Problem 1

A sensor system emits a signal having a rectangular shape with $\boldsymbol{duration\ T_P = 0.5ms}$ and variable amplitude V_P. The available voltage amplifier has a bandwidth of 100 MHz and input referred noise generator featuring **unilateral** spectral density $\sqrt{S_V} = \frac{10nV}{\sqrt{Hz}}$ and $\frac{1}{f2}$ noise with f_c=1kHz. A sync signal is available.

1) Discuss the best obtainable SNR in these conditions using the optimum filter theory and evaluate the minimum amplitude V_P that could be measured in two cases: (a) using this filter, (b) using a practically feasible filter.

2) Evaluate how it change the answer to point 1) if the amplifier features a $\frac{1}{f}$ noise instead of $\frac{1}{f2}$ but with the same f_c.

3) Both in conditions of point 1) and 2) evaluate how it changes the minimum measurable amplitude if the signal is emitted in a periodic way with period 10ms and the amplitude changes with a timescale of around 1s.

Problem 2

A compression sinusoidal force acts on a steel bar (Young Modulus $22 * 10^4 N/mm^2$, section $6mm^2$) with a period of 100ms (sync available) with a baseline force of 5N. A system based on strain gauges has to be designed to measure the force with high sensitivity. The system is powered on every day and it is active for at least 20 hours. The signal can be read out by a differential amplifier featuring input-referred wideband noise $\sqrt{S_V} = 10\text{nV}/\sqrt{Hz}$ (unilateral spectral density) a single pole at 100MHz and 1/f noise with f_c=10kHz.

1) Design and describe a simple suitable acquisition scheme for this application, providing a quantitative explanation of every choice considering that bending must not affect the measurement and that only constant power supply is available. Evaluate the minimum amplitude of the sinusoidal force that could be measured without any filter.

2) Considering now that the compression force changes on a timescale of 2s, evaluate the minimum amplitude of the sinusoidal force that could be measured. Any filter can be added to the setup explaining the reasons of each choice.

3) Evaluate how it changes the answer to point 2) if it is now possible to use sinusoidal power supply or square wave power supply. Compare the attainable results.