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MODELING AND CONTROL OF CHAOTIC MULTI-SCROLL JERK SYSTEM IN LABVIEW[1]

V. Rusyn[1], Postgraduate student, A. Stancu[2], Professor, Doctor, L. Stoleriu[2], Associate Professor, Doctor

[1]Yuriy Fedkovych Chernivtsi National University, Chernivtsi, Ukraine, rusyn_v@ukr.net

[2]Alexandru Ioan Cuza University of Iasi, Romania, alstancu@uaic.ro, lstoler@uaic.ro

Introduction

The generation, control and application of multi-scroll chaotic attractors have been studied with increasing interest and have become a central topic in research due to its great potential in chaos communication technology [1, 2].

Chaotic multi-scroll Jerk system is one of chaotic systems used for security of the information carrier [3].

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 multi-scroll Jerk system. The software has been created in one of the most modern system LabView (LabVIEW 2010 (32 bit) for Windows).

Modeling of Chaotic Multi-Scroll Jerk System in LabView

In [4] a sine function was replacing the nonlinear characteristic of Chua's circuit. Using the sine function different numbers of scrolls can be designed. A similar approach can be applied to Jerk circuit

$$\frac{dx}{dt} = y, \quad \frac{dy}{dt} = z, \quad \frac{dz}{dt} = -ay - az + ag(x), \tag{1}$$

where $g(x) = \sin(2\pi bx)$ – nonlinear function, x, y, z – dynamic variables that determine the phase space, a, b – system parameters [5, 6].

The Jerk circuit consists of a linear circuit and a nonlinear circuit (see Figure 1). The design and realization of the linear circuit are simple. Therefore its design and realization mainly depends on synthesizing the nonlinearity by an electrical circuit. Here the nonlinearity is chosen to obtain a sine function and it

[1] http://radap.kpi.ua/radiotechnique/article/view/1084

can be realized by a commercial trigonometric function chips [4].

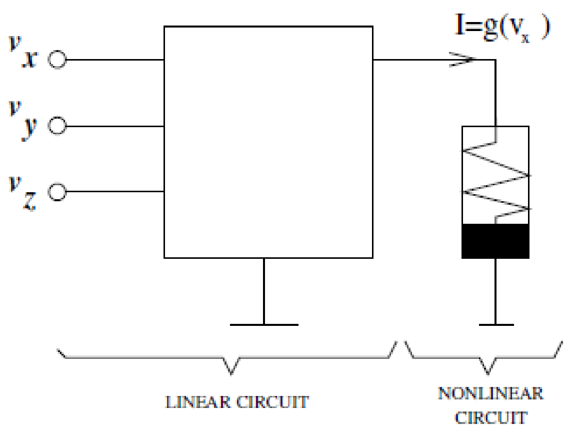

Figure. 1. The Jerk circuit consists of a linear circuit and a nonlinear circuit. The υ_x, υ_y, υ_z voltages correspond to the x, y, z state variables in the model (1), respectively.

Figure 2 shows a block scheme that implements chaotic multi-scroll Jerk 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) 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 and time distributions of chaotic coordinates X, Y and Z.

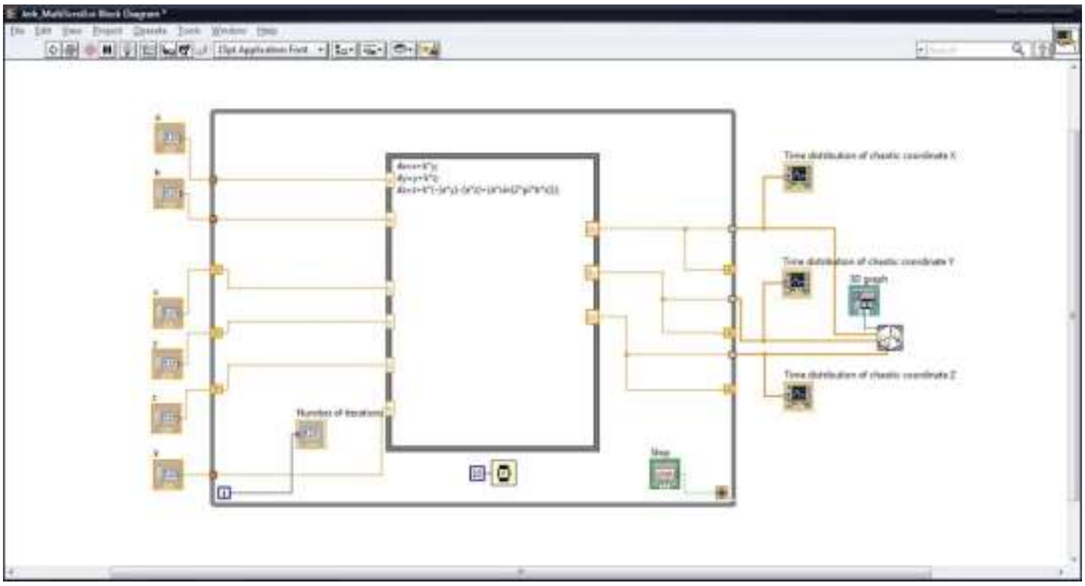

Figure. 2. Block scheme that implements chaotic multi-scroll Jerk system

Figure 3 shows interface of the program that graphically demonstrates the mathematical solution of the chaotic multi-scroll Jerk system, i.e. 3D graph and time distributions of chaotic coordinates X, Y, Z for system parameters $a=0.3$, $b=0.25$, initial conditions $x=y=z=1$, number of iterations $N=5000$, control coefficient $k=0.15$.

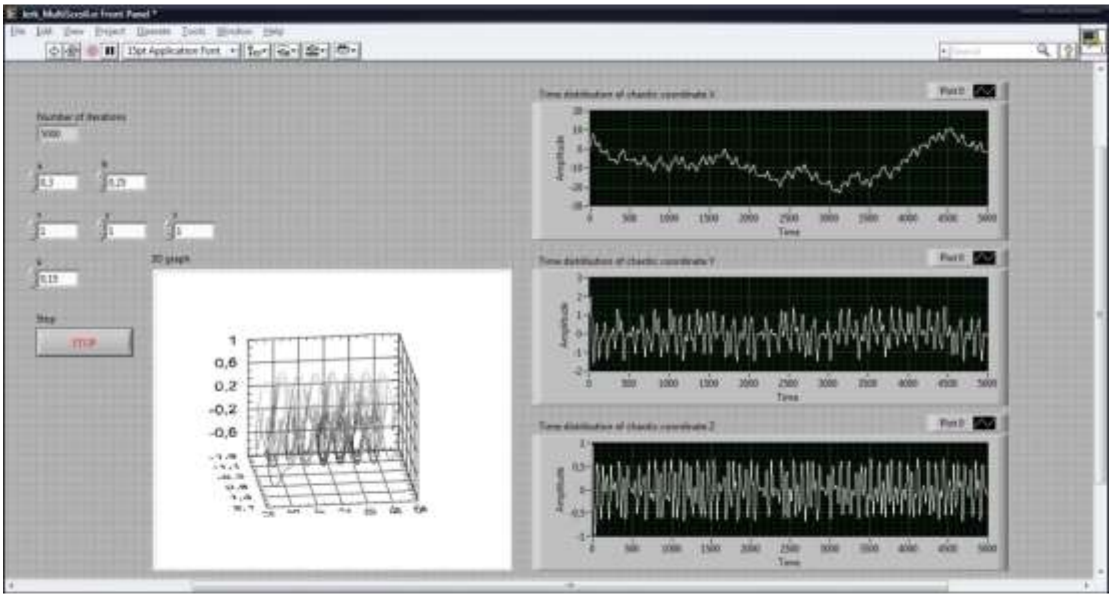

Figure. 3. Interface for generate 3D graph and time distributions of the multi-Jerk system

Control of Chaotic Multi-Scroll Jerk System

For control of the chaotic oscillations of multi-scroll Jerk system we add in each equation (1) control coefficient k.

$$\frac{dx}{dt} = k \cdot y,$$
$$\frac{dy}{dt} = k \cdot z, \qquad (2)$$
$$\frac{dz}{dt} = k \cdot \left(-ay - az + ag(x)\right).$$

Table 1 shows the values of control coefficients in which possible control of chaotic attractors of the multi-scroll Jerk system.

Table 1

The values of control coefficient	Number of scrolls of the chaotic attractor
1	**2**
$k = 0.01$, $k = 0.02$	2
$k = 0.03$	3
$k = 0.04$	4
$k = 0.05$	5
$k = 0.06$	4
$k = 0.07$	5
$k = 0.08$	3
$k = 0.09$	6
$k = 0.1$	5
$k = 0.11$	9
$k = 0.12$	5

Table 1. continuation

1	**2**
$k = 0.13$	11
$k = 0.14$	6
$k = 0.15$	7
$k = 0.16$	8
$k = 0.17$	9
$k = 0.18$	2
$k = 0.19$	7
$k = 0.20$	6
$k = 0.21$	11
$k = 0.22$	12
$k = 0.23$	7
$k = 0.24$	11
$k = 0.25$	16
$k = 0.26$	Chaotic
$k = 0.27$	Chaotic
$k = 0.28$	1
$k = 0.29$	Chaotic
$k > 0.30$	Chaotic

Figure 4 shows example of the control of the chaotic multi-scroll Jerk system for system parameters $a = 0.3$, $b = 0.25$, initial conditions $x = y = z = 1$, number of iterations $N = 5000$, control coefficient $k = 0.1\frac{\partial^2\Omega}{\partial u \partial v}$.

The result of the control is 5-scroll attractor, shown in 3D graph and presented time distributions of chaotic coordinates X, Y, Z.

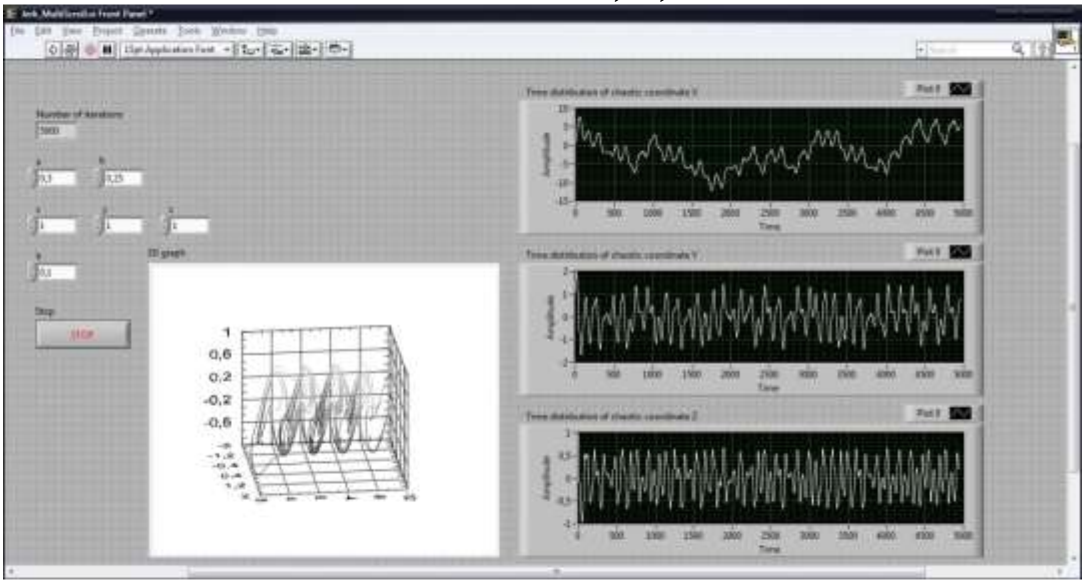

Figure. 4. Interface that shows 5-scroll controlled attractor and time distributions of chaotic coordinates X, Y, Z of the multi-scroll Jerk system

Figure 5 shows another example of control of the chaotic multi-scroll attractors of Jerk system. This modeling was performed with the following parameter values $a = 0.3$, $b = 0.25$, initial conditions $x = y = z = 1$, number of iterations $N = 5000$, control coefficient $k = 0.24$.

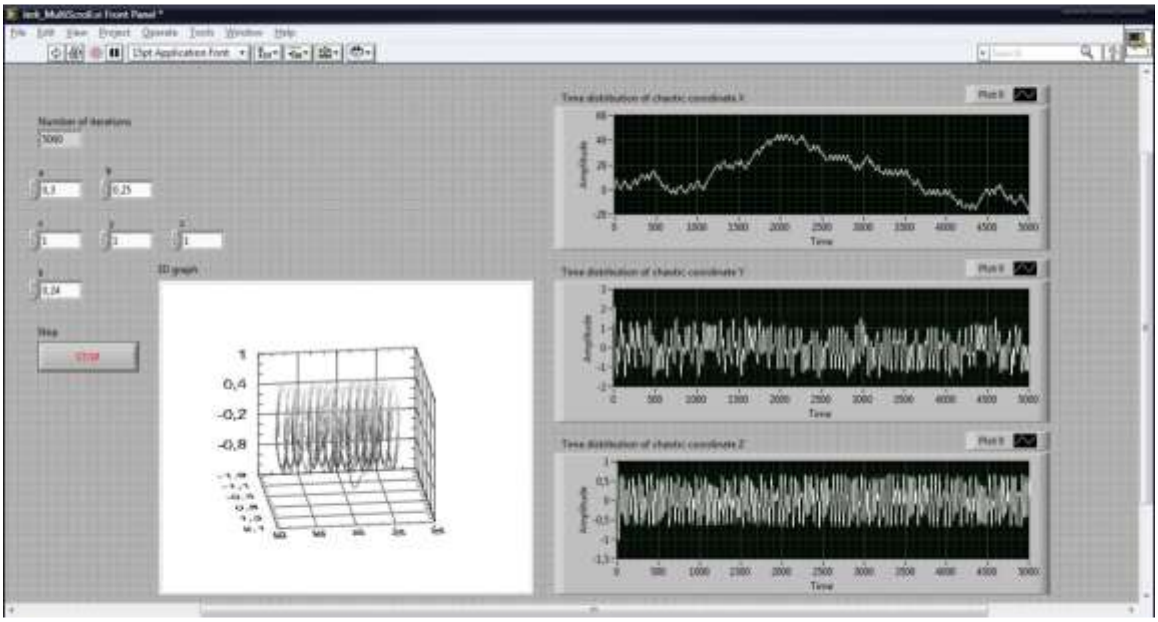

Figure. 5. Interface that shows 16-scroll controlled attractor and time distributions of chaotic coordinates X, Y, Z of the multi-scroll Jerk system

The result of the control is 16-scroll attractor, shown in 3D graph and presented time distributions of chaotic coordinates X, Y, Z.

Conclusions

For the first time was conducted control multi-scroll Jerk system with the corresponding values of control coefficients that are shown in Table 1. For demonstration was applied modern software environment LabView. The values of control coefficient can be used as keys for masking and decryption of information carrier in modern systems transmitting and receiving information.

Acknowledgment

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Русин В., Станку А., Столеріу Л. ***Моделювання та керування хаотичною мульти-листковою Jerk системою з допомогою програмного середовища LabView.*** *У роботі представлений програмний інтерфейс, що був розроблений в програмному середовищі LabView. Він дає змогу генерувати та досліджувати хаотичну мульти-листкову Jerk систему. Представлено часовий розподіл трьох хаотичних координат та 3D відображення. Також приведено значення коефіцієнтів, при яких генеруються керовані хаотичні мульти-листкові атрактори Jerk системи.*

Ключові слова*: хаос, керування, система, Jerk, LabView.*

Русын В., Станку А., Столериу Л. ***Моделирование и управление хаотической мульти-лепестковой Jerk системою с помощью программной среды LabView.*** *В работе представлен программный интерфейс, разработанный в программной среде LabView. Он позволяет генерировать и исследовать хаотическую мульти-лепестковую Jerk систему. Представлено временное распределение трех хаотических координат и 3D отображение. Также приведены значения коэффициентов, при которых генерируются управляемые хаотические мульти-лепестковые аттракторы Jerk системы.*

Ключевые слова: *хаос, управление, система, Jerk, LabView.*

Rusyn V., Stancu A., Stoleriu L. ***Modeling and Control of Chaotic Multi-Scroll Jerk System in LabView***

Introduction. In this paper is presented a theoretical basis of multi-scroll chaotic attractors.

Modeling of Chaotic Multi-Scroll Jerk System in LabView. Submitted programming interface that has been developed in LabView software environment. It allows generating and researching chaotic multi-scroll Jerk system. Submitted by time distribution of three chaotic coordinates and 3D graph.

Control of Chaotic Multi-Scroll Jerk System. Submitted values of coefficients in which generated controlled chaotic multi-scroll attractors of the Jerk system.

Conclusions. For the first time was conducted control multi-scroll Jerk system with the corresponding values of control coefficients that can be used as keys for masking and decryption of information carrier in modern systems transmitting and receiving information.

Keywords: *chaos, control, system, Jerk, LabView.*