Exam in Signal analysis and representation, 7.5 credits.
Course code: dt8010
Date: 2011-08-16

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

Teacher: Kenneth Nilsson, Phone 035-167136.

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 causal FIR-system is described by its impulse response:

$$h(n) = \partial(n) + \partial(n-1) + \partial(n-2)$$

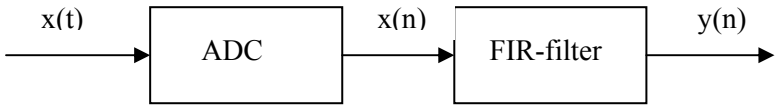
a) Compute the poles and zeros of the system and sketch the pole-zero pattern. (0.7p)
b) Compute the frequency response function H(ω), and sketch the magnitude function for $0 \leq \omega \leq 2\pi$.
Present H(ω) as $H(\omega) = H_{real}(\omega)e^{-j\omega(M-1)/2}$ where $H_{real}(\omega)$ is a real function and M is the length of h(n). (0.7p)
c) Compute the cut-off frequency, i.e. compute the frequency where the magnitude function has decreased with the factor $\frac{1}{\sqrt{2}}$ relative the value when ω=0. (0.6p)

2. (2p)
A causal LTI system is represented by the difference equation:

$$y(n) - y(n-1) + (0.25 + a)y(n-2) = x(n-1)$$

a) Determine the values of a>0 for which the system is stable. (1p)
b) Put a=0.25 and compute the output y(n) when the input is x(n)=u(n). (1p)

3. (2p)
A periodic signal $x(t) = \sin(2\pi F_0 t) + 0.33\sin(2\pi 3F_0 t) + 0.2\sin(2\pi 5F_0 t) + 0.14\sin(2\pi 7F_0 t)$ with F_0=200 Hz is sampled by F_S=800 Hz and then filtered by a causal FIR-filter with the impulse response h(n)={1, 1, 1, 1}.
No anti-aliasing filter is used before sampling!



a) Determine the time discrete signal x(n). (1p)
b) Determine the steady state response y(n). (1p)

4. (2p)

a) Compute the linear convolution y(n)=x(n)*h(n) when:

$$h(n) = \frac{1}{3}\left[\partial(n) + \partial(n-1) + \partial(n-2)\right] \quad \text{and} \quad x(n) = u(n) - 2u(n-3) + u(n-6). \quad \text{(0.8p)}$$

b) Compute the convolution in a) by using N-points DFT and IDFT when N=6. (0.6p)
Hint: Do the computation in the time domain.

c) An analog signal x(t) that contains a sum of three cosine signals with frequency 1200, 4200, and 6800 Hz is sampled by F_s=10 kHz.
A frequency analysis is done by DFT in N=1024 points of the windowed signal. A rectangular window of length 256 is used.
The figure below shows the magnitude of the DFT, i.e. $|X(k)|$ for 0 ≤ k ≤ 1023.
Identify respective cosine signal in the magnitude function. (0.6p)