L.EEC025 - FUNDAMENTALS OF SIGNAL PROCESSING

Academic year 2024-2025, week 1
PL preliminary exercises

Topics: Introduction to Matlab, revisiting the discrete-time convolution, FIR/IIR discrete-time systems

Problem 1

Create an `.m` file of Matlab commands implementing the following operations:

- asks the user to enter an integer number N (N>30) using the keyboard,

- creates a line vector, `n`, including the integers 0, 1, …, N-1,

- creates a line vector $h = \alpha^n$ with $\alpha = 0.95\exp(j\pi/3)$,

- represents graphically the absolute value of the elements of vector `h`, using vector `n` to index the abscissae axis;

- also adds the following commands:

```
>> xlabel('n \rightarrow');
>> ylabel('Magnitude \rightarrow');
>> legend('Envelope')
>> title(Complex Exponential');
```

(OBS: always use command `pause`; after a `plot` or `stem` command)

- starts a new graphical window using `figure(2)`; this figure will then be split in order to represent three plots vertically (i.e., it will be configured as a 3×1 matrix),

- uses command `stem` to represent in the upper part of figure 2, the real part of vector `h`, and using vector `n` to index the abscissae axis;

- creates a line vector `x`, comprising N elements and whose non-zero values are given by the discrete-time sequence $u[n-20]-u[n-30]$,

- uses command `stem` to represent in the middle part of figure 2, vector `x`, and using vector `n` to index the abscissae axis;

- uses command `conv` to create in vector `y` the result of the discrete convolution between the real part of vector `h` and vector `x`;

- displays the message "`Convolution completed!`",

- shows the result of commands `size(y)` and `length(y)` (what is the difference ?),

- uses command `stem` to represent in the lower part of figure 2, the first N elements of vector `y` using symbol `'pentagram'`, and using vector `n` to index the abscissae axis;

- adds suitable labels to the abscissae and ordinates axis of figure 2.

Find yourself the answers to these questions:

i) Commands `sum(h.*conj(h))` and `h*h'` deliver the same result, why ?
ii) What is the difference between `h*h' and h*h.' ?` And if we had instead `h.*h ?`
iii) Where we used command `conv`, could we have used command `filter` ?
iv) What is the difference between commands `who` and `whos` ?

Exercise 2

A discrete-time system is described by the difference equation $y[n]=\frac{1}{4}\left(x[n]+x[n-1]+x[n-2]\right)$.

a) Obtain its impulse response, $h[n]$.

b) Obtain the output of the system to the input $x[n]=0.5\delta[n]+\delta[n-1]+0.5\delta[n-2]$.

c) Confirm the previous result using Matlab.

Exercise 3

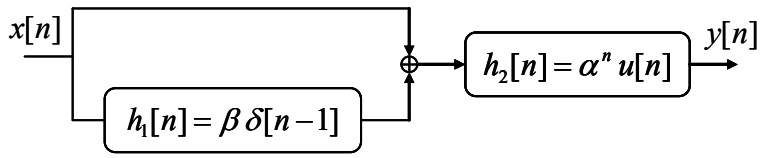
The impulse response of a discrete-time system is given by $h[n]=2^{-n}u[n]$. Obtain the output of the system when the input is $x[n]=u[n]-u[n-10]$. Confirm the result using Matlab.

Exercise 4

Obtain the impulse response of the system that is described by the difference equation $y[n]=0.3x[n]+0.7y[n-1]$ and assuming that it starts from rest. Confirm the result using Matlab.

Exercise 5

In the illustrated discrete-time system (consisting of several subsystems) α and β are real-valued constants whose absolute value is less than the unity.



a) Obtain the impulse response of the complete system, $h[n]$.

b) Obtain the frequency response of the complete system, $H\left(e^{j\omega}\right)$.

c) Obtain a difference equation (relating $y[n]$ and $x[n]$) describing the complete system.