FEEDBACK AMPLIFIER PROBLEMS

1.) Use the concepts of negative feedback to design $R_D$ and $R_S$ so that if $g_m$ varies by $\pm 50\%$ that the voltage gain, $V_2/V_1$, is equal to $-10 \pm 10\%$. The nominal value of $g_m = 2 \times 10^{-3}$ mhos and $r_d$ is infinite. (Answer: $R_D = 25$ kilohms and $R_S = 2$ kilohms)

2.) A single-loop feedback circuit is shown. Solve for the input resistance defined as $R_{in} = V_1/I_1$ for the element values shown. (Answer: $R_{in} \approx 10^9$ ohms)

3.) Find the output impedance of the circuit shown where this impedance is designated as $R_{out}$. Assume that $r_d$ is infinite and that $g_m = 5 \times 10^{-3}$ mhos. (Answer: $R_{out} = 2.22$ kilohms)
4.) A negative feedback circuit is shown below. Use the techniques of feedback analysis to analyze this circuit and find the voltage gain, \( \frac{V_2}{V_1} \), the current gain, \( \frac{I_2}{I_1} \), the input resistance, \( \frac{V_1}{I_1} \), and the output resistance, \( \frac{V_2}{I_2} \). Assume that \( r_{mi} = 1 \text{k} \) and \( B = 100 \) for both transistors. Ignore \( r_o \) and \( r_u \).

(Answer: \( \frac{V_2}{V_1} = 2.94 \), \( \frac{I_2}{I_1} = -1874 \), \( \frac{V_1}{I_1} = 6.376 \text{ M} \), \( \frac{V_2}{I_2} = 80.43 \text{ k} \))

5.) Use the methods of opening the feedback loop to find \( R_{in} \), \( \frac{V_2}{V_1} \), and \( R_{out} \) of the circuit shown. Assume the \( g_m = 3 \times 10^{-3} \text{ mhos} \), \( r_d \) is infinite, \( B = 100 \) and \( r_{in} = 1000 \text{ ohms} \).

(Answer: \( \frac{V_2}{V_1} = 20.12 \), \( R_{in} = 1 \text{ M} \), \( R_{out} = 280 \text{ k} \))
6.) A feedback amplifier using BJT's is shown below.

a.) What type of single loop feedback topology is this circuit?
Identify the variables \( X_s, X_f, X_k, \) and \( X_0 \) with regard to their location in the circuit and whether they are voltages or currents.
(Answer: voltage series)

b.) Assume that the open loop gain is much greater than unity and find an approximate value for \( V_o/V_{in} \).
(Answer: 100)

c.) Calculate the voltage gain, \( V_o/V_{in} \), using the methods of opening the feedback loop and calculating A and B. Do not assume that the loop gain is greater than unity.
(Answer: 79.67)

d.) Calculate \( R_{in} \) and \( R_{out} \) of this circuit.
(Answer: \( R_{in}=63.98 \, k\Omega \), \( R_{out}=164\Omega \))

(Answer: \( r_{\pi 1}=r_{\pi 2}=r_{\pi 3}=1\, k\Omega \) \( B_1=B_2=B_3 = 50 \))

7.) Use the concepts of feedback analysis to find \( V_2/V_1, V_1/I_1=R_{in}, \) and \( V_2/I_2=R_{out}. \)
Do not assume that the open loop gain is much greater than unity. Assume that all transistors are identical with \( B=100 \) and \( r_o=r_d=∞ \) and \( I_{C1}=0.6\, mA, \) \( I_{C2}=1\, mA, \) and \( I_{C3}=4\, mA. \)
(Answer: \( V_2 = 50, 21, R_{in}=3.187\, M\Omega, \) \( \frac{V_2}{V_1} \)
\( R_{out} = 600\Omega \)})
8.) A two stage feedback circuit is shown below. Assume that both transistors are identical and have a $B=100$ and an $r_n=1000$ ohms. Use the methods of feedback analysis to find: $B$, $A_f$, $R_{in} = V_1/I_1$, $R_{out} = V_2/I_1$, and $V_2/V_1$.

(Answer: $A = 0.04975$ mhos, $B = 2K\Omega$, $A_f = 4.95 \times 10^{-4}$ mhos, $R_0 = 10K\Omega$, $V_2 = -4.9$, $R_{in} = 20M\Omega$)

9.) A feedback circuit is shown. Do not assume that the loop gain is much greater than unity. Find $V_2/I_1$, $R_{in}$, and $R_{out}$. Assume that $r_n = 1000$ ohms, $B = 100$, $g_m = .001$ mhos, and $r_d = \infty$.

(Answer: $\frac{V_2}{I_1} = -34,400\Omega$, $R_{in} = 643\Omega$, $R_{out} = 10K\Omega$)

10.) A feedback circuit is shown. Do not assume that the loop gain is much greater than unity. Find $V_2/V_1$, $R_{in} = V_1/I_1$, and $R_{out} = V_2/I_2$. Assume all transistors are identical and have $B = 100$ and $r_n = 1000$ ohms. (Answer: $\frac{V_2}{V_1} = 100.79$, $R_{in} = 1K\Omega$, $R_{out} = 10K\Omega$)
11.) For the feedback network shown find \( V_o/V_g, R_{in}, \) and \( R_{out} \). Assume that \( r_{m1}=r_{m2}=r_{m3}=1000 \) ohms and \( B_1=B_2=B_3=100 \).

(Answer: \( \frac{V_o}{V_g} = -20.0 \), \( R_{in} = 1000.03 \) ohms, \( R_{out} = 0.126 \) ohms)

12.) A single loop negative feedback circuit is shown. Assume that \( B=100 \), \( r_m=1000 \) ohms, and that \( r_u=r_o=0 \) for all BJT's and that \( g_m=1\times10^{-3} \) mhos and \( r_d \) is infinite for the JFET. Do not assume that the loop gain is much greater than one. Use the methods of opening the feedback loop and identify \( \chi_S, \chi_I, \chi_F, \) and \( \chi_o \); find values for \( A \) and \( B \); and solve for \( V_{out}/V_{in}, R_{in}, \) and \( R_{out} \).

(Answer: \( A=9.09 \times 10^6 \) ohms, \( B= -10^{-5} \) mhos, \( \frac{V_{out}}{V_{in}} = 98.912 \), \( R_{in} = 1000.1 \) ohms, \( R_{out} = 98.87 \) ohms)
13.) A negative feedback circuit is shown. Do not assume that the loop gain is greater than one and use the methods of opening the loop to calculate a value of $\frac{V_2}{V_1}$ and $R_{in}=\frac{V_1}{I_1}$. Assume that $A_B=100$, $r_\pi=1000$ ohms, $g_m=10^{-3}$ mhos, and $r_{ds}=\infty$. 

(Answer: $\frac{V_2}{V_1} = 5.025$, $R_{in} = 10.187$ ohms)

14.) The negative feedback amplifier shown has the current-shunt topology. Do not assume that $A_B>1$ and use the methods of opening the feedback network to calculate $A$ and $\beta$ and numerically evaluate $\frac{V_2}{V_1}$, $R_{in}$, and $R_{out}$. Assume both transistors are identical and have $B=100$ and $r_\pi = 1000$ ohms.

(Answer: $\frac{V_2}{V_1} = 1.0007 \times 10^5$, $R_{in} = 0.1$ ohms, $R_{out} = 10K$ ohms)
15.) A two stage feedback circuit is shown below. Assume that both JFET's are identical and have a $g_m = 10^{-3}$ mhos and $r_d = \infty$. Use the methods of feedback analysis to find $A$, $\beta$, $A_f$, $R_{in} = \frac{V_1}{I_1}$, $R_{out} = \frac{V_2}{I}$, & $\frac{V_2}{V_1}$.

(Answer: $A = -334$, $B = -\frac{1}{101}$, $A_f = -77.47$, $\frac{V_2}{V_1} = 33.4$, $R_{in} = 23.29K$ ohms, $R_{out} = 10K$ ohms)

16.) In the feedback circuit shown, assume that all the transistors are equal with $\beta = 100$, $r_m = 1000$ ohms, and $r_u=r_o=\infty$. Do not assume that the loop gain is much greater than unity. Use the techniques of feedback analysis to find $\frac{V_2}{V_1}$, $R_{in}$, and $R_{out}$.

(Answer: $\frac{V_2}{V_1} = 9.899$, $R_{in} = 1010.1$ ohms, $R_{out} = 10K$ ohms)
17.) For the feedback amplifier shown, find $V_2/V_1$, $I_2/I_1$, $R_{in}$, and $R_{out}$. Assume that Q1 and Q2 are identical with small signal parameters of $r_n = 1000$ ohms and $\beta = 100$. Do not assume that $|A|\gg 1$.

(Answer: $\frac{V_2}{V_1} = 4.805$, $R_{in} = 1000.476$ ohms, $R_{out} = 1K$ ohms)

18.) For the circuit shown, assume that the $\beta$'s of all BJT's and the $g_m$ of all JFET's are very large, approaching infinity. Assume further that $h_i$'s are zero and that $r_d$ is infinite. Identify the topology, label the variables $X_5$, $X_i$, $X_f$, and $X_0$ where $X$ is a voltage or current, and find the approximate gain if a.) $R_2$ is the load resistor and b.) $R_3$ is the load resistor.

(Answer: a.) $\frac{I_0}{I_1} = 1$, b.) $\frac{V_0}{V_1} = 1$)

\[ \text{Diagram of circuit} \]
19.) For the circuit shown, assume that the $\beta$ of all BJTs and the $g_m$ of all JFETs are very large, approaching infinity. Assume further that $r_\pi$'s are zero and that $r_d$ is infinite. Identify the topology, label the variables $X_S, X_I, X_F$, and $X_0$ where $X$ is a voltage or current, and find the approximate gain if a.) $R_4$ is the load resistor and b.) $R_5$ is the load resistor.

(Answer: a.) $I_O = R_1$, b.) $V_O = R_1$)

20.) A negative feedback circuit is shown. You are to use the assumption that $A_\beta >> 1$.

1. Find the approximate value of the DC output voltage, $V_{Out}(DC)$. (Answer: 11.3V)

2. Find the approximate AC voltage gain, $V_{out}/V_{in}$. (Answer: 9)

3. Give an estimate of the open loop forward gain of this circuit if all the transistors have an $\beta = 100$. (Answer: $A = 6230$)

4. If $1/(R_1C_1) << 1/(R_2C_2)$, find the lower -3dB frequency and the upper -3dB frequency. (Answer: $f_{-3dB \ (lower)} = 15.9 \ Hz$, $f_{-3dB \ (upper)} = 15.9 \ kHz$)