Department of Signal Processing and Acoustics
S-88.3104 Digital Signal Processing Systems (6 cr)

Write in each answer paper your name, department, student number, the course name and code, and the date. Number each paper you submit and denote the total no. of pages. 5 problems, 26 points total. Exam problems in English only. Please feel free to answer in Finnish or English. No additional material is allowed in the exam.

1. (4p) (a) Show that the structure below is linear time invariant system and determine its transfer function $H(z) = Y(z)/X(z)$.

   (b) Show that the structure is an identity system, i.e. $y[n] = x[n]$ if

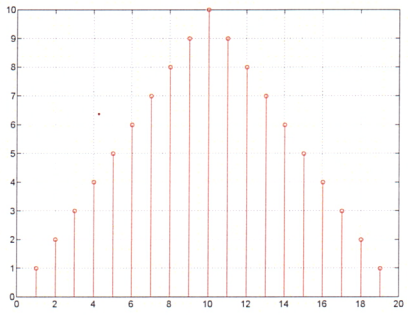
$$\frac{1}{L}\sum_{k=0}^{L-1} G(z^{1/L}e^{-j2\pi k/L}) = 1$$

2. (4p) Suppose that the spectrum of an analog signal is located between 7 kHz and 9 kHz and is zero elsewhere. What is the smallest possible sampling frequency that can be used to sample the signal without aliasing?

3. (8p) Describe as many different ways of implementing fractional change of sampling rate as you can imagine. What are the pros and cons of the different approaches?

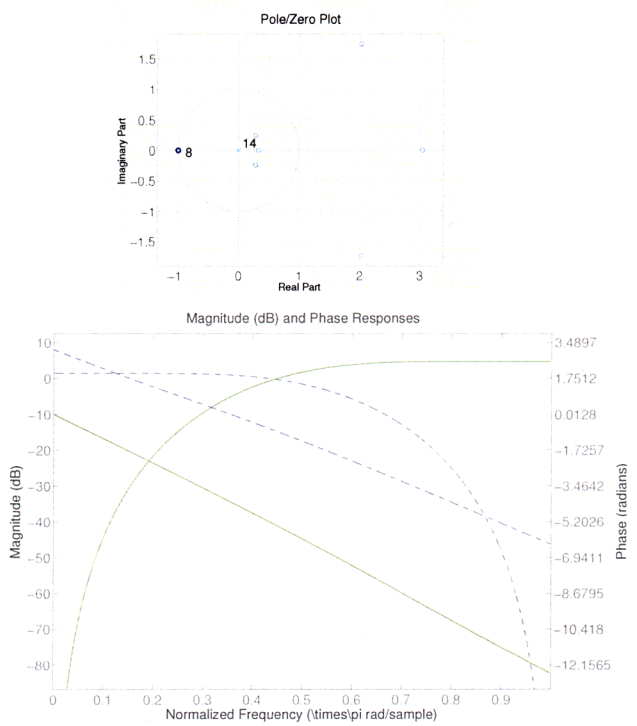
4. (6p) Consider the following system

   where the impulse response of the filter $H(z)$ is given by.

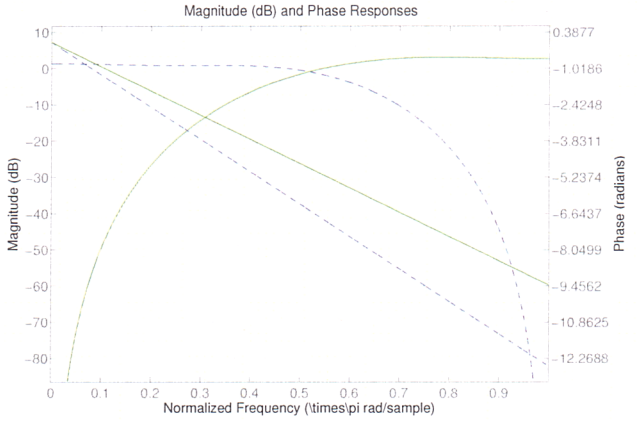


   Write down a block diagram of the equivalent cascaded integrator comb filter implementation.

5. (4p) The figure below shows the pole-zero diagram of the FIR product filter, and the other two figures show magnitude and phase responses of quadrature mirror filter bank analysis filters resulting from two different factorizations of the product filter. Describe based on the pole-zero diagram, what kind of factorizations of the product filter have been used to design the analysis filters, whose magnitude and phase responses are shown in Figs (a) and (b).



(a) Phase and magnitude responses of analysis filters from factorization I



(b) Phase and magnitude responses of analysis filters from factorization II