Name: Key

Student No: ______

Electrical and Computer Engineering Department
University of Puerto Rico - Mayaguez, P.R.
Electronics II - Fall 1999 - Third Exam - Prof. Manuel Toledo

EACH PROBLEM IS 25 POINTS
BE CLEAR AND WELL ORGANIZED OR LOOSE POINTS

1. An amplifier with an open-loop gain of 1,000 delivers 10W of output power at 10% distortion when the input signal is 10 mV. A negative voltage-series feedback with $\beta = 0.01$ is applied. The output power is to remain at 10W. For the feedback amplifier, determine
   (a) the required input signal
   (b) the percentage distortion

a) $D = 1 + \beta A = 1 + (.01)(1000) = 11$

$A_f = \frac{A}{D} = \frac{A}{11}$; since the output should remain the same while the gain is reduced by 11, the input should be increased by this amount;

∴ input singal = 11(10mV) = **110mV**

b) $d_f = \frac{d}{D} = \frac{10\%}{11} = $ **0.9%**

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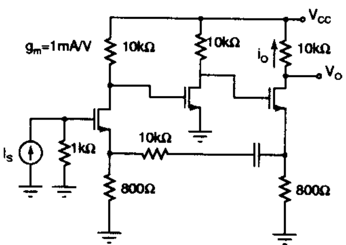
2. In the following amplifier, current-series feedback is used. Find

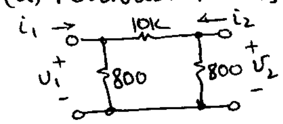
   (a) the feedback amplifier transconductance, G_{mf}.

   (b) output resistance of the feedback amplifier, R_{Of}

   Assume that the capacitor is a short circuit at the operating frequency.



(a) Feedback net. is



$Z_{12} = \left.\frac{v_1}{i_2}\right|_{i_1=0}$

$= (800 \| 10800)\frac{800}{10800}$

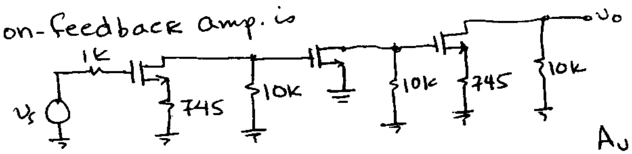
$= 55.17$

since $i_2 = -i_o \Rightarrow \boxed{\beta = -55.17}$

$Z_{11} = \left.\frac{v_1}{i_1}\right|_{i_2=0} = 800 \| 10800 = 745\Omega$

$Z_{22} = \left.\frac{v_2}{i_2}\right|_{i_1=0} = 745\Omega = Z_{22}$

Non-feedback amp. is



$A_{v_1} = \frac{-(1mA)(10k\Omega)}{1+(1mA)(745\Omega)}$

$A_{v_1} = -5.73$

$A_{v_2} = -(1mA)(10k\Omega) = -10$

$A_{v_3} = A_{v_1} = -5.73$

$A_v = (-5.73)(10)(-5.73) = -328.3$

$G_M = \frac{i_o}{v_s} = \frac{v_o/R_o}{v_s} = \frac{1}{R_o}A_v = (-328.3)\left(\frac{1}{10k\Omega}\right) = -3.283\times10^{-2}\ \mho$

$D = 1 + \beta G_M = 1 + (-55.17)(-3.283\times10^{-2}) = 2.8$

$G_{Mf} = G_M/D = \boxed{1.17\times10^{-2}\ A/V}$

(b)

(b) $R_o = 1/g_m$

$R_{of} = D R_o$

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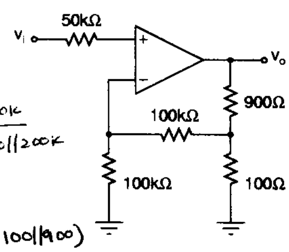
3. In the amplifier shown below, voltage-series feedback is employed. The active element is an opamp, for which the open-loop gain is 10^5, the output resistance is $R_O = 1k\Omega$, and the input resistance is $R_i = 100k\Omega$.

   (a) Find the feedback network's β, h_{11} and h_{22}.

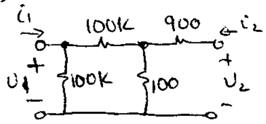
   (b) Replace the opamp with it's two-port network equivalent circuit and draw the resulting non-feedback amplifier diagram, including the loading effects of the feedback network.

   (c) Find the non-feedback amplifier's voltage gain A_v, input resistance R_i and output resistance R_o that should be used to apply feedback theory.

   (d) Use feedback theory to find the feedback amplifier's voltage gain A_{vf}, input resistance R_{if} and output resistance R_{of}.



a)



$h_{12} = \frac{v_1}{v_2}\Big|_{i_1=0} = \frac{100k}{200k} \cdot \frac{100\|200k}{900 + 100\|200k}$

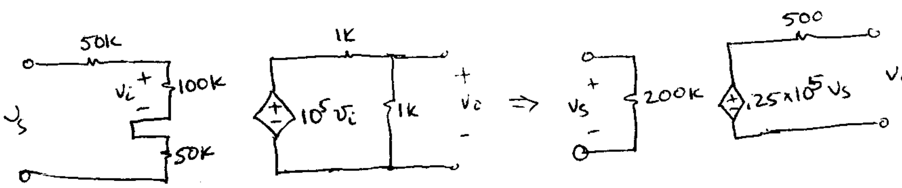
$\approx (0.5)(.1) = .05 = \beta$

$h_{11} = \frac{v_1}{i_1}\Big|_{v_2=0} = 100k \| (100k + 100\|900)$

$= 50k$

$h_{22} = \frac{i_2}{v_2}\Big|_{i_1=0} = \left[900 + 100\|200k\right]^{-1} \approx \frac{1}{1k\Omega}$

b)



c) $A_v = 25{,}000$; $R_i = 200k$; $R_o = 500\Omega$

d) $D = 1 + (.05)(25{,}000) = 1251$

$A_{vf} = \frac{25000}{1251} = \boxed{19.98}$; $R_{if} = DR_i = 1251(200k) = \boxed{2.5\times10^8\,\Omega}$

$R_{of} = R_o/D = \frac{500}{1251} = \boxed{0.4\,\Omega}$

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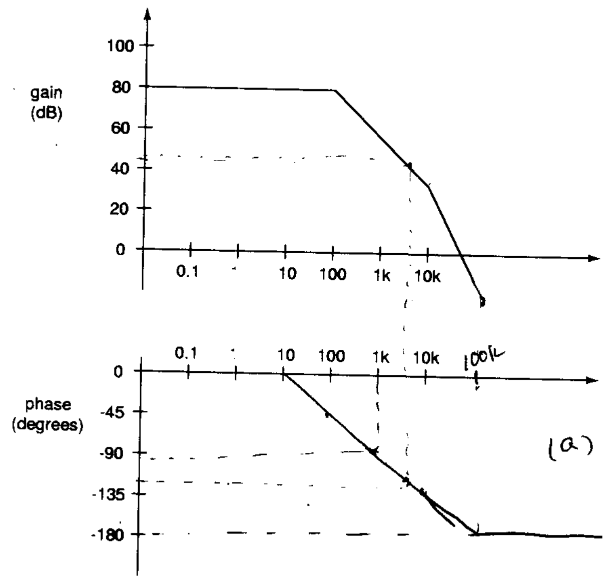
4. Shown below is the frequency response for the voltage gain of a non-feedback amplifier. The response shows poles at 100Hz and 10kHz.

   (a) Draw the phase response on the space provided.

   (b) Determine the approximate value of the feedback network's β that will yield a phase margin of 60 degrees.

   (c) Find the gain margin for the β found in part (b).



b) about 45 dB = $\frac{1}{\beta}$ → $\frac{1}{\beta} = 178$ ⇒ $\beta = \frac{1}{178} = .0056$

exact number should be 46.7 dB

$\frac{1}{\beta} = 215$ → $\beta = \frac{1}{215} = .0046$