ECEN321: Engineering Statistics
Laboratory Session 2
Noise

Due: 9:00 a.m., Monday 4 May 2020

Write a report according the format outlined in the first lab (yes it is possible) and in it answer the following questions.

1. An amplifier with voltage gain equal to 10 is used to amplify a DC signal with noise. The DC level is 3 V, and the noise is normal having zero mean and variance 4 V^2.

   Create 1000 samples of the DC signal and then from the signal estimate the mean and standard deviation.

   Then simulate the function of the amplifier amplifying this signal and again determine the resulting mean and standard deviation. Explain your results.

2. Signal averaging is a common method used to improve the signal to noise ratio and is used extensively in MRI where repeat experiments are performed and the resultant signals averaged.

   Create 16 signals as in Part 1, and calculate the mean and standard deviation of one of them. Now sum all 16 signals and divide by 16 to normalise. Recalculate the mean and standard deviation. Explain your results.

3. In many experiments the desired signal is often corrupted by noise that reduces the correlation between the captured output and original parameter being measured.

   Create a $\sin(x)$ signal using 1000 points of x on a uniform grid from 0 to 20.

   Then add noise of variance 1.

   Plot a scatter diagram of the original and the noise corrupted signal.

   Calculate the covariance of the original and the noisy signal.

   Calculate the correlation coefficient. Explain your results.

4. Suppose we measure two voltages V_1 and V_2 and need to calculate $V_2 - V_1$, and its uncertainty.

   The two voltages are measured on different ranges of a volt meter, and hence have different quantisation errors (assumed to be uniformly distributed).

   $$V_1 = 1.934 \pm 0.001 \qquad V_2 = 2.53 \pm 0.01$$

   Using a simulation with a sample size of 100 000, draw a diagram of the probability density of $V_2 - V_1$. Explain your results.