York University

Department of Electrical Engineering and Computer Science

EECS 4214

Lab #2 Deterministic and Random Signals

Amir M. Sodagar

1. Purpose

In this lab, you will be introduced to random variables and processes. Using a computer, you will learn how to generate random signals as well as deterministic ones, and take them to the frequency domain using the Fourier transform. You will also apply some of the functions taught in the class on a combination of deterministic and random signals, which is usually the actual case when studying digital communication systems.

2. Objectives

By the end of this project, you will be able to: 1) Generate random variables of commonly used probability density functions (PDFs) including Gaussian PDFs. 2) Derive and plot the autocorrelation function of a sequence of rectangular pulses. 3) Calculate both time average and ensemble average for a set of random variables, observed from a random process, and examine the ergodicity of the process.

3. References

1) Handouts on “Deterministic and Random Signals” available on the course homepage on Moodle.

2) Bernard Sklar text: Chapter 1.

Problem 1 **FFT of a periodic deterministic signal**

In MATLAB®, generate the signal $x(t)=\sin 2\pi f_1 t + (1/3)\sin 2\pi(3f_1)t + (1/5)\sin 2\pi(5f_1)t$ for t=0:1μs:0.999ms, where f_1=1kHz. This is indeed an approximation for a 1-kHz square wave, using the first 3 terms of its Fourier series expansion. Suppose that this is the signal of interest in this problem. Plot the signal in the time domain as well as its fft (in the frequency domain). Try to enhance the frequency resolution for the plotted fft.

Problem 2 **FFT of a noisy signal (mixture of a deterministic periodic signal and random noise)**

Using `randn` in MATLAB, add a random noise, n(t), with normal distribution (mean=0, SD=2) to the signal, x(t), you generated in Problem 1. Plot the noisy signal, x(t)+n(t), in the time domain as well as its fft in the frequency domain.

Problem 3 **Time average, Ensemble average**

Using a single `randn` command in MATLAB, generate 100 random variables with normal distribution (mean=0, SD=1), each with 1000 samples. Let us assume that all the 10 signals are generated using the same random process. Calculate 3 time averages and 3 ensemble averages of your choice. According to the results, is this random process *ergodic*?

Note: *If your computer is too slow to process 100 random variables, you may write your program for 10 variables, run it 10 times, and combine the results in a proper way. Explain how your program(s) handles 100 variables.*

Problem 4 **Autocorrelation**

A signal is defined as follows:

$$y(t) = \begin{cases} 0 & t < 1s \ \ and \ t > 4s \\ 1 & 1s < t < 3s \\ -1 & 3s < t < 4s \end{cases}$$

First, find and draw the autocorrelation of this signal by hand calculations, and then do the same thing using MATLAB.