## A7.0 FEEDBACK RESISTORS AND AMPLIFIER NOISE

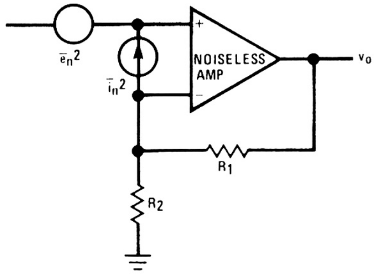


**FIGURE A7.1 Practical Feedback Amplifier**

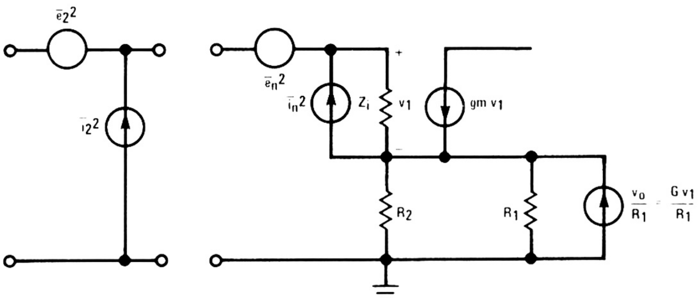


**FIGURE A7.2 Model of First Stage of Amplifier**

To see the effect of the feedback resistors on amplifier noise, model the amplifier of Figure A7.1 as shown in Figure A7.2.

We must now show that the intrinsic noise generators $\overline{e_n}^2$ and $\overline{i_n}^2$ are related to the noise generators outside the feedback loop, $\overline{e_2}^2$ and $\overline{i_2}^2$. In addition, the output noise at $v_O$ can be related to $v_1$ by the open loop gain of the amplifier G, i.e.,

$$v_O = v_1 G$$

Thus $v_1$ is a direct measure of the noise behavior of the amplifier. Open circuit the amplifier and equate the effects of the two noise current generators. By superposition:

$$v_1 = i_2 Z_i$$

also $\quad v_1 = i_n Z_i$

$$\therefore\ \overline{i_n}^2 = \overline{i_2}^2$$

Short circuit the input of the amplifier to determine the effect of the noise voltage generators. To do this, short the amplifier at $\overline{e_2}^2$ and determine the value of $v_1$, then short circuit the input at $\overline{e_n}^2$ and find the value of $v_1$.

$$e_2 = v_1 + R_1 \| R_2 \left(gm\, v_1 + \frac{G v_1}{R_1}\right)$$

$$v_1 = e_2 \frac{1}{1 + gm\, R_1\|R_2 + G \dfrac{R_1\|R_2}{R_1}} \tag{A7.1}$$

Now short the input at $\overline{e_n}^2$; $\overline{e_n}^2$ and $\overline{i_n}^2$ both affect $v_1$.

$\overline{e_n}^2$ gives:

$$v_1 = e_n \frac{1}{1 + gm\, R_1\|R_2 + G \dfrac{R_1\|R_2}{R_1}} \tag{A7.2}$$

$\overline{i_n}^2$ gives:

$$-v_1 = Z_i \| R_1 \| R_2 \left(gm\, v_1 + G \frac{v_1}{R_1} - i_n\right)$$

Assume $Z_i \gg R_1 \| R_2$

$$v_1 = \frac{i_n R_1\|R_2}{1 + gm\, R_1\|R_2 + G \dfrac{R_1\|R_2}{R_1}} \tag{A7.3}$$

Add Equations (A7.2) and (A7.3) and equate to Equation (A7.1):

$$\frac{\overline{e_n}^2 + \overline{i_n}^2 (R_1\|R_2)^2}{\left(1 + gm\, R_1\|R_2 + G \dfrac{R_1\|R_2}{R_1}\right)^2} =$$

$$\frac{\overline{e_2}^2}{\left(1 + gm\, R_1\|R_2 + G \dfrac{R_1\|R_2}{R_1}\right)^2}$$

$$\therefore\ \overline{e_2}^2 = \overline{e_n}^2 + \overline{i_n}^2 (R_1\|R_2)^2.$$