**Problem 1**

We want to measure the amplitude $V_p$ of an exponential signal (as shown in the figure below) featuring a decay time of 100ns, coming from the output of an amplifier limited by a single pole ($f_A$=100 MHz) and affected by an input referred white noise with unilateral spectral density $\sqrt{S_V} = \frac{1nV}{\sqrt{Hz}}$.
The signal is acquired by means of a digital acquisition chain consisting of a sampler and a programmable elaboration unit. A sync signal is available.

a) Considering a sampler with a maximum sampling frequency of 50MHz, discuss and design a suitable DIGITAL filtering scheme and calculate the corresponding minimum signal amplitude that could be measured with the proposed solution.

b) Assuming now that an additional wideband noise component comes with the signal (low-frequency unilateral spectral density $\sqrt{S_V} = \frac{100nV}{\sqrt{Hz}}$, one pole at 1MHz, lorentzian spectrum) and that the maximum sampling frequency is 5MHz, discuss and design a DIGITAL solution for this case and calculate the new minimum measurable signal.

c) Demonstrate in detail, from a theoretical point of view, what the optimal ANALOG filter would be for the scenario of point a) and comment on the result.

**Problem 2**

The optical power of a slowly varying light signal with a wavelength of 500nm and a bandwidth of approximately 5Hz is to be measured. To this aim, a PMT with the following characteristics is available: G=$10^6$, photon detection efficiency=10% and dark current equivalent to 1000 electrons per second. The sensor is readout by means of a voltage preamplifier featuring a wide bandwidth limited by a single pole at 100 MHz and affected by both wideband and 1/f noise ($\sqrt{S_V} = \frac{10nV}{\sqrt{Hz}}$, $f_c$=2kHz).

a) Calculate the minimum measurable optical power assuming that the measurement has a maximum duration of 1h.

b) Now assuming we can modulate the signal via a chopper system, how does the answer to point 1) change?

c) Describe in detail the operation of a PMT describing advantages and disadvantages compared to a simple phototube solution.