

Exam in Signal analysis and representation, 7.5 credits.

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)

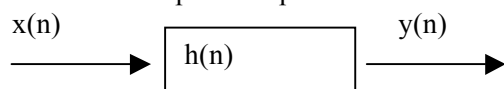
A *nonrecursive* FIR-system is described by the difference equation:

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

- 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)

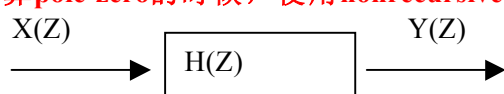


**h(n) is impulse response(), y(n) is response, so in this problem ,What we should do is to determine the impulse response h(n), not the response y(n).**

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  $x(n) = \delta(n)$ 。

- 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



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  $G(\omega)$  of the *causal* FIR-system  $g(n)=h(n-2)$ .

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

- b) Sketch the magnitude- and phase-function of the causal system  $g(n)$  for  $-\pi \leq \omega \leq \pi$ . (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.  $|\hat{X}(k)|$  for  $0 \leq k \leq 511$ .

- Which *analog* frequencies are contained in the signal  $x(t)$ ? No aliasing is present. (0.8p)
- Determine the *analog* frequency resolution  $\Delta F$  that you can expect in the analysis. (0.6p)
- 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)

