Laboratory 1

$LPC$ Simulation Using Adaptive Filtering

It is desired to determine the LPC coefficients of a time series, which we will obtain by generating a 6th-order autoregressive series. The LPC coefficients are obtained in the usual way, by minimizing the mean-square error $e^2(n)$ with respect to the six coefficients, where

$$e(n) = y(n) - \hat{y}(n)$$

where,

$$\hat{y}(n) = a1*y(n-1) + a2*y(n-2) + a3*y(n-3) + a4*y(n-5) + a5*y(n-5) + a6*y(n-6)$$

We will use the LMS Adapt filter block (under ADAPTIVE in SPW) and generate the following block diagram for LPC analysis. Once the block diagram is generated, you can run it cgs (generate/compile/run) and observe the output $e(n)$ and the filter weights $w(n)$. 
Figure 1: LMS adaptive filter

PROCEDURE:

MAKING THE BLOCK DIAGRAM FOR LPC ANALYSIS
Build the block diagram shown, under BDE and confirm that you are indeed generating the error signal, that you would wish for a predictor.
Go one level below in the LMS block and change the filter size to 6 and set $\mu = 0.01$. Go one level below in the vector sink and set vector size to “6”, Comment to “weights” and File format to “ascii”.
Label Signal source (smith/lpctest)
Label Vector Signal Source (smith/flitout).
Label Signal Sink (smith/lpcout).
Pushback VSS and Comment ‘weights’ File format ‘ascii’.
(This so that you can observe how the weights are evolving, under /siglib.)
Pushback SG and Comment ‘output’.

MAKING A STABLE ALL-POLE FILTER FOR GENERATING AUTOREGRESSIVE PROCESS
Go to FDS and do the following:
METHOD SELECT Bessel BandPass
Change Parameters to 1000 (sampling frequency), 200, 100,3 6.
METHOD MAKE _ FILT Freq, Impulse, Pole _ Zero
EDIT COEFS CONVERT SOS _ TO _ POLY
Now change b0=1 and all other b coefficients to zero. Leave the “a” coefficients unchanged.
ANALYZE FREQ,IMPULSE,POLE _ ZERO and observe that you have the same (stable) poles. You can observe the new frequency response.
(NOTE: Leave the FDS screen with the filter coefficients “active” since you will be using “current” FDS values to filter a noise signal).
MAKING AUTOREGRESSIVE PROCESS

Go to SDE and do the following:
SIG _ GEN UDN dbv=0 NEW _ SIGNAL seed=(whatever) num _ of pts=2000 samp _ freq=1000 SELECTXY
FILES SAVE _ SIG SELECTXY [filename=smith/lpcuniform]
FILTER LINEAR FDS _ GET CURRENT _ FDS FILTER NEW _ SIGNAL ALLPOINTS SELECTXY
(Point to smith/lpcuniform and point to signal above which you wish to show the filtered noise)
FILES SAVE _ SIG SELECTXY (filename=smith/lpcetest)
You can see how uncorrelated the noise is by: ANALYSIS AUTO _ CORR AUXILLARY [SINGLE _ SIDED] ALLPOINTS SELECTXY
You can see a “line” representation by:
DISPLAY FORMAT LINE _ STYLE HISTOGRAM SELECTXY
You can see just a few points by:
DISPLAY WINDOW _ SIZE size=6
or by
DISPLAY WINDOW _ SIZE start-pt=1000 end _ pt=1006
You may also wish to observe how correlated or uncorrelated is lpcetest.
RUNNING PROGRAM
Under BDE, go to CGS.
Do Generate, Compile, Run. (run for 2000 iterations)
Go to SDS and do FILES READ _ SIG GET _ SIM APPEND
Observe lpcout and filout (6 x 2000 values).
Are the weights converging?
Did the adaptation whiten the output e(n) lpcout? Change mu to a smaller value and repeat experiment and note differences.

HANDIN
Frequency response of the original all pole filter that you used to color the white noise.
Frequency response of the filter you got after adaptation.