BME354L (Palmeri)

Spring 2013

Exam #1

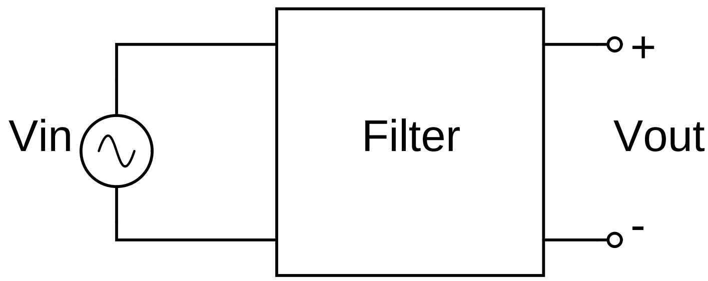
Instructions:

- Write your name at the top of each page.
- **Show all work (this is** *critical* **for partial credit!)**.
- Remember to include units with all answers and label all plot axes.
- Clearly box all answers.
- Assume that all components are ideal unless otherwise stated.
- Please keep your answers brief for questions where I ask 'why?'.

In keeping with the Duke Community Standard, I have neither given nor received aid in completion of this examination.

Signature:______________________________________

Problem #1 [50 points]



You build the generalized circuit above in lab, and you measure the following V_{out} signals for the specified V_{in} signals (all measurements have $\pm 10\%$ tolerance on them):[1]

V_{in} (V)	$V_{\text{out}}(V)$
$15\,\sin(2000t)$	$1.5\,\sin(2000t + \frac{\pi}{2})$
$10\,\sin(20000t + \frac{\pi}{2})$	$\frac{10\sqrt{2}}{2}\,\sin(20000t + \frac{3\pi}{4})$
$2.5\,\cos(300000t)$	$2.5\,\cos(300000t)$
$1.2\,\sin(4500000t)$	$\frac{1.2\sqrt{2}}{2}\,\sin(4500000t - \frac{\pi}{4})$
$0.5\,\sin(45000000t + \frac{\pi}{2})$	$0.05\,\sin(45000000t)$

(a) Sketch Bode plots for the amplitude and phase transfer functions for your filter. Label everything important, including cut-off / resonance frequencies, if applicable.[2] [15 points]

(b) You need to design a **[low-pass / high-pass / bandpass / bandstop]** filter for these $V_{\text{in}} : V_{\text{out}}$ relationships? Why? [5 points, choose one answer]

(c) Does your filter need to be active, or could you design a passive filter to achieve this $V_{\text{in}} : V_{\text{out}}$ behavior? Why? [5 points]

(d) Draw the circuit diagram for your filter with all key components labeled with specified values. If you are using op amps, then please specify their rail voltages. [10 points]

(e) What is the input impedance of your filter? [5 points]

(f) Design an amplifier for your filter output that can generate a maximum output voltage of $\pm$ 12 V and does not saturate ("rail") for filter output voltages (V_{out}) as large as $\pm$ 2.5 V. Make sure that your amplifier does not corrupt the phase of the filter output (V_{out}). Remember to consider the impedance relationship between your filter and your amplifier. [10 points]

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[1] It may help to think of these $V_{\text{in}} : V_{\text{out}}$ pairs in terms of phasors.

[2] I have only given you 5 discrete data points for your filter, but you can assume that all circuit behavior between these points is smooth and monotonic.

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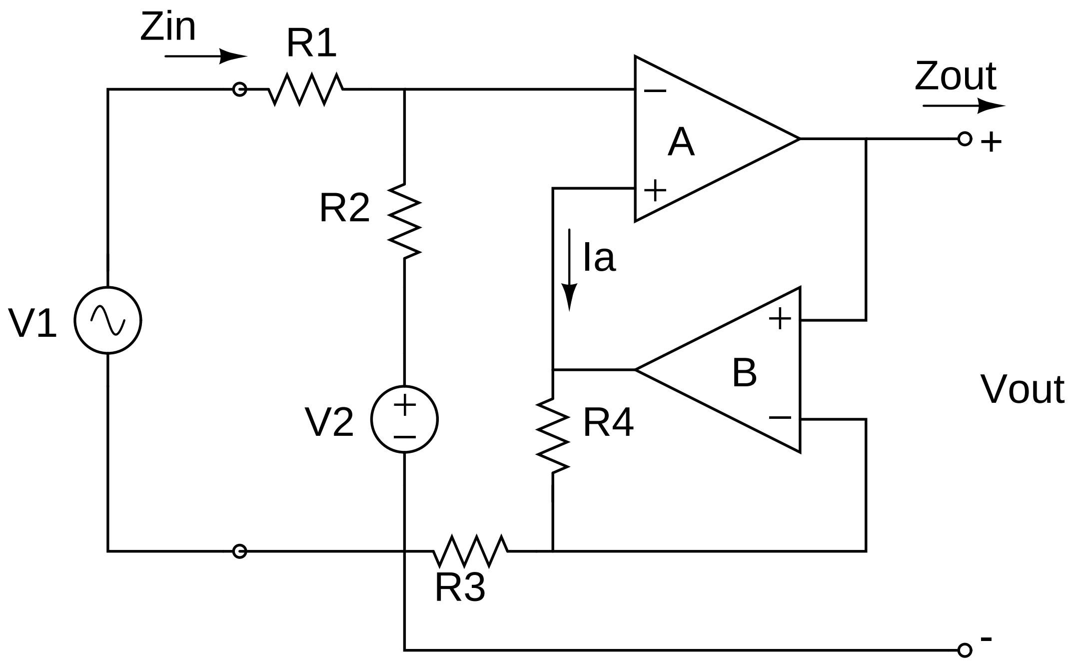
Problem #2 [50 points]



All of the components in the circuit above should be considered ideal and have the following values:

- Component Values: $R_1 = R_2 = R_3 = R_4 = 10\ \text{k}\Omega$; V_2 = -1 V
- Rail voltages for op amp A: $\pm$ 2 V
- Rail voltages for op amp B: $\pm$ 12 V

(a) What is the input impedance (Z_{in}), as indicated on the circuit diagram (as "seen" by V_1). [5 points]

(b) Op amp A is configured with **[no / negative / positive]** feedback. Why? [5 points, choose one answer]

(c) Op amp B is configured with **[no / negative / positive]** feedback. Why? [5 points, choose one answer]

(d) Write an expression for I_a, as indicated on the circuit diagram. [5 points]

(e) What is the purpose of V_2 in this circuit? [5 points]

(f) Sketch V_{out} for V_1 = -12:12 V. Please be sure to indicate the overall function of this circuit and show your steps in solving for V_{out} to maximize partial credit!! [15 points]

(g) Sketch V_{out} for 2 cycles of V_1 = 12 $\cos(100t)$ V, starting at t = 0. [5 points]

(h) What is the output impedance, Z_{out}, as indicated on the circuit diagram? [5 points]