Assignment 9
Finite Precision and Multirate DSP

Due March 26, 1996

Please show your work. For those questions that ask you to use Matlab show the exact commands you used to compute the results.

Question 1

Consider the 8-th order Elliptic bandpass filter designed in Question 3 in the previous assignment. Scale the coefficients so their maximum absolute value is 1. Quantize the filter coefficients to 6 bits (assume one of the 6 bits is required for a sign bit) using `round()`. Evaluate the amplitude response. Repeat for 12 bits.

Question 2

Find the poles and zeros of the above (unquantized) filter. Find the coefficients for a cascade realization of this filter using four 2nd-order IIR sections (ignore pole/zero pairing). Quantize the coefficients of each second order sections to 6 bits, scaling so the largest coefficient is 1 as before. Find the response of the cascade realization of the filter with quantized coefficients. You may find the Matlab `roots()`, `poly()` and `series()` functions useful.

Question 3

Use Matlab to generate 16 samples of a sine wave with an amplitude of 1 and a frequency of $F_s/3$. Design a 4-th order Butterworth interpolation filter with a -3 dB frequency of $F_s/3$ and use it to increase the sampling rate by a factor of 6. Plot the original and the interpolated waveforms. Explain the change in amplitude.

Question 4

This question asks you to design a rate-6 decimator for a signal with a 3 kHz bandwidth sampled at 48 kHz. Use an FIR decimation filter. The overall decimator should should have a passband ripple of ± 1 dB or less and the level of any aliasing at 4 kHz should be at least 40 dB below the mean signal level.

(a) Find the most efficient implementation by finding the number of operations required for each of the three possible implementations. You may assume the number of filter coefficients estimated by `remezord()` is correct and that the number of operations for a given stage is equal to the sampling frequency times the number of filter coefficients.

(b) Design optimum equiripple FIR decimation filter(s) for the most efficient design and plot their amplitude responses.