EEC 103

Assignment-5

Feedback Amplifiers

1. A negative feedback amplifier has a closed loop gain $A_f = 100$ and an open loop gain $A = 10^5$. What is the feedback factor β? If a manufacturing error results in a reduction of A to 10^3, what closed loop gain results? What is the percentage change in A_f corresponding to this factor of 100 reduction in A?

2. Consider the feedback amplifier configuration of figure 1. Assume the op-amp has infinite input resistance and zero output resistance. Calculate β. If $A = 100$, what is the closed Loop gain? What is the gain in dB?

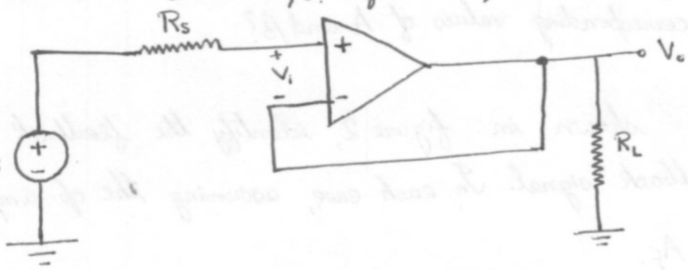

Figure 1

3. Consider the usual circuit configuration of a negative feedback amplifier. Find the relationship between A and β for which the sensitivity of closed loop gain to open loop gain – i.e. $(dA_f/A_f)/(dA/A)$ is −20dB. For what value of $A\beta$ does the sensitivity become ½?

4. It is required to design an amplifier with a gain of 100 that is accurate to within ±1%. You have available amplifier stages with a gain of 1000 that is accurate to within ± 30%. Provide a design that uses a number of these gain stages in cascade with each stage employing negative feedback of an appropriate amount.

5. In a feedback amplifier for which $A = 10^4$ and $A_f = 10^3$ what is the gain desensitivity factor? Find the gain A_f exactly and approximately when A drops by 10% and A drops by 40%.

6. A particular amplifier has a nonlinear transfer characteristic that can be approximated as follows:
   (a) for small input signals, $|V_I| \le 10\,mV$, $V_o/V_I = 10^3$.
   (b) for intermediate input signals, $10\,mV \le |V_I| \le 50\,mV$, $V_o/V_I = 10^2$.
   (c) for large input signals, $|V_I| \ge 50\,mV$, the output saturates. If the amplifier is connected in a negative feedback loop, find the feedback factor β that reduces the factor of 10 change in gain (occurring at $|V_I| = 10\,mV$) to only a 10% change. What is the transfer characteristic of the amplifier with feedback?

7. A series shunt feedback amplifier represented by the standard configuration uses an ideal basic voltage amplifier and operates with $V_s = 100\,mV$, $V_f = 90\,mV$ and $V_o = 10\,V$. Calculate A and β.

8. A shunt series feedback amplifier uses an ideal basic current amplifier and operates with $I_s = 100\mu A$, $I_f = 90\mu A$ and $I_o = 10mA$. Calculate A and β.

9. A series series feedback amplifier using an ideal transconductance amplifier operates with $V_s = 100mV$, $V_f = 95mV$ and $I_o = 10mA$. What are the corresponding values of A and β?

10. A shunt shunt feedback amplifier using an ideal transresistance amplifier operates with $I_s = 100\mu A$, $I_f = 95\mu A$ and $V_o = 10V$. What are the corresponding values of A and β?

11. For each of the op-amp circuits shown in figure 2, identify the feedback topology, the output variable being sampled and the feedback signal. In each case, assuming the op-amp to be ideal, find an expression for β and hence A_f.

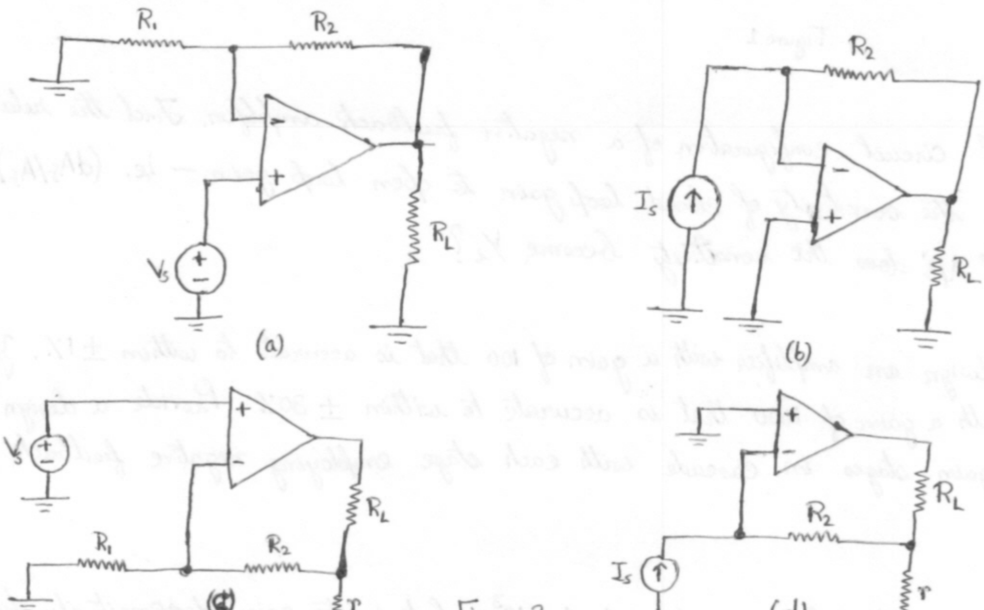

Figure 2

12. A series shunt feedback amplifier employs a basic amplifier with input and output resistances each of $1k\Omega$ and gain $A = 1000 V/V$. The feedback factor $\beta = 0.1 V/V$. Find the gain A_f, input resistance R_i, and the output resistance R_o of the closed loop amplifier.

13. A series shunt feedback circuits employs a basic voltage amplifier that has a dc gain of $10^4 V/V$ and an STC frequency response with a unity-gain frequency of 1MHz. The input resistance of the basic amplifier is $10K\Omega$ and its output resistance is $1K\Omega$. If the feedback factor $\beta = 0.1 V/V$, find the input impedance Z_{if} and the output impedance Z_{of} of the feedback amplifier. Give equivalent circuit representations of these impedances. Also find the value of each impedance at $10^3 Hz$ and at $10^5 Hz$.

14. A feedback amplifier utilizing voltage sampling and employing a basic voltage amplifier with a gain of 100 and an output resistance of 1000Ω has a closed loop output resistance of 100Ω. What is the closed loop gain? If the basic amplifier is used to implement a unity gain voltage buffer, what output resistance do you expect?

15. A series-series feedback amplifier employs a transconductance amplifier having $G_m = 100\ mA/V$, input resistance of $10K\Omega$ and output resistance of $100K\Omega$. The feedback network has $\beta = 0.1\ V/mA$, an input resistance (with port 1 open circuited) of 100Ω, and an input resistance (with port 2 open circuited) of $10K\Omega$. The amplifier operates with a signal source having a resistance of $10K\Omega$ and with a load resistance of $10K\Omega$. Find A_f, R_{in} and R_{out}.

16. A transresistance amplifier having an open circuit "gain" of $100\ V/mA$, an input resistance of $1K\Omega$, and an output resistance of $1K\Omega$ is connected in a negative feedback loop employing a shunt-shunt topology. The feedback network has an input resistance (with port 1 short circuited) of $10K\Omega$ and an input resistance (with port 2 short circuited) of $10K\Omega$ and provides a feedback factor $\beta = 0.1\ mA/V$. The amplifier is fed with a current source having $R_s = 10K\Omega$, and a load resistance $R_L = 1K\Omega$ is connected at the output. Find the transresistance A_f of the feedback amplifier, its input resistance R_{in} and its output resistance R_{out}.

17. Negative feedback is to be used to modify the characteristics of a particular amplifier for various purposes. Identify the feedback topology to be used if:
(a) Input resistance is to be lowered and output resistance raised.
(b) Both input and output resistances are to be raised.
(c) Both input and output resistances are to be lowered.

18. Consider the circuit in figure 3. Use the feedback method to find the voltage gain V_o/V_s, the input resistance R_{in} and the output resistance R_{out}. The op-amp has open loop gain $\mu = 10^4\ V/V$, $R_{id} = 100K\Omega$ and $r_o = 1K\Omega$.

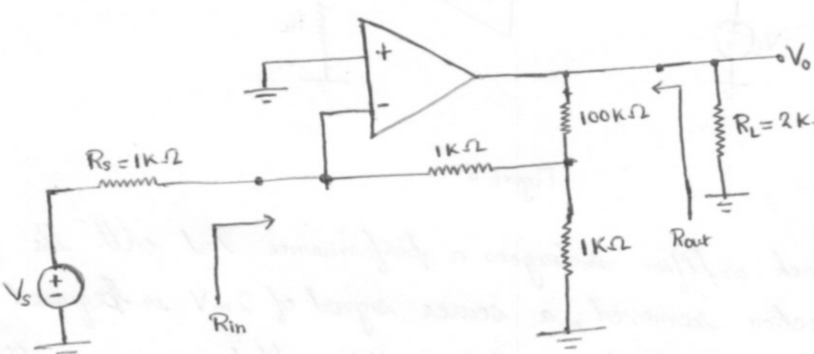

Figure 3

19. A current amplifier with a short circuit current gain of $100\ A/A$, an input resistance of $1K\Omega$ and an output resistance of $10K\Omega$ is connected in a negative feedback loop employing the shunt series topology. The feedback network provides a feedback factor $\beta = 0.1\ A/A$. Lacking complete data about the situation, estimate the current gain, input resistance and output resistance of the feedback amplifier.

20. Figure 4 shows how a shunt series feedback amplifier can be employed to design a current amplifier using op-amp.

(a) Show that for large loop gain, the current gain is approximately given by $\frac{I_o}{I_s} \simeq 1 + \frac{R_F}{r}$.

(b) Find the closed loop gain I_o/I_s, the input resistance (excluding R_s), and the output resistance (excluding R_L) for the case: open loop voltage gain of op-amp $= 10^4$ V/V, $R_{id} = 100\,k\Omega$, op-amp output resistance $= 1\,k\Omega$, $R_s = R_L = 10\,k\Omega$, $r = 100\,\Omega$ and $R_f = 1\,k\Omega$.

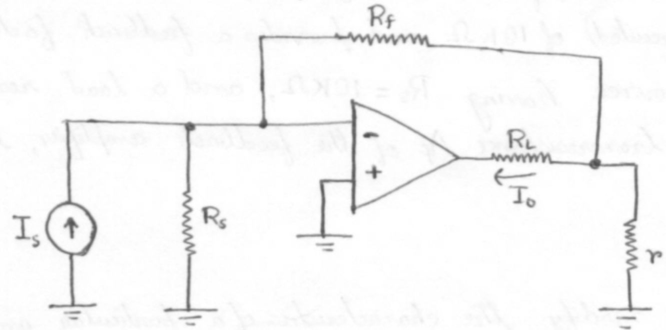

Figure 4.

21. Consider the circuit in figure 5. Show that, if the loop gain is large, the voltage gain is approximately given by $\frac{V_o}{V_s} \simeq -\frac{R_f}{R_s}$.

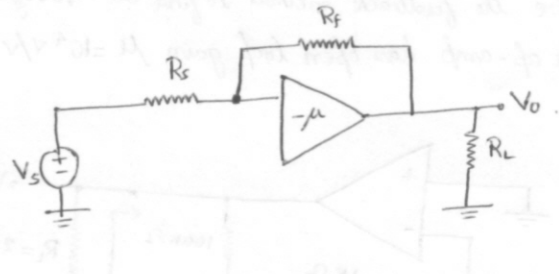

Figure 5

22. A newly constructed feedback amplifier undergoes a performance test with the following results: With the feedback connection removed, a source signal of 2mV is required to provide a 10V output to the load; with the feedback connected, a 10V output requires a 200mV source signal. For this amplifier, identify values of A, β, Aβ, the closed loop gain and the amount of feedback (in dB).