Experiment No.: 01

1 Aim

1. To get familiarity with basic commands in MATLAB.
2. To explore the connection between system impulse response and the solution of linear ordinary constant coefficient differential equation.
3. To understand and implement convolution routine for discrete time finite lenght sequences.

2 Software Used

1. MAT LAB

3 Theory

For theory, we can refer the text book: **Alan V.Oppenheim, Alan S.Willsky, Signals and Systems Systems, Second edition, Prentice hall (1997)**.

4 Procedure

Exercise 1 *Generate and plot following signals/functions*

$$x_1(t) = e^{-t}cos(2\pi t) \tag{1}$$
$$x_2(t) = 1 + 1.5cos(2\pi t) - 0.6cos(4\pi t) \tag{2}$$
$$x_3(t) = |cos(2\pi t)| \tag{3}$$

Simulations and calculations on computing devices are performed with a discretized version of the continuous signal. For example, $x(t)$ is represented by a finite length sequence $x(n) = x(t = nT_s)$, where T_s is the sampling time interval. For this exercise use $T_s = 0.001sec$.

Exercise 2 *Convolution of two infinite length sequences $x(n)$ and $h(n)$ is given by*

$$y(m) = \sum_{k=-\infty}^{\infty} x(k) \cdot h(m-k). \tag{4}$$

Rewrite this expression to convolve two finite length sequences/signals. Show the relationship between the lengths of input and output. Write a MATLAB function ($[y] = myconv(x, h)$) that takes input arguments as two finite length sequences and produces convolution of these two sequences as an output. For the input sequence $x(n)$ and system impulse responses $h_1(n)$ and $h_2(n)$,

$$x(n) = [\vec{1}, 1, 1, 1, -1, -1, -1, -1, -1, 1, 1, 1, 1, -1, -1, -1, -1, 1, 1, 1, 1] \tag{5}$$
$$h_1(n) = [\vec{1}, 1] \quad and \quad h_2(n) = [\vec{1}, -1],$$

calculate the corresponding output sequences $y_1(n) = x(n) * h_1(n)$ and $y_2(n) = x(n) * h_2(n)$ using your own convolution routine.

Exercise 3 (Analysis of LTI Systems) *Consider an RC low pass filter circuit. The relationship between the input voltage $x(t)$ and the output voltage $y(t)$ is given by the differential equation*

$$x(t) = y(t) + RC\frac{dy(t)}{dt} \tag{6}$$

In order to discretise the differential equation, we approximate the derivative of $y(t)$ sampled at spacing T_s, at a time kT_s, as

$$\frac{dy(t)}{dt} \approx \frac{y_k - y_{k-1}}{T_s} \tag{7}$$

Inserting this approximation into the differential equation of the RC filter lead to the following expression

$$RC\frac{y_k - y_{k-1}}{T_s} + y_k = x_k. \tag{8}$$

This equation can be easily solved in terms of y_k. The solution has the form $y_k = ax_k - by_{k-1}$ where $a = \frac{1}{1+\frac{RC}{T_s}}$ and $b = \frac{-1}{1+\frac{T_s}{RC}}$. Write a MATLAB code to solve this difference equation with input specified by $x(t)$ in terms of two step functions,

$$x_1(t) = u(t) \quad \textit{and} \quad x_2(t) = -u(t-1) \tag{9}$$
$$x(t) = x_1(t) + x_2(t). \tag{10}$$

Assume $x_1(n)$ and $x_2(n)$ are discrete versions of $x_1(t)$ and $x_2(t)$ with finite length L=2000. Take $T_s = 0.001$ sec.

Exercise 4 *Output of the RC filter discussed in Exercise 3 can also be characterized by impulse response $h(t)$ of the filter. Output of a given LTI system is characterized by the convolution of input with the system impulse response.*

$$y(t) = \int_{-\infty}^{+\infty} x(\tau)h(t-\tau)\,d\tau. \tag{11}$$

In order to compute convolution discretely, we approximate the integration in the above expression, and we get:

$$y(m) = T_s \sum_{k=-\infty}^{\infty} x(k) \cdot h(m-k). \tag{12}$$

5 Observation

Write/ Plot Your Own With Observation Table (If Required).

6 Analysis of Results

Write Your own.

7 Conclusions

Write Your Own.

Precautions

Observation should be taken properly.