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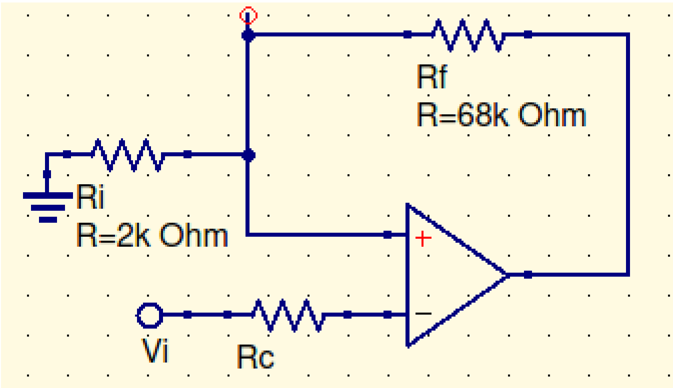
Homework 4: Due 2/10/2020

9. Given the circuit below:



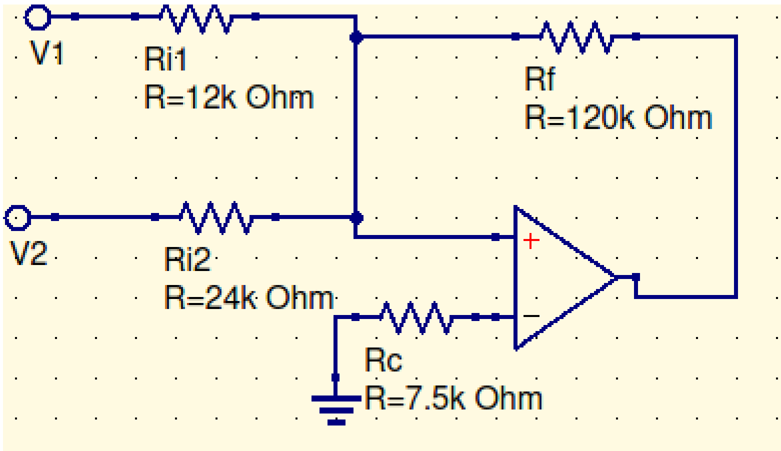
1. Determine the noise gain (K_n) for the circuit.

$$K_n = \frac{1}{\beta};\ \beta = \frac{R_i}{R_i + R_f} \tag{1}$$
$$K_n = \frac{68k\Omega + 2k\Omega}{2k\Omega}$$
$$\boxed{K_n = 35}$$

2. Use the result to calculate the exact signal gain at DC and low frequencies if $A_o = 10^5$.

$$K_n = \frac{1}{\beta};\ \beta = \frac{1}{35} \tag{2}$$
$$A_{CL} = \frac{A_o}{1 + A_o\beta} = \frac{10^5}{1 + (10^5)(\frac{1}{35})}$$
$$\boxed{A_{CL} = 3.9998 \approx 4}$$

11. Given the circuit below:



1. Determine the noise gain (K_n) for the circuit.

$$K_n = \frac{1}{\beta};\ \beta = \frac{R_i}{R_i + R_f};\ R_i = 12k\Omega||24k\Omega = 8k\Omega \quad (3)$$

$$K_n = \frac{8k\Omega + 120k\Omega}{8k\Omega}$$

$$\boxed{K_n = 16}$$

2. Use the result to calculate the exact gain factors for the two signals if $A_o = 5 \times 10^4$.

$$K_n = \frac{1}{\beta};\ \beta = \frac{1}{16} \quad (4)$$

$$A_{CL} = \frac{A_o}{1 + A_o\beta} = \frac{5 \times 10^4}{1 + (5 \times 10^4)(\frac{1}{16})}$$

$$\boxed{A_{CL} = 15.9949 \approx 16}$$

13. For the circuit shown in problem 9, assume the following:

$$V_{io} = 1.2mV \quad (5)$$
$$I_b = 60nA$$
$$I_{io} = 8nA$$

1. Determine the magnitude of the output DC voltage $|V_{o1}|$ produced by the input offset voltage.

$$V_{o1} = V_{io}(\alpha);\ \alpha = \frac{R_f}{R_i + R_f} = \frac{34}{35} \tag{6}$$
$$V_{o1} = 1.2mV(\frac{34}{35})$$
$$\underline{\overline{|V_{o1} = 1.6mV|}}$$

2. With $R_c = 0$ determine the magnitude of the output dc voltage $|V_{o2}|$ produced by the input bias currents.

$$V_{o2} = R_c(\alpha)i_b^+ - R_f(I_b^2);\ R_c = 0 \tag{7}$$
$$i_{io} = i_b^+ - i_b^-;\ i_b = \frac{i_b^+ + i_b^-}{2}$$
$$8nA = i_b^+ - i_b^-;\ 120nA = i_b^+ + i_b^-$$
$$i_b^+ = 64nA;\ i_b^- = 56nA$$

$$V_{o2} = 0 - 68k\Omega(56nA)$$
$$\underline{\overline{|V_{o2} = -3.808mV|}}$$

3. Determine the optimum value of R_c.

$$R_{c_{ideal}} = 2k\Omega||68k\Omega \tag{8}$$
$$\underline{\overline{|R_{c_{ideal}} = 1.94k\Omega|}}$$

4. Given your new value for R_c, find $|V_{o2}|$.

$$V_{o2} = R_c(\alpha)i_b^+ - R_f(I_b^2);\ R_c = 0;\ i_b^+ = 64nA;\ i_b^- = 56nA \tag{9}$$
$$V_{o2} = 1.94k\Omega(\frac{34}{35})(64nA) - 3.808mV$$
$$\underline{\overline{|V_{o2} = -3.688V|}}$$

25. An op-amp is used at DC and very low frequencies. A closed loop gain of 200 is required. Specifications indicate that the error due to finite open loop gain cannot exceed 0.1%. Determine the minimum value of the DC open loop gain required.

I am unsure how to do this problem. It feels like there is not enough information do this problem, but I can't seem to wrap my head around it.

27. Assume the design of problem 25, with the following additional parameters:

$$DC\ output\ due\ to\ input\ offset\ voltage \leq 100mV \qquad (10)$$
$$DC\ output\ due\ to\ input\ offset\ current \leq 5mV$$

1. Determine the maximum value of input offset voltage allowed for the op-amp.
2. When an op-amp is selected to meet the requirements for the above, assume that $I_{io} = 12\mu A$. Calculate the maximum value of R_f permitted, assuming that a compensating resistors will be used.

Due to this question being directly related to question 25, I cannot do this question either.