Department of Information Technology
Division of Systems and Control
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Homework Assignment no. 1

PSD's and Autocorrelation Sequences

Deadline: Sept. 12

The first homework is based on **Exercise C1.12** . You do not need to download any Matlab code for this homework. Here follow a hint and some clarifications for the corresponding parts of **Exercise C1.12**:

(a) **Hint:** Consider the following DTFT (*Discrete Time Fourier Transform*) pair (for $|\alpha| < 1$):

$$c(k) = \begin{cases} \alpha^k, & k \geq 0 \\ (\alpha^*)^{-k}, & k < 0 \end{cases} \Longleftrightarrow C(\omega) = \frac{1 - |\alpha|^2}{(1 - \alpha e^{-j\omega})(1 - \alpha^* e^{j\omega})} \quad (1)$$

Show that (1) constitute a DTFT pair!

(b) Use your analytical expression for the two-sided $r(k)$ from **(a)** and use Matlab to plot it in a normalized manner (i.e., $r(k)/r_0$) for different values of a_1 and b_1. We propose that you use the following values $a_1 = -0.95, -0.75, -0.55, -0.35$ and $b_1 = -0.9, -0.7, -0.5$. This way you should be able to comment on how $|a_1|$ dictates the decay for the tails of $r(k)$ and conclude that when $a_1 \simeq b_1$ then $r(k) \simeq \delta_{k,0}$. Also, try to explain why $r(k) \approx \delta_{k,0}$. Use Matlab's "`subplot(4,3,`$n$`)`" and "`plot`" to plot $r(k)/r(0)$ for the twelve ($n = 1, \ldots, 12$) different pairs of a_1, b_1 on one page for easy comparison. Remember to label the axes and plots using "`title`", "`xlabel`", "`ylabel`" and make sure you have the correct axes. If you are unsure how to use any Matlab command type "`help <command>`".

(c) If you have done **(b)** as described above, you have also done **(c)**.

(d) Use "`help <command>`" to find out about the syntax for "`filter`" and "`conv`". You can also type "`help function`" if you have forgotten how to write functions in Matlab. Make sure you comment your code generously and explain the input/output data formats.

(e) Compare the approximate ACS from your `genacs.m` function with the true ACS (from **(a)**) for both values of M and show these results in two plots with the approximate ACS and the true ACS superimposed (use `hold on/off`). Explain why the larger M gives a more accurate result. Suggest a rule of thumb for choosing M in relation to the poles of the filter (You may want to try several values of a_1 and b_1). Explain why you chose this particular rule of thumb.