Simon Fraser University
Mechatronic Systems Engineering

MSE 491 – Digital Signal Processing LAB #2

Frequency Domain

Deliverables

1. Lab Report: Submitted via Canvas (with due date and time as specified in the Canvas assignment)

Objectives

Students will:

- Get familiar with DFT and its implementation
- Get familiar with built-in functions for Fourier transform in MATLAB
- See how frequency domain analysis can help solve real-life problems

Lab Assignments

1. Using the definition of the discrete Fourier transform (DFT) (not the MATLAB built-in FFT functions), calculate the DFT of the sequence {2, 1, -1, -2}. Show your calculations for each point. Check your results using the MATLAB FFT function.

2. Compute the 4-point Inverse DFT (IDFT) of the result of Problem 1, using the definition of the IDFT (not the MATLAB built-in IFFT functions). Once again, show your calculations for each point. Also, show that your result is indeed equal to {2, 1, -1, -2}. Check yourself with the MATLAB IFFT function.

3. Let $x[n]$ be a discrete-time sequence:

$$x[n] = \begin{cases} (0.7)^n, & 0 \le n \le 7 \\ 0, & otherwise \end{cases}$$

   a. Determine the analytical expression for the DTFT of $x[n]$ and plot the magnitude and phase of the DTFT.
   b. Compute in MATLAB the 8-point DFT of $x[n]$, $0 \le n \le 7$ using the *fft* function. Plot the magnitude and phase. Use the *stem*, *abs*, and *angle* commands.
   c. Compute, in MATLAB, the 16-point DFT of $x[n]$, $0 \le n \le 15$ and *stem* plot its magnitude and phase. Comment on the effect of zero-padding the signal on its DFT.

4. Telephone dialing is an example of the everyday use of Fourier analysis. The basis for touch-tone dialing is the Dual Tone Multi-Frequency (DTMF) system. The telephone dialing pad acts as a 4–by–3 matrix. Associated with each row and column is a frequency. Each digit in a telephone number is encoded by a signal which is the sum of two sine waves whose frequencies are the row and column frequencies associated with the digit. Here is the matrix, with the row frequencies indicated on the side and the column frequencies on the bottom.

697	1	2	3
770	4	5	6
852	7	8	9
941	*	0	#
	1209	1336	1477

For example, 1 is encoded by the pair of frequencies 697, 1209, while 3 is encoded by the pair 697, 1477.

   a. Create a MATLAB function (y) to generate dial tones (use the sampling rate of 2^{15}).
   b. Use MATLAB to generate a random integer between 0 and 9 (r). Use MATLAB to play the corresponding tone.
   c. Plot 16 milliseconds of the tone waveform.
   d. Create a MATLAB script to plot the absolute value of the Fourier transform Y of a signal y as a function of frequency over a specified range of frequencies.
   e. Use the generated figure to find the pair of frequencies in your dial tone to encode the tone.

Lab Report / Deliverables

Your lab report should document the following in one mlx (MATLAB live script) file

- MATLAB code, well comments and structured
- Professional quality, high resolution plots with clear labels, units, legends, etc.