Problem 1

A rectangular signal with a duration of 150µs comes from a voltage source accompanied by a broadband noise with effective spectral density $(S_V)^{1/2} = 20$ nV / (Hz) $^{1/2}$ (unilateral density) and $1/f^2$ component with $f_C = 10$ kHz. The signal is overlapped to a sinusoidal disturb with 20 kHz frequency and unknown amplitude. To amplify the signal there is a broadband amplifier with a bandwidth limited by a single pole with frequency $f_P = 1$MHz, wide-band noise generators referred to the input with effective spectral density $(S_V)^{1/2} = 5$ nV / (Hz) $^{1/2}$ and $(S_I)^{1/2} = 0.5$pA / (Hz) ^{½} (one-sided density).

a) Considering a practical acquisition case and a negligible amplitude of the disturb, calculate the signal to noise ratio without using any filter. Explain in detail every used formula.

b) Calculate the optimum filter considering negligible the amplitude of the disturb. Explain in detail every used formula.

c) It is now necessary to approximate the optimum filter with a practical filter, consider separately the case with negligible disturb amplitude and the case with dominant disturb amplitude. How does it change your filter design? Calculate the new signal to noise ratio in both cases.

d) Considering now that the preamplifier voltage noise generator features a 1/f component with 5 kHz of corner frequency, evaluate the effect of the previous chosen filter on the 1/f component.

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

Problem 2

A strain-gage based measurement system is used to measure a low frequency (<100Hz) compression/extension force. The system is connected to a preamplifier with $S_V^{1/2} = 5nV/Hz^{1/2}$ white noise power density (unilateral) limited by a single pole at $f_{pa} = 50\ MHz$ and 1/f frequency corner: 3kHz.

1) Describe the strain gauge principle and the meaning of the Gauge Factor.

2) Describe the measurement system and explain what the input signal fed to the preamplifier is.

3) Calculate the maximum acceptable temperature variation in one hour of measurement to be able to use just one strain gage sensor and a simple low pass filter.

4) Design a complete measurement system in order to improve the minimum detectable signal. Motivate any choice and calculate the minimum detectable signal using two strain gages.