Problem

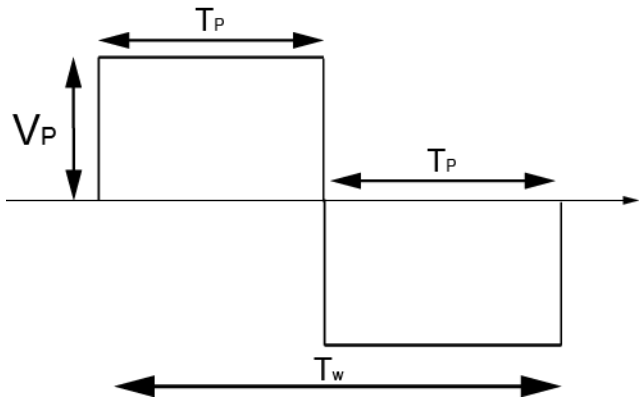
A portable sensor system emits a double rect signal having the shape shown in Figure, with **T_P = 10ms, T_W=20ms** and a variable amplitude V_P. The system preamplifier bandwidth is 100 MHz and its input-referred noise generator features an **unilateral** spectral density $\sqrt{S_V} = 10nV/\sqrt{Hz}$ and **$1/f^2$** noise component with f_C=10kHz. An auxiliary signal synchronous to the signal of interest is provided with a high SNR. The maximum duration of the measurement with this system is 1 hour.

1) Describe in detail how you can calculate the **optimum filter** and evaluate the minimum detectable signal with this filter.

2) In the same conditions of point 1), consider now the possibility of replacing the **matched** filter with an analog or a digital filter.

- In the analog approach, it is possible to use only a **SINGLE** gated integrator: choose the filter parameters and calculate the minimum detectable signal amplitude.
- In the digital approach, it is possible to use a maximum sampling frequency of 100kHz. Discuss the guidelines to design a digital filter and provide the expression of the resulting signal to noise ratio (SNR).

3) Considering now also the presence of **$1/f^3$ noise with fc = 2kHz** at the output of the sensor, evaluate the effect of this noise on the measurement. Considering **only the analog approach**, discuss qualitatively how it would be possible to modify the filtering scheme to minimize its effect.



Signal Recovery