

### Assignment #3

**1-33.** Design an inverting amplifier with voltage gain  $\approx -5.6$  and an input resistance  $\approx 10 \text{ k}\Omega$  using an OP27 OpAmp. The OP27 has the following typical performance parameters:

Input resistance --  $2 \text{ G}\Omega$   
Voltage gain --  $1.5 \text{ MV/V}$   
Output resistance --  $70 \Omega$

Determine the variation from the ideal design goals due to the non-ideal properties of the OP27 OpAmp.

Solution: MathCAD

**#1-33**

$R_f := 56000$     $R_S := 10000$     $R_i := 2 \cdot 10^9$     $R_o := 70$     $A := 1.5 \cdot 10^6$

Guess

$v_{1\_vi} := 1$     $vo\_vi := -1$

Given

$$\frac{1}{R_S} = v_{1\_vi} \cdot \left( \frac{1}{R_S} + \frac{1}{R_f} + \frac{1}{R_i} \right) - vo\_vi \cdot \left( \frac{1}{R_f} \right)$$

$$0 = v_{1\_vi} \cdot \left( \frac{A}{R_o} - \frac{1}{R_f} \right) - vo\_vi \cdot \left( \frac{1}{R_f} + \frac{1}{R_o} \right)$$

$a := \text{Find}(v_{1\_vi}, vo\_vi)$     $v_{1\_vi} := a_0$     $vo\_vi := a_1$   
 $v_{1\_vi} = -3.73802 \times 10^{-6}$     $vo\_vi = -5.60002$

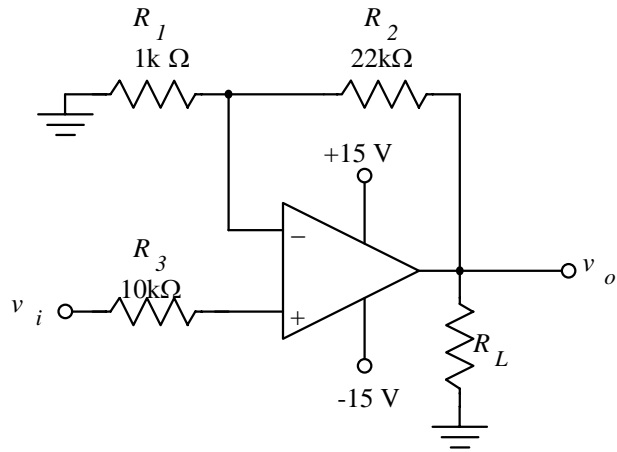
$$\text{variation\_percent} := \frac{-5.6 - (vo\_vi)}{-5.6} \cdot 100 \quad \text{variation\_percent} = -0.00044 \%$$

**1-40.** For the amplifier shown below, determine the values of the load resistor,  $R_L$ , that will lead to gain that deviates from the ideal value by  $-0.01\%$ . Assume the OpAmp has the following properties:

$A_V = 500,000$

$R_i = 1 \text{ M}\Omega$

$R_o = 75 \Omega$



**Solution:** MathCAD

#1-40

The following are circuit and OpAmp parameters:

$$A := 500 \cdot 10^3 \quad R_i := 10^6 \quad R_o := 75$$
$$R_1 := 1000 \quad R_2 := 22 \cdot 10^3 \quad R_3 := 10 \cdot 10^3 \quad R_L := 10^9$$

Confirm the gain of the amplifier using the solve block

Guess

$$v_{li} := 1.001 \quad A_v := 25$$

The two simultaneous equations are:

Given

$$v_{li} \cdot \left( \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_i + R_3} \right) - A_v \cdot \left( \frac{1}{R_2} \right) = \frac{1}{R_i R_3}$$

$$v_{li} \cdot \left[ \frac{-1}{R_2} - \frac{A}{R_o} \cdot \left( -\frac{R_i}{R_i + R_3} \right) \right] + A_v \cdot \left( \frac{1}{R_2} + \frac{1}{R_L} + \frac{1}{R_o} \right) = \frac{A \cdot R_i}{R_o \cdot (R_i + R_3)}$$

Solve for the gain,  $A_v = v_o/v_i$ , and the value of  $v_i$ :

$$\text{Find}(A_v, v_{li}) = \begin{pmatrix} 23.021 \\ 1 \end{pmatrix}$$

So the gain of the amplifier using the simplified OpAmp model is 23.021 which is in good agreement with the results calculated from the ideal model of the OpAmp.

Now find value of  $R_L$  such that gain -0.01% of ideal. That gain is:

$$A_{v\_new} := 0.999923 \quad A_{v\_new} = 22.998$$

Let  $A_v := A_{v\_new}$

Solve for  $R_L$  for  $A_{v\_new} = 22.998$ :

Guess

$$v_{li} := 1 \quad R_L := 75$$

Given

$$v_{li} \cdot \left( \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_i + R_3} \right) - A_v \cdot \left( \frac{1}{R_2} \right) = \frac{1}{R_i R_3}$$

$$v_{li} \cdot \left[ \frac{-1}{R_2} - \frac{A}{R_o} \cdot \left( -\frac{R_i}{R_i + R_3} \right) \right] + A_v \cdot \left( \frac{1}{R_2} + \frac{1}{R_L} + \frac{1}{R_o} \right) = \frac{A \cdot R_i}{R_o \cdot (R_i + R_3)}$$

$$\text{Find}(v_{li}, R_L) = \mathbf{\bullet}$$

So  $R_L = 65.8 \Omega$  for a -0.01% change in gain.