Problem 1

A sensor system emits triangular pulses having the shape reported in Figure 1 with **2Tp = 300ns** and variable amplitude. The signal is acquired by means of a preamplifier, featuring a bandwidth of 10 MHz and affected by input-referred noise having **unilateral** spectral density $\sqrt{S_V} = 4nV/\sqrt{Hz}$, followed by a digital acquisition and processing chain.

1) Choose a practical sampling rate and calculate the minimum amplitude of the signal that could be acquired. What would be the minimum detectable signal amplitude if the digital system was ideal? Motivate all answers.

2) Consider now that the sensor emits the pulses with a period of 10kHz and the amplitude slowly varies with a timescale of 1s. Evaluate whether it is possible to improve the measurement with respect to point 1) in both cases.

3) Considering now that the digital system must use the **same weight for each sample**, discuss how this new scenario would affect the answer to the questions of point 1) and recalculate the minimum detectable signal amplitude in the two cases.

Problem 2

A strain-gage based measurement system is used to measure a square wave compression force. The compression force is applied for 1ms every 2ms. The system is connected to a preamplifier having wideband noise (**unilateral** spectral density $\sqrt{S_V} = 5nV/\sqrt{Hz}$) and a single pole at f_{PA} = 50 MHz.

1) Design and describe a suitable measurement system and explain what the input signal fed to the preamplifier is. Considering the use of only ONE strain gauge and a temperature variation of 0.3 degree, calculate the minimum theoretical strain that can be measured.

2) Assuming from now on that a dummy cell can be used and that the force value changes slowly with a timescale of 500ms, design a filter to maximize the signal to noise ratio and calculate the minimum measurable strain.

3) Considering the presence of a 1/f noise with f_C = 2kHz and a measurement of 10 minutes, estimate the effect of the noise 1/f on the measurement. Quantitatively describe how to modify the system to further improve the measurement by calculating the new minimum measurable signal.

Fig. 1