1/2/2021 – Short solution

Problem 1

1) a. practical sampling: a few samples with uncorrelated noise. $T_{sample} = 5 * T_{corr,\ noise}$ = 80ns. Position of samples: 1 sample at the signal peak and two "lateral" samples at a distance 80ns from the peak. Weights are {1, (Tp-80ns)/Tp}. A_{MIN}=13.2µV.
   b. in an ideal system we could have fsample=∞ and therefore we could implement the optimum filter in the digital domain. $A_{MIN,OPT}$=8.94µV.

2) exponential weighting of multiple pulses in a time frame of 1s. In both cases of point A the SNR is improved by a factor $\sqrt{(2 * 1s/5 * f_{Rep})}$ = 63.2. A_{MIN}=0.21µV; $A_{MIN,OPT}$=0.14µV
3) same weight for each sample:
   a. practical sampling as in point 1. A_{MIN}=14.2µV.
   b. gated integrator with optimized duration and position. A_{MIN}=9.5µV.

Problem 2

1) Wheatstone bridge with a constant bias, e.g. V_{BIAS} = 5V. Strain gauge parameters: G=2, ß=4*10^{-3} 1/K (temperature coefficient). Signal $v_D = V_{BIAS}/4 * G * \varepsilon$.
   With a single strain gauge it is not possible to compensate for thermal effects.
   $\varepsilon_T = \beta * \Delta\mathrm{T}/G$= 600µstrain, dominant with respect to $\varepsilon_{MIN}|noise =$ 17.8µstrain.
2) The dummy cell is used to compensate for thermal effects, which can be neglected from now on. A boxcar can be used to improve the measurement. In this case, ε_{MIN} = 4.5nstrain. As an alternative, a square-wave LIA could be exploited with comparable results.
3) A zero setting can be considered. Worst case is a measurement after 10minutes. In this case, ε_{MIN} = 340nstrain.
   To avoid 1/f noise, which is the dominant contribution, we can change the bias voltage of the bridge, using a +5V/-5V square wave. We can then use a +/-1 square wave LIA going back to the situation of point b.