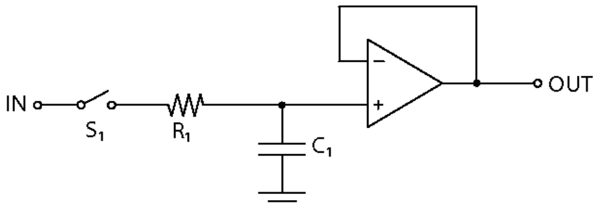
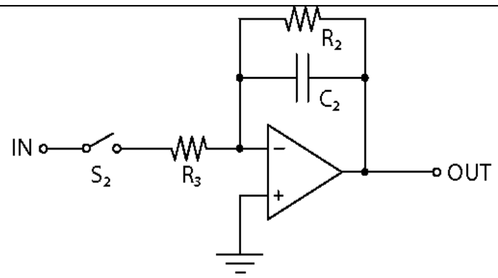
Problem 1



R_1 = 10kΩ *C_1 to be selected* *$T_{F1} = R_1 C_1$*



R_2 = 100kΩ *R_3 = 1kΩ*

C_2 to be selected *$T_{F2} = R_2 C_2$*

Signal: square pulse with Amplitude A, duration $T_P=10\mu s$.
In Sec. (A) single pulse
In Sec.s (B), (C), (D) repetitive pulses with amplitude A constant for time intervals < 10s .
in Sec. (B) pulses with constant repetition frequency $f_R=100\ Hz$;
in Sec. (C) pulses with repetition frequency f_R variable from *100 Hz to 200Hz*
in Sec. (D) pulses with random repetition at mean repetition rate $m_R=100$ *pulses/s*

Noise: white with spectrum $\sqrt{S_{bu}} = 20nV/\sqrt{Hz}$ unilateral

(A) Describe and explain the ideal optimum weighting filter for the measurement of the pulse amplitude A. Discuss how to select the parameters of the two real filters above reported in order to obtain with them a good approximation of the optimum filtering. Compare the S/N, the minimum measurable input pulse amplitude A_{min} and the output signals of the two filters. Select the preferred filter for the measurement of a single pulse, explaining the reasons of the choice.

(B) Revise the selection of the parameters of the two filters for operating on the repetitive pulses exploiting the information redundancy for obtaining better S/N and A_{min}. For each filter explain and compute the improvement of S/N and A_{min}. Compute also the output signals. Select the preferred filter for the measurement on the pulse sequence, explaining the reasons of the choice.

(C) Consider now a case where the sequence of pulses has a repetition frequency f_R which is not controlled and varies in the range from $f_R=100\ Hz$ to $f_R=200Hz$. Taking into account the properties of the filters (and considering also the possibility of revising the filter parameters) analyze the operation of each one of the two filters, ascertain whether it is well suitable for the measurement, and evaluate the results obtained, in comparison with the case in (B)

(D) Consider now a case where the sequence of pulses is generated by ionizing radiations emitted from a source (for instance gamma rays from a Co^{60} source in a hospital laboratory) and detected by a nuclear radiation detector. The arrival times of the radiations at the detector are independent and random, so that the time intervals between the pulses are not constant; the pulses are statistical with a mean repetition rate m_R= *100 pulses/s*. Taking into account the characteristic properties of the two filters, analyze and discuss for each filter whether the fact that the impulses are random can introduce further fluctuations in the measured amplitude A with respect to the previous cases (B) and (C). In positive case, try to give a quantitative evaluation of such fluctuations, at least in approximate intuitive terms.

B: see text also on the other side of the sheet)

Problem 2

PMT PHOTOMULTIPLIER	**PIN SILICON PHOTODIODE**
Photocathode S20 Quantum detection efficiency $\eta_{DM} = 0,005 = 0,5\%$ at λ_1=800 nm Dark-emission of cathode: $n_{BM}=10^3$ elettroni/s Gain G $=10^6$ Excess noise factor F=1,5	Reflection coefficient R=0,3 Surface layer thickness w_n=*1 micron* Depletion layer thickness w_i=*20 micron* Optical absorption length at λ_1=800 nm $L_a = 10\mu m$ Dark current $I_{BD}=10^{-14}$ A
CURRENT PREAMPLIFIER • voltage noise referred to input S_{va} negligible (because of the high impedance source) • white current noise referred to input: S_{ia}=0,01pA/Hz$^{1/2}$ (unilateral) a *1/f* noise component in S_{ia} with corner frequency f_c= *1kHz* must be taken into account only in Sec. C	**LASER DIODE** • Emission wavelength λ_1=800nm The diode can generate light power: • stationary (constant diode current) or • modulated to on-off squarewave (diode current modulated on-off at high frequency, up to 100kHz)

A light beam generated by a Laser diode source is directed to plane reflector objects far from the source and the intensity of light reflected has to be measured. Two detectors are available as above reported

A) Define and evaluate the NEP (Noise Equivalent Power) of the two detectors for the measurement required. Comment and discuss the suitability of the NEP as parameter used for selecting the photodetector

B) In operation with constant intensity of the light beam (i.e. with slow and small variation of intensity over time intervals > 0,1s) and taking into account only the white noise component (i.e. not considering the 1/f component) evaluate the minimum detected optical power that can be measured with each of the two detectors,

C) Analyze and discuss for each of the two detectors whether the effect of the 1/f component of the amplifier noise has significant effect and should be considered. In case it should be considered, explain how the measurement with constant light intensity can be carried out limiting the 1/f effect with a simple filtering and evaluate the minimum detected optical power that can be measured.

D) In case where the 1/f noise of the preamplifier is significant, explain how the measurement can be improved by exploiting the modulation of the diode light intensity and evaluate the minimum detected optical power that can be measured

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