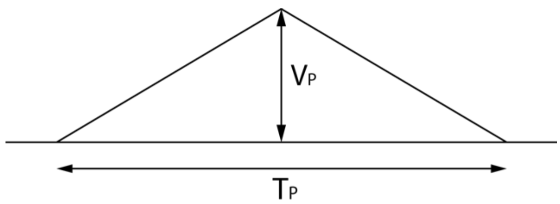
Problem 1

Pulse signal V_P variable pulse amplitude $T_P = 10\ \mu s$ main pulse duration	
Preamplifier $S_V^{1/2} = 20 nV/Hz^{1/2}$ white noise power density (unilateral) $f_{pa} = 5\ MHz$ upper band-limit	in (C): $f_P = 100$ Hz pulse repetition frequency

A) Describe and explain the ideal optimum weighting filter for the measurement of the pulse amplitude V_P and evaluate the minimum measurable amplitude V_P min.

B) Consider now to employ filters with variable parameters. Select a suitable practical filter, select its parameters for maximizing the Signal-to-Noise ratio (S/N) and evaluate the minimum measurable amplitude V_P min.

C) Consider now a case where the sequence of pulses has a repetition frequency f_P and the amplitude of the signal is constant for time intervals <10s. Explain how it is possible to use this information to increase the S/N and reduce minimum measurable amplitude V_P min. Select two different filter for the measurement of the pulse sequence, explaining the reasons of the choice and compute the improvement of S/N.

D) Consider now a case where the arrival times of the pulses are independent and random, so that the time intervals between the pulses are not constant; the pulses are statistical with a mean repetition rate mR= 100 pulses/s. Taking into account the characteristic properties of the two filters, analyze and discuss for each filter whether the fact that the pulses are random can introduce further fluctuations in the measured amplitude. In positive case, try to give a quantitative evaluation of such fluctuations, at least in approximate intuitive terms.

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

PIN PHOTODIODE	**PREAMPLIFIER**
Area=4 mm^2 Upper neutral layer $w_s = 1\mu m$; Depleted layer $w_D = 10\mu m$ Dark current I_D=1pA Reflection coefficient @800nm= 0.1	- Load Input Resistance R_L=1kΩ - Load Input Capacitance C_L=2 pF - Current Noise (unilateral) at amplifier input $\sqrt{S_{iA}} = 1\, pA/\sqrt{Hz}$ - Voltage Noise (unilateral) at amplifier input $S_{vA} = 1 nV/\sqrt{Hz}$

Laser signals with λ= 800nm are transmitted in free air and weakly reflected by distant objects. The reflected pulse amplitude (i.e. the optical power) must be measured in 10s employing as analog photo detector the photodiode and the preamplifier as above specified.

A) Evaluate the spectral responsivity of the photodiode and its electrical capacity C_D. Describe the equivalent circuit of the detector-preamplifier assembly and evaluate its possible filtering action.

B) To perform measurements using constant optical power, choose and dimension a suitable filtering by explaining the criteria used. Determine the S/N so obtainable taking into account the various sources of noise. Clearly explain the use of each formula.

Now consider that there is also a 1 / f noise component with angle characteristic f_C = 10kHz.

C) Still operating with constant optical power, also consider the 1 / f noise component. Explain how you can proceed to limit the 1 / f noise contribution, evaluate the minimum measurable optical power under these conditions.

D) Change the measurement approach using now modulated optical power. Choose the characteristics of the modulation. Therefore choose a filtering fit for this new situation and determine the S / N so obtainable. Assess the minimum measurable optical power, commenting on the result compared to the one obtained in (B) with constant power and only white noise.