1. A non-feedback amplifier with voltage gain $A_v = 1,000 \pm 100$ is available. It is necessary to have a voltage-series feedback amplifier whose voltage gain varies by no more than $\pm 0.1\%$.

(a) Find the $\beta$ 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\%

\[ D = \frac{10\%}{0.1\%} = 100 = 1 + \beta A \]

Since $A = 1000$

\[ \beta = \frac{A}{1000} = 0.001 \]

(\text{b}) $A_{vf} = \frac{A_v}{D} = \frac{1000}{100} = 10 = A_{vf}$
2. In the amplifier shown below, voltage-shunt feedback is being employed. The active element is an opamp, with open-loop voltage gain \( A_{OL} = 10^6 \), output resistance \( R_{out} = 1k\Omega \), and input resistance is \( R_i = 10k\Omega \).

(a) Find the feedback network's \( \beta \) 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 \( A_{af} = \frac{v_{out}}{v_{in}} \), input resistance \( R_i \) and output resistance \( R_o \). (10 pts)

\[ V_1 = \frac{1}{10k} \]
\[ V_2 = \frac{1}{10k} \]
\[ \beta = \frac{1}{100k} \]

**HINT:**

\[ A_{af} = \frac{33.33 \times 10^5}{V/V} \]
Setting the feedback to zero and noting that the required gain is a transresistance,

\[ \begin{align*}
\text{Lin} & = \frac{V_i}{100} \\
\text{100} & \quad \text{150k} \\
\text{100} & \quad \text{150k} \\
\text{1} & \quad \text{1k2} \\
\end{align*} \]

\[ \begin{align*}
\text{Lin} & = \frac{V_i}{100} \\
\text{qq32} & \quad + \\
\text{qq9l} & \quad \text{qq9l} \\
\text{qq9} & \quad \text{qq9l} \\
\text{qq32} & \quad + \\
\text{qq9l} & \quad \text{qq9l} \\
\end{align*} \]

\[ \begin{align*}
R_{in} & = q9.2 \\
R_{out} & = 993.2 \\
\end{align*} \]

\[ \begin{align*}
R_{in} & = q9.2 \\
R_{out} & = 993.2 \\
\end{align*} \]

\[ \begin{align*}
\text{D} & = 1 + \beta R_m = 1 + (-3.33 \times 10^5)(-9.8 \times 10^5) = 4.26 \\
R_{inf} & = \frac{-9.8 \times 10^5}{4.26} = -2.3 \times 10^5 \Omega \\
\therefore A_{inf} & = \frac{V_{out}}{V_{in}} = \frac{R_{inf}}{R_{in}/100} = -2.3 \times 10^{-4} \\
R_{ip} & = \frac{R_i}{D} = \frac{q9}{4.26} = 23.2 \Omega = R_{ip} \\
R_{of} & = \frac{R_o}{D} = \frac{993}{4.26} = 233.1 \Omega = R_{of} \\
\end{align*} \]
3. A FET non-feedback amplifier has a voltage gain \( A_V = +g_mR_D \). When the amplifier is operating at 25 degrees Celsius (room temperature), the nominal values for \( g_m \) and \( R_D \) are 10mA/V and 10KΩ, respectively. While \( g_m \) drops with increasing temperature at a rate of approximately 0.5% per degree Celsius, the resistance increases at about 10Ω per degree Celsius.

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

\[
\begin{align*}
\text{determine} & \\
\text{(a) the } \beta \text{ of the feedback network (5 pts)} & \\
\text{(b) the temperature sensitivity of the non-feedback amplifier's voltage gain (5 pts)} & \\
\text{(c) the temperature sensitivity of the feedback amplifier's voltage gain (5 pts)} & \\
\end{align*}
\]

\[
\begin{align*}
(\text{a}) & \\
\beta & = \left. \frac{v_2}{v_1} \right|_{T=25^\circ C} = \frac{100\text{KΩ}}{1\text{KΩ}} = 1 \text{ or } 100 \\

(\text{b}) & \\
S_T^V & = \frac{T}{\Delta T} = \frac{1}{\Delta T} \\
S_T^V & = \frac{25}{100} \left( \frac{99.6 - 100}{26 - 25} \right) = -0.1 = -10\% \\

(\text{c}) & \\
S_T^{AV} & = \frac{S_T^V}{\beta} \\
\Delta V & = 1\times\beta A = 1+\left( \frac{1}{100} \right) (100) = 10.09 \\

S_T^{AV} & = -10\% \\
S_T & = -10\% \\
\end{align*}
\]
4. (BONUS) Draw a schematic diagram of a circuit that approximates the feedback amplifier described in problem 3. (5 pts)

Since $A_u = +g_m R_0$, the amplifier must be a common gate. A possible implementation would be:

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\[ \text{Vin} \quad \overset{R_s}{\rightarrow} \quad \overset{R_o=10k\Omega}{\rightarrow} \quad \text{Oup} \]
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\[ 1M\Omega \quad 1M\Omega \quad 100k\Omega \quad 1 \]