Problem 1

A double rectangular voltage signal (Fig. 1) having T_P=10µs is fed to a preamplifier featuring $\sqrt{S_{V,u}} = 40nV/\sqrt{Hz}$ and a bandwidth of 30MHz. A sync signal is provided.

1. Consider the exploitation of a Gated Integrator filter to improve the S/N ratio. Calculate the minimum detectable signal V_{Pmin}.
2. Consider now that the preamp is affected by $1/f^2$ noise with fc=500 kHz. Evaluate the lowest V_{Pmin} that can be ideally measured.
3. Consider now that the preamp is also affected by $1/f^3$ noise with fc=10kHz calculate the effect of this new source of noise on the S/N of the point 2).

Problem 2

A liquid solution flows rapidly in a pipe with a solute concentration that has large oscillations in short times (a few tenths of a second). We want to accurately detect its trend over time by making an optical beam generated by an 800 nm LED pass through the pipe and measuring the transmitted intensity, since the optical attenuation is proportional to the concentration. It is required to detect the trend continuously for periods of 15 minutes, separated by rest intervals of one minute. For the measurement, a silicon p-i-n photodiode is used.

1. Describe the equivalent circuit of the detector-preamplifier assembly, quantitatively indicating all the significant parameters for this problem and describing possible advantages and disadvantages compared to the use of a phototube.
2. Considering a constant optical led power, design a suitable filtering to improve the S / N in the measurement. Explain with what criteria the filtering was chosen and dimensioned, evaluate the minimum measurable transmitted optical power P min. Then, consider the exploitation of a detector with internal gain: discuss how this choice would change the situation.
3. Considering the presence of 1/f noise with fc = 10kHz and the possibility of modulating the power of the LED. Modify the setup with the p-i-n photodiode to maximize the S / N ratio justifying each choice and evaluate the minimum measurable transmitted optical power P min.

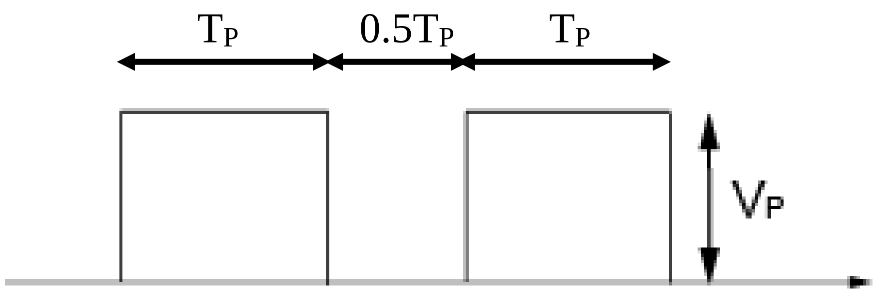

Fig.1