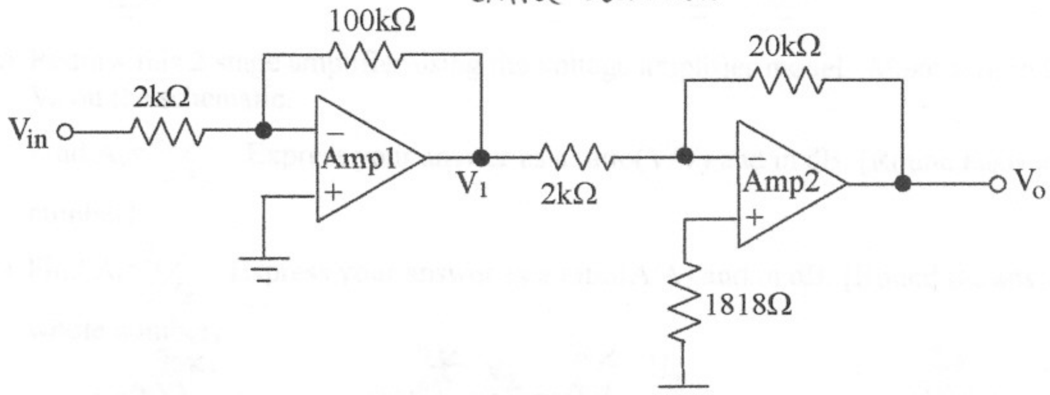
Homework #2:

1. (a) Explain how an amplifier works in your own words.: multiplies an input by a "gain" amount
   (b) Explain in your own words what R_i is. : input resistance
   (c) Explain in your own words what R_o is. : output resistance
   (d) Describe the ideal characteristics for an amplifier (i.e. ideal value for R_i, R_o, A_{vo}) → ∞, 0, ∞
   (e) Describe the characteristics for a buffer amplifier.
   • provides $V_o = V_{in}$ and supplies extra current.

2. Use the circuit below:



Amp1 is a CA3140 and Amp2 is an LM741. (See attached datasheet information)

(a) State each amplifiers frequency response transfer function (V_1/V_{in} and V_o/V_1)
(b) State the overall transfer function (V_o/V_{in})
(c) Solve for the overall f_{3dB} of the above circuit.

a. Amp 1 ⇒ $f_c = \frac{4.5MHz}{50} = 90{,}000\ Hz$

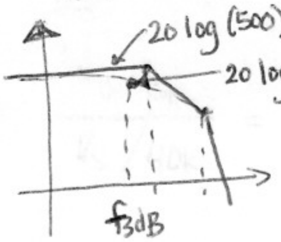
$$\frac{V_1}{V_{in}} = \frac{-50}{\left(\frac{s}{90KHz}+1\right)}$$

Amp 2 ⇒ $f_c = \frac{1MHz}{\left(\frac{20K}{2K}\right)} = 100KHz$

$$\frac{V_o}{V_1} = \frac{-10}{\left(\frac{s}{100KHz}+1\right)}$$

b. $$\frac{V_o}{V_{in}} = \frac{V_o}{V_1}\cdot\frac{V_1}{V_{in}} = \frac{-50}{\left(\frac{s}{90KHz}+1\right)}\cdot\frac{-10}{\left(\frac{s}{100KHz}+1\right)} = \frac{+500}{\left(\frac{s}{90KHz}+1\right)\left(\frac{s}{100KHz}+1\right)}$$

c.

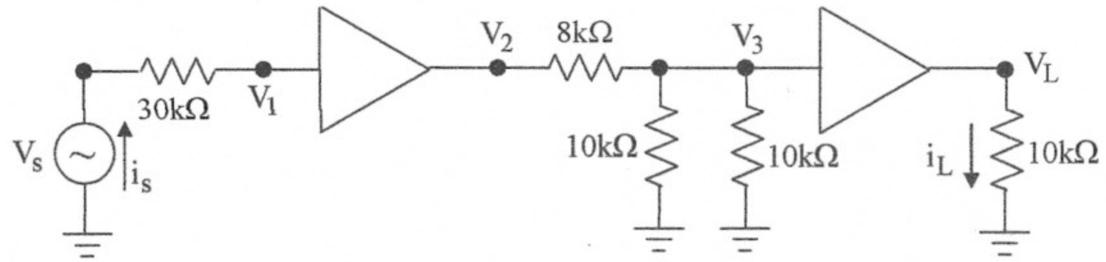


$20\log(500) - 3 \cong 50.98dB \cong 354\ V/V$

$$354\ V/V = \frac{500}{\sqrt{1+\left(\frac{f_{3dB}}{90K}\right)^2}\cdot\sqrt{1+\left(\frac{f_{3dB}}{100K}\right)^2}} \Rightarrow$$ solve with matlab $f_{3dB} \cong 57KHz$

3. v_s is an AC signal. Both amplifiers have the following characteristics:

$A_{vo}=20$, $R_i=10k\Omega$, $R_o=2k\Omega$, Clipping levels: $L=\pm 12V$ (unloaded)

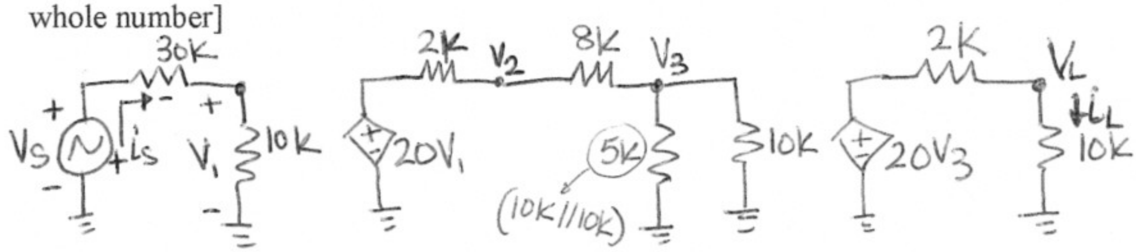


(a) Redraw this 2 stage amplifier using the voltage amplifier model. Make sure to label V_S, V_1, V_3, and V_O on the schematic.

(b) Find $A_v = v_L / v_s$. Express your answer as a ratio(V/V) and in dB. [Round answer to the nearest whole number]

(c) Find $A_i = i_L / i_s$. Express your answer as a ratio(A/A) and in dB. [Round the answer to the nearest whole number]

a.



b. $V_L = \dfrac{20 V_3 \cdot 10K}{12K} = \dfrac{200}{12} V_3$

$V_3 = \dfrac{20 V_1 \cdot (5K \| 10K)}{(5K \| 10K) + 8K + 2K}$

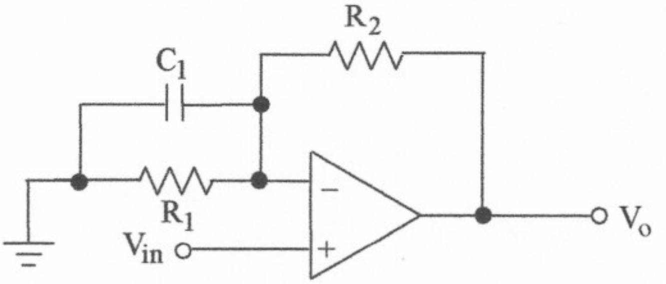
$V_1 = \dfrac{V_S (10K)}{40K}$

$V_L = \dfrac{200}{12} \cdot \dfrac{20 (5K \| 10K)}{(5K \| 10K) + 10K} \cdot \dfrac{10K}{40K} \cdot V_S \Rightarrow$ $\boxed{\dfrac{V_L}{V_S} = 21 \text{ V/V} \approx 26\text{dB}}$

c. $i_L = \dfrac{V_L}{10K}$; $i_S = \dfrac{V_S}{40K}$

$\dfrac{i_L}{i_S} = \dfrac{V_L / 10K}{V_S / 40K} = \dfrac{V_L}{V_S} \cdot \dfrac{40K}{10K} = \boxed{84 \text{ V/V} \cong 39\text{dB}}$

4. Analyze the circuit below to obtain the transfer function, V_o/V_{in}. Assume an ideal op amp. Sketch the straight line approximation for the Bode Plots.

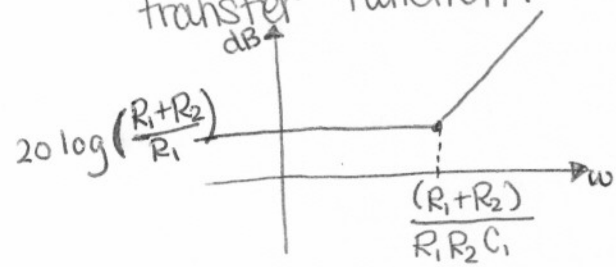


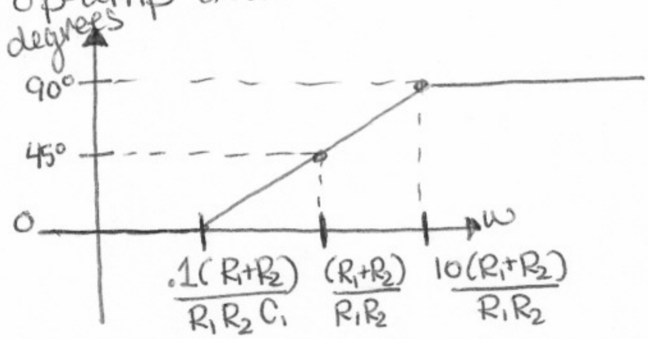
$$\frac{V_o}{V_{in}} = \left(\frac{R_2}{(R_1 \| \frac{1}{C_1 s})} + 1 \right)$$

$$R_1 \| \frac{1}{C_1 s} = \left[\frac{R_1 \left(\frac{1}{C_1 s} \right)}{R_1 + \frac{1}{C_1 s}} \right] \frac{C_1 s}{C_1 s} = \frac{R_1}{R_1 C_1 s + 1}$$

$$\frac{V_o}{V_{in}} = \frac{R_2(C_1 R_1 s + 1) + R_1}{R_1} = \boxed{\frac{(R_1 + R_2)\left(\frac{R_1 C_1 s R_2}{(R_1+R_2)} + 1\right)}{R_1}}$$

Assume ideal ⇒ f_T huge so op-amp does not affect transfer function:





5. Redraw or add to the schematic below to show how to reduce the effect of the **input bias current**. State the symbolic value(s) of any components added to the schematic.