ECE/ENGRD 2100 – Spring 2019 — Issued: April 12, 2019, 10 am

Homework 6 — Due: April 26, 2019, 11:59 pm

Helpful readings for this homework: Nilsson and Riedel, Chapter 15, Chapter 12, Chapter 13 and Chapter 9.

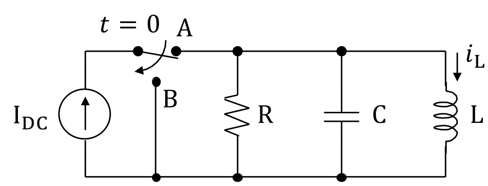
Grading Criteria

Show all work, as each problem will be graded using the grading criteria given below:

- 100% of maximum score if approach is correct and answer is also correct
- 80% of maximum score if approach is correct, but answer is incorrect due to algebraic or other math error
- 60% of maximum score if approach is mostly correct, but there is some conceptual error
- 40% of maximum score if problem has been seriously attempted, but approach is incorrect and/or there are major conceptual errors.
- 20% of maximum score if problem has been attempted, but is illegible.
- 0% of maximum score if there is no attempt to solve the problem.

Problem 6.1: [Problem 12.28 from Nilsson and Riedel] ($8\frac{1}{3}$ points)

The switch in the circuit shown to the right has been in position A for a long time. At time $t = 0$, the switch moves instantaneously to position B.



(a) Derive the differential equation that governs the behavior of the inductor current $i_\mathrm{L}(t)$ for $t \geq 0^+$.

(b) Determine the value of the inductor current at $t = 0^-$, i.e., $i_\mathrm{L}(0^-)$, and the value of the time derivative of the inductor current at $t = 0^-$, i.e., $i_\mathrm{L}'(0^-)$.

(c) Using s-domain analysis (i.e., Laplace Transforms), show that:

$$\mathrm{I_L}(s) = \frac{\mathrm{I_{DC}}\left(s + \frac{1}{\mathrm{RC}}\right)}{s^2 + \frac{s}{\mathrm{RC}} + \frac{1}{\mathrm{LC}}}$$

Problem 6.2: [Problem 12.40(a) from Nilsson and Riedel] ($8\frac{1}{3}$ points)

Determine the time-domain function $f(t)$ associated with the following s-domain function:

$$\mathrm{F}(s) = \frac{6(s + 10)}{(s + 5)(s + 8)}$$

Hint: Use partial fraction expansion and a table of Laplace Transform pairs.

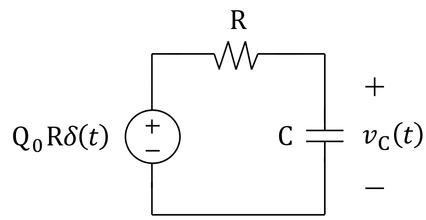
Problem 6.3: [Problem 12.41(b) from Nilsson and Riedel] ($8\frac{1}{3}$ points)

Determine the time-domain function $f(t)$ associated with the following s-domain function:

$$\mathrm{F}(s) = \frac{-\mathrm{s}^2 + 52\mathrm{s} + 445}{s(\mathrm{s}^2 + 10\mathrm{s} + 89)}$$

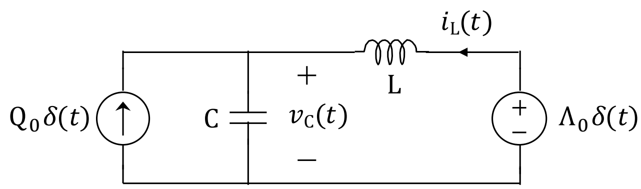
Problem 6.4: ($8\frac{1}{3}$ points)

In the network to the right, the voltage source delivers an impulse of area Q_0R volt-seconds at time $t = 0$. Using s-domain analysis, determine an expression for the capacitor voltage $v_C(t)$ for $t > 0$.



Problem 6.5: ($8\frac{1}{3}$ points)

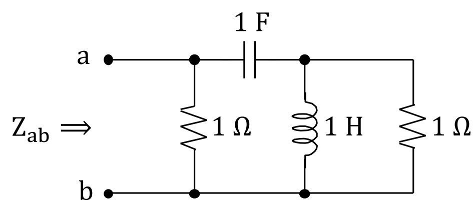
In the circuit to the right, the current source delivers an impulse of area Q_0 coulombs at time $t = 0$, and the voltage source delivers an impulse of area Λ_0 volt-seconds at time $t = 0$. Using superposition in the s-domain, determine an expression for the capacitor voltage $v_C(t)$ for $t > 0$.



Problem 6.6: [Problem 13.7 from Nilsson and Riedel] ($8\frac{1}{3}$ points)

Consider the circuit shown on the right.

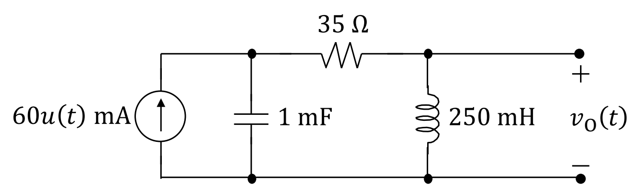
(a) Determine the impedance $Z_{ab}(s)$ seen looking into the terminals a,b of the circuit.
(b) Determine the values of the poles and zeros of $Z_{ab}(s)$.



Problem 6.7: [Problem 13.17 from Nilsson and Riedel] ($8\frac{1}{3}$ points)

Consider the circuit shown on the right.

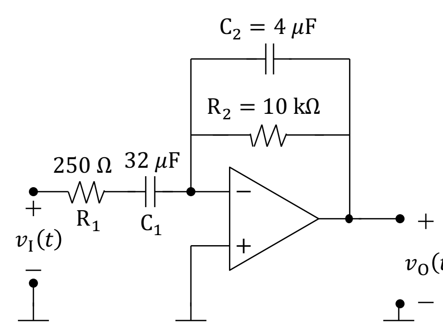
(a) Using s-domain analysis, determine the expression for $V_O(s)$.
(b) Use the s-domain expression derived in (a) to predict the initial- and final-values of $v_O(t)$.
(c) Determine the time-domain expression for $v_O(t)$.



Problem 6.8: [Problem 13.54 from Nilsson and Riedel] ($8\frac{1}{3}$ points)

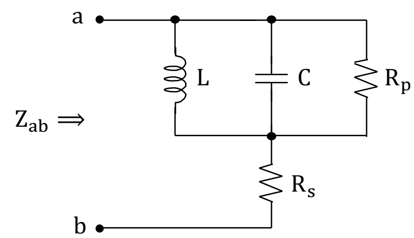
The op-amp in the circuit to the right is ideal.

(a) Determine an expression for the transfer function $H(s) = V_O(s)/V_I(s)$ in terms of R_1, R_2, C_1, C_2 and s.
(b) Determine the numerical values of the poles and zeros of $H(s)$.
(c) Sketch the magnitude Bode plot of this circuit's transfer function $H(j\omega)$, and identify whether it is a low-pass, band-pass, or high-pass filter.



Problem 6.9: ($8\frac{1}{3}$ points)

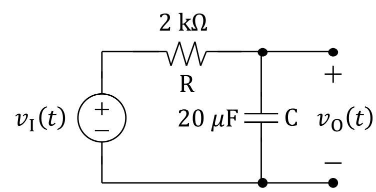
For the circuit shown on the right, determine an expression for the impedance $Z_{ab}(s)$ seen looking into its terminals a,b in terms of R_s, R_p, L, C and s.



Problem 6.10: [Problem 13.52 from Nilsson and Riedel] ($8\frac{1}{3}$ points)

Consider the circuit shown to the right.

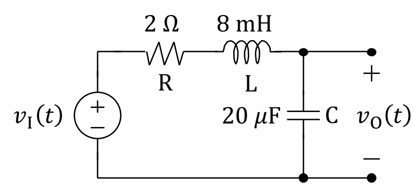
(a) Determine an expression for its transfer function $H(s) = V_O(s)/V_I(s)$ in terms of R, C and s.
(b) Determine the numerical values of the poles and zeros of $H(s)$, and show these on the complex s-plane.
(c) Sketch the magnitude and phase Bode plot of this circuit's transfer function $H(j\omega)$.



Problem 6.11: ($8\frac{1}{3}$ points)

Consider the circuit shown to the right.

(a) Determine an expression for its transfer function $H(s) = V_O(s)/V_I(s)$ in terms of R, L, C and s.
(b) Determine the numerical values of the poles and zeros of $H(s)$, and show these on the complex s-plane.
(c) Sketch the magnitude and phase Bode plot of this circuit's transfer function $H(j\omega)$.



Problem 6.12: [Problem 9.6 from Nilsson and Riedel] ($8\frac{1}{3}$ points)

The root-mean-square (rms) value of the sinusoidal voltage supplied to the convenience outlet of a home in Scotland is 240 V. What is the maximum value of the voltage at the outlet?