Fall 2021, Zewail City of Science and Technology, 6th
October City, 12588 Giza, Egypt

ANALYSIS OF STOCHASTIC PROCESSES

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PROCESS

The code was made to adapt to any sample process from a MatLab file with time ***t*** and amplitude ***X***. More attention was directed into making sure the program does not crash or just stop, but on the contrary, communicates with the user and send error messages and notes to direct the user.

CODE

```
clc;
clear;
load('Sample_Process.mat');

%%%plot%%%%%%%%%%%%%%%
M=input("enter number of sample functions wanted");
for i=1:M
    figure;
    plot(t,X(i,:));
    title(['Sample Function ',num2str(i)]);
end
%%plot(t,X(1:M,:));

%%ensemble mean%%%
enmean=mean(X);
figure;
plot(t,enmean);
title('Ensemble Mean');

%%%%time mean%%%%
N=input("enter the number of sample function you want to calculate time average to");
while N>M
fprintf('error, number must be less than %d \n',M);
N=input("enter the number of sample function you want to calculate time average to");
end
tmean=mean(transpose(X(N,:)))/0.1;
disp(tmean);

%%ensemble ACF%%%%%%%%%%
j=input('inset j');
autoc=X(:,i).*X(:,j);
autocmean=mean(autoc);
figure;
plot(t,autocmean,".");

%%%time ACF%%%%
NN=input("enter the number of sample function you want to calculate time average to");

multi=0;
for tao=1:101
    for q=1:101
        if (q+tao)<102
```

```
44 -            multi=multi+X(NN,q)*X(NN,q+tao);
45 -           end
46 -       end
47 -       TimeACF(tao)=multi;
48 -       multi=0;
49 -   end
50 -   disp(TimeACF);
51 -   figure;
52 -   plot(-t,TimeACF,t,TimeACF);
69 -   for v=1:100
70 -       tvp(v)=sum(X(v,:).*X(v,:));
71 -   end
72     %%disp("this is B");
73     %%disp(mean(tvp))
74 -   pAVG=mean(tvp);
75
76
77     %%PSD%%%
78 -   psd=abs(fft(TimeACF,100)).^2/101;
79 -   figure,bar(psd);
80
81     %%%%%%%%%%
82 -   for i=1:100
83 -       for j=1:100
84 -           ACF(i,j)=mean(X(:,i).*X(:,j));
85 -       end
86 -   end
87 -   disp (ACF)
88 -   figure;
89 -   x1=1:100;
90 -   x2=1:100;
91 -   surf(ACF)
```

Note that this code was edited to suit the demands of the GUI in terms of interactivity and linking parameters and variables. The code used to develop the GUI is also attached.

RESULTS

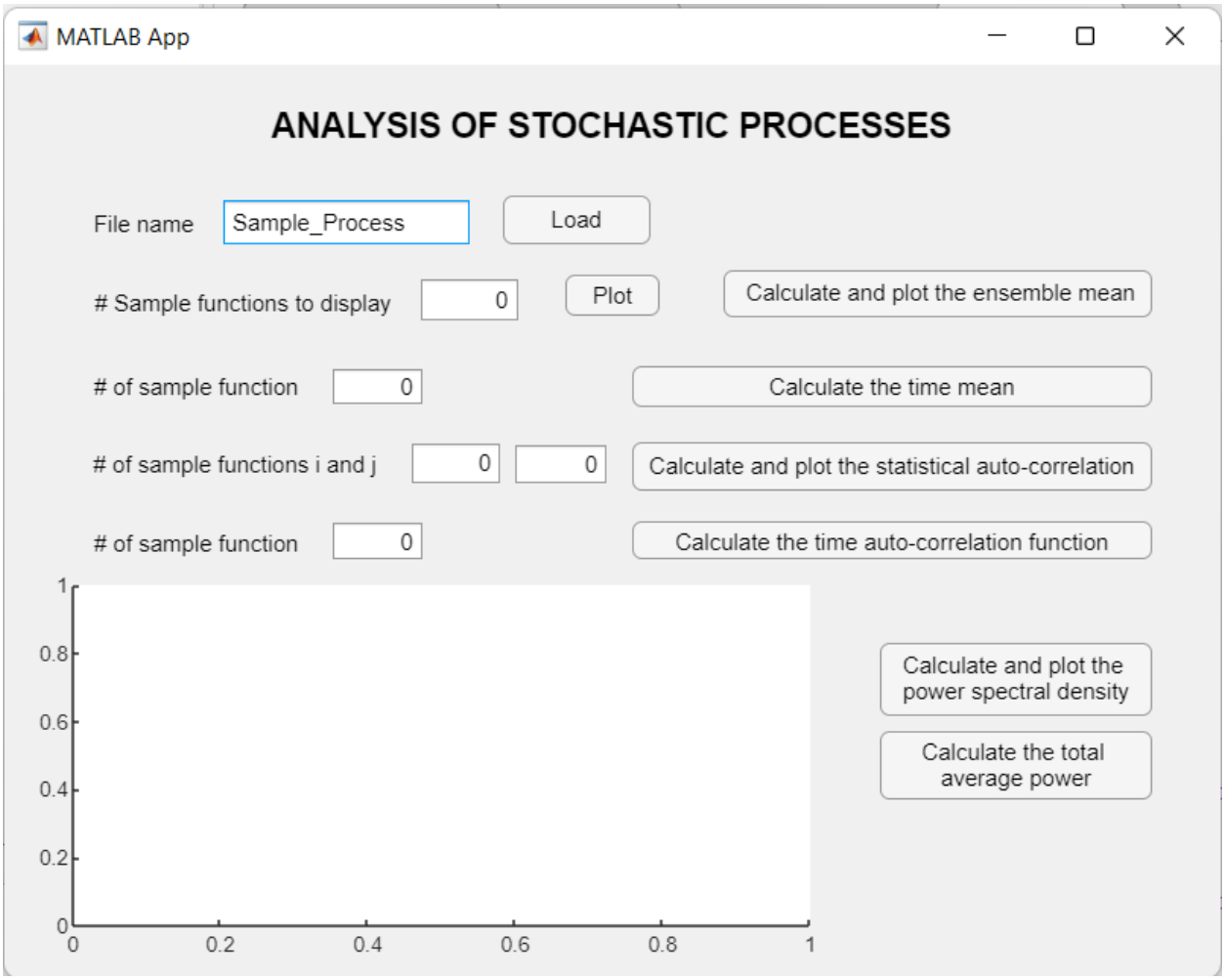


FIGURE 1 SCREENSHOT FROM THE GUI

The user can enter the name of the file or its location provided its without double quotations “ ”.

SAMPLE FUNCTIONS OF THE ENSEMBLE OF THE PROCESS

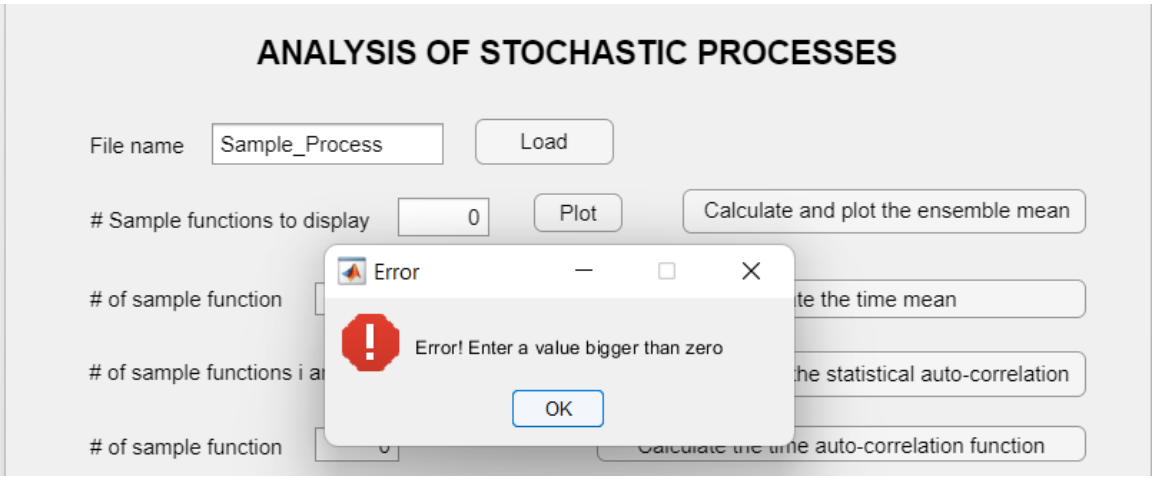


FIGURE 3 ERROR EXAMPLE WHEN A USER ENTERS A ZERO OR A NEATIVE NUMBER AND PRESSES THE PLOT BUTTON

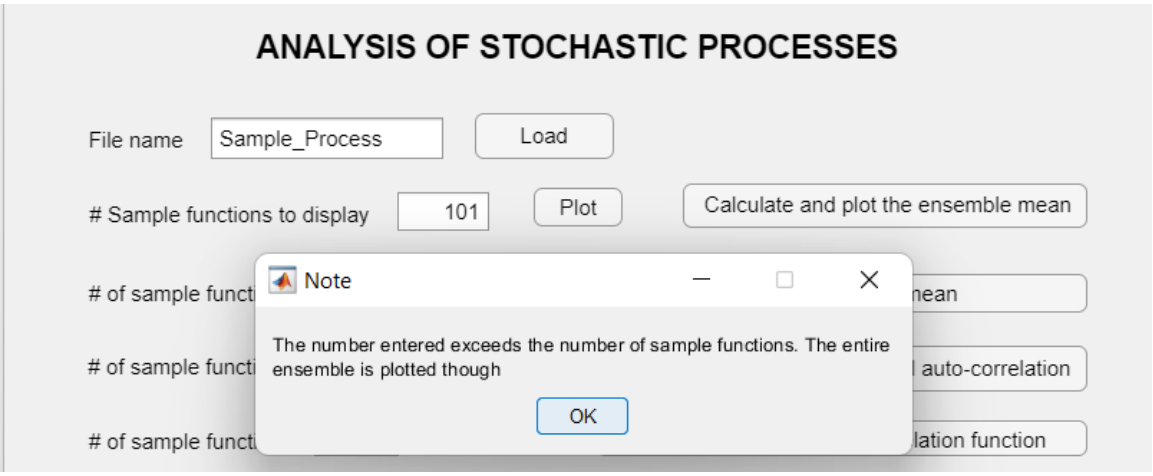


FIGURE 2 ERROR EXAMPLE WHEN A USER ENTERS A BIGGER NUMBER THAN NUMBER OF SAMPLES AND PRESSES THE PLOT BUTTON

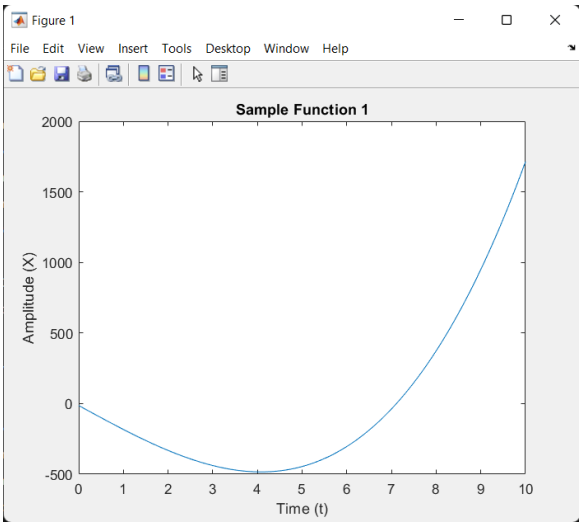


Figure 1
File Edit View Insert Tools Desktop Window Help
Sample Function 1
Amplitude (X)
Time (t)

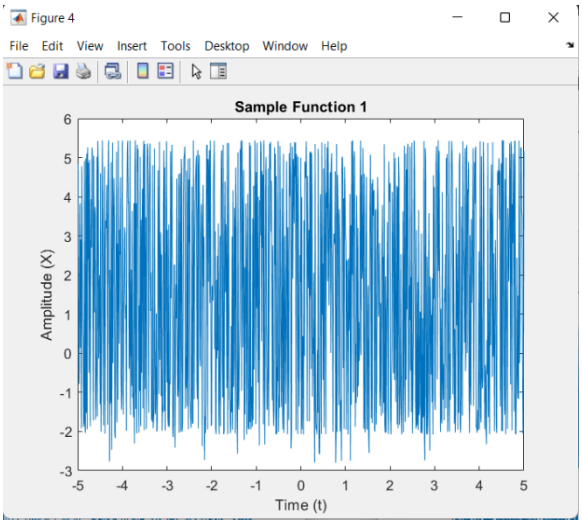


Figure 4
File Edit View Insert Tools Desktop Window Help
Sample Function 1
Amplitude (X)
Time (t)

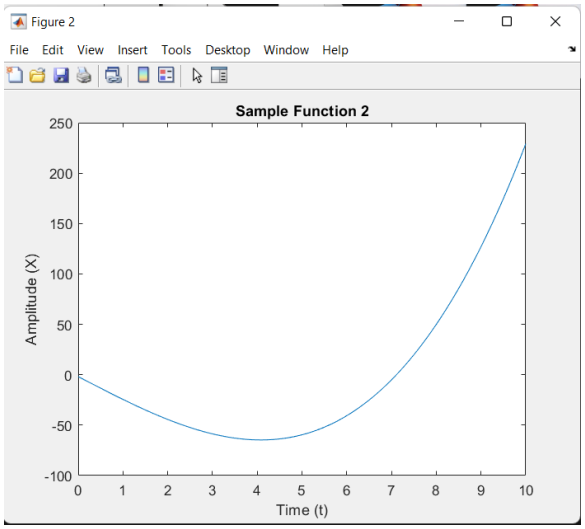


Figure 2
File Edit View Insert Tools Desktop Window Help
Sample Function 2
Amplitude (X)
Time (t)

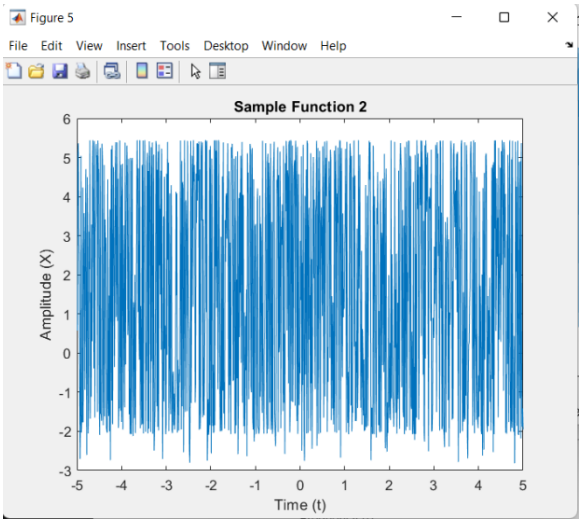


Figure 5
File Edit View Insert Tools Desktop Window Help
Sample Function 2
Amplitude (X)
Time (t)

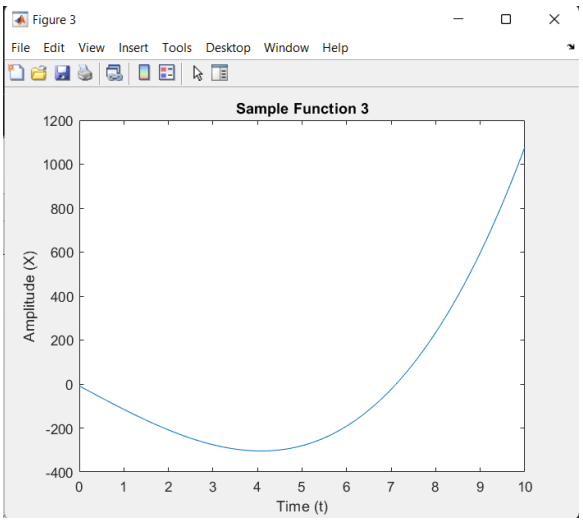


Figure 3
File Edit View Insert Tools Desktop Window Help
Sample Function 3
Amplitude (X)
Time (t)

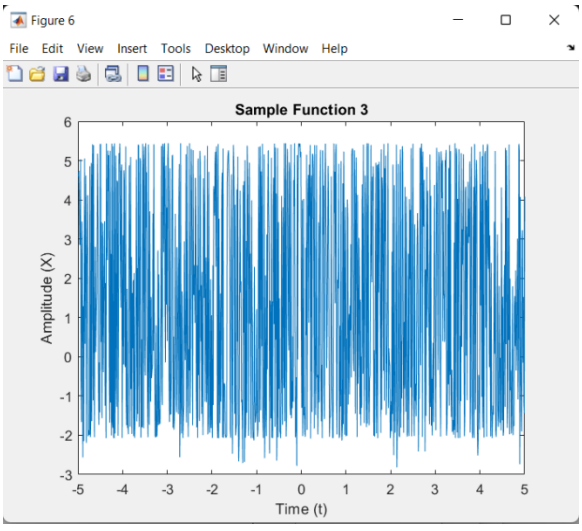


Figure 6
File Edit View Insert Tools Desktop Window Help
Sample Function 3
Amplitude (X)
Time (t)

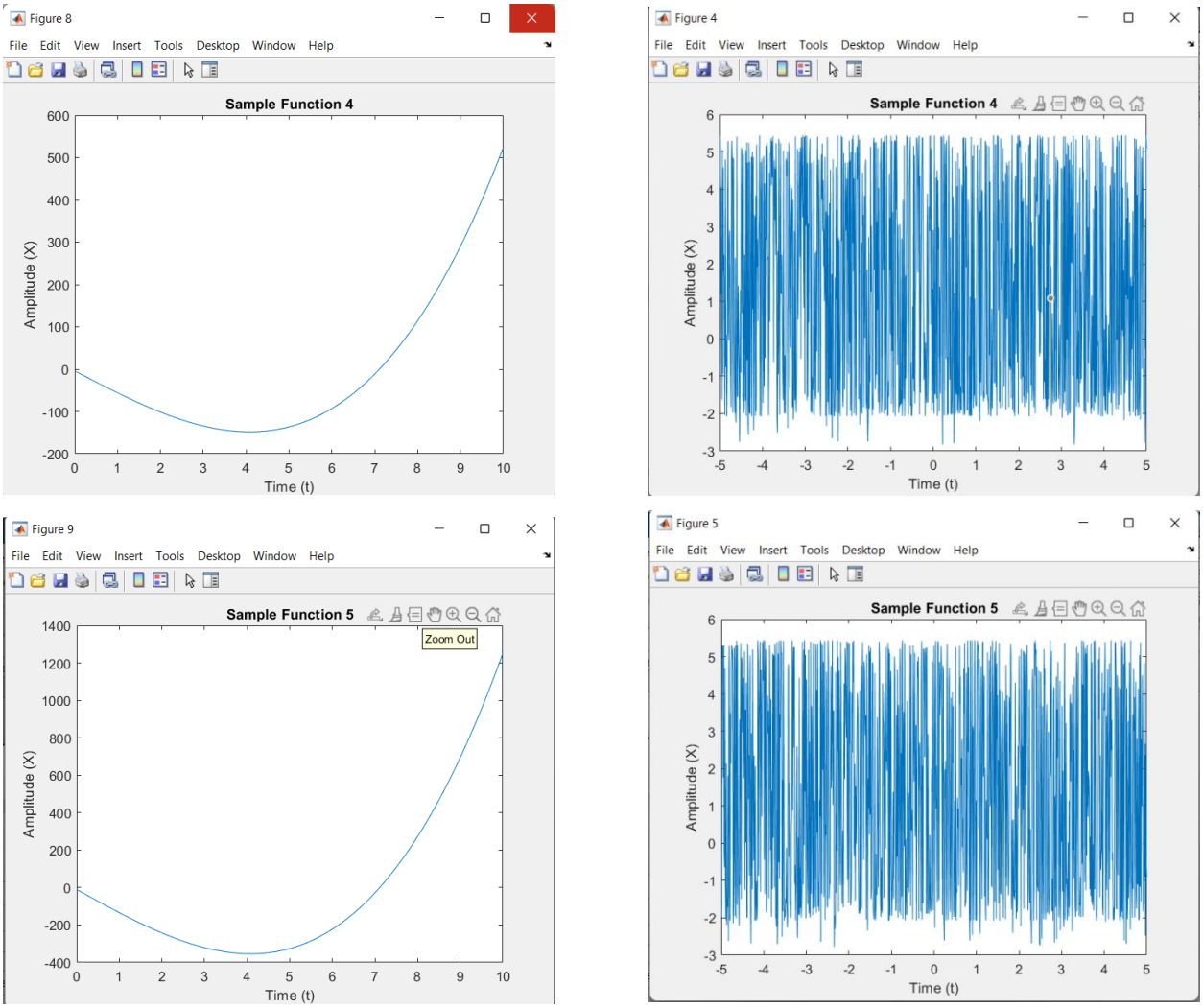


FIGURE 4 FIVE SAMPLE FUNCTIONS PRINTED FOR THR SAMPLE PROCESS GIIVEN, ON THE LEFT, AND THE PROCESS DISCREIBED BY THE FUNCTION Y, ON THE RIGHT

THE ENSEMBLE MEAN OF THE PROCESS

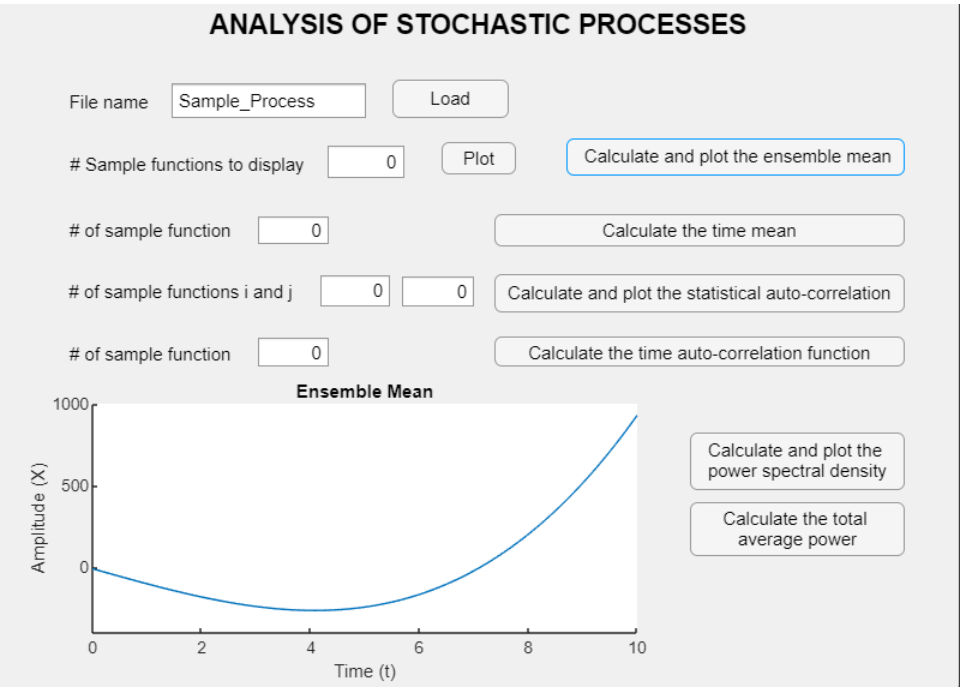


FIGURE 6 ENSEMBLE MEAN OF THE GIVEN SAMPLE PROCESS

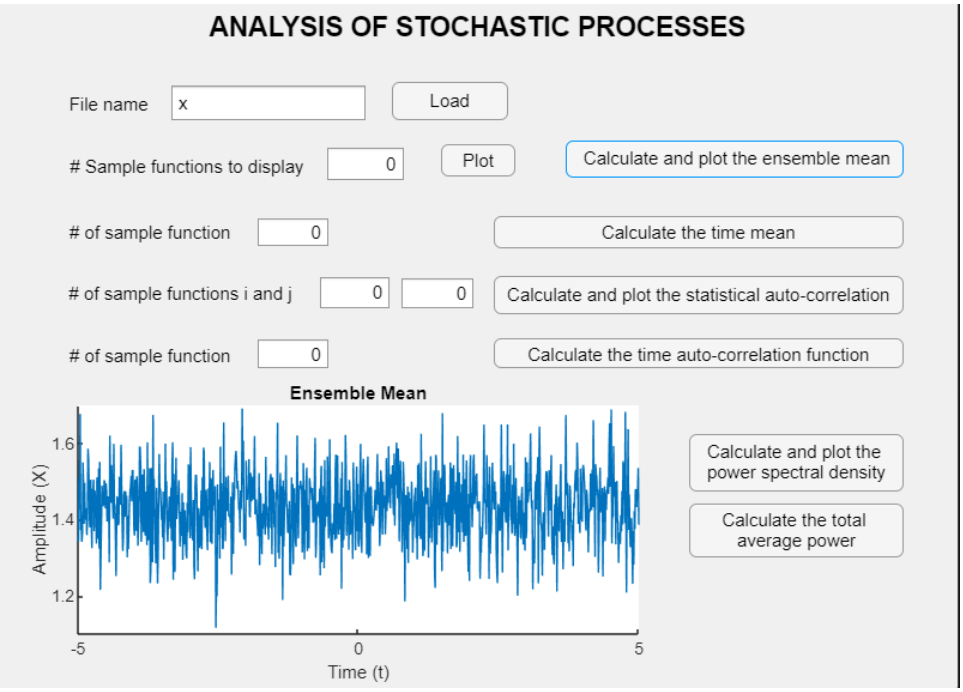


FIGURE 5 ENSEMBLE MEAN OF THE PROCESS DISCREIBED BY THE FUNCTION Y

No comment.

THE TIME MEAN OF ANY SAMPLE FUNCTION OF THE PROCESS

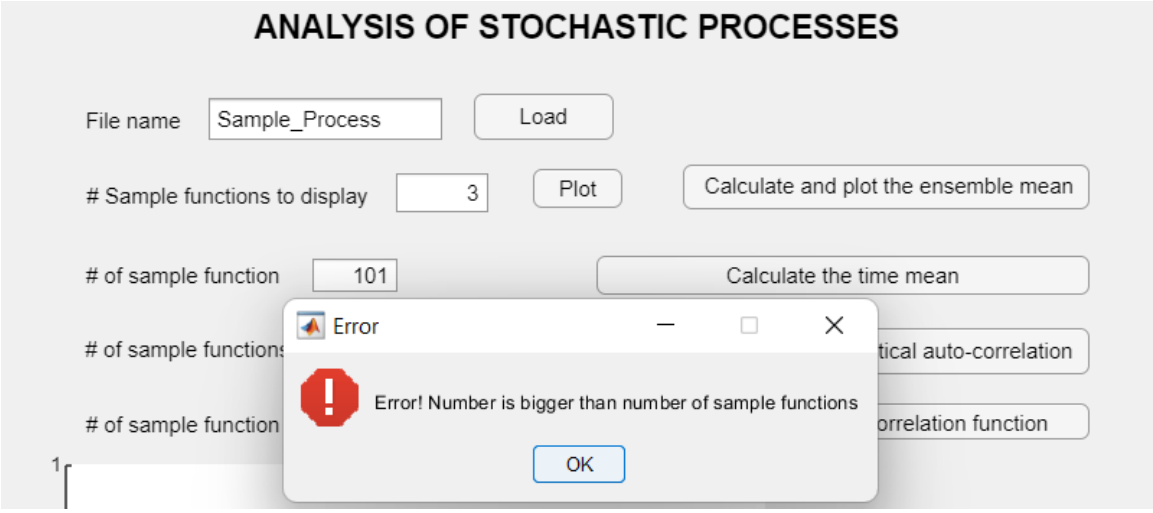


FIGURE 8 EXAMPLE ERROR WHEN THE USER ENTERS A VALUE BIGGER THAN NUMBER OF SAMPLES AND PRESSES THE CALCULATE THE TIME MEAN BUTTON

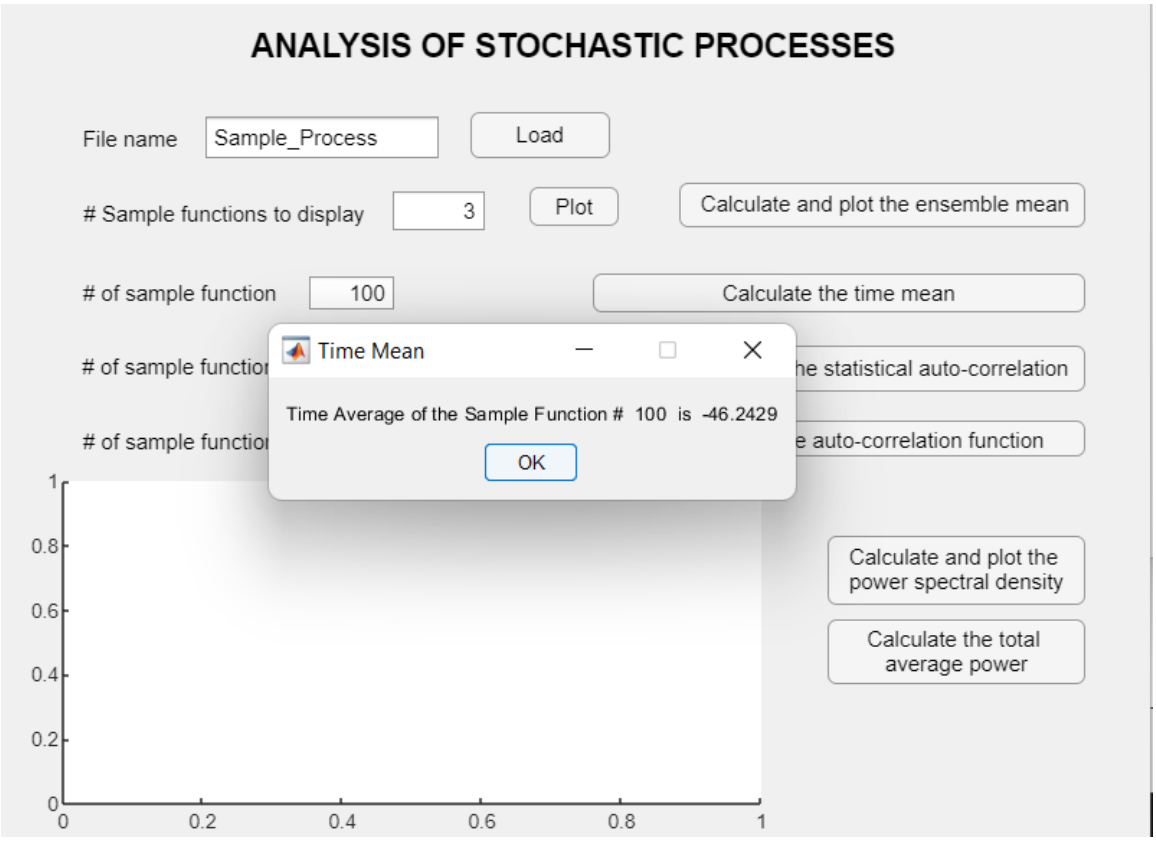


FIGURE 7 TIME MEAN OUTPUT FOR THE 100TH SF OF THE GIVEN SAMPLE FUNCTION

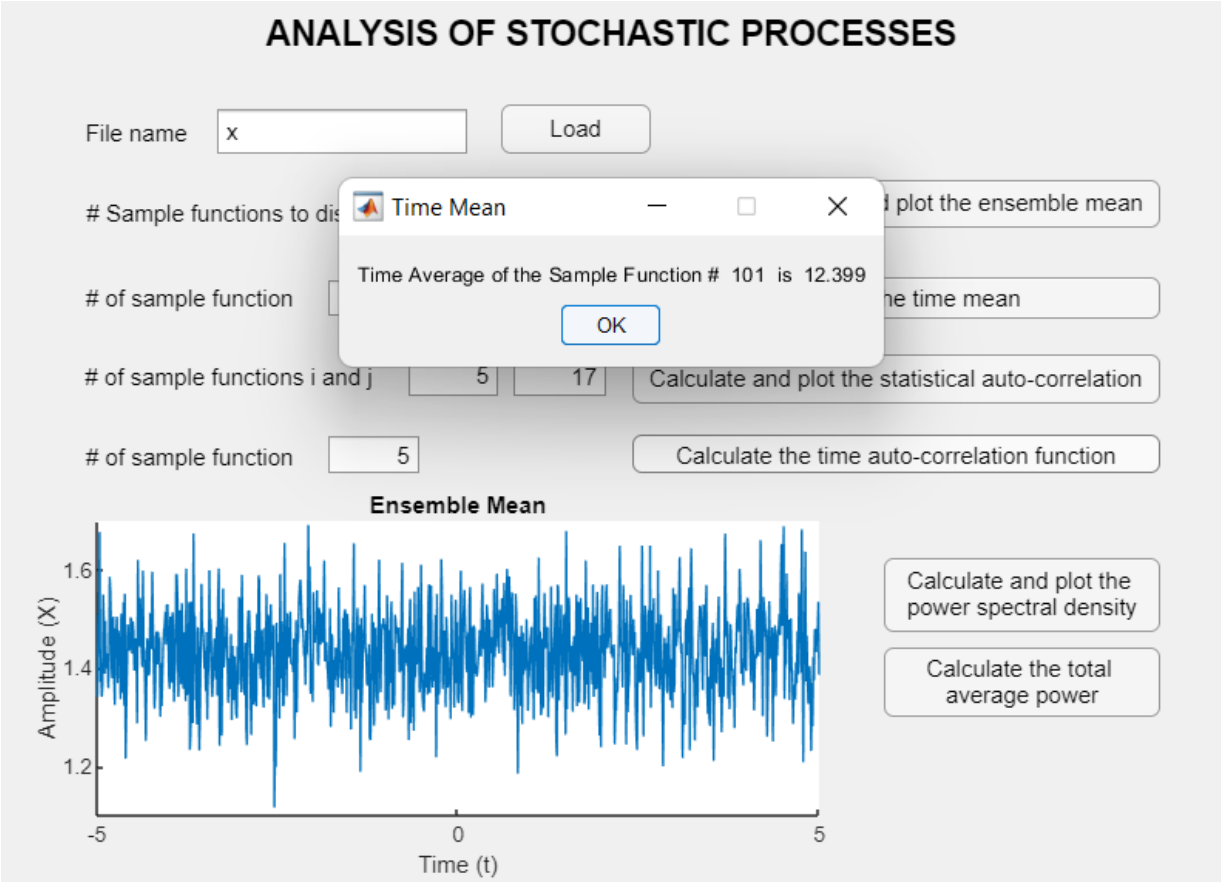


FIGURE 9 TIME MEAN OUTPUT FOR THE 101ST SF OF THE PROCESS DISCREIBED BY THE FUNCTION Y

Is there a relation between the statistical mean and the time mean, for the test process?

There is no relation between the statistical mean and the time mean unless the process is ergodic, which is not the case in neither process.

THE STATISTICAL AUTO-CORRELATION FUNCTION BETWEEN 2 SAMPLE FUNCTIONS

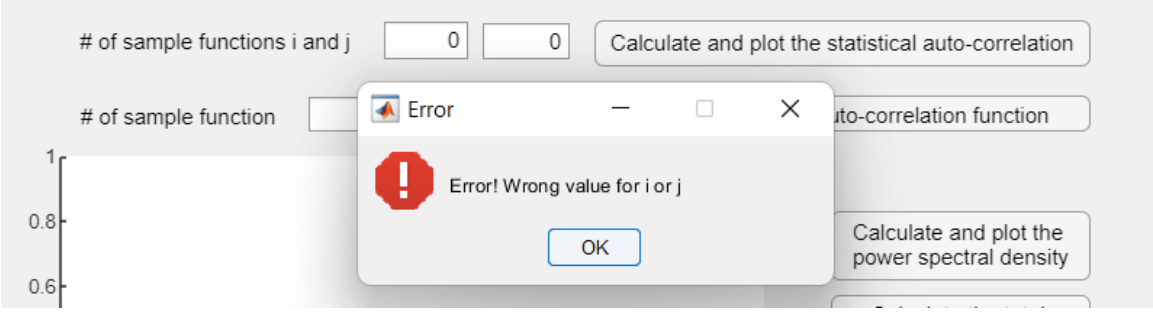
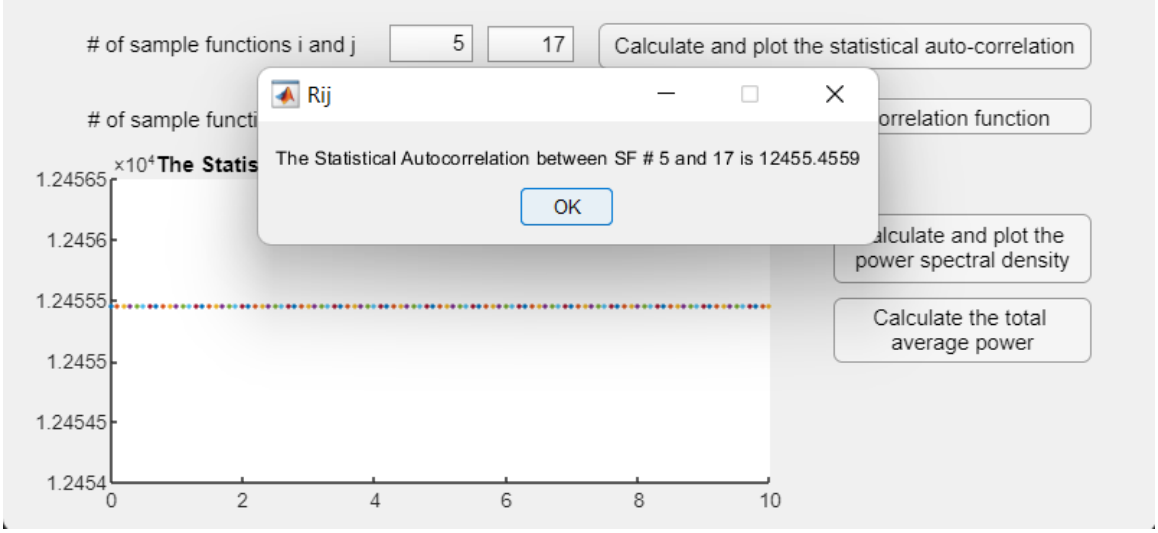


FIGURE 10 EXAMPLE ERROR WHEN THE USER ENTERS AN UNALLOWED VALUE FOR I OR J



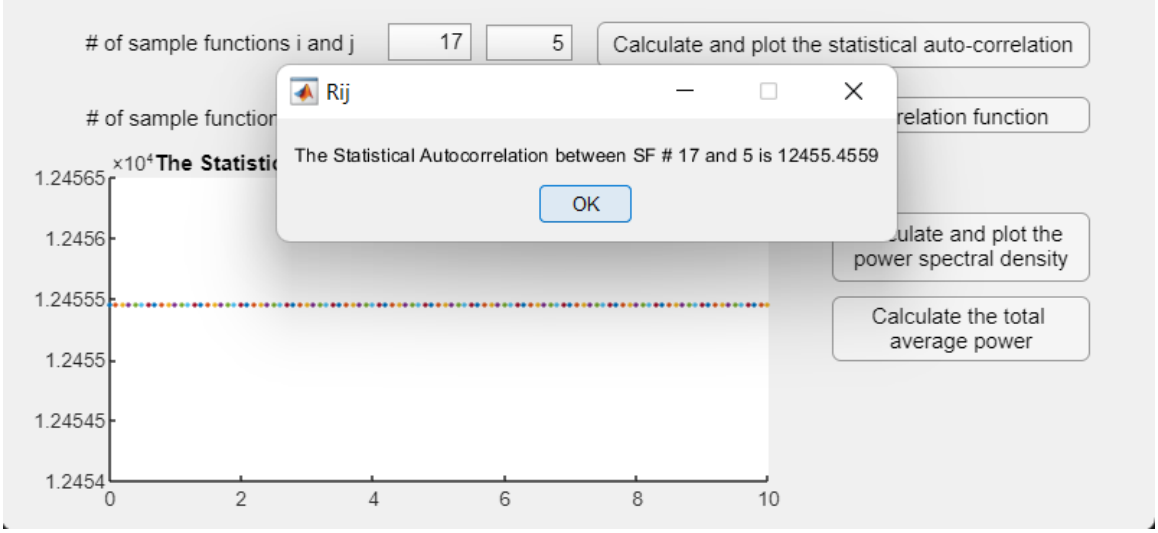


FIGURE 11 RESULTS FOR STATISTICAL ACF BETWEEN 5 AND 17, AND 17 AND 5 OF THE GIVEN SAMPLE PROCESS

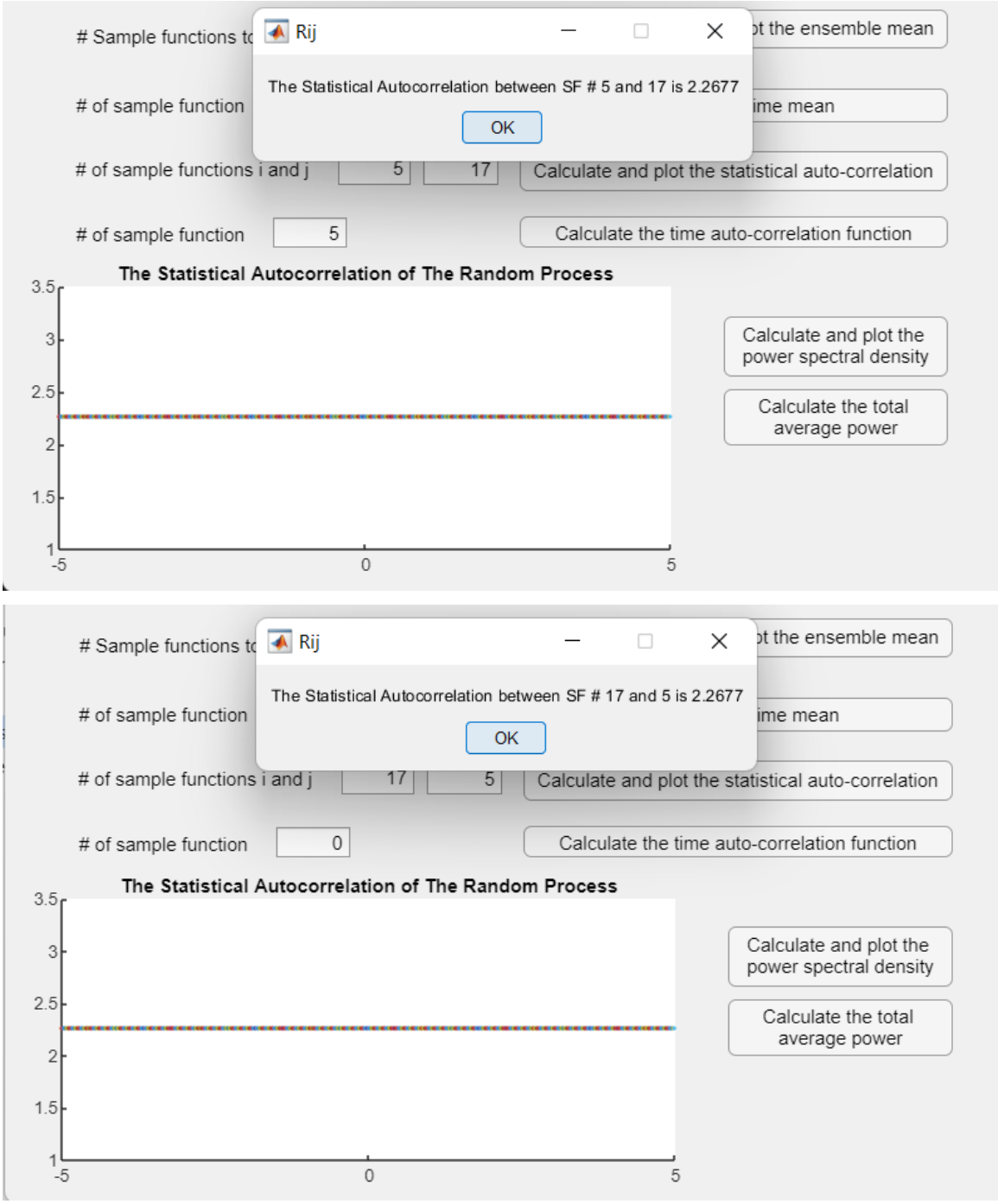


FIGURE 12 13 RESULTS FOR STATISTICAL ACF BETWEEN 5 AND 17, AND 17 AND 5 OF THE PROCESS DISCREIBED BY THE FUNCTION Y

This check was made to make sure the right algorithm was used. It can be noticed that order of ***i*** and ***j*** does not matter, for either process.

THE TIME AUTO-CORRELATION FUNCTION FOR A SAMPLE FUNCTION AND THE POWER SPECTRAL DENSITY OF THE PROCESS

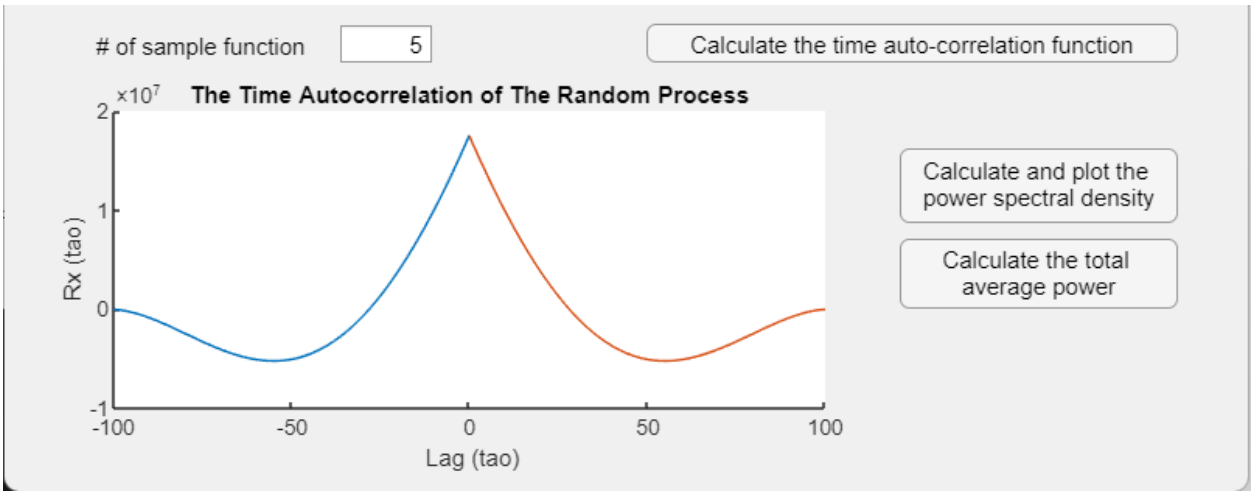


FIGURE 14 TIME ACF OUTPUT FOR THE 5TH SF OF THE SAMPLE PROCESS GIVEN

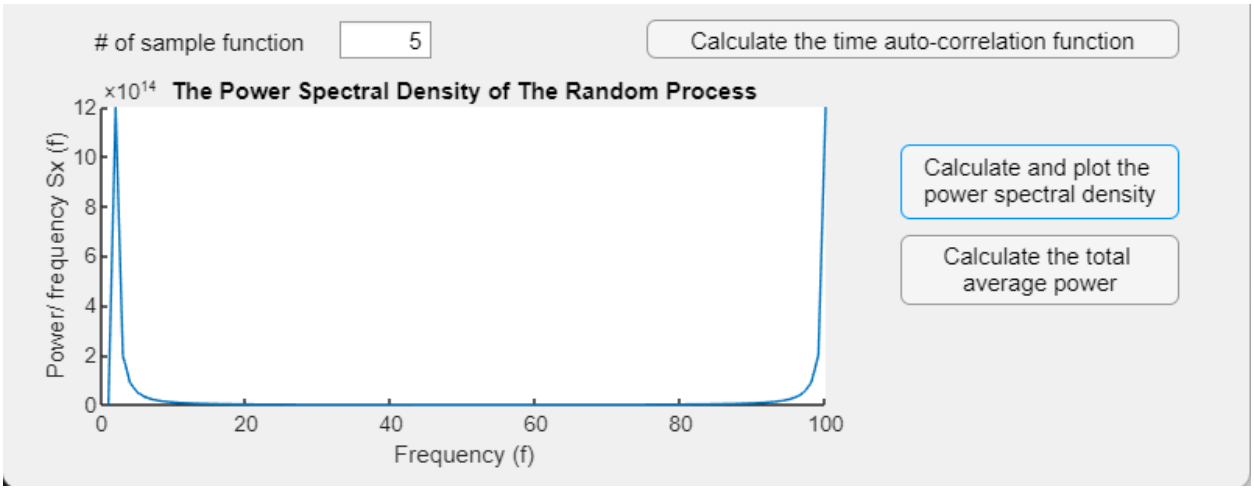


FIGURE 15 16 PCD OUTPUT FOR THE 5TH SF OF THE SAMPLE PROCESS GIVEN

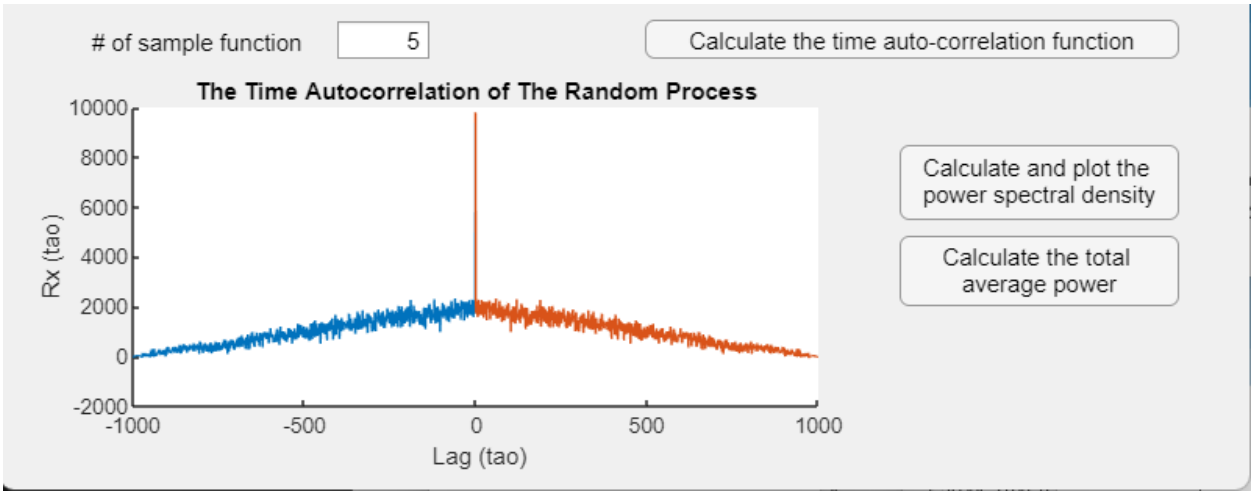


FIGURE 17 TIME ACF OUTPUT FOR THE 5TH SF OF THE PROCESS DISCREIBED BY THE FUNCTION Y

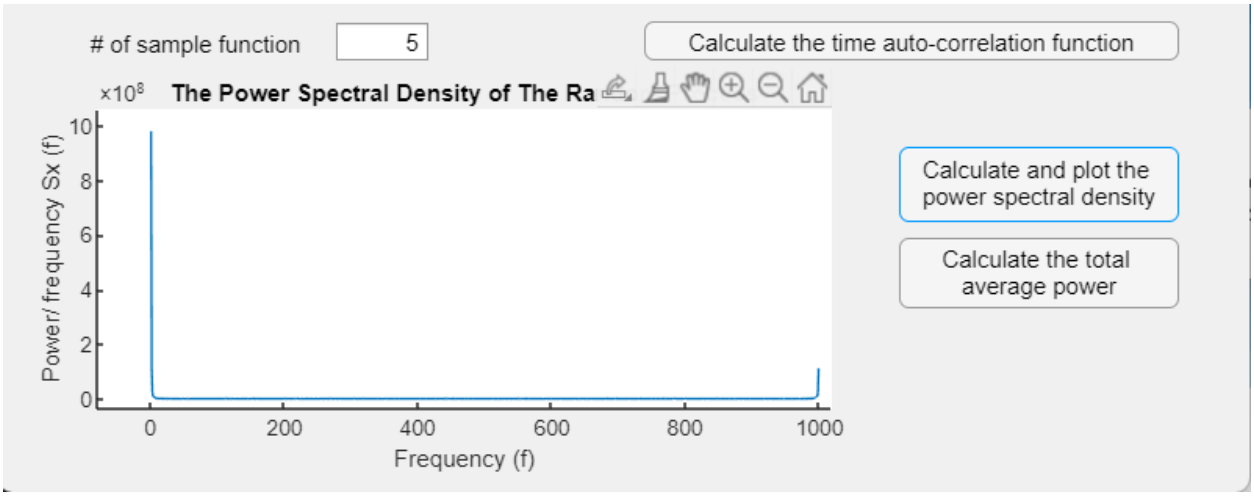


FIGURE 18 PCD OUTPUT FOR THE 5TH SF OF THE PROCESS DISCREIBED BY THE FUNCTION Y

It can be seen that even though the value of signal can be negative sometimes, both the ACF and the PCD are positive real, and symmetric around the vertical line.

It can be noticed that the highest value of the time ACF graph lies on the zero-lag line. This is because the highest correlation is to be between the signal and itself, without no lag.

Is there a relation between the statistical ACF and the time ACF, for the test process?

There is no relation between the statistical mean and the time mean unless the process is ergodic, which is not the case in neither process.

THE TOTAL AVERAGE POWER OF THE PROCESS

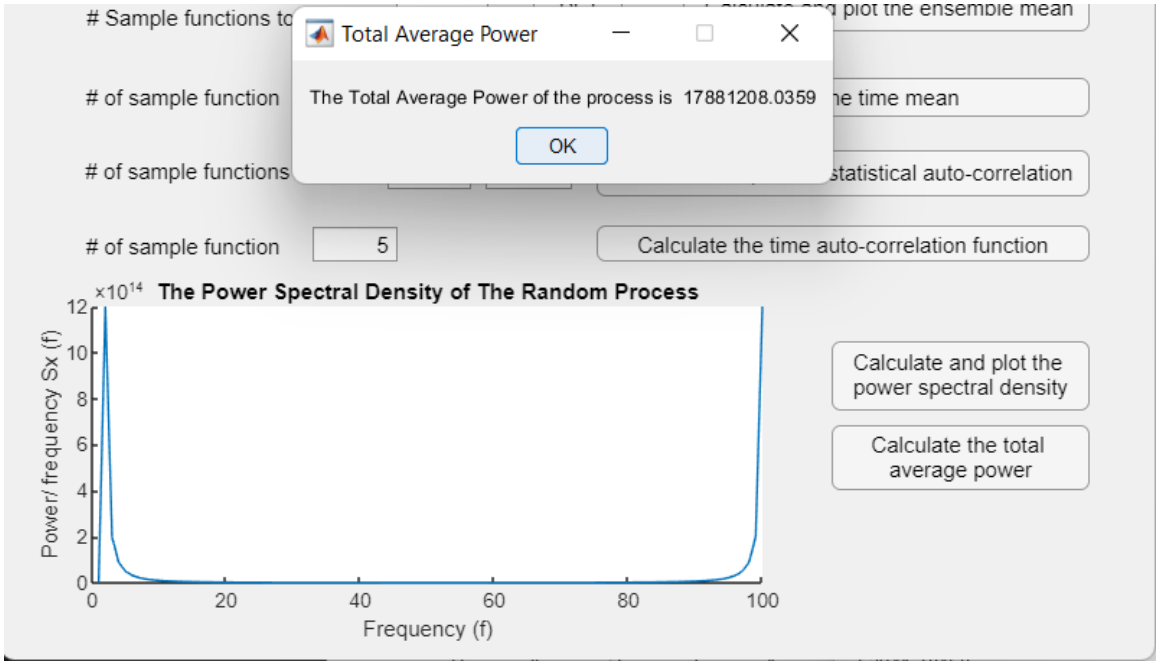


FIGURE 20 FOR THE GIVEN PROCESS

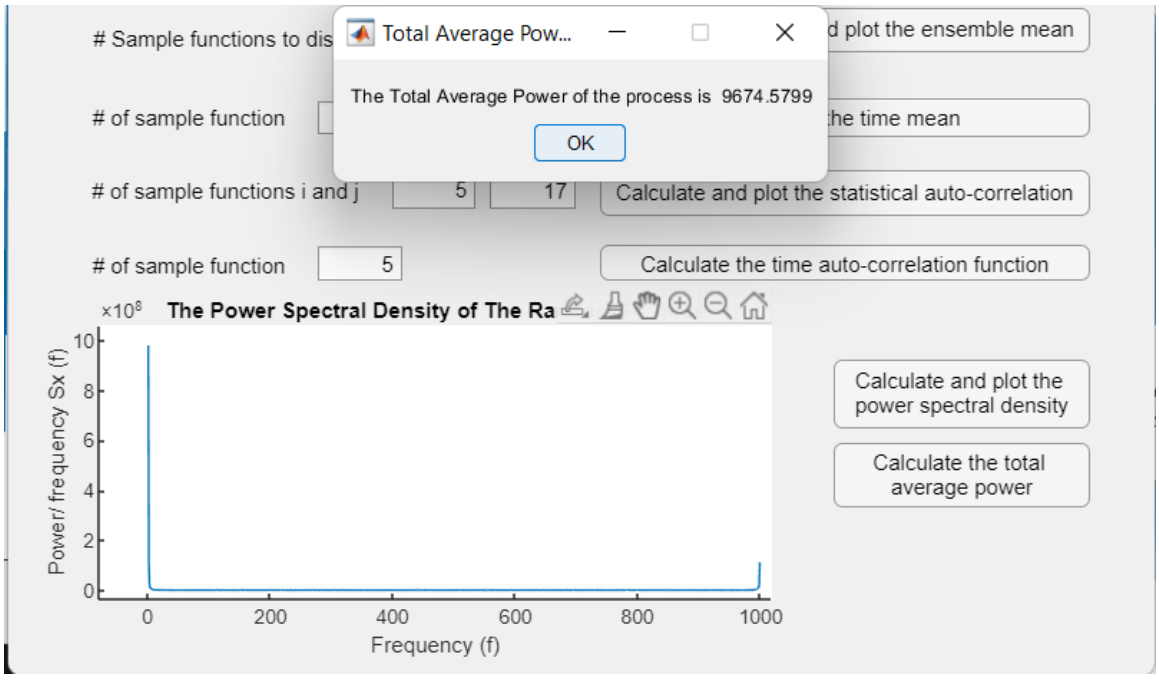


FIGURE 19 FOR THE PROCESS DISCREIBED BY THE FUNCTION Y

It can be noticed that the total average power is the value of $S_x(0)$, in both sample processes.

3D PLOT

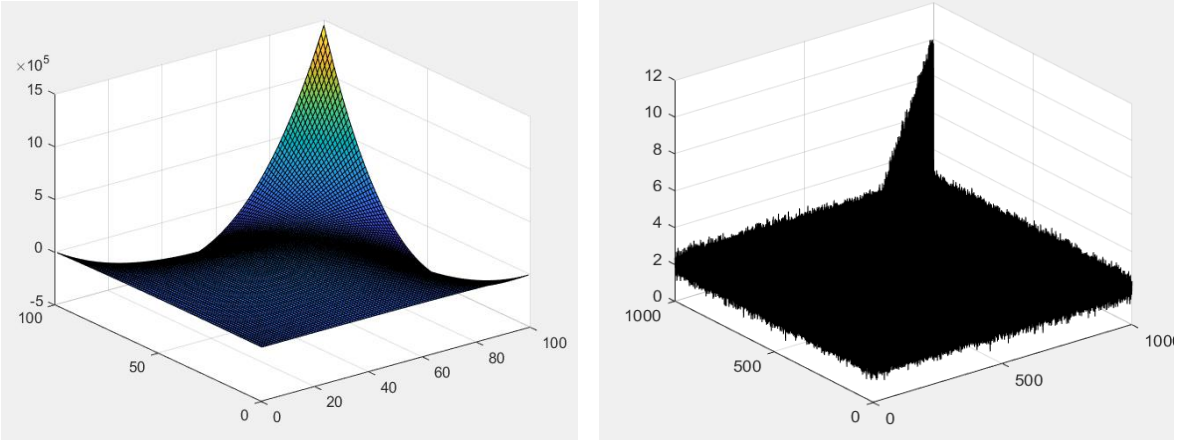


FIGURE 21 THE PLOT OF THE ACF BETWEEN ITH SAMPLE AND THE JTH SAMPLE FOR EVERY I AND J FOR THE GIVEN SAMPLE PROCESS, ON THE LEFT, AND THE PROCESS DEINED BY FUNCTION Y, ON THE RIGHT

It can be noticed that the highest values lie on the ***j=i*** line, which makes sense since the highest correlation must be between the signal and itself.