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Problem 1)

a) Due to the presence of $1/f^2$ noise, a whitening filter is necessary, that is a high pass filter with fp=fc=2MHz. The filter changes the shape of the signal, that becomes a sequence of four exponential pulses with amplitudes Vp, -1/3Vp, +1/3Vp and -Vp, respectively. In this scenario, the matched filter can be designed following the known signal shape. With such filter, Vpmin=23.8uV.

b) In this case it is necessary to keep the same whitening filter of point a) to avoid that 1/f noise contribution diverges with only a single GI. The single GI must be applied when the signal is higher and its optimized duration is Tg=1.25tau. The resulting sensitivity is Vpmin=39.4 uV.
With three GIs it is still convenient to keep the whitening filter and acquire the exponential signal on the first and the last pulse (amplitude |Vp|) and on one of the lower pulses. The gain must be tuned accordingly, while the optimized duration is Tg=1.25tau also in this case. With this acquisition strategy, Vpmin=27.4 uV

c) See theory.

Problem 2)

a) Two active strain gauges can be used to acquire the signal of interest, while 2 additional dummy strain gauges could be used to remove unwanted components and/or for temperature compensation. Considering a Wheatstone bridge with a bias voltage of 3.3V, a low pass filter with a bandwidth of 10Hz and a zero setting every one hour, white noise is 39.6nV while 1/f noise is 1.57uV. With such acquisition scheme, the minimum measurable deformation is 0.5microstrain.

b) In this case the square wave modulation is preferable in terms of SNR. After demodulating the modulated signal, a gated integrator can be used in order to both provide a low pass filtering action and to filter out the disturbance. With Tg=Td=1/fd=0.4s the disturbance can be filtered out, achieving a sensitivity as low as 3.4*nanostrain.
Comments:
-achieving the theoretical extremely low sensitivity of point b) is unlikely in a real case because non idealities of the electronic components come into play.
-this solution does not fully exploit the available signal because it is not necessary. Nevertheless, it is worth mentioning that a larger integration window (Tg=0.8s) and/or a boxcar could be used in a similar scenario to further improve the SNR.

c) See theory.