Elec4621 Lab3 - S1 2018

April 12, 2018

You are reminded that you must upload your working to Moodle using the submission box.

1. A Fourth order filter has the transfer function:

$$H(z) = 1 + 0.74417z^{-1} + 0.52604z^{-2} + 0.625z^{-3} - 0.1296z^{-4}$$

   (a) What is the Nyquist gain of the filter?
   (b) Using Matlab, find the zeroes of the filter.
   (c) How many filters have the same magnitude response? List their transfer functions. Plot their magnitude responses in Matlab to confirm that they are identical. [Make sure the DC gains of all the filters are normalised to 1 and plot them on the same axes].
   (d) Plot the phase response these filters (on the same axes). What do you observe?
   (e) Recalling that the group delay is the derivative of the phase response with respect to frequency (that is $\tau_g(\omega) = \frac{d\theta(\omega)}{d\omega}$), write a Matlab script that calculates the group delay of each of the filters. [Hint: the derivative can be approximated numerically as the first order difference (or higher order difference) and the approximation is good provided the frequency grid is fine)]. Plot the group delays on the same axes. Which filter has the smallest group delay? what are its zeros? What do you conclude?

2. A fourth order all-pole filter has poles at

$$p_1 = -0.55,\ p_2 = -0.65,\ p_3 = 0.98e^{j0.67\pi},\ p_4 = 0.98e^{-j0.67\pi}.$$

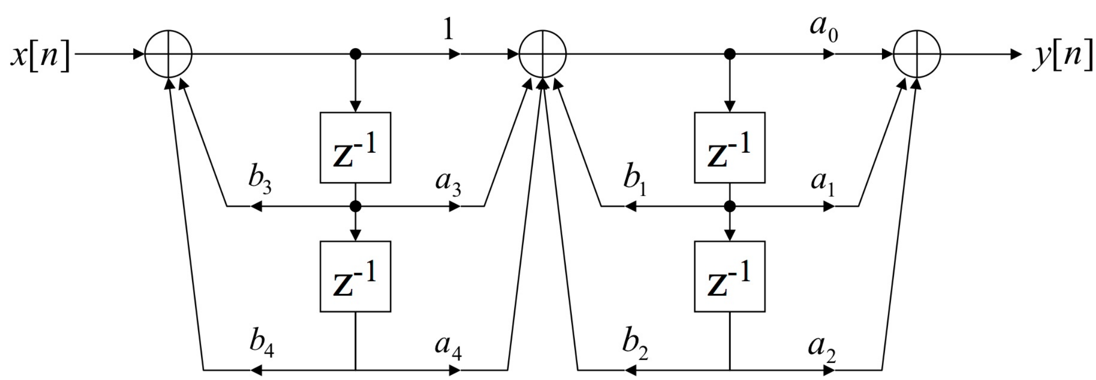

Figure 1:

(a) What is the transfer function of the filter?

(b) The filter is to be implemented in cascade form, as shown in Figure 1. Determine the coefficients used by this implementation.

(c) Let us assume for simplicity that filter coefficients are not quantized and consider only the numerical round-off effects. Assume that the input signal $x[n]$, lies in the range $-1 < x[n] < 1$ and has a signed 1.7 fixed-point representation. Assume that all quantities which are subject to multiplication must also be kept as 8-bit words, with an appropriate fixed-point representation.

(d) Using the BIBO gain method, determine appropriate fixed-point representations for the output of each of the three accumulator blocks. To save time here, it is recommended that you use the Matlab "filter" function to recover the relevant impulse responses by filtering an impulsive input.

(e) Based on your findings from part (a), determine the effective round-off noise power appearing at the output of each accumulator block.

(f) Determine and plot the noise-power spectrum at the output of the filter. Note, that you are not being asked to implement the filter here, but to compute the anticipated noise power spectrum using Matlab. In light of your results, explain why the 8-bit implementation precision is unlikely to be sufficient.