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

- `psd()` of the same signal
Magnitude of $\text{psd()}$

- $\text{psd()}$ zoomed in to the spectral peaks
- Higher tone is $-6\text{dB}$ down from lower tone
Magnitude of `pwelch()`

- `pwelch()` estimates the spectrum using Welch’s averaged, modified periodogram method using a Hamming window.
Matlab for the Previous 7 Plots

```matlab
% estim_spect_mag.m
% 2003/05/19 Written
% 2019/03/05 Fixed 0 - N-1 offsets, improved axes placements, etc.
% 2021/02/09 Added pweich()

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 comprised 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;
psd(wave, 1024);
title('psd()');
if PrintOn print -dtiff filter5.tiff; end

figure(6); clf;
psd(wave, 1024);
title('psd()');
axis ([0 0.12 20 30]);
if PrintOn print -dtiff filter6.tiff; end

figure(7); clf;
pwelch(wave);
title('pwelch(): Welch Power Spectral Density Estimate');
axis ([0 pi/2 -60 20]);
if PrintOn print -dtiff filter7.tiff; end
```

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