Name: KEY

Student No: ______

Electrical and Computer Engineering Department
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Electronics II - Spring 2000 - Third Exam - Prof. Manuel Toledo

BE CLEAR AND WELL ORGANIZED OR LOOSE POINTS

1. A non-feedback amplifier with voltage gain $A_V = 1,000 \pm 100$ is available. It is necesary to have a voltage-series feedback amplifier whose voltage gain varies by no more than $\pm 0.1\%$.
   (a) Find the β of the feedback network. (5 pts)
   (b) Determine the gain of the feedback amplifier. (5 pts)

(a) variability of non-feedback amp $= \frac{100}{1000} \times 100\%$
$= 10\%$

$\therefore D = \frac{10\%}{.1\%} = 100 = 1 + \beta A$

Since $A = 1000$

$\beta = \frac{99}{1000} = 0.099$

(b) $A_{vf} = \frac{A_v}{D} = \frac{1000}{100} = 10 = A_{vf}$

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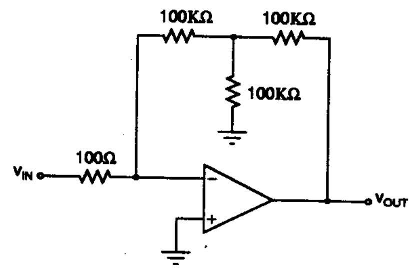
2. In the amplifier shown below, voltage-shunt feedback is being employed. The active element is an opamp, with open-loop voltage gain $A_{OL} = 10^4$, output resistance $R_{out} = 1k\Omega$, and input resistance is $R_d = 10k\Omega$.

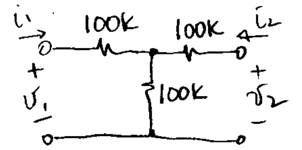
   (a) Find the feedback network's β, and the *11* and *22* parameters that correspond to the type of feedback being used. (5 pts)

   (b) Find the non-feedback amplifier's gain, input resistance R_i and output resistance R_o that should be used to apply feedback theory. (10 pts) (HINT: REPLACE OPAMP BY ITS TWO-PORT NETWORK MODEL)

   (c) Use feedback theory to find the feedback amplifier's voltage gain $A_{vf} = \frac{v_{OUT}}{v_{IN}}$, input resistance R_{if} and output resistance R_{of}. (10 pts)



(a) feedback is voltage-shunt – y model



β - network

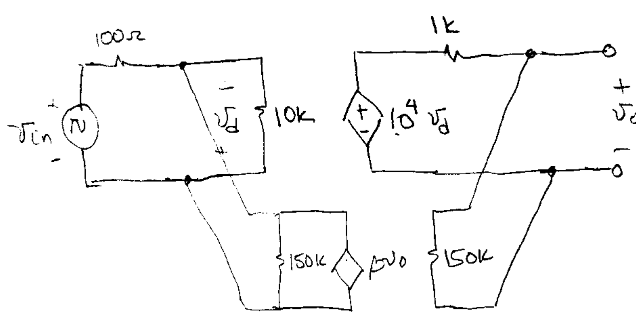
$$y_{11} = \left.\frac{i_1}{v_1}\right|_{v_2=0} = \frac{1}{150k}$$

$$y_{22} = \left.\frac{i_2}{v_2}\right|_{v_1=0} = \frac{1}{150k}$$

$$y_{12} = \left.\frac{i_1}{v_2}\right|_{v_1=0} = \frac{-1}{150k}\ \frac{100k}{200k}$$

$$y_{12} = -3.33\times10^{-6}\ A/V = \beta$$

(b)



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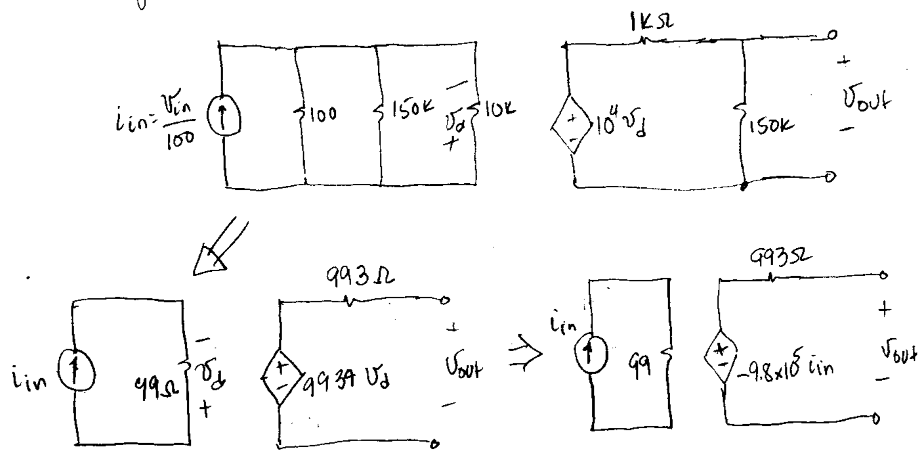
Setting the feedback β to zero and noticing that the required gain is a transresistance,



$\therefore$ $R_{in} = 99\Omega$ $\qquad R_M = -9.8\times10^5\ \Omega$

$R_{out} = 993\Omega$

(c) $D = 1 + \beta R_M = 1 + (-3.33\times10^{-6})(-9.8\times10^5\Omega) = 4.26$

$$R_{Mf} = \frac{-9.8\times10^5\Omega}{4.26} = -2.3\times10^5\ \Omega = \frac{v_{out}}{i_{in}} = \frac{v_{out}}{v_{in}/100\Omega}$$

$$\therefore\ A_{vf} = \frac{v_{out}}{v_{in}} = \frac{R_{Mf}}{100} = \boxed{-2.3\times10^4}$$

$$R_{if} = \frac{R_i}{D} = \frac{99}{4.26}\Omega = \boxed{23.2\ \Omega = R_{if}}$$

$$R_{of} = \frac{R_o}{D} = \frac{993}{4.26} = \boxed{233.1\Omega = R_{of}}$$

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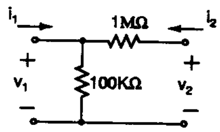
3. A FET non-feedback amplifier has a voltage gain $A_V = +g_m R_D$. When the amplifier is operating at 25 degrees Celsius (room temperature), the nominal values for g_m and R_D are $10mA/V$ and $10K\Omega$, respectively. While g_m drops with increasing temperature at a rate of approximately 0.5% per degree Celcius, the resistance increases at about 10Ω per degree Celcius.

If the following circuit is used to establish voltage-series feedback,



determine

(a) the β of the feedback network (5 pts)

(b) the temperature sensitivity of the non-feedback amplifier's voltage gain (5 pts)

(c) the temperature sensitivity of the feedback amplifier's voltage gain (5 pts)

(a) $\beta = \left.\frac{v_1}{v_2}\right|_{i_1=0} = \frac{100K\Omega}{1100K\Omega} = \boxed{\frac{1}{11}}$

(b) $S_T^{A_V} = \frac{T}{A}\frac{dA}{dT} \simeq \frac{T}{A}\frac{\Delta A}{\Delta T}$; at $25°C$, $A_V = (10mA/V)(10K\Omega) = 100$

at $26°C$, $A_V(26°) = (10\frac{mA}{V} \times .995) \times (10010\Omega)$

$A_V(26°) = 99.6$

$S_T^{A_V} \simeq \frac{25}{100}\frac{(99.6-100)}{(26-25)}$

$= -0.1 = \boxed{-10\%}$

(c) $S_T^{A_{vf}} = \frac{S_T^{A_V}}{D}$; $D = 1+\beta A = 1 + \left(\frac{1}{11}\right)(100) = 10.09$

$\therefore S_T^{A_{vf}} = \frac{-10\%}{10.09} \simeq \boxed{-1\%}$

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4. **(BONUS)** Draw a schematic diagram of a circuit that approximates the feedback amplifier described in problem 3. (5 pts)

Since $A_v = +g_m R_D$, the amplifier must be common gate. A posible implementation would be: