EEE-4510: Introduction to Digital Signal Processing **Fall 2019**
Computer Project **Due: December 12, 2019**

In this project you will analyze, implement and test 4 simple discrete-time LTI systems. You are first asked to deal with each one of them separately, and then comment on the comparisons between them.

You can use any simulation or high-level computer language for this assignment, but it is suggested that you use Matlab.

I. CREATE TEST SEQUENCES:

Create, save and plot the following test sequences:

$x1(n) = \cos(\pi n/4)$ for values of n = 0 …. 255.

$x2(n) = \cos(\pi n/2)$ for values of n = 0 …. 255.

$x3(n) = \cos(3\pi n/4)$ for values of n = 0 …. 255.

d(n) = 0 for n = 0, 1,2, …255 , but d(**10**) = 1; (implementation of a unit impulse delayed by 10 time units)

CREATE xt(n), as the point-to-point sum of x1(n), x2(n) and x3(n):

$$xt(n) = x1(n) + x2(n) + x3(n)$$

Compute the 256-point DFT of x1(n), x2(n), x3(n), xt(n) and d(n) (YOU MAY USE THE Matlab function "fft", with its default window if you are using Matlab). <u>Display ("plot") the magnitude of the first 128 DFT coefficients found</u>, which represent the frequency contents of the signals, from DC to Fs/2.

II. ANALYZE, IMPLEMENT AND TEST 4 LTI SYSTEMS

II.1 Consider the system characterized by the following difference equation:

$$y(n) = x(n) + 2\,x(n-1) + x(n-2) + 0.8\,y(n-1) - 0.64\,y(n-2)$$

*(**NOTE**: Do a, b, and c, "by hand", and use the computer to do d, e, f, g, h, and i)*

a) Draw its block diagram
b) b.1 - Obtain its transfer function H(z)
   b.2 – Calculate and PLOT $|H(e^{j\theta})|$, for θ = 0, π/4. π/2, 3π/4, and π.
c) Obtain and plot its poles and zeros, in the z-plane

d) Write a program or Matlab function that implements the difference equation for the system (assuming null initial conditions). – INCLUDE THE SOURCE CODE IN YOUR REPORT

e) Use your program to calculate the response of the system to d(n), the impulse sequence you created. Plot (stem) the resulting output, to n = 255. This is the impulse response of the system. Does it have the shape that you would expect from the pole locations for this system?

f) Use your program to obtain the output sequence that results when you use x1(n) as the input. Plot (stem) the resulting output, to n = 255. What is the amplitude of the output sequence? Was the signal amplified through the system? By how much? Obtain the 256-point DFT of the output. Plot the magnitude of the first 128 DFT coefficients.

g) Do as in f), but now using x2(n) as the input to the system.

h) Do as in f), but now using x3(n) as the input to the system.

i) Do as in f), but now using xt(n) as the input to the system.

j) Which kinds of frequencies (low frequencies, high frequencies, mid frequencies) are attenuated the least through this system?

II.2 Repeat the same process as in II.1, but now use this system:

$$y(n) = x(n) - 2\,x(n-1) + x(n-2) + 0.8\,y(n-1) - 0.64\,y(n-2)$$

II.3 Repeat the same process as in II.1, but now use this system:

$$y(n) = x(n) - x(n-2) + 0.8\,y(n-1) - 0.64\,y(n-2)$$

II.4 Repeat the same process as in II.1, but now use this system:

$$y(n) = x(n) - x(n-2) + 0.2\,y(n-1) - 0.04\,y(n-2)$$

III. COMPARISON BETWEEN SYSTEMS

Now that you have analyzed and tested each of the four systems, MAKE COMMENTS ON THE RESULTS OBTAINED FOR EACH SYSTEM, comparing them in terms of their zeros and poles, their impulse responses and the way in which each system processes different types of frequencies.