Measuring systems

Problem set n° 6

Estimating and reducing noise

Exercise 1 (Differential amplifier and uncertainty of the measurement)

A differential amplifier is characterized by a gain A_d and a common mode rejection ratio $CMRR|_{dB}$. We want to use the amplifier in a Wheatstone bridge to amplify the voltage U_{ab} (see Figure 1). The bridge is connected to a voltage source U_s and consists of a strain gauge of resistance R+ΔR and three other resistances *R.* We assume that the input resistance of the amplifier is large compared to the resistances *R*.

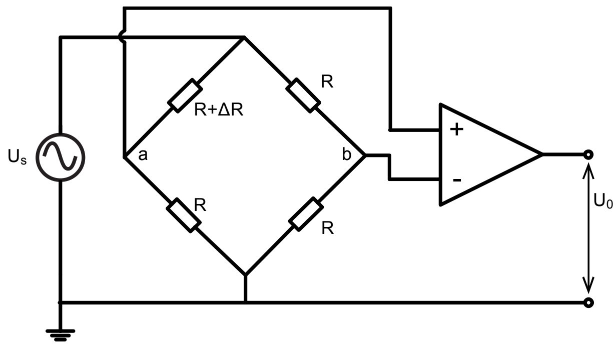

Figure 1: Wheatstone bridge and a differential amplifier

- What is the residual voltage U_o at the output of the differential amplifier when the bridge is in equilibrium, i.e. when the relative variation of resistance $\Delta R/R$ is zero?
- Which value of $\Delta R/R$ ($\varepsilon_{\Delta R/R}$) corresponds to an output voltage equal to U_o? Make a conclusion about the precision of the measurement.

Numerical data :

$CMRR|_{dB} = 80\ dB$ $\qquad A_d = 100$

$U_s = 10\ V$

Exercise 2 (Power and RMS of thermal noise)

a) Considering the resistor network depicted on Figure 2, calculate the total power of thermal noise transmitted to a connected circuit. The ambient temperature is ambient T_a=290 K. Consider bandwidths of Δf_1=3.1 kHz (analogue telephone line) and Δf_2=5MHz (television broadcast).

b) Determine the RMS of voltage due to thermal noise, appearing between the two terminals of the network shown on Figure 1 if the temperature is 290 K and the considered bandwidth is 100 kHz.

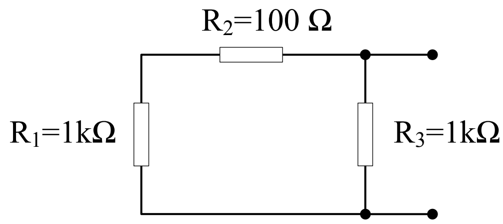

Figure 2: Resistor network

Exercise 3 (Intrinsic noises)

Consider the circuit on Figure 3. We know that the voltage U is a sinusoid with an amplitude $\hat{U}$ and frequency f. Calculate the parasitic voltage e_{nR} between terminals A and B due to intrinsic noises (Johnson noise, shot noise and $1/f$ noise), during the positive and negative alternations respectively, for a bandwidth Δf. You can neglect the voltage drop across the diode itself.

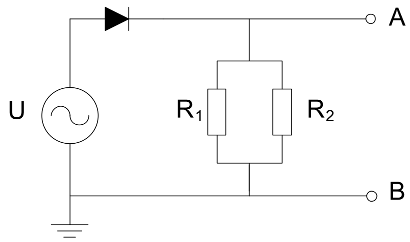

Figure 3 : Electrical circuit

<u>Numeric values:</u>

$\hat{U} = 5\,V$

$f = 50\ Hz$

$\Delta f\ = 10\,Hz - \ 1\,MHz$

$K_{\frac{1}{f}} = 1.7\,fV^2$

$R_1 = 20\,\Omega$

$R_2 = 10\,\Omega$

$T = 25\,°C$