

View parameters, plot waveform, compute and display spectrum. Verify that the frequency of the sinusoid (as measured using the FFT) is the expected frequency.

```
clear
```

Load .wav file

```
[x, Fs] = audioread('author.wav');
[nbits, opts] = audioread('author.wav');

whos
```

Name	Size	Bytes	Class	Attributes
Fs	1x1	8	double	
nbits	25500x1	204000	double	
opts	1x1	8	double	
x	25500x1	204000	double	

```
Fs
```

```
Fs =
    16000
```

```
nbits
```

```
nbits = 25500x1
    0.915527343750000
    0.305175781250000
         0
         0
         0
         0
         0
    -0.305175781250000
         0
         0
         0
         :
         :
```

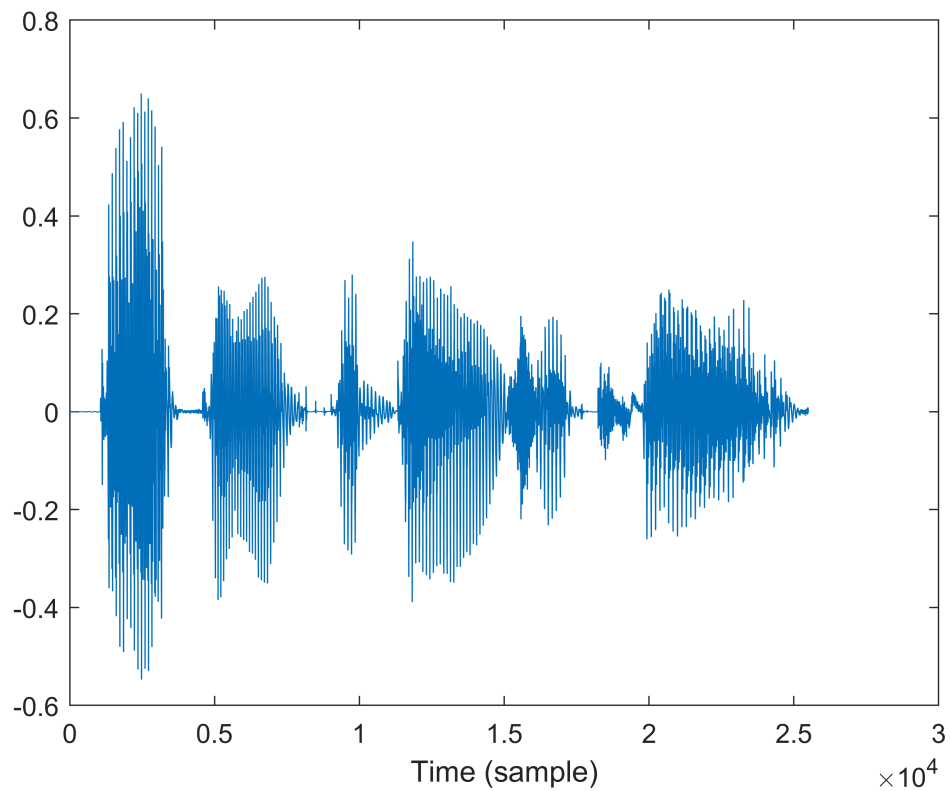
```
opts
```

```
opts =
    16000
```

```
soundsc(x, Fs)
```

Plot waveform

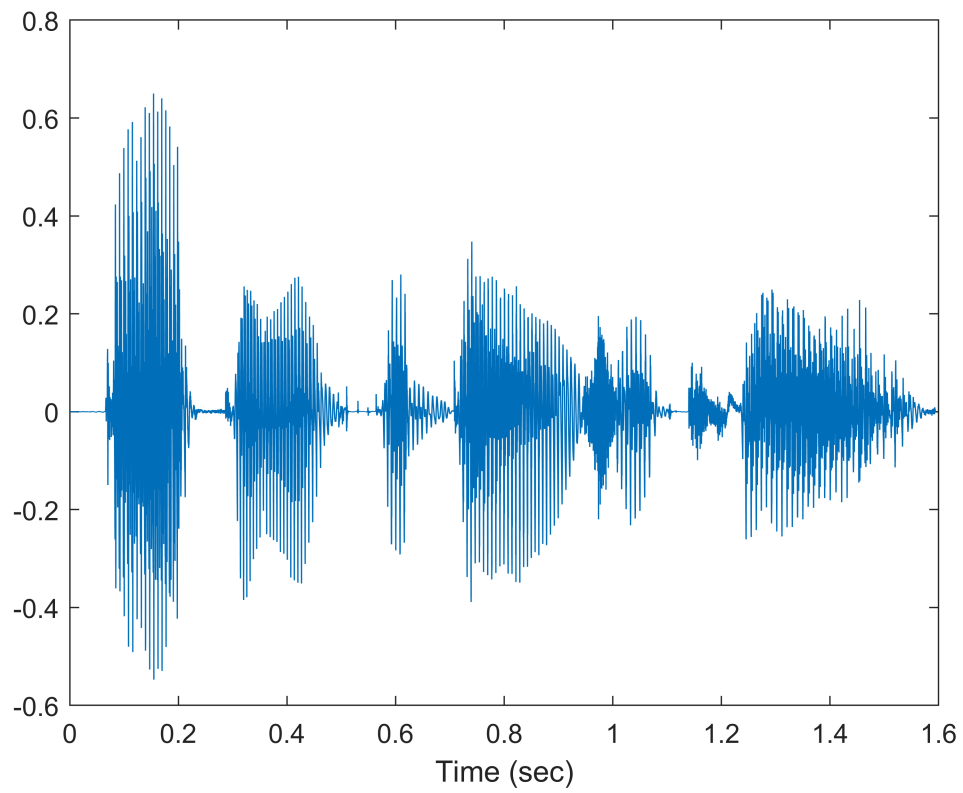
```
figure(1)
clf
plot(x)
xlabel('Time (sample)')
```



Time axis in seconds

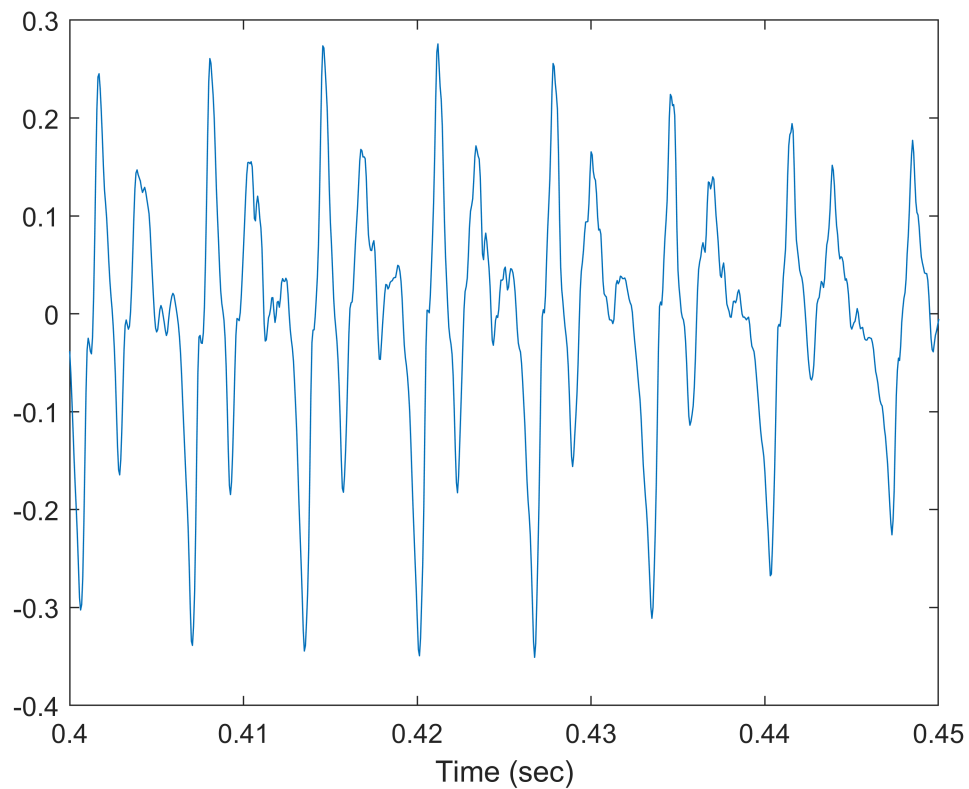
```
N = length(x);
t = (1:N)/Fs;

figure(1)
clf
plot(t, x)
xlabel('Time (sec)')
```



Zoom in to 50 msec

```
xlim(0.4 + [0 0.050])
```



```
%imp = [1 zero(1,N)];
%h = filter (x, imp)

%figure(1)
%clf
%stem(0:N,h)
%xlabel('Discrete time(n)')
%title('impulse response')
```

Frequency spectrum

Use Fast Fourier Transform (FFT)

```
% Use power of 2 for FFT efficiency
N = length(x)
```

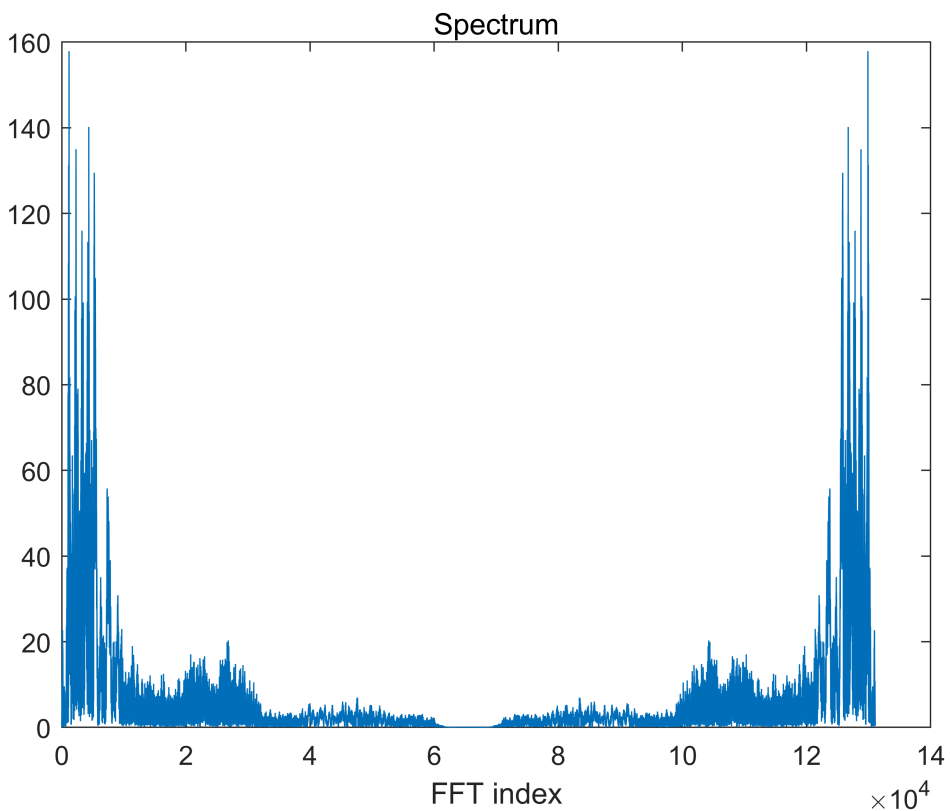
```
N =
    25500
```

```
Nfft = 2^ceil(2+log2(N))           % Use FFT length longer than signal length
```

```
Nfft =  
131072
```

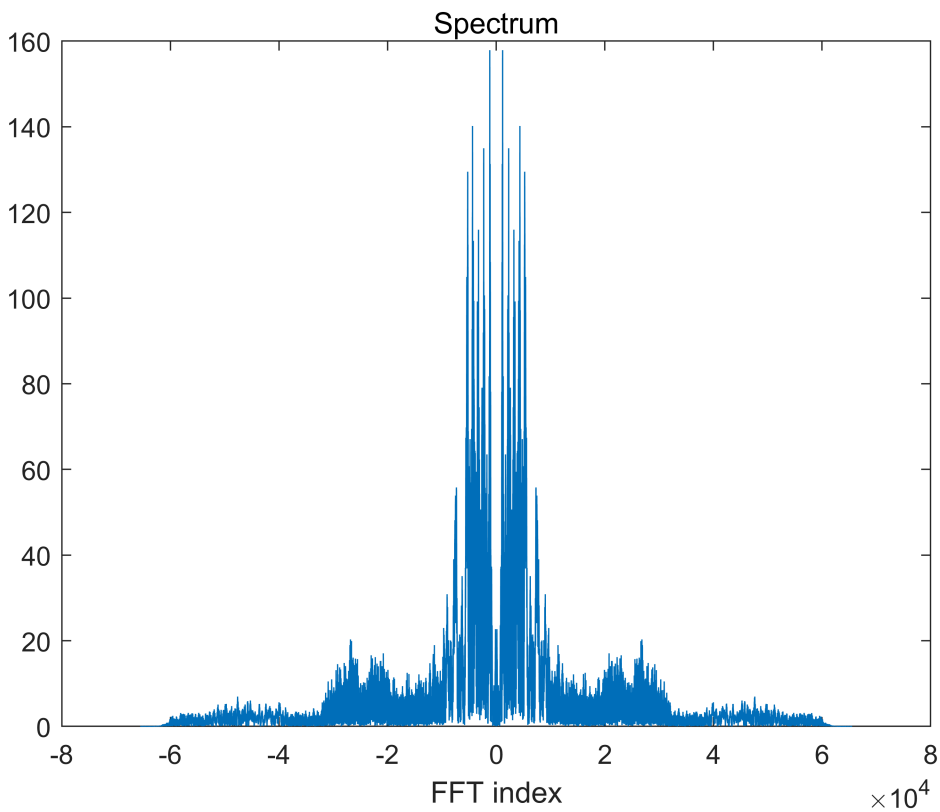
Compute Fourier transform

```
X = fft(x, Nfft);  
k = 0:Nfft-1;      % FFT index  
  
figure(1)  
clf  
plot(k, abs(X))  
xlabel('FFT index')  
title('Spectrum')
```



Center dc

```
X2 = fftshift(X);  
k2 = -Nfft/2 : Nfft/2-1;  
  
figure(1)  
clf  
plot(k2, abs(X2))  
xlabel('FFT index')  
title('Spectrum')
```

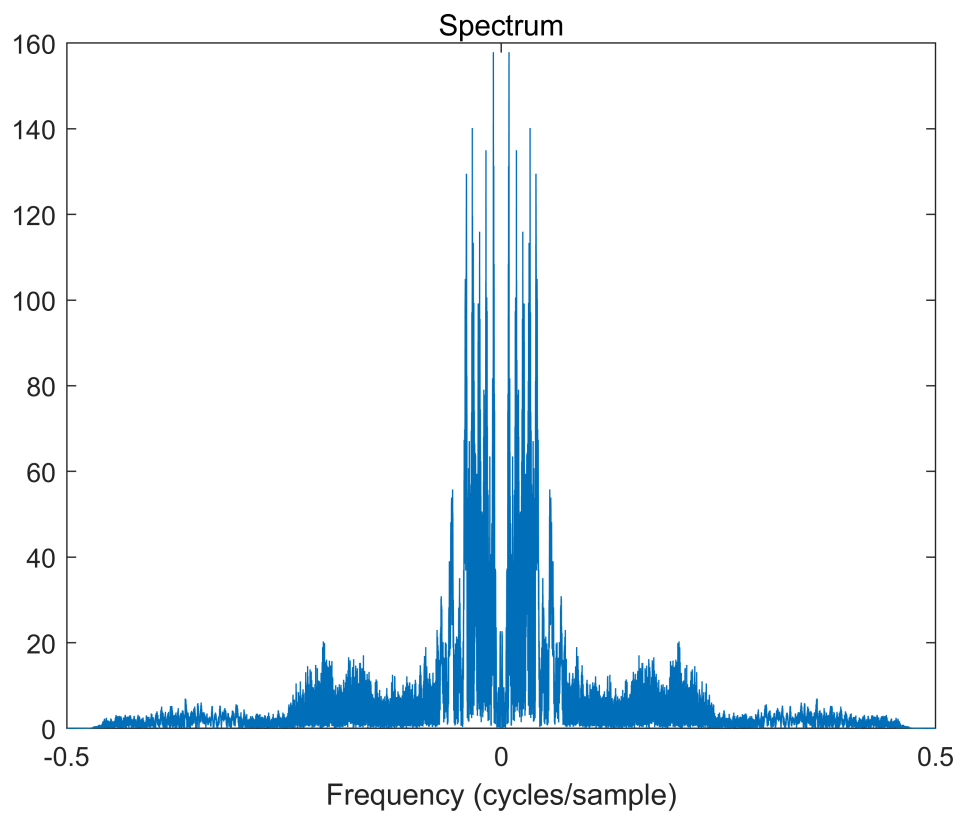


Normalized frequency

Normalized frequency is in units of [cycles per sample]

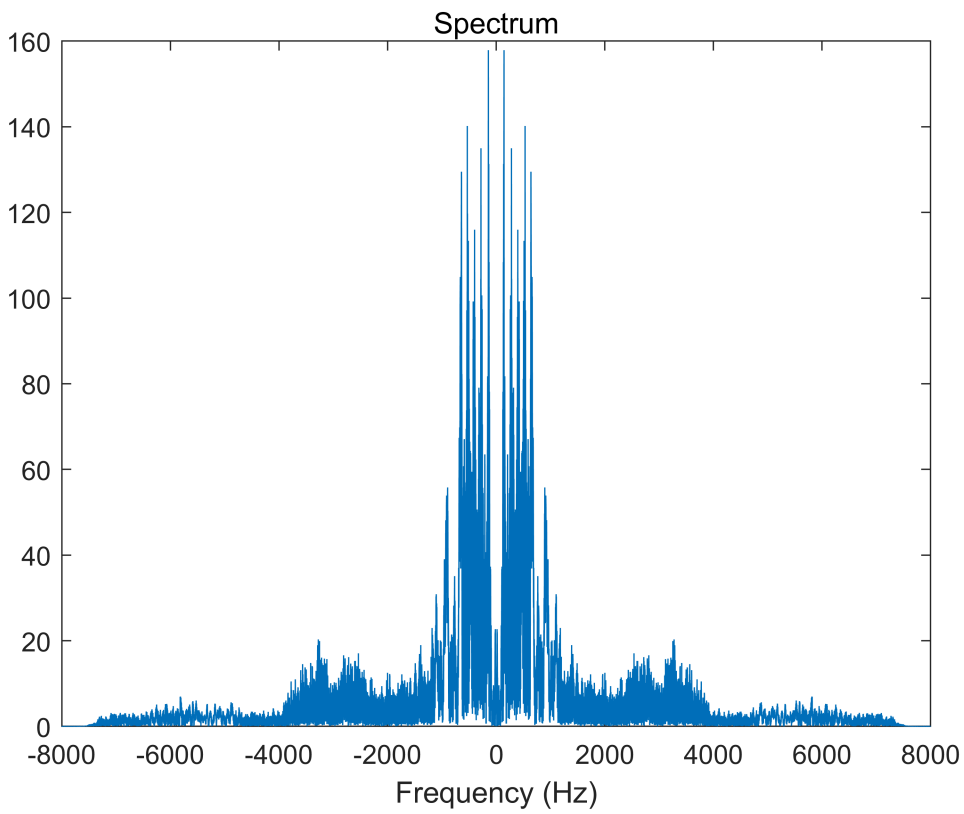
```
fn = ( -Nfft/2 : Nfft/2-1 ) / Nfft;
```

```
figure(1)
clf
plot(fn, abs(X2))
xlabel('Frequency (cycles/sample)')
title('Spectrum')
```



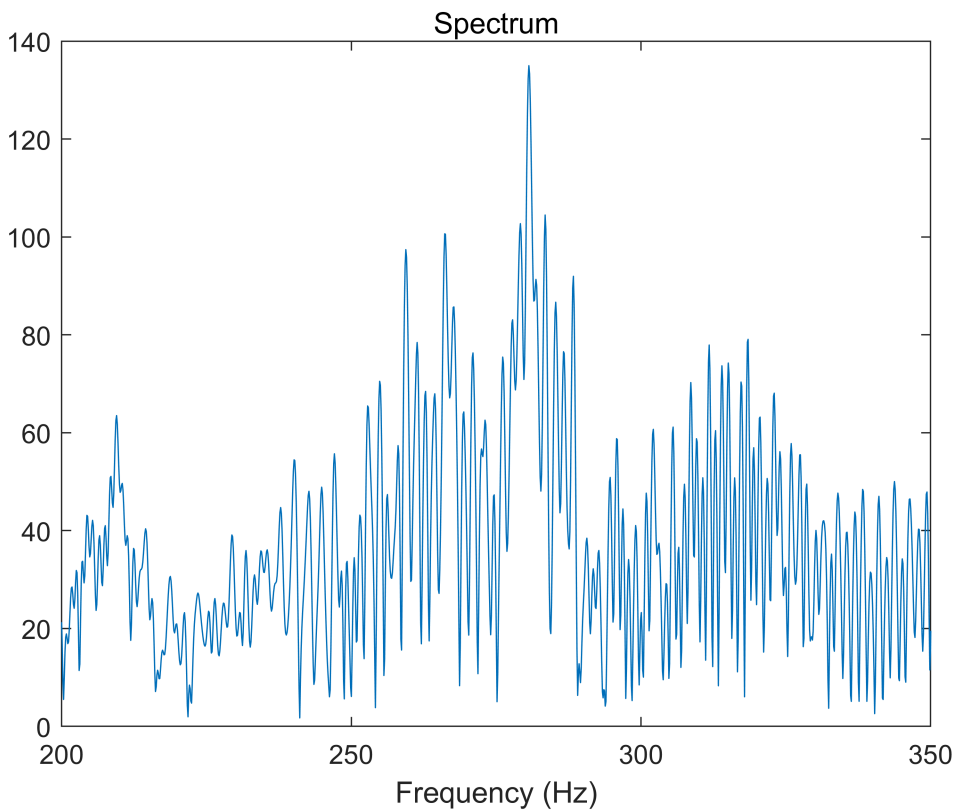
Frequency in Hz

```
f = fn * Fs;  
  
figure(1)  
clf  
plot(f, abs(X2))  
xlabel('Frequency (Hz)')  
title('Spectrum')
```



Zoom to frequency band [200 350] Hz. Notice the sidelobes

```
xlim([200 350])
```

Fourier transform in dB

```
X_dB = 20*log10(abs(X2));  
  
figure(1)  
clf  
plot(f, X_dB)  
xlabel('Frequency (Hz)')  
title('Spectrum (dB)')  
  
xlim([0 Fs/2])  
grid
```

