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

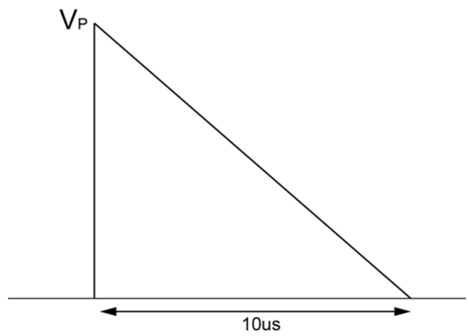
Problem 1

Pulse signal

V_P variable pulse amplitude
A *sync* signal is provided for each pulse.

Preamplifier

$S_V^{1/2} = 10nV/Hz^{1/2}$ white noise power density (unilateral)
$f_{pa} = 100\ MHz$ upper band-limit



A) Evaluate the minimum measurable amplitude $V_{P,MIN}$ without using any kind of filter. Consider now to employ a gated integrator, select its parameters for maximizing the Signal-to-Noise ratio (S/N) and evaluate the minimum measurable amplitude $V_{P,MIN}$.

Now consider the case in which a series of pulses with a random arrival time arrive at the preamplifier. The mean value of the arrival time is 50us. We want to measure the amplitude of each individual pulse. The measurement takes about 8 hours. Also 1/f noise component is present in the amplifier with a frequency corner of 10kHz.

B) Discuss how much 1/f component has an impact on the final S/N and how to minimize this effect. Calculate the new final S/N.

C) Now consider the case in which the pulses arrive periodically with a period equal to 50µs. How does the answer change to the previous point?

D) The amplitude of the individual pulses changes slowly with a time scale around 1s. Assuming you are no longer interested in measuring the single pulse, how can you exploit this new information? How does the signal to noise ratio improve? Provide a quantitative evaluation.

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

Problem 2

Signal:	**TRANSIMPEDANCE AMPLIFIER**
Between 400 and 800nm Slow variations ≈ 1s	- Gain= 1kΩ - Current Noise (unilateral) at amplifier input $\sqrt{S_{iA}} = 1\, pA/\sqrt{Hz}$ - Voltage Noise (unilateral) at amplifier input $\sqrt{S_{vA}} = 1\, nV/\sqrt{Hz}$

A spectroscopy measurement consists in focusing the light emitted by a LED on a sample and in the measurement of the constituent wavelengths of the scattered signal. A prism is used to separate the light components and an array of photodetectors, where each pixel is demanded to the detection of a single wavelength, is exploited.

A) Consider the exploitation of an array of identical PIN photodiodes, each one read-out by means of a transimpedance amplifier featuring the characteristics reported above. Describe and explain the characteristics that the device should have to meet the application's requirements, describe the measurement setup and evaluate the minimum optical signal that could be measured in these conditions.
B) Consider now that the preamplifier is affected by a 1/f noise component with corner frequency f_C=1kHz. Evaluate the impact of this additional noise component. Propose and describe a solution to mitigate the effect of 1/f noise, if necessary. Finally, evaluate the minimum optical signal that can be measured in these conditions.
C) In the scenario of point A), replace the array of photodiodes with an array of PMTs. How does this change the situation? Evaluate the minimum optical signal that could be measured in these new conditions.
D) To avoid any damage of the sample, you are now asked to use a pulsed laser with an extremely low power budget. Describe and explain the difference of using a PMT or a SPAD both in single photon counting. Evaluate the minimum signal that you could measure exploiting one of the two detectors with a laser pulse of 5ns.