Exercise 2

1 Aliasing

(a) Generate a 10Hz sine wave, which is sampled at 100 samples/seconds. Does aliasing happen? What if the frequency of the sine wave was 40Hz? Plot the sampled 10Hz sine wave both in time and in frequency domain (Hint: `freqz(sig,1,512,Fs)`).(1 point)

(b) Sample a 50Hz sine wave at the same sampling frequency. What do you notice now? Plot the sampled sine both in time and in frequency domain.(2 point)

(c) Sample a 90Hz sine wave at the same sampling frequency. Does aliasing occur? If so, what is the aliased frequency? Plot the sampled sine wave both in time and in frequency domain.(3 points)

2 Filter Specifications:Ripple

(a) Convert the following from linear scale to dB scale:(1 point)

- 0.01 in the passband
- 0.01 in the stopband

(b) Convert the following from dB to linear scale:(1 point)

- 0.1dB in the passband
- 60dB in the stopband

3 Implementing Digital Filters and Z-Transform

(a) Consider the following difference equations:

- $0.5x[n-2] + 3x[n-1] + x[n] = y[n]$
- $x[n] = y[n] - 2y[n-2]$
- $2x[n-2] + 3x[n-1] + 2x[n] = y[n-2] + 2y[n-1] + y[n]$

Show the implementations for each case, using the difference equation (Lecture notes: Part 1, pp 3 - 4)(4.5 points)

(b) Write down the transfer function for each case.(1.5 points)

4 MATLAB and Transfer Function

(a) Consider the system with the impulse response $h[n] = [1\ 2\ 3\ 4]$. Plot its frequency response (with amplitude response in dB), linear scale amplitude response, group delay, zeros and poles. (Hint: MATLAB functions `freqz`, `grpdelay` and `zplane`).(2 points)

(b) Do the same for the following system:(2 points)

$$2x[n-2] + 3x[n-1] + 2x[n] = y[n-2] + 2y[n-1] + y[n]$$

5 Stability

Consider the filter (difference equation):

$$x[n] = y[n] - ay[n-1]$$

(a) Write down the transfer function of the system and find the value of its pole(s).(0.5 point)

(b) Using MATLAB, plot the impulse response and the pole-zero plot of the system with different values for a.(0.5 point)

(c) What is the relation between the variable a and the stability of the system?(0.5 point)

(d) For the special case $a = 1$, is the system stable or unstable?(0.5 point)