Problem 1

The amplitude V_P of the square wave reported in figure is to be tracked over time. The frequency of the wave is 10MHz, its duty cycle is 50%, and its amplitude slowly varies on a time scale of a few seconds. The signal is readout by a preamplifier featuring a wide bandwidth limited by a single pole (200MHz) and input referred noise having unilateral wideband component ($\sqrt{S_V} = \frac{10nV}{\sqrt{Hz}}$) and $\frac{1}{f^2}$ component ($f_C = 1kHz$). A sync signal is available.

a) Due to electronics limitations, non-constant parameter filters can be used only for a measurement of ten periods. Describe the best filter that you could design in this case and calculate the corresponding minimum measurable value of V_P.

b) Assuming now no predefined limitations to the duration of the measurement, discuss the criteria you would use to acquire the signal of interest. Design a filter, size its parameters and calculate the minimum measurable signal in this new scenario.

c) Consider now a digital acquisition scheme relying on a sampler featuring a maximum sampling frequency of 20Mcounts/s. Describe a digital filtering scheme that could be implemented and the minimum measurable signal thus obtainable.

Problem 2

A mechanical piece is subject to both compression and bending forces. Using strain gauges, we want to study only the bending component which has a maximum frequency of 100Hz. The available amplifier is characterized by a single pole (f_P=100MHz) and two input-referred noise sources with unilateral spectral densities $S_V = \left(\frac{2nV}{\sqrt{Hz}}\right)^2$ and $S_I = \left(\frac{1pA}{\sqrt{Hz}}\right)^2$. The readout electronics is biased at 3.3V.

a) Design, size and describe a suitable measurement setup. Quantify the minimum measurable strain assuming that one strain gauge can dissipate a maximum of 0.1mW.

b) Assuming that there is also a 1/f component with a corner frequency of 1kHz and that the measurement can last 1h, check what the effect is on the minimum measurable strain being able to use only a continuous power supply. Explain in detail from a theoretical point of view how the result was obtained and under what assumptions.

c) Supposing now to be able to modulate the supply voltage, calculate how the answer to point b changes, also providing a detailed comparison between the sine wave and the square wave modulation in terms of achievable signal to noise ratio.