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

Problem 1

Signal

Rectangular pulses

Amplitude: V_P (variable)

Duration: T_P=100µs

Repetition rate: 100Hz

Noise

$S_V^{½} = 10nV/Hz^{1/2}$ white noise spectral density (unilateral)
B/f^2 component, with f_c=20kHz

$f_{pa} = 10\ MHz$ upper band-limit of the preamplifier

The time-varying amplitude V_P of a sequence of rectangular pulses of duration T_P is to be measured for each pulse individually. The signal is read-out by a preamplifier and the total noise superimposed to the signal consists of a wideband component and a B/f^2 component as above specified.

A) Evaluate the minimum measurable amplitude $V_{P,MIN}$ without using any additional filter. Then, describe and explain the ideal filter that makes it possible to measure the pulse amplitude V_P with the best possible Signal-to-Noise ratio and evaluate the minimum amplitude $V_{P,MIN}$ thus measurable.

B) Select a suitable practical filter that is a good approximation of the optimum filter for this signal, select the filter parameters and evaluate the minimum amplitude $V_{P,MIN}$ that can be measured in these conditions. Consider that a sync signal can be provided with the signal, if needed.

C) Consider now the exploitation of a fully digital approach to approximate the optimum filter. Discuss the guidelines to select the sampling frequency and how this choice could have an impact on the Signal-to-Noise ratio. Choose a reasonable value for the sampling frequency and evaluate the minimum amplitude $V_{P,MIN}$ that can be measured in this case.

D) Consider now an additional 1/f noise component superimposed to the two noise components considered so far. Evaluate the maximum corner frequency of the 1/f component that can be tolerated to guarantee a negligible impact of the 1/f noise.

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

Problem 2

STRAIN GAUGE	**PREAMPLIFIER**
R=300Ω G= 2; Max. Power= 3μW	$S_{vA} = 10nV/\sqrt{Hz}$ $f_{pA} = 1MHz$

A metal bar is subject to both compression/extrusion and bending strain. We want to measure only the compression/extrusion strain. To carry out this measurement we have strain gauges with the characteristics reported above.

A) Considering the exploitation of only **two** strain gauges, draw the configuration that you would use to achieve the goal. Provide a quantitative explanation of your design.

B) Evaluate the maximum temperature variation that can be tolerated to have a sensitivity of 50microstrain. Consider a typical temperature dependence for the strain gauges. Discuss if and how it is possible to mitigate this issue if more than two strain gauges can be exploited.

C) Describe into details the weighting function in the time domain and the frequency behavior of a lock-in amplifier with a sinusoidal reference and with a square wave reference.

D) Consider now that the preamplifier is affected by an additional 1/f noise component with a corner frequency f_C=5kHz. Provide a quantitative evaluation of the sensitivity that can be achieved exploiting the two filters discussed in C).