EEE 331 SIGNALS AND SYSTEMS
LAB 2 SYSTEM FEATURES AND CONVOLUTION

Objective

The objective of this experiment is to introduce using MATLAB to define an LTI system and determine on its main features, such as; linearity, causality stability invertibility and time variance. This is achieved by examining the performance of the system for particular inputs that will show those characteristics.

1. Linearity:

A system is linear if superposition holds. Specifically, a linear system must satisfy the two properties:

1 Additive: the response to $x_1(t)+x_2(t)$ is $y_1(t) + y_2(t)$

2 Scaling: the response to $ax_1(t)$ is $ay_1(t)$

3 Combined: $ax_1(t)+bx_2(t) \rightarrow \quad ay_1(t) + by_2(t)$

Exercise 1

The system $y[n] = sin\,(\frac{\pi}{2}x[n])$ is not linear. Write matlab code and show that how it violates linearity

Give a counter example. A good example is the set of signals $x1[n] = \delta[n]$ ve $x2[n] = 2\delta[n]$

Write a MATLAB code to demonstrate this example. This can be done as follows:

- Define the domain of the two signals to be from -3 to 3 and save it as a vector n
- Define the signal x1 as a vector of the values [0 0 0 1 0 0 0]
- Define the signal x2 =2x1
- Evaluate the output corresponding to the x1 input, and label it as y1
- Evaluate the output corresponding to the x2 input, and label it as y2

On the same graph window, plot the signals x1, x2, y1 and y2 using the commands (subplot) and (stem). Your results should be as depicted in Figure 1. ***Q**: Is y2 equal to 2y1, what is your coment?*

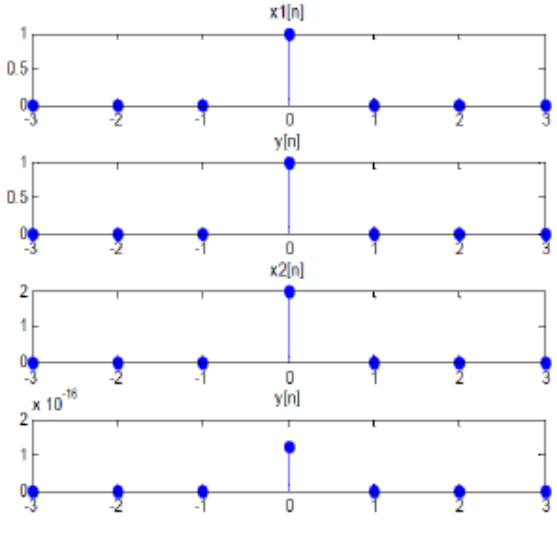

Figure 1 Exercise 1 Result

Objective

The objective of this experiment is to introduce using MATLAB to perform discrete time convolution, and to simulate continuous time convolution for some common signals.

Convolution:

The convolution of the signals x(t) and h(t) is mathematically defined as:

$$y(t) = x(t) * h(t) = \int_{-\infty}^{+\infty} x(\tau).h(t-\tau)d\tau$$

And for the discrete time signals x[n] and h[n], it is defined as:

$$y[n] = x[n] * h[n] = \sum_{k=-\infty}^{\infty} x[k].h[n-k]$$

Convolution gif : http://amber.feld.cvut.cz/vyu/eo2/english/lectures.htm

Exercise 2

Use MATLAB to evaluate the convolution of x[n] with itself, where

$$x[n] = \begin{cases} 1 & 0 \le n \le 5 \\ 0 & otherwise \end{cases}$$

Procedure:

- Define the signal x as a vector of values [1 1 1 1 1 1], using the (**ones**) command.
- Use the (**conv**) function to evaluate the convolution of x with itself, and name it as y.
- Define the index vector n to range from 0 to 10.
- Using the function (**stem**), plot y versus n.
- Label the vertical and horizontal axes as (Amplitude) and (Time), respectively.
- Title the figure as (y[n]).
    - ***Comment on the relationship between the length of y[n] and x[n]***

Exercise 3

I. Consider the discrete time signals:

$$x[n] = \begin{cases} n & 0 \le n \le 5 \\ 0 & otherwise \end{cases}$$

$$u[n] = \begin{cases} 1 & 0 \le n \le 5 \\ 0 & otherwise \end{cases}$$

- Define the signal x as a vector of values [0 1 2 3 4 5].
- Define the signal u as a vector of values [1 1 1 1 1 1], using the (**ones**) command.

- Use the function (**conv**) function to evaluate the convolution of x with u, and name it as y.
- Define the index vector n to range from 0 to 10.
- Using the function (**stem**), plot y versus n.
- Label the vertical and horizontal axes as (Amplitude) and (Time), respectively.
- Title the figure as (y[n]).

II. **Repeat** part I using u[n+5] instead of u[n].

Q: Comment on the relationship between y[n] in part I, and y[n] of part II.

Exercise 4

In this part, continuous time convolution will be simulated in the discrete case. Consider the continuous time signals x(t) and h(t). Generate these functions using a time step of 0.1.

$$x(t) = \begin{cases} 1 & 1 \le n \le 5 \\ 0 & otherwise \end{cases}$$

$$h(t) = \begin{cases} 1 & 2 \le n \le 7 \\ 0 & otherwise \end{cases}$$

Yöntem:

- **1'den 5'e 0.1** adımlarla artarak giden x domain (alan) vektörünü oluşturup **tx** olarak adlandırınız.
- **2'den 7'ye 0.1** adımlarla artarak giden h domain (alan) vektörünü oluşturup **th** olarak adlandırınız.
- tx boyutunda ve 1'lerden oluşan x vektörünü oluşturunuz. (ip ucu= ones, length)
- th boyutunda ve 1'lerden oluşan h vektörünü oluşturunuz. (ip ucu= ones, length)
- x ve h vektörlerinin konvolüsyonu olan z vektörünü bulunuz. (ip ucu= konvolüsyonu zaman adımı olan 0.1 ile çarpmayı unutmayınız.)
- x,h,z vektörlerini çizdiriniz. (ip ucu= stem)
- x,h, z vektörlerinin büyüklüğü arasında bir ilişki var mıdır?