Problem 9.38

(a) This circuit has negative series voltage feedback with $\beta = \frac{v_f}{v_o} = \frac{-R_2}{R_1 + R_2}$. (The minus sign is due to the reference polarity for $v_f$ shown in Figure P9.38.) Also notice that the open-loop amplifier gain is negative. For very large loop gain, the amplifier tends toward an ideal voltage amplifier with $A_{vf} = 1/\beta = -1 + R_1/R_2$, the input impedance approaches infinity, and the output impedance approaches zero.

(b) This circuit has negative series current feedback with $\beta = \frac{v_f}{i_o} = \frac{-R}{5}$. (The minus sign is due to the reference polarity for $v_f$ shown in Figure P9.38.) Also notice that the open-loop amplifier gain is negative. For very large loop gain, the amplifier tends toward an ideal transconductance amplifier with $Gmf = 1/\beta = -5/R$, the input impedance approaches infinity, and the output impedance approaches infinity.

(c) This circuit has negative parallel current feedback with $\beta = \frac{i_f}{i_o} = \frac{-R_1}{R_1 + R_2}$. (The minus sign is due to the reference direction for $i_f$ and $i_o$ shown in Figure P9.38.) Also notice that the open-loop amplifier gain is negative. For very large loop gain, the amplifier tends toward an ideal current amplifier with $A_{if} = 1/\beta = -(1 + R_2/R_1)$, the input impedance approaches zero, and the output impedance approaches infinity.

(d) This circuit has negative series voltage feedback with

$$\beta = \frac{v_f}{v_o} = \frac{R_2 \parallel (R_1 + R_2)}{R_1 + R_2 \parallel (R_1 + R_2)} \times \frac{R_2}{R_1 + R_2} = \frac{R_2^2}{R_1 + 3R_1R_2 + R_2^2}$$

where as usual $R_2 \parallel (R_1 + R_2)$ denotes the parallel combination of $R_2$ and $(R_1 + R_2)$. For very large loop gain, the amplifier tends toward an ideal voltage amplifier with $A_{vf} = 1/\beta = 1 + 3(R_1/R_2)^2 + (R_1/R_2)^2$, the input impedance approaches infinity, and the output impedance approaches zero.
Here is a suitable circuit configuration:

By repeated application of the current divider principle, we have

\[ \beta = \frac{i_f}{i_o} = -\frac{R_2}{R_1 + \frac{R_2}{R_3 + (R_1/R_2) + R_4}} \]

One set of resistances that meets the objective is \( R_1 = 909 \) \( \Omega \), \( R_2 = 100 \) \( \Omega \), \( R_3 = 909 \) \( \Omega \), and \( R_4 = 113 \) \( \Omega \). Many other correct solutions exist.

To attain a nearly ideal voltage amplifier, we should use series voltage feedback. A suitable circuit configuration is

Because \( A_{vf} = 1/\beta \) we want \( R_1/(R_1 + R_2) = \beta = 0.01 \). To avoid problems with loading, we want \( R_1 \ll R_i \) and \( R_1 + R_2 \gg R_o \). A good choice is \( R_1 = 1 \) k\( \Omega \) and \( R_2 = 100 \) k\( \Omega \). Using the formulas of Table 9.1 we have:
\[ A_{vf} = A_v / (1 + A_v \beta) = 5000 / [1 + 5000(1/101)] = 99.0 \]
\[ R_{if} = R_i (1 + A_v \beta) = 5.05 \text{ M} \Omega \]
\[ R_{of} = R_o / (1 + A_v \beta) = 0.99 \text{ } \Omega \]

Using a PSpice transfer function analysis yields:
\[ A_{vf} = 98.86 \quad R_{if} = 4.82 \text{ M} \Omega \quad R_{of} = 1.01 \text{ } \Omega \]

(The formulas in Table 9.1 do not account for loading effects of the feedback network and are therefore approximate.)

**Problem 9.50**

(a) To increase input resistance and reduce output resistance, we need to use negative series voltage feedback. Neglecting loading, we have

\[ R_{if} = (1 + A_v \beta) R_i = (1 + 5000 \beta) 100 \text{ k} \Omega = 1 \text{ M} \Omega. \]

Solving we determine that \( \beta = 1.8 \times 10^{-3} \).

(b) A suitable circuit configuration is:

![Circuit Diagram]

To avoid loading, we want \( R_2 \ll R_i \) and \( R_1 \gg R_o \). A suitable choice of 1%-tolerance resistors is \( R_2 = 1 \text{ k} \Omega \) and \( R_1 = 549 \text{ k} \Omega \).