Problem 1

A test setup produces bursts of 3-5 pulses. Each pulse features the shape reported in Figure, with $T_P = 100ns$ and unknown amplitude V_P. The time distance between pulses within the burst is $200ns$, while the burst repetition rate is $r_B = 1Hz$. A sync signal marks the arrival of the first pulse of each burst. The device under test (DUT) is changed every 10 minutes. During the change, the setup is in idle state for 0.5min. The signals are acquired by means of a high-impedance preamplifier featuring a bandwidth limited by a single pole at $f_{PA} = 250MHz$ and input-referred wideband noise featuring unilateral spectral density $\sqrt{S_V} = 10nV/\sqrt{Hz}$.

1) 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.
2) Consider now a **practical alternative** to the optimum filter: select a filter, size its parameters and evaluate the minimum amplitude $V_{P,MIN}$ that could be measured with the proposed solution.
3) Consider now an **additional 1/f noise component** with $f_C = 1kHz$ affecting the preamplifier. Propose a solution to limit its effect on the measurement and evaluate the minimum amplitude $V_{P,MIN}$ thus measurable.

Problem 2

A strain gauge placed on the wheel of a bike is subject to a sinusoidal compression and extrusion force given by the chain. The frequency of the signal ($f_P = 5Hz$) can be easily derived from a synchronous reference signal, while the deformation of the gauge is to be measured with a sensitivity of at least $100\ microstrain$. A differential preamplifier featuring a wideband limited by a single pole at $f_{PA} = 50MHz$ and input-referred noise having a wideband component with unilateral spectral density $\sqrt{S_V} = 10nV/\sqrt{Hz}$ and a 1/f noise component with $f_C = 10kHz$ is available. The system can provide a maximum power $P_{MAX} = 1\mu W$ to the sensor.

1) Describe a suitable **acquisition scheme** for the signal of interest. Provide a quantitative discussion on the potential need of a **temperature compensation scheme**.
2) Considering a constant power supply, discuss how would you extract the signal of interest if you could acquire up to $\boldsymbol{N = 1000}$ **samples** of the signal. Explain the acquisition scheme specifying the sampling frequency, evaluate the minimum strain ε_{MIN} thus measurable, and comment on the result.
3) Having now the **possibility of changing the setup** of point 2), discuss an **alternative solution** to improve the sensitivity of the system. Evaluate the minimum strain ε_{MIN} that could be measured in the new conditions.