## 3TP3 LAB FOUR

McMaster University

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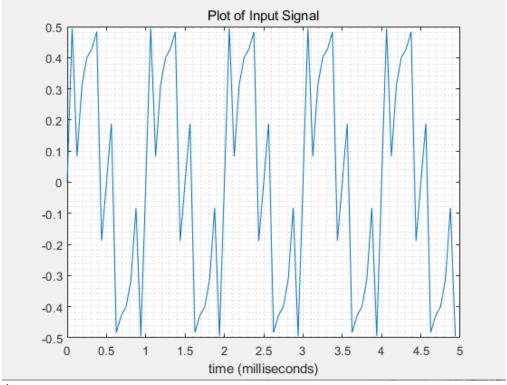
Yichen Lu\_400247938

## Part 1

2. We can hear a high-frequency sound for 10 seconds after playing the sound file.

3.

```
1
         %Yichen Lu (400247938) Cheng Fei (400228518)
 2
         % Read in the signal from the audio file
         [signal, Fs] = audioread("tones2021.wav");
3
         L = length(signal);
5
         T = 1/Fs;
         t = [0:L-1]*T;
6
         % Plot the signal for t_plot msec
7
8
         t_plot = 5;
9
         msec_per_sec = 1000;
10
         numSamples = t_plot*Fs/msec_per_sec;
         plot(msec_per_sec*t(1:numSamples), signal(1:numSamples));
11
12
         title('Plot of Input Signal');
13
         xlabel('time (milliseconds)');
14
         grid('minor');
         exportgraphics(gcf,'../Figures/part1q3.png');
15
```

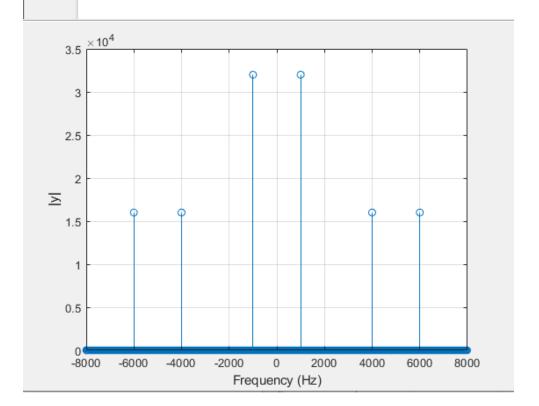


4.

According to the graph above, there are 5 periodic waves per 5 ms, implying that each signal repeats every 1 ms. As a result, 1000Hz is the frequency. The Fourier transform can be used to estimate the number of sinusoids that make up the signal.

5.

```
%Yichen Lu (400247938) Cheng Fei (400228518)
 1
 2
         clc;clear
 3
         % Read in the signal from the audio file
 4
         [signal, Fs] = audioread("tones2021.wav");
 5
         L = length(signal);
 6
         T = 1/Fs;
 7
         t = [0:L-1]*T;
 8
9
         y = fft(signal);
10
         z = fftshift(y);
11
         ly = length(y);
12
         f = (-1y/2:1y/2-1)/1y*Fs;
13
14
         stem(f,abs(z))
15
         xlabel 'Frequency (Hz)' ylabel '|y|'
16
17
18
         grid
```



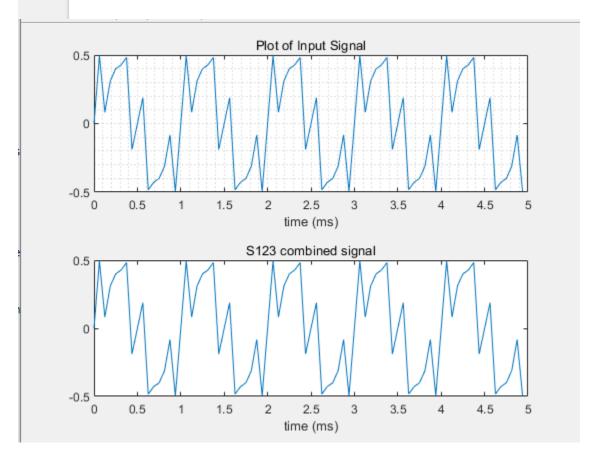
```
6.
   1
           %Yichen Lu (400247938) Cheng Fei (400228518)
   2
            clc;clear;
   3
            % Take the DFT
            [signal, Fs] = audioread("tones2021.wav");
   4
   5
            L = length(signal);
   6
           y = fft(signal);
   7
            Y = fft(signal)/L;
   8
            f = Fs/2*linspace(0,1,L/2+1);
   9
           % Plot the single-sided magnitude spectrum.
  10
           plot(f,2*abs(Y(1:L/2+1)));
           title('Single-Sided Magnitude Spectrum')
  11
  12
           xlabel('Frequency (Hz)')
  13
           ylabel('|Y(f)|')
  14
           axis([0 Fs/2 0 .5]);
  15
            grid('minor');
                        Single-Sided Magnitude Spectrum
      0.5
     0.45
      0.4
     0.35
      0.3
  0.25
      0.2
     0.15
      0.1
     0.05
        0
               1000
                      2000
                              3000
                                     4000
                                            5000
                                                    6000
                                                           7000
                                                                   8000
```

The signal is made up of three sinusoidal waves with frequencies of 1000 Hz, 4000 Hz, and 6000 Hz with magnitudes of 0.4, 0.2, and 0.2, respectively, as shown in the graph.

Frequency (Hz)

7.

```
1
         %Yichen Lu (400247938) Cheng Fei (400228518)
         % Read in the signal from the audio file
2
 3
         [signal, Fs] = audioread('tones2021.wav');
         L = length(signal);
4
 5
         T = 1/Fs;
         t = [0:L-1]*T;
 6
         % Plot the signal for t_plot msec
8
         t_plot = 5;
9
         msec_per_sec = 1000;
10
         numSamples = t_plot*Fs/msec_per_sec;
11
         plot(msec_per_sec*t(1:numSamples), signal(1:numSamples));
         s1 = 0.4*sin(2*pi*1000*t);
12
         s2 = 0.2*sin(2*pi*4000*t);
13
         s3 = 0.2*sin(2*pi*6000*t);
14
15
         s123_signal = s1+s2+s3;
16
        tiledlayout('flow');
17
        nexttile;
         plot(msec_per_sec*t(1:numSamples), signal(1: numSamples));
18
         title('Plot of Input Signal');
19
        xlabel('time (ms)');
20
21
         grid('minor');
22
         nexttile; plot(msec_per_sec*t(1:numSamples), s123_signal(1:numSamples));
23
         title('S123 combined signal');
         xlabel('time (ms)');
24
         exportgraphics(gcf, 'part1q8.png');
25
26
```



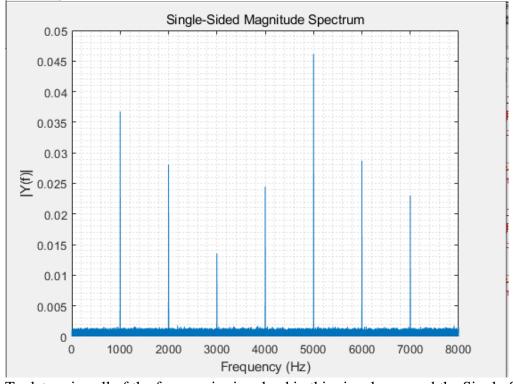
## Discussion:

We can see from the graph that the input signal plot is identical to the generated Sine 123 combined signal plot. As a result, we can deduce that the input signal is the sum of the three sinusoids.

## Part 2

2. The sound signal has a lot of background noise, and the tone changes somewhat during the whole thing.

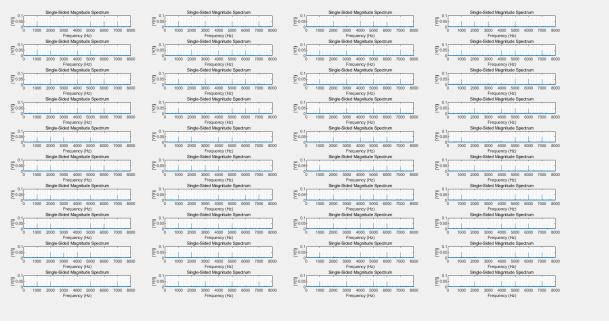
```
3.
           %Yichen Lu (400247938) Cheng Fei (400228518)
   1
   2
           % Read in the signal from the audio file
           [signal, Fs] = audioread('SecretMessage2021.wav');
   4
           L = length(signal);
   5
           T = 1/Fs;
           t = [0:L-1]*T;
   6
   7
           Y = fft(signal)/L;
   8
           f = Fs/2*linspace(0,1,L/2+1);
           plot(f,2*abs(Y(1:L/2+1)));
  9
  10
           title('Single-Sided Magnitude Spectrum');
           xlabel('Frequency (Hz)');
  11
           ylabel('|Y(f)|');
  12
  13
           axis([0 Fs/2 0 .05]);
  14
           grid('minor');
  15
           exportgraphics(gcf, 'part2q3.png');
```



To determine all of the frequencies involved in this signal, we used the Single-Sided Magnitude Spectrum display. The frequencies employed in these signals are 1000 Hz, 2000 Hz, 3000 Hz, 4000 Hz, 5000 Hz, 6000 Hz, 7000 Hz, with magnitudes of roughly 0.037, 0.028, 0.014, 0.0245, 0.045, 0.029, 0.023, according to the created graph below.

To decode the secret message, we must split the signal into its 1-second symbol period in a loop and perform an FFT on each symbol period. To store the data for each second of the input signal, we generate a 16000\*1 split matrix.

```
%Yichen Lu (400247938) Cheng Fei (400228518) clc;clear;
           [signal, Fs] = audioread("SecretMessage2021.wav");
% L = length(signal);
           % t = [0:L-1]*T;
           % Plot the signal for t_plot msec
t_plot = 1000;
msec_per_sec = 1000;
10
           numSamples = t_plot*Fs/msec_per_sec;
11
           posi = 0;%determine where to put the graph
12
           split = zeros(1000,1);
13
14
15
           for i = 1:40
                for j = 1:16000
16
                     split(j) = signal(j+(16000*(i-1)));
17
18
19
                L = length(split);
t = [0:L-1]*T;
20
21
22
                Y = fft(split)/L;
23
24
25
26
                f = Fs/2*linspace(0,1,L/2+1);
                posi = posi + 1;
                subplot(10,4,posi);
27
                plot(f, 2*abs(Y(1:L/2+1)));
28
                title('Single-Sided Magnitude Spectrum');
29
30
31
32
33
34
35
                xlabel('Frequency (Hz)')
ylabel('|Y(f)|')
axis([0 Fs/2 0 .1]);
                grid('minor');
                  posi = posi + 1;
36
37
38
                  subplot(20,4,posi);
                  plot(msec_per_sec*t(1:numSamples), split(1:numSamples))
39
                  title('Plot of Input Signal')
40
                  xlabel('time (milliseconds)')
41
42
                  grid('minor');
```



Yichen in Yoory 7938 Cheng Fei 400228518 1567 T 1357 6 2456 — 1235 B 1245 E 2456 - 1357 0 1457 R 2436 - 1356 N 1357 D 1567 T 2456 — 1567 T 1357 0 1235 B 1245 E 2606 — 2476 \_ 1567 T 1256 H 1234 A 1567 T
1257 I 1467 S 2456 1266 H 1245 E 2456 2345 U 1245 E 1467 S 2456 -1567 T 1456 Q 1467 S 1356 N 1567 T 1257 I 1357 0 2457 O TO-BE-OR-NOT-TO-BE-THAT-IS-THE-QUESTION