LAB 2: Time-Domain Analysis of Discrete-Time Systems-Part 2

Objective

In lab2, you will use Matlab to determine unit impulse response, zero state response and total response for LTID systems. In lab 1, we solved these problems recursively. Here, you will solve the system equation by finding the characteristic modes. Also, you will examine the stability of a system.

Preparation

- Read chapter 3, specially sections 3.7, 3.8 and 3.9 from *Linear Signals and Systems by B.P. Lathi*.
- Work through Example 3.18 and 3.19 of the textbook.
- Work through Computer Example 3.25 of the textbook.
- Work through Computer Example 3.11.2 of the textbook.

Lab Assignment

A. Unit impulse response

1) In this assignment, we will find the unit impulse response $h[n]$ for the following systems. Use *filter* command from MATLAB to determine $h[n]$ and then sketch the result.

   I. $y[n] + \frac{1}{6}y[n-1] - \frac{1}{6}y[n-2] = \frac{1}{3}x[n]$

   II. $y[n] + \frac{1}{4}y[n-2] = x[n]$

2) To verify your answers, calculate $h[n]$ by hand. You need to find characteristic modes and then compute the impulse response (See example 3.18 in the textbook).

3) Check if the value of $h[3]$ is the same in both methods.

Note: All the initial conditions are zero.

B. Zero input response

A system is specified by the following equation:

$$y[n] - \frac{3}{10}y[n-1] - \frac{1}{10}[y-2] = 2x[n]$$

Use *filtic* command in MATLAB to define the initial conditions. Then use *filter* command to find and sketch the zero input response of the system for $y[-1] = 1$ and $y[-2] = 2$.

C. Zero-state response

1. Use MATLAB to determine and sketch the zero-state response of the system in part B to the input $x[n]$ given below,

$$x[n] = 2\cos\left(\frac{2\pi n}{6}\right)(\,u[n] - u[n-10])$$

D. Total response

1. Use MATLAB to find and sketch the total response of the system in part B to the input $x[n]$ (part C) with initial conditions $y[-1] = 1$ and $y[-2] = 2$.

2. Examine if the total response can be found by adding the zero-input response from part B and the zero-state response in part C.

E. Convolution and system stability

Zero-state response of a system can be found by using convolution of the input signal and unit impulse response:

$$y[n] = x[n] * h[n]$$

1. Use *conv* command from MATLAB to compute the zero-state response of the system defined in part B to the input $x[n]$ in part C.

2. Is the result same as what you found in part (C)?
3. Is this system asymptotically stable? Why?

F. Moving average filter

A causal N-point moving-average filter calculates the average of the N points from a signal. For a signal $x[n]$ the N-point moving average $y[n]$ is as follows:

$$y[n] = \frac{1}{N}(x[n] + x[n-1] + \cdots + x[n-(N-1)])$$

and its impulse response is $h[n] = (u[n] - u[n-N])/N$.

1. Determine a constant coefficient difference equation that has impulse response *h*[*n*].
2. Write a MATLAB function that will compute the parameters necessary to implement an *N*-point moving-average filter using MATLAB's *filter* command. That is, your function should output filter vectors "b" and "a" given a scalar input "*N*".
3. Test your filter and MATLAB code by filtering a length-45 input defined as $x[n] = cos(\pi n/5) + \delta[n-30] - \delta[n-35]$. Separately plot the results for $N = 4, N = 8$, and $N = 12$. Comment on the filter behavior.