Section M7: Statistical DSP blocks

These blocks appear at the top of the simulation area

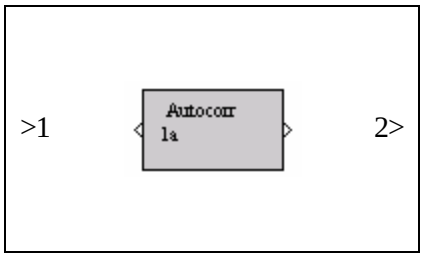
Table of blocks	
Block notation	Description
Autocorr	Computes the autocorrelation values of a signal
LPC	Computes the linear predictor coefficients (LPC)
LPC+	Computes the linear predictor coefficients (LPC)
Lag Win	Windows a time-domain signal
Sym Corr	Finds the symmetric autocorrelation
Corlogrm	PSD estimation using Correlogram method
Prdogrm	PSD estimation using Periodogram method
Spectrogram	Provides frequency versus time plots
AR Est.	AR estimation based on the Levinson-Durbin algorithm

M7.1

Block name : Autocorrelation **Notation**: ***Autocorr***

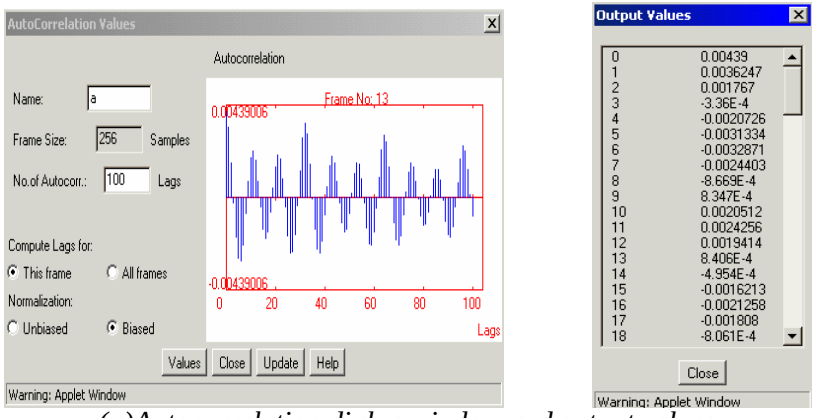
Description: This block calculates the autocorrelation sequence of a signal. The user needs to specify the number of lags and select whether they are computed for a particular frame ("this frame") or for "all frames". An option for "biased" or "unbiased" normalization is provided.

Pin assignment:



Pin	Description
1	Time-domain signal $x(n)$
2	Autocorrelation $r_{xx}(m)$
3	
4	
5	
6	

Dialog window(s):



(a)Autocorrelation dialog window and output values

Script use:

Name: autocorr

Example code: <param name = "3" value = "B3-autocorr(3,1)">

Equation(s) Implemented :

$$r_{xx}(m) = \frac{1}{L}\sum_{n=0}^{N-m-1} x^{*}(n+m)x(n)$$

where, m is the number of lags; $0 = m = N-1$

If $L = N$, a biased autocorrelation sequence is obtained

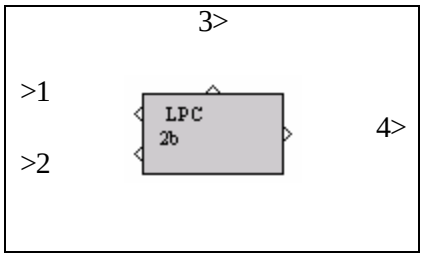
If $L = N - m$, an unbiased autocorrelation sequence is obtained

M7.2

Block name : Linear prediction coefficients **Notation**: ***LPC***

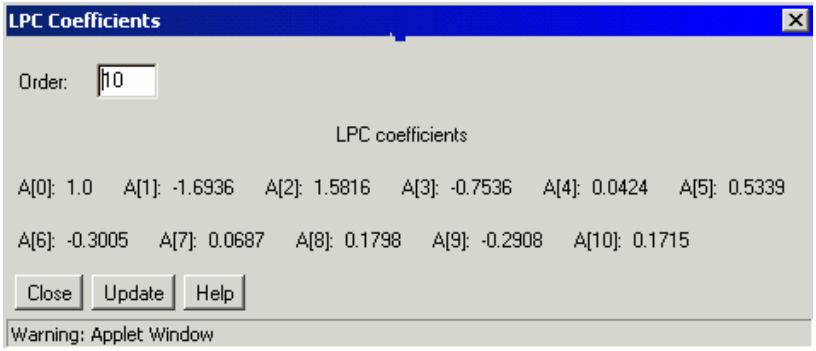
Description: This block computes the linear predictor coefficients (LPC) based on the Levinson-Durbin algorithm.

Pin assignment:



Pin	Description
1	Time-domain signal, *x(n)*
2	Autocorrelation sequence, $r_{xx}(m)$
3	LP coefficients, a_i
4	Residual signal, *e(n)*
5	
6	

Dialog window(s):



(a)LPC dialog window

Script use:

Name: LPC

Example code: <param name = "3" value = "B3-LPC(3,1)">

Equation(s) Implemented :

$$\text{Residual signal is given by, } e(n) = x(n) - \sum_{i=1}^{p} a_i x(n-i)$$

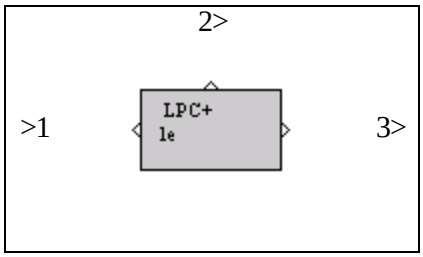
$$\text{LP synthesis filter is given by, } H(z) = \frac{1}{1 + \sum_{i=1}^{p} a_i z_i^{-i}}$$

M7.3

Block name : Linear prediction coefficients + **Notation**: ***LPC+***

Description: This block calculates the linear predictor coefficients (LPC). The autocorrelation function is incorporated in this block in contrast to the LPC block.

Pin assignment:



Pin	Description
1	Time-domain signal, *x(n)*
2	LP coefficients, a_i
3	Residual signal, *e(n)*
4	
5	
6	

Dialog window(s):

- None-

Script use:

Name: LPC+

Example code: <param name = "3" value = "B3-LPC+(3,1)">

Equation(s) Implemented :

Residual signal is obtained by using the equation, $e(n) = x(n) - \sum_{i=1}^{p} a_i x(n-i)$

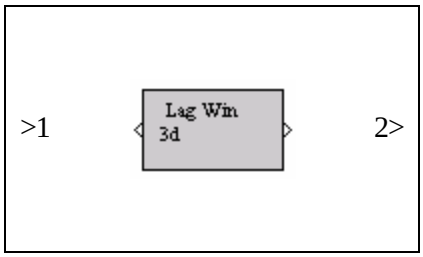
LP synthesis filter is given by, $H(z) = \frac{1}{1 + \sum_{i=1}^{p} a_i z_i^{-i}}$

M7.4

Block name : Lag window **Notation**: ***Lag. Win***

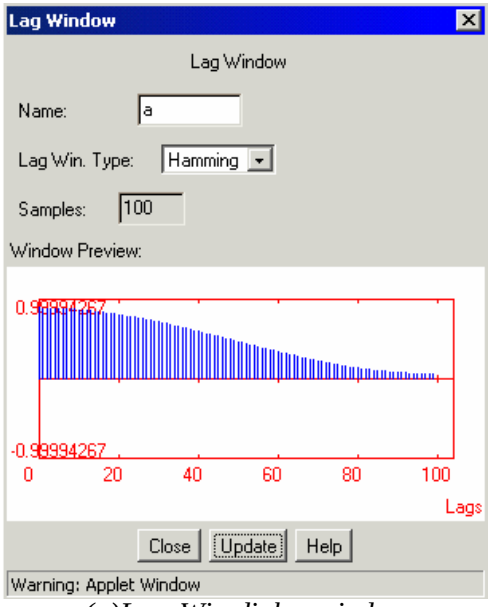
Description: This block windows the input signal with a user-defined window function. The window functions available are: Hamming, Hanning, rectangular, Bartlett, Blackman, and Kaiser. The maximum window length is 256 samples.

Pin assignment:



Pin	Description
1	Autocorrelation sequence, $r_{xx}(m)$
2	Windowed autocorrelation, $r^{w}(m)$
3	
4	
5	
6	

Dialog window(s):



(a)Lag. Win dialog window

Script use:

Name: lagwindow

Example code: <param name = "3" value = "B3-lagwindow(3,1)">

Equation(s) Implemented :

$$r^{w}_{xx}(m) = w(m)r_{xx}(m)$$

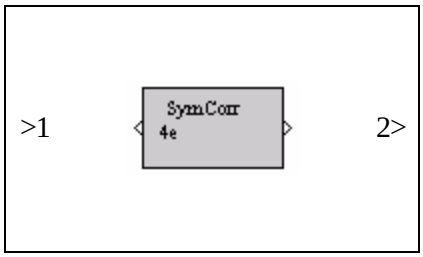
$r_{xx}(m)$ is the autocorrelation sequence and $r^{w}_{xx}(m)$ the windowed autocorrelation.

M7.5

Block name : Symmetric correlation **Notation**: ***Sym. Corr.***

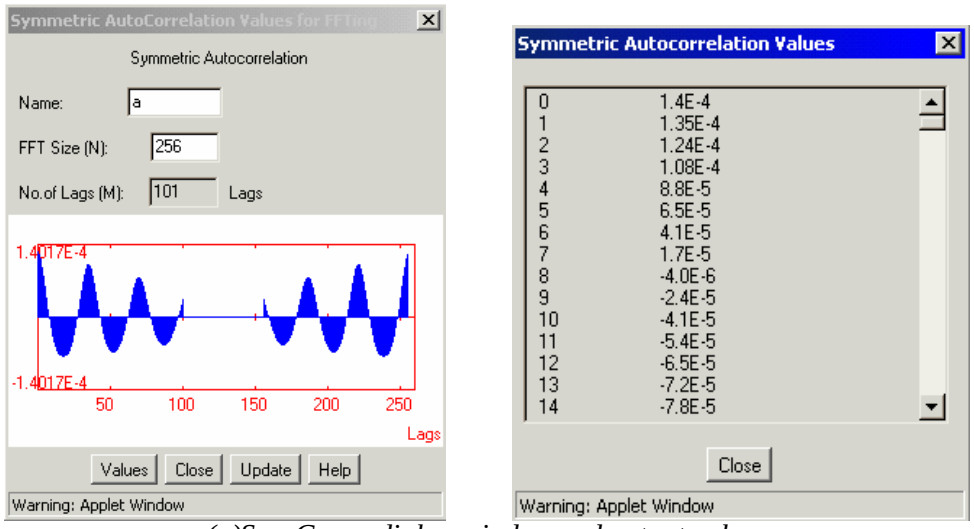
Description: This block makes the autocorrelation lags, r_{xx} symmetric so that they can be used with the FFT block in order to calculate the power spectral density (PSD). Symmetry of the autocorrelation sequence around 0 is modified to symmetry around the edges

Pin assignment:



Pin	Description
1	Autocorrelation sequence, $r_{xx}(m)$
2	Symmetric autocorrelation sequence, $r_{xx}^{(s)}(m)$
3	
4	
5	
6	

Dialog window(s):



(a)Sym.Corr. dialog window and output values

Script use:

Name: symcorr
Example code: <param name = "3" value = "B3-symcorr(3,1)">

Equation(s) Implemented:

$$r^{(s)}_{xx}(N-m) = r_{xx}(m);$$

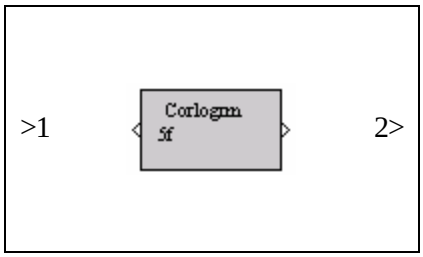
where n = FFT size and m = number of lags
For example if the FFT size, N = 8, and the number of lags is 3, then
$r^{(s)}_{xx}(8) = r_{xx}(0)$, $r^{(s)}_{xx}(7) = r_{xx}(1)$, $r^{(s)}_{xx}(6) = r_{xx}(2)$, and so on.

M7.6

Block name : Correlogram **Notation**: ***Correlogram***

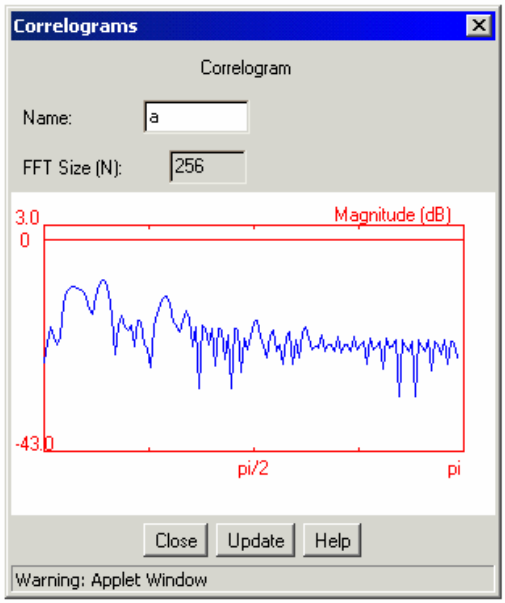
Description: This block computes a PSD estimate by performing an FFT on the symmetric autocorrelation sequence.

Pin assignment:



Pin	Description
1	Symmetric autocorrelation sequence, $r_{xx}^{(s)}(m)$
2	PSD estimate, $R_{xx}(k)$
3	
4	
5	
6	

Dialog window(s):



(a)Correlogram dialog window

Script use:

Name: corrlog

Example code: <param name = "3" value = "B3-corrlog(3,1)">

Equation(s) Implemented :

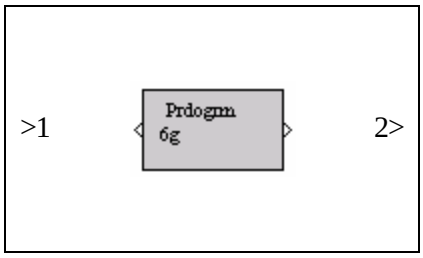
$$R_{xx}(k) = \frac{1}{N}\left[\sum_{m=0}^{N-1} r^{(s)}_{xx}(m) e^{-\left[\frac{j2p\,km}{N}\right]}\right]$$

N = the length of the sequence

Block name : Periodogram **Notation**: ***Prdogm*.**

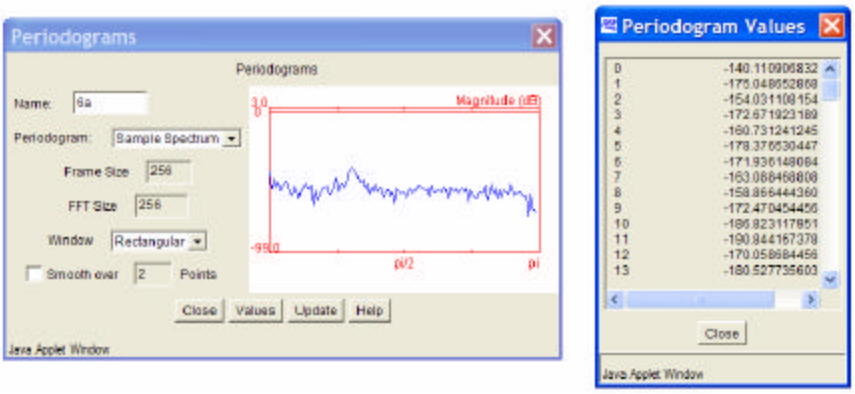
Description: This block estimates the power spectral density (PSD) by operating directly on the data set. Two different periodograms can be used to estimate the PSD: sample spectrum or Welch periodogram. The user can specify the number of "smooth over" points to implement the Daniell periodogram over the sample or the Welch periodograms.

Pin assignment:



Pin	Description
1	Input $x(n)$
2	PSD estimate, $R_{xx}(k)$
3	
4	
5	
6	

Dialog window(s):



(a) Prdogm dialog window and output values

Script use:

Name: periodgm

Example code: <param name = "3" value = "B3-periodgm(3,1)">

Equation(s) Implemented :

The sample spectrum of the p^{th} frame is given by, $R_{xx}^{p}(k) = \frac{1}{N}\left|\sum_{n=0}^{N-1} w(n)x^{p}(n)e^{-\frac{j2p\,kn}{N}}\right|^{2}$,

Welch periodogram, $R_{xx}^{w}(k) = \frac{1}{P}\sum_{p=1}^{P} R_{xx}^{p}(k)$

$w(n)$ = window, $x^{p}(n)$ = The p^{th} frame of the time-domain input signal.

$R_{xx}^{w}(k)$ = Welch PSD estimate of all the frames.

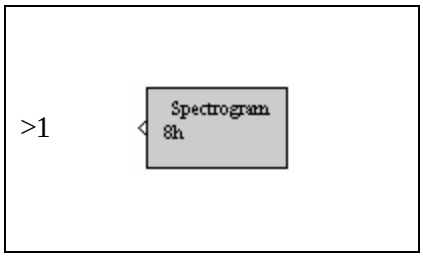
$R_{xx}^{p}(k)$ = Sample PSD estimate of the p^{th} frame.

M7.8

Block name : Spectrogram **Notation**: ***Spectrogram***

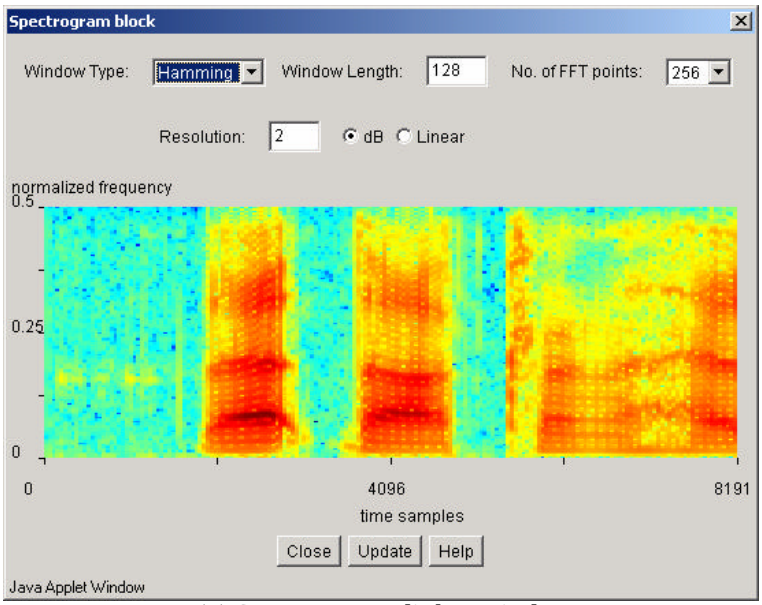
Description: This block calculates the spectrogram (frequency versus time plot) of the given input signal. The window types available are: Hamming, Hanning, rectangular, Gaussian, Bartlett, and Kaiser. The window length, the number of FFT points and the resolution can be specified by the user. By moving the cursor on the plot, the normalized magnitude, and the x-y coordinates can be viewed.

Pin assignment:



Pin	Description
1	Time-domain signal, *x(n)*
2	
3	
4	
5	
6	

Dialog window(s):



(a) Spectrogram dialog window

Script use:

Name: specgram

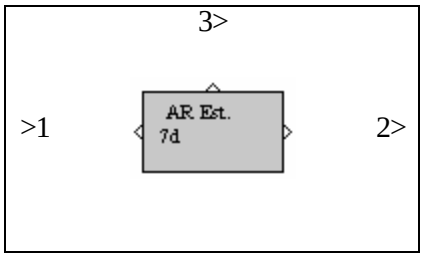
Example code: <param name="3" value="B2-specgram(3,1)">

M7.10

Block name : AR estimator **Notation**: ***AR Est.***

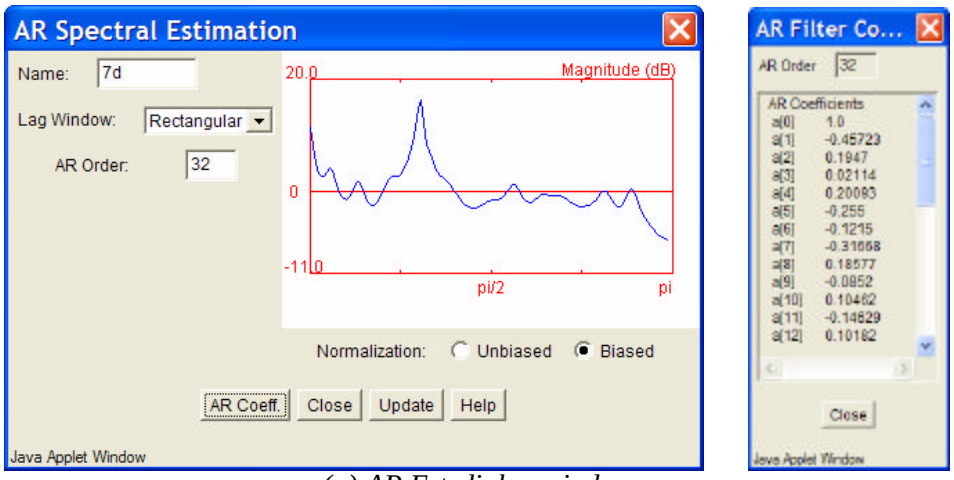
Description: This block computes the AR coefficients and plots the auto-regressive spectrum of the input signal using the Levinson-Durbin algorithm. The following lag windows are available: rectangular, Hamming, triangular, and Gaussian. The maximum number of AR coefficients allowed = 64.

Pin assignment:



Pin	Description
1	Time-domain signal, $x(n)$
2	LPC spectrum, $R^{AR}_{xx}(k)$
3	AR coefficients, a_i
4	
5	
6	

Dialog window(s):



(a) AR Est. dialog window

Script use:

Name: AREst

Example code: <param name = "3" value = "B3-AREst(3,1)">

Equation(s) Implemented :

$$R_{xx}^{AR}(k) = \left| \frac{1}{1 + \sum_{i=1}^{P} a_i z^{-i}} \right|^2$$

Here, a_i = Linear Prediction (LP) coefficients and N is the order of the LP filter