5.40 The inverting amplifier in the circuit in Fig. P5.40 has an input resistance of 400 kΩ, an output resistance of 2 kΩ, and an open-loop gain of 500,000. Assume that the amplifier is operating in its linear region.

a) Calculate the voltage gain (v_o/v_g) of the amplifier.

b) Calculate the value of v_n in microvolts when $v_g = 50$ mV.

c) Calculate the resistance seen by the signal source (v_g).

d) Repeat (a)–(c) using the ideal model for the op amp.

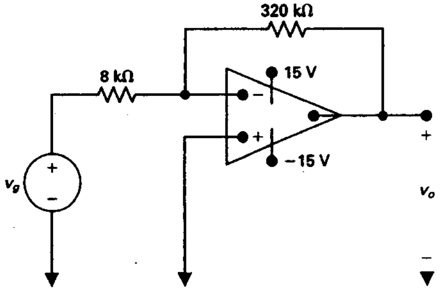
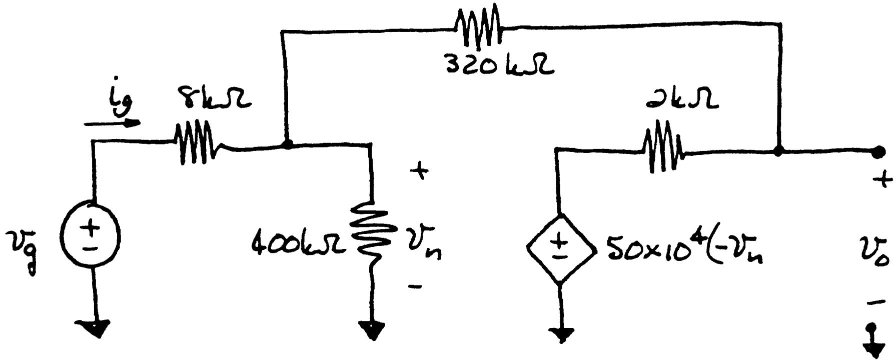


Figure P5.40

P 5.40 [a]



$$\frac{v_n}{400} + \frac{v_n - v_g}{8} + \frac{v_n - v_o}{320} = 0$$

$$\therefore \quad 41.8v_n - v_o = 40v_g$$

$$\frac{v_o - 500{,}000(-v_n)}{2} + \frac{v_o - v_n}{320} = 0$$

$$\therefore \quad 80 \times 10^6 v_n + 161 v_o = 0$$

$$\Delta = \begin{vmatrix} 41.8 & -1 \\ 80 \times 10^6 & 161 \end{vmatrix} = 80{,}006{,}729.8$$

$$N_o = \begin{vmatrix} 41.8 & 40v_g \\ 80 \times 10^6 & 0 \end{vmatrix} = -32 \times 10^8 v_g$$

$$v_o = \frac{N_o}{\Delta} = -39.997v_g; \qquad \text{so } \frac{v_o}{v_g} = -39.997$$

[b] $$N_1 = \begin{vmatrix} 40v_g & -1 \\ 0 & 161 \end{vmatrix} = 6440v_g$$

$$v_n = \frac{N_1}{\Delta} = 8.05 \times 10^{-5} v_g$$

$$v_g = 50\,\text{mV}, \qquad v_n = 4.02\,\mu\ \text{V}$$

[c] $$i_g = \frac{v_g - v_n}{8} = \frac{v_g - 8.05 \times 10^{-5} v_g}{8}$$

$$R_g = \frac{v_g}{i_g} = \frac{v_g}{v_g - 8.05 \times 10^{-5} v_g} \cdot (8000) = 8000.644\Omega$$

[d] $$\frac{v_o}{v_g} = -40; \qquad v_n = 0\ \text{V}; \qquad R_g = 8000\,\Omega$$