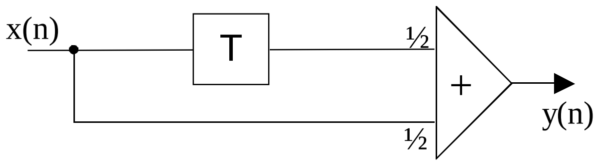
Digital Signal Processing: Stochastic Signals

1. System response to white noise

1.1. Let x(n) be an ergodic and uniformly distributed white noise process. What are the values of the the variance σ^2 and the power P ?

1.2. What are the values of the autocorrelation function (ACF) of the stochastic process in 1.1 (the process has zero mean and is not correlated)

1.3. The stochastic signal is now passed through the following system. What are the values of the system (impulse) response h(n) and the system's correlation function $s_{hh}^{E}(k)$?



1.4. Compute the ACF at the sytem's output, using $s_{xx}(k)$ and $s_{hh}^{E}(k)$. What can you deduct about the variance at the output?

1.5. Compute the power density spectrum $S_{yy}(f)$, using the Wiener−Lee−Theorem in the frequency domain.

2. Autoregressive (AR) Process

2.1. From a series x(n), a rectangular window has extracted the values $x(0)=1,\ x(1)=-2,\ x(2)=5,\ x(3)=3$. All other values known to us are zero.

2.2. Compute the ACF $\hat{s}_{xx}(k)$ with N=4.

3. MATLAB computer experiments

3.1. Using Matlab, control the values of the ACF from 2.2

3.2. From $\hat{s}_{xx}(k)$, let Matlab compute the prediction coefficients of an AR model of order 2.
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3.3. What is the transfer function H(z) of this model?

3.4. Let Matlab compute the prediction coefficients of an AR model of higher orders. Regarding that you have only available 4 values after windowing, what model order is needed to perfectly resemble these values in theory? Why does this not work in practice, with your 4 values given? Scetch the deviations.

3.5. Let Matlab compute the prediction coefficients of an AR model of even higher orders. What happens?

3.6. Under what conditions does the AR model predict (approximately) correct values also for the values of the series outside the window which was known to us?

3.7. Show that indeed the prediction values (output) are orthogonal to all *previous* input values, i.e. $s_{YX}[\kappa] = E\{Y(k)\cdot X(k-\kappa)\}=\delta(\kappa)$
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