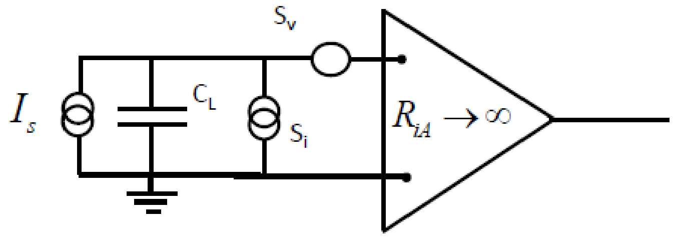
Problema 1



Piezoelectric Sensor of Force	**Force F applied**
A_q= 5pC/N force-to-charge conversion C_S= 500pF total capacitance of sensor and electronic circuit connected (I_s represents the piezoelectric effect in the sensor)	Rectangular pulse waveform with duration T_A = 80ms

Voltage Preamplifier
Input resistance R_{iA} very high > 500 MΩ , to be considered → ∞
Band-limit f_{pa}=20MHz set by single pole
$\sqrt{S_{v,u}} = 4nV/\sqrt{Hz}$ wide-band voltage noise (unilateral)
$\sqrt{S_{i,u}} = 0{,}01pA/\sqrt{Hz}$ wide-band current noise (unilateral);
where stated, consider in S_i and in S_v also *1/f* components with corner frequency f_c=500 Hz

A piezoelectric force sensor, connected to a voltage preamplifier with the characteristics above reported, is employed for measuring the force applied to the sensor. A suitable electrical filtering can be employed at the sensor-amplifier output for improving the sensitivity of the measurement by improving the S/N.

A) Without considering the *1/f* noise components describe and explain the filtering that gives the optimum result in the measurement. Compute the optimum S/N value thus obtained and evaluate the minimum measurable voltage on the sensor, the corresponding minimum piezoelectric charge and the force in Newton.

B) Show how a Gated Integrator can be employed for obtaining a practical approximation of the optimum filtering seen in (A). Discuss how to select the GI setting for getting the best performance with this filtering. Evaluate the minimum voltage on the sensor measurable with the GI filtering, the corresponding minimum piezoelectric charge and the force in Newton. Compare this result with that given by the optimum filter.

C) Consider now also the *1/f* components. With the filtering seen in (B), the output noise receives additional contributions by the *1/f* noise components and it is required to keep them at level lower than or at least comparable to that of the wide-band noise previously computed in (B). Consider first the 1/f component in the current noise, evaluate its contribution and discuss whether it is necessary to introduce a further filtering for limiting the 1/f contribution or not. Consider then the 1/f component in the voltage noise and carry out the same analysis as done for the 1/f current noise.

(NB: see text also on the other side of the sheet)

Problema 2

<table>
<tr><td>RTD Thermoresistance PT100
Reference value at 0°C (273 K) R_{T0} =100 Ω
temperature coefficient $\alpha = 3,9 \cdot 10^{-3}$ /°C
Max dissipation P_d < 50µW</td><td>Si pn Junction Diode Sensors
Current-Voltage Characteristics
$I = I_S \left[\exp\left(\frac{qV}{kT}\right) - 1 \right]$ with $I_s < 0{,}1\,pA = 100\,fA$
Max dissipation P_d< 50µW</td></tr>
<tr><td colspan="2">Differential Preamplifier
Band-limit by a simple pole at f_{pa} = 1 MHz
Effective noise power density
$S_v^{1/2}$ = 80 nV/Hz$^{1/2}$ white (unilateral) and 1/f component with f_c = 20 kHz
$S_i^{1/2}$ = 1 pA/Hz$^{1/2}$ white (unilateral) and 1/f component with f_c = 20 kHz</td></tr>
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For monitoring the operation of a chemical reactor working at room temperature, it is required to measure small temperature variations down to 10 mK occurring in fairly short time intervals, down to 0,1s. Measurement cycles of about 20 minutes are carried out, separated by an interval where controls and regulations of the apparatus can be done. The sensors and preamplifier above reported are available for implementing the measurement apparatus.

A) Consider first to implement the apparatus with sensors operating with DC bias supply. For each type of sensor specified describe the circuit configuration employed, explaining the quantitative selections made (voltage supply for the sensor, etc.). Evaluate for each sensor the conversion factor dV/dT from temperature to output voltage.

B) For both the apparatus considered in Sec.A operating with sensor with DC bias voltage (thermoresistance or junction diode) evaluate the r.m.s. noise and the corresponding minimum measurabile temperature variation ΔT_{min} and compare it with the specified requirement. Carry out the evaluation in two cases: (B1) employing only a reset to zero of the amplifier baseline in the idle interval, without any further filter; (B2) employing also a suitable filter at the preamplifier output for reducing the noise.

C) In order to improve the noise filtering and attain higher sensitivity, consider now to employ a time varying bias on the sensor. For each type of sensor select and explain the time varying bias voltage applied to the sensor, the circuit configuration employed to implement the apparatus and the filtering of the preamplifier output adopted, specifying and explaining the quantitative selections made. Evaluate for each sensor the r.m.s. noise obtained and the corresponding minimum measurabile temperature variation ΔT_{min} .

D) Summarize the results obtained in Sec. B and Sec. C, commenting the essential aspects that explain in intuitive terms how and why satisfactory results can be obtained.