MATLAB Assignment 2

1. The goal of this problem is to experimentally validate our theory on Periodogram based power spectrum estimation. Consider a Gaussian random process which is generated as the output of a linear system with transfer function

$$H(z) = \frac{1 - .9z^{-1} + .81z^{-2}}{1 - 2.76z^{-1} + 3.809z^{-2} - 2.654z^{-3} + .924z^{-4}}$$

   driven by zero mean, Gaussian white noise with variance 1.

   (a) What is the true autocorrelation function of the random process?

   (b) Generate 1024 samples of this stationary random process and carry out the following qualitative study. Estimate the autocorrelation sequence using 64, 128, 256, 512, and 1024 samples and compare it with the true values.

   (c) What is the true power spectrum of the random process?

   (d) Use the generated 1024 samples and compute Periodogram estimates for the 5 data lengths mentioned above and compare with the true spectrum.

   (e) Validate the statistical properties of the Periodogram estimate by generating several realizations of the random process and computing the sample mean and variance of the corresponding Periodogram estimate.

2. The file "exhaust.wav" is an audio recording of the exhaust pipe of a car while idling.

   (a) Plot the estimated periodogram and autocorrelation function of this signal.

   (b) **(Challenge - 20% bonus credit to the student with the closest answer - not required)** Use the course material and your knowledge of the harmonic series to estimate *what RPM the engine is running at.* (Hint: This is a four-cylinder engine, and each cylinder fires on every other revolution.)

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