Problem 1

A periodical pulsed laser emits pulses at 500nm featuring a triangular shape as reported in Fig. 1 and a repetition rate of 100kHz. The duration of each pulse is **2Tp=20ns.** The light signal is sent towards objects placed in turbid water and photodetectors are used to locate such objects by measuring the time of flight of the light pulses. The speed of light in water is about 1/3 of the light speed in vacuum. Considering a 100% reflection from the object and no attenuation from the water:

1) Being able to choose between a photodiode and a phototube, discuss what would be the most appropriate detector for this application. Describe a reasonable, simple setup to extract the information carried by each pulse **individually** and evaluate the minimum laser power that has to be sent towards the target to detect the position of the object. Use reasonable values for any omitted parameter.
2) Discuss **two** possible filtering approaches to improve the SNR with respect to point a). Then, design **one** filtering scheme, select its parameters and evaluate the minimum laser power that is needed in this case.
3) Consider the exploitation of a detector with internal gain: discuss how this choice would change the situation with respect to point a, choose a suitable detector and provide a quantitative evaluation of the minimum laser power that has to be sent towards the target in this case.

Problem 2

An almost rectangular voltage signal (Fig. 2) having $\mathbf{T_P=30ns}$ and symmetrical rising and falling edge with a duration of **about** 1/10 T_P is fed to a preamplifier featuring $\sqrt{S_{V,u}} = 40nV/\sqrt{Hz}$. A sync signal is provided.

1) Discuss the criteria to select the bandwidth of a suitable preamplifier for extracting the signal and evaluate the minimum detectable signal V_{Pmin}
2) Consider now that the rising and falling edge (0-100%) are both a line with an exact duration equal to 1/10 T_P. Evaluate the lowest V_{Pmin} that can be **ideally** measured then design a practical filter, select its parameters and evaluate V_{Pmin}.
3) Consider now that the preamp is affected by 1/f noise with **fc=10kHz** and the source emits every second a burst of 10 pulses with a time between pulses that can change between 10 and 30 ns from pulse to pulse. Each burst carries different information. Discuss the guidelines to design a filter for this problem. Select a filter and evaluate V_{Pmin}.

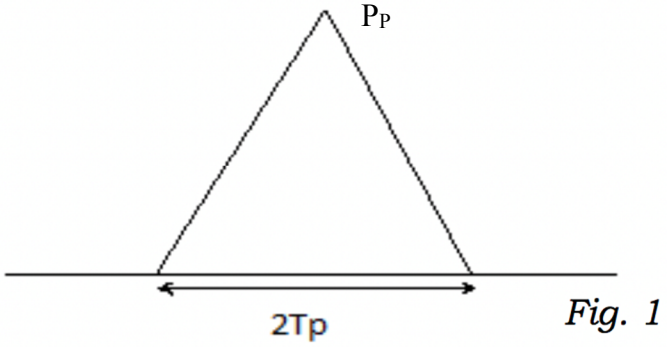

Fig. 1

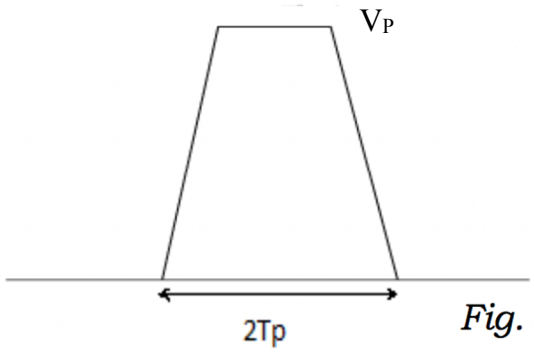

Fig. 2

Signal Recovery