Exam in Signal analysis and representation, 7.5 credits.
Course code: dt8010
Date: 2009-08-15

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)
Determine the frequency description and sketch the magnitude and phase function of the following signals:

a) $x_1(n) = 3\cos\left(\frac{\pi}{3}(n-2)\right) \quad -\infty \le n \le \infty$ (1p)

b) $x_2(n) = 0.5\cos\left(\frac{2\pi}{3}n\right) + 0.8\sin\left(\frac{2\pi}{5}n\right) \quad -\infty \le n \le \infty$ (1p)

Hint: the Fourier-series expansion of a periodic discrete time signal.

2. (2p)
A *nonrecursive* FIR-system is described by the difference equation:

$$y(n) = 0.2\left[x(n) + x(n-1) + \cdots\cdots + x(n-4)\right].$$

a) Determine the difference equation of the *recursive* system. (0.6p)
b) Determine the impulse response h(n) for the system. (0.4p)
c) Compute the frequency response function H(ω) of the system. 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).
Also sketch the magnitude- and phase-function for $-\pi \le \omega \le \pi$. (1p)

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

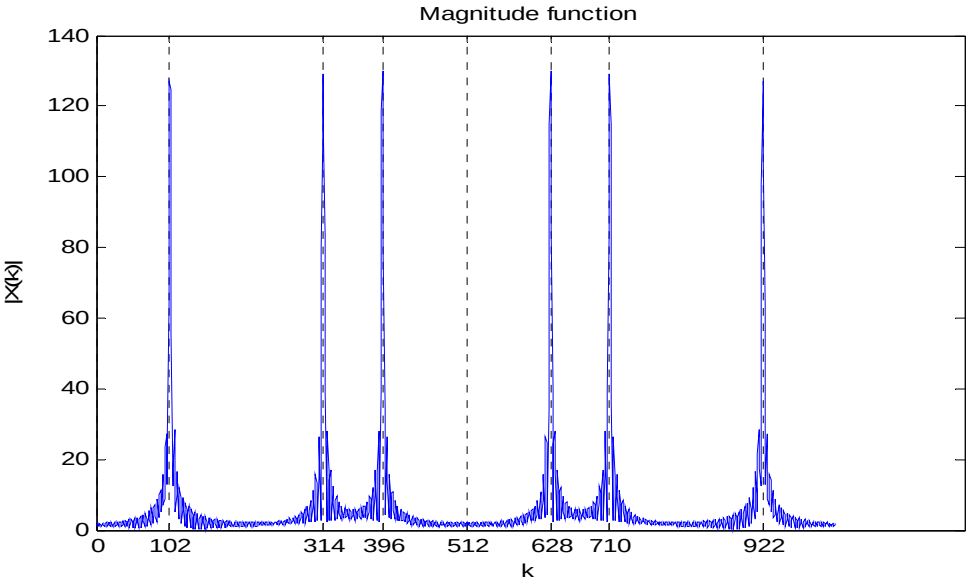
$$h(n) = \left[5\left(-\frac{3}{4}\right)^n - 4\left(-\frac{1}{2}\right)^n\right]u(n).$$

a) Plot the pole-zero pattern of the system and determine if the system is stable. (0.7p)
b) Determine the steady state response of y(n) of the system when the input signal is

$$x(n) = 5.8 + 0.1\cos\left(\frac{5\pi}{6}n\right). \quad (1.3p)$$

4. (2p)
An analog frequency resolution of 60 Hz is required when doing frequency analysis using the DFT and rectangular window function.
a) Determine the minimum length of the window to fulfill the frequency resolution goal when the sampling frequency is 15 kHz. (0.8p)
b) The sampling frequency is changed from 15 kHz to 20 kHz. Determine the change in the frequency resolution of the analysis (the length of the window function is unchanged). (0.4p)

c) An analog signal x(t) that contains a sum of cosine signals is sampled by F_s=15 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 $0 \le k \le 1023$.
Which *analog* frequencies are contained in the signal x(t)? No aliasing is present. (0.8p)


Magnitude function
140
120
100
80
60
40
20
0
|X(k)|
0
102
314
396
512
628
710
922
k