ECE 3355: Electronics

Section 12324/17103
Fall 2023

Exam 1

Version A

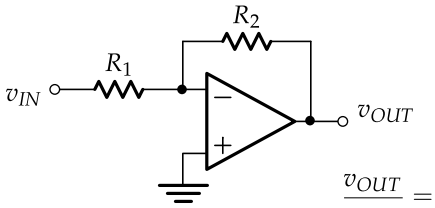
October 7, 2023

Do *not* open the exam until instructed to do so. Complete the exam on your own, without the help of your notes, prior examples or solutions, your book, or any communication/interaction with others. You must write a complete solution that shows the steps you took to solve the problem to receive full credit. You may use a calculator and a crib sheet is provided as part of this exam. Answer the questions in the spaces provided on the question sheets. If you run out of room for an answer, continue on the back of the page. **You will have 1 hour 15 minutes to finish the exam.**

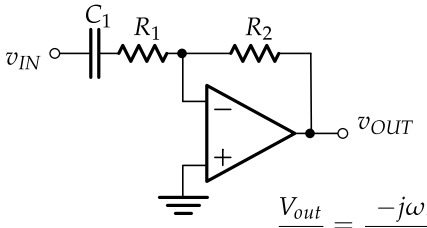
Student's Name: _____

Question	Points	Score
1	15	
2	15	
3	20	
4	20	
5	15	
6	15	
Total:	100	

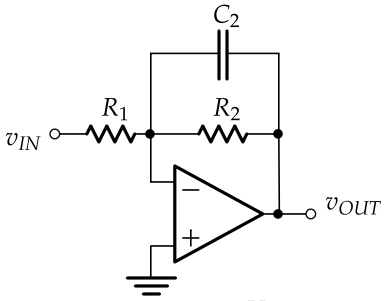
Inverting Amplifier



$$\frac{v_{OUT}}{v_{IN}} = -\frac{R_2}{R_1}$$

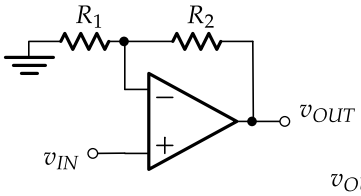


$$\frac{V_{out}}{V_{in}} = \frac{-j\omega R_2 C_1}{1 + j\omega R_1 C_1}$$

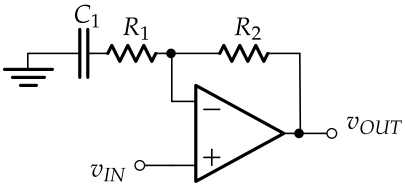


$$\frac{V_{out}}{V_{in}} = \frac{-\frac{R_2}{R_1}}{1 + j\omega R_2 C_2}$$

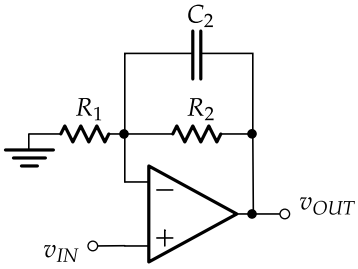
Non-inverting Amplifier



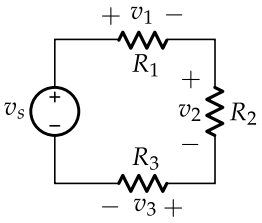
$$\frac{v_{OUT}}{v_{IN}} = 1 + \frac{R_2}{R_1}$$



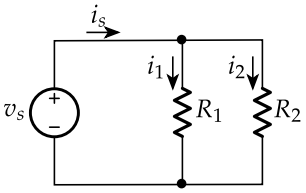
$$\frac{V_{out}}{V_{in}} = \frac{1 + j\omega\left(R_1 + R_2\right)C_1}{1 + j\omega R_1 C_1}$$



$$\frac{V_{out}}{V_{in}} = \left[1 + \frac{R_2}{R_1}\right]\left[\frac{1 + j\omega\left(R_1 || R_2\right)C_2}{1 + j\omega R_2 C_2}\right]$$



$$v_1 = \frac{R_1}{R_1 + R_2 + R_3} v_s$$
$$v_2 = \frac{R_2}{R_1 + R_2 + R_3} v_s$$
$$v_3 = \frac{R_3}{R_1 + R_2 + R_3} v_s$$

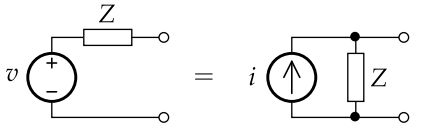


$$i_1 = \frac{R_2}{R_1 + R_2} i_s$$
$$i_2 = \frac{R_1}{R_1 + R_2} i_s$$

$$v_B = \underbrace{V_B}_{\text{DC}} + \underbrace{v_b}_{\text{AC}}$$

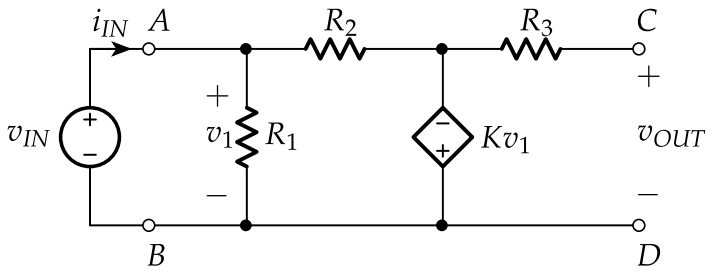
$\overline{V}_b \rightarrow$ Phasor notation

$$CMRR = 20 \log_{10} \frac{|A_d|}{|A_{cm}|}$$



$$v = i \cdot Z$$
$$i = \frac{v}{Z}$$

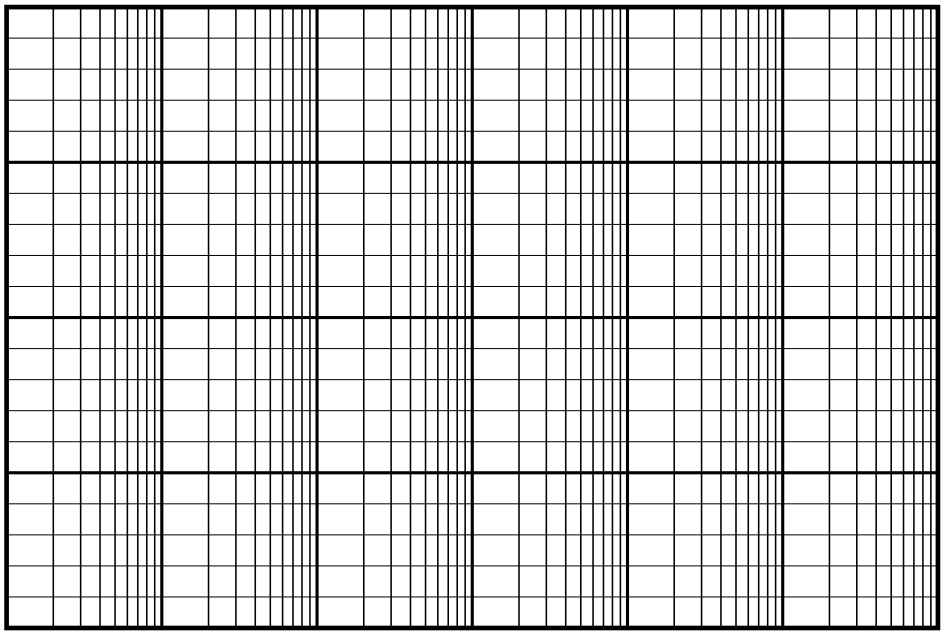
1. (15 points) For the following circuit, find the voltage gain, $\frac{v_{OUT}}{v_{IN}}$, and the input and output resistances.



2. (15 points) Bode Plots

   (a) Plot a straight-line approximation of the Bode plot on the graph paper provided for the *magnitude only* for the following transfer function (the unit for the values in the denominator of the imaginary terms is $^{\text{rad}}/_{\text{sec}}$).

$$H(j\omega) = -100\frac{\left(1+j\frac{\omega}{20}\right)}{\left(1+j\frac{\omega}{700}\right)\left(1+j\frac{\omega}{20{,}000}\right)\left(1+j\frac{\omega}{40{,}000}\right)}.$$



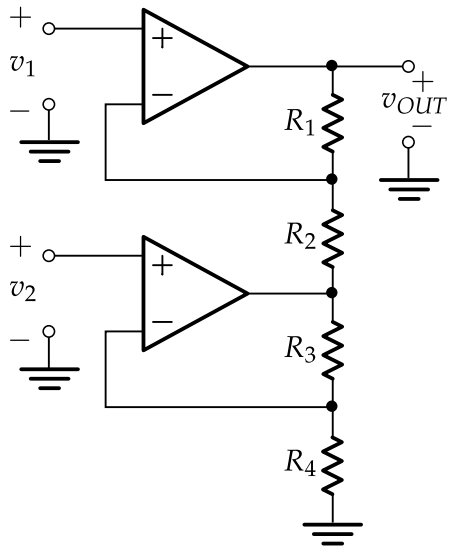
   (b) What is the starting phase (i.e., the phase at low frequencies)?

   (b) _____

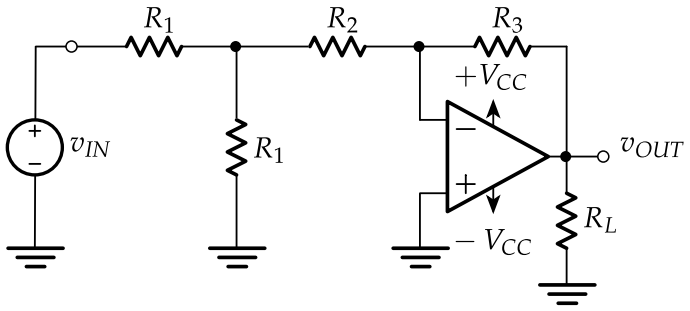
   (c) What is the ending phase (i.e, the phase at high frequencies)?

   (c) _____

3. (20 points) Difference Amplifier
   (a) Determine the ratios of the resistors (R_1, R_2, R_3, and R_4) that allow for this circuit to be a difference amplifier. (*Hint:* use superposition.)
   (b) What is the difference gain (A_d) when $R_1 = R_4 = 9\,\text{k}\Omega$ and $R_2 = R_3 = 1\,\text{k}\Omega$?
   (c) Using the values above, except for $R_2 = 0.9\,\text{k}\Omega$, what is the CMRR? (*Hint:* you do not need to recalculate the difference gain with the new value of R_2 - just use the value from above.)
   (d) What is the input resistance seen at each of the input terminals (i.e., at v_1 and v_2)?



4. (20 points) For the following circuit, the op-amp is powered by a pair of $\pm V_{CC} = \pm 15\,\text{volt}$ supplies (as shown). Also, $R_1 = 6\,\text{K}\Omega$, $R_2 = 3\,\text{K}\Omega$, $R_3 = 12\,\text{K}\Omega$, $R_L = 600\,\Omega$, and $v_{IN} = -10\,\text{V}$.

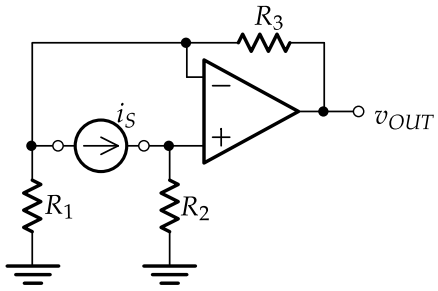


(a) Show whether or not the circuit is in voltage saturation.

(b) Show whether or not the circuit is in current saturation if $i_{max} = 25\,\text{mA}$.

(c) What is v_{OUT}?

5. (15 points) For the following circuit,
   (a) find an expression for the transresistance gain, $\frac{v_{OUT}}{i_S}$.
   (b) find the resistance seen by the source i_S.



6. (15 points) Design a circuit that has the following straight-line approximation to the Bode plot. Indicate which order the stages should be placed in to ensure that the input resistance does not vary with frequency.