EE 3TI4 Lab I : Introduction to MATLAB

The aim of this first lab is to get you familiarized with MATLAB. MATLAB, short for "MATrix LABoratory" is an easy-to-use programming language to perform sophisticated matrix operations without having to write detailed C or Fortran codes. In addition to the core matrix manipulation capabilities, MATLAB comes with several "toolboxes" such as the Communications Toolbox and the Signal Processing Toolbox which provide various standard functions.

The best way to learn MATLAB, or any other programming language for that matter, is through a hands-on approach. But first, you will have to learn the syntax of MATLAB. Use the MATLAB Primer handout, the MathWorks guides or any of the numerous introductory books on MATLAB. Once you feel comfortable with MATLAB, you can have a go at the following exercise. No write up is required but you are strongly advised not to miss this opportunity to learn MATLAB as it is essential to the forthcoming labs.

In this exercise, you are asked to write a program to evaluate the frequency content of a signal $g(t)$ via the Fourier Transform (FT) defined as

$$G(f) = \int_{-\infty}^{\infty} g(t) \exp(-j2\pi ft)dt \tag{1}$$

The above expression can be numerically evaluated using a discrete approximation known as the Discrete-Time Fourier Transform (DTFT) defined as

$$G(e^{j2\pi f}) = \sum_{n=-\infty}^{\infty} g(n) \exp(-j2\pi fn) \tag{2}$$

where $G(e^{j2\pi f})$ is the frequency domain representation or *spectrum* of the discrete-time or sampled sequence $g(n)$. It turns out that the process of uniformly sampling a continuous-time signal of finite duration results in a periodic spectrum with a period equal to the sampling frequency. Hence the notation $G(e^{j2\pi f})$ for the spectrum.

Write a MATLAB program to evaluate the DTFT of a sampled signal. Your function heading should look like:

function G = dtft(g,f,nl,T)

where g is the discrete-time sequence in column vector format
f is a row vector of frequency values at which G is to be evaluated
$n1$ is an integer corresponding to time of the first sample of g
T is the sampling period in seconds and
G is the desired DTFT

1 DTFT of Rectangular Pulse

Use your program to evaluate the DTFT of the sampled rectangular pulse given by

$$g(n) = \begin{cases} 1 & -15 \leq n \leq 15 \\ 0 & otherwise \end{cases} \quad (3)$$

You can define the input arguments as follows:

```
n1 = -15;
T = 1;
g = ones (-2*n1+1,1);
f = -0.5:0.01:0.5;
```

Call your program with G = dtft(g,f,n1,T) and plot the magnitude and phase of the sequence G vs f.

2 Power Spectrum of the Random Noise Generator

The power spectrum (or power spectral density PSD) is just the magnitude-squared of the spectrum. To evaluate the spectrum of a random sequence, many spectra must be averaged. This is because the spectrum of a random signal is random itself. Therefore to obtain the underlying spectral characteristics, we must average the magnitude-squared over many realizations of random spectra. Here is what to do:

```
n = 64; % length of random vector
f = -0.5:0.01:0.5;
nit = input ('input number of spectra to average'); % input nit from keyboard
                                                   % use 100, 500, 1000, etc.
ave = zeros (length(f),1);    % initialize "ave" to zeros
for i = 1:nit                 % loop to calculate avarage PSD
g = randn(n,1);               % sample of random sequence
G = dtft(x,f,0,1);            % call to your program
ave = ave + abs(G) .∧ 2;      % add returned |G|^2 of sample to ave
end
ave = ave/nit;                % averaged PSD
```

Plot your results. Try different values of 'nit' and try explaining what you observe. What should the averaged PSD of an ideal random generator look like ? Conmment on the quality of this random generator.