EE-384 Classwork-3

Problem 1: Discrete Fourier Transform (DFT) and Fast Fourier Transform (FFT)

The DFT of a sequence x(n) with length N is defined:

$$\boldsymbol{X}[\boldsymbol{k}] = \sum_{\boldsymbol{n}=\boldsymbol{0}}^{\boldsymbol{N-1}} \boldsymbol{x}[\boldsymbol{n}]\boldsymbol{W}^{\boldsymbol{kn}} \quad for\ each\ k = 0,1,\dots,N-1$$

Where $W = e^{-j(2\pi/N)}$

The inverse DFT is given by:

$$\boldsymbol{x}[\boldsymbol{n}] = \frac{\boldsymbol{1}}{\boldsymbol{N}}\sum_{\boldsymbol{n}=\boldsymbol{0}}^{\boldsymbol{N-1}} \boldsymbol{X}[\boldsymbol{k}]\boldsymbol{W}^{-\boldsymbol{kn}} \quad for\ each\ n = 0,1,\dots,N-1$$

The **Fast Fourier transform** (**FFT**) is an efficient algorithm to compute the DFT.

a) Use ‘***fft***’ function to calculate the Fourier Transform of a sequence, x = [1, 2, 3, 4, 5, 6, 7, 8].

b) Use ‘***ifft***’ function to calculate the inverse Fourier Transform of the result you get in (a).

c) Re-do (a) and (b) using your own DFT and inverse DFT functions.

Problem 2: Analyze the signal in the frequency domain

It is difficult to identify the frequency components by looking at the original signal in the time domain. We can analyze the signal in the frequency domain using Matlab tools or FFT.

Let the sampling frequency fs be 8 kHz, and the time t varies from 0 to 1 second.

a) Create and plot the signal $y(t) = \sin(2\pi f_1 t) + \sin(2\pi f_2 t)$ where $f_1 = 697\,Hz$ and $f_2 = 1209\,Hz$. Properly zoom-in so that we can see the sine wave pattern in your plot.

b) Plot the frequency spectrum of $y(t)$ using Matlab’s spectral estimation tool. Put markers in the plot to show the main frequency components of the signal.

c) Re-do (b) using Matlab’s ***sptool***.

d) Re-do (b) using FFT. Properly label your axis.