Tekniska Högskolan i Linköping
Institutionen för Systemteknik, Elektroniksystem

Exam in TSEI50/TEN1, Linear Systems

Time: 2013-01-09, 14-18

Place: U3

Teacher: Håkan Johansson, 0703432897

Aid:
Pocket calculator
Söderkvist: Formler & Tabeller
Ingelstam, Rönngren, Sjöberg: Tefyma
Ekbom: Tabeller & Formler NT
Nordling: Physics Handbook for Science and Engineering
Strid: Formler & Lexikon
Mathematical tables

Instructions:
Maximum 70 points, 30 points required to pass the exam.
Note that a **motivation** is required for each answer to get the maximum number of points for a problem!

Note that 10 points obtained at the **seminars** means that the first problem does not have to be solved. In case of 5 points, problems 1(a) and 1(b) do not have to be solved.

Results: Available by 2013-01-23

1 a) Explain what linear and time-varying systems mean. (2.5 p)

b) Explain what stable and causal systems mean. (2.5 p)

c) Which type of sequences can be Fourier series expanded? (2.5 p)

d) A filter (LTI system) has the transfer function $H(z) = 1+z^{-1}$. Is it a lowpass or high-pass filter? Motivate the answer. (2.5 p)

2) Use convolution to determine the output sequence $y(n)$ of an LTI system with the following input sequence $x(n)$ and impulse response $h(n)$:

$x(n) = 0.9^n u(n)$, $h(n) = 0.1^n u(n)$ ($u(n)$ is the unit step sequence) (10 p)

3) A causal LTI system is given by the following difference equation:

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

a) Determine the transfer function of the system. Also determine the poles and zeros of the system and indicate them in the z-plane. (4 p)

b) Determine the impulse response of the system. (4 p)

c) Determine the magnitude response of the system. (2 p)

4) A continuous-time signal, $x_a(t)$, has a real-valued Fourier transform according to Fig. 1. Three sequences, $x_1(n)$, $x_2(n)$, and $x_3(n)$, are formed by sampling the continuous-time signal with the three different sampling frequencies 100 Hz, 50 Hz, and 40 Hz, respectively.

a) Sketch the Fourier transforms of the three sequences, that is, sketch $X_1(e^{j\omega T})$, $X_2(e^{j\omega T})$, and $X_3(e^{j\omega T})$. (6 p)

b) Three continuous-time signals $x_{r1}(t)$, $x_{r2}(t)$, and $x_{r3}(t)$ are reconstructed from $x_1(n)$, $x_2(n)$, and $x_3(n)$, respectively, using ideal PAM. Sketch the Fourier transforms of the three signals, that is, sketch $X_{r1}(j\omega)$, $X_{r2}(j\omega)$, and $X_{r3}(j\omega)$. (4 p)

Indicate level constants and frequency edges in the sketches so that the Fourier transforms are completely specified.

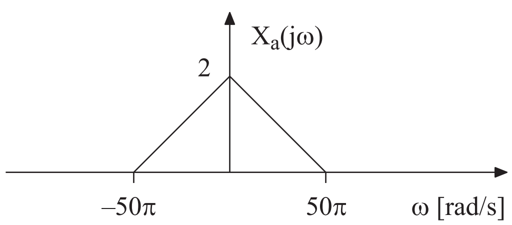

Figure 1.

5) A causal LTI system is given by the following transfer function:

$$H(z) = \frac{z}{z - 0.1}$$

Determine the output sequence $y(n)$ of the system when the input sequence is $x(n) = u(n) - u(n-5)$, where $u(n)$ is the unit step sequence. (10 p)

6) A sequence is given as

$$x(n) = \begin{cases} 0, & n \le -1 \\ 1, & n = 0, 1, 2, 3 \\ 0, & n \ge 4 \end{cases}$$

A new sequence $y(n)$ is formed by convolving $x(n)$ with itself. That is,

$$y(n) = \sum_{k=-\infty}^{\infty} x(k)x(n-k)$$

Compute $|V(k)|$ for all values of k ($k = 0, 1, ..., 7$) where $V(k)$ is an 8-point DFT of the length-8 sequence $v(n)$ given below. (10 p)

$$v(n) = y(n), \quad n = 0, 1, \ldots, 7$$

7) A causal LTI system is given by the following transfer function:

$$H(z) = a_0 + a_1 z^{-1} + a_0 z^{-2}$$

Determine the constants a_0 and a_1 so that the system completely eliminates the stationary part of the output sequence when the input sequence is $\sin(\omega_0 Tn)u(n)$, where $u(n)$ is the unit step sequence and $\omega_0 T = 0.28\pi$. The gain of the system should be $H(1) = 1$. (10 p)