**Problem 1**

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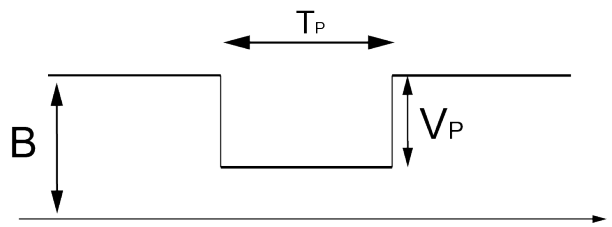
| **Pulse signal**<br>$V_P$ variable pulse amplitude<br>$T_P$= 0.5ms<br>B constant value<br><br>**Preamplifier**<br>$S_V^{½} = 4nV/Hz^{1/2}$ white noise power density (unilateral)<br>$f_{pa} = 150\ MHz$ upper band-limit<br>$1/f^2$ component with $fc = 20kHz$ |  |

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 constant 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 the exploitation of a fully digital approach. Discuss how to select the sampling frequency and how it could impact on the Signal-to-Noise ratio. Choose a reasonable value for this frequency and calculate the S/N.

D) Explain, both in the time domain and in the frequency domain, how a digital filter can approximate an analogue filter in terms of S / N as the sample rate changes

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

| | **PREAMPLIFIER** |
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| | $S_V^{½} = 5nV/Hz^{1/2}$ white noise power density (unilateral)<br>1/f frequency corner: 3kHz<br>$f_{pa} = 50\ MHz$ upper band-limit |

A strain-gage based measurement system is used to measure a sinusoidal-type Compression/Extension force coming from an engine rotating at an unkown constant speed between 5000rpm and 10000rpm. The system is connected to a preamplifier whose features are described above.

1) Describe the measurement system and explain what the input signal fed to the preamplifier is, assuming to use two strain gages and having 3.3V maximum power supply to measure a deformation of 1 microstrain

2) Evaluate the signal to noise ratio using only passive filters with constant parameters.

3) Describe how it is possible to reduce the effect of noise 1/f by electrically modulating the signal. Evaluate the SNR that can be obtained with this approach.

4) Being able to choose between a square and a sinusoidal wave for both the modulation and the reference signal, discuss and evaluate how the signal to noise ratio changes in the 4 possible cases.