Correlation Signal Analysis in MATLAB Environment

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Abstract – **The correlation signal analysis is applicable by detection and identifying of the different signals on the noise background as well as by the accident processes. This is one of the very important problems in the theory of the signals. It's made a trial in the paper to present the possibility of the computer simulation in MATLAB environment by deeper studying the type of correlation functions, their properties and relation with the power spectral density in case of analogue and digital signals. The paper can be used in engineering education in studying this process.**

Keywords – **Correlation functions, detection and identifying of signals, accident processes, power spectral density, computer simulation.**

I. INTRODUCTION

At the university level, the material studied becomes more abstract and more mathematical. It's described in the paper a laboratory exercises for the course on Signals and Systems of students from faculty of communications and from faculty of computer systems.

The correlation signal analysis can present the change of the signals in time domain without their spectrum. On the base of theory of correlation signal analysis, with help of computer simulation, the students get deeper insight of the auto correlation and cross correlation. They can investigate their properties and their relation with power spectral density of the signals.

The computer simulation can be realized in the program environment of MATLAB with using the system for visual modelling SIMULINK. A model can be created, which generate the analysed signals and functions. There are 2 methods to create a model in SIMULINK. First it's can be used mathematical formulae for creating building blocks, which computed the correlation functions and second by direct using of blocks for auto correlation and cross correlation. By generation in case of analogue signals can be used functions from SIMULINK, as well as functions from files in MATLAB [1]. A program can be made in case of digital signals, so the signals can be choose from the user.

II. PROBLEM FORMULATION

The problem on the correlation signal analysis can be presented with following features:

- There are 2 types of signal - analogue and digital (periodic and aperiodic). The analogue signals can have different forms such as rectangular, triangular, saw-tooth, exponential, Gaussian. Their parameters can be determinate by the students. Digital signals and their parameters can be determinate totally from the students.
- Two types of correlation functions can be investigated – auto correlation and cross correlation. Their mathematical description is given in Eq.1, respectively in Eq.2 [3].

$$\Psi(\tau) = \lim_{T\to 0} \frac{1}{T} \int_{-\frac{T}{2}}^{\frac{T}{2}} S(t)S(t-\tau)dt \qquad (1)$$

$$\Psi_{12}(\tau) = \lim_{T\to 0} \frac{1}{T} \int_{-\frac{1}{T}}^{\frac{1}{T}} S_1(t)S_2(t-\tau)dt \qquad (2)$$

where $S(t), S_1(t), S_2(t)$ are the represented signals and τ is a time delay.

- Following properties of the correlations function can be investigated – even, periodic, max value, one to one correspondence to signals.
- The relation of the functions with the power spectral density can be investigated. Its mathematical description is given in Eq.3 and in Eq.4 [3].

$$\Psi(\tau) = \frac{1}{2\pi} \int \left| S(j\omega) \right|^2 e^{j\omega\tau} d\omega \qquad (3)$$

$$\left|S(j\omega)\right|^2 = \int_{-\infty}^{\infty} \Psi(\tau) e^{-j\omega\tau} d\tau \qquad (4)$$

where $\left|S(j\omega)^2\right|$ is the power spectral density of the analyzed signal.

So on base of computer simulation we can formulate following problems:

1. To create a model of the generated signals and correlation functions.
2. To analyze the properties of the correlation functions by the definite signals.
3. To investigate the influence of the spectrum band width on the correlations function.
4. To analyze the influence of the amplitude spectral density of the different signals on the correlation functions.

By the simulation we need to see the going processes. The characteristics can be given in digital and graphical mode.

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III. EXPERIMENTAL PART

The formulated problems are solved by computer simulation in MATLAB, version 6.5 environment with using the SIMULINK TOOLBOX.

For a model creating are used direct the existing in SIMULINK blocks for auto correlation and cross correlation [2]. This method gives better results, it's precisely and we can see the computed functions direct in graphical mode, too.

To generate the analogue signals with different forms such as rectangular, triangular, saw-tooth, exponential and Gaussian, the students can use the following blocks: 'Ramp', 'Step', 'Repeating Sequence', 'Fcn', 'MATLAB Function', 'Product', 'Pulse Generator'. The using blocks can be connected in the model informative and by the control, too. The type of the connection is dependent on the block and on the logic of his work. The exchanging data can be described in scalar, vectors and matrices. The running time can be set in constant or variable step. The students can observe a running process by the block 'Scope', which is included in the model, too. An example for a simulated model is given in Fig.1. It's generated a signal with Gaussian form and also computed its correlation function.

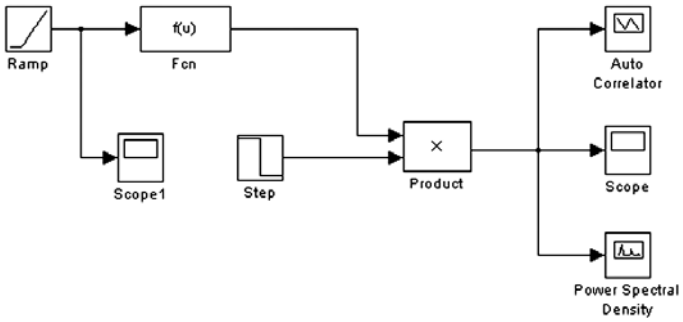

Fig.1 Model for autocorrelation with Gaussian signal

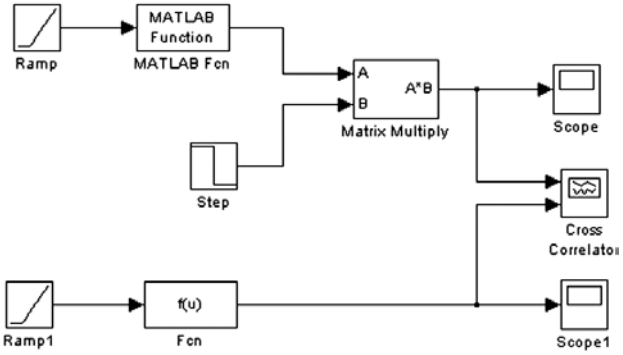

Fig.2 Model for cross correlation with Gaussian and exponential signal

The other example for a model of computing a cross correlation of signals with Gaussian and exponential form is given in Fig.2.

Fig.3 presents in graphical mode the signal and its power spectral density. The investigated signal has a Gaussian form with amplitude 3V and continue time 3 s.

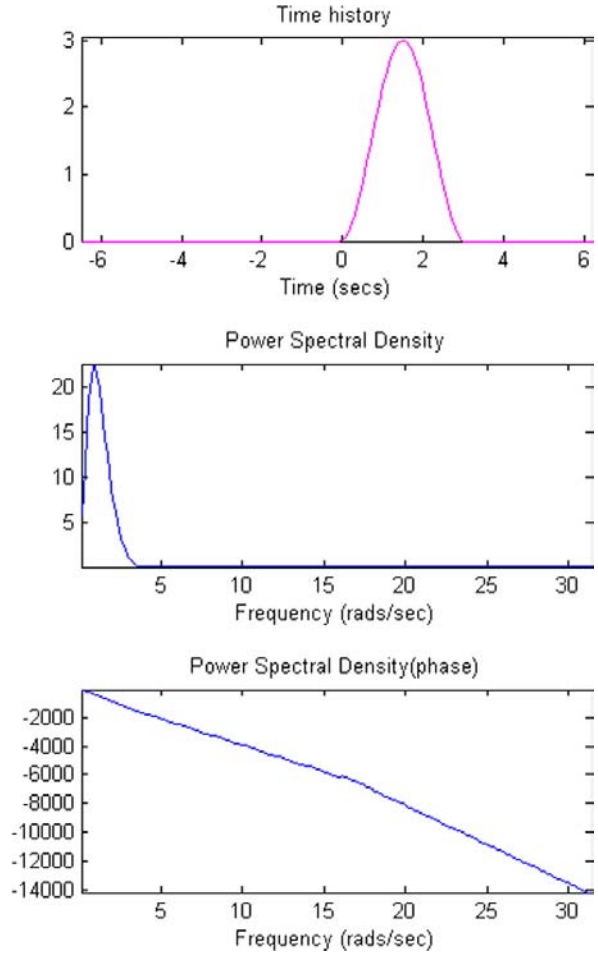

Fig.3. Power Spectral Density of the Gaussian signal

The exactly program is used for generation of digital signals and computing of the auto correlation and cross correlation. Its algorithm make possible to be choose the signal (as combination of "0" and "1"), its length (8, 16, 32 bits) and the type of correlation, too.

IV. CONCLUSION

The correlation signal analysis is one of the very important problems in the theory of the signals. It's made a trial in the paper to present the possibility of the computer simulation in MATLAB environment to get deeper insight on studying the type of correlation functions, their properties and relation with the power spectral density in case of analogue and digital signals. The students can create models to generate different signals and to change their parameters. They can also generate models to compute the correlation functions. So with the help of simulation they can investigate the influence of the signal parameters on the correlation and observe the running processes.

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