Exam in Signal analysis and representation, 7.5 credits.
Course code: dt8010
Date: 2012-01-07

Allowed items on the exam:
Tables of Signal processing formulas.
Tables of Mathematical formulas.
Calculator.

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Maximum points: 8.
In order to pass the examination with a grade 3 a minimum of 3.3 points is required.
To get a grade 4 a minimum of 4.9 points is required, and to get a grade 5 a minimum of 6.5 points is required.

Give your answer in a readable way and motivate your assumptions.

Good Luck!

1. (2p)
A digital IIR-filter is described by its impulse response:

$$h(n) = ab^n u(n) \quad \text{where b>0.}$$

a) Find the values of the constant b for a BIBO-stable system. (0.6p)
b) Find the value of the constant a so that the value of the frequency response function H(ω) at ω=0 is equal to 1 (assuming a BIBO-stable system). (0.6p)
c) Find the difference equation of the filter. (0.8p)

2. (2p)
A causal LTI system is described by its difference equation:

$$y(n) + y(n-1) + 0.5y(n-2) = x(n)$$

where y(-1)=2 and y(-2)=1.

a) Compute the poles and zeros of the system H(z) and sketch the pole-zero plot. (0.5p)
b) Determine the impulse response h(n). (0.7p)
c) Determine the output y(n) when the input is x(n)= u(n) (0.8p)

3. (2p)
A causal FIR-filter is described by its impulse response:

$$h(n) = \left\{\frac{1}{4}, \frac{1}{2}, \frac{1}{4}\right\}$$

a) Compute the value of the magnitude response function |H(ω)| at ω=5π/16. (0.5p)
b) A new FIR-system $h_2(n)$ is generated from h(n) by convolving h(n) by itself: $h_2(n)=h(n)*h(n)$. Compute the value of the magnitude response function $|H_2(\omega)|$ at ω=5π/16. (0.7p)
c) Sketch the magnitude response function of the two filters in the same graph for $-\pi \le \omega \le \pi$. (0.8p)

4. (2p)
a) Sketch the impulse response h(n) and compute the N-point DFT H(k) for N=16 when

$$h(n) = \big(\delta(n-1) - \delta(n-3)\big)\big(u(n) - u(n-N)\big).$$

Present your answer as: $H(k) = H_{real}(k)e^{-j\theta(k)}$. (0.8p)

b) Sketch the magnitude- and phase-function of H(k) for k in the interval [0, N-1]. (0.7p)
c) Compute the steady-state output of the system when $x(n) = 1.5\cos\left(\frac{5\pi}{8}n\right)$. (0.5p)