

L.EEC025 - FUNDAMENTALS OF SIGNAL PROCESSING

Academic year 2025-2026, week 1
PL preliminary exercises

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

Exercise 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 $0, 1, \dots, N-1$,
- 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 $y[n] = \frac{1}{4}(x[n] + x[n-1] + x[n-2])$.

- Obtain its impulse response, $h[n]$.
- Obtain the output of the system to the input $x[n] = 0.5\delta[n] + \delta[n-1] + 0.5\delta[n-2]$.
- Confirm the previous result using Matlab.

Exercise 3

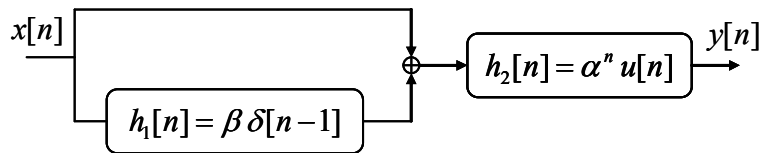
The impulse response of a discrete-time system is given by $h[n] = 2^{-n}u[n]$. Obtain the output of the system when the input is $x[n] = u[n] - u[n-10]$. Confirm the result using Matlab.

Exercise 4

Obtain the impulse response of the system that is described by means of 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.



- Obtain the impulse response of the complete system, $h[n]$.
- Obtain the frequency response of the complete system, $H(e^{j\omega})$.
- Obtain a difference equation (relating $y[n]$ and $x[n]$) describing the complete system.