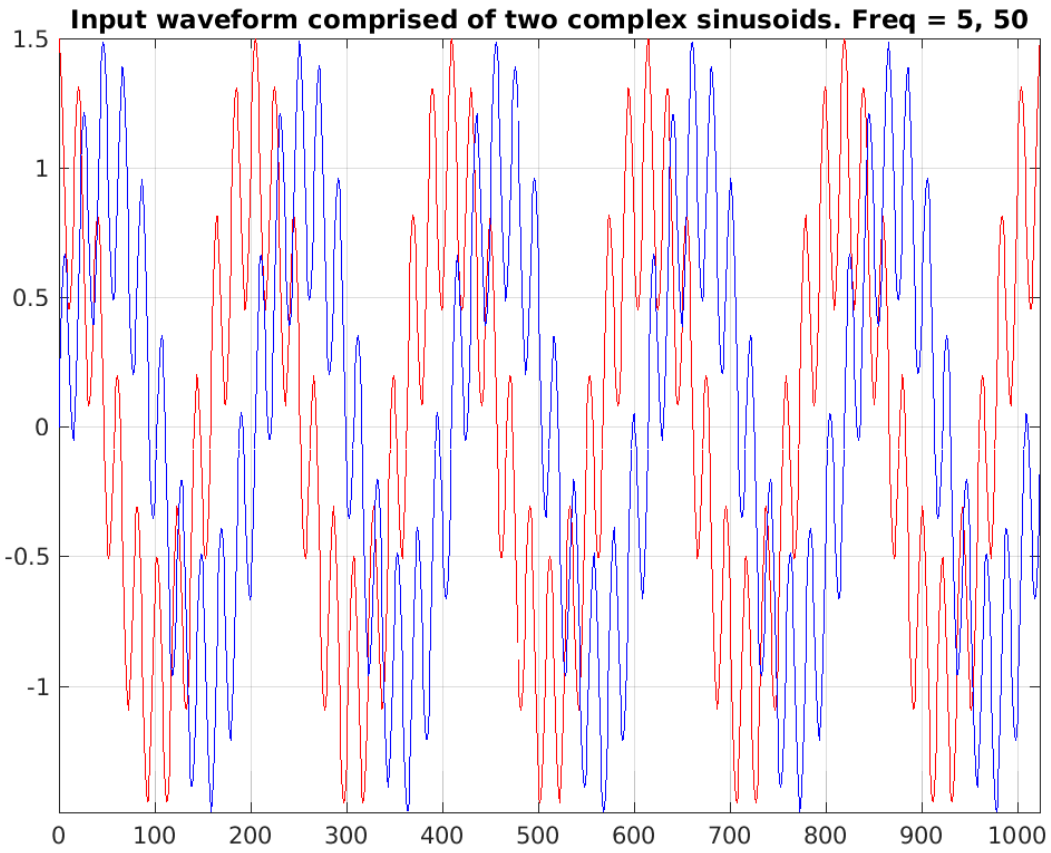
ESTIMATING SPECTRAL MAGNITUDE (in Matlab)

Frequency Representation of a Signal

- There are several key ways to see the frequency domain representation of a signal in matlab
  - `abs(fft())`
  - `psd()`
  - `spectrum()` is now obsolete and will be removed in the future. Matlab suggests using `pwelch()`, `tfestimate()`, or `mscohere()` instead.

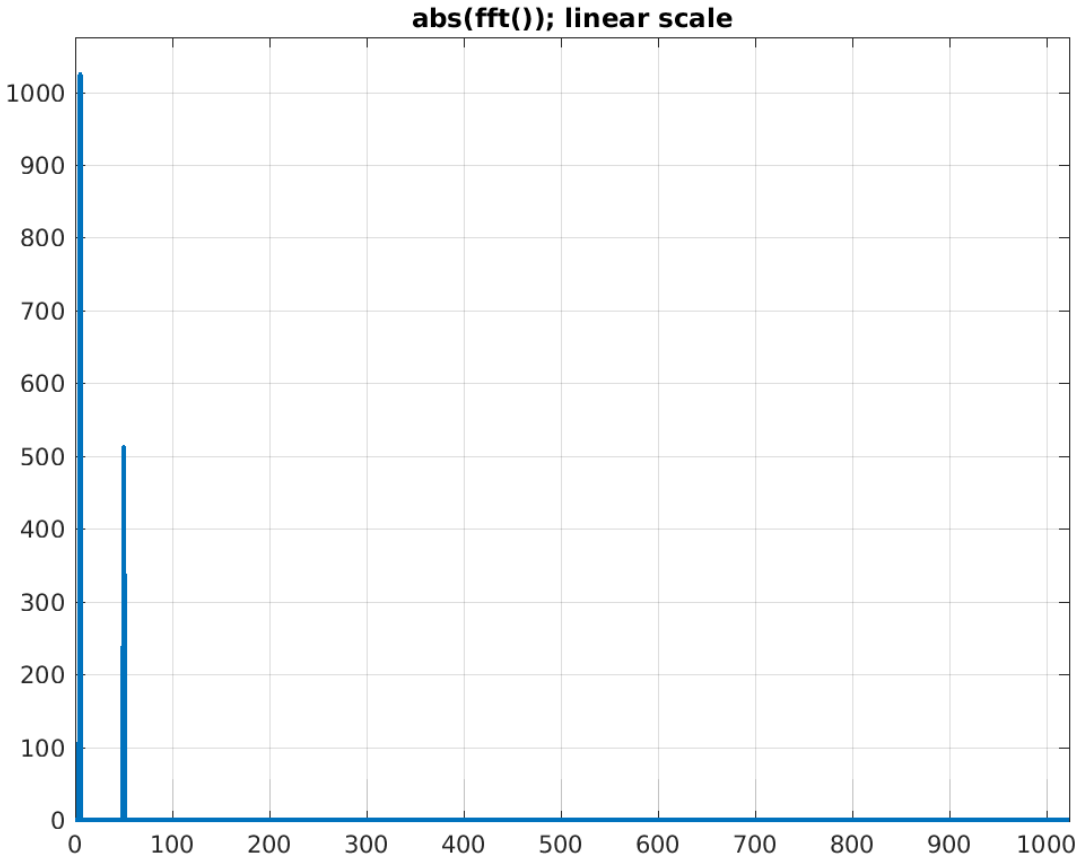
Example Checking Signal Magnitude

- Input waveform made up of two complex sinusoids. Red=real, blue=imag
- The higher frequency is half the magnitude of the lower-freq tone



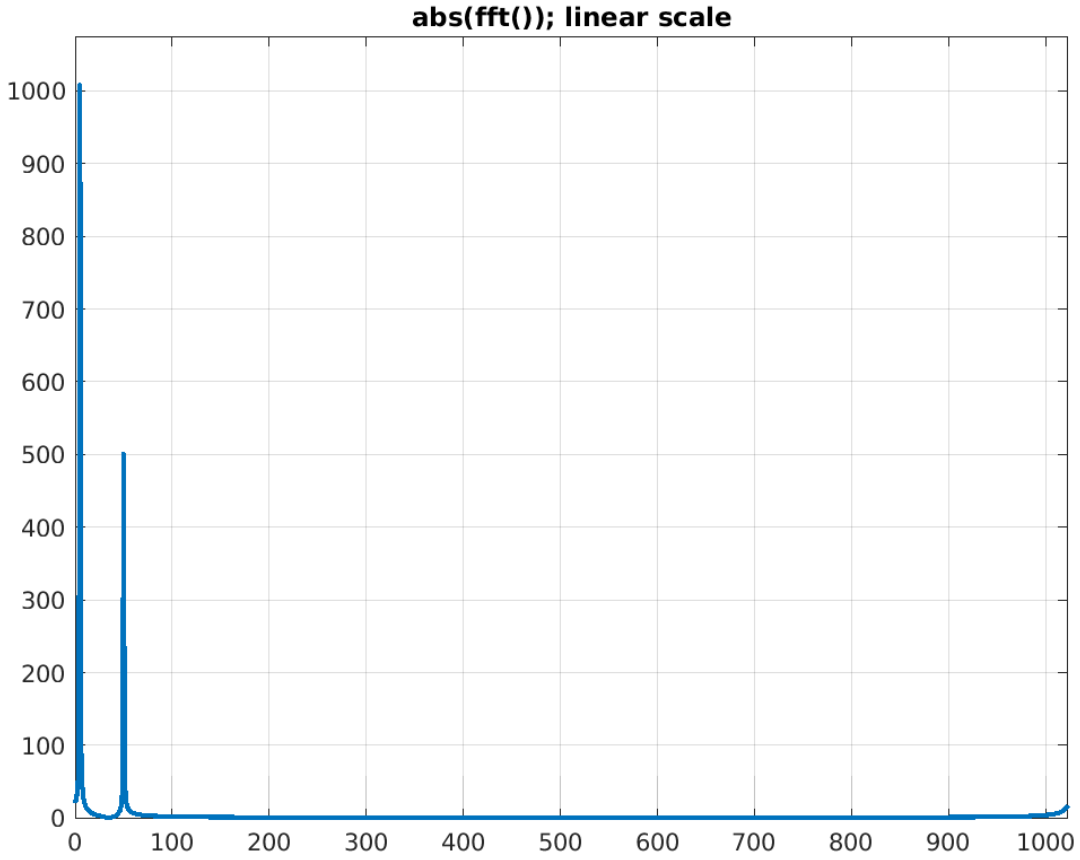
Magnitude of abs(fft())

- magnitude of fft() of the signal plotted on a linear scale



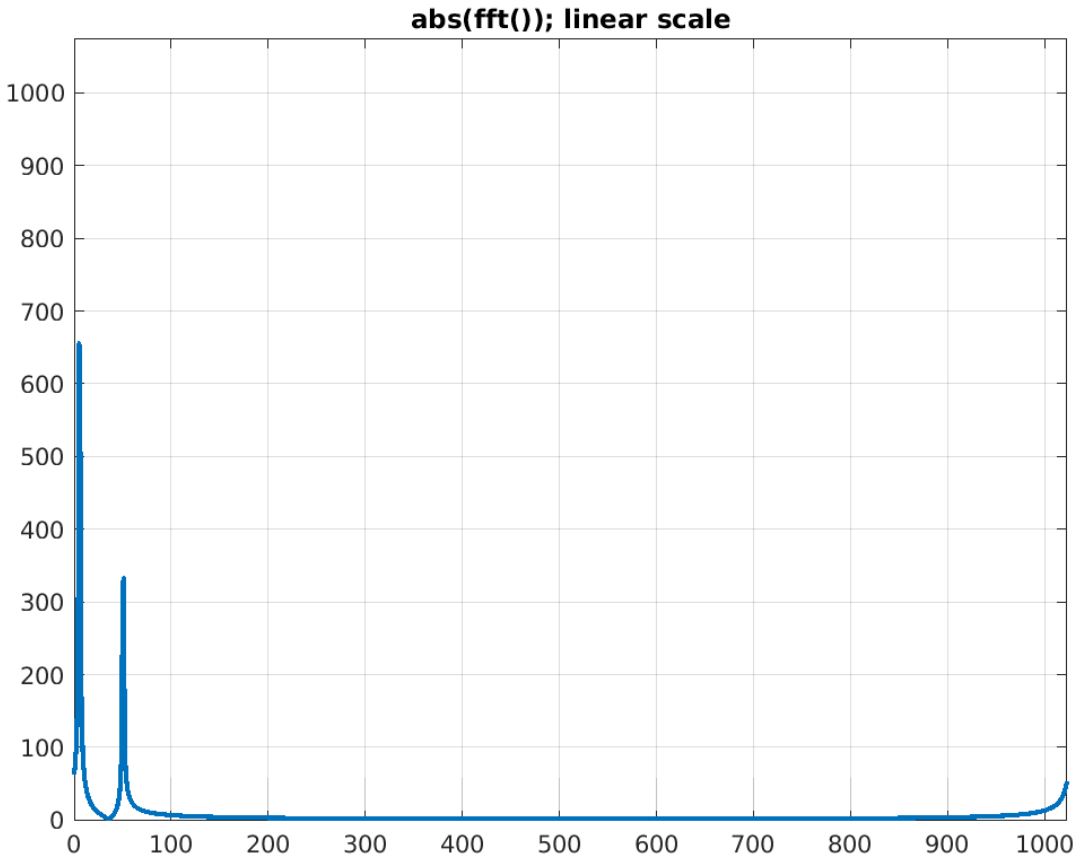
Magnitude of abs(fft()) Frequencies: 5.1 and 50.1

- magnitude of fft() of the signal plotted on a linear scale



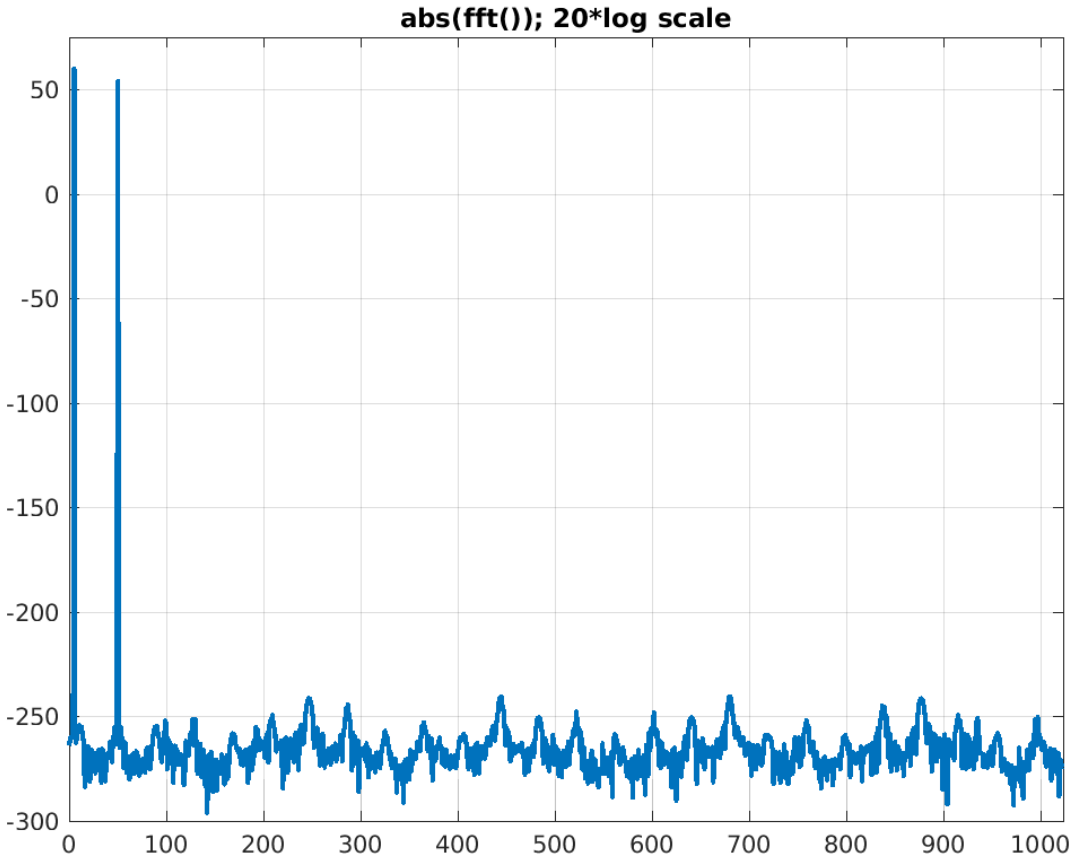
Magnitude of abs(fft()) Frequencies: 5.5 and 50.5

- magnitude of fft() of the signal plotted on a linear scale



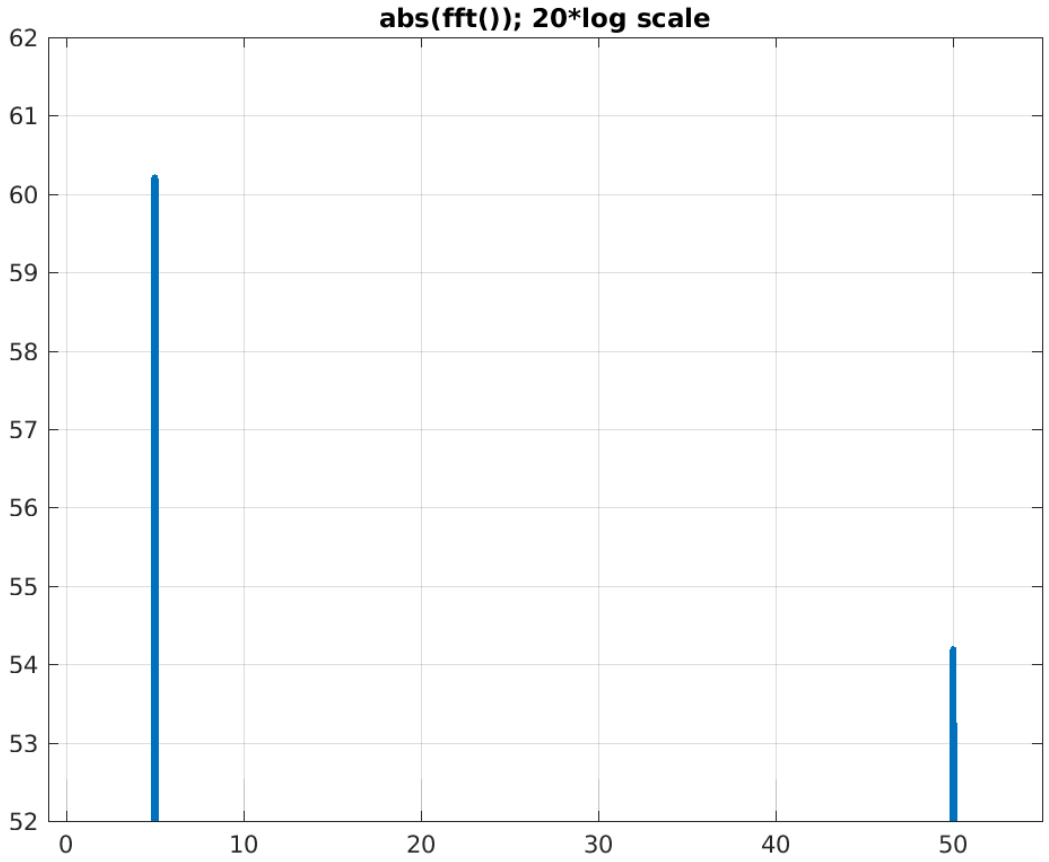
Magnitude of abs(fft())

- magnitude of fft of signal on magnitude-log scale
- Note double precision floating point has 52-bit mantissa (52 bits x 6 dB = 312 dB)



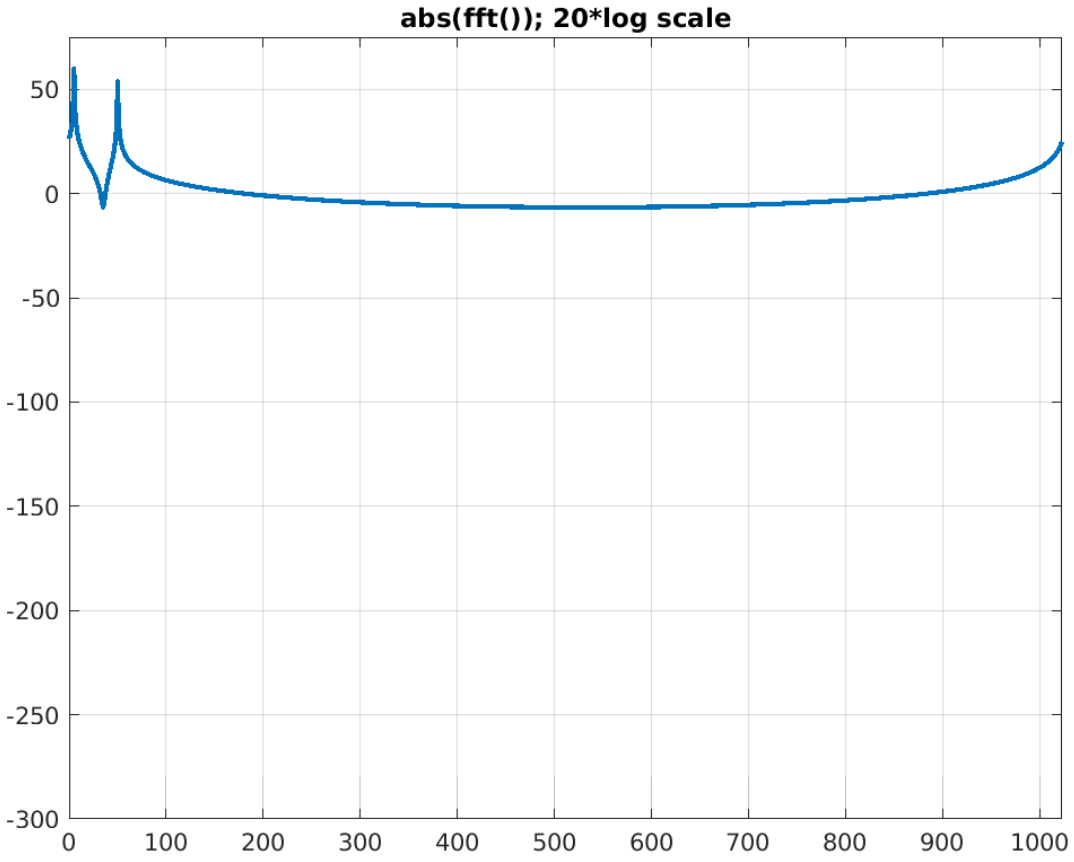
Magnitude of abs(fft())

- magnitude of fft of signal on magnitude-log scale
- Higher tone is –6dB down from lower tone



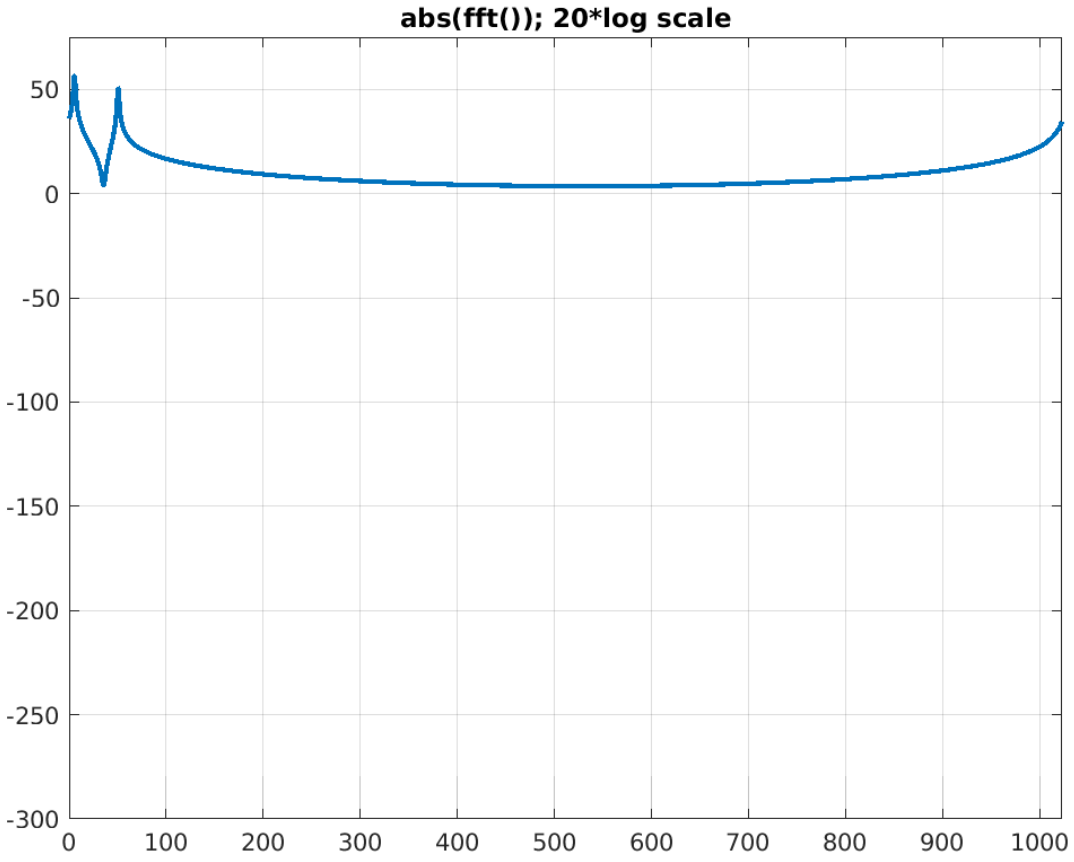
Magnitude of abs(fft()) Frequencies: 5.1 and 50.1

- magnitude of fft of signal on magnitude-log scale



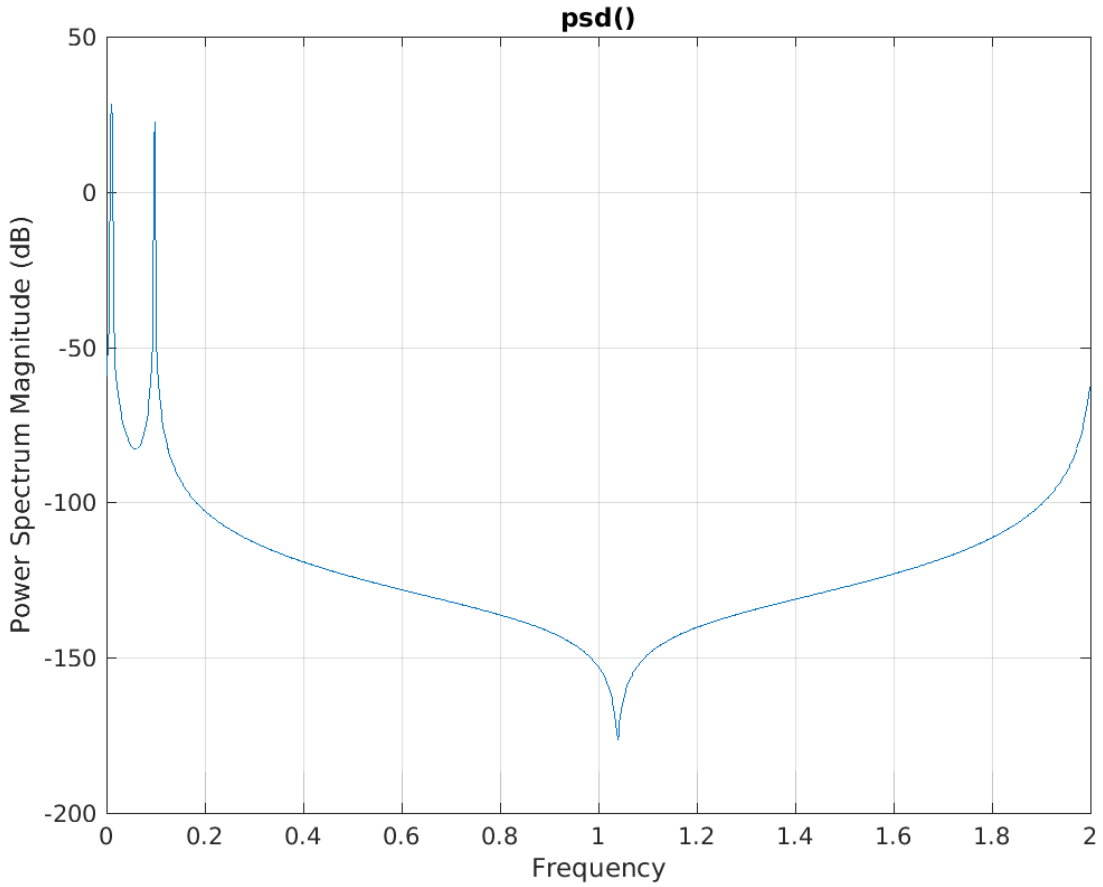
Magnitude of abs(fft()) Frequencies: 5.5 and 50.5

- magnitude of fft of signal on magnitude-log scale



Magnitude of psd()

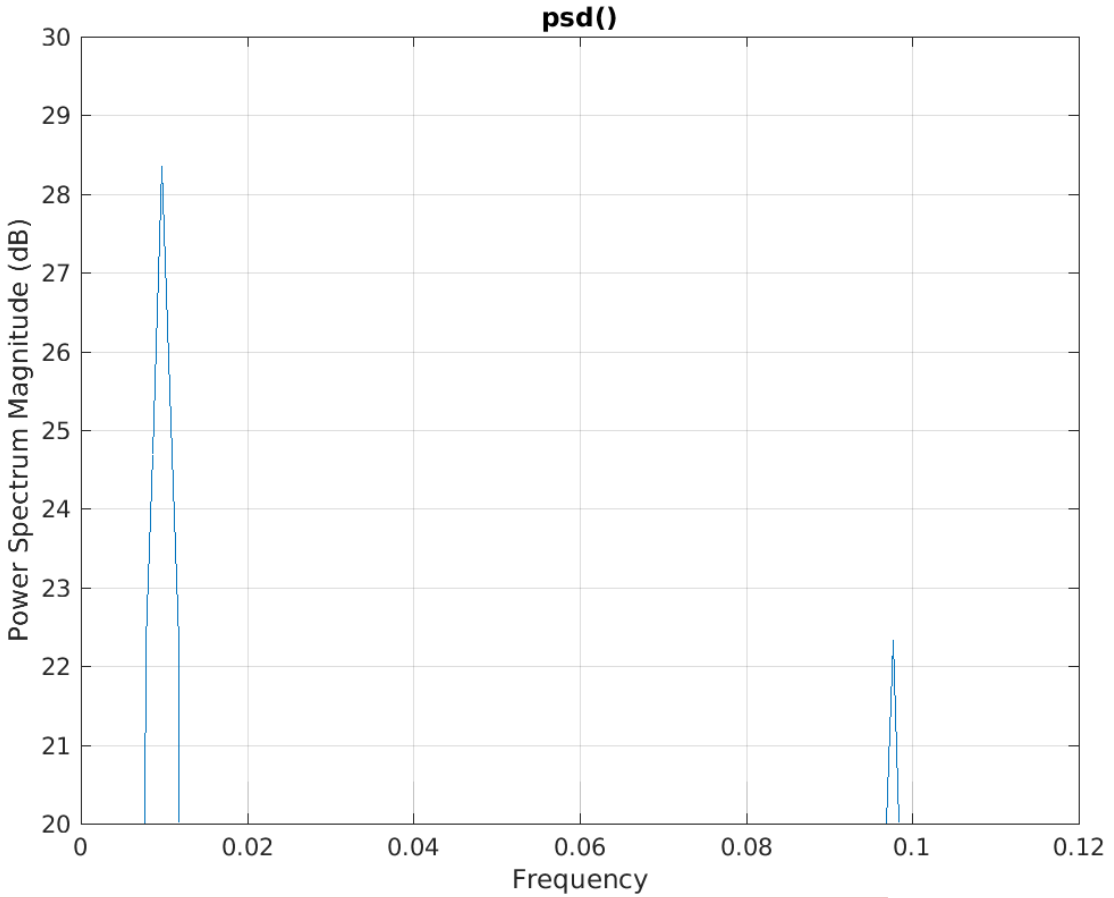
- psd() of the same signal




```
Error using psd (line 3)
PSD has been deprecated. Use PERIODOGRAM or PWELCH instead.
```

Magnitude of psd()

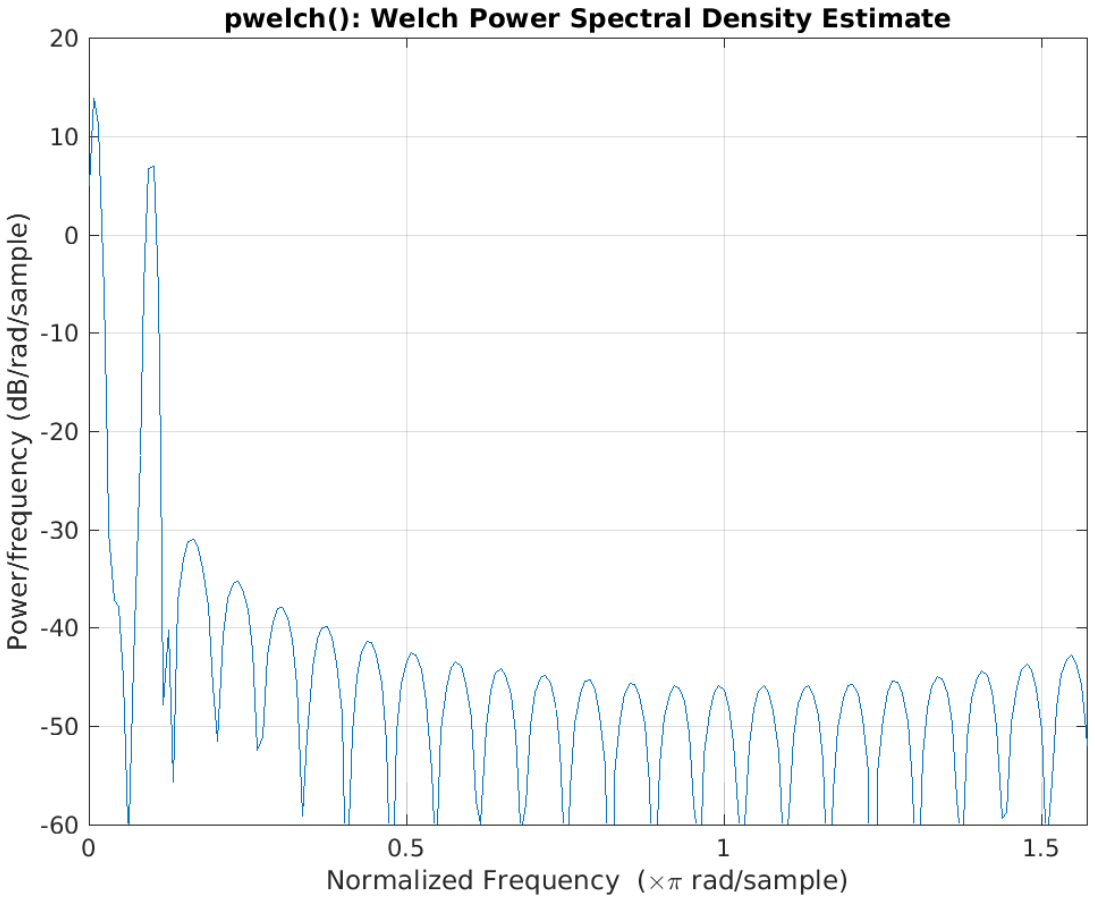
- psd() zoomed in to the spectral peaks
- Higher tone is –6dB down from lower tone




```
Error using psd (line 3)
PSD has been deprecated. Use PERIODOGRAM or PWELCH instead.
```

Magnitude of pwelch()

- pwelch() estimates the spectrum using Welch's averaged, modified periodogram method using a Hamming window



Matlab for the Previous Plots

```
% estim_spect_mag.m
%
% 2003/05/19  Written
% 2019/03/05  Fixed 0 - N-1 offsets, improved axes placements, etc.
% 2021/02/09  Added pwelch()
% 2022/02/10  Commented psd() because matlab now quits when it sees it

PrintOn = 0;
Length  = 1024;
Freq1   = 5;
Freq2   = 50;

in      = 0:Length-1;

wave =              cos(Freq1*2*pi*in/Length) ...
                    + sqrt(-1) * sin(Freq1*2*pi*in/Length);
wave = wave + 0.5*(cos(Freq2*2*pi*in/Length) ...
                    + sqrt(-1) * sin(Freq2*2*pi*in/Length));
```

```
figure(1); clf;
plot_complex(wave, 1, 0);
title('Input waveform composed of two complex sinusoids. Freq = 5, 50');
axis tight;
if PrintOn  print -dtiff filter1.tiff;  end

figure(2); clf;
plot(in, abs(fft(wave)), 'linewidth', 2);
title('abs(fft()); linear scale');
axis ([0 Length-1 -1 Length*1.05]);
grid on;
if PrintOn  print -dtiff filter2.tiff;  end

figure(3); clf;
plot(in, 20*log10(abs(fft(wave))), 'linewidth', 2);
title('abs(fft()); 20*log scale');
axis ([0 Length-1 -300 75]);
grid on;
if PrintOn  print -dtiff filter3.tiff;  end

figure(4); clf;
plot(in, 20*log10(abs(fft(wave))), 'linewidth', 3);
title('abs(fft()); 20*log scale');
axis ([-1 1.1*Freq2 52 62]);
grid on;
if PrintOn  print -dtiff filter4.tiff;  end

figure(5); clf;
pwelch(wave);
title('pwelch(): Welch Power Spectral Density Estimate');
axis ([0 pi/2 -60 20]);
if PrintOn  print -dtiff filter7.tiff;  end
```