Dyson School of Design Engineering

Imperial College London

DE2.3 Electronics 2

Lab Experiment 0: Introduction to Matlab

(webpage: http://www.ee.ic.ac.uk/pcheung/teaching/DE2_EE/)

Objectives

By the end of this experiment, you should have achieved the following:

- Have Matlab running on your personal laptop;
- Able to plot signals with Matlab;
- Understand basic Matlab syntax and language;
- Use functions within Matlab;
- Analyse simple signals such as ECG signal;
- Extract useful information from signals.

Before you start

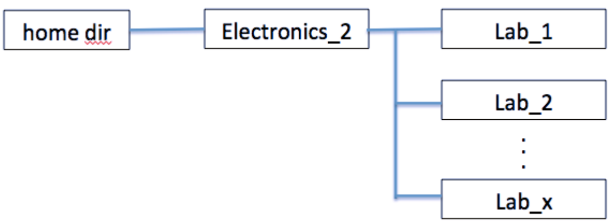
This Lab Experiment should be undertaken by yourself outside schedule Lab hours BEFORE the first Lab Session next Wednesday (15 January).

As in the first year, you are required to keep an electronic logbook for all the laboratory sessions for this module. You will find a useful instruction on how to keep an electronic logbook on the course webpage. While your logbook will not be formally marked, you are expected to answer some questions during your oral examination by referring to the electronic logbook.

Getting started with Matlab

For the rest of this Experiment, make sure that your laptop computer has Matlab running properly. Furthermore, you will also investigate the ideas covered in Lectures 1 and 2.

Before you start, I strongly recommend that you to create a directory structure for all the Matlab codes you will be writing for this module. A possible structure may looks something like this. Trust me – a little effort now will save you lots of time later.



Exercise 1: Sinusoidal signal generation

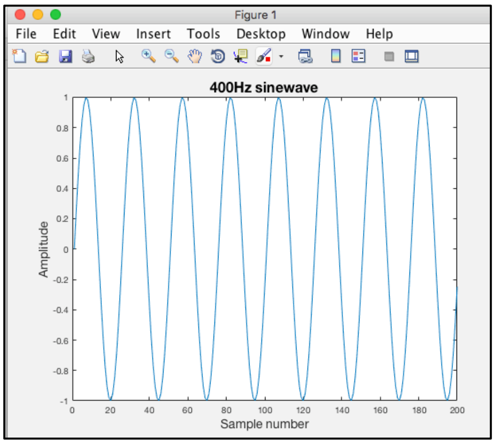
Enter the following Matlab function to generate a sinusoidal signal using the filename: **sine_gen.m**. Test the function to produce the plot as shown.

```
function [sig] = sine_gen(amp, f, fs, T)
% Function to generate a sinewave of amplitude amp, frequency f
%   ....   with a sampling frequency fs for a duration T
%
%   usage:     signal = sine_gen(1.0, 440, 8800, 1)
%
% author: Peter YK Cheung, 9 Jan 2019

    dt = 1/fs;
    t = 0:dt:T;
    sig = amp*sin(2*pi*f*t);
```

Test this function in the interactive mode of Matlab:

```
>> s1 = sine_gen(1.0, 400, 10000, 1);
>> plot(s1(1:200));
>> xlabel('\fontsize{14}Sample number');
>> ylabel('\fontsize{14}Amplitude');
>> title('\fontsize{16}400Hz sinewave');
```



Make notes in the electronic logbook about what you have learn, and the results you get.

Exercise 2: Spectrum of the signal

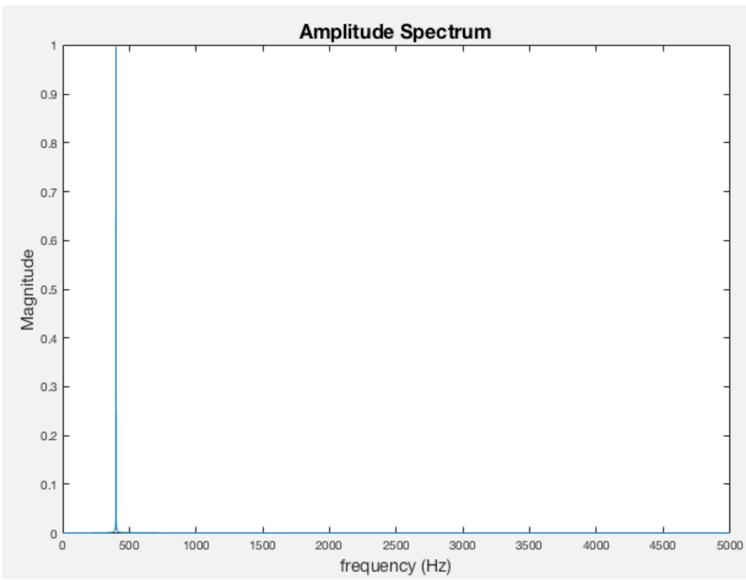
Enter the following function using the filename: **plot_spec.m**. This function uses the Matlab built-in function "fft" to compute the frequency spectrum of the signal. Don't worry about exactly how this works for now. (I deliberately want you to type the code into Matlab instead of doing cut-and-paste. In this way, there is a higher chance that you will remember some of the syntax of Matlab.)

```
function plot_spec(sig, fs)

% Function to plot frequency spectrum of sig
%   usage:
%           plot_spectrum(sig, 1000)
%
% author: Peter YK Cheung, 9 Jan 2019
    magnitude = abs(fft(sig));
    N = length(sig);
    df = fs/N;
    f = 0:df:fs/2;
    Y = magnitude(1:length(f));
    plot(f, 2*Y/N)
    xlabel('\fontsize{14}frequency (Hz)')
    ylabel('\fontsize{14}Magnitude');
    title('\fontsize{16}Spectrum');
```

Test this function in the interactive mode of Matlab and you should see the following frequency spectrum plot. You can zoom onto the peak frequency at 400Hz using the  button.

```
>> s1 = sine_gen(1.0, 400, 10000, 1);
>> plot_spec(s1,10000);
>> title('\fontsize{16}Amplitude Spectrum');
```



Exercise 3: Two tones

Now generate two sinewaves, s1 at 400Hz (amplitude 1.0V) and s2 at 1000Hz (amplitude 0.5V), using a sampling frequency of 10kHz and each having a duration of 1.0 second. Add these together as "sig" and plot the waveform.

Plot the spectrum of the combined signal.

Exercise 4: Two tones + noise

Assume that your two-tone signal is called "sig", create a noisy version of this signal using:

```
noisy = sig + randn(size(sig));
```

The function randn(.) produces a set of random numbers. How many samples? That is decided by the number of data samples in "sig" with the function size(.). Now, plot noisy and its spectrum.

What have you learned from this exercise?

Exercise 5: Projection using dot product

Let us now treat the two sinusoid signals s1 (400Hz) and s2 (1000Hz) as two vectors. You can find the projection of s1 on s2 by computing their **dot product** (also known as **inner product**) in Matlab:

```
dot_product = s1*s2';
```

What value do you get? Now create another sinewave s3 at 401Hz, and find the dot product of s1 on s3. What do you get?

Sometime, dot product is called cross-correlation coefficient, or projection of s1 onto s2. It is a measure of how much of the s1 signal can be found in s2 signal.

Finally, find the **dot product** of (s1 + s2) on s1. What do you get?

I will be explaining all the Matlab code and the ideas behind this laboratory session during the next lecture/tutorial.