MatLab-Simulink Model of the Digital Data Transmission with the Use of Chaotic Masking

Dmytro Vovchuk, Serhii Hahiuk,
Leonid Politanskii, Nazar Ivanyshyn

Radio Engineering and Information Security Department, Yuriy Fedkovych Chernivtsi National University, Chernivtsi, Storozhynetska Str., 101, Ukraine
E-mail: dimavovchuk@gmail.com

***Abstract* – The paper touches upon the topical problem of finding efficient ways to transmit hidden information and retrieve it. The use of a modified scheme of chaotic masking for messages bits of the hidden information is offered as an alternative. The information signal is a harmonic, chaotic or noise which initially modulates a digital signal, that's why chaotic oscillations, generated by Chua's circuit, proved to become a signal carrier. Some specific conditions for increasing signal secrecy in the channel with and without noise are investigated and reveals the possibility of information bits recovery with the help of MatLab-Simulink model.**

Key words – hidden information, chaotic masking, digital signal, chaotic and noise signal, scheme model.

I. Introduction

The modern state of telecommunications requires further development of new digital communication systems. The hidden information transmission is based on the use of deterministic chaos, so chaotic oscillations generated by Chua's circuit can successfully be used as a signal carrier. This is due to the fact that chaotic oscillations have a high information capacity and continuous spectrum, occupying a broad band of frequencies.

The use of the deterministic chaos system in telecommunications depends on the quality of chaotic synchronous response of interacting systems. There are several types of chaotic synchronization and data introduction methods in the carrier oscillation [1, 2].

The aim of the work is to investigate the ability of modified chaotic masking scheme for hidden communication with the help of the MatLab-Simulink model.

II. Page Setup

Chaotic masking is one way of information transmitting using chaos synchronization [3, 4]. The research of hidden communication transmission and noise immunity demonstrated the unsuitability of such a system for practical use while transmitting digital signals [5].

In [5] presents to use of pre-modulation information signal by harmonic for hidden information increase. As a result, a modulated information signal is added to the chaotic signal carrier. The modulated information signal is a sequence of radio pulses. It would be difficult for an outside observer to distinguish a message from the intercepted signal in the channel if the value of the frequency filling for radio pulses is within the range of the chaotic signal.

Besides, the use of harmonic signal does not provide a sufficient secrecy value, since the application of bandwidth filters remains an opportunity to detect the information signal.

A signal with spectral characteristics similar to the carrier chaotic oscillations is, therefore, advisable to use as a modulating oscillation. Another chaotic signal of this generator can be used as an information signal to simplify the scheme.

We chose Chua's circuit to be used as a driving generator. The circuit is divided into two parts after decomposition. They are combined together into a single ring of feedback and work as a self-oscillating system. The ring of feedback is disconnected in response generator. As a result, it is passive and follows the dynamics of the driven generator when being attached to unidirected coupled communication with equal parameters. Under these circumstances we can speak about chaotic synchronous response setting.

The information masking takes place due to additive adding to the carrier oscillation. The scheme of this system is presented by fig. 1. The use of signal W_1 as information proved to be efficient, as the research has shown that the spectrum range of V_1 signal covers the spectrum of signal W_1 providing a higher level of information secrecy in the communication channel (fig. 2).

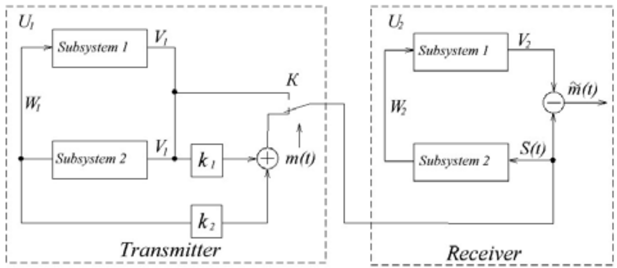

Fig. 1. The scheme of hidden transmission for digital information using the chaotic signal masking

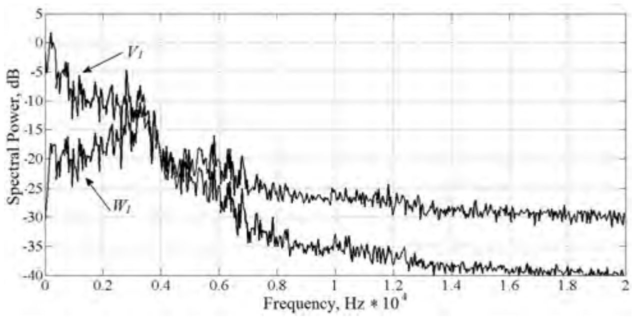

Fig. 2. The spectral characteristics of the carrier and information signals

The obtained signal is sent into the channel as a result of the following conditions:

$$S(t)=\begin{cases} V_1,\ if\ \ m(t)=1 \\ k_1V_1+k_2W_1,\ if\ \ m(t)=0 \end{cases}, \quad (1)$$

where k_1 is used to ensure that the signals cannot be distinguished by value of their power; k_2 – is the increasing factor for W_1 signal.

As a result of subtraction of the receiver's input signal and the *subsystem 1* output signal without noise we obtain the following value for the driven generator:

$$\tilde{m}(t) = \begin{cases} 0, \; if \;\; m(t) = 1 \\ (1-k_1)V_1 - k_2 W_1, \; if \;\; m(t) = 0 \end{cases} \qquad (2)$$

If we use the noise signal w as information, then $W_1 \equiv w$ in equal (1) and (2).

We developed a scheme model in the environment Simulink (Fig. 3) to evaluate its performance applicability according to its mathematical model:

$$\begin{cases} \dot{x}_1 = \alpha(y_1 - x_1 - f(x_1)) \\ \dot{y}_1 = x_1 - y_1 + z_1 \\ \dot{z}_1 = -\beta y_1 \\ \dot{x}_2 = \alpha(y_2 - x_2 - f(x_2)) \\ \dot{y}_2 = S(t) - y_2 + z_2 \\ \dot{z}_2 = -\beta y_2 \end{cases} \qquad (3)$$

A nonlinear element is implemented as a separate subsystem and labeled *Nr* in the scheme. A *Pulse Generator* bloc is used for message signal imitation. A *Band-Limited White Noise* bloc is used as a noise generator and for the noise effect modeling in the channel.

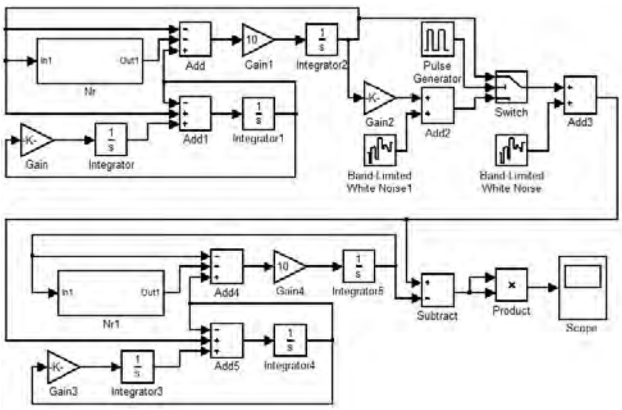

Fig. 3. MatLab-Simulink model of the investigated system

The time diagrams of signal in the channel when the channel is without noise are present by fig. 4.

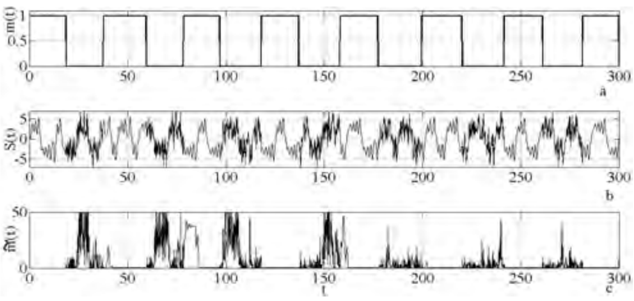

Fig. 4. The signal in the channel without noise
and the retrieved signal

Having compared fig. 4a and fig. 4c we can conclude that the information signal can be recovered with high accuracy using the offered technique.

A noise is always present in a real channel. It leads to information distortion and incorrect recovery (fig. 5). To increase the probability level of error-free signal restoration it is necessary to increase the bit length and information signal power. These conditions will provide the required value of signal/noise. The oscilograms of the information signal and receiver output signal are given in fig. 6.

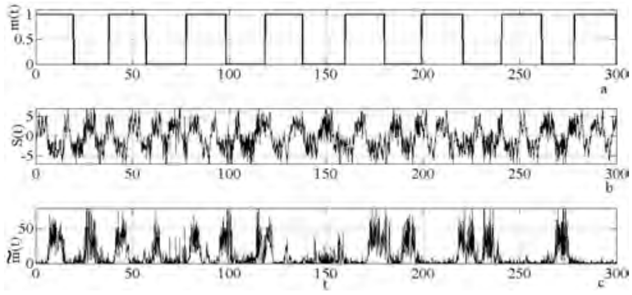

Fig. 5. The signal in the channel without noise
and the recovered signal

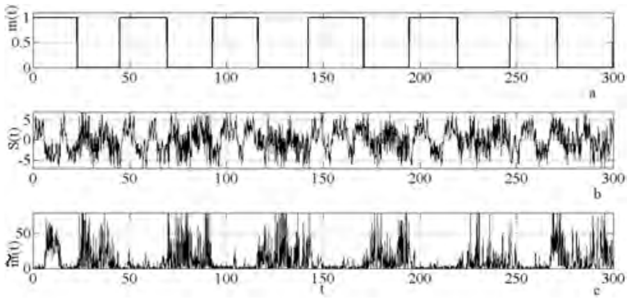

Fig.6 The signal in the channel with noise
and the recovered signal

The main problem for information recovery is a transitory process when bits are switched and noise is present in a channel. To address these problems, a compromise between decreasing the value of secrecy and the speed of transmission is required. The use of the chaotic masking scheme for hidden transmission of digital information has proved the potential applicability of the offered model for practical use in communication systems.

References

[1] Dmitriev A., Panas A. Dynamic chaos: novel type of information carrier for communications systems. Izdatel'stvo Fiziko–matematicheskoj literatury, 2002.

[2] L. Politansky, S. Galiuk, M. Kushnir, R. Politansky Osoblivosti sinhronizaciї haotichnih sistem (ogljad), Skladni sistemi i procesi – №2, pp. 3-29, 2011.

[3] A. Koronovskii, O. Moskalenko, A. Hramov On the use of chaotic synchronization for secure communication, Uspekhi Fizicheskikh Nauk – № 12, pp. 1282-1310, 2009.

[4] P. Ivanyuk, L. Politansky, R. Politansky, O. Eliyashiv Chaotic masking of information signals using generator based on the Liu System, Tekhnologiya i Konstruirovanie v Elektronnoi Apparature - №3, pp. 11-17, 2012.

[5] D. Vovchuk, S. Haliuk, L. Politanskii Adaptation of the chaotic masking method for digital communication, Eastern-European Journal of Enterprise Technologies – № 2/4(62). – pp. 50-55, 2013.