ECE-2026 Lab #3 Fall-2023
LAB COMPLETION REPORT

Name: Mythri Muralikannan Lab Section: L02 Date: 10/16/2023

Part 1a: Did you attend the lab in week 1? Yes

Part 1b: Did you attend the lab in week 2? Yes

Part 2: Did you get full check-offs for in-lab demo? Yes

Part 3.1 Chirp Aliasing

(a) Chirp formula: $\cos(\psi(t)) =$ cos(2π(760)t^2 + 2π(400)t + φ)

(b) $L_{\text{SECT}} =$ 128 and $T_{\text{SECT}} =$ 0.0512

(c) Guess why "ups and downs" in spectrogram (more about **sampling and aliasing** in Lab #4):
After the frequency reaches fs*2, that is the maximum possible frequency after which aliasing occurs and then the graph folds in on itself.

Part 3.2 Spectrogram of periodic full-wave rectified sine wave using a long section duration.

(b) $T_{\text{SECT}} =$ 5 and $L_{\text{SECT}} =$ 5*2000 = 10,000

(d) List frequencies of visible harmonics = 0, +2, -2, +4, -4, +6, -6, ...

(e) Fundamental Frequency = 2 Hz

(f) $|a_1| =$ 0.212 $|a_5| =$ 0.006 and dB difference = 30.96 dB

Part 3.3 Questions about decibels:

(a) Explain 12 dB.
Given 20 log10(A2) = 20 log10(A1) - 12 dB = 20 log10(A1) - 20 log10(1/4) = 20 log10((1/4)A1)
Therefore, A2 = (4)A1

(b) dB difference between $|a_1|$ and $|a_5|$ =
dB difference = 20 log10(0.212/0.006) = 30.96 dB

Part 3.4 dB-Spectrogram of periodic full-wave rectified sine wave using a long-duration section.

(a) List frequencies of harmonic lines = 0, +2, -2, +4, -4, +6, -6, +8 -8, +10, -10, ...

(b) Best value of $T_{\text{SECT}} =$ 2*T

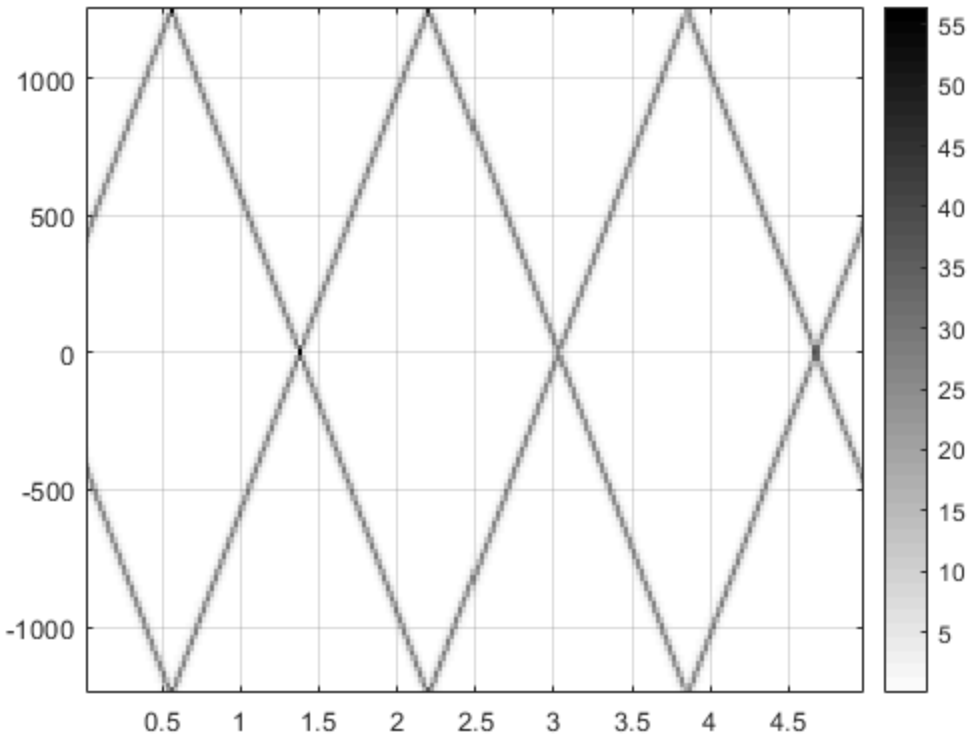
Part 3.5 Using the sample.wav, make a linear and a dB spectrogram with a long section length, e.g., $L_{\text{SECT}} = 512$. Since the vowel region of the recording is a signal that is quasi-periodic, the spectrograms should exhibit a harmonic line characteristic (parllel horizontal lines) during that time. Try different section lengths L_{SECT} until the harmonic lines are easy to see in the spectrograms.

fundamental frequency = 1500/11 = 136.36

3.1

```
clc; clear; close all

fSamp = 2500; %-Number of time samples per second
dt = 1/fSamp;
tStart = 0;
tStop = 5;
fStart = 400;
fStop = 8000;
tt = tStart:dt:tStop;
mu = 760;
fzero = 400; %"
phi = 2*pi*rand; %-- random phase

Lsect = 128;
Tsect = Lsect/fSamp;
%
psi = 2*pi*mu*tt.^2 + 2*pi*fzero*tt + phi;   %% <================== FILL IN
 THE CODE HERE %
cc = real( exp(j*psi) );
% soundsc( cc, fSamp ); %-- uncomment to hear the sound
plotspec( cc+j*1e-12, fSamp, Lsect ), colorbar, grid on %-- with negative
 frequencies
```

```
ans =

  Image with properties:

          CData: [128×194 double]
    CDataMapping: 'scaled'

  Use GET to show all properties
```



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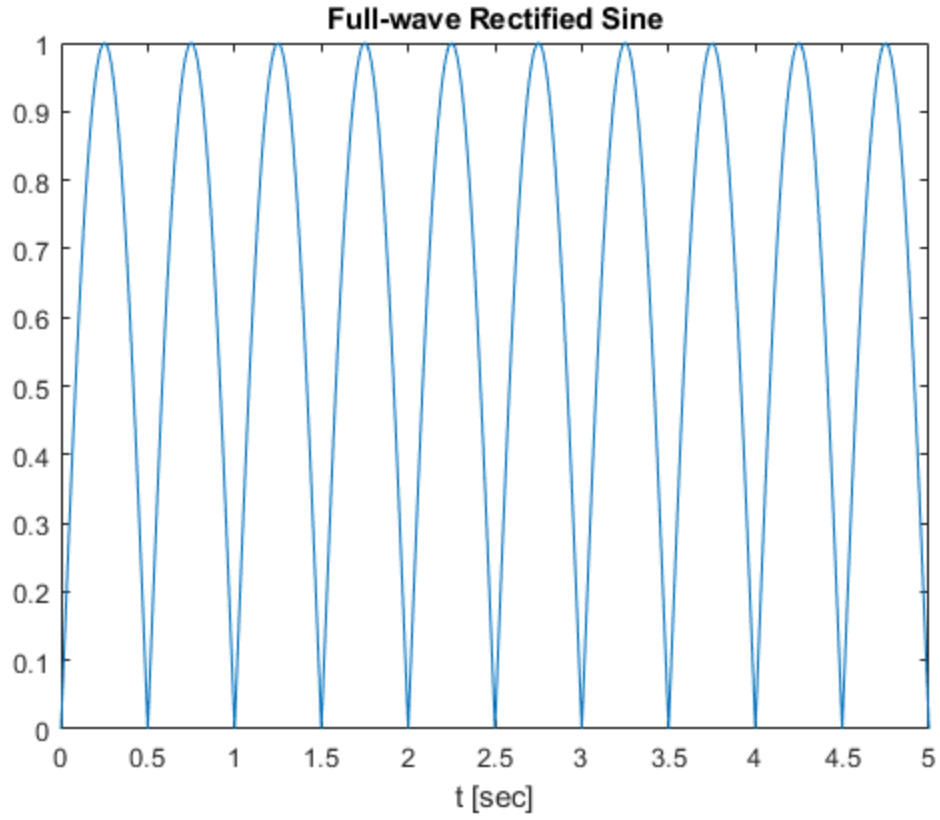
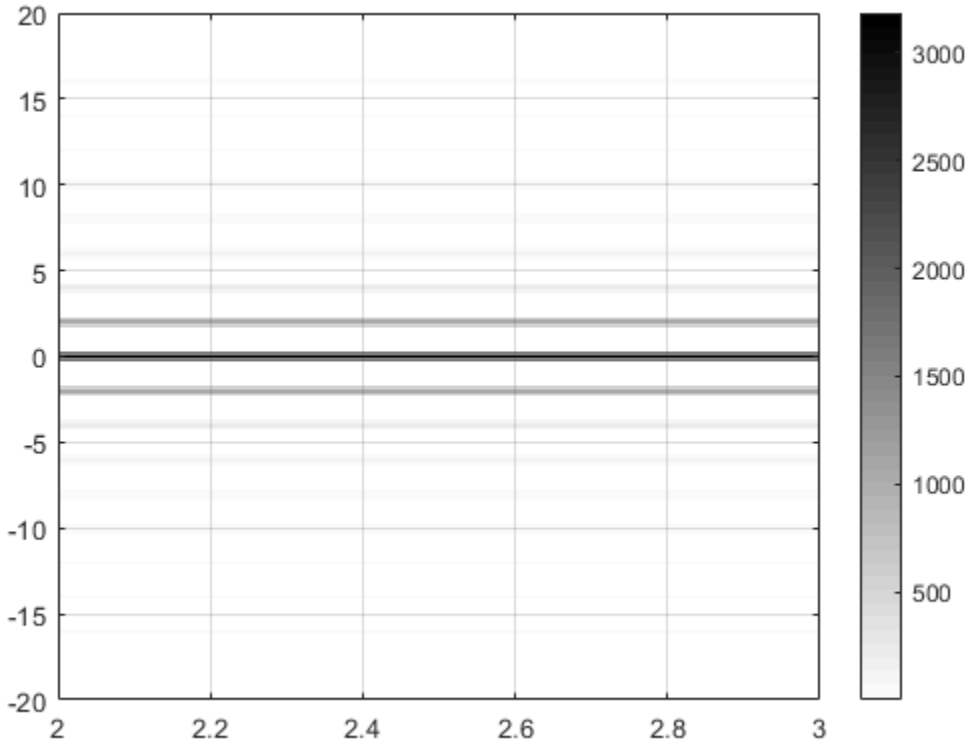
3.2

```
clc;clear;close all
```

Fill in the values

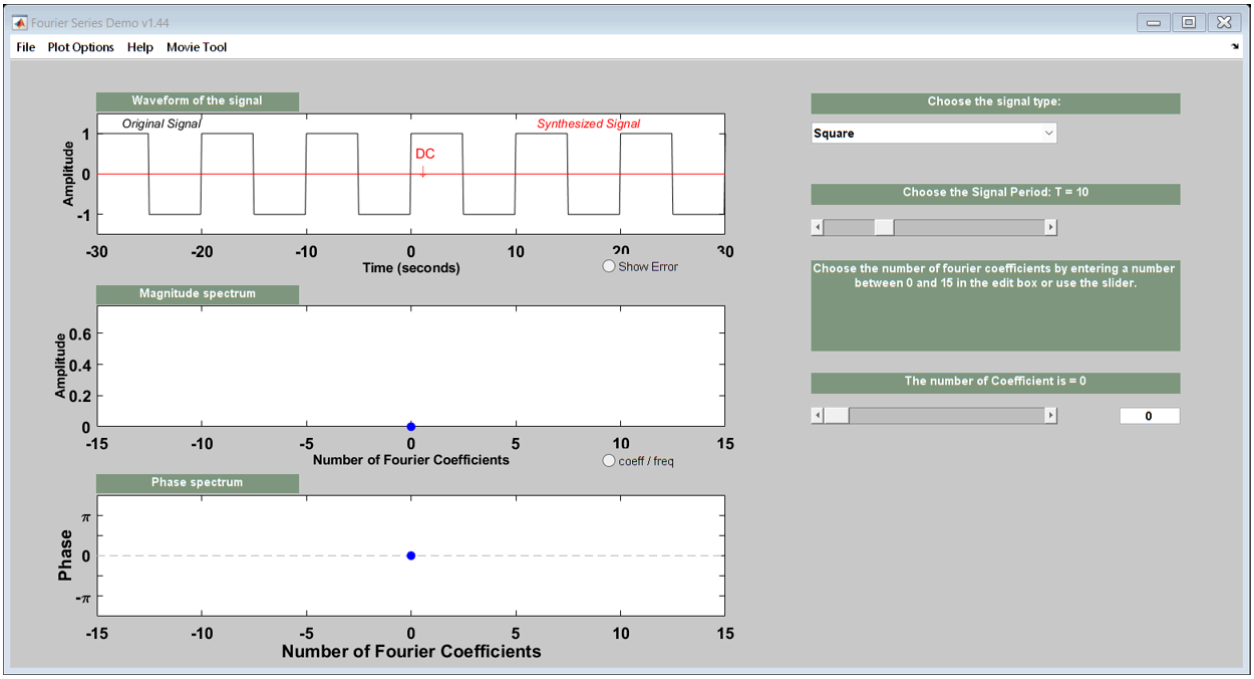
```
fs = 2000;
Amp = 1;
T = 1;
tStop = 5;

tt=0:(1/fs):tStop;
xx=Amp*abs(sin(2*pi*tt/T));

Tsect = 5*T;
Lsect = Tsect*fs;

figure
plot(tt,xx);
title('Full-wave Rectified Sine'); xlabel('t [sec]')

figure
plotspec( xx+j*1e-12, fs, Lsect ), colorbar, grid on %-- with negative
 frequencies
ylim([-20,20])
% *****Hint: Zoom in on the verticle axis to see the harmonics*****

% Fundamental freq = 2 Hz


ans =

  Image with properties:

          CData: [10000×1 double]
    CDataMapping: 'scaled'

  Use GET to show all properties
```


Full-wave Rectified Sine
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
t [sec]


20
15
10
5
0
-5
-10
-15
-20
2
2.2
2.4
2.6
2.8
3
3000
2500
2000
1500
1000
500

GUI

```
fseriesdemo       %<==Uncomment to use the GUI

% a1=0.212
% a5=0.006
```



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3.3

```
clc;clear;close all

a1 = 0.212;
a5 = 0.006;
dB_difference = 30.96 ;


%Ratios become differences on a dB scale
%P/Q become
%20log10(P/Q) = 20log10(P) - 20log10(Q)
%A2 = (2)A1 then A2 is 6 dB bigger than A1, because with logs, we get
%20 log10(A1) = 20 log10((1/2)A2) = 20 log10(A2) +
%20 log10(1/2) = 20 log10(A2) # 6.02 dB

%Similarly, given 20 log10(A2) = 20 log10(A1) - 12 dB = 20 log10(A1) -
%20 log10(1/4) = 20 log10((1/4)A1)
%Therefore, A2 = (4)A1


%WHICH a to use
```

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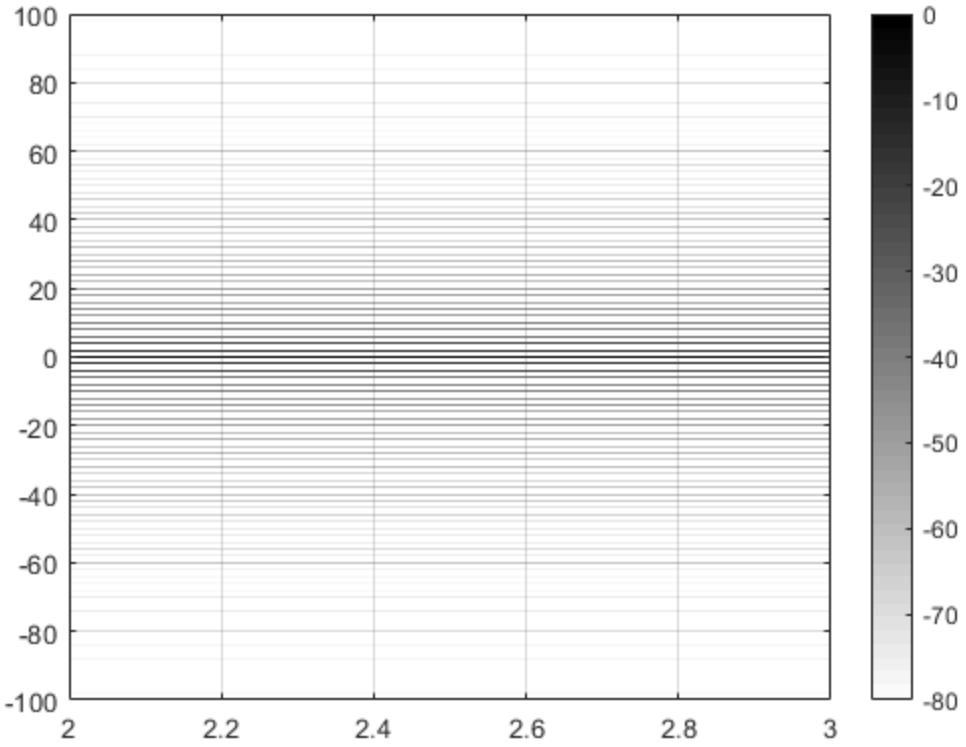
3.4

```
clc;clear;close all
```

Part(a) Fill in the values

```
fs = 1000 ;
Amp = 1 ;
T = 1;
tStop = 5;

tt=0:(1/fs):tStop;
xx=Amp*abs(sin(2*pi*tt/T));

Tsect = 5*T;
Lsect = Tsect*fs;
DBrange = 80;

figure
plotspecDB( xx+j*1e-12, fs, Lsect, DBrange), colorbar, grid on %-- with
 negative frequencies
ylim([-100, 100])


ans =

  Image with properties:

          CData: [5000×1 double]
    CDataMapping: 'scaled'

  Use GET to show all properties
```



Part(b) Fill in the values

```
fs = 1000;
Amp = 1;
T = 2;
tStop = 5;

tt=0:(1/fs):tStop;
xx2=Amp*abs(sin(2*pi*tt/T));

Tsect = 2*T;
Lsect = Tsect*fs;
DBrange = 80;

figure
plotspecDB(xx2+j*1e-12, fs, Lsect, DBrange), colorbar, grid on %-- with
 negative frequencies
ylim([-100, 100])


ans =

  Image with properties:

            CData: [4000×1 double]
    CDataMapping: 'scaled'
```

```
Use GET to show all properties
```

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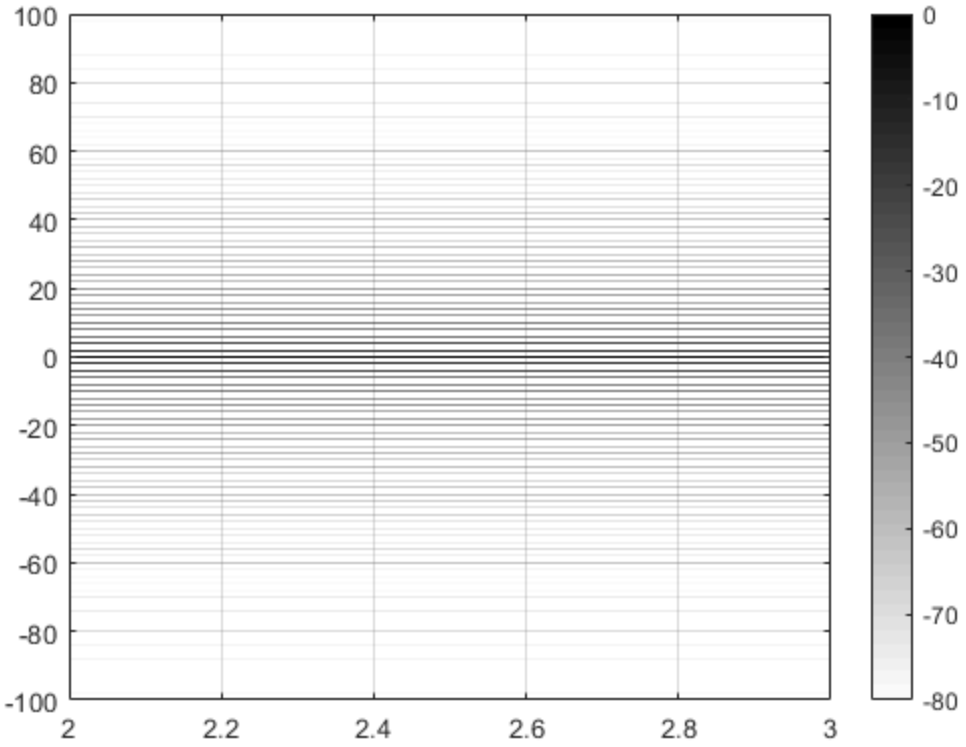
3.4

```
clc;clear;close all
```

Part(a) Fill in the values

```
fs = 1000 ;
Amp = 1 ;
T = 1;
tStop = 5;

tt=0:(1/fs):tStop;
xx=Amp*abs(sin(2*pi*tt/T));

Tsect = 5*T;
Lsect = Tsect*fs;
DBrange = 80;

figure
plotspecDB( xx+j*1e-12, fs, Lsect, DBrange), colorbar, grid on %-- with
 negative frequencies
ylim([-100, 100])


ans =

  Image with properties:

          CData: [5000×1 double]
    CDataMapping: 'scaled'

  Use GET to show all properties
```



Part(b) Fill in the values

```
fs = 1000;
Amp = 1;
T = 2;
tStop = 5;

tt=0:(1/fs):tStop;
xx2=Amp*abs(sin(2*pi*tt/T));

Tsect = 2*T;
Lsect = Tsect*fs;
DBrange = 80;

figure
plotspecDB(xx2+j*1e-12, fs, Lsect, DBrange), colorbar, grid on %-- with
 negative frequencies
ylim([-100, 100])


ans =

  Image with properties:

            CData: [4000×1 double]
    CDataMapping: 'scaled'
```

```
Use GET to show all properties
```

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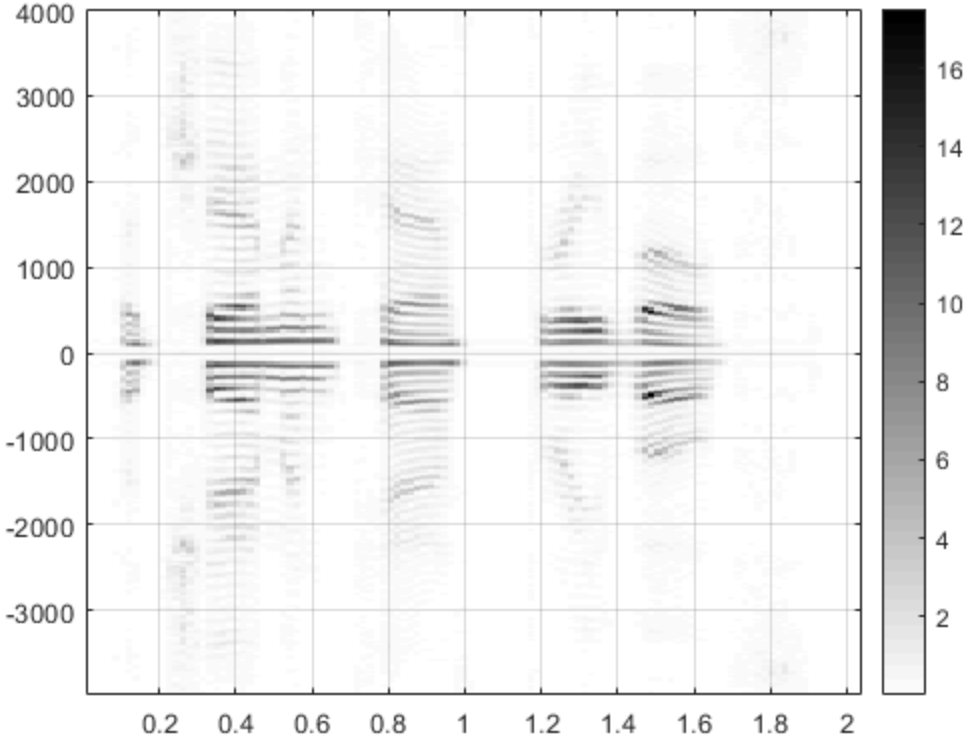
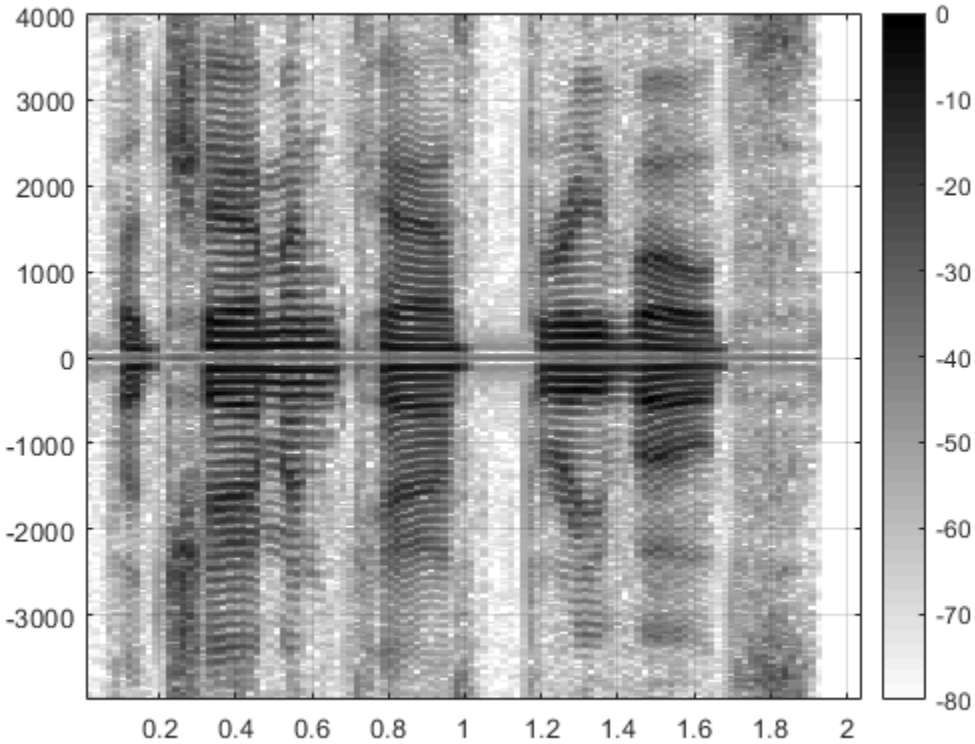
3.5

```
clc; clear; close all

[xx,fs] = audioread('sample.wav');

Tsect = 0.035; %WHAT NUMBER
Lsect = (round(Tsect*fs));
DBrange = 80;

% Linear spectrogram
figure
plotspec( xx+j*1e-12, fs, Lsect), colorbar, grid on %-- with negative
 frequencies

% DB spectrogram
figure
plotspecDB( xx+j*1e-12, fs, Lsect, DBrange), colorbar, grid on %-- with
 negative frequencies
```

```
ans =

  Image with properties:

            CData: [280×116 double]
    CDataMapping: 'scaled'

  Use GET to show all properties


ans =

  Image with properties:

            CData: [280×116 double]
    CDataMapping: 'scaled'

  Use GET to show all properties
```


4000
3000
2000
1000
0
-1000
-2000
-3000
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
16
14
12
10
8
6
4
2


4000
3000
2000
1000
0
-1000
-2000
-3000
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
0
-10
-20
-30
-40
-50
-60
-70
-80

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```
function him = plotspecDB(xx,fsamp,Lsect,DBrange)
%PLOTSPECDB   plot a Spectrogram as an image
%         (display magnitude in decibels)
%  usage:   him = plotspec(xx,fsamp,Lsect,DBrange)
%      him = handle to the image object
%       xx = input signal
%    fsamp = sampling rate
%    Lsect = section length (integer, power of 2 is a good choice)
%              amount of data to Fourier analyze at one time
%  DBrange = defines the minimum dB value; max is 0 dB

% 16-Feb-2013 J McClellan, created from plotspec.m

if( nargin<4 )
    disp('PLOTSPECDB: DB range defaulting to 60 dB')
    DBrange = 60;
end
if( nargin<3 )
 Lsect = 256;  %- default section length is 256
end
if( nargin<2 )
 disp('PLOTSPECDB: Sampling Frequency defaulting to 8000 Hz')
 fsamp = 8000;
end
if( length(xx)<1000 )
 warning('PLOTSPECDB: Signal length must be greater than 1000 to get a
 reasonable spectrogram')
end
Lfft = Lsect;
Noverlap = round(Lsect/2);  %-- overlap defaults to 50%
[B,F,T] = spectgr(xx,Lfft,fsamp,Lsect,Noverlap);
Bdb = 20*log10(abs(B));
Bmax = max(Bdb(:));
Bdb = Bdb - Bmax;
Bmin = - DBrange;
Bdb = Bdb.*(Bdb>=Bmin) + Bmin.*(Bdb<Bmin);
him = imagesc(T,F,Bdb);
axis xy
colormap(1-gray)   %-- use colormap(jet) if you like bright colors !
```

```
PLOTSPECDB: DB range defaulting to 60 dB
PLOTSPECDB: Sampling Frequency defaulting to 8000 Hz

Not enough input arguments.

Error in plotspecDB (line 25)
if( length(xx)<1000 )
```

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