<u>Exam in Signal analysis and representation, 7.5 credits.</u>
Course code: dt8010
Date: 2008-10-27
Time period: 9:00-13:00.

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 *nonrecursive* FIR-system is described by the difference equation:

$$y(n) = 0.1[x(n) + x(n-1) + \cdots\cdots + x(n-9)].$$

a) Determine the difference equation of the *recursive* system. (1p)
//什么是递归系统，什么是非递归系统，

b) Determine the impulse response for the nonrecursive and for the recursive system. (0.4p)

$$x(n) \longrightarrow \boxed{h(n)} \longrightarrow y(n)$$

h(n) is impulse response(), y(n) is response, so in this problem ,What we should do is to determine the impulse response h(n), not the response y(n).

注意这里的**impulse response**的另外一个含义是：冲击波响应决定了输入一定是一个冲击波，所以有**x(n)=δ（n）.**

c) Determine and sketch the pole-zero pattern for the system. (0.6p)

在计算**pole-zero**的时候，使用**nonrecursive**和**recursive**表达式进行**Z**变换都一样

$$X(Z) \longrightarrow \boxed{H(Z)} \longrightarrow Y(Z)$$

在时域中，x(n),h(n),y(n) 都是小写的，其中h(n)是冲击响应
在Z域中，H(Z),H(Z),Y(Z) 都是大写的，其中H(Z)叫系统函数，所以上面求的是H(Z)。

该题有两种方法，用recursive和nonrecursive的都可以，答案讲解了两种解题方法。

2. (2p)
A *noncausal* FIR-system is described by its impulse response:

$$h(n) = \{h(-2), h(-1), h(0), h(1), h(2)\} = \{0.2, 0.2, 0.2, 0.2, 0.2\}.$$

a) Compute the frequency response function G(ω) of the *causal* FIR-system g(n)=h(n-2). Present G(ω) as $G(\omega) = G_{real}(\omega)e^{-j\omega(M-1)/2}$ where $G_{real}(\omega)$ is a real function and M is the length of h(n). ($G(\omega) = G_{real}(\omega)e^{-j\omega(M-1)/2}$ 这句话的作用是什么？) (1p)

b) Sketch the magnitude- and phase-function of the causal system g(n) for $-\pi \le \omega \le \pi$. (1p)

3. (2p)
An LTI-system is described by its impulse response:

$$h(n) = \delta(n) + \left(\frac{1}{\sqrt{2}}\right)^{n-1} \cos\left(\frac{\pi}{4}(n-1)\right)u(n-1).$$

a) Determine its system function H(z). (0.8p)
b) Determine the response of the system when x(n)=u(n) and y(-1)=1, y(-2)=0.
The response should be presented as a real signal. (1p)
When can we use
As we have talked, response is the output of the system y(x)
c) Identify the steady state response and the transient response. (0.2p)

4. (2p)
An analog signal x(t) that contains a sum of cosine signals is sampled by F_s=20 kHz.

A frequency analysis is done by DFT in N=512 points of the windowed signal $\hat{x}(n) = x(n) \cdot w(n)$, where x(n) is the sampled signal and w(n) is a rectangular window function of length L=256.

The figure below shows the magnitude of the DFT, i.e. $\left|\hat{X}(k)\right|$ for $0 \leq k \leq 511$.

a) Which *analog* frequencies are contained in the signal x(t)? No aliasing is present. (0.8p)

b) Determine the *analog* frequency resolution ΔF that you can expect in the analysis. (0.6p)

c) The sampling frequency F_s is increased to 30 kHz.
   Determine the *analog* frequency resolution you expect to have now.
   You want to have the same analog frequency resolution as in b). How do you achieve this? (0.6p)