Tekniska Högskolan i Linköping
Institutionen för Systemteknik, Elektroniksystem

Exam in TSEI10/TEN1, Analog Filters

Time:	2015-03-19, 14-18
Place:	U1
Examiner:	Håkan Johansson
Aid:	Pocket calculator Tables and formulas for analog and digital filters Söderkvist: Formler & Tabeller Ingelstam, Rönngren, Sjöberg: Tefyma Ekbom: Tabeller & Formler NT Nordling: Physics Handbook for Science and Engineering Strid: Formler & Lexikon Mathematical tables
Number of problems:	7
Instructions:	Maximum 70 points, 30 points required to pass the exam. **Note** that a **motivation/solution** is required to get the maximal number of points for a problem! **Note** that 10, 8, 6, 4, or 2 points obtained at the **seminars** means that you do not have to solve Problem 1, 1(a)-(d), 1(a)-(c), 1(a)-(b), or 1(a), respectively.
Results:	Available 2015-04-02

1 a) What does a linear-phase response of an analog filter mean? (2 p)

b) What are lowpass and highpass notch sections? (2 p)

c) How is an inductor transformed in a lowpass-to-bandpass frequency transformation? (2 p)

d) Explain what the gain-bandwidth product of an OP-amplifier is. (2 p)

e) Why should one generally not use parallel-form structures when implementing analog filters? (2 p)

2) Synthesize a lowpass Chebyshev-I filter that meets the following specification: $\omega_c = 2\pi \times 20$ krad/s, $\omega_s = 2\pi \times 52$ krad/s, $A_{max} = 0.5$ dB, and $A_{min} = 50$ dB. Determine the poles and zeros, and indicate their locations in the s-plane. The filter order should not be higher than necessary. (10 p)

3) Realize a highpass Cauer filter that meets the following specification: $\omega_c = 2\pi \times 50$ krad/s, $\omega_s = 2\pi \times 10$ krad/s, $A_{max} = 0.1$ dB, and $A_{min} = 44$ dB. Use a π-type ladder structure. Determine the element values assuming $R_1 = R_2 = 50\Omega$. (10 p)

4) Assume that we have a first-order prototype lowpass filter with a transfer function

$$H(S) = \frac{G}{S - S_{LP}}$$

and that we frequency transform this filter into bandpass and bandstop filters.

a) Determine the zeros and poles of the transformed filters when $S_{LP} = -2$ and $\omega_I^2 = 4\pi^2$. (6 p)

b) For the bandstop filter, determine the value of G so that the frequency response equals one for $\omega = 0$. (4 p)

5) The transfer function of a second-order filter section can generally be expressed as

$$H(s) = \frac{As^2 + Bs + C}{s^2 + Ds + E}$$

a) Determine A, B, and C so that the filter corresponds to a lowpass, highpass, and bandpass filter, respectively. (5 p)

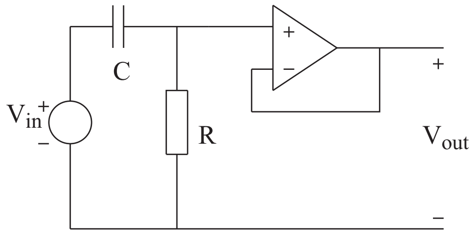
b) With $A = 2$, determine B and C so that the filter corresponds to a notch filter with a notch frequency at $\omega = 2\pi \times 10$ rad/s. (3 p)

c) State the relation between D and E that ensures that the poles form a complex-conjugated pole pair. (2 p)

6) Derive an expression for the transfer function $H(s) = V_{out}(s)/V_{in}(s)$ for the filter below. What type of filter is it?

a) Assume an ideal OP-amplifier ($A = \infty$). (5 p)

b) Assume an OP-amplifier with the transfer function $A(s) = \dfrac{A_0}{1 + \dfrac{s}{\omega_{3dB}}}$. (5 p)



7) Determine $Z_{in}(s) = V_1(s)/I_1(s)$ in the terminated two-port below. Also determine the magnitude $|Z_{in}(j\omega)|$. What is the function of the terminated two-port? The elements in the chain matrix of the two-port are $A = C = 2$, $B = -1$, and $D = 1$. The terminating impedance is $Z_2(s) = 1/s$. (10 p)