

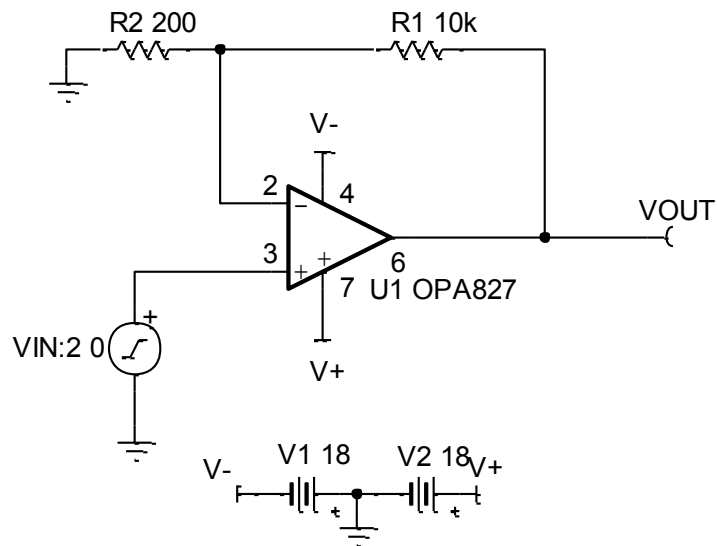
Noise 3

Exercises

TI Precision Labs – Op Amps



1. Find the total noise due to:
 - a. Resistance
 - b. Op amp broadband voltage noise
 - c. Op amp 1/f voltage noise
 - d. Op amp current noise
 - e. Compute the total combined noise.



Noise 3

Solutions

TI Precision Labs – Op Amps



1. Find the total noise due to:
a. Resistance

$$G_n = \frac{R_f}{R_1} + 1 = \frac{10\text{k}\Omega}{200\Omega} + 1 = 51$$

$$f_c = \frac{\text{GBW}}{G_n} = \frac{22\text{MHz}}{51} = 431\text{kHz}$$

$$\text{BW}_n = K_n \cdot f_c = (1.57)(431\text{kHz}) = 677\text{kHz}$$

$$E_N = \sqrt{4k \cdot T \cdot R \cdot \text{BW}_n} = \sqrt{4(1.38 \cdot 10^{-23} \text{ J/K})(298\text{K})(200\Omega)(677\text{kHz})} = 1.49\mu\text{V}$$

b. Op amp broadband voltage noise

$$E_{\text{nBB}} = (e_n)\sqrt{\text{BW}_n} = (3.8 \text{ nV}/\sqrt{\text{Hz}})\sqrt{(677\text{kHz})} = 3.13\mu\text{V rms}$$

c. Op amp 1/f voltage noise

$$e_{\text{nnormal}} = e_{\text{nf}}\sqrt{f_o} = (60 \text{ nV}/\sqrt{\text{Hz}})\sqrt{0.1\text{Hz}} = 19\text{nV}$$

$$E_{\text{nflicker}} = e_{\text{nnormal}} \sqrt{\ln\left(\frac{f_H}{f_L}\right)} = (15.8\text{nV}) \sqrt{\ln\left(\frac{677\text{kHz}}{0.1\text{Hz}}\right)} = 75.3\text{nV rms}$$

d. Op amp current noise

$$e_{ni} = R_{eq} \cdot i_n = (196\Omega)(2.2 \text{ fA}/\sqrt{\text{Hz}}) = 0.00043 \text{ nV}/\sqrt{\text{Hz}}$$

$$E_{ni} = e_{ni} \sqrt{BW_n} = (0.00043 \text{ nV}/\sqrt{\text{Hz}}) \sqrt{677 \text{ kHz}} = 0.353 \text{ nV rms}$$

d. Total combined noise

$$E_{n_total} = \sqrt{E_{nr}^2 + E_{nBB}^2 + E_{nflicker}^2 + E_{ni}^2}$$

$$E_{n_total_in} = \sqrt{(1.477\mu\text{V})^2 + (3.13\mu\text{V})^2 + (75.3\text{nV})^2 + (0.353\text{nV})^2} = 3.46\mu\text{V rms}$$

$$E_{n_total_out} = G_n E_{n_total_in} = (51)(3.56\mu\text{V}) = 177\mu\text{V rms}$$

$$E_{n_total_out_pp} = 6E_{n_total_out} = 6(177\mu\text{V}) = 1.06\text{mVpp}$$