Tekniska Högskolan i Linköping
Institutionen för Systemteknik, Elektroniksystem

Exam in TSEI10/TEN1, Analog Filters

Time:	2015-06-10, 14-18
Place:	TER2
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 2015-06-24

1 a) What is the difference between passive and active components and filters? (2 p)

b) What is the potential disadvantage of using frequency transformations when synthesizing bandpass and bandstop filters? (2 p)

c) Why do doubly resistively terminated LC-filters have lower sensitivity than singly terminated LC filters? (2 p)

d) What is characteristic of the frequency response of a distributed-element filter, as opposed to lumped-element filters? (2 p)

e) What is an inverting amplifier? How can it be realized using an OP amplifier and resistors? (2 p)

2) Synthesize a highpass Chebyshev-I filter that meets the following specification: $\omega_c = 2\pi \times 60$ krad/s, $\omega_s = 2\pi \times 20$ krad/s, $A_{max} = 0.5$ dB, and $A_{min} = 60$ 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 lowpass Cauer filter that meets the following specification: $\omega_c = 2\pi \times 30$ krad/s, $\omega_s = 2\pi \times 150$ krad/s, $A_{max} = 0.1$ dB, and $A_{min} = 45$ dB. Use a T-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, expressed in terms of S_{LP} and the parameter ω_I^2 which is used in the transformations. (6 p)

b) Assume that we realize the prototype lowpass filter with a first-order T-type ladder structure, and that we transform this realization into the bandstop filter realization. Show that the inductor, with value L, in the lowpass filter is transformed into a parallel connection of an inductor, with value L, and a capacitor, with value $1/(\omega_I^2 L)$. (4 p)

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

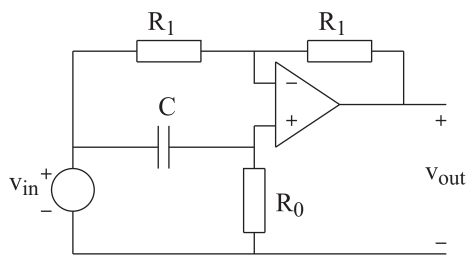
$$H(s) = \frac{as^2 + bs + c}{s^2 + ds + e}$$

a) Determine a, b, and c so that the filter corresponds to a lowpass, highpass, and bandpass filter, respectively. (5 p)

b) What is the relation between d and e that ensures that the poles form a complex-conjugated pole pair? (2 p)

c) Express the Q factor in terms of d and e. The Q factor is defined as $Q = -r_p/(2\sigma_p)$ where r_p denotes the pole radius and σ_p denotes the real part of the poles. It is assumed that the poles form a complex-conjugated pole pair. (3 p)

6) Determine the transfer function $H(s) = V_{out}(s)/V_{in}(s)$ for the filter below. Assume an ideal OP amplifier. Also determine the poles and zeros, expressed in terms of R_0 and C. What type of filter is it? (10 p)



7) Determine the input impedance $Z_{in}(s) = V_1(s)/I_1(s)$ in the terminated two-port below. The elements in the chain matrix is $A = D = 0$, $B = 1000$, $C = 1$. The terminating impedance is $Z_2(s) = 1/(s \times 10^{-7})$. What is the function of the terminated two-port? (10 p)