Application of the Self-Similarity of Chaotic Processes for Digital Communication Systems

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Abstract – **In this paper investigate the possibility of using fractal features of the superposition of noise signals in order to design a digital communication system.**

Keywords – **Chaotic processes, self-similarity, Hurst parameter.**

I. Introduction

Self-similarity is one of the most important characteristics of chaotic process. The Hurst parameter numerically characterizes the degree of the self-similarity [1]. The random process $X(t)$ is self-similar with Hurst parameter, if processes $X(t)$ and $a^{-H}X(at)$ have identical probability distribution for all $a>0$, i.e. their statistical properties are the same. If Hurst parameter is given within the range $0{,}5<H<1$, the process, under consideration, possesses features of the self-similarity.

II. Main Part

The aim of this paper is to investigate the possibility of using fractal features of the superposition of noise signals, which are governed by the Gaussian distribution, in order to design a digital communication system. Signals with different Hurst parameter, for example 0.1 and 0.9 will mean the transmission of binary bit "0" and "1". The mathematical model that describes the fractal noise is given by the following expression [2]:

$$X(j,H)=\frac{1}{\Gamma\left(H+\frac{1}{2}\right)}\left[\sum_{i=0}^{j}\left(\left(j+1\right)-\frac{i}{n}\right)^{H-\frac{1}{2}}x(i)-\sum_{i=0}^{j-1}\left(j-\frac{i}{n}\right)^{H-\frac{1}{2}}x(i)\right] \quad (1),$$

where $x(i)$ is the noise-like signal with the Gaussian distribution, $\Gamma\left(H+\frac{1}{2}\right)$ is the gamma function.

In the case of an unauthorized access to information transmitted via the communication channel using the conventional power receiver, which is based on the principle of signal integration the only sign of properties change in the received signal is the energy change at the neighboring time intervals. The system based on the self-similar processes possesses higher level of information protection, since the power receiver does not allow to identify the differences between the bits corresponding to "0" and "1".

Phase diagrams of the signals with different Hurst parameters are shown in fig 1. Fig. 2 shows the chaotic signal that transmits letter A in the ASCII code. Binary bits corresponding to "0" and "1" possess almost the same energy. Therefore, they can not be recognized.

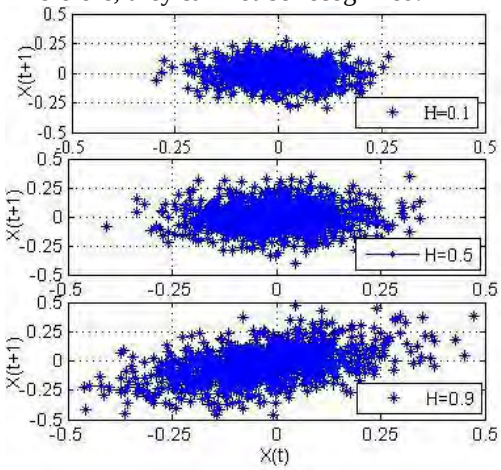

Fig.1 Phase diagrams of the signals with different Hurst parameters.

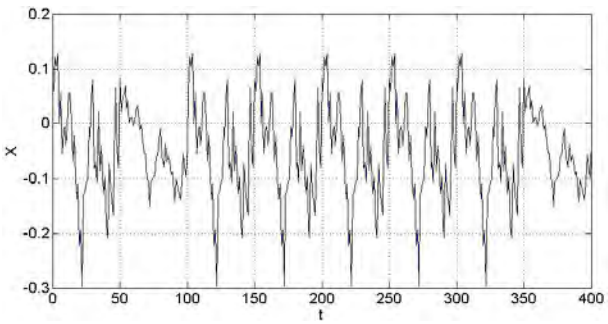

Fig.2 Chaotic signal transmitting letter A (01000001).

The Hurst parameter of a generated signal is manipulated by the binary sequence of bits. The recognition of bits of the received signal on the background of the white Gaussian noise, which is relevant in the communication channel, is reduced to detection of the moments of the change of the H parameter, by which recognition of the information signal will be performed.

III. Conclusion

The proposed method is stable to an unauthorized access to information due to the energy similarity of the bits corresponding to "0" and "1".

References

[1] О.И Шелухин., А.М Тенякшев., А.В. Осин, "Фрактальные процессы в телекоммуникациях," М.: Радиотехника, 2003, 480 с.

[2] К.С. Васюта, "Метод передачи информации, основанный на манипуляции показателя Херста фрактального "цветного" гауссовского шума," *Системи обробки інформації*, №6(87), 2010.

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