Noise reduction by averaging (Lab 7)

Power, RMS, mean, variance and standard deviation of a sine signal

a) Generate a signal by using a "Sine Pattern" generator with amplitude 1V, 1 cycle, 100 samples. Develop a "vi" that computes the mean, variance and standard deviation of this signal. How are these measurements related to the power and the RMS values of the sine signal?

b) Add 1V constant to the sine signal and find the mean, variance and standard deviation in this case. What are the power of the total signal, the power of the DC, and the power of AC (sinus) component? And how are these values related to the mean, variance and standard deviation?

DC in Gaussian noise[1]

Run "lab_07_2.vi". In this vi, a noisy DC signal shall be measured, and the noise is to be reduced either through a N-length running average FIR filter or with an IIR filter. The signal consists of 1V DC and Gaussian noise with RMS value 0.1V.

The FIR filter output is: $y(n) = \frac{1}{N} \sum\limits_{i=0}^{N-1} x(n-i)$.

The IIR filter output is: $y(n) = \alpha x(n) + (1-\alpha) y(n-1)$.

a) When we take one measurement of the DC value, we can expect with 95.45% certainty that the measured value is less than 0.2V away from the correct DC. Select "No averaging" and "tolerance" = 0.2 to check this.

b) How many samples must be averaged if we want the measured value with 95.45% certainty to be within 0.05V away from the correct DC? Use "lab_07_2.vi" to control your estimated averaging length. Repeat for the case where we want the error in the measured DC to be less than $\pm 0.01V$ with 95.45% certainty.

c) Use an exponential averager (IIR filter) to achieve the same as you did in b) and verify your configuration by testing it.

d) What is the advantage and disadvantage of using an IIR filter as in c) compared with the method in b)?

Sine signal in noise

a) Run "lab_07_3.vi" with a 128 point DFT (averages = 1). Observe the noise level and standard deviation.

b) Take the average of 4, 16, 64 and 256 of these 128 point DFT computations. What happens to the noise level and variations? Explain the results.

c) Repeat a) and b) with 512 and 2048 points DFT.

[1] In this part, it is not necessary to change any VI programs. Just adjust the input parameters.

d) Use the standard deviation value for averages = 1 and N = 128 as reference. Find the standard deviations for averages = 4, 16, 64, 256 and N=128 respectively. Calulate the relative gains in dB[2] of doing averaging for the above average numbers, i.e., when averages = 4, 16, 64, 256 respectively. Can you find a pattern in these dB values?

[2] #dB = 20lg(standard deviation/reference standard deviation).