Indian Institute of Technology, Tirupati
EE3701: Digital Signal Processing Lab

Labsheet 5 : Discrete Time Fourier Transform and Z Transform

Prelab:

1. **Pole-zero map**

   Use MATLAB to plot the pole-zero map, and list the possible ROCs for left sided, right sided and two sided signal.

$$X(z) = \frac{1}{(1 - 0.5z^{-1})(1 + 2z^{-1})}$$

$$X(z) = \frac{sin(\frac{\pi}{12})z^{-1}}{1 - 2cos(\frac{\pi}{12})z^{-1} + z^{-2}}$$

2. When the input to an LTI system is

$$x[n] = \left(\frac{1}{3}\right)^n u[n] + 2^n u[-n-1]$$

   the corresponding output is

$$y[n] = 5\left(\frac{1}{3}\right)^n u[n] - 5\left(\frac{2}{3}\right)^n u[n]$$

   (a) Find the system function $H(z)$ of the system analytically and using Matlab. Indicate the region of the convergence.

   (b) Write a difference equation that is satisfied by the given input and output (c) Is the system stable? Is it causal?

Lab Exercises:

1. (a) Consider the following difference equation

$$y[n] - 0.4y[n-1] + 0.75y[n-2] = 2.2403x[n] + 2.4908x[n-1] + 2.2403x[n-2]$$

   write a program to find the impulse response of the above equation using `impz` function.

   (b) Modify the program to generate the first 40 samples of the impulse response of the following causal LTI system

$$\begin{aligned} &y[n] + 0.71y[n-1] - 0.46y[n-1] - 0.62y[n-3] \\ &= 0.9x[n] - 0.45x[n-1] + 0.35x[n-2] + 0.002x[n-3] \end{aligned}$$

   (c) Write a Matlab program to generate the impulse response of the system using `filter` function for first 40 samples and compare the response with question 1b.

   (d) Write a Matlab program to generate the step response for first 40 samples.

2. Use function `ztrans` to find z transform of $a^n u[n]$. Find inverse z- transform using `iztrans` and verify.

3. Let $X_1(z) = 6z^2+3z+2+3z^{-1}+4z^{-2}$ and $X_2(z) = 4z+7+5z^{-1}+6z^{-2}$. Determine $X_3(z) = X_1(z)X_2(z)$ using `conv` function. Verify the result theoretically.

4. Determine the output response of an LTI system. Suppose a causal LTI system has a transfer function

$$H(z) = \frac{z^{-1}+3}{(1-0.5z^{-1})(1+0.25z^{-1})}$$

Assume the z-transform of the signal is $X(z) = \frac{1-z^{-1}}{1-0.6z^{-1}}$

(a) Plot the pole zero maps for $H(z)$, $X(z)$, $Y(z)$.

(b) Plot the impulse response $h[n]$.

(c) Plot the output signal $y[n]$.

5. Plot the pole-zero map of the transfer function $H(z)$ of the system discussed in prelab question (2). Also plot the impulse response $h[n]$, input signal $x[n]$ and the output signal $y[n]$.

Experimental Exercises:

1. Decode the mobile number from DTMF encoded tone by using manual segmentation and Fourier transform. You will be provided with the *.wav file. use the DTMF table provided below.

	1209 Hz	1336 Hz	1477 Hz	1633 Hz
697 Hz	1	2	3	A
770 Hz	4	5	6	B
852 Hz	7	8	9	C
941 Hz	*	0	#	D