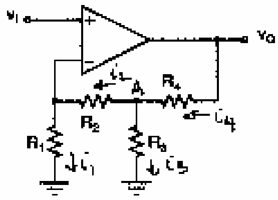
NAME: KEY STUDENT NO.: Ex 2b

University of Puerto Rico
Electrical and Computer Engineering Department
INEL 4202 - Electronics II - Fall 2002 - Exam 2b - Prof. M. Toledo
THERE ARE THREE PROBLEMS - BE CLEAR OR LOOSE POINTS

1. For the amplifier shown below, assume an ideal opamp.

   (a) Derive an expression for $A_v = v_o/v_i$ in terms of R_1, R_2, R_3 and R_4; (25 points)

   (b) Find $A_v = v_o/v_i$ if $R_1 = R_3 = 1k\Omega$, $R_2 = 10k\Omega$ and $R_4 = 20k\Omega$; (5 points)



(a) $v_- = v_+ = v_i$; $i_1 = v_i/R_1 = i_2$; $V_A = v_- + i_2 R_2$

$$V_A = v_i + \frac{R_2}{R_1} v_i = v_i\left(1+\frac{R_2}{R_1}\right)$$

$$i_3 = \frac{v_A}{R_3} = \frac{v_i}{R_3}\left(1+R_2/R_1\right)$$

$$V_o = i_4 R_4 + V_A = i_3 R_4 + i_2 R_4 + V_A$$

$$= v_i \frac{R_4}{R_3}\left(1+\frac{R_2}{R_1}\right) + \frac{R_4}{R_1} v_i + v_i\left(1+\frac{R_2}{R_1}\right)$$

$$\boxed{\frac{v_o}{v_i} = \frac{R_4}{R_1} + \left(1+\frac{R_4}{R_3}\right)\left(1+\frac{R_2}{R_1}\right)}$$

(b) $$\frac{v_o}{v_i} = \frac{20K}{1K} + \left(1+\frac{20k}{1k}\right)\left(1+\frac{10K}{1K}\right)$$

$$= 20 + 21 \times 11 = \boxed{+251}$$

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2. For the amplifier shown in problem 1, assume that the opamp can be represented with the model shown below, with $r_d = 10k\Omega$, $a = 10^4 V/V$ and $r_o = 100\Omega$.

   (a) Identify the type of feedback being used. (10 points)

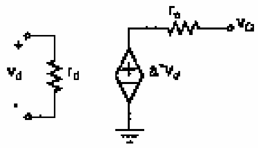
   (b) Draw a diagram of the feedback network. (10 points)

   (c) Find the feedback network's R_{11}, R_{22} and β as defined in lecture. (10 points)

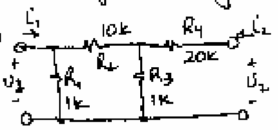
   (d) Draw a diagram of the non-feedback amplifier that must be analyzed to properly use the feedback method discussed in lecture. (10 points)

   (e) Find the non-feedback amplifier gain that must be used in the feedback method discussed in lecture. (10 points)

(a) voltage-sampling, voltage-mixing



(b)

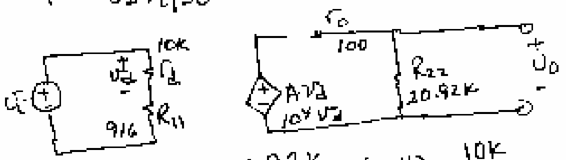


(c) $R_{11} = \frac{v_1}{i_1}\Big|_{v_2=0} = \left[(20K \| 1k) + 10K\right] \| 1K = \boxed{916\Omega}$

$R_{22} = \frac{v_2}{i_2}\Big|_{i_1=0} = 11K \| 1K + 20K = \boxed{20.92K\Omega}$

$\beta = \frac{v_1}{v_2}\Big|_{i_1=0} = \frac{1}{R_{22}} \frac{1K}{12K}(1K) = \boxed{\frac{1}{251}} = .0399$

(d)



$\frac{v_o}{v_i} = \frac{20.92K}{21.02K}(10^4)\frac{10K}{10{,}916\Omega} = \boxed{~~[illegible]~~ V/V}$ 9117 V/V

3. An amplifier will be used in a feedback configuration. Its d.c. gain $A_0 = 10^4$. Its frequency response displays poles at $f_{p1} = 20kHz$, $f_{p2} = 500kHz$, $f_{p3} = 20MHz$. You want to use this amplifier to obtain a gain with feedback $A_f \approx \frac{1}{\beta} = 100$. Determine the new position of f_{p1} if the pole-shifting technique will be used to compensate the amplifier for a phase margin of 45°. (20 points)

$$A(f_{p_2}) \simeq 80dB - (20\ dB/dec)(\log f_{p_2}/f_{p_1}\ decs)$$
$$= 80dB - 20\ dB/dec \times 1.4\ dec.$$
$$= 52\ dB$$

(For a more accurate estimate of $A(f_{p2})$
subtract an additional 3 dB to correct
the assimptotic behavior being used;
or use the gain formula $A(f) = A_0 / \Pi \sqrt{1+(f/f_p)^2}$)

Since $(1/\beta)_{dB} = 40\ dB$, for $\phi_M = 45°$ $A(f_{p2})$
must drop by 12 dB. ∴ move the first
pole down by $12dB / 20\ dB/dec = 0.6$ decs.

or $\quad .6 = \log(f_{p1}/f_{new})$

yields $\boxed{f_{new} \approx 5kHz}$

as the new frequency of the 1st pole.