SIMON FRASER UNIVERSITY
SCHOOL OF ENGINEERING SCIENCE

Summer 2011
ENSC 320: ELECTRIC CIRCUITS II

Final Examination
Saturday, August 13, 2011

Duration: 180 minutes. Attempt all four problems. Questions are not equally weighted. Derive all expressions. Laplace transform table is provided. Closed book and closed notes. Calculators, PDAs, laptops, and wireless phones are not permitted. Use a ball-point pen for writing the exam (no pencils, please).

1. **Laplace Transform Analysis: Circuit Applications (25 points)**

   For the circuit shown in Figure 1, $C_1 = 0.2\ mF$ and $C_2 = 0.5\ mF$. The initial conditions are $v_{C1}(O^-) = 80\ mV$ and $v_{C2}(0^-) = 0V$. The input is $V_{in} = 400u(t)\ mV$.

   - Find the zero-state response.
   - Find the zero-input response.
   - Find the complete response.
   - Specify the general form of the natural response.
   - Specify the transient and steady-state responses.

2. **Resonant and Bandpass Circuits (30 points)**

   For the series resonant circuit shown in Figure 2, let I_s be the desired output. Find:

   - The transfer function $H(s) = I_s(s)/V_s(s)$.
   - The peak frequency ω_m.
   - The half-power frequencies ω_1 and ω_2.
   - The bandwidth B_w.
   - The circuit Q_{circ} defined as ω_m/B_w.
   - The frequency at which the angle of $H(j\omega)$ is zero.

3. **Magnetically Coupled Circuits and Transformers as Two-Ports (15 points)**

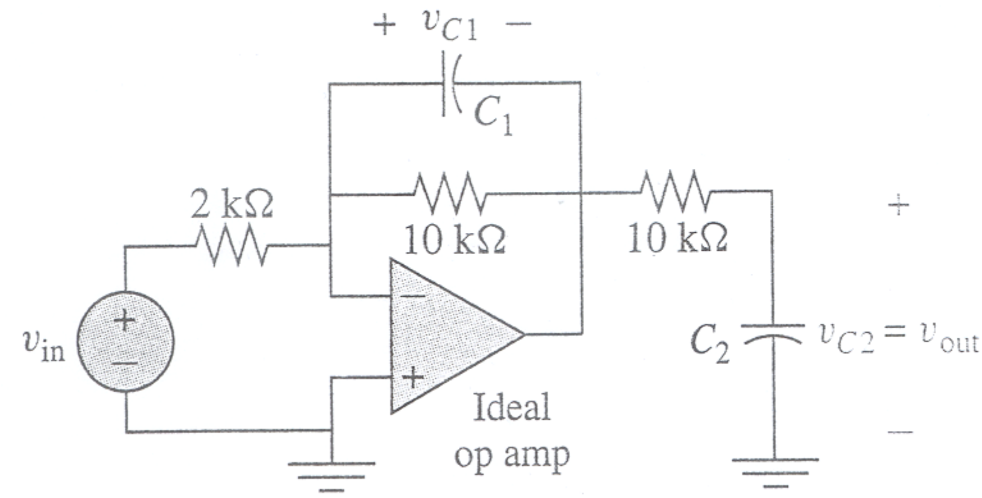
   Compute the $z-$, $y-$, and $t-$ parameters for the circuit shown in Figure 3.

4. **Principles of Basic Filtering (30 points)**

   Consider the Sallen and Key circuit shown in Figure 4. Assume that the op-amp is ideal.

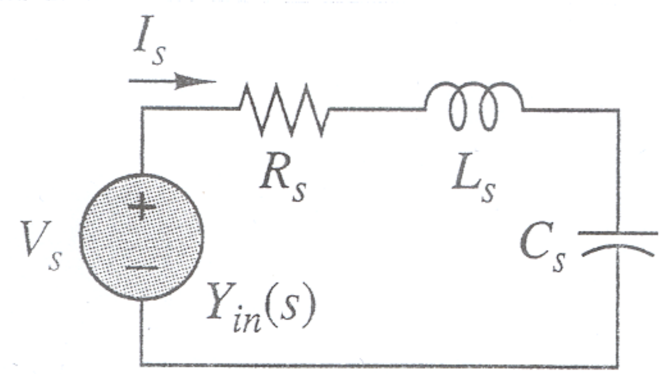
   - Find transfer function $H(s) = V_{out}/V_{in}$.
   - Find the zeros and the poles of $H(s)$.
   - Find the magnitude and the phase of the frequency response.
   - Identify the type of this circuit.

(1)



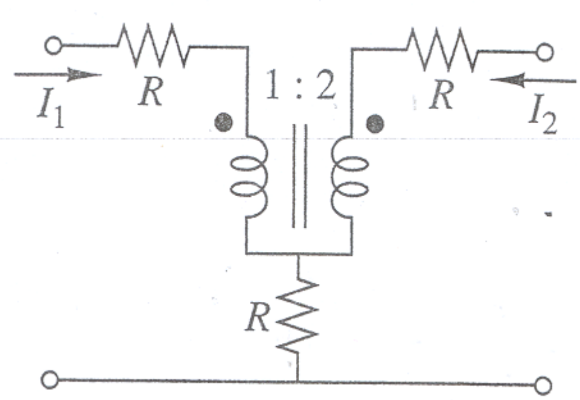
+ v_{C1} −
C_1
2 kΩ
10 kΩ
10 kΩ
+
v_{in}
C_2
$v_{C2} = v_{out}$
Ideal
op amp
−

(2)



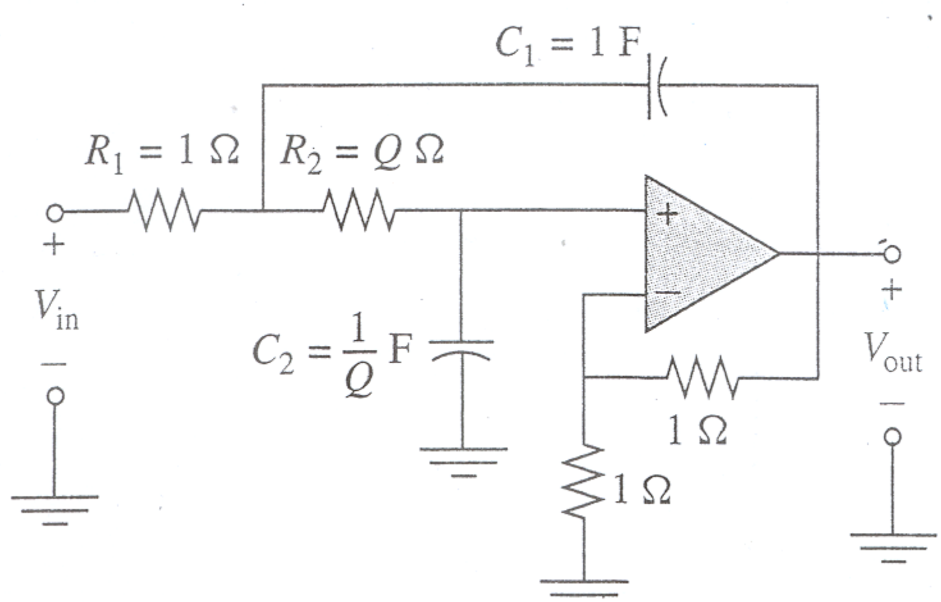
I_s
R_s
L_s
V_s
C_s
$Y_{in}(s)$

(3)



I_1
R
1 : 2
R
I_2
R

(4)



$C_1 = 1$ F
$R_1 = 1\ \Omega$
$R_2 = Q\ \Omega$
+
V_{in}
−
$C_2 = \frac{1}{Q}$ F
+
V_{out}
−
1 Ω
1 Ω

TABLE 13.1 Laplace Transform Pairs

Item number	$f(t)$	$\mathcal{L}[f(t)] = F(s)$
1	$K\delta(t)$	K
2	$Ku(t)$ or K	$\frac{K}{s}$
3	$r(t)$	$\frac{1}{s^2}$
4	$t^n u(t)$	$\frac{n!}{s^{n+1}}$
5	$e^{-at}u(t)$	$\frac{1}{s+a}$
6	$te^{-at}u(t)$	$\frac{1}{(s+a)^2}$
7	$t^n e^{-at}u(t)$	$\frac{n!}{(s+a)^{n+1}}$
8	$\sin(\omega t)u(t)$	$\frac{\omega}{s^2+\omega^2}$
9	$\cos(\omega t)u(t)$	$\frac{s}{s^2+\omega^2}$
10	$e^{-at}\sin(\omega t)u(t)$	$\frac{\omega}{(s+a)^2+\omega^2}$
11	$e^{-at}\cos(\omega t)u(t)$	$\frac{s+a}{(s+a)^2+\omega^2}$
12	$t\sin(\omega t)u(t)$	$\frac{2\omega s}{(s^2+\omega^2)^2}$
13	$t\cos(\omega t)u(t)$	$\frac{s^2-\omega^2}{(s^2+\omega^2)^2}$
14	$\sin(\omega t+\phi)u(t)$	$\frac{s\sin(\phi)+\omega\cos(\phi)}{s^2+\omega^2}$
15	$\cos(\omega t+\phi)u(t)$	$\frac{s\cos(\phi)-\omega\sin(\phi)}{s^2+\omega^2}$
16	$e^{-at}[\sin(\omega t)-\omega t\cos(\omega t)]u(t)$	$\frac{2\omega^3}{[(s+a)^2+\omega^2]^2}$
17	$te^{-at}\sin(\omega t)u(t)$	$2\omega\frac{s+a}{[(s+a)^2+\omega^2]^2}$
18	$e^{-at}\left[C_1\cos(\omega t)+\left(\frac{C_2-C_1 a}{\omega}\right)\sin(\omega t)\right]u(t)$	$\frac{C_1 s+C_2}{(s+a)^2+\omega^2}$
19	$2\sqrt{A^2+B^2}\,e^{-at}\cos\left[\omega t-\tan^{-1}\left(\frac{B}{A}\right)\right]$	$\frac{A+jB}{s+a+j\omega}+\frac{A-jB}{s+a-j\omega}$
20	$2\sqrt{A^2+B^2}\,te^{-at}\cos\left[\omega t-\tan^{-1}\left(\frac{B}{A}\right)\right]$	$\frac{A+jB}{(s+a+j\omega)^2}+\frac{A-jB}{(s+a-j\omega)^2}$