2.163J/6.455J/12.518
Sonar, Radar and Seismic Signal Processing

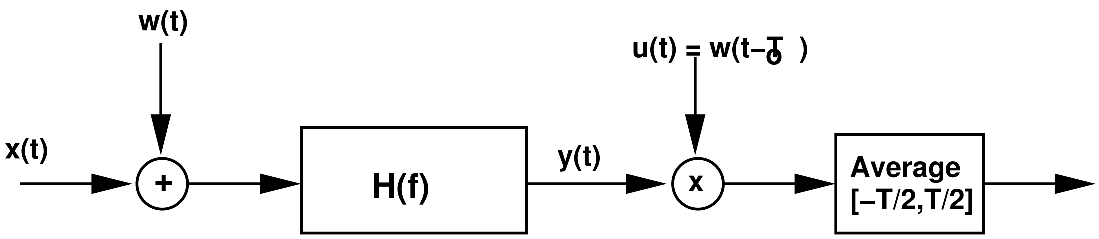
Quiz 2

Issued: November 13, 2006

Due: November 27, 2006

Problem 1: System Identification

Part 1) One problem with LTI models is that they are only incrementally linear around some nominal operating point; hence, we must be able to find the effective impulse response while operating the system. One way of doing this is to inject white noise and cross correlate with the output as shown in the figure below. The input, $x(t)$, is the nominal input. To this



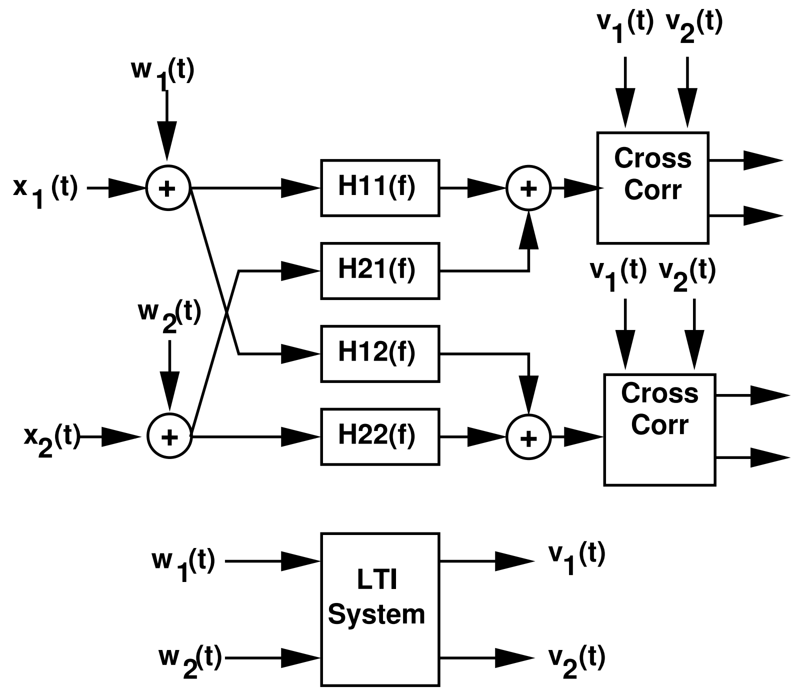
Cross correlation for Impulse response

we add a small amount of white noise, $w(t)$. The filter, $H(f)$, is the incremental transfer function which we seek. a) Show that the average of the output is the impulse response $h(T_o)$

b) Determine the mean and variance of the estimate of the transfer function assumming the transfer function is smooth.

c) Show that the maximum group delay through the system puts lower bounds upon the windows one uses in either the direct or indirect methods (Your pick vis a vis method)

Part 2) We consider a two dimensional version of this as in most systems there are multiple inputs and outputs. This is indicted in the figure below Describe a method (there are many) for estimating the transfer functions similar to descrbed above. One can put the input white noises through any multichannel LTI system to output signals which are available for use for cross correlation at the output. Indicate how one would determine the means and variances. If you use a multistep process such as turning on a process $w_i(t)$ on and then off, describe how this influences your calculations of the mean and variance. For example, if both processes are on, then results are correlated, but perhaps with a lower variance. If on/off, then one has uncorrelated estimates whose variances add. Note that this part is a "thought" problem that is intended to probe your understanding of spectral estimation. .



Multichannel system identification

Problem 2

The data on the web page of the subject are 1000 sec in duration and sampled at 1000 Hz. The numbers are formatted so any programming language can read them. Your task is simply to estimate the power density spectrum as well as the bias and variance. Please note areas where your windowing may cause significant problems with bias as well as your variance computations. This means explicit statements about your window lengths, averaging extents, *etc* and not a philosophical discussion. Please submit a copy of your code. You may not use MATLAB for your submitted solution, but obviously you can use MATLAB to check your work. (You may find minor differences between your work and MATLAB.) Please note all significant spectral features such as peaks, their widths, sprectral slopes (log/log is often useful). Also, there are some subtle aspects of this time series which may be useful to note.