read_sin_01.m

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('sin_02_stereo.wav');
[nbits, opts] = audioread('sin_02_stereo.wav');

whos
```

```
  Name          Size             Bytes  Class     Attributes

  Fs            1x1                  8  double
  nbits      8000x2             128000  double
  opts          1x1                  8  double
  x          8000x2             128000  double
```

```
Fs
```

```
Fs = 8000
```

```
nbits
```

```
nbits = 8000×2   行 7990:7999 | 列 1:2
         0         0
    0.1719    0.3387
    0.3387    0.6374
    0.4955    0.8607
    0.6374    0.9823
    0.7604    0.9877
    0.8607    0.8763
    0.9354    0.6613
    0.9823    0.3681
    0.9999    0.0314
```

```
opts
```

```
opts = 8000
```

```
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])
```

What is the quantization increment ?

```
x(100:110)
```

```
ans = 1×11
   -0.9851   -1.0000   -0.9851   -0.9409   -0.8686   -0.7705   -0.6494   -0.5090 ···
```

```
x(100:110) * 2^14
```

```
ans = 1×11
10^4 ×
   -1.6140   -1.6384   -1.6140   -1.5415   -1.4232   -1.2624   -1.0641   -0.8340 ···
```

```
x(100:110) * 2^15
```

```
ans = 1×11
10^4 ×
   -3.2280   -3.2768   -3.2280   -3.0831   -2.8463   -2.5248   -2.1281   -1.6680 ···
```

```
% Quantization size is 1 / 2^15
2^15
```

```
ans = 32768
```

Frequency spectrum

Use Fast Fourier Transform (FFT)

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

```
N = 8000
```

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

```
Nfft = 32768
```

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

print -dpdf read_sin_01_spectrum
```