HELSINKI UNIVERSITY OF TECHNOLOGY **Exam May 13th, 2008**
Signal Processing Laboratory
S-88.3105 Digital Signal Processing Systems (5 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. 4 problems, 30 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. (8p) Explain *briefly* the following concepts:

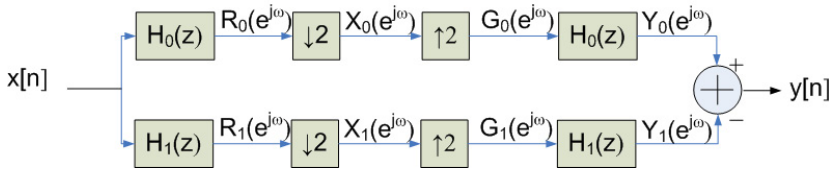
(a) Cosine modulated filter bank

(b) Cascaded integrator comb filter

(c) Discrete wavelet transform

(d) Interpolated FIR filter

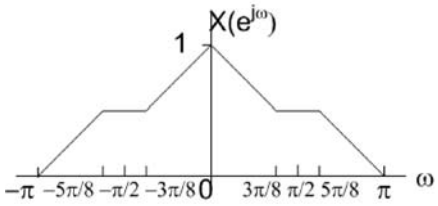
2. (8p) Consider the analysis/synthesis system shown below.

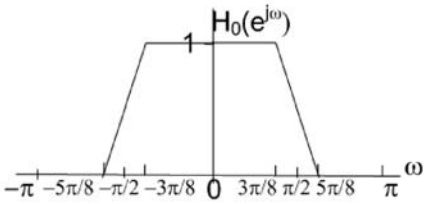


The low-pass filter $H_0(z)$ and high-pass filter $H_1(z)$ in the analyzer and synthesizer are identical, and their Fourier-transforms are related as

$$H_1(e^{j\omega}) = H_0(e^{j(\omega-\pi)})$$

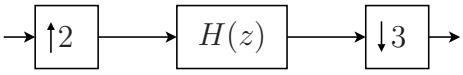
If $X(e^{j\omega})$ and $H_0(e^{j\omega})$ are as shown below, sketch $R_i(e^{j\omega}), X_i(e^{j\omega}), G_i(e^{j\omega}), Y_i(e^{j\omega})$, $i = 0, 1$, and $Y(e^{j\omega})$.





Is the system alias-free, perfect-reconstruction, or both?

3. (8p) Consider the fractional sampling rate converter with a conversion factor 2/3 shown below.



- Explain step-by-step by drawing block diagrams how this system can be transformed into a computationally efficient sampling rate converter.
- Hints: You should exploit the polyphase decomposition, noble identities, and the fact that the order of down-sampling by factor M and up-sampling by factor L can be changed if M and L are mutually prime.

4. (6p)

(a) The system in Fig. 1 is obtained by using a lifting scheme. Show that the structure satisfies the perfect reconstruction condition.

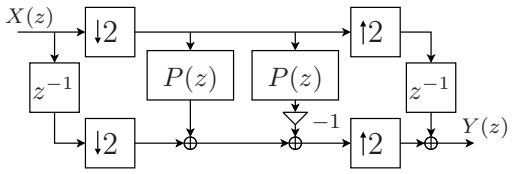


Figure 1:

(b) The lifting scheme can be repeatedly applied to develop perfect reconstruction systems with more desired features. The structure of Fig. 2 is derived from the structure of Fig. 1 by applying the lifting scheme a second time. Show that this structure also satisfies the perfect reconstruction condition.

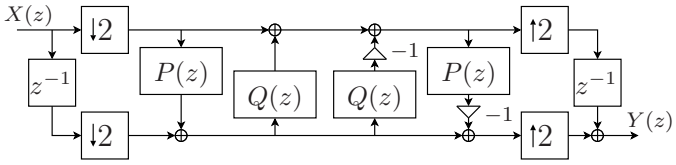


Figure 2: