Exercise: Session 8

Exercise 1:

A piezoresistive sensor is mounted in a Wheatstone bridge for measurement of deformation. The gage factor, K varies with the temperature, T (in Kelvin) according to the following relationship: $K = 200e^{-0.005T}$

a) Find an expression for the variation of sensitivity (where the sensitivity is defined as $S = u_o/\varepsilon$) as a function of sensor-temperature.

b) A thermistor R_t is added to the Wheatstone bridge in series as shown in Fig. 1. Calculate the temperature coefficient that the thermistor must have in order to compensate for the change in strain gage sensitivity with temperature (Hint: compensation implies $\frac{\Delta S}{S} = 0$).

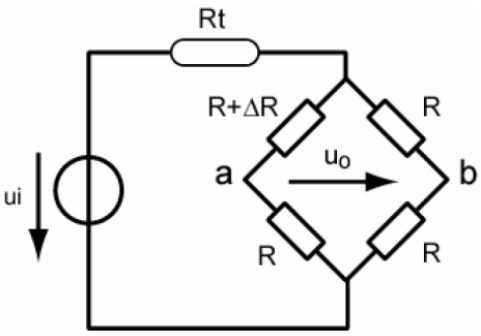
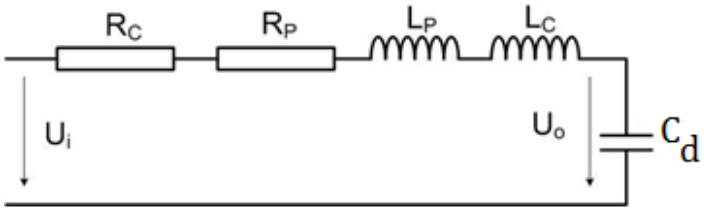


Figure 1

Exercise 2:

A sensor for extravascular pressure measurement (see fig. course) is composed of a catheter of length 1 m and diameter 2 mm filled with water at 20°C.



U_i: total pressure-drop across system ('input voltage')
R_C, L_C: lumped-model resistance and inductance of the un-pinched portion of the catheter, respectively
R_P, L_P: lumped-model resistance and inductance of the pinched portion of the catheter, respectively
C_d: Sensor diaphragm compliance, which is the lumped-model capacitance
U_o: pressure-drop ('voltage') across sensor diaphragm

a) Show that the catheter system is equivalent to a second-order damped system (Hint: write an expression for U_o/U_i).

Given that a pinch along the catheter reduces its diameter by 75%:

b) Calculate the length of the pinch so that the damping coefficient is equal to 0.4
c) Sketch the frequency response of the system with and without pinching, and comment on the respective low-pass cutoff frequencies
d) Discuss if both the systems can correctly measure arterial blood pressure in humans (1 to 3.3 pulse/s), dogs (1.5 to 5 pulse/s) and mice (12 to 22 pulse/s)

Internal radius of the catheter = 0.46 mm, volume modulus of the elasticity of the diaphragm $E_d = 1/C_d = 0.49*10^{15}$ N/m^5, $\rho_{water} = 10^3$ kg/m^3, η_{water}(20°C) = 0.001 Pa.s