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

Labsheet 4: Discrete Fourier Transform

Prelab Exercises:

1. State and prove the following properties of discrete Fourier transform
   (a) Linearity
   (b) Time reversal
   (c) Convolution-multiplication
   (d) Time Shifting
   (e) Parseval's Theorem

Lab Exercises:

1. Verify the above properties of Fourier transform using function of MATLAB `fft`. You may use following sequences–

$$x_1[n] = \begin{bmatrix}0.59 & 0.95 & 0.95 & 0.59 & 0.00 & 0.59 & 0.95 & 0.95 & 0.59 & 0.00\end{bmatrix}$$
$$x_2[n] = \begin{bmatrix}0.16 & 0.97 & 0.96 & 0.49 & 0.80 & 0.14 & 0.42 & 0.92 & 0.79 & 0.96\end{bmatrix}$$

2. Generate the following discrete signals and observe their frequency content.
   (a) Generate the rectangular pulse signal of appropriate size. Use MATLAB to find the Fourier transform. Write, in brief, about your observations.
   (b) Generate a sinusoidal signal of length 0.5 seconds with frequency 100Hz, sampled at 8000Hz. Plot the magnitude and phase spectrum of the Fourier transform. Write, in brief, about your observations.
   (c) Generate a Gaussian function with zero mean and variance 1. Plot the magnitude spectrum of the Fourier transform of the signal.

3. Using eigenfunction property of the Fourier transform, calculate the output signal $y[n]$, when $x[n] = sin(\frac{\pi}{4}n)$ is given as an input to the system $H(e^{j\omega}) = \frac{e^{-j2\omega}}{1+\frac{1}{2}e^{-j4\omega}}$. Evaluate the same using Matlab. How many ways are you aware of doing this exercise in Matlab !!

4. Following are the signals of different nature like complex, real, even, odd, etc. Take the Fourier transform of those signals and identify the nature of the transformed signals.
   (a) $x_1 = sin(200\pi n/8000);\ -100 \leq n \leq 100$
   (b) $x_1 = cos(200\pi n/8000);\ -100 \leq n \leq 100$
   (c) $x_2 = e^{0.02n};\ -100 \leq n \leq 100$

5. Playing with the frequency axis resolution and identifying frequencies present in the signal.

   (a) Generate a dual tone signal by adding two sinusoidal signals of length 0.5 seconds and different frequencies. Normalize the frequency axes to find out / relate the frequencies present in the given signal.

   (b) Generate the signal $x(t) = 2cos(2000\pi t)$ with a sampling rate of $Fs = 8000Hz$. Use the Matlab DFT to compute the signal spectrum (amplitude and power spectrum) with the frequency resolution to be equal to (a) 1 Hz, (b) 8 Hz, (c) 16 Hz. Explain, in brief, about your observations.

Experimental Exercises:

1. Find the frequency content of the audio signals (sinusoid, rectangular and the speech signals) you have generated in the last Lab. And comment on your observation and give inferences !!