

## Lab 3 – DT systems - applications

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**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.

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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:  $y[n] = \frac{1}{N} \sum_{k=n-N}^n x[k]$

- Write a MATLAB script to implement the above MA system.
- Test the system with a unit step function ( $u[n]$ ) as input.
- Find the trend of the given test sequence  $s_1[n]$ , the signal provided in q1.mat file.
- 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:*

$$y[n] = \frac{n}{M} \text{ if } n \text{ is an integer multiple of } M > 1$$
$$= 0 \text{ otherwise}$$

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

- Write a script to implement the upsampler with  $M = 2$  and 3. Experiment with zero order hold and linear interpolation.
- 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  $\omega_0 = \omega_c$ . 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

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

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

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