Lab 3 – DT systems - applications

Objectives: In this lab we will learn to build simple discrete time (DT) systems to perform some tasks and recognise the patterns of pole-zeros, ROC vs. properties and impulse response of a second order system.

3.1. A **Moving Average** (MA) system is used to detect trends from a given signal. It is related to the accumulator. It finds the average of the signal over the past few samples.

Accumulator: $y[n] = \sum_{k=-\infty}^{n} x[k]$ Moving average system: $y[n] = \frac{1}{N}\sum_{k=n-N}^{n} x[k]$

a) Write a MATLAB script to implement the above MA system.
b) Test the system with a unit step function ($u[n]$) as input.
c) Find the trend of the given test sequence $s_1[n]$, the signal provided in q1.mat file.
d) Experiment with different values for N and find the value appropriate for $s_1[n]$. Why do you think it is appropriate?

3.1.1 Find the impulse response of the MA system and implement it using convolution; Find the trend of $s_1[n]$. using this implementation. Is there any difference in the result? What are the pros and cons of the 2 implementations?

3.2. An **Upsampler** is a system which increases the length of a given sequence and interpolates to find the values of the new samples. A popular application of upsampling is magnifying/zooming an image.

Upsampling step 1:

$y[n] = \frac{n}{M}$ if n is an integer multiple of $M > 1$

= 0 otherwise

Upsampling step 2: Estimate the value of the newly inserted samples, i.e., do interpolation.

a) Write a script to implement the upsampler with M = 2 and 3. Experiment with zero order hold and linear interpolation.
b) Upsample the given test sequences in q2_1.mat and q2_2.mat files. What do you observe?

3.3. An **Amplitude Modulation** (AM) system is used to shift the frequency of a given signal in a communication system. This is done by multiplying the given (message signal) $x[n]$ with a high frequency (carrier) signal, usually a sinusoid.

$$y[n] = (cos\omega_0 n)x[n]$$

a) Write a script to implement an AM system. Assume $\omega_0 = —$. Test this system with (i) a low frequency sinusoid for the message signal. What do you observe?
b) Find the system function H(z) of this AM system.
c) Plot the poles and zeros of this system.
d) What is the ROC of this system?

3.4. Given

$$H(z) = \frac{z^2 - (2\cos\theta)\, z + 1}{z^2 - (2r\cos\theta)z + r^2},$$

$r = 0.95$ and $\theta = \frac{\pi}{3}$.

(a) Where are the poles and zeros of this Z-Transform? How do they change as the parameters r and θ are changed?
(b) Find the impulse response $x[n]$ by finding inverse of this Z-transform as you vary the parameters.