EE6401-2022 : Assignment

Submission Deadline: 26th September 2022

- The softcopy of your assignment solution must be submitted through the NTULearn portal.
- Solutions must be **TYPE-WRITTEN** and submitted in **PDF**.
- Note that your submission will not be returned.
- **There will be a penalty for late submissions.**
- **Heavy PENALTY will be enforced for any form of PLAGIARISM and CHEATING in your assignment solution.**

Question 1:

Given a signal $x(t)$ sampled at **21 kHz**, you are required to design the most efficient multi-rate filtering scheme using only linear phase FIR filters, with the following overall filtering specifications:

Passband frequency:	4 kHz
Stopband frequency:	5 kHz
Passband Ripple:	1e-2
Stopband Ripple:	1e-4
Final Sampling Rate:	**10 kHz**

State All Assumptions. (Hint: You will need to try a few configurations to determine the best.)

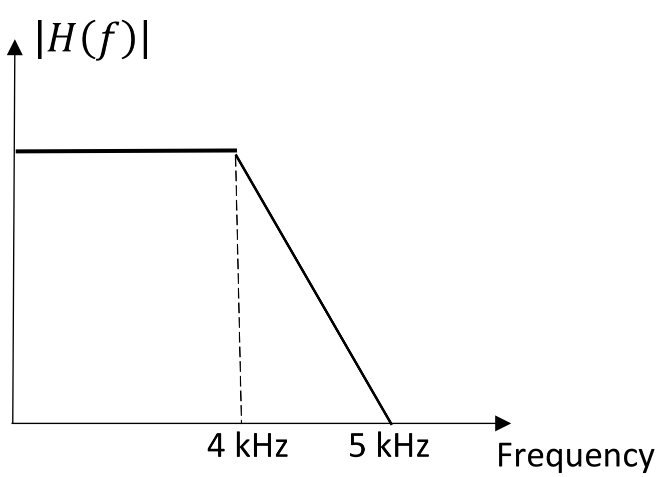

Figure 1 : Transfer function of the overall filtering specifications

a. Draw a block diagram of your overall scheme.

b. For every FIR filter designed, state all the parameters used, namely,
   i. Passband frequency (Hz)
   ii. Transition band (Hz)
   iii. Pass-band ripple
   iv. Stop-band ripple
   v. Order of the filter (Method and Computation must be shown)

c. Work out the multiplication rates of each filter and hence the overall multiplication rate.

(60 marks)

Question 2:

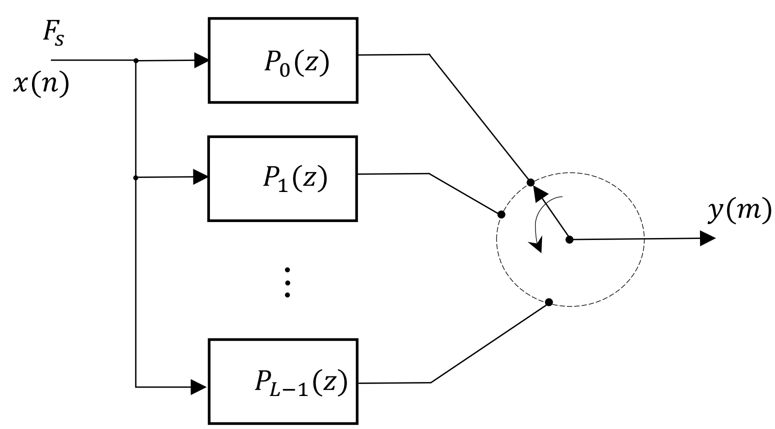

Figure 2

Figure 2 shows an interpolator implemented using a polyphase structure with a commutator where the input sampling rate is F_s and interpolation rate is L.

a. Work out the output time-domain expression of $y(m)$ in terms of the input $x(n)$ and polyphase sub-filters, $\rho_i(n)$, where $P_i(z) = \sum_{n=0}^{\infty} \rho_i(n) z^{-n}$, $i = 0, 1, \dots, L-1$.

b. Hence or otherwise work out $Y(z)$ in terms of the input and polyphase sub-filters, where $Y(z) = \sum_{m=0}^{\infty} y(m)z^{-m}$

(20 Marks)

Question 3:

Given a discrete-time signal $x(n)$, investigate the type of filter to be used to achieve linear interpolation by a factor of 3 as shown in Figure 3.

a. Derive the filter to be used to achieve linear interpolation?
b. Compare the differences between the use of a low-pass brick filter and linear interpolation filter, in terms of up-sampling accuracy. (State all assumptions)

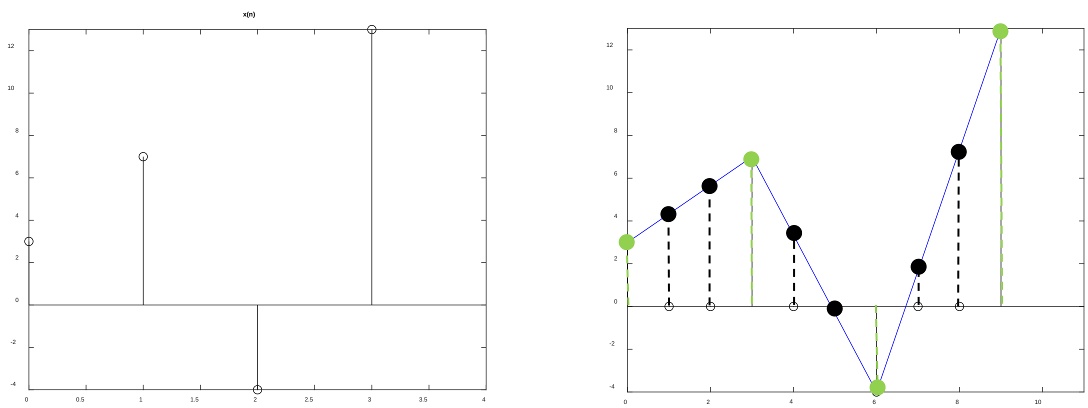

Figure 3: The graph on the left is the original signal. The graph on the right is the upsampled interpolated signal. The green dots represent the original signal points and the black dots represent the linearly interpolated points.

(20 Marks)