UNIVERSITY of OULU

DEPT. OF ELECTRICAL AND INFORMATION ENGINEERING

11.01.2008

Circuit Theory II (Graphical calculator and an A4-sized crib sheet are allowed)

1. From the circuit in fig. 1, calculate voltage $v_0(t)$. Voltage $v_{in}(t)$ is a unit impulse $\delta(t)$, $i_L(0)$=1A and $u_C(0)$=1V. The latter two are the initial current and the initial voltage for inductor and capacitor, respectively.

2. The opamp in fig. 2 is assumed ideal. Scale the components of the circuit in fig. 2 so that all the corner frequencies in the circuit's frequency response will increase four-fold. It is also required, that the capacitor is scaled to value 100nF. After scaling, calculate the voltage transfer function $V_{out}(s)/V_{in}(s)$ and draw the corresponding pole-zero map.

3. A frequency response of a voltage amplifier a(s) is shown in fig. 3. The amplifier has a DC-gain of 40dB and it has three negative poles. The amplifier is used in a negative feedback system, whose feedback has a constant gain f.

The loop gain is therefore: $T(s) = a(s) \cdot f \quad ,f > 0$.

Estimate with a brief explanation, what is the value of f, where

a) the feedback system is unstable and

b) phase margin is 60°.

c) What is the gain margin, when the phase margin is 60°?

4. Calculate the z-parameters for the two-port in fig. 4.

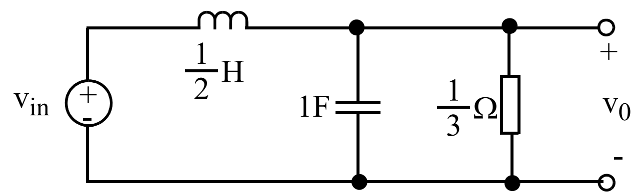

Figure 1

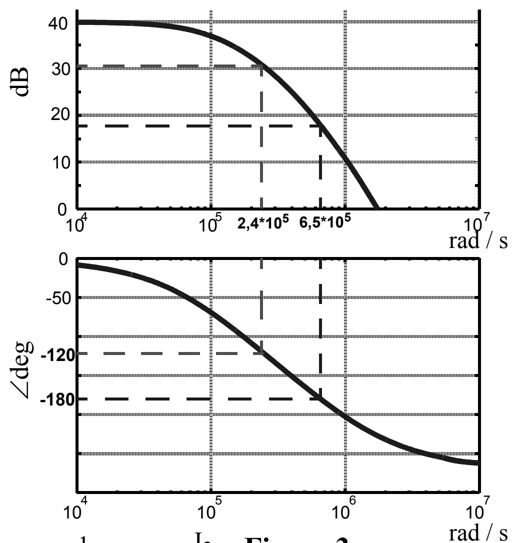

Figure 3

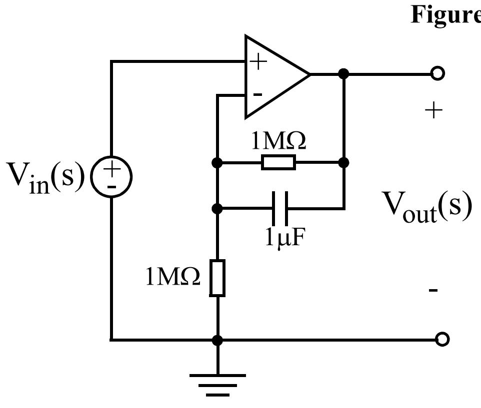

Figure 2

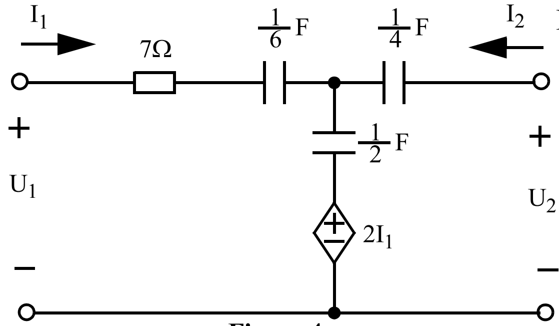

Figure 4

PO Box 4500, 90014 University of Oulu Tel. +358 8 553 1011 FAX +358 8 553 2600

DEPT. OF ELECTRICAL AND INFORMATION ENGINEERING

11.01.2008

Circuit Theory II (Graphical calculator and an A4-sized crib sheet are allowed)

Table 1: Common Laplace-transform pairs

	x(t)	X(s)
impulse	$\delta(t)$	1
unit step	1	1 / s
ramp	t	$1 / s^2$
n^{th} power	t^n	$n! / s^{n+1}$
a^{th} power (a>0)	$t^{a-1} / \Gamma(a)$	$1 / s^a$
	$1 / \sqrt{(\pi t)}$	$1 / \sqrt{s}$
exp. function	e^{-at}	1 / (s+a)
	$1 - e^{-at}$	a / (s(s+a))
	$t^n e^{-at}$	$n! / (s+a)^{n+1}$
sin	$\sin(\omega t)$	$\omega / (s^2+\omega^2)$
cos	$\cos(\omega t)$	$s / (s^2+\omega^2)$
sinh	sinh(at)	$a / (s^2-a^2)$
cosh	cosh(at)	$s / (s^2-a^2)$
Linearity	ax(t) + by(t)	aX(s) + bY(s)
translation in freq	$e^{-at} x(t)$	X(s+a)
translation in time	x(t-T)	$e^{-sT}X(s)$
first time derivative	dx(t) / dt	sX - x(0)
n^{th} time derivative	$d^n x(t) / dt^n$	$s^n X(s) - s^{n-1} x(0) - s^{n-2} x^{(1)}(0) \ldots - x^{(n-1)}(0)$
Time integral	$\int_o^t x(t)dt$	$\frac{X(s)}{s} + \frac{1}{s} \cdot \int_{-\infty}^0 x(t)dt$
convolution	$\int_o^t x(\tau)g(t-\tau)d\tau$	G(s)X(s)
n^{th} freq derivative	$(-t)^n x(t)$	$d^n X(s) / ds^n$