Effects of filters applied to noise signals

Lab 11, SDP

Objective

Students should observe the effects of filtering a noise signal, like the quantization noise generated in finite word length implementrations.

Theoretical notions

Exercises

1. In Matlab, generate the following signals, for a value of $\Delta = 0.001$. The signal length should be 10000.

   a. A random signal with uniform distribution $U\left[-\Delta/2, \Delta/2\right]$
   b. A random signal with uniform distribution $U\left[0, \Delta/2\right]$
   c. A random signal with uniform distribution $U\left[-\Delta, \Delta\right]$

   Requirements:

   - For each signal, compute the mean, variance, and average power (use `mean()`, `var()`). Which signal has the smalles power?
   - Display the signals on three separate subfigures on the same figure

2. In Matlab, filter each signal above with the filter:

$$y[n] = ay[n-1] + x[n]$$

   Compute the mean, variance, and average power for each of the output signals.

   Try different values of a: 0.1, 0.5, 0.9.

3. Do the same filtering in Simulink, as follows:

   - Create a model to implement the system

- Use a `From Workspace` block to read the signals from the Workspace
- Use a `To Workspace` block to output the results back in the Workspace

Use a `Dashboard Scope` for a nice visualization of the input and output signals.

4. Compute the impulse response of this filter (using `impz()`) and verify numerically the relation:

$$\sigma_o^2 = \sigma_e^2 \sum_n h[n]^2 = \sigma_e^2 \frac{1}{1-a^2}$$

5. Compute the ratio $Q = \frac{\sigma_o^2}{\sigma_e^2}$ for 100 values of a between $a \in [0.01, 0.99]$ and plot the value of Q as a function of a. Which function is represented here?

Final questions

1. TBD