FACULTY OF ENGINEERING, UNIVERSITY OF JAFFNA

DIGITAL SIGNAL PROCESSING – EC5011

LABORATORY SESSION 2

DIGITAL SIGNAL PROCESSING THEORY AND APPLICATION

PART1: **Analysis of a digital filter**

$$\mathrm{H(Z)} = \frac{Z^4 + 10Z^2 + 3Z + 28}{Z^4 + 0.35Z^2 - 0.35Z + 0.425}$$

1. Plot the pole zero map (Hint: Use "zplane" command)
2. Find and plot impulse response without using inbuilt commands (generate an impulse, filter it and get the response)
3. Plot the magnitude and phase response using the impulse response obtained in part (2).
4. Find the frequency response directly without using impulse response? (Hint :you can use freqz command see the appendix for getting help of the commands)

PART2: **Digital filter design in Matlab**

Two first order digital filters are given as follows:

$$\mathrm{H(Z)} = \frac{1}{1 + aZ^{-1}}$$

$$\mathrm{G(Z)} = 1 - \mathrm{aZ}^{-1}$$

Find the value of 'a'(you must choose the correct value from -0.9,0.9,9,-9) to make H(z) and G(z) as a lowpass or high pass filter and give the reasons for your selection? (Here you need to fill the table)

Tick the filter behavior for FIR or IIR for the selected "a" value

Fill with the value 'a'

Filters	Low pass			High pass		
H(Z)		FIR			FIR	
		IIR			IIR	
G(Z)		FIR			FIR	
		IIR			IIR	

PART3: **Allpass filter**

$$\mathrm{H(Z)} = \frac{Z^4 + 4}{4\,\mathrm{Z}^4 + 1}$$

1. Plot the pole zero map and write the poles and zeroes?
2. Determine the value of the poles and zeros (use root command)
3. Find Magnitude response and phase response of the filter using inbuilt command?
4. From the magnitude response what is the specific property for this filter?
5. Comment on the relationship between poles and zeros of this filter?

PART4: **Min phase, Max phase & Mixed phase**

A filter have zeros at 0.7+j0.2, 0.7-j0.2, -0.4+j0.4, -0.4-j0.4.

1. Find the transfer function of the filter (use Matlab function zp2tf)
2. Plot the pole-zero map, magnitude and phase responses of the filter.
3. Determine whether it is the minimum/maximum/mixed phase filter.
4. Determine the transfer function of the filters that have the same magnitude response as above but with minimum/maximum/mixed phase characteristic.

PART5: **Linear phase filter**

$$G(Z) = 5\,Z^8 + 26\,Z^4 + 5$$

1. Plot the pole zero map and write the zeroes?
2. Find Magnitude response and phase response of the filter using inbuilt command 'fvtool'?
3. From the phase response what is the specific property for this filter? Comment on the relationship on the zeros of this filter? (Are zeros reciprocal? conjugate reciprocal?)

PART6 (optional): **Fast Fourier Transform implementation**

Implement Fast Fourier Transform in Matlab without using the inbuilt Matlab command fft?

- First separate samples into odd and even samples
- Find weight given function W
- Then depend on the sample number get N value from min ($log_2 number\ of\ samples$)
- Then separate the samples and ligned them the odd samples and even sample in a manner
- Then perform the loop function with given weightage and get outcome from them.

Appendix

There are many inbuilt MATLAB functions that facilitate filter designs. Some of them are given below

Take a transfer function $C(Z) = \frac{b_n Z^n + b_{n-1} Z^{n-1} + b_{n-2} Z^{n-2} + \cdots + b_1 Z + b_0}{a_m Z^m + a_{m-1} Z^{m-1} + a_{m-2} Z^{m-2} + \cdots + a_1 Z + a_0}$

The functions numerator should be given in vector form like

$$numerator = [\, b_n \;\; b_{n-1} \;\; b_{n-2} \;\; \ldots \; b_1 \;\; b_0 \,]$$

Likewise denominator should be in the form of

$$denominator = [a_m \; a_{m-1} \; a_{m-2} \ldots \; a_1 \; a_0 \;\;]$$

- fvtool: for filter can get any responses/ information
  fvtool (numerator, denominator) computes the magnitude response of the digital filter defined with numerator and denominator of the transfer function.
- zplane: plots the transfer function poles and zeros.
  zplane (numerator, denominator)
- freqz: for filter magnitude, phase responses
  freqz (numerator, denominator) computes the magnitude response of the digital filter

For further help in Matlab functions type “help function” in command window, for example help in freqz command type **`help freqz.`**