

**MODELING AND RESEARCH OF CHAOTIC ROSSLER SYSTEM
WITH LABVIEW AND MULTISIM SOFTWARE ENVIRONMENTS¹**

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**МОДЕЛЮВАННЯ ТА ДОСЛІДЖЕННЯ ХАОТИЧНОЇ СИСТЕМИ РОСЛЕРА З
ДОПОМОГОЮ ПРОГРАМНИХ СЕРЕДОВИЩ LABVIEW І MULTISIM.**

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Introduction

Deterministic chaos is one of the new elements which is recently started to be frequently used in modern communication systems. Chaotic systems allow masking information carrier for a certain chaotic law [1]. Since mathematical models describing the work of transmitting-receiving units of modern chaotic information systems have become more complex, modelling of information properties of deterministic chaos is becoming more topical [2].

Chaotic Rossler system is one of chaotic systems used for security of the information carrier, and described by three nonlinear differential equations:

$$\begin{aligned}\frac{dx}{dt} &= -y - z, \\ \frac{dy}{dt} &= x + ay, \\ \frac{dz}{dt} &= b + z(x - c),\end{aligned}\tag{1}$$

where x, y, z – dynamic variables that determine the phase space, a, b, c – system parameters [3-5].

In communication systems using deterministic chaos big problem is the selection of the same circuit parameters of generator that generate chaotic signal. A small deviation parameters on the receiving side makes it impossible to decrypt the received message. The solution to this problem is to create software that allows to generate and explore chaotic Rossler system. The software has been created in one of the most modern system LabView (LabVIEW 2010 (32 bit) for Windows). It serves as a substitute circuit realization of the chaotic Rossler generator.

¹ Електронний варіант статті: <http://radar.kpi.ua/index.php/radiotechnique/article/view/832>

Modelling of Chaotic Rossler System in LabView

Figure 1 shows a block scheme that implements chaotic Rossler system. The main functional part of the block scheme is the formula node, in which recorded three nonlinear differential equations (1).

In the input formula node served values of system parameters (a, b, c) and values of dynamic variables (x, y, z). From the block scheme output is an opportunity to demonstrate the solution of equations in three dimensions.

When changing the system parameters and initial conditions we can be analysed in detail and investigate the behaviour of chaotic Rossler system, which can serve as a basic element of the functional blocks of chaotic secure communication systems.

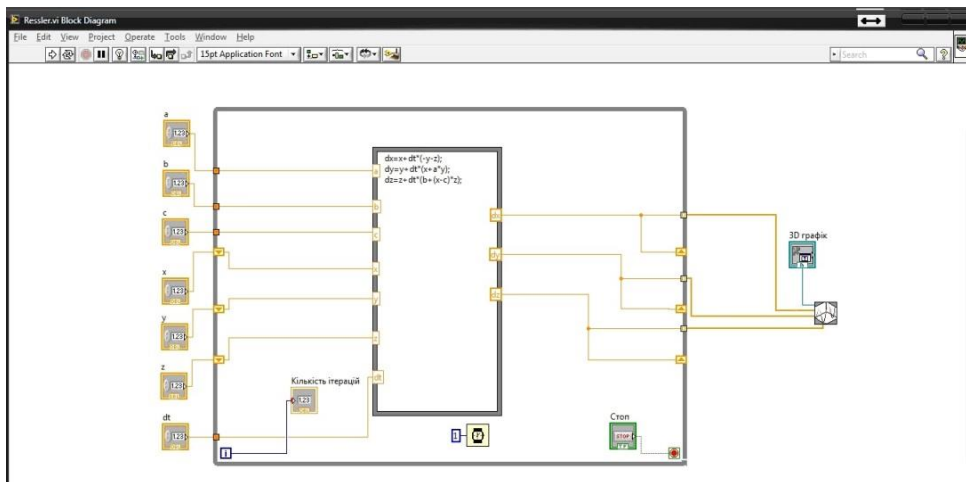


Fig. 1. – A block scheme that implements a chaotic Rossler system

Results of the research time dependences X, Y, Z are shown in Figure 2, with the number of iterations $N = 10000$, the system parameters $a = 0,398$, $b = 2$, $c = 4$ and dynamic variables that equal $x = y = z = 1$.

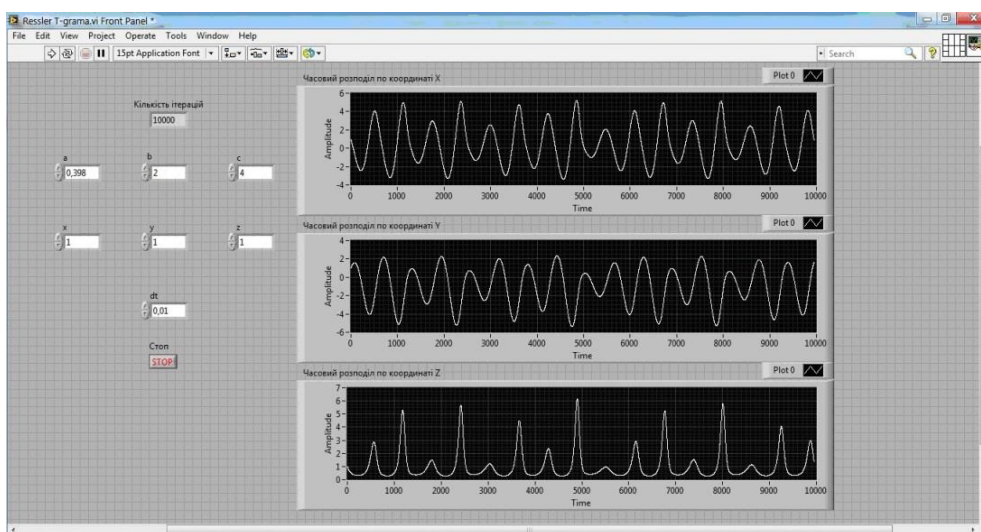


Fig. 2. – Time dependences of the Rossler system

For masking of the information carrier is advisable to use variables x and y

because the variable z does not show behaviour of chaotic system. This result is confirmed by Fourier spectral analysis (Figure 3). Peak spectrum corresponds to 160 Hz.

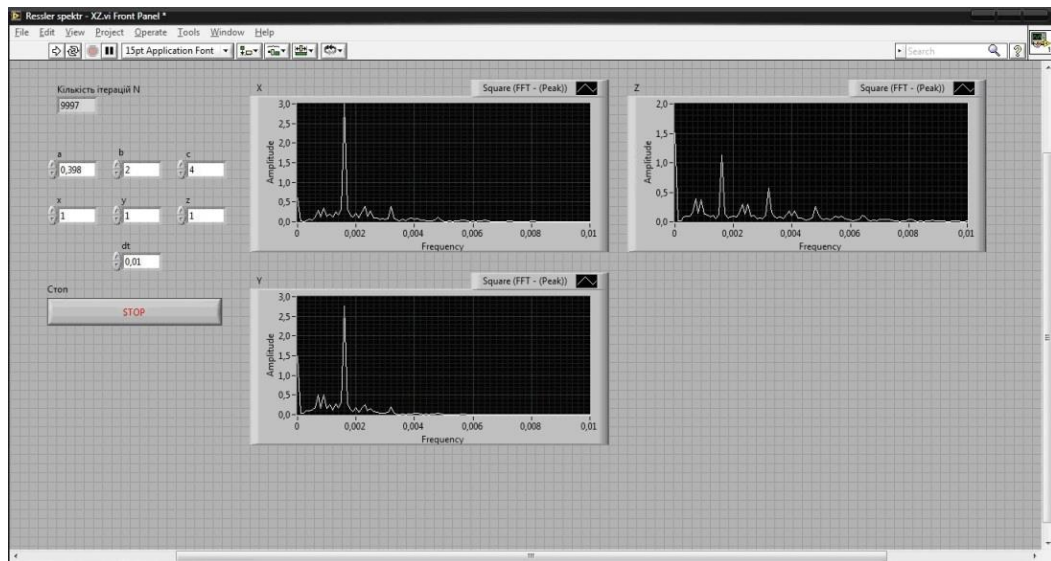


Fig. 3. – Fourier spectral analysis when the number of iterations $N = 10000$

Figure 4 shows the software interface, demonstrating chaotic masking of the information carrier, such as a chaotic Rossler system (1).

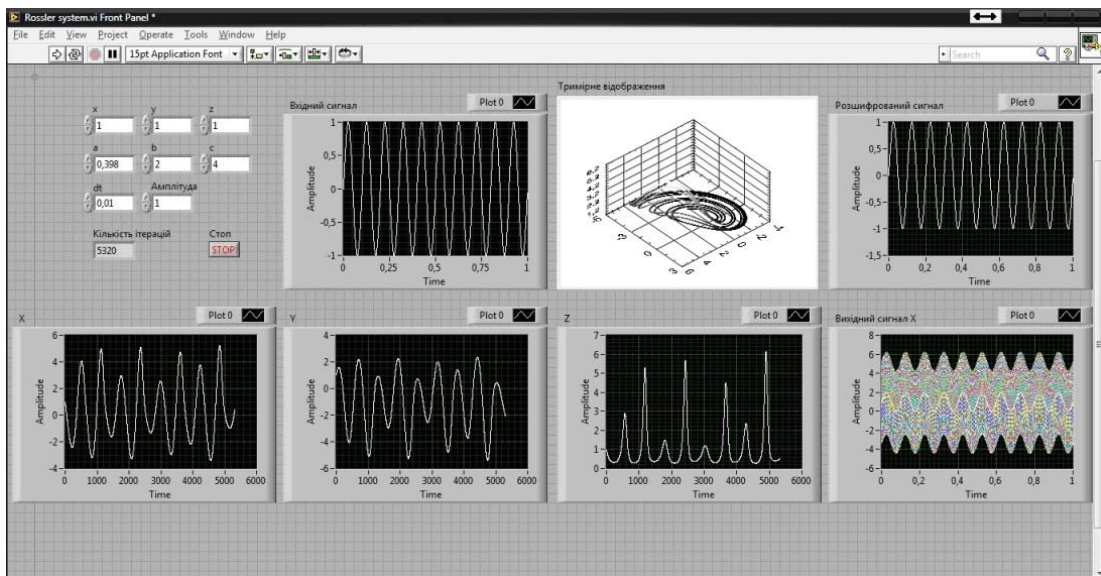


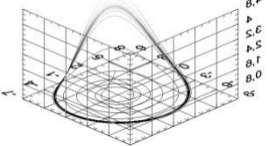
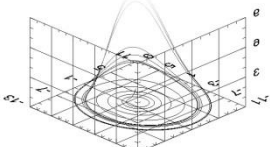
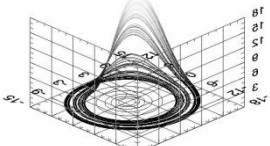
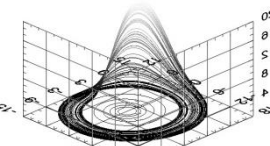
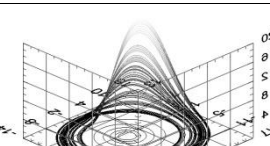
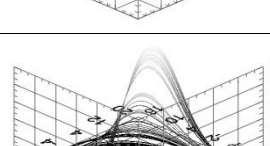
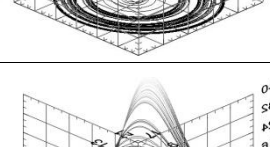
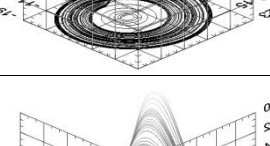
Fig. 4. – Software interface for masking and decryption of the information carrier with the chaotic Rossler system

Chaotic masking of the information carrier is provided by blending chaotic signal with the information. As an information input was used a sinusoidal signal (useful signal) with amplitude of 1 V and parameters $x = y = z = 1$, $a = 0,398, b = 2, c = 4$. Dynamic variables and system parameters are the keys for the masking information. The chaotic output masking signal transmitted to the recipient. Decryption algorithm has opposite effect, i.e., in the receiving side

recipient subtract of the chaotic signal and receive of the information signal [6].

It should be noted that the masking key of the useful (information) signal can be used as the period number of orbits of the chaotic attractor. Table 1 shows the

Table 1

The values of variables	Number of periods of the chaotic attractor	A three-dimensional image
$a = 0,1, b = 0,1, c = 4$	1-period attractor	
$a = 0,1, b = 0,1, c = 6$	2-period attractor	
$a = 0,1, b = 0,1, c = 8,5$	4-period attractor	
$a = 0,1, b = 0,1, c = 8,7$	8-period attractor	
$a = 0,1, b = 0,1, c = 9$	Chaotic attractor	
$a = 0,1, b = 0,1, c = 12$	3-period attractor	
$a = 0,1, b = 0,1, c = 12,6$	6-period attractor	
$a = 0,1, b = 0,1, c = 13$	Chaotic attractor	

values of variables in which the generated different period (controlled) chaotic attractors of the Rossler system [7].

Modeling of Chaotic Rossler System in MultiSim

Figure 5 shows simulated scheme of generator that implements a chaotic Rossler system by using MultiSim.

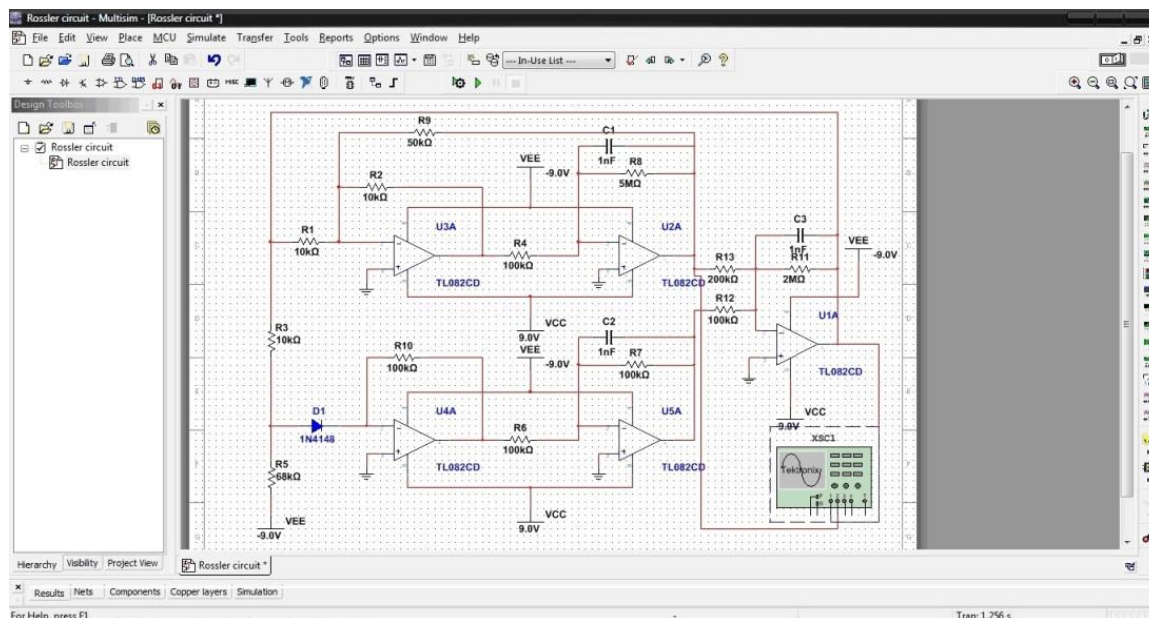


Fig. 5. – Scheme of generator that implements a chaotic Rossler system

Figure 6 shows the result of circuit simulation. Generated chaotic signal in the plane XY presented on the virtual oscilloscope. Coordinate X in the circuit correspond output of the operational amplifier U1A, coordinate Y – the output of operational amplifier U2A, coordinate Z – the output of operational amplifier U5A.



Fig. 6. – Simulated chaotic signal of the Rossler system

In Figure 7 shows time dependences of the coordinates X, Y and Z respectively (on the oscilloscope screen from top to bottom).



Fig. 7. – Time dependences of the coordinates X, Y and Z

Figures 8 – 10 shows spectra of chaotic Rossler system.



Fig. 8. – The spectral distribution of the X coordinate



Fig. 9. – The spectral distribution of the Y coordinate



Fig. 10. – The spectral distribution of the Z coordinate

Conclusions

The develop scheme in LabView programming environment allows the software to generate a chaotic attractor and controlled with a fixed period that can be used in modern systems transmitting and receiving information. The software interface demonstrates masking and decryption of information carrier of the chaotic Rossler system.

Modelled circuit of generator confirms correspondence scheme-technical solution to mathematical apparatus that describing chaotic Rossler system.

Bold different period orbits (see Table 1) let's use the Rossler system in digital communication systems.

References

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Русин В. Б. Моделювання та дослідження хаотичної системи Реслера з допомогою програмних середовищ LabView і MultiSim. У роботі представлений програмний інтерфейс, що був розроблений в програмному середовищі LabView. Він дає змогу генерувати та досліджувати хаотичну систему Реслера. Представлено часовий розподіл трьох хаотичних координат та спектральний аналіз. Також приведено значення змінних, при яких генеруються різноперіодні (керовані) хаотичні аттрактори системи Реслера. Створений програмний інтерфейс демонструє маскування та розшифрування інформаційного носія хаотичною системою Реслера. За допомогою програмного середовища MultiSim проведено схемотехнічний аналіз генератора, що реалізує хаотичну систему Реслера. Змодельована схема генератора підтверджує відповідність схемотехнічного рішення математичному апарату, що описує хаотичну систему Реслера.

Ключові слова: хаос, керування, система, Реслер, LabView, MultiSim.

Русын В. Б. Моделирование и исследование хаотической системы Рёслера с помощью программных сред LabView и MultiSim. В работе представлен программный интерфейс, разработанный в программной среде LabView. Он позволяет генерировать и исследовать хаотическую систему Рёслера. Представлено временное распределение трех хаотических координат и спектральный анализ. Также приведены значения переменных, при которых генерируются разнопериодические (управляемые) хаотические аттракторы системы Рёслера. Созданный программный интерфейс демонстрирует маскировку и расшифровку информационного носителя хаотической системой Рёслера. С помощью программной среды MultiSim проведен схемотехнический анализ генератора, что реализует хаотическую систему Рёслера. Смоделированная схема генератора подтверждает соответствие схемотехнического решения математическому аппарату, что описывает хаотическую систему Рёслера.

Ключевые слова: хаос, управление, система, Рёслер, LabView, MultiSim.

Rusyn V. B. Modelling and Research of Chaotic Rossler System with LabView and Multisim Software Environment

Introduction. In this paper a theoretical basis of chaotic Rossler system is presented.

Modelling of Chaotic Rossler System in LabView. Programming interface developed in LabView software environment is submitted. It allows generating and researching chaotic Rossler system submitted by time distribution of three chaotic coordinates and spectral analysis. Values of variables in which generated different period (controlled) attractors of the chaotic Rossler system are also submitted. The software interface demonstrates masking and decrypt information carrier of the chaotic Rossler system.

Modelling of Chaotic Rossler System in MultiSim. Scheme technical analysis circuit of a generator that implements a chaotic Rossler system is conducted using MultiSim software environment.

Conclusions. Circuit of generator confirming correspondence scheme-technical solution to mathematical apparatus describing chaotic Rossler system is modelled.

Keywords: chaos, control, system, Rossler, LabView, MultiSim.