EXPERIMENT 2

OBJECTIVE: Verification of discrete time system characteristics from the input-output relationship.

PRE-LAB READING/BACKGROUND READING:

1. What is a an LTI system?
   Test the system given by Input Output relationship is LTI or not? x[n] is the input and y[n] is the output.

   y[n]=5x[n]+3x[n-3]+x[n-10]

2. What is a causal system? Test whether the following system is causal or not?
   y[n]=$\sum_{k=n}^{\infty} x[n-k]$

3. Define stability (BIBO) of a system? Test whether the system given by the following I-O relationship is stable or not?
   $$y[n] = \frac{e^{x[n]}}{x[n-1]}$$
4. An LTI system with impulse response h[n] = {3,0,6,8}.
   Determine the impulse response of the system to input
   x[n] = {3,4,6,8,1,3} with h[0]=0 and x[0]=4.

IMPLEMENTATION:

1. **Impulse response of an IIR system-MATLAB**
   [REF: Pg-506,Problem 8.17]

   A discrete time IIR system is represented by the difference equation: y[n] = 0.15y[n-2]+x[n], $n \geq 0$
   x[n] being input and y[n] the output.

(a) Find out the impulse response h[n] of the system with all zero initial conditions, y[n]=h[n]=0 , n<0. Find recursively the values of h[n] for values$n \geq 0$.

(b) Use MATLAB function filter to get impulse response h[n].

2. FIR Filter – MATLAB [REF: Pg-507,Problem 8.18]

An FIR filter has a non-recursive input-output relation:

$$y[n] = \sum_{k=0}^{5} kx[n-k]$$

(a) Find and plot using MATLAB, the impulse response h[n] of the filter

(b) Explain the causality and stability of the filter?

(c) Find and plot the unit step response s[n] for this filter.

(d) Use MATLAB function filter to compute the impulse response and step response s[n] for the given filter and plot it.

3. Generate a synthetic signal

$$x[n] = [\sin\left(2\pi \frac{440}{F_s} n\right) \quad \sin\left(2\pi \frac{494}{F_s} n\right) \quad \sin\left(2\pi \frac{554}{F_s} n\right) \quad \sin\left(2\pi \frac{587}{F_s} n\right) \quad \sin\left(2\pi \frac{660}{F_s} n\right) \quad \sin\left(2\pi \frac{698}{F_s} n\right) \quad \sin(2\pi \frac{784}{F_s} n)]$$

(a) x[n] is a concatenated signal ,Sample it at 8 KHz and listen to it.

(b) Add random noise to it using randn, x_s=x+N.

(c) Filter the signal using using an averaging filter with I-O relationship given by:

$z[n] = \frac{1}{M} \sum_{k=0}^{M-1} y[n-k]$

with y[n] as the output and x[n] as the input. Compare the filter outputs using M=3 and M=15.

RESULTS AND DISCUSSION:

MINI PROJECT-2

Problem Statement: Discrete Envelope detector-MATLAB
[REF: Pg-509,Problem 8.25]

Consider an envelope detector that would be used to detect the message sent in an AM system. Consider the envelope detector as a system composed of the cascading of two systems: one which computes the absolute value of the input and a second one that low pass filters its input. A circuit that is used as an envelope detector consists of a diode circuit that does the absolute value operation and an RC circuit that does the low pass filtering. The following is an implementation of these operations in the discrete time system.

Let the input to the envelope detector be a sampled signal
$x(nT_s) = p(nT_s)\cos(2000\pi nT_s)$
where $p(nT_s) = u(nT_s) - u(nT_s - 20T_s) + u(nT_s - 40T_s) - u(nT_s - 60T_s)$

where two pulses of duration $20T_s$ and amplitude equal to one.

(a) Choose $T_s=0.01$,and generate 100 samples of the input signal $x(nT_s)$ and plot it.

(b) Consider then the subsystem that computes the absolute value of input $x(nT_s)$ and compute and plot 100 samples of $y(nT_s)=|x(nT_s)|$.

(c) Let the low pass filtering be done by a moving average of order 15, that is if $y(nT_s)$ is the input , then the filter output is $z(nT_s) = \frac{1}{15}\sum_{k=0}^{14} y(nT_s - kT_s)$
Implement this filter using MATLAB function filter and plot the results. Explain your results.

(d) Is this a linear system? Come up with an example using the script developed above to show that the system is linear or not?

Interpretation: