Noise 2

Exercises

TI Precision Labs – Op Amps

1. Assume that an amplifier has a -3dB signal bandwidth of 10kHz.
    a. Assuming a 1st order filter response, what is the noise bandwidth?
    b. Assuming the spectral density given below. What is the total rms voltage flicker noise?
    c. What is the total rms broadband voltage noise.
    d. What is the combined noise from broadband and flicker?

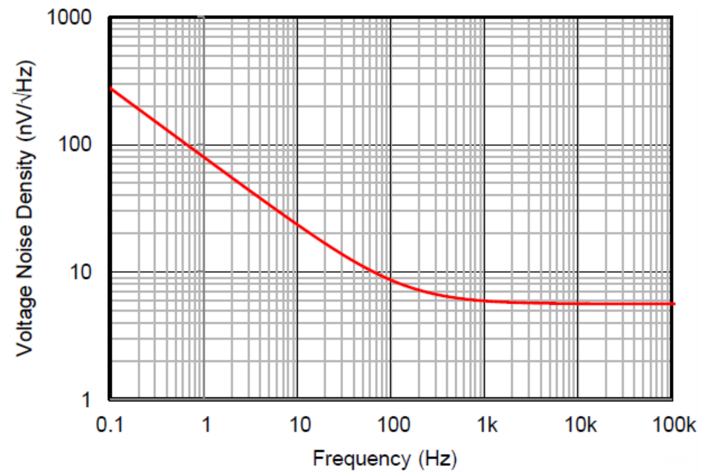

Figure 14. INPUT VOLTAGE NOISE SPECTRAL DENSITY vs FREQUENCY

2. Assume that an amplifier has a 1kHz -3dB signal bandwidth, and spectral density of e_n = 20nV/rtHz.
   a. What is the total rms noise for a 1^{st} order filter?
   b. What is the total rms noise for a 2^{nd} order filter?
   c. What is the total rms noise for a 4^{th} order filter?
   d. What conclusion can you draw from these calculations?

Noise 2

Solutions

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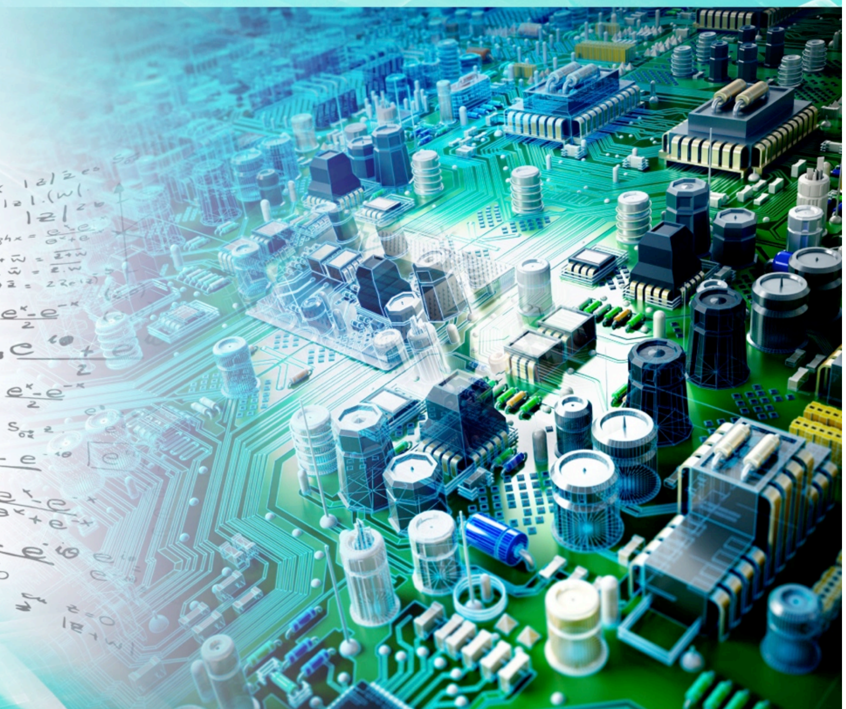

1. **Assume that an amplifier has a -3dB signal bandwidth of 10kHz.**

   a. **Assuming a 1st order filter response, what is the noise bandwidth?**

   $$BW_n = K_n \cdot f_c = (1.57)(10kHz) = 15.7kHz$$

   b. **Assuming the spectral density given below. What is the total rms voltage flicker noise?**

   $$e_{n_{normal}} = e_{nf}\sqrt{f_o} = (300\,nV/\sqrt{Hz})\sqrt{0.1Hz} = 94.8nV$$

   $$E_{n_{flicker}} = e_{n_{normal}} \sqrt{\ln\left(\frac{f_H}{f_L}\right)} = (94.8nV)\sqrt{\ln\left(\frac{15.7kHz}{0.1Hz}\right)} = 328nV$$

   c. **What is the total rms broadband voltage noise.**

   $$E_{bb} = e_{bb}\sqrt{BW_n} = (5\,nV/\sqrt{Hz})\sqrt{(15.7kHz)} = 626nV\ rms$$

   d. **What is the combined noise from broadband and flicker?**

   $$E_{total} = \sqrt{E_{bb}^{\ 2} + E_{n_{flicker}}^{\ \ 2}} = \sqrt{(626nV)^2 + (328nV)^2} = 707nV\ rms$$

2. **Assume that an amplifier has a 1kHz -3dB signal bandwidth, and spectral density of e_n = 20nV/rtHz.**

a. **What is the total rms noise for a 1st order filter?**

$$BW_n = K_n \cdot f_c = (1.57)(1\text{kHz}) = 1.57\text{kHz}$$
$$E_{bb} = e_{bb}\sqrt{BW_n} = \left(20\,\text{nV}/\sqrt{\text{Hz}}\right)\sqrt{(1.57\text{kHz})} = 792\text{nV rms}$$

b. **What is the total rms noise for a 2nd order filter?**

$$BW_n = K_n \cdot f_c = (1.22)(1\text{kHz}) = 1.22\text{kHz}$$
$$E_{bb} = e_{bb}\sqrt{BW_n} = \left(20\,\text{nV}/\sqrt{\text{Hz}}\right)\sqrt{(1.22\text{kHz})} = 698\text{nV rms}$$

c. **What is the total rms noise for a 4th order filter?**

$$BW_n = K_n \cdot f_c = (1.13)(1\text{kHz}) = 1.13\text{kHz}$$
$$E_{bb} = e_{bb}\sqrt{BW_n} = \left(20\,\text{nV}/\sqrt{\text{Hz}}\right)\sqrt{(1.13\text{kHz})} = 672\text{nV rms}$$

d. **What conclusion can you draw from these calculations?**

Increasing the filter order does reduce the total noise because the "skirt" of the filter is steeper and has less area under it. However, the amount of the noise reduction is relatively small. In general, a higher order filter more helpful in reducing extrinsic noise than intrinsic noise.