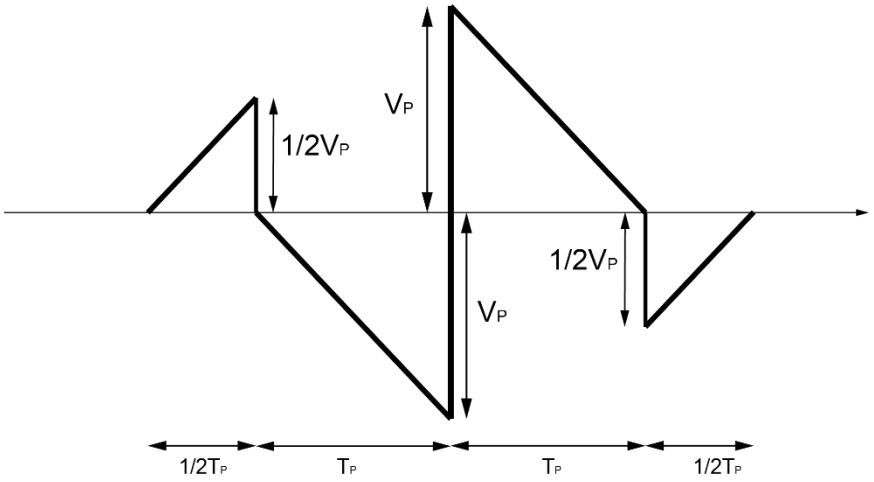
Problem 1

A sensor system emits a voltage signal having the shape shown in the figure with $\boldsymbol{T_P = 1us}$ and variable amplitude $\boldsymbol{V_P}$. The available voltage amplifier has a wide bandwidth limited by a single pole at 50 MHz and input referred noise generator featuring **unilateral** spectral density $\sqrt{S_V} = 10nV/\sqrt{Hz}$. A sync signal is provided.

1) It is possible to use a gated integrator. Assuming that it is possible to close and open the switch just one time during the duration of the signal, calculate the best signal-to-noise ratio that can be obtained in this case, clearly pointing out when the switch will be closed and open. Compare this value with the signal-to-noise ratio without any filter.
2) Considering now that **more than one replica of the signal** is available, with a repetition rate of 1 kHz. Assuming that the value of V_P slowly changes with a timescale in the order of 1s and that again it is possible to close and open the switch only one time for each replica, discuss if it is possible to improve the signal-to-noise ratio using this new information and in case calculate the new sensitivity of the system.
3) Consider now that the amplifier is also affected by 1/f noise with $f_C = 5kHz$. Considering first the presence of just a single replica of the signal, **discuss qualitatively** how the measurement with a single integration window would be affected by this additional noise component. How would the answer change if it is possible to use two gated integrators and any additional linear electronics? Provide a **quantitative evaluation** in this case. Finally, provide a **qualitative discussion** also on how the answer to point 2) would change in this scenario.



Signal Recovery