

Smart Sensors for IoT

Exercise 4 (11.10.2023)

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Problem 1 Thermal Noise

Consider the circuit shown in Fig. 1, with noisy resistors R .

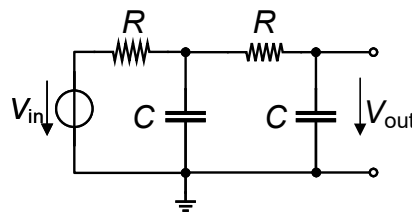


Figure 1: RC -circuit.

Calculate the variance of the thermal noise voltage across V_{out} :

- by simply solving the circuit;
- by applying the Nyquist Theorem (N.B. the derivation of the imaginary part of the output impedance and the solution of the integral can be very tedious, if you can I suggest you to use a mathematics software);
- by applying the Bode Theorem.

Problem 2 Noise of Positive Gain Stage

Consider the example of the Noise of Positive Gain Stage reported in the lecture slides (page 63) and shown in Fig. 2.

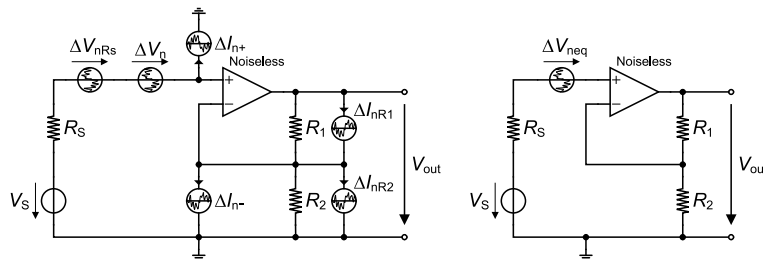


Figure 2: Noise of Positive Gain Stage

- Derive the final result of the equivalent input noise voltage PSD.
- Consider $R_s = 1 \text{ k}\Omega$ and $A = 12$. The noise characteristics of the OpAmp, referred to the input is shown in Fig. 3 where the corner frequency of the input referred noise voltage is 100 Hz and its high frequency value is $3 \times 10^{-16} \text{ V}^2/\text{Hz}$ whereas the corner frequency of the input referred noise current is 1 kHz and its high frequency value is $3 \times 10^{-25} \text{ A}^2/\text{Hz}$. Define the resistors R_1 and R_2 so that their input referred noise at the higher frequency is negligible (that is at least 10 times smaller) with respect to the source resistor R_s .

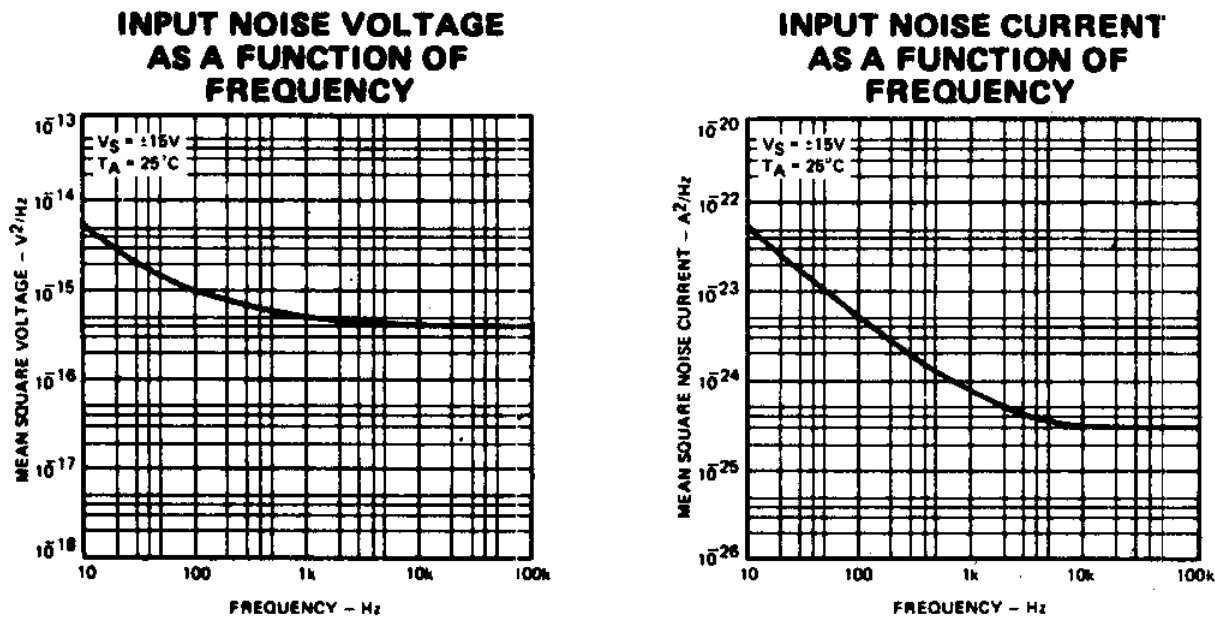


Figure 3: OpAmp noise input characteristics wrt the frequency.

- Calculate numerically the final result of the equivalent input noise voltage PSD.