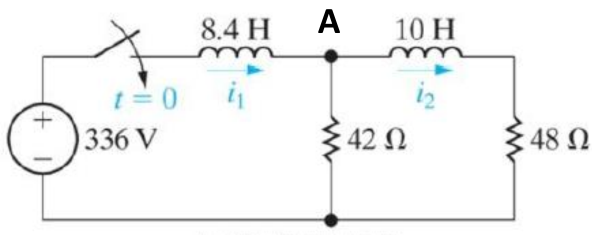
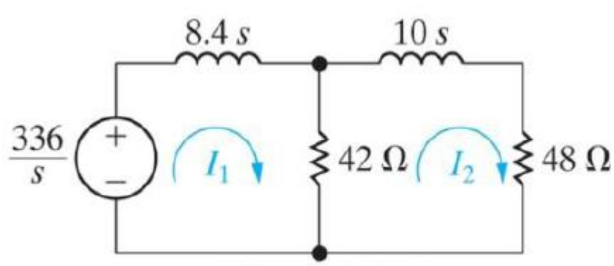
American University of Beirut
Department of Electrical and Computer Engineering
EECE 290 – Analog Signal Processing
Spring 2017
Quiz II - Solution

Problem 1 (9 pts)

For the system shown below, the switch closes at t=0s.



a. Draw the s-domain equivalent circuit. (3 pts)



b. Write node equation at node A. (3 pts)

$$\frac{V_A - \frac{336}{s}}{8.4s} + \frac{V_A}{42} + \frac{V_A}{48+10s} = 0$$

-1 for every incorrect term

c. Write two mesh equations. (3 pts)

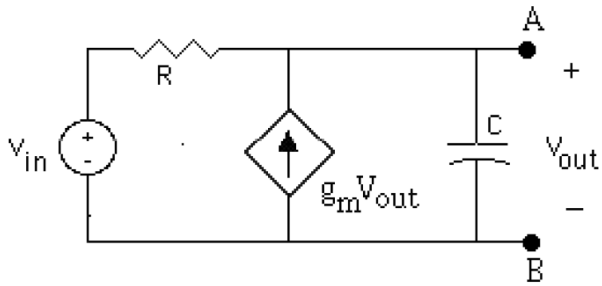
$$-\frac{360}{s} + 8.4sI_1 + 42(I_1 - I_2) = 0$$

$$42(I_2 - I_1) + 10sI_2 + 48I_2 = 0$$

-1 for every incorrect term

Problem 2 (6 pts)

In the circuit shown below, R=0.1Ω, g_m=5, and C=1F.



a. Determine the system transfer function. (3 pts)

$$H(s) = \frac{10}{s+5}$$

Incorrect Transfer function -2

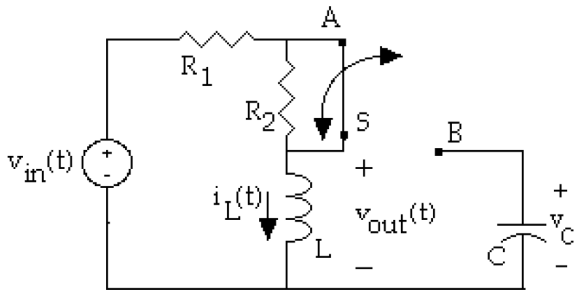
b. Determine the system impulse response. (3 pts)

$$h(t) = 10e^{-5t}u(t)$$

Missing u(t) -1
Incorrect Inverse from (a), -2

Problem 3 (8 pts)

In the ciruit shown below, R_1=1 Ω, R_2=1.5 Ω, L=1H, and C=0.2 F. Suppose $i_L(0^-) = v_C(0^-) = 0$. The switch S is in position A for $0 \le t \le 10$ and moves to Position B at t=10s where it remains. For $0 \le t < 10$, $v_{in}(t) = 10(1 - e^{-2t})u(t)$ Volts and for $t \ge 10$ s, $v_{in}(t) = 0$ volts.



a. For $0 \le t < 10$, Determine the system transfer function. (2 pts)

$$V_{out}(s) = \frac{Ls}{Ls + R_1} V_i(s) \rightarrow H(s) = \frac{s}{(s+1)}$$

Incorrect Transfer function -2

b. For $0 \le t < 10$, compute $V_{out}(s)$. (2 pts)

$$V_{out}(s) = \frac{s}{(s+1)} \cdot \left[\frac{10}{s} - \frac{10}{s+2} \right] = \frac{20}{(s+1)(s+2)}$$

c. For $0 \le t < 10$, compute $v_{out}(t)$. (2 pts)

$$V_{out}(s) = \frac{20}{(s+1)(s+2)} = \frac{20}{s+1} - \frac{20}{s+2} \Rightarrow$$

$$v_{out}(t) = 20\left[e^{-t} - e^{-2t} \right] u(t) \text{ Volts}$$

d. Compute $i_L(10^-)$. (2 pts)

$$i_L(t) = \frac{1}{L} \int_0^t v_{out}(\tau) d\tau = 20 \int_0^t \left[e^{-\tau} - e^{-2\tau} \right] d\tau = 20\left[1 - e^{-t}\right] - 10\left[1 - e^{-2t}\right] \text{ A}$$

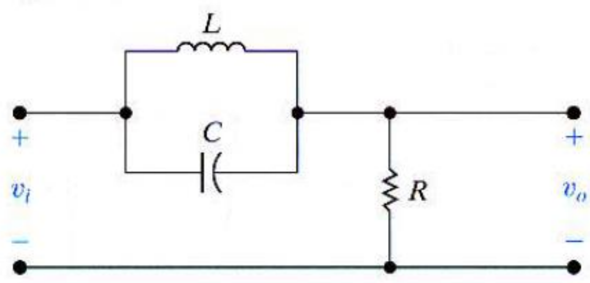
For t=10s, $i_L(10^-) = 10$ A

e. Determine the equivalent impedance for $10 \le$ t s. (2 pts)

$$Z_{eq}(s) = \frac{5s}{s^2 + 5} + 2.5$$

Problem 4 (8 pts)

For the circuit shown below,



a. Determine the system transfer function H(s). (3 pts)

$$H(s) = \frac{R}{R + (Ls // 1/Cs)}$$

$$H(s) = \frac{(s^2 + \frac{1}{LC})}{\left(s^2 + \frac{1}{RC}s + \frac{1}{LC}\right)}$$

Incorrect Transfer Function: -3 pts

b. For R=80KΩ, L=625μH, and C=25pF, determine H(s). (1 pt)

$$H(s) = \frac{(s^2 + 64 \cdot 10^{12})}{\left(s^2 + 500 \cdot 10^3 s + 64 \cdot 10^{12}\right)}$$

c. What type of filter is now obtained (1 pt)
Band-reject filter

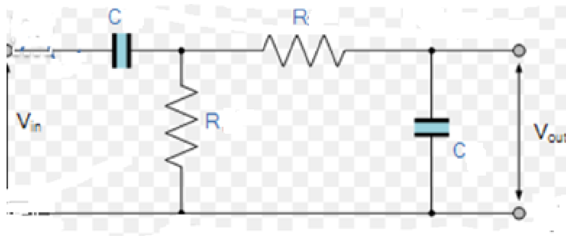
d. Calculate the center frequency in rad/s if any? (1 pt)
$\omega_0 = 8 \cdot 10^6$ rad/s

e. Find the filter bandwidth in rad/s? (1 pt)
$\beta = 500 \cdot 10^3$ rad/s

f. Find the quality factor if possible. (1 pt)

$$Q) = \frac{\omega_0}{\beta} = 16$$

Problem 5 (8 pts)
For the circuit shown below,



g. Determine the system transfer function H(s). (3 pts)

$$H(s)=\left(\frac{\frac{1}{Cs}}{R+\frac{1}{Cs}}\right)\left(\frac{R}{R+\frac{1}{Cs}}\right)=\left(\frac{1}{1+RCs}\right)\left(\frac{RCs}{1+RCs}\right)$$

$$H(s)=\frac{\frac{1}{RC}s}{s^2+\frac{2}{RC}s+\frac{1}{R^2C^2}}$$

-3 for incorrect Transfer function

h. For R=8 KΩ, C=312.5pF, determine H(s). (1 pt)

$$H(s)=\frac{400s}{s^2+800s+160000}$$

i. What type of filter is now obtained (1 pt)
Band-bass filter

j. Calculate the center frequency if any? (1 pt)
$\omega_0 = 400$ rad/s

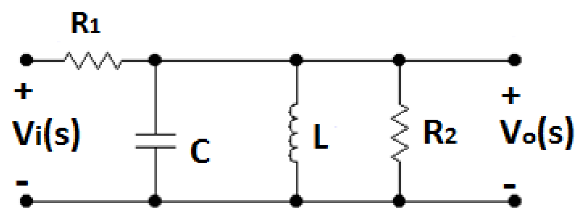
k. Find the filter bandwidth? (1 pt)
$\beta = 800$ rad/s

l. Find the quality factor if possible. (1 pt)

$$Q=\frac{\omega_0}{\beta}=0.5$$

Problem 6 (8 pts)

For the circuit shown below, determine



a. Determine the system transfer function H(s). (3 pts)

$$H(s)=\frac{\frac{s}{R_1C}}{s^2+\frac{(R_1+R_2)}{CR_1R_2}s+\frac{1}{LC}}$$

-3 for incorrect Transfer function

b. For R_1=100KΩ, R_2=400KΩ, L=5mH, and C=200pF, determine H(s). (1 pt)

$$H(s)=\frac{50{,}000s}{s^2+62500s+10^{12}}$$

c. What type of filter H(s) represents? (1 pt)

Band-pass filter

d. Find the center frequency ω_o. if any?(1 pt)

$\omega_0^2=10^{12}\Rightarrow\omega_0=10^6$ rad/s

e. Find the frequency bandwidth β. (1 pt)

$\beta==62.5Krad/s$

f. Find the quality factor Q if possible. (1 pt)

$$Q=\frac{\omega_0}{\beta}=16$$