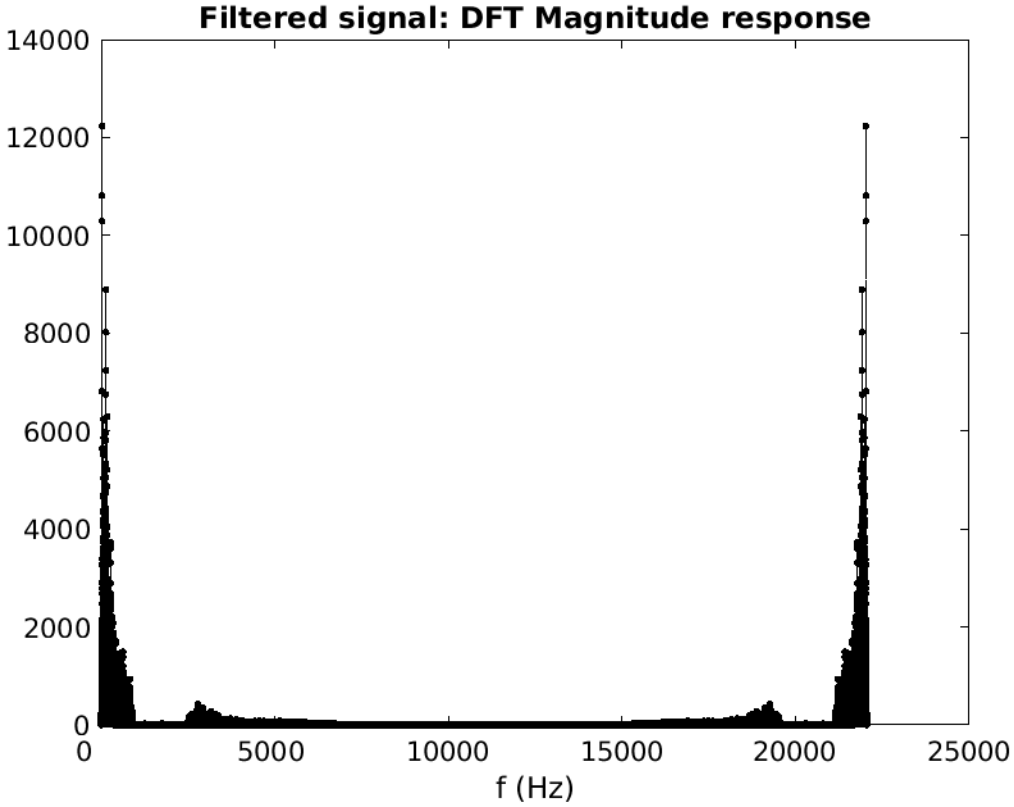

Figure 4: Filtered magnitude response

MATLAB codes

The following script was used: (complete source available at:github/mehdi/digital-filter-design)

```
%% reading File:
Fs = 44100;
[s,Fs]=audioread('NoisyHUAnthem.wav');
% sound(s,Fs);
pause(5);

%% Analysis:
N = length(s); % determine length of signal
n = ceil(log2(N)); % ceil to the closest power of 2
N = 2^n; % use this N for fft
X= fft(s, N);

f = linspace(0, Fs,N);
```

```
stem(f, abs(X), '.')

set(gca, 'XTickLabel', get(gca, 'XTick'));
title('Original signal: DFT Magnitude response')
print -deps dft_original.eps

%% Filtering:
close all
filter_coeffs = load('lpf_a.mat')
filtered = filter(filter_coeffs.Hd, s);
sound(filtered,Fs);

%calculate fft:
N = length(filtered); % determine length of signal
n = ceil(log2(N)); % ceil to the closest power of 2
N = 2^n; % use this N for fft
X= fft(filtered, N);

figure()
stem(f, abs(X), '.')
title('Filtered signal DFT')
xlabel('f (Hz)')
set(gca, 'XTickLabel', get(gca, 'XTick'));
title('Filtered signal: DFT Magnitude response')
print -deps dft_filtered.eps
audiowrite('recovered.wav', filtered, Fs)
```