Tik-61.246 Digital Signal Processing and Filtering

2nd Mid Term Exam 13.12.2000 at 9-12. Halls A, B, and C.
You may use a (graphical) calculator and a mathematical reference book. Storing additional material into the calculator's memory is strictly forbidden.

1. (2p) Are the following statements right or wrong? Correct answer: +0.5 p, no answer: 0 p, wrong answer: -0.5 p; the point total is still between 0 and 2 points.

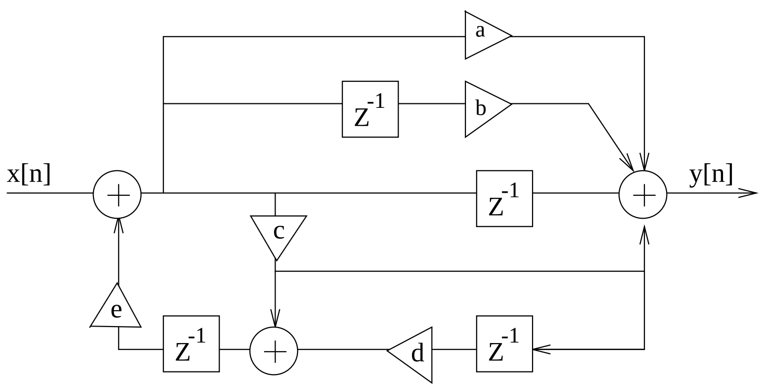
   a) An allpass filter always has linear phase.

   b) The order of the filter $H(z) = \frac{p_0+p_1z^{-1}+p_2z^{-2}}{1+d_1z^{-1}+d_2z^{-2}}$ is 4.

   c) Gibbs phenomenon refers to the oscillatory behavior of the magnitude responses of FIR filters which can be reduced by selecting a suitable window function.

   d) Quantizing the coefficients of an IIR filter causes error which can affect the stability of the filter.

2. (4p) Transform the filter structure in the figure below to a canonic (w.r.t. delay units) filter structure having the same transfer function.



3. (6p) Consider an analog lowpass filter whose transfer function in s-domain is

$$H_{LP}(s) = 1/(s+1)$$

   a) Derive the corresponding digital transfer function $H_i(z)$ designed with the impulse-invariant method.

   b) Derive the corresponding digital transfer function $H_b(z)$ designed with bilinear transform. Suppose that the frequency distortion has already been compensated for.

   c) What are the differences between these two methods?

4. (6p) The sampling frequency of a discrete-time signal $x[n]$ is to be lowered to two thirds of the original sampling frequency ω_s. The interesting band of the signal (bandlimited signal) is between $[0, \frac{\omega_s}{4}]$.

   Design the required system and sketch the signal in the frequency domain after each component. Determine also the highest possible cut-off frequency ω_r of the aliasing suppression filter.

Laplace transforms: $H_{LP}(s) = \frac{1}{s+1} \quad \Leftrightarrow \quad h_{LP}(t) = \begin{cases} 0 & , \quad t < 0 \\ e^{-t} & , \quad t \geq 0 \end{cases}$

Bilinear transform: $s = \frac{1-z^{-1}}{1+z^{-1}}$