

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:

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

= 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 $\omega_0 = 20000\pi$. Test this system with a low frequency sinusoid for the message signal, assume amplitude $A_m = 5$ and frequency $f_m = 100$. Plot the obtained waveform after AM. 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 θ are changed?
- (b) Find the impulse response $x[n]$ by finding inverse of this Z-transform as you vary the parameters.